

External Shocks and FX Intervention Policy in Financially Dollarized Economies^{*}

ALEX CARRASCO[†]

DAVID FLORIAN HOYLE[‡]

February 2025

We examine the role of sterilized FX interventions as a monetary policy tool in response to external shocks for dollarized emerging market economies. Our model highlights an agency problem that limits banks' ability to secure funds in both domestic and foreign currencies, with its intensity linked to currency mismatches in the banking sector. This leads to endogenous deviations from the standard UIP condition, resulting in a non-neutral FX intervention policy. Sterilized FX interventions stabilize financial conditions not only by stabilizing real exchange rates but also by acting as a balance sheet policy that directly influences credit supply. Our quantitative analysis shows that FX policy rules that counteract exchange rate deviations reduce volatility in interest rate spreads including UIP deviations, credit, investment, and output, leading to significant welfare improvements compared to a flexible exchange rate regime.

JEL classifications: E32, E44, E52, F31, F41, F44.

Keywords: FX intervention, External shocks, Monetary policy, Financial frictions, Dollarization

^{*}The opinions expressed in this paper are solely those of the authors and do not necessarily reflect the views of the International Monetary Fund (IMF) or the Central Reserve Bank of Peru (BCRP). The authors gratefully acknowledge the support of the Financial Stability and Development Network, the Inter-American Development Bank (IDB), the State Secretariat for Economic Affairs/Swiss Government (SECO), and the Central Reserve Bank of Peru throughout the various stages of this research. The authors also acknowledge the insightful discussions with Roberto Chang, Lawrence Christiano, Paul Castillo, David Coble, Carlos Montoro, Chris Linnios, Marco Ortiz, Rafael Nivin, Carlos Pereira, and Haozhou Tang. We thank seminar participants at the BCRP 2019 annual conference, the WEAI 95th annual virtual conference, the BCRP research virtual seminar 2020, the XXV Meeting of Central Bank Researchers Network, the conference "Financial Frictions: Macroeconomic Implications and Policy Options for Emerging Economies" organized by IDB, Central Bank of Chile and The Journal of International Economics, and the LACEA-LAMES annual meeting 2022. Jelfert Guzman provided excellent research assistance. Any remaining errors are the responsibility of the authors.

[†]Corresponding author at: Department of Economics, Massachusetts Institute of Technology, 50 Memorial Drive, Cambridge, MA, 02142. Email: alexcm@mit.edu.

[‡]International Monetary Fund. Email: dflorian@imf.org.

1 Introduction

Emerging market economies (EMEs) frequently experience volatile external shocks that influence their capital flows and exchange rate dynamics. These capital flows, often triggered by global events, affect domestic financial conditions and credit growth, primarily through fluctuations in the availability of foreign currency-denominated funds and exchange rates. As a result, the domestic financial system becomes particularly vulnerable to international developments. In response, EMEs' central banks employ sterilized foreign exchange (FX) reserve accumulation and interventions (hereafter FX interventions) to smooth the effects of rapid capital flow shifts on financial conditions, reduce exchange rate volatility, and provide insurance against exchange rate risks.^{1,2}

This paper examines the effectiveness of FX intervention policy rules in enhancing financial stability as a response to external shocks. We analyze the transmission mechanism of FX interventions and evaluate the welfare gains and losses associated with these policy rules in the context of domestic financial market imperfections and external shocks. The focus is on a family of policy rules that counteract exchange rate movements that exacerbate the impact of borrowing constraints on financial conditions, influence interest rate spreads, and lead to deviations from the uncovered interest parity (UIP) condition when the economy faces external shocks. Given the direct impact of exchange rates on financial stability, this study explores the role of FX interventions in mitigating associated risks.

We extend the small open economy DSGE model with nominal rigidities to include financial intermediaries (banks) and dollarization. Intermediate good firms face a “fund-in-advance-of-production” constraint, which requires them to secure external funding before starting production. Due to market segmentation and frictions in the financial market, households cannot lend directly to firms in the form of debt and face transactions costs when holding assets. In this context, banks collect household deposits and provide loans to firms. A key feature is that deposits and loans can be denominated in pesos (domestic currency) and dollars (foreign currency), and banks have access to external borrowing in dollars.³ An agency problem, however, limits banks' access to funding and introduces an endogenous leverage constraint linking credit flows to banks' net worth, generating interest rate spreads between lending and funding interest rates (*lending interest rate spread*). Additionally, the severity of the bank's

¹Sterilized FX interventions refer to the central bank's purchase/sells of FX reserves in exchange for domestic-currency-denominated bonds to offset any impact on domestic liquidity.

²See Céspedes et al. (2014) for a discussion of LATAM central banks' experiences in response to global events as the 2008 Global Financial Crisis.

³Corrales and Imam (2021) show that in many EMEs, firms and households hold substantial foreign currency liabilities, exposing them —and by extension, their creditors— to significant exchange rate risks.

agency problem is linked to its currency mismatch ratio –the net foreign-currency liabilities relative to total assets, limiting banks arbitrage opportunities between domestic and foreign currency borrowing.⁴ As a result, interest rate spreads between domestic and foreign currency liabilities (*UIP deviations*) emerge in equilibrium.

Taking international prices as given, commodity good producers accumulate stock of capital which is the only input needed to produce commodity goods. Commodity production is entirely exported abroad and any profit from this sector is entirely rebated to their owners. Thus, fluctuations in commodity prices not only affect the aggregate commodity sector activity, but they also spill over the non-commodity sector through their effect on households' resources. Furthermore, the source of uncertainty is an exogenous external sector, summarized in three interrelated components: global demand that determines domestic exports, foreign interest rates affecting foreign currency investments, and international commodity prices. In addition to controlling the nominal interest rate of deposits in pesos via a Taylor rule, the central bank intervenes in the FX market.

The central bank issues domestic bonds and maintains official FX reserves, which are invested in foreign assets. FX interventions are sterilized through adjustments in the supply of domestic bonds, which are exclusively held by banks. The sole purpose of central bank bonds is to operationalize sterilized FX interventions. In our framework, FX interventions operate through two key transmission mechanisms: the Foreign Exchange channel (FX channel) and the Balance Sheet channel (BS channel). When the central bank purchases foreign assets, it drives up the real exchange rate and creates expectations of future currency appreciation. The higher exchange rate reduces banks' net worth, as their foreign liabilities are revalued, while expectations of future appreciation increase currency mismatches (making external borrowing cheaper) and lower the leverage ratio. The resulting decline in banks' capital investment and economic activity constitutes the FX channel of FX policy and is associated with UIP deviations. Additionally, the sterilization of the central bank's FX purchases leads to a crowding-out effect on banks' portfolios, reducing credit supply. As banks hold more central bank bonds, fewer resources are available for lending, driving up the lending interest rate spread. This describes the BS channel of FX policy and is associated with lending interest rate spreads.

Under exchange rate flexibility, the real exchange rate amplifies the initial effects of an external shock (e.g., global demand shocks) by affecting banks' balance sheets, currency mismatches

⁴The prominence of currency mismatches in amplifying the impact of financial market imperfections is consistent with the underdeveloped FX markets in many EMEs, where limited market depth and insufficient hedging instruments can lead to disorderly market conditions in response to sudden changes in capital flows.

and credit constraints, creating financial instability that adversely impacts macroeconomic performance. Hence, FX policies that lean against real exchange rate movements are desirable.⁵ As a consequence, an FX policy rule stabilizing real exchange movements shields the domestic economy from external shocks. For instance, a commodity price boom under a floating exchange rate regime appreciates the exchange rate, enhancing banks' net worth and intermediation capacity, thereby expanding credit availability. Conversely, active FX intervention during such shocks mitigates the exchange rate appreciation, restricts credit growth, and stabilizes consumption and investment through FS and BS channels.

We take the model to the data by considering the Peruvian economy as a representative inflation-targeter and commodity exporter with financial dollarization and active FX policy.⁶ The parameters associated with the banking block of the model are calibrated to replicate financial targets for Peru's banking system. The rest of the parameterization is done by matching the impulse responses of our model to the impulse responses of an SVAR model identified with block exogeneity and zero restrictions under the small open economy assumption. Then, having the external sector as the unique source of shocks, we design numerical experiments to quantify the differences in the economy's response to external shocks under active FX policy and flexible exchange rates. Additionally, we measure the welfare consequences of the FX intervention regime relative to exchange rate flexibility.

Our main quantitative results suggest that FX intervention operations successfully reduce macroeconomic volatility relative to a free-floating regime. In particular, under the FX intervention regime, credit, investment, and output volatility fall by around 73, 51, and 55 percent, respectively, compared to a flexible exchange rate regime. Then, FX interventions play the role of an external shock absorber. These stability implications indicate that FX intervention might create significant welfare gains in response to external shocks. Standard welfare analysis reveals that non-intervention during external shocks would lead to a consumption welfare loss of 4.0 percent, highlighting the effectiveness of FX policy under external disturbances.

We evaluate the welfare gains of FX interventions across various scenarios to test the robustness of our findings. In some scenarios, the welfare gains are larger, such as when there is greater financial vulnerability, and, in others, the welfare gains are smaller, as in cases without financial dollarization or consumption habit formation. Nonetheless, the welfare gains

⁵This holds true even if the UIP condition is met, as long as lending interest rate spreads depend on aggregate banks' balance sheets. In such cases, FX interventions act as unconventional balance sheet policies.

⁶Christiano et al. (2021) and Dalgic (2024) calibrate their models to Peruvian data arguing that Peru exemplifies economies facing significant currency mismatches, minimal capital controls, and a substantial gap between domestic and foreign currency interest rates.

remain significant.⁷ We also explore an alternative managed float regime where the Taylor rule responds to exchange rate deviations, showing that while exchange rate stabilization occurs, it comes at the cost of real economic destabilization. This underscores the benefits of having FX interventions as an independent policy tool. Finally, to capture additional aspects of FX policies beyond our model, we introduce ad-hoc sterilization operations costs and find that welfare gains fluctuate between 1.5 and 5 percent of consumption.

Related Literature. Our paper is related to different strands of literature. It follows the frameworks of [Gertler and Kiyotaki \(2010\)](#) and [Gertler and Karadi \(2011\)](#) for modeling the market imperfection of banking sector under limited commitment constraint. These studies primarily explore the role of unconventional monetary policy’s role in closed economies during times of financial distress. We argue that FX intervention policies function as a form of unconventional monetary policy, but specifically in small open economies, serving as an additional tool to stabilize domestic financial conditions. This dimension of FX interventions (BS channel of FX policies) is highlighted by [Chang and Velasco \(2017\)](#) and [Chang \(2019\)](#), and has recently gained empirical support from [Hofmann et al. \(2019\)](#) and [Ceron et al. \(2023\)](#), who use granular bank data from Colombia and Peru, respectively. Building on these concepts, we construct a medium-scale macroeconomic model that captures key characteristics of EMEs (e.g., financial dollarization) and assesses the quantitative significance of an FX intervention rule that stabilizes the real exchange rate in shaping business cycle dynamics.

The paper builds on [Gertler et al. \(2012\)](#) and [Aoki et al. \(2021\)](#), introducing an interaction between the bank’s agency problem and its debt structure. [Gertler et al. \(2012\)](#) uses the maturity debt structure (short vs. long-term debt) in closed economies, while [Aoki et al. \(2021\)](#) the currency debt structure (domestic vs. external debt) in open economies.⁸ Although our work is closely related to [Aoki et al. \(2021\)](#), we diverge by conceptually exploring the transmission mechanisms of FX interventions and quantitatively examining the impact of FX intervention rules in a financially dollarized small open economy.⁹

At the core of the FX channel lies the portfolio balance approach, originally proposed by [Kouri \(1976\)](#) and [Branson et al. \(1977\)](#), and recently revisited by [Gabaix and Maggiori \(2015\)](#). It suggests that FX interventions influence the exchange rate in segmented currency markets, where domestic and foreign assets are imperfect substitutes. An FX intervention increases

⁷An exception arises when UIP holds, either by households or banks engaging in unlimited arbitrage between foreign and domestic currency assets. In this case, while the FX policy rule still effectively reduces aggregate volatility (due to the BS channel of FX policy), the welfare gains are negligible.

⁸[Aoki et al. \(2021\)](#), and [Mendoza and Rojas \(2019\)](#), examine the role of macroprudential policies, such as capital controls, in economies with foreign liabilities.

⁹While the source of financial dollarization is beyond the scope of this paper, recent studies addressing this issue include [Bocola and Lorenzoni \(2020\)](#), [Christiano et al. \(2021\)](#), and [Dalgic \(2024\)](#).

the relative supply of domestic assets, raising the risk premium and creating depreciation pressure on the exchange rate.¹⁰ We extend this framework by introducing currency mismatches as an additional factor influencing the financial constraint faced by banks, which influence asset substitutability and triggers revaluation effects on balance sheets due to exchange rate fluctuations and foreign liabilities.¹¹

Several studies have leveraged segmented currency markets to examine the optimal Ramsey allocation (e.g., [Cavallino \(2019\)](#), [Fanelli and Straub \(2021\)](#), [Itskhoki and Mukhin \(2023\)](#), and [Yakhin \(2024\)](#)). These studies suggest that FX intervention rules responding to deviations to UIP, or UIP premiums, can implement optimal allocations in their settings, where currency mismatches play a minimal role in transmitting external shocks. We contend that in our model, the interaction between currency mismatches and market imperfections, and large revaluation effects make the real exchange rate a critical target for FX interventions.

The literature empirically evaluating the effectiveness of FX interventions in influencing exchange rate dynamics and stabilizing financial conditions is extensive.¹² However, the welfare gains of such interventions are less explored; notable exceptions include [Faltermeier et al. \(2022\)](#) and [Yakhin \(2024\)](#), who evaluate welfare improvements from adopting optimized FX intervention policies that stabilize UIP premiums. Our paper contributes by measuring the welfare gains from adopting FX intervention rules that counteract real exchange rate movements, in a setting where the domestic economy is exposed to commodity price, foreign interest rates, and global demand shocks.

Layout. The remainder of the paper is organized as follows. [Section 2](#) provides cross-country evidence on financial dollarization and [Section 3](#) describes a general equilibrium model with a special emphasis on the financial system and the implementation of FX interventions. [Section 4](#) presents the parameterization strategy. The main results are discussed in [Section 5](#). [Section 6](#) concludes.

¹⁰This approach has proved a fertile ground for understanding the use of FX intervention as a policy tool. See [Liu and Spiegel \(2015\)](#), [Benes et al. \(2015\)](#), [Cavallino \(2019\)](#), [Fanelli and Straub \(2021\)](#), [Alla et al. \(2020\)](#), [Montoro and Ortiz \(2023\)](#), [Itskhoki and Mukhin \(2023\)](#), [Castillo et al. \(2024\)](#), and [Yakhin \(2024\)](#).

¹¹The revaluation of agents' net worth due to exchange rate movements is an important aspect of financially dollarized EMEs and their policy authorities. See [Calvo \(2001\)](#), [Calvo and Reinhart \(2002\)](#), [Céspedes et al. \(2003\)](#), and [Céspedes et al. \(2004\)](#).

¹²See [Blanchard et al. \(2015\)](#), [Daude et al. \(2016\)](#), [Ghosh et al. \(2018\)](#), [Fratzscher et al. \(2018\)](#), [Adler et al. \(2019\)](#), and [Castillo et al. \(2024\)](#) for studies exploiting aggregate cross-country data, and [Hofmann et al. \(2019\)](#) and [Ceron et al. \(2023\)](#) for analyses based on granular bank-level datasets.

2 Evidence on financial dollarization across countries

We present summary statistics on loan and deposit dollarization across countries. To do so, we use the dataset used in [Corrales and Imam \(2021\)](#) which is constructed using the International Financial Statistics database (IFS) from the International Monetary Fund. The database covers the period 2001–2016 and includes a total of countries from levels of income.¹³ Based on World Bank’s classification of countries by level of income, the dataset comprises 22 high income countries, 20 low income countries, 35 lower-middle income countries, and 37 higher-middle income countries.¹⁴ We group lower-middle and higher-middle income countries in only one category, say “middle income countries.”

	Mean	Q1	Q2	Q3
Low income				
Loan Dollarization	31.16	19.27	28.78	42.55
Deposit Dollarization	17.39	0.00	0.00	28.72
Middle income				
Loan Dollarization	44.00	27.17	45.32	59.12
Deposit Dollarization	25.09	0.37	10.19	44.69
High income				
Loan Dollarization	56.86	49.76	58.47	68.37
Deposit Dollarization	11.06	0.63	5.39	14.85

Source: Dataset from [Corrales and Imam \(2021\)](#).

Table 1. Dollarization Statistics By Income Groups

The database considers loan and deposit dollarization for firms and households. We study the main statistics of firms’ loan dollarization (simply “Loan dollarization”) and households’s deposit dollarization (simply “Deposit dollarization”). The main reason to do so is that our model does not explicitly capture the omitted types of dollarization (say firms’ deposit dollarization and households’ loan dollarization). [Table 1](#) summarizes the loan and deposit dollarization in this dataset. On average, loan dollarization increases with income level. Low-income countries exhibit an average loan dollarization of 31%, while middle-income countries show a higher level at 44%. High-income countries report the highest loan dollarization at 57%. Instead, deposit dollarization follows a non-monotonic relation with level of income. The

¹³As noted in [Corrales and Imam \(2021\)](#), some caveats in this dataset are that: (i) many countries do not have refined data on household and firm credit or deposits, meaning that not all countries are included in the analysis; (ii) many countries, particularly developing ones, individuals and firms may not be properly captured, potentially biasing some of the statistics.

¹⁴[Table A.1](#) enlists the country in each category. In the sample we do not consider countries that issue a reserve currency (namely, Japan and Euro area countries) as well as fully-dollarized countries.

average total deposit dollarization stands at 17% for low-income countries, 25% for middle-income countries, and 11% for high-income countries. The fact that deposit dollarization is the lowest in high-income countries indicates a greater preference for local currency deposits as financial development progresses.

Examining the quartiles (Q1, Q2, Q3) reveals the distribution of dollarization across countries within each income group. In low-income countries, deposits show a median (Q2) of 0%, indicating that a significant share of countries has little to no deposit dollarization. In contrast, middle-income countries exhibit more balanced distributions, with deposit dollarization reaching 44.69% at Q3 and loan dollarization peaking at 59.12%. High-income countries display higher levels of loan dollarization (49.76% at Q1, 57.74% at Q2, and 68.37% at Q3), confirming the stronger reliance of firms on foreign currency financing.

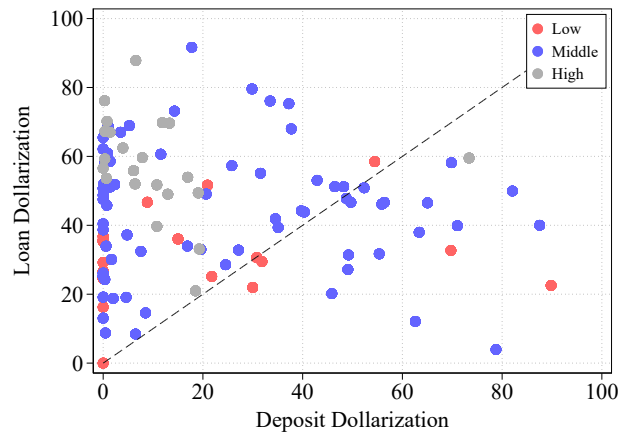
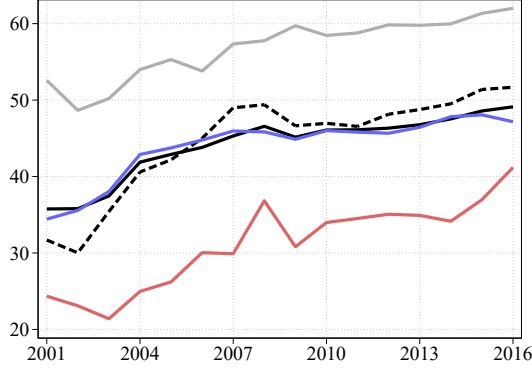


Figure 1. Loans and Deposits Dollarization

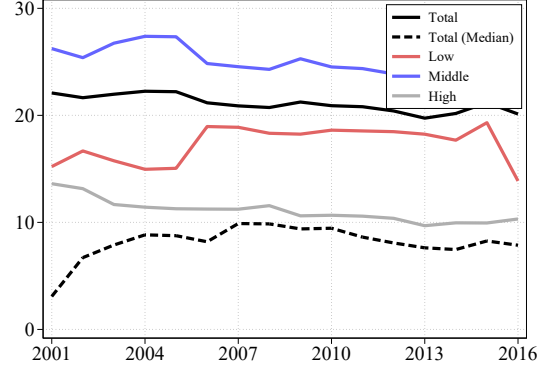
The data reveals significant variation in financial dollarization across income levels. Loan dollarization rises with income, while deposit dollarization peaks in middle-income countries before declining in high-income economies, suggesting a shift toward local currency deposits as economies mature. [Figure 1](#) illustrates this pattern with a scatter plot of loan versus deposit dollarization, color-coded by income groups: red for low-income, blue for middle-income, and gray for high-income countries. The dashed 45-degree line indicates equality between the two measures. While loan dollarization is prevalent, especially in high-income countries, deposit dollarization remains notable in several cases. Notably, middle-income countries often exhibit both high loan and deposit dollarization. Finally, [Figure 2](#) examines the persistence of dollarization by showing the evolution of firms' loan dollarization and households' deposit dollarization over time, segmented by income groups.

Other empirical evidence on dollarization. Empirical studies demonstrate that financial dollarization and currency mismatches modeled in this paper are not unique to Peru but are

(a) Loan Dollarization



(b) Deposit Dollarization

**Figure 2.** Loans and Deposits Dollarization (Average)

common across many EMEs. For example, [Yeyati \(2014\)](#) studied 97 countries and found that many emerging markets exhibit high levels of liability dollarization, where a significant share of banking sector loans and deposits is denominated in foreign currency.

[Corrales and Imam \(2021\)](#) studies loan and deposit dollarization for households and firms. They show that these two groups account for 57.5 percent of deposits and 68.7 of loans being dollarized. These statistics point to the prevalence of currency mismatches beyond Peru, reinforcing the notion that our model’s assumptions are reasonable across a broad set of countries. More recently, [Dalgic \(2024\)](#) finds similar results based on central banks and BIS datasets. Thus, many countries in Latin America, Eastern Europe, and Asia experience currency mismatches due to the widespread use of foreign currency in domestic banking activities.

While many international banks and large corporations attempt to minimize currency mismatches by hedging, banks and firms in EMEs often face a different reality. Using Chilean granular data for trade credit, international trade, foreign currency debt, and FX derivative contracts with firms, [Alfaro et al. \(2021\)](#) document that operational hedging is quantitatively limited and that only large firms hedge this risk by actively using financial hedging. Moreover, using Hungarian administrative household credit registry data, [Verner and Gyöngyösi \(2020\)](#) show that the revaluation of debt burdens causes higher default rates and a collapse in spending.

3 A small open economy model

We extend the small open economy DSGE model with nominal rigidities to incorporate banks, dollarization, and a commodity sector. Due to financial frictions, households cannot lend directly to firms and face transaction costs when holding assets. Firms must secure

external funding before production, relying on banks that collect deposits and issue loans in either domestic or foreign currency. An agency problem constrains banks' ability to obtain funds, making them vulnerable to external shocks, which in turn impact credit conditions and economic activity.

Commodity producers accumulate capital, the sole input for their production, and export all output abroad, with profits rebated to households. Thus, fluctuations in commodity prices influence both the commodity sector and the broader economy by affecting household income. The model features six agents: households, banks, non-commodity good producers, commodity good producers, non-commodity capital producers, and monopolistically competitive retailers. The latter introduces nominal price rigidities in the model. Moreover, a central bank conducts conventional (policy rate) and unconventional (FX interventions) monetary policy. In this setting, we study the role of FX interventions in financial intermediation, macroeconomic stabilization, and exchange rate volatility.

3.1 Households

There is a continuum of identical households with a unit measure. Each household consumes, saves and supplies labor. Households save by lending funds to competitive banks and purchasing private securities issued by intermediate good producers. Within each household there are two types of members: workers and bankers. Workers supply labor and return labor income to their household. Each banker manages a bank and similarly transfers any earnings back to their household. Then, the household effectively owns the bank that its bankers manage; however, the deposits it holds are in banks that it does not own. Furthermore, within the family there is perfect consumption insurance. It is worth emphasizing that this simple form of heterogeneity allows us to introduce banks in a meaningful way within an otherwise representative agent framework.¹⁵

At any moment in time there is a constant fraction of workers and bankers. Over time each member can switch between the two occupations. A banker stays banker next period with probability $\sigma \in [0, 1)$, which is independent of how long the member has been a banker. Upon retirement, bankers are replaced by an equal number of workers who randomly transition into banking roles, ensuring the proportion of bankers and workers remains constant. Newly appointed bankers receive some start-up funds from their household. This switching regime ensures that banks do not reach the point where they can fund all investments from their own

¹⁵This modeling strategy is standard in the literature on financial and labor market frictions. In particular, we are following a convention used in the study of unconventional monetary policy initiated by [Gertler and Karadi \(2011\)](#).

net worth.

Let C_t be consumption and H_t the labor effort in terms of hours worked. Following [Gertler et al. \(2012\)](#), households preferences are given by

$$\mathbb{W}_t(\{C_{t+j}, H_{t+j}\}_{j=0}^{\infty}) = (1 - \beta) \mathbb{E}_t \left[\sum_{j=0}^{\infty} \beta^j \frac{1}{1 - \gamma} \left(C_{t+j} - \mathcal{H}C_{t+j-1} - \frac{\zeta_0}{1 + \zeta} H_{t+j}^{1+\zeta} \right)^{1-\gamma} \right] \quad (1)$$

where $\beta \in (0, 1)$ is the subjective discount factor, $\gamma > 0$ measures the elasticity of intertemporal substitution, and ζ_0 controls the dis-utility of labor. Additionally, the Frisch elasticity is determined by the interaction of $\zeta > 0$ and the degree of internal habit formation, $\mathcal{H} \in [0, 1)$. For instance, if there is no habit formation (i.e., $\mathcal{H} = 0$), this specification abstracts from wealth effects on labor supply and the Frisch elasticity is $1/\zeta$.

We permit households to directly hold private securities and deposits in dollars but facing limits on their market participation, captured by convex transaction costs. For private securities, $\mathcal{S}_t$, a household face holding costs equal to $\frac{\kappa_S}{2}(\mathcal{S}_t - \bar{\mathcal{S}})^2$; while for deposits in dollars, $D_t^{*,h}$, they face holding costs equal to $e_t \frac{\kappa_{D*}}{2}(D_t^{*,h} - \bar{D}^{*,h})^2$. Accordingly, there is a certain amount of each asset that the household can hold costlessly, $\bar{\mathcal{S}}$ and $\bar{D}^{*,h}$, and parameters κ_S and κ_{D*} control the curvature of the marginal transaction cost. Moving away from these levels involves transaction costs that are increasing at the margin. We motivate this cost structure as capturing in a simple way limited participation in asset markets by households that leads to incomplete arbitrage.

Let D_t be the total real quantity of deposits in pesos, R_t the real return on peso deposits, R_t^* the real return on dollar deposits, R_t^{knc} the real return on non-commodity capital, e_t the real exchange rate, w_t denotes the real wage, Π_t is net payouts to the household from the ownership of firms, and T_t the lump-sum taxes. Accordingly, the household budget constraint becomes

$$C_t + D_t + T_t + e_t \left[D_t^{*,h} + \frac{\kappa_{D*}}{2}(D_t^{*,h} - \bar{D}^{*,h})^2 \right] + \mathcal{S}_t + \frac{\kappa_S}{2}(\mathcal{S}_t - \bar{\mathcal{S}})^2 = w_t H_t + \Pi_t + R_t D_{t-1} + R_t^* e_t D_{t-1}^{*,h} + R_t^{knc} \mathcal{S}_{t-1}. \quad (2)$$

The representative worker chooses consumption, labor supply, and bank deposits to maximize (1) subject to (2). Defining $\Lambda_{t,t+1} \equiv \beta \frac{u_{c,t+1}}{u_{c,t}}$ as the household's stochastic discount factor, the household's first order conditions for labor supply and consumption/saving decisions are $1 = \mathbb{E}_t[R_{t+1}\Lambda_{t,t+1}]$,

$$\zeta_0 H_t^\zeta \left(C_t - \mathcal{H}C_{t-1} - \frac{\zeta_0}{1 + \zeta} H_t^{1+\zeta} \right)^{-\gamma} = \mathbb{E}_t u_{c,t} w_t \quad (3)$$

$$\mathbb{E}_t \left[\Lambda_{t,t+1} (R_{t+1}^{knc} - R_{t+1}) \right] = \kappa_S (\mathcal{S}_t - \bar{\mathcal{S}}) \quad (4)$$

$$\mathbb{E}_t \left[\Lambda_{t,t+1} (R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^*) \right] = \kappa_{D*} (\bar{D}^{*,h} - D_t^{*,h}) \quad (5)$$

where $u_{c,t}$ is the marginal utility of consumption.¹⁶ The demand of private securities above its frictionless level is increasing in the excess return of non-commodity capital. Instead, the demand of deposit in dollars is written as a decreasing function of their opportunity cost, i.e., the excess return of peso deposits relative to dollar deposits. Absent these transaction costs (i.e., $\kappa_{D*} = \kappa_S = 0$), households engage in frictionless arbitrage of asset returns.

The household asset demand structure captures three important features in a parsimonious way. First, there is a considerable size of persistent deposit dollarization in many emerging economies, specially for those countries that had suffered from hyperinflation episodes in the last five decades. Second, households differ in their ability to manage a sophisticated portfolio: A limited supply of “sophisticated” households accordingly prevents frictionless arbitrage of security and deposits returns. Third, a small fraction of non-financial firms (typically large, well-established entities) can obtain funds by issuing securities directly to households on the open market, complementing their borrowing from banks. Our model provides a very simple way to account for this pattern of asset holdings that is meant to be a stand-in for a more explicit treatment.

3.2 Banks

Banks lend funds obtained from households and foreigners to non-financial firms. That is, foreign agents are precluded from lending directly to non-financial firms. All financial contracts offer by the bank are nominal, short-term, non-contingent, and, thus, nominal riskless. Although there is no friction in transferring funds between a bank and goods producers, an agency problem limits the ability of banks to obtain funds from households and foreigners.

Loans in pesos and dollars (l_t and l_t^* , respectively) and central bank’s bonds (b_t) comprise the assets of banks, which are financed through a combination of household deposits in pesos and dollars (d_t and $d_t^{*,h}$, respectively), foreign borrowing ($d_t^{*,f}$), and banks’ own net worth (n_t).¹⁷ The bank’s balance sheet expressed in real terms is

$$l_t + e_t l_t^* + b_t = n_t + d_t + e_t (d_t^{*,h} + d_t^{*,f}) \quad (6)$$

where e_t is the real exchange rate. Deposits and external funding are perfect substitutes from bankers’ perspective. Net worth is accumulated through retained earnings, the difference

¹⁶That is, $u_{ct} = \left(C_t - \mathcal{H} C_{t-1} - \frac{\zeta_0}{1+\zeta} H_t^{1+\zeta} \right)^{-\gamma} - \mathcal{H} \beta \left(C_{t+1} - \mathcal{H} C_t - \frac{\zeta_0}{1+\zeta} H_{t+1}^{1+\zeta} \right)^{-\gamma}$.

¹⁷We assume a strict segmentation on the market of central bank’s bonds: Only banks can buy these assets, households cannot participate in this market.

between the gross return on assets and the cost of liabilities:

$$n_{t+1} = R_{t+1}^l l_t + R_{t+1}^{l*} e_{t+1} l_t^* + R_{t+1}^b b_t - R_{t+1} d_t - e_{t+1} R_{t+1}^* d_t^* \quad (7)$$

where $d_t^* \equiv d_t^{*,h} + d_t^{*,f}$ denotes the total funding in dollars and R_t^b , R_t^l , and R_t^{l*} are the real gross returns to the bank from government bonds, loans in pesos, and loans in dollars, respectively. Similarly, R_t and R_t^* are the real gross interest rates the bank pays on peso- and dollar-denominated liabilities.¹⁸ Bankers' objective is to maximize the expected discounted stream of profits that are transferred back to the household, i.e., its expected terminal wealth,

$$V_t \equiv \mathbb{E}_t \sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} (1 - \sigma) n_{t+j}$$

where $\Lambda_{t,t+j}$ is the stochastic discount factor of the representative household from $t + j$ to t and $\mathbb{E}_t[\cdot]$ is the expectation operator conditional on information set at t .¹⁹ In addition to (6) and (7), banks face portfolio constraints that arise from an agency problem.

Agency problem. At the beginning of each period, bankers can act honestly or divert funds from their assets. If bank managers act honestly, assets will be retained until payoffs are realized in the next period, allowing them to repay their liabilities to creditors (both domestic and foreign). Conversely, if bank managers divert funds, those assets are secretly redirected from lending and consumed by their households. Consequently, bank managers abscond with funds if the amount they can divert exceeds the optimal continuation value of the bank. To ensure that creditors are willing to supply funds to the banker, any financial arrangement satisfies an incentive constraint:

$$V_t \geq \overbrace{\Theta(x_t)}^{\text{Composition}} \overbrace{[l_t + \varpi^* e_t l_t^* + \varpi^b b_t]}^{\text{Claim/Size}} \quad (8)$$

where $\varpi^*, \varpi^b \geq 0$, $\Theta(x) = \theta (1 + \frac{\varkappa}{2} x^2)$ with $\theta, \varkappa > 0$, and x_t is a bank-level currency mismatch measure which is defined as

$$x_t = (e_t d_t^* - e_t l_t^*) / (l_t + e_t l_t^* + b_t). \quad (9)$$

That is, we assume that the fraction of funds the bank may divert depends on its balance sheet composition, x_t . A higher currency mismatch increases the severity of the bank's incentive constraint. In this regard, x_t measures the exposure of the bank's balance sheet to abrupt

¹⁸All real interest rates are ex-post. For instance, $R_t = \frac{1+i_t-1}{1+\pi_t}$ where i_t is the nominal interest rate on deposits (monetary policy rate).

¹⁹Notice that using $\Lambda_{t,t+j}$ to discount the stream of bank profits means that households effectively own the banks that their banker members manage.

foreign capital reversals and exchange rate movements. Hence, banks with higher x_t , being more vulnerable to unexpected economic conditions, face tighter financial constraints.²⁰

Note that (8) indicates that some assets are more difficult to divert than others: a banker can divert a fraction $\Theta(x_t)$, $\Theta(x_t)\varpi^*$, and $\Theta(x_t)\varpi^b$ of domestic currency loans, foreign currency loans, and government bonds, respectively. This implies that, for some assets, the constraint on arbitrage is weaker.

Optimal contracting problem. Given a sequence of interest rates, government policies, and n_t , each bank chooses $\{l_t, l_t^*, b_t, d_t, d_t^*\}$ to maximize the franchise value:

$$V_t = \max_{l_t, l_t^*, b_t, d_t, d_t^*} \mathbb{E}_t \Lambda_{t,t+1} \{(1 - \sigma)n_{t+1} + \sigma V_{t+1}\}$$

subject to (6), (7), (8), and (9). The necessary conditions for banks' optimal portfolio are associated with two types of interest rate spreads: 1) Spreads between asset returns and liability costs (Domestic interest rate spreads), and 2) Currency differentiated spreads between deposit interest rates and between loan returns (UIP deviations). To describe these spreads, let $\Omega_{t+1} \equiv \Lambda_{t,t+1}(1 - \sigma + \sigma V_{t+1}/n_{t+1})$ be the shadow value of a unit of net worth to the bank at $t + 1$, $\tilde{R}_{t+1} \equiv x_t \frac{e_{t+1}}{e_t} R_{t+1}^* + (1 - x_t) R_{t+1}$ be the weighted average of returns on bank liabilities, and λ_t^b be the Lagrangian multiplier for the portfolio restriction (8).

Domestic interest rate spreads. There are two spreads within this category: (i) the spread between the return on loans in pesos and its funding cost, $\Delta_t^l \equiv \mathbb{E}_t \Omega_{t+1} [R_{t+1}^l - \tilde{R}_{t+1}]$, and (ii) the spread between the return on government bonds and its funding cost, $\Delta_t^b \equiv \mathbb{E}_t \Omega_{t+1} [R_{t+1}^b - \tilde{R}_{t+1}]$. The optimal behavior of banks imply that these spreads are

$$\Delta_t^l = \frac{1}{\varpi^b} \Delta_t^b = \frac{\lambda_t^b}{1 + \lambda_t^b} \Theta(x_t). \quad (10)$$

Banks invest in each asset to the point where the marginal benefit of an additional unit of each asset is equal to its marginal cost. The marginal benefit of each asset is given by the discounted excess of its return and its funding costs: an extra unit of l_t or b_t is funded by a fraction x_t of domestic currency deposits and a fraction $1 - x_t$ of foreign currency deposits. Instead, the marginal cost of each asset is given by the tighter incentive constraint. It is worth emphasizing that domestic interest rate spreads are a consequence of banks' binding financial constraints ($\lambda_t^b > 0$). They do not depend on the effects of the composition of banks' balance sheet over the financial conditions.

²⁰The significance of currency mismatches in determining the severity of the assumed financial friction aligns with the primary characteristics of underdeveloped FX markets, namely the limited depth of the FX market and insufficient hedging possibilities. These constraints make it challenging for market participants in EMEs to effectively manage currency risk, thereby amplifying the impact of currency mismatches on financial stability.

UIP Deviations. The second type of interest rate spreads consists of deviations from the uncovered interest rate parity condition (UIP): (i) the spread between deposits in pesos and deposits in dollars, $\Delta_t^* \equiv \mathbb{E}_t \Omega_{t+1} \left(R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right)$, and (ii) the spread between loans in pesos and loans in dollars, $\Delta_t^{l*} \equiv \mathbb{E}_t \Omega_{t+1} \left(R_{t+1}^l - \frac{e_{t+1}}{e_t} R_{t+1}^{l*} \right)$. The corresponding UIP deviations are obtained from banks' optimal condition for x_t , l_t^* and d_t^* :

$$\Delta_t^* = \frac{\lambda_t^b}{1 + \lambda_t^b} \left(\frac{l_t + \varpi^* e_t l_t^* + \varpi^b b_t}{l_t + e_t l_t^* + b_t} \right) \frac{d\Theta(x_t)}{dx_t} \quad (11)$$

$$\Delta_t^{l*} = (1 - \varpi^*) \Delta_t^l + \Delta_t^*. \quad (12)$$

Contrary to domestic interest rate spreads, non-trivial UIP deviations not only depend on binding financial constraints but on a positive marginal effect of the currency mismatch over the tightness of financial constraints (i.e., $\frac{d\Theta(x)}{dx} > 0$).

Leverage and Financial Accelerator. The optimal decisions on the bank's balance sheet are summarized by the following credit constraint: $l_t + \varpi^* e_t l_t^* + \varpi^b b_t \leq \Phi_t n_t$ where

$$\Phi_t = \frac{v_t}{\Theta(x_t) - \Delta_t^l} \quad (13)$$

is the maximum ratio of (weighted) assets to net worth that a bank can hold without violating the incentive constraint and $v_t \equiv \mathbb{E}_t [\Omega_{t+1} R_{t+1}]$ is the expected discounted value of having another unit of net worth. When the incentive constraint binds, banks are restricted in obtaining funds from creditors. The leverage ratio, Φ_t , is increasing in 1) the savings of deposit costs from another unit of net worth, v_t , and 2) the discounted marginal benefit (or excess value) of lending in domestic currency, Δ_t^l . Conversely, Φ_t decreases with the fraction of assets that banks can abscond, $\Theta(x_t)$. As a result, a higher currency mismatch has two opposite effects on banks' leverage through $\Theta(x_t)$ and Δ_t^l .

Since the leverage ratio is independent of bank-specific factors, we can sum across individual banks to obtain the relation for the (weighted) total bank assets as a function of total net worth as

$$L_t + \varpi^* e_t L_t^* + \varpi^b B_t = \Phi_t N_t \quad (14)$$

where capital letters denote the aggregate counterpart of individual variables. Thus, aggregate bank balance sheet size is constrained by the aggregate bank capital. Note that this constraint acts as a financial accelerator of economic activity: as balance sheets strengthen with improved economics conditions, the external finance problem declines, which works to enhance credit, thus enhancing the boom. The power of this financial accelerator depends on the degree of

financial vulnerability, measured by x_t . In particular, for shocks that induced a countercyclical movement of x_t , the financial accelerator is more powerful.

It is worth emphasizing that equation (14) can be interpreted as the supply of total credit in the domestic economy. In particular, it determined the (weighted) value of bank assets. The composition of assets is undetermined from the supply side, so it is the demand of each type of lending (coming from firms and the government) that determines the composition.

Financially constrained regime. When the incentive constraint (8) does not bind, financial markets are frictionless, implying that the standard arbitrage conditions hold: $\Delta_t^l = \Delta_t^* = 0$. In this scenario, financial intermediaries are irrelevant for the macroeconomic allocation, rendering both balance sheet policies, such as FX interventions, neutral.

Conversely, when (8) binds, banks face limits to arbitrage portfolios, resulting in endogenous interest rate spreads. Under this “constrained” equilibrium, two possible scenarios emerge. If $\frac{d\Theta(x)}{dx} \neq 0$, banks cannot freely choose the currency composition of their deposits (in pesos or in dollars) or the size of their balance sheets. Their optimal portfolio decision depends on $\Delta_t^* \neq 0$ and $\Delta_t^l \neq 0$, both of which are determined by macroeconomic aggregates in equilibrium.²¹ In this case, the non-neutrality of FX policy has two sources: (i) Binding financial conditions, $\lambda_t^b > 0$, and (ii) the dependence of the agency problem on currency mismatch (i.e., $\frac{d\Theta(x_t)}{dx_t} \neq 0$).

If $\frac{d\Theta(x)}{dx} = 0$, banks face no restrictions on the currency composition of their deposits, allowing them to arbitrage freely between domestic and foreign deposits. As a result, the UIP condition holds in equilibrium, implying $\Delta_t^* = 0$. However, financial frictions continue to limit the size of banks’ balance sheet, leading to non-trivial domestic interest rate spreads, $\Delta_t^l \neq 0$.²² Note, however, that FX operations might still affect the macroeconomic allocation through its effects on the banks’ balance sheet and over Δ_t^l .

We assume that portfolio constraints are always binding and that a greater reliance on foreign currency borrowing exacerbates the moral hazard problem, i.e., $\frac{d\Theta(x)}{dx} > 0$.

3.3 Production sector

Four types of non-financial firms make up the production side of the model economy: i) non-commodity final good producers, ii) capital good producers, iii) intermediate good producers,

²¹Gertler et al. (2012) and Aoki et al. (2021) use a similar financial structure for banks to analyze the role of balance sheet composition.

²²In this case, the model simplifies to a framework akin to those used for analyzing unconventional monetary policies in closed economies. See Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler and Karadi (2013).

and iv) commodity-sector firms which take global commodity prices and external demand as given.

Non-commodity final good producers. Final goods in the non-commodity sector are produced under perfect competition and using a variety of differentiated intermediate goods $\{y_{jt}^{nc}\}_{j \in [0,1]}$ according to a constant returns to scale technology

$$Y_t^{nc} = \left(\int_0^1 y_{jt}^{nc \frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}} \quad (15)$$

where $\eta > 1$ is the elasticity of substitution across non-commodity goods. The representative firm chooses $\{y_{jt}^{nc}\}_{j \in [0,1]}$ to maximize profits $P_t^{nc} Y_t^{nc} - \int_0^1 p_{jt}^{nc} y_{jt}^{nc} dj$ subject to the production function (15). The first-order condition for the j th input induces the demand schedule

$$y_{jt}^{nc} = \left(\frac{p_{jt}^{nc}}{P_t^{nc}} \right)^{-\eta} Y_t^{nc}.$$

The price index for non-commodity domestic product is $P_t^{nc} = \left(\int_0^1 p_{jt}^{nc 1-\eta} dj \right)^{\frac{1}{1-\eta}}$. The final homogeneous good can be used either for consumption or to produce capital goods. In addition, part of the final good production is exported for foreign consumption.

Capital Good Producers. There is a continuum of capital producers operating in a competitive market. Using final goods as inputs in the form of non-commodity investments, as well as the undepreciated capital bought from intermediate good producers, new capital is produced according to $K_t^{nc} = I_t^{nc} + \lambda_{nc} K_{t-1}^{nc}$ where K_t^{nc} is sold to intermediate good producers at the price q_t^{nc} . Producing capital implies an additional adjustment cost of investment $\Phi^{nc} \left(\frac{I_t^{nc}}{I^{nc}} \right) I_t^{nc}$ where I^{nc} is the level of non-commodity investment at the steady-state.²³

Intermediate good producers. There is a continuum of monopolistically competitive firms, indexed by $j \in [0,1]$, producing differentiated intermediate goods that are sold to final good producers. Combining capital k_{t-1}^{nc} , imported goods m_t , and labor h_t , each intermediate good producer operates the following constant return to scale technology

$$y_{jt}^{nc} = A^{nc} \left(\frac{k_{j,t-1}^{nc}}{\alpha_k} \right)^{\alpha_k} \left(\frac{m_{jt}}{\alpha_m} \right)^{\alpha_m} \left(\frac{h_{jt}}{1 - \alpha_k - \alpha_m} \right)^{1 - \alpha_k - \alpha_m}$$

where $\alpha_k > 0$, $\alpha_m > 0$, $\alpha_k + \alpha_m \in (0,1)$, and A^{nc} denotes the total factor productivity level of the representative intermediate good producer. Intermediate good producers face a “funds-in-advanced-of-production” constraint, which requires them to secure funds before starting production to buy capital from capital good producers. They have two sources of funding.

²³The function $\Phi^{nc}(\cdot)$ must satisfy the following restrictions: $\Phi^{nc}(1) = \Phi^{nc'}(1) = 0$ and $\Phi^{nc''}(\cdot) > 0$.

First, the intermediate good producers issue private securities (equity), $\mathcal{S}_{j,t}$, that are purchased by domestic households. Second, they can borrow from banks to get final loan services, $\mathcal{F}_{j,t}$. Hence the purchase of capital is, $q_t^{nc} k_{j,t}^{nc} = \mathcal{S}_{j,t} + \mathcal{F}_{j,t}$.

Each intermediate good producer needs a combination of domestic and foreign currency-denominated loans to obtain final loan services. In particular, loans from different currencies are aggregated according to

$$\mathcal{F}_{j,t} = A^e l_{j,t}^{1-\delta^f} (e_t l_{j,t}^*)^{\delta^f}$$

where A^e is the productivity scale for aggregate loan services, $l_{j,t}$ and $l_{j,t}^*$ denote domestic and foreign currency-denominated bank loans respectively and the parameter δ^f controls for the degree of credit dollarization in the economy. At the end of each period, intermediate good producers sell back the undepreciated capital, $\lambda_{nc} k_{j,t-1}^{nc}$, to capital good producers.

Moreover, intermediate good producers sets prices facing nominal rigidities in the form of price adjustment costs as in [Rotemberg \(1982\)](#). That is, when setting the price of their output, p_t^{nc} , the producer of each differentiated intermediate goods face a convex cost $\frac{\kappa}{2} \left(\frac{p_{j,t}^{nc}}{p_{j,t-1}^{nc}} - 1 \right)^2$ where $\kappa > 0$ controls the degree of price rigidities.

Hence, the optimal behavior for intermediate good producers are associated with three different objectives: (i) cost minimization, (ii) optimal borrowing from banks and equity issuing to households, and (iii) optimal price setting. We describe the key aspects of these decisions. Issuing equity and borrowing from banks are considered to be perfect substitutes to intermediate good producers. This generates a non-arbitrage condition that equalizes the discounted real funding costs to the discounted return of capital, $\mathbb{E}_t[\Lambda_{t,t+1} R_{t+1}^k]$, where $R_t^k \equiv \frac{z_t + \lambda_{nc} q_t^{nc}}{q_t^{nc}}$. The optimal composition of the demand for banks' loans are:

$$l_{j,t} = (1 - \delta^f) \frac{\mathbb{E}_t[\Lambda_{t,t+1} R_{t+1}^k]}{\mathbb{E}_t[\Lambda_{t,t+1} R_{t+1}^l]} \mathcal{F}_{j,t} \quad \text{and} \quad e_t l_{j,t}^* = \delta^f \frac{\mathbb{E}_t[\Lambda_{t,t+1} R_{t+1}^k]}{\mathbb{E}_t[\Lambda_{t,t+1} \frac{e_{t+1}}{e_t} R_{t+1}^{l*}]} \mathcal{F}_{j,t}.$$

In equilibrium, the degree of credit dollarization is an endogenous variable that depends on domestic financial conditions, in particular, on the UIP deviation Δ_{t+1}^{l*} . The higher Δ_{t+1}^{l*} , the higher the credit dollarization rate. It is worth emphasizing that this ad-hoc assumption is a modeling shortcut to determine the composition of firms' demand for loans in each currency, which in turn determines the extent of credit dollarization in equilibrium.²⁴

²⁴Recall that the currency composition of the supply of loans is undetermined with the banks willing to supply any loan in pesos and dollars as long as their aggregate leverage is Φ_t . Therefore, the current assumption determines the extent of credit dollarization.

From the first-order condition with respect to p_{jt}^{nc} evaluated under symmetric equilibrium $p_{jt}^{nc} = P_t^{nc}$, we obtain the following New Keynesian Phillips Curve (NKPC):

$$(1 + \pi_t)\pi_t = \kappa^{-1}(1 - \eta + \eta mc_t) + \mathbb{E}_t [\Lambda_{t,t+1}(1 + \pi_{t+1})\pi_{t+1}Y_{t+1}^{nc}/Y_t^{nc}].$$

where $\pi_t = \frac{P_t^{nc}}{P_{t-1}^{nc}} - 1$ is the inflation rate of final non-commodity goods, which coincides with the consumer price inflation.²⁵

Commodity good producer. Commodity production is entirely exported abroad and is conducted by a representative firm using physical capital as the only input.²⁶ The representative firm acquires capital directly from final good producers, without any lending from the banking, and uses a technology represented by $Y_t^c = A^c(K_{t-1}^c)^{\alpha_c}$ where Y_t^c is the commodity production, K_t^c is the specific capital for the commodity sector, and A^c is the productivity scale in this sector. Given price of commodity and investment adjustment costs $\Phi^c(\cdot)$, the representative commodity producer chooses $\{K_{t+s}^c, I_{t+s}^c\}_{s \geq 0}$ to maximize profits

$$\sum_{s=0}^{\infty} \Lambda_{t,t+s}(1 - \tau^c) \left(p_{t+s}^c A^c(K_{t+s-1}^c)^{\alpha_c} - \left[1 + \Phi^c\left(\frac{I_{t+s}^c}{I^c}\right) \right] I_{t+s}^c \right)$$

subject to $K_{t+s}^c = I_{t+s}^c + \lambda_c K_{t+s-1}^c$ for all $s \geq 0$, where τ^c is the profit tax rate. The ownership of the commodity firm is divided between domestic and foreign shareholders: domestic households own a fraction χ^c , while foreign families own $1 - \chi^c$. Consequently, a fraction $1 - \chi^c$ of the profits are transferred abroad to foreign owners.²⁷

In this framework, fluctuations in commodity prices generate a wealth effect in the domestic economy through household profits and government tax revenues. This effect is further amplified by the strong co-movement between commodity prices and the real exchange rate. Since exchange rate dynamics directly influence the agency problem faced by banks, financial conditions ease when commodity prices rise and tighten when they decline, reinforcing the transmission of external shocks to the domestic economy.

3.4 Consolidated government

The consolidated government consists of a monetary authority (the central bank) and a fiscal authority. The central bank has two instruments to stabilize macroeconomic and financial

²⁵In a Calvo style model in which each monopolistic producer can change its price according to a Bernoulli process with arrival rate $1 - \varrho$, we get the same log-linearized version of NKPC if we choose $\kappa = \frac{(\eta-1)\varrho}{(1-\varrho)(1-\beta\varrho)}$.

²⁶Terms-of-trade fluctuations constitute an important driver of business cycle fluctuations in EMEs. For example, episodes of persistently high commodity prices generate significant economic expansions as well as credit booms. For empirical evidence on this fact, see [Fornero et al. \(2015\)](#), [Shousha \(2016\)](#), [Fernández et al. \(2017\)](#), [García-Cicco et al. \(2017\)](#), and [Drechsel and Tenreyro \(2018\)](#).

²⁷We assume the foreign stochastic discount factor is the same as its domestic counterpart. Hence, $\Lambda_{t,t+1}$ is the discount factor for the future commodity sector's cash flows independent of ownership.

business cycles: FX intervention and the conventional policy rate. In turn, the role of the fiscal authority is to collect taxes to finance central bank's operational results and government expenditure.

FX intervention. The central bank issues domestic bonds, denoted as B_t , and holds official FX reserves, F_t , which are invested in foreign assets. A sterilized FX intervention occurs when the central bank simultaneously buys or sells FX and offsets the impact of such operation over domestic liquidity by adjusting its holdings of domestic currency-denominated bonds. This procedure is captured by the central bank sterilization equation (or balance sheet)²⁸:

$$B_t = e_t F_t. \quad (16)$$

As long as $R_t^b > R_t^*$, the central bank produces operational losses associated with the sterilization process that are transferred to the central government, representing a fiscal costs of FX interventions. Then, the central bank's quasi-fiscal deficit is:

$$CB_t = e_t(F_t - R_t^* F_{t-1}) - (B_t - R_t^b B_{t-1}) = \left(R_t^b - \frac{e_t}{e_{t-1}} R_t^* \right) B_{t-1}. \quad (17)$$

where the second equality uses the sterilization equation (16). Furthermore, the central bank issues bonds systematically, according to the following FX intervention rule:

$$\ln B_t = \ln B - v_e (\ln e_t - \ln e) \quad (18)$$

where $v_e \geq 0$ measures the response of FX interventions to real exchange rate deviations from its steady state value (e) and B denotes the steady state level of central bank bonds. Thus, the central bank sells official FX reserves in response to a real depreciation (specifically, whenever the real exchange rate is above its steady state value).

Monetary policy. In addition to implementing the FXI policy rule (18), the monetary authority sets the short-term nominal interest rate i_t according to a simple rule that belongs to the class of Taylor-type rules given by:

$$i_t - i = \rho_i (i_{t-1} - i) + (1 - \rho_i) \left[\omega_\pi \pi_t + \omega_y \ln \left(\frac{\text{GDP}_t}{\text{GDP}} \right) \right] \quad (19)$$

where ρ_i measures the persistence of the policy rate and ω_π and ω_y controls the degree of the policy rate response to inflation and gross domestic product (GDP), respectively. It is worth emphasizing that this is the nominal return for deposits in pesos, while the real return of it

²⁸The central bank's balance sheet is relevant solely for FX intervention operations. Central bank bonds serve as an independent policy tool to implement sterilized FX interventions, with banks being the only agents allowed to hold them. Households, in contrast, do not participate in the market for central bank assets

and the other assets (included the return on government bonds) are determined in general equilibrium. That is, the central bank controls the interest rate of deposits, while only partially controls the real return of the bonds it offers through its effects on R_{t+1} .²⁹

Fiscal policy. The consolidated government sector collects taxes from households and receives a fraction τ^c of the aggregate profits generated by commodity producers. These resources are then used to finance public consumption G and central bank operational losses, i.e.,

$$\tau^c \Pi_t^c + T_t = CB_t + G_t. \quad (20)$$

Equation (20) indicates that commodity price movements as well as central bank operational losses affect household's decisions through variations in lump-sum taxes. For simplicity, our baseline analysis assumes that the central bank's operational results are financed through non-distortionary taxes. However, in Section 5.4, we explore how additional FX intervention costs may impact our main findings.

3.5 External sector

The foreign demand for non-commodity exports of the domestic final good $Y_t^{nc,x}$ is increasing with respect to the real exchange rate e_t , and global demand or foreign income Y_t^* , given by $Y_t^{nc,x} = e_t^\varphi Y_t^*$, where $\varphi > 0$ is the price elasticity. The external block has its own dynamics without any feedback from domestic variables. The variables considered in the external block are foreign output Y_t^* , the foreign interest rate R_t^* , and the commodity price index p_t^{wc} . The cyclical components of those variables are collected in vector $\hat{\mathbf{X}}_t = [\hat{Y}_t^* \ \hat{R}_t^* \ \hat{p}_t^*]'$ where $\hat{Y}_t^* = \ln \frac{Y_t^*}{Y^*}$, $\hat{R}_t^* = R_t^* - R^*$, and $\hat{p}_t^* = \ln \frac{p_t^{wc}}{p^{wc}}$. We assume that $\hat{\mathbf{X}}_t$ follows a first-order vector autoregressive system given by

$$\hat{\mathbf{X}}_t = \mathbf{C}\hat{\mathbf{X}}_{t-1} + \mathbf{B}\mathbf{u}_t^X \quad (21)$$

where $\mathbf{C}$ and $\mathbf{B}$ are 3×3 matrices that rule the dynamics of the vector $\hat{\mathbf{X}}_t$, and $\mathbf{u}_t^X$ is the vector of external structural shocks. Section 4 presents further details about the data, estimation, and identification strategy.

²⁹Recall that R_{t+1}^b will be pinned down by Δ_t^b which verifies (10).

3.6 Market equilibrium

The non-commodity output net of adjustment, transaction, and “management costs” is either consumed, invested, or exported:

$$Y_t^{nc} = C_t + G_t + I_t^{nc} + I_t^c + Y_t^{x,nc} + \text{REST}_t \quad (22)$$

where REST_t captures additional costs in the model economy, such as investment and price adjustment costs, transaction costs for households’ foreign currency deposits, and equity portfolio investments. REST_t also includes the difference between the aggregate amount of real loans received from the banking sector and the aggregate loan services that intermediate good producers use to buy capital. We interpret the latter as “management costs” that intermediate good producers incur to generate the optimal bundle of loans.³⁰

Gross Domestic Product (GDP) is defined as the aggregate value added of the total production in the non-commodity and commodity sectors but evaluated at constant prices: $\text{GDP}_t = Y_t^{nc} - eM_t + p^c Y_t^c$ where p^c and e are the steady-state levels for the commodity price index and the real exchange rate, respectively. Therefore, GDP_t captures only real output movements and is unaffected by valuation effects.

The market-clearing condition for foreign currency implies that aggregate deposits denominated in foreign currency is composed by household’s bank deposits and banks’ foreign borrowing: $D_t^* = D_t^{*,h} + D_t^{*,f}$. The aggregate net foreign asset position of the economy, NFAP_t , is equal to FX official reserves net of aggregate foreign liabilities in the banking system (i.e., $\text{NFAP}_t = F_t - D_t^{*,f}$), and evolves as a function of financial income of net foreign assets from the previous period plus the difference between the trade balance and the fraction of aggregate profits in the commodity sector transferred abroad,

$$e_t [\text{NFAP}_t - R_t^* \text{NFAP}_{t-1}] = Y_t^{x,nc} + p_t^c Y_t^c - e_t M_t - (1 - \tau^c)(1 - \chi^c) \Pi_t^c$$

Finally, as newly appointed bankers receive a fraction ξ of total assets from the household as start-up funds, the aggregate net worth for banks evolves according to:

$$N_t = (\sigma + \xi) (R_t^l L_{t-1} + R_t^{l*} e_t I_{t-1}^* + R_t^b B_{t-1}) - \sigma R_t D_{t-1} - \sigma e_t R_t^* D_{t-1}^*. \quad (23)$$

In period t , the composition of banks’ balance sheets is given. Equation (23) indicates that movements in N_t uniquely depend on the real exchange rate and real interest rates dynamics. Thus, when the currency mismatch is large enough, any increase in the real exchange rate reduces N_t , affecting aggregate credit conditions.

³⁰ $\text{REST}_t = \frac{\kappa}{2} \pi_t^2 Y_t^{nc} + e_t \frac{\kappa_{D^*}}{2} (D_t^{*,h} - \bar{D}^{*,h})^2 + \frac{\kappa_S}{2} (S_t - \bar{S})^2 + \Phi^c \left(\frac{I_t^c}{I^c} \right) + \Phi^{nc} \left(\frac{I_t^{nc}}{I^{nc}} \right) + L_t + e_t L_t^* - \mathcal{F}_t$.

3.7 Inspecting the mechanisms

This section provides an overview of the primary mechanism by which FX interventions operate, using a simplified version of the model. The main simplifying assumptions are: (i) no domestic financial dollarization (i.e., $L_t^* = D_t^{*,h} = 0$ for all t), and (ii) bank assets are equally weighted in their incentive constraint (i.e., $\varpi^b = \varpi^* = 1$). Additionally, there are no government expenditures, no habits in consumption, full depreciation of capital after production, no adjustment costs of investment, no commodity sector, and fixed prices. To ensure tractability, we assume no aggregate uncertainty and focus on the temporary (partial) equilibrium under perfect foresight for credit and FX asset markets taking expectations as given. In particular, we develop a graphical tool to characterize the equilibrium in the FX and credit markets, where the exchange rate e_0 and the lending interest rate spread Δ_1^l are determined. To simplify the exposition, we provide intuitive arguments for the functions we plot, but details of the discussion below are in [Appendix D](#).³¹

Partial equilibrium analysis. [Figure 3](#) shows the joint determination of e_0 and Δ_1^l in the interrelated FX and credit markets. For pedagogical reasons, we associate the supply of FX assets, S^{FX} , with the resources disposable to accumulate foreign assets mainly determined by the net exports, while the demand of credit, $\mathcal{D}^L$, is pinned down by the firm's loan-in-advance decisions. As expected, a currency depreciation at $t = 0$ leads to increased global demand for domestic goods resulting in higher net exports, while a decrease in Δ_1^l boosts the demand for credit.

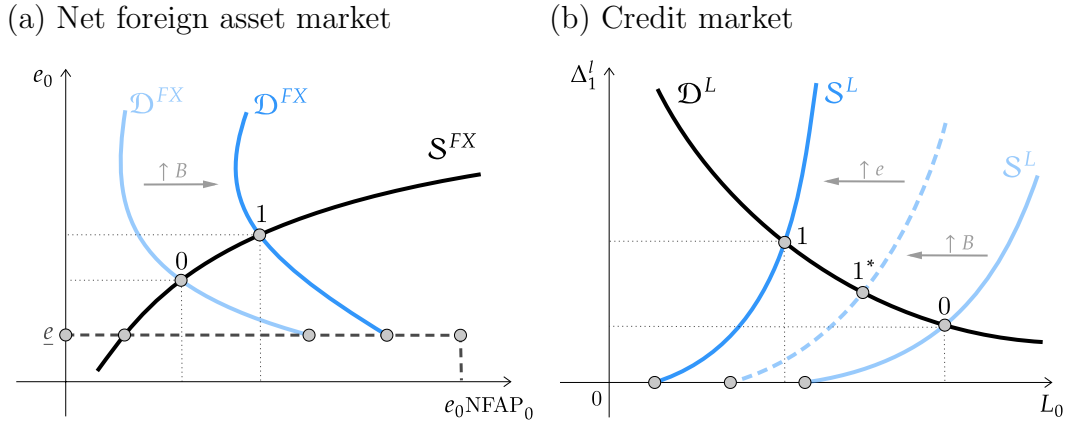


Figure 3. Effects of FX interventions in Net foreign asset and Credit markets

³¹As discussed in Case 1 of [Section 5.4](#), FX intervention policy remains efficient and welfare-improving even in the absence of dollarization. While the exchange rate channel is entirely muted, the balance sheet channel remains the primary transmission mechanism. Since banks remain financially constrained even without financial dollarization, the sterilization component of FX intervention effectively functions as a central bank balance sheet policy.

The supply of credit results, $\mathcal{S}^L$, from aggregate banks' leverage decisions, $\Phi_t N_t$, net of the central bank's bonds B_t . In turn, the demand of FX assets, $\mathcal{D}^{FX}$, assets reflects the central bank's foreign asset holdings, B_t expressed in pesos, net of private banks' foreign liabilities, $e_t D_t^*$. Consistent with our discussion in [Section 3.2](#), these schedules exhibit two distinct regions. When the banks' balance sheet is sufficiently small —either due to low L_0 or low D_0^* — the portfolio constraint does not bind, and both curves are flat. This is the “frictionless” region, where neither interest rate spreads nor UIP deviations occur. Conversely, when the banks' balance sheet reaches a certain size, the borrowing constraints become binding, causing both the interest rate spread and UIP deviations to depend on the macroeconomic allocation. In this “constrained” region, an increase in the domestic lending spread raises the marginal benefits of lending and reduces the currency mismatch, leading to an unambiguous loosening of the borrowing constraint and an expansion of credit supply. On the other hand, an increase in the real exchange rate have mixed effects on the net demand for foreign assets, driven by how banks adjust their demand for external funds. These opposing effects arise from the impact of exchange rate changes on banks' net worth and leverage ratios, further amplified by x_t . Consistent with our baseline calibration, we focus on the scenario where $\mathcal{D}^{FX}$ is downward sloping.

Suppose the economy initially lies in the “constrained” region (represented by the grey dot marked as “0”). An exogenous accumulation of FX reserves by the central bank triggers the following immediate effects across the key markets involved in the transmission mechanism of FX intervention policies:

1. **Foreign Exchange (FX) Channel:** The central bank's purchase of foreign assets shifts the net FX asset demand curve to the right, leading to an immediate depreciation of the real exchange rate (shifting the FX market equilibrium from “0” to “1”).
2. **Balance Sheet (BS) Channel:** The sterilization of this FX purchase reduces credit supply through a crowding-out effect on banks' portfolios. As banks holds more central bank bonds, fewer resources are available for lending, causing the domestic spread to rise at the initial exchange rate level (shifting the credit market equilibrium from “0” to “1*”).³²

Additionally, the increase in the real exchange rate tightens banks' borrowing constraints by reducing their net worth and leverage ratio, further contracting the credit supply. As a result,

³²This aspect of FX interventions is conceptually emphasized by [Chang and Velasco \(2017\)](#), [Céspedes and Chang \(2019\)](#), and [Chang \(2019\)](#), and empirically supported by [Hofmann et al. \(2019\)](#) and [Ceron et al. \(2023\)](#).

the credit supply curve shifts leftward, widening the domestic interest rate spread.³³ In the new equilibrium, the real exchange rate, the interest rate spread, and e NFAP all rise, while total credit diminishes (indicated by the “1” markers).^{34,35}

General equilibrium analysis. The previous discussion of FX interventions focused on a partial equilibrium framework. In [Appendix B.1](#), relying on our quantitative framework explained in detail in the next section, we numerically examine the broader general equilibrium effects of a 1% increase in FX reserves. In summary, the buildup of FX reserves causes real exchange rate depreciation, pushing the economy into a credit crunch and recession. As emphasized in the partial equilibrium analysis, the interaction between banks’ net worth, leverage ratio, and balance sheets is central to the transmission mechanisms of FX interventions.

3.8 Discussion

Currency mismatches. Concerns about the role of currency mismatches in our framework may emerge in situations where financial markets offer instruments to hedge exchange rate risks. However, when banks lend in foreign currency to domestic borrowers whose revenues are in denominated in local currency, a depreciation increases the real burden of those loans, heightening the risk of default. Thus, even if banks appear hedged on paper, they remain indirectly exposed to substantial currency risk. This dynamic is common in many EMEs, where shallow FX markets provide limited hedging options. Consequently, small and medium-sized enterprises (SMEs) often lack the ability to hedge their foreign currency exposure, leaving both, them and their banks, vulnerable to exchange rate fluctuations.³⁶

Financial frictions. The competitive equilibrium in our simple framework is inefficient due to imperfections in the credit market. Our analysis integrates two important strands of literature: (i) the role of financial frictions in interactions between domestic and foreign agents, particularly regarding foreign currency-denominated assets and liabilities, and (ii) the impact of balance-sheet policies during financial crises in closed economies.

³³The exchange rate affects credit supply through a net worth effect and a leverage ratio effect. An increase in e_t reduces banks’ net worth while the leverage ratio effect has opposing impacts: (i) Enhancing banks’ lending profitability by making external funds cheaper through the expected appreciation and (ii) raising the currency mismatch. We assume that $\partial \mathcal{S}^L / \partial e_0 < 0$.

³⁴Second-round effects arise because shifts in Δ_1^I also influence the demand for FX. The schedules in [Figure 3](#) account for these interactions, ensuring that the equilibrium markers reflect the outcome after all adjustments.

³⁵If the initial equilibrium lies in the “frictionless” region for the FX market and in the “constrained” region for the credit market, the FX channel remains muted, yet sterilized FX interventions can still have non-neutral effects due to their impact on the balance sheet. We quantitatively assess this scenario in our robustness checks (See [Section 5.4](#)).

³⁶This approach captures the interaction between borrowers’ currency mismatches and financial frictions in the literature (e.g., see [Mendoza and Rojas \(2019\)](#), [Bocola and Lorenzoni \(2020\)](#), and [Christiano et al. \(2021\)](#)). Moreover, [Alfaro et al. \(2021\)](#) document that operational hedging is quantitatively limited and that only large firms hedge this risk by actively using financial hedging.

At the core of our model is the portfolio balance approach revitalized by [Gabaix and Maggiori \(2015\)](#) to be consistent with imperfect financial markets. This approach introduces a moral hazard problem between international financiers that actively take risks in currency markets, who intermediate between domestic and foreign agents, and their creditors. In our model, these financiers are analogous to domestic banks when there is not domestic dollarization, $\sigma = 0$, $b_t = 0$ and $d_t = 0$.³⁷ The credit constraint, in the form of a limited commitment constraint, faced by financiers in these models typically takes the form:

$$\underbrace{\gamma \cdot \overbrace{\text{Var}(e_{t+1}/e_t)}^{\text{Volatility}} \cdot \underbrace{l_t}_{\text{Size}}}_{\text{Diverted portion}} \cdot \underbrace{l_t}_{\text{Claim/Size}} \leq V_t.$$

This implies that financiers' risk-taking capacity is limited by the complexity of their financial positions, which encompasses the size, composition, and volatility of their balance sheets. Larger and riskier balance sheets result in more complex positions and complicate fund recovery in the event of default, increasing creditors' exposure.

Financial institutions in EMEs face heightened risks due to more complex balance sheets, often exacerbated by currency mismatches from dollarized assets and liabilities. These mismatches intensify exposure to exchange rate volatility, increasing financial fragility. Consequently, currency mismatches heighten banks' ability to divert funds by complicating their balance sheets. Our model reflects this type of complexity. Moreover, banks in our model are forward-looking and exposed to balance sheet effects from expected exchange rate fluctuations.^{38,39} Furthermore, this same portfolio constraint creates domestic inefficiencies in the intermediation of deposits and loans, resulting in positive domestic lending spreads. This structure, commonly used to study unconventional monetary policies in closed economies,⁴⁰ allows us to analyze the role of sterilized FX interventions in a small open economy. We argue that these interventions operate as a balance sheet policy in the domestic credit market, ultimately crowding out domestic lending.

FXI effectiveness and financial dollarization. The analysis in [Section 3.7](#) has assumed that the economy does not exhibit domestic financial dollarization. In this, the strength of the FX channel depends on the UIP deviations which are first-order effects as the steady state exhibits currency mismatch due to banks' external liabilities. If banks could not borrow in

³⁷Similar frameworks have been applied by several authors, including [Cavallino \(2019\)](#), [Fanelli and Straub \(2021\)](#), and [Itskhoki and Mukhin \(2023\)](#).

³⁸The balance sheet effect of real exchange rate fluctuations originates in early 2000s literature. See [Calvo \(2001\)](#), [Calvo and Reinhart \(2002\)](#), [Céspedes et al. \(2003\)](#), and [Céspedes et al. \(2004\)](#).

³⁹[Aoki et al. \(2021\)](#) explores a similar financial structure focusing on macroprudential policies such as capital controls. In contrast, we emphasize the role of sterilized FX intervention rules on the macroeconomic allocation and quantify their welfare gains.

⁴⁰See [Gertler and Kiyotaki \(2010\)](#), [Gertler and Karadi \(2011\)](#), and [Gertler and Karadi \(2013\)](#).

dollars, the FX intervention might be still effective and efficient due to the sterilization effect on credit markets in a financially constrained equilibrium.

To study the effects of financial dollarization in our setting, consider the plot [Figure 3](#) in our previous discussion. When households have access to bank deposits in dollars, the net demand for foreign assets shifts upwards with a steeper (flatter) slope if households' arbitrage frictions are quantitatively larger (smaller) than banks'. Instead, credit dollarization makes $\mathcal{S}^L$ less dependent on e_t as banks have more instruments to mitigate exchange rate risks by lending in foreign currency. Hence, the final effect of FX interventions on credit and economic activity is larger than in a non-dollarized economy if households' arbitrage limits are severe, and smaller otherwise. Additionally, since the macroeconomic variables are more volatile under a flexible exchange rate regime, the FX policy may become more desirable. We study how the lack of domestic financial dollarization affects our results in [Section 5.4](#).

4 Parameterization strategy

We discipline the model to replicate relevant unconditional and conditional moments for the Peruvian economy.⁴¹ We calibrate a subset of the parameters to be consistent with some steady-state targets associated with Peruvian historical averages. Following [Schmitt-Grohe and Uribe \(2018\)](#), we estimate another subset of parameters by using a limited information method based on an impulse response matching function estimator.

Data. We use quarterly data from the Peruvian economy between 2002Q1 and 2018Q4. Aggregate macroeconomic variables such as GDP, consumption, inflation, and the real exchange rate are sourced from the Central Reserve Bank of Peru (BCRP). Additionally, we combine aggregate bank data from individual bank reports to the Superintendencia de Banca y Seguros (SBS), the bank regulator, matching the aggregate bank balance sheets to the model variables. Further details are provided in [Appendix A](#).

⁴¹The Central Reserve Bank of Peru (BCRP) is constitutionally mandated to preserve monetary stability and is prohibited from financing the Public Treasury to maintain its autonomy. Since 2001, the BCRP has followed an inflation-targeting regime, using additional tools like foreign exchange (FX) interventions and reserve requirements to manage risks from financial dollarization. FX interventions help reduce exchange rate volatility without affecting long-term trends, mitigate balance sheet risks, and provide liquidity during periods of stress.

Description	Parameter	Value
Elasticity of Intertemporal Substitution	γ	2.00
Inverse Frisch Elasticity	ζ	3.00
Elasticity of Substitution of Goods	η	6.00
Undepreciated NC Capital Rate	λ^{nc}	0.975
Undepreciated C Capital Rate	λ^c	0.975
Domestic Ownership on Commodity Firms	χ^c	0.00
Tax on Commodity Sector Profit	τ^c	0.60
Banker's Survival Rate	σ	0.945
MP Rate Smoothing	ρ_i	0.70
MP Rate response to Inflation	ω_π	1.50
MP Rate response to Output Gap	ω_y	0.125
FXI efficiency cost	τ^{fx}	0.00

Table 2. Calibrated parameters

Note. Set of parameters that are calibrated based on external references.

Calibrated parameters. The following are parameters calibrated externally. The elasticity of intertemporal substitution for household preferences is 1/2. Households' preferences have a Frisch elasticity of the labor supply equal to 1/3. In the production sector, the elasticity of substitution among intermediate goods is set at six and the capital depreciation rate is set at 10 percent annually for both sectors. Only foreign agents own commodity firms (i.e., $\chi^c = 0$), and a commodity profit tax of 60 percent is in line with [Garcia-Cicco et al. \(2017\)](#). The parameters controlling the conventional monetary policy response (ρ_i ω_π ω_y) are set to standard values commonly used in the literature. Following [Aoki et al. \(2021\)](#), we fix the bank's survival rate, σ , at 0.945. [Table 2](#) summarizes our calibration strategy.

Additionally, we parameterize (ϖ^* , ϖ^b , ξ , θ , κ , δ^f) to be consistent with the following steady-state financial targets for Peru: an annual domestic currency lending rate of 6 percent, an annual foreign currency lending rate of 4 percent, an annual return of 4 percent for central bank bonds, a domestic currency leverage of 3.00, dollar deposits to total assets ratio of 60 percent, and a credit dollarization rate of 50 percent. See [Figure A.2](#) and [Figure A.1](#) for the evolution of the banking system variables in Peru from 2002 to 2018.

Similarly, the vector of parameters (A^e , ζ_0 , Y^* , p^{wc} , A^{nc}) is calibrated to attain 8 percent of annual non-commodity capital return, 0.33 of worked hours and steady-state levels for the real exchange rate, the commodity price index, and GDP normalized at 1. Furthermore, the vector ($\bar{D}^{*,h}$, $\bar{\mathcal{S}}$, α^c , A^c , α^k , α^m , B^{fx}) is parameterized to target empirical ratios, such as consumption to GDP, commodity to non-commodity investment or FX reserves to GDP, among others. [Table A.2](#) in [Appendix A](#) summarizes our parameterization based on the steady-state targets.

Description	Parameter	Value
Non-Commodity Capital Adjustment Cost	κ_{Inc}	0.05
Commodity Capital Adjustment Cost	κ_{Ic}	0.15
FX Intervention response to RER	v_e	9.71
Non-Commodity Exports Price Elasticity	φ	0.09
Household FC Deposit Adjustment Cost	κ_{D*}	3.00
Houosehold Capital Adjustment Cost	κ_S	0.02
Household Habit Formation	$\mathcal{H}$	0.90

Table 3. IRF matching estimation results

Note. Set of parameters estimated to match model and empirical (SVAR) responses to external shocks.

Empirical VAR and impulse-response matching. The rest of the parameter set is estimated to match impulse responses to external shocks between an SVAR model and the DSGE model. We consider an SVAR model with two recursive blocks similar to Canova (2005), Cushman and Zha (1997), and Zha (1999). Let $\mathbf{X}_t = [Y_t^* \ R_t^* \ p_t^{wc}]^\top$ denote the vector of foreign variables and $\mathbf{D}_t = [TB_t, \text{GDP}_t, C_t, I_t, L_t, e_t L_t^*, e_t]^\top$ the vector of domestic variables. The external variables Y_t^* , R_t^* , and p_t^{wc} denote the real GDP index for the G-20 group of countries, the Baa U.S corporate spread, and a metal export price index relevant for the Peruvian economy given its status of an emerging market commodity exporter. The domestic variables GDP_t , C_t , I_t , L_t , and $e_t L_t^*$ denote real indexes for Peru’s GDP, consumption, investment, and real bank lending in domestic and foreign currency, respectively, while e_t denotes the bilateral real exchange rate and tb_t the trade balance-to-GDP ratio.

Following Canova (2005), the baseline specification considers $\mathbf{X}_t$ as an exogenous block, with no feedback dynamics from the domestic block, $\mathbf{D}_t$, at any point in time. The main identification assumption is that an emerging small open economy such as Peru takes as given world prices and quantities. The baseline specification assumes that all variables are expressed in log levels.⁴² Therefore, we consider an SVAR in levels with zero restrictions between the two recursive blocks, capturing the SOE property of the Peruvian economy, and a linear/quadratic time trends. Moreover, shocks within each block are identified recursively with zero contemporaneous restrictions.⁴³

Let Ξ be the subset of parameters to be estimated by matching the impulse responses to external shocks, $\mathcal{M}^{\text{data}}$ the corresponding empirical impulse responses from the SVAR model, and $\mathcal{M}^{\text{model}}$ the theoretical counterpart of $\mathcal{M}^{\text{data}}$. Then, we set Ξ to be the solution to the

⁴²The only variables expressed in percentage terms are R_t^* and tb_t

⁴³We use quarterly data, covering from 2002Q1 to 2018Q4 for the domestic block and from 1980Q1 to 2018Q4 for the foreign block. Following Fernández et al. (2017), we first estimate the foreign block separately and impose the corresponding estimated parameters in the estimation of the domestic block. See Appendix A for methodological details. See Walerych and Weso (2021) and Siklos (2018) for an alternative empirical approach to identifying the effects of external shocks in emerging market economies.

following problem

$$\Xi^* = \arg \min_{\Xi} \sum_{i=1}^k \varrho_i^{-1} \cdot [\mathcal{M}_i^{\text{model}}(\Xi) - \mathcal{M}_i^{\text{data}}]^2 \quad (24)$$

where ϱ_i is a scalar containing the width of the 68% confidence interval associated with the i th variable in $\mathcal{M}^{\text{data}}$. This scalar penalizes the elements of the estimated impulse response functions associated with large error intervals.

Using the same foreign block in our model as in the empirical SVAR, $\Xi = \{\kappa_{Inc}, \kappa_{Ic}, \nu_e, \varphi, \kappa_{D*}, \kappa_S, \mathcal{H}\}$ are estimated matching the responses of GDP, consumption, investment, domestic currency denominated loans (DC loans), and the real exchange rate for the first 24 quarters to perform the matching estimation. Our estimation results are summarized in Table 3 and Figure 4. Our empirical model indicates that a foreign interest rate shock causes a real exchange rate depreciation and a contraction in aggregate credit and output. On the other hand, the global demand and the commodity price shocks are expansionary in terms of domestic output, investment, and total credit. These empirical responses are closely followed by the theoretical responses of our DSGE model (see Fig. 4).⁴⁴

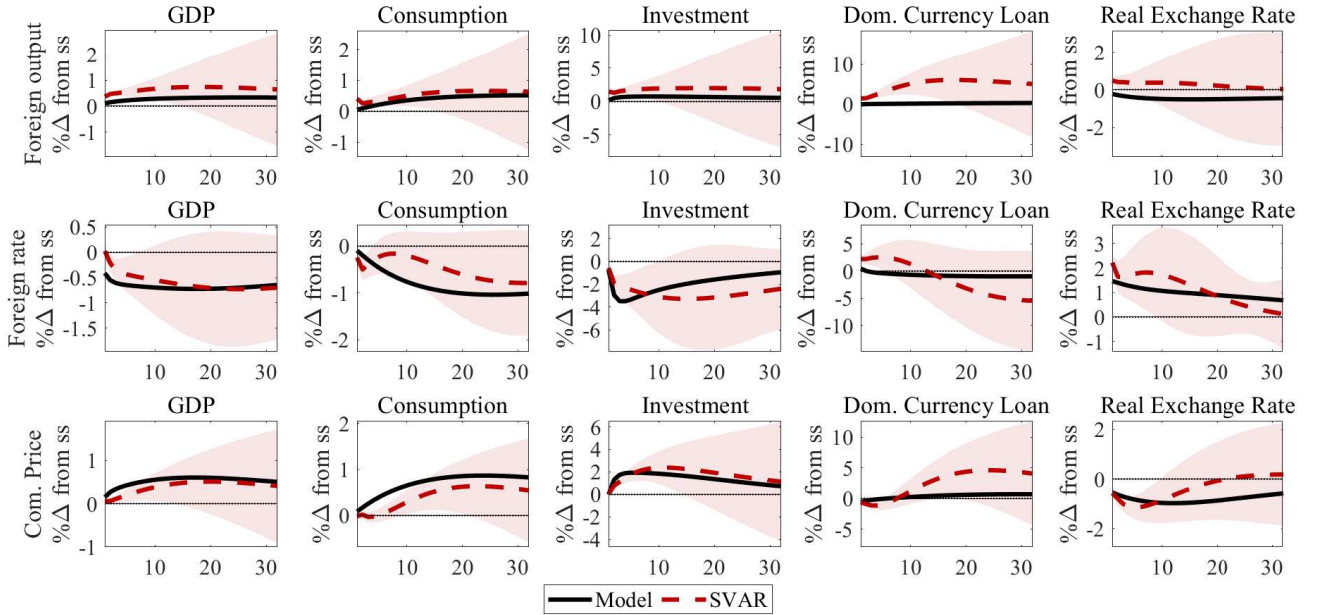


Figure 4. Impulse response matching estimation

Note. Solid-black (red-dashed) lines show point estimates of DSGE's (SVAR's) impulse response, while red-shaded areas depict 68% confidence bands associated with the SVAR's impulse response.

⁴⁴Except for some parameters associated with financial dollarization (δ^f, κ_{D*} , and $\bar{D}^{*,h}$) as well as the endogenous response of FX operations (ν_e), our baseline parameterization is consistent with values for any typical emerging market economy. Moreover, in Section 5.4, we explore more general assumptions about the financial sector and find that our key results are still valid.

Table 4 shows a remarkable similarity between the model-based standard deviations relative to GDP and the first-order autocorrelation of GDP, consumption, investment, and the real exchange rate when compared to their empirical counterparts consistent with the estimated SVAR.⁴⁵ This indicates that our baseline parameterized model accurately captures the patterns observed in the aggregate business cycles of a typical small open economy that is a commodity exporter and has financial dollarization.

	Gross Dom. Product	Consumption	Investment	Real Exchange Rate
RELATIVE STANDARD DEVIATION W.R.T. GDP				
<i>Data</i>	1.00	0.98	5.10	2.24
<i>Model</i>	1.00	0.86	5.83	2.39
AUTOCORRELATION (1ST ORDER)				
<i>Data</i>	0.91	0.87	0.91	0.93
<i>Model</i>	0.86	0.96	0.87	0.71

Table 4. Second moments of main macro variables: Data versus Model:

Note. Model-based first-order autocorrelation and relative standard deviations of key macroeconomic variables (w.r.t. GDP) are compared to their empirical counterparts.

5 Numerical experiments

This section presents a series of simulations to explore the effects of FX intervention operations on credit markets and the broader economy. Our first simulation examines the transmission mechanisms for an exogenous, highly persistent unanticipated accumulation (purchase) of FX reserves. Next, we investigate the transmission of a sudden global commodity boom to financial and aggregate variables under two distinct policy-rule regimes (systematic responses consistent with (18)): Exchange Rate Flexibility (FER), where $v_e = 0$, and FX Intervention Policy (FXI), with v_e at its baseline level. We also explore the effects of this systematic FX intervention on the macroeconomic variables' volatility when all external shocks hit the economy. Our last exercise evaluates the welfare gains and costs associated with various exchange rate regime policy rules that range from FER to different degrees of FXI relative to our baseline scenario. This analysis includes examining the optimal FX intervention rule assuming that the central bank faces adjustment costs when implementing the associated sterilization operations.

In this and the subsequent section, we assign labels to the interest rate spreads and UIP deviations as follows: The spread between the return on pesos lending (correspondingly, dollars lending) and funding costs, Δ_t^l (correspondingly, Δ_t^b), will be referred to as “Interest rate spread 1” (correspondingly, “Interest rate spread 2”). Similarly, the UIP deviations defined by Δ_t^* and

⁴⁵See [Appendix A](#) for methodological details.

Δ_t^{l*} will be denoted as “UIP Deviation 1” and “UIP Deviation 2”, respectively.

5.1 Responses to a commodity price shock

Figure B.3, Fig. 6, and Fig. 7 shows the response of the main macroeconomic variables to a commodity price shock (one standard deviation) when the central bank intervenes in the FX market following the systematic rule (18). To maintain the clarity of our analysis, we isolate the impact of commodity price movements by mitigating its correlation with the rest of the foreign-block sector, i.e., global demand and the foreign interest rate do not deviate from their steady-state level. The black-solid line corresponds to the flexible exchange rate regime in these figures, while the red dashed line represents the FX intervention regime.

The flexible exchange rate regime. Under exchange rate flexibility, a persistent increase in commodity prices raises exports. A large fraction of the revenues from commodity exports remains in the economy, leading to a persistent exchange rate appreciation of around 4.5 percent at impact (see Fig. B.3). The commodity sector experiences a prolonged economic boom that spreads to the rest of the economy through a significant wealth effect and a higher demand for investment goods. The response of the shadow price of the incentive compatibility constraint (IC multiplier in Fig. B.3) indicates that banks are less constrained with a significant improvement in financial conditions. However, the leverage ratio declines at the outset of the commodity shock but improves persistently after. Notice that exchange rate appreciation relaxes the agency constraint that banks face through a significant currency mismatch reduction of 4.0 percentage points and a 6 percent increase in net worth see Fig. 6). But at the same time, both interest rate spreads decline at impact, producing a one-period contraction on the leverage ratio response.

These responses constitute an expansionary financial effect induced by the real exchange rate appreciation. Hence, lending in both currencies rises at impact (3 percent for domestic currency loans and 8 percent for foreign currency loans). Under exchange rate flexibility, agents expect a real exchange rate depreciation, making borrowing in dollars more expensive than borrowing in pesos. In contrast, lending in foreign currency becomes more profitable than lending in domestic currency. As a result, the banks’ balance sheets experience a 1.0 p.p. increase in credit dollarization and a reduction of 3 percentage points in deposit dollarization at impact. The commodity boom and the subsequent expansionary financial conditions (credit boom) modify the dynamics of real macroeconomic variables. Investment and consumption increase persistently by around 8.0 percent and 1.6 percent at the peak of their responses, respectively (see Fig. 7). Under the flexible exchange rate regime, the commodity boom induces persistent economic expansion, with GDP increasing by 1.6 percent at impact.

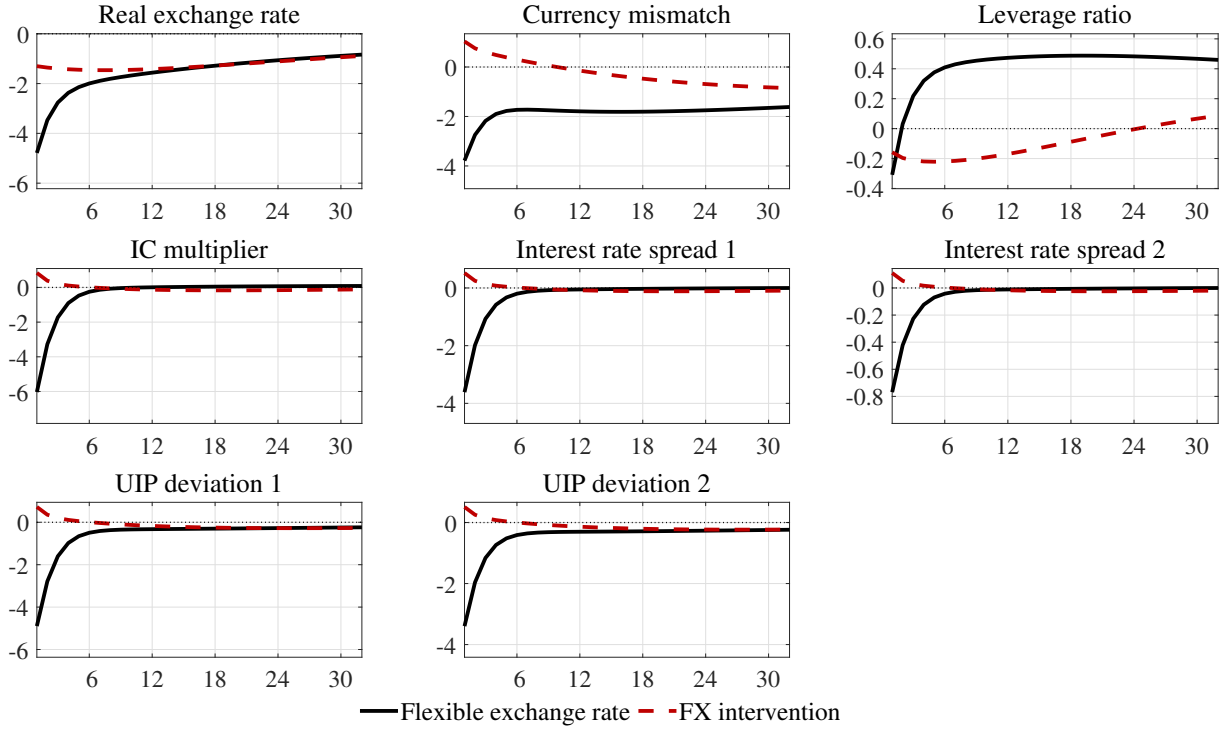


Figure 5. Responses of financial variables to a commodity price shock

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

The FX intervention regime. When faced with rising commodity export prices (and real exchange appreciation relative to its steady-state level), the central bank accumulates FX reserves and issues central bank bonds to counteract the downward pressure on the exchange rate. The potential for stabilization through these interventions aligns with the discussions presented in [Section 3.7](#): due to the binding agency problem, the accumulation of FX reserves limits exchange rate appreciation, ultimately reducing bank credit expansion and hindering the growth of macroeconomic aggregates such as consumption, investment, and GDP. The effects of the systematic FX rule are divided into two main channels: Foreign Exchange (FX) and Balance Sheet (BS).

Foreign exchange channel. In response to a commodity price shock, the central bank intervenes by purchasing foreign exchange reserves, which modifies the net foreign asset position of the economy. Consequently, the dynamics of the exchange rate change in comparison to the flexible exchange rate regime. At impact, the real exchange rate appreciates by 1.6 percent instead of 4.5 percent (see [Fig. B.3](#)). At the initial impact, banks' net worth increases less than under free-floating (2 percent instead of 6 percent). Subsequently, aligned with the negative response of the leverage ratio, the banks' net worth response is higher compared to the FER regime (see [Fig. 6](#)).

The enhanced stability of the real exchange rate has implications for the costs and returns

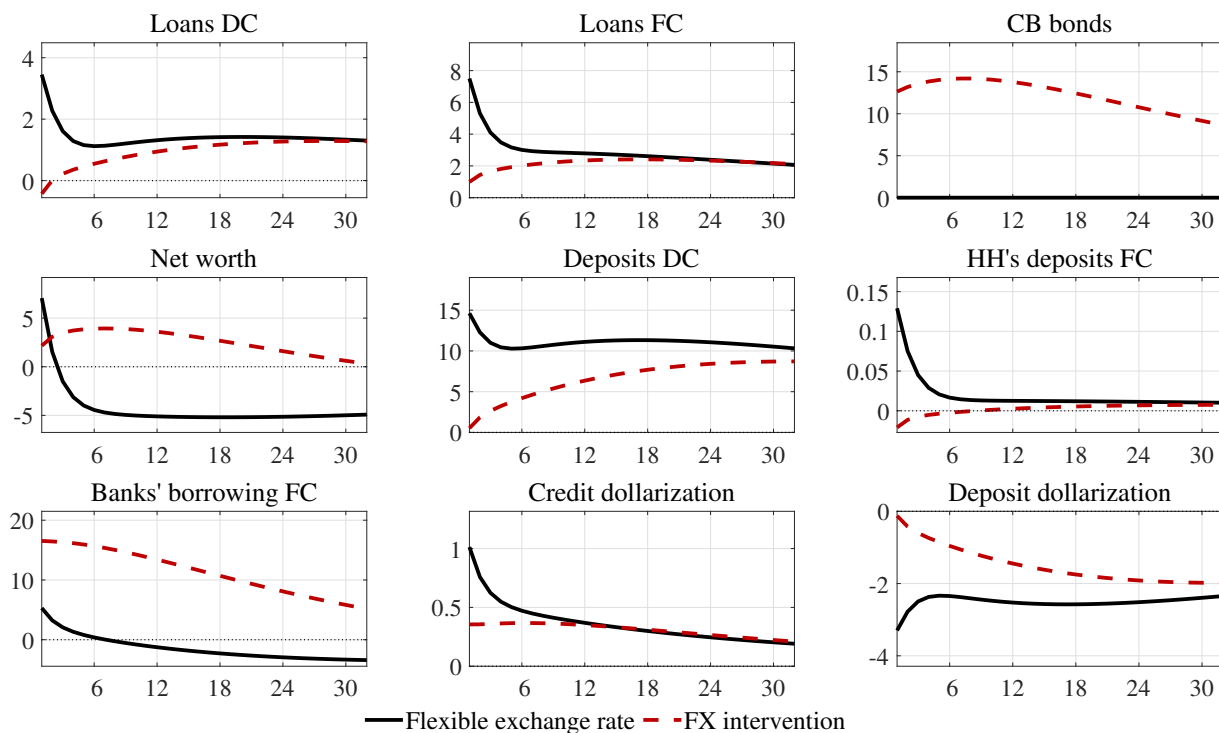


Figure 6. Responses of financial variables to a commodity price shock

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

associated with borrowing and lending in foreign and domestic currency, as demonstrated by the response of the spreads and UIP deviations in Fig. B.3. In line with our discussion in Section 3.2, the response of banks' currency mismatch and leverage ratio reflects this increased stability, leading to smoother responses in financial and real variables compared to the FER regime (see Fig. 6 and Fig. 7). Indeed, the observed initially less expansionary credit conditions can be attributed to the less expansionary bank's net worth, which results from the balance sheet effect caused by the real exchange rate depreciation. However, as time progresses and we move into the second year, the lower leverage ratio assumes a more crucial role in influencing credit conditions.

Additionally, as households anticipate future exchange rate appreciation, they tend to decrease their deposits in dollars. Consequently, banks rely more on external borrowing instead of domestic deposits in both currencies. This trend is evident from the fact that external dollars deposits increase by 16 percent under FXI, in contrast to the 5 percent increase observed under the FER regime (see "Banks' borrowing FC" in Fig. 6). Furthermore, due to the expected real exchange rate appreciation, banks are inclined to offer more credit in dollars relative to credit in pesos. However, this same expectation also prompts intermediate goods producers to demand more dollars loans than pesos ones, increasing credit dollarization, albeit to a lesser extent than would be observed under a flexible exchange rate regime (see "Credit dollarization" in Fig. 6).

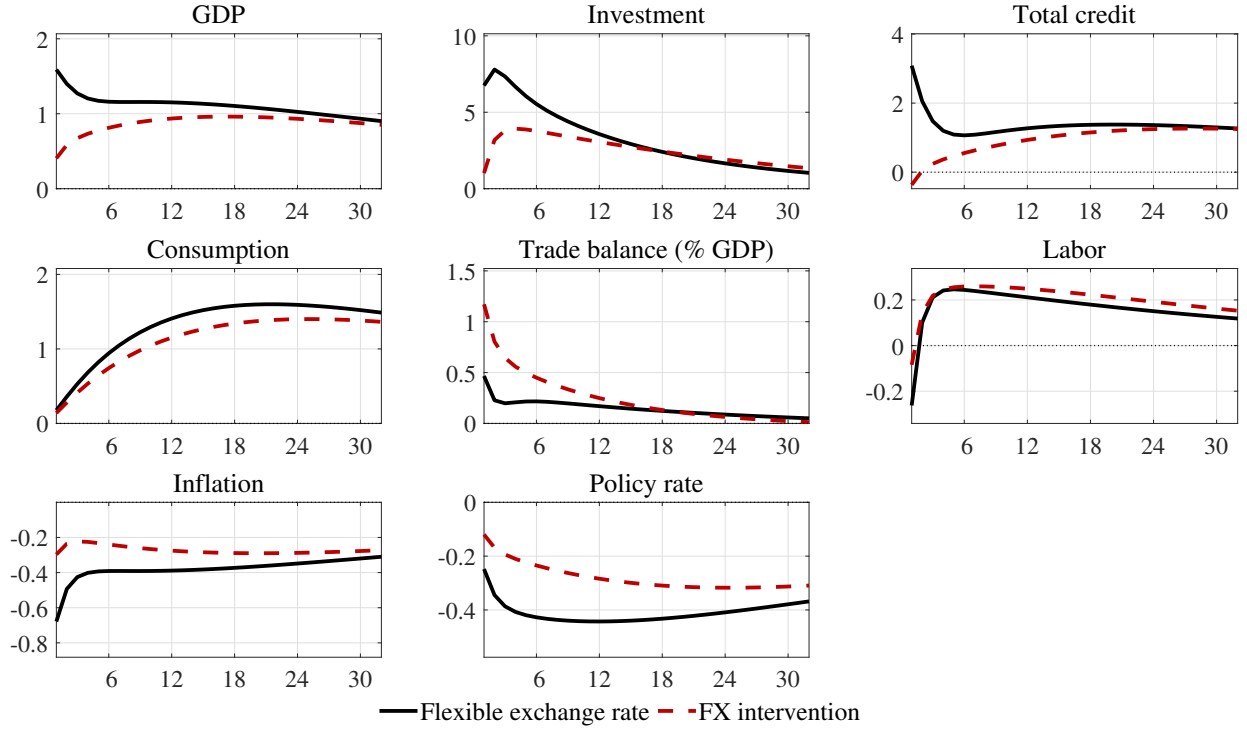


Figure 7. Responses of macroeconomic variables to a commodity price shock

Note. All variables are presented as percentage deviations from their steady state, except for interest rates and spreads which are displayed as deviations from their respective steady states.

Balance sheet channel. The central bank's response to building FX reserves is accompanied by a sterilization operation. This operation entails the central bank selling its own bonds to offset the impact on domestic liquidity. This operation leads to a significant shift in the banks' balance sheets: banks tend to allocate their additional funds to central bank bonds rather than lending, leading to a lower increase in lending in both currencies compared to what would be observed under a FER regime (as illustrated in Figure 6).

Consequently, both the exchange-rate-smoothing and balance-sheet crowding-out channels play a critical role in the effectiveness of the FX policy rule in stabilizing economic credit conditions. This stability, in turn, extends to other macroeconomic variables, leading to a higher level of overall stability, as evidenced in Fig. 7.⁴⁶

Notably, the responses of central bank bonds and the exchange rate closely aligns with periods of FX reserve accumulation in the Peruvian economy. In Appendix A.3, we show that these episodes are characterized by an average increase in reserves of approximately 15% and an exchange rate appreciation of 2% —movements that are consistent with our quantitative results (in the model, the behavior of central bank bonds determines the dynamics of central

⁴⁶The notable exception can be observed in the trade balance, which exhibits a higher response compared to the FER regime. This result can be explained by the less expansionary boom that reduces imported inputs, resulting in a more favorable trade balance outcome in this scenario.

bank FX reserves).⁴⁷

5.2 Aggregate volatility and external shocks

The simulation results clearly indicate the significant effectiveness of FX operations as an external shock absorber. The FX operations successfully mitigate the impact of external shocks on the economy, showcasing their role in maintaining stability and resilience in the face of such shocks. To measure the FX effectiveness, we quantify the reduction in the volatility of macroeconomic variables within the FXI regime compared to the FER regime. This evaluation is conducted when the economy experiences frequent external shocks and the foreign-sector block exhibits co-movements (as discussed in [Section 3](#)).

Financial variables				Real variables			
	FXI	FER	$\Delta\%$		FXI	FER	$\Delta\%$
Currency Mismatch	1.79	4.35	-59	Real exchange rate	2.07	5.48	-62
Leverage Ratio	44.71	68.90	-35	Total Credit	1.04	3.88	-73
Net Worth	6.57	11.16	-41	Investment	5.03	10.31	-51
Interest Rate Spread 1	0.91	4.63	-80	Consumption	0.71	0.94	-24
Interest Rate Spread 2	0.19	0.99	-80	GDP	0.86	1.91	-55
UIP Deviation 1	1.28	6.16	-79	Inflation	0.34	0.74	-53
UIP Deviation 2	0.91	4.24	-79	Labor	0.40	0.51	-23

Table 5. Aggregate volatility conditional on external shocks

Note. FXI and FER denote Foreign Exchange Intervention and Flexible Exchange Rate policy regimes, respectively. The computation considers the external block as the only source of aggregate volatility. Results are based on 2500 replications of 120 periods of simulated trajectories.

Under the FX intervention policy regime, macroeconomic volatility is substantially reduced, compared to the flexible exchange rate regime, when external shocks occur (see [Table 5](#)). Specifically, the volatility of the real exchange rate (RER) decreases by 62 percent, while total credit volatility declines by 73 percent. This outcome is consistent with considerable reductions in the volatility of financial variables such as interest rate spreads, UIP deviations, currency mismatches, banks' net worth, and leverage ratio. Additionally, the volatility of output, investment, and consumption decreases by approximately 55 percent, 51 percent, and 24 percent, respectively. Consequently, our findings suggest that FX interventions effectively stabilize domestic macroeconomic volatility under external shocks.⁴⁸

⁴⁷This serves as an alternative validation of our calibration strategy. In [Appendix A.3](#) we also consider episodes of deaccumulation of FX reserves by the central bank.

⁴⁸Even though the FXI rule (18) implies a linear response to any deviation of the real exchange rate from its steady state, the reduction of macroeconomic volatility is not a necessary result. Below, we explore cases where the FXI regime does not succeed according to the volatility smoothing and welfare criterion.

5.3 Welfare analysis

We identify the optimal FX policy intervention from a set of policy rules defined by equation (18). Following the approach of [Schmitt-Grohe and Uribe \(2007\)](#), we consider a policy rule to be implementable if it guarantees a locally unique rational expectations equilibrium. An optimal policy rule is both implementable and results in the highest level of lifetime utility, given the initial state of the economy, among the considered set of policy rules. Our objective is to determine the policy rule that satisfies these criteria.

Consider two monetary policy regimes: i) the reference policy regime, denoted by $\mathcal{R}$, and ii) the alternative policy regime, denoted by $\mathcal{A}$. A particular parameterization of the FXI and monetary policy rule characterizes each policy regime. In the $\mathcal{R}$ -regime, each policy rule is parameterized as in our baseline model: $\rho_i = 0.7$, $\omega_\pi = 1.5$, and $\omega_y = 0.125$ for the interest rate rule, and $v_e = 9.7$ for the FX intervention rule.⁴⁹ The alternative policy regime $\mathcal{A}$ differs from $\mathcal{R}$ in the value of the policy response coefficients (ω_π, v_e) . The set of policy regimes we evaluate changes the dynamics of the model but not its steady state, i.e., welfare measures are conditioned upon the same initial steady state for $\mathcal{R}$ and $\mathcal{A}$.

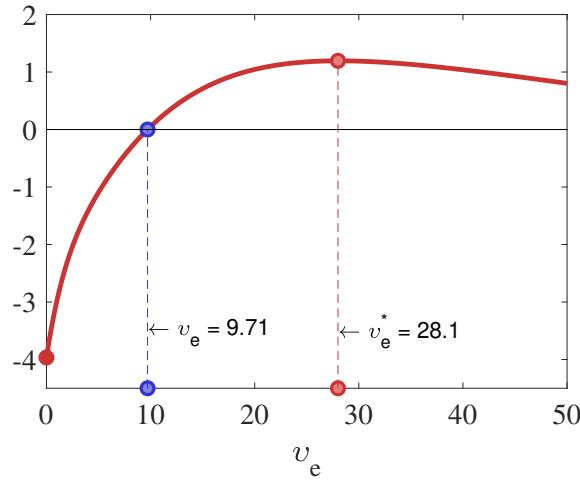


Figure 8. Welfare gains of FX intervention policy

Note. The welfare gain represents the proportion of consumption in the baseline calibrated model that a household would be willing to sacrifice in order to maintain the same level of welfare in an economy where the FX policy rule exhibits a distinct endogenous response to the real exchange rate, governed by v_e .

Our welfare gain measure ς is the fraction of the consumption process of the reference regime $\mathcal{R}$ that a household would be willing to give up to be as well off under the alternative policy

⁴⁹Recall that, in our baseline model, v_e is one of the parameters estimated by impulse-response matching, while the parameterization of the interest rate rule follows the standard calibration found in the literature. Therefore, none of the parameterization of the reference regime is necessarily optimal.

regime $\mathcal{A}$ as under regime $\mathcal{R}$, i.e.,

$$\mathbb{W}(\{C_t^{\mathcal{A}}, H_t^{\mathcal{A}}\}_{t \geq 0}) = \mathbb{W}(\{(1 + \varsigma)C_t^{\mathcal{R}}, H_t^{\mathcal{R}}\}_{t \geq 0}). \quad (25)$$

If $\varsigma > 0$, there is a welfare gain, while if $\varsigma < 0$, there is a welfare loss under the alternative regime relative to $\mathcal{R}$. Hereafter, “welfare gains/losses” refers to welfare changes relative to $\mathcal{R}$. We approximate ς up to a second order of accuracy. Figure 8 displays the welfare gains for different implementable FXI rules, keeping the Taylor coefficient at its baseline level ($\omega_\pi = 1.5$). The flexible exchange rate regime ($v_e = 0$) causes a welfare loss of 4.0 percent in consumption. Moreover, it turns out that the optimal FX policy coefficient, $v_e^* = 28.1$, is higher than its estimated level and associated with a welfare gain of 1.2 percent in terms of consumption. More aggressive FX intervention responses (in the region $v_e > 28.1$) reduce welfare gains as the benefits from macroeconomic stabilization do not compensate for the higher central bank operational losses.

Table C.5 reports the welfare gains for various combinations of policy parameters (ω_π, v_e). Conditional to external shocks, the FX policy and standard Taylor rules improve welfare in a considerable region of the reported (ω_π, v_e) -space. The flexible exchange rate regime might be welfare-improving if the Taylor rule coefficient is high enough ($\omega_\pi \geq 3$). Nevertheless, the optimal FX intervention rule coefficient is non-zero. For instance, when $\omega_\pi = 3$, the optimal value for v_e is around 10 (almost one third of v_e^* when $\omega_\pi = 1.5$). Thus, the active use of FX interventions as an additional monetary policy tool is welfare-improving relative to a flexible exchange rate regime. The welfare gains of an optimal FX intervention rule are between 1 and 2.2 percent of consumption.⁵⁰

$\omega_\pi \setminus v_e$	0.0	2.5	5.0	9.71	20.0	30.0	50.0	100.0
1.25	-14.4	-11.0	-8.9	-5.7	-1.9	-0.5	0.1	-0.3
1.50	-4.0	-2.0	-1.1	0.0	1.0	1.2	0.8	-0.2
2.00	-0.6	0.7	1.2	1.6	1.8	1.6	0.9	-0.2
3.00	0.5	1.5	1.8	2.1	2.0	1.7	1.0	-0.2
5.00	0.8	1.7	2.0	2.2	2.1	1.7	1.0	-0.3

Table 6. Welfare gains/losses of Taylor rule and FX policy rule

Note. The parameter ω_π measures the interest rate response to fluctuations in inflation, while v_e measures the response of FX interventions to real exchange rate deviations. For each combination of (ω_π, v_e) we compute ς which is defined above and report $\varsigma \times 100\%$. Only external shocks are considered in this simulation.

Recently, Fanelli and Straub (2021), Itskhoki and Mukhin (2023), and Yakhin (2024) examine the optimal Ramsey allocation when market imperfections affect the trading of domestic and

⁵⁰These numbers are large in the business-cycle literature. This is driven by the financial frictions generating endogenous UIP deviations and our focus only on external shocks.

foreign bonds. They argue that FXI rules responding to UIP deviations can achieve optimal allocations in their settings, where currency mismatches are not significant in transmitting external shocks. In contrast, we contend that in our model, large balance-sheet effects make the real exchange rate a critical target for FX interventions.⁵¹

5.4 Robustness exercises

We examine the effectiveness of FX interventions in response to external shocks across various scenarios (“Cases”), each designed to test the robustness of our findings under more general assumptions. This section outlines the key features of each case and highlights the general quantitative insights they provide. Further details are presented in [Appendix C](#).

Case 1: Increased currency mismatch. Two noteworthy scenarios that increase the economy’s currency mismatch are:

- *Case 1A: Non-Dollarized Financial System.* In this case, intermediate goods producers borrow from banks only in domestic currency, while households cannot hold foreign currency deposits.⁵² Although FX interventions are still effective, their impact is less pronounced than in a financially dollarized economy. Although the banking sector has a higher currency mismatch, the non-financial sector is less exposed to exchange rate movements, leading to less desirable FX interventions.
- *Case 1B: Lower-cost external borrowing.* An international environment with more favorable access to foreign debt, modeled as lower R^* in the steady state, increases the incentive for banks to hold portfolios with larger steady-state currency mismatches, heightening financial risks. In this scenario, the economy becomes more financially fragile, and FX interventions become more effective at reducing volatility and delivering welfare gains. This is because interest rate spreads and UIP deviations are present but with a more severe financial friction.

Case 2: UIP conditions holds. This environment can arise under two sub-cases:

- *Case 2A: Frictionless households’ arbitrage.* In this scenario, households are free to fully participate in foreign currency bank deposits, making their demand for these deposits

⁵¹Exploring optimal allocations in settings where exchange rate depreciations impact balance sheets is a promising avenue for future research.

⁵²This case attempts to extend our results for an emerging market economy without financial dollarization such as Chile, Colombia, Mexico, etc.

infinitely responsive to arbitrage opportunities. As a result, the FX channel is muted. However, macroeconomic volatility still declines due to the sterilization leg of FX interventions, combined with ongoing borrowing constraints faced by banks.

- *Case 2B: Frictionless banks' arbitrage.* The severity of banks' agency problem is assumed to depend on an industry-wide measure of currency mismatch, which banks take as given, implying that $\Theta'(x) = 0$. This means banks no longer internalize the impact of dollar borrowing on their agency problem. As a result, the real exchange rate's response to external shocks is identical under both FX interventions and exchange rate flexibility, effectively muting the FX channel. However, the sterilization aspect of FX interventions still plays a stabilizing role, as the balance sheet channel remains effective, helping to reduce macroeconomic volatility compared to the baseline case.

Case 3: Absence of habit formation. We explore the effects of removing habit formation, setting $\mathcal{H} = 0$, from household consumption decisions, a feature that can influence the quantitative implications of the FX intervention regime on macroeconomic volatility and welfare relative to exchange rate flexibility. Habit formation typically has two opposing effects: it increases the persistence of shocks while dampening their immediate impact, leading to an overall ambiguous effect on volatility that must be evaluated quantitatively. Our numerical results suggest that macroeconomic volatility remains largely unchanged. However, the welfare gains diminish, since our welfare measure is closely tied to this parameter: The benchmark welfare gain of 4% falls to 2.8% when habit formation is excluded.

Case 4: Uniformly divertible bank assets. The effectiveness of FX interventions in mitigating the impact of external shocks depends on the parameter ω^b , which governs how easily banks can divert central bank bonds. This parameter influences the tightness of the credit constraint banks face. We explore the scenario where $\varpi^* = \varpi^b = 1$, meaning the credit constraint treats all assets equally, and all domestic spreads are reduced to one. In this case, central bank bonds exert a greater influence on the total amount of divertible funds than in our baseline model, and consequently, on banks' lending capacity. As a result, FX interventions become more effective in absorbing external shocks compared to the baseline model, enhancing their stabilizing role in the economy.

Case 5: Alternative monetary policy regimes. We analyze the effects of implementing various monetary policy regimes in the absence of FX intervention. First, we compare the baseline FX intervention regime with an alternative policy regime where the Taylor rule is extended to respond to deviations in the real exchange rate from its steady state. Our analysis shows that while using the monetary policy rate to stabilize exchange rates can help

mitigate financial instability, it does so at the expense of increased volatility in the real sector, particularly in investment. The welfare analysis reveals that the FX intervention regime delivers more consistent welfare gains compared to the extended Taylor rule, especially across different parameter values for the interest rate’s sensitivity to exchange rate fluctuations.

Second, we address the concern of a central bank mitigating deposit rate spreads by extending the Taylor rule to respond to deviations of the UIP spread from its steady state. Our results are similar to a Taylor rule extended to response to exchange rate deviations: It reduces financial volatility but increases real sector volatility, as the monetary policy rate partially absorbs fluctuations in the UIP spread.

Case 6: Sterilization operational costs. To account for additional aspects of FX intervention and reserve management not explicitly modeled in our framework, we introduce adjustment costs associated with sterilization operations. Specifically, we assume that the central bank incurs costs proportional to the level of sterilization, CB_t . The central bank’s quasi-fiscal deficit is then modeled as $\widehat{CB}_t = \exp(\tau^{fx}(B_t - B)CB_t)$, where τ^{fx} represents the adjustment cost parameter. As τ^{fx} increases from 0 to 5, the optimal FX policy coefficient declines from 28.1 to 3.5. Correspondingly, the welfare cost of maintaining a flexible exchange rate—relative to an optimized FX intervention—shrinks from 5 percent to 1.5 percent of consumption. This finding emphasizes that exchange rate flexibility leads to notable welfare losses compared to an optimized FX policy, particularly when sterilization costs are included.

Case 7: Alternative FX Intervention Rules. In this case, we examine whether different FX intervention (FXI) rules would significantly alter our results. While a full exploration of the optimal FXI rule lies beyond the scope of this paper, we show that the effects of external shocks remain similar when the central bank’s FXI rule incorporates inertia and responds to both real exchange rate depreciation and UIP deviations. This closely aligns with our baseline scenario. As argued by [Itskhoki and Mukhin \(2023\)](#), an FXI rule targeting interest rate spreads would likely be less practical than one focused on exchange rate deviations, supporting the feasibility of our chosen approach.

6 Concluding remarks

We propose a macroeconomic model with financial frictions for a small open economy to analyze and quantify the effectiveness of FX interventions in stabilizing the impact of external shocks. Our model considers FX interventions as a balance-sheet policy induced by an agency problem between banks and their investors (domestic depositors and foreign lenders). Two key

assumptions are important for our results. First, the severity of banks' agency problem depends directly on a measure of currency mismatch at the bank level. Second, FX intervention is such that the central bank leans against real exchange rate fluctuations but in a sterilized manner.

Our results shed light on the transmission mechanism of external shocks under an FX policy regime. We highlight two reinforcing effects when FX policy responds to external shocks: the foreign exchange and the balance sheet channels. The former channel is active whenever banks and households cannot fully exploit arbitrage opportunities between domestic and foreign currency-denominated portfolios. Instead, if either banks or households can engage in frictionless arbitrage between domestic and foreign currency-denominated assets, the standard UIP equation holds, and this channel is no longer active. In this case, even though the incentive constraint binds, the response of the real exchange rate to external shocks is the same under FX interventions and flexible exchange rates. On the other hand, the balance sheet channel stems from the sterilization operation associated with FX interventions, which modifies the supply of central bank bonds in banks' balance sheet and their asset composition together with interest rate spreads.

The financial friction view of FX interventions needs further research. FXI differs from the unconventional monetary policy framework for closed economies in several ways. First, FX interventions have been implemented effectively even in normal times in EMEs, contrary to the unconventional monetary policy tools studied in closed economies. Second, what matters for EMEs is how tight financial constraints are, and not necessarily if they bind or not. Third, in practice, the communication of FX interventions is at odds with the communication of unconventional policies in closed economies. For example, there seems to be less forward guidance associated with FX interventions than with QE or LSAP. Finally, the effective lower bound for EMEs may not only be related to the nominal interest rate, but also to a non-negative amount of official FX reserves needed to implement FX interventions within an inflation-targeting regime.

References

- Adler, G., Lisack, N., and Mano, R. C. (2019). Unveiling the effects of foreign exchange intervention: A panel approach. *Emerging Markets Review*, 40:100620.
- Alfaro, L., Calani, M., and Varela, L. (2021). Granular corporate hedging under dominant currency. Working Paper 28910, National Bureau of Economic Research.

- Alla, Z., Espinoza, R. A., and Ghosh, A. R. (2020). Fx intervention in the new keynesian model. *Journal of Money, Credit and Banking*, 52(7):1755–1791.
- Aoki, K., Benigno, G., and Kiyotaki, N. (2021). Monetary and Financial Policies in Emerging Markets. Technical report, Mimeo.
- Benes, J., Berg, A., Portillo, R., and Vavra, D. (2015). Modeling Sterilized Interventions and Balance Sheet Effects of Monetary Policy in a New-Keynesian Framework. *Open Economies Review*, 26(1):81–108.
- Blanchard, O., Adler, G., and de Carvalho Filho, I. (2015). Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks? Working Paper Series WP15-18, Peterson Institute for International Economics.
- Bocola, L. and Lorenzoni, G. (2020). Financial crises, dollarization, and lending of last resort in open economies. *American Economic Review*, 110(8):2524–57.
- Branson, W., Halttunen, H., and Masson, P. (1977). Exchange rates in the short run: The dollar-dentschemark rate. *European Economic Review*, 10(3):303–324.
- Calvo, G. A. (2001). Capital markets and the exchange rate, with special reference to the dollarization debate in latin america. *Journal of Money, Credit and Banking*, 33(2):312–334.
- Calvo, G. A. and Reinhart, C. M. (2002). Fear of floating. *The Quarterly Journal of Economics*, 117(2):379–408.
- Canova, F. (2005). The transmission of US shocks to Latin America. *Journal of Applied Econometrics*, 20(2):229–251.
- Castillo, P., Lama, R., and Medina, J. P. (2024). Escaping the financial dollarization trap: The role of foreign exchange intervention.
- Cavallino, P. (2019). Capital Flows and Foreign Exchange Intervention. *American Economic Journal: Macroeconomics*, 11(2):127–170.
- Ceron, M., Nivin, R., and Yamunaque, D. (2023). FX intervention and domestic credit in a partially dollarized economy: Evidence using microdata from Peru. IHEID Working Papers 11-2023, Economics Section, The Graduate Institute of International Studies.

- Céspedes, L. F., Chang, R., and Velasco, A. (2003). Is-lm-bp in the pampas. *IMF Staff Papers*, 50:143–156.
- Céspedes, L. F., Chang, R., and Velasco, A. (2004). Balance sheets and exchange rate policy. *American Economic Review*, 94(4):1183–1193.
- Chang, R. (2019). Foreign Exchange Intervention Redux. In Álvaro Aguirre, Brunnermeier, M., and Saravia, D., editors, *Monetary Policy and Financial Stability: Transmission Mechanisms and Policy Implications*, volume 26 of *Central Banking, Analysis, and Economic Policies Book Series*, chapter 7, pages 205–247. Central Bank of Chile.
- Chang, R. and Velasco, A. (2017). Financial frictions and unconventional monetary policy in emerging economies. *IMF Economic Review*, 65(1):154–191.
- Christiano, L., Dalgic, H., and Nurbekyan, A. (2021). Financial Dollarization: Efficient Intranational Risk Sharing or Prescription for Disaster? NBER Working Papers 29034, National Bureau of Economic Research, Inc.
- Corrales, J.-S. and Imam, P. A. (2021). Financial dollarization of households and firms: How does it differ by level of economic development? *Review of International Economics*, 29(4):927–978.
- Cushman, D. O. and Zha, T. (1997). Identifying monetary policy in a small open economy under flexible exchange rates. *Journal of Monetary Economics*, 39(3):433–448.
- Céspedes, L. F. and Chang, R. (2019). Optimal foreign reserves and central bank policy under financial stress. Working in progress.
- Céspedes, L. F., Chang, R., and Velasco, A. (2014). Is Inflation Targeting Still on Target? The Recent Experience of Latin America. *International Finance*, 17(2):185–208.
- Dalgic, H. C. (2024). Financial dollarization in emerging markets: An insurance arrangement. *International Economic Review*, 65(3):1189–1219.
- Daude, C., Levy Yeyati, E., and Nagengast, A. J. (2016). On the effectiveness of exchange rate interventions in emerging markets. *Journal of International Money and Finance*, 64:239–261.
- di Giovanni, J., Kalemli-Ozcan, S., Ulu, M. F., and Baskaya, Y. S. (2017). International Spillovers and Local Credit Cycles. NBER Working Papers 23149, National Bureau of Economic Research, Inc.

- Drechsel, T. and Tenreyro, S. (2018). Commodity booms and busts in emerging economies. *Journal of International Economics*, 112(C):200–218.
- Faltermeier, J., Lama, R., and Medina, J. P. (2022). Foreign exchange intervention for commodity booms and busts. *European Economic Review*, 143:104018.
- Fanelli, S. and Straub, L. (2021). A Theory of Foreign Exchange Interventions. *The Review of Economic Studies*, 88(6):2857–2885.
- Fernández, A., Schmitt-Grohé, S., and Uribe, M. (2017). World shocks, world prices, and business cycles: An empirical investigation. *Journal of International Economics*, 108:S2 – S14. 39th Annual NBER International Seminar on Macroeconomics.
- Fornero, J., Kirchner, M., and Yany, A. (2015). Terms of Trade Shocks and Investment in Commodity-Exporting Economies. In Caputo, R. and Chang, R., editors, *Commodity Prices and Macroeconomic Policy*, volume 22 of *Central Banking, Analysis, and Economic Policies Book Series*, chapter 5, pages 135–193. Central Bank of Chile.
- Fratzscher, M., Lo Duca, M., and Straub, R. (2018). On the international spillovers of us quantitative easing. *The Economic Journal*, 128(608):330–377.
- Gabaix, X. and Maggiori, M. (2015). International Liquidity and Exchange Rate Dynamics. *The Quarterly Journal of Economics*, 130(3):1369–1420.
- Garcia-Cicco, J., Kirchner, M., Carrillo, J., Rodríguez, D., Perez, F., Gondo, R., Montoro, C., and Chang, R. (2017). Financial and real shocks and the effectiveness of monetary and macroprudential policies in Latin American countries. BIS Working Papers 668, Bank for International Settlements.
- Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58(1):17–34.
- Gertler, M. and Karadi, P. (2013). QE 1 vs. 2 vs. 3. . . : A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool. *International Journal of Central Banking*, 9(1):5–53.
- Gertler, M. and Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In Friedman, B. M. and Woodford, M., editors, *Handbook of Monetary Economics*, volume 3, chapter 11, pages 547–599. Elsevier, 1 edition.

- Gertler, M., Kiyotaki, N., and Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, 59(S):17–34.
- Ghosh, A., Ostry, J., and Qureshi, M. (2018). *Taming the Tide of Capital Flows: A Policy Guide*, volume 1. The MIT Press, 1 edition.
- Hofmann, B., Shin, H. S., and Villamizar-Villegas, M. (2019). FX intervention and domestic credit: evidence from high-frequency micro data. Borradores de Economía 1069, Banco de la Republica de Colombia.
- Itskhoki, O. and Mukhin, D. (2023). Optimal Exchange Rate Policy. NBER Working Papers 31933, National Bureau of Economic Research, Inc.
- Kouri, P. J. K. (1976). The exchange rate and the balance of payments in the short run and in the long run: A monetary approach. *The Scandinavian Journal of Economics*, 78:280 – 304. Proceeding of a Conference on Flexible Exchange Rates and Stabilization Policy.
- Liu, Z. and Spiegel, M. M. (2015). Optimal Monetary Policy and Capital Account Restrictions in a Small Open Economy. *IMF Economic Review*, 63(2):298–324.
- Mendoza, E. and Rojas, E. (2019). Positive and normative implications of liability dollarization for sudden stops models of macroprudential policy. *IMF Economic Review*, 67(1):174–214.
- Montoro, C. and Ortiz, M. (2023). The portfolio balance channel of capital flows and foreign exchange intervention in a small open economy. *Journal of International Money and Finance*, 133:102825.
- Rossini, R., Armas, A., Castillo, P., and Quispe, Z. (2019). International reserves and forex intervention in Peru. In for International Settlements, B., editor, *Reserve management and FX intervention*, volume 104 of *BIS Papers chapters*, pages 191–207. Bank for International Settlements.
- Rotemberg, J. (1982). Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49(4):517–531.
- Schmitt-Grohe, S. and Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics*, 54(6):1702–1725.
- Schmitt-Grohe, S. and Uribe, M. (2018). How important are term of trade shocks. *International Economic Review*, 59(1):86–111.

- Shousha, S. (2016). Macroeconomic effects of commodity booms and busts: The role of financial frictions. Unpublished manuscript.
- Siklos, P. L. (2018). Boom-and-bust cycles in emerging markets: How important is the exchange rate? *Journal of Macroeconomics*, 56:172–187.
- Velarde, J. and Montoro, C. (2023). Twenty years of inflation targeting in Peru: lessons and challenges ahead. In for International Settlements, B., editor, *Central banking in the Americas: Lessons from two decades*, volume 127 of *BIS Papers chapters*, pages 129–147. Bank for International Settlements.
- Verner, E. and Gyöngyösi, G. (2020). Household debt revaluation and the real economy: Evidence from a foreign currency debt crisis. *American Economic Review*, 110(9):2667–2702.
- Walerych, M. and Weso, G. (2021). Fed and ecb monetary policy spillovers to emerging market economies. *Journal of Macroeconomics*, 70:103345.
- Yakhin, Y. (2024). Foreign Exchange Interventions in the New-Keynesian Model: Transmission, Policy, and Welfare. Bank of Israel Working Papers 2024.01, Bank of Israel.
- Yeyati, E. L. (2014). Financial dollarization: evaluating the consequences. *Economic Policy*, 21(45):62–118.
- Zha, T. (1999). Block recursion and structural vector autoregressions. *Journal of Econometrics*, 90(2):291–316.

A Data and parameterization

A.1 Dataset from Corrales and Imam (2021)

Low income			
Afghanistan	Benin	Burkina Faso	Burundi
Central African Rep.	Chad	Comoros	Dem. Rep. of Congo
Gambia	Guinea-Bissau	Haiti	Mali
Mozambique	Nepal	Niger	Rwanda
Senegal	Sierra Leone	Tanzania	Togo
Uganda			
Lower middle income			
Armenia	Bangladesh	Bhutan	Bolivia
Cambodia	Cameroon	Cape Verde	Rep. of Congo
Cote d'Ivoire	Egypt	Ghana	Guatemala
Honduras	Indonesia	Kenya	Kyrgyz Rep.
Lesotho	Moldova	Mongolia	Morocco
Nicaragua	Pakistan	Papua New Guinea	Philippines
Sao Tome & Principe	Solomon Islands	Sri Lanka	Sudan
Swaziland	Syrian Arab Rep.	Tajikistan	Tonga
Ukraine	Vanuatu	Zambia	
Upper middle income			
Albania	Algeria	Angola	Rep. of Azerbaijan
Belarus	Belize	Bosnia & Herzegovina	Botswana
Brazil	Bulgaria	Colombia	Costa Rica
Dominica	Dominican Rep.	Equatorial Guinea	Fiji
Gabon	Georgia	Grenada	Guyana
Jamaica	Kazakhstan	Macedonia	Malaysia
Maldives	Mauritius	Mexico	Namibia
Panama	Romania	Rep. of Serbia	South Africa
St. Lucia	St. Vincent & Grens.	Suriname	Thailand
Turkey	Venezuela		
High income			
Antigua & Barbuda	Australia	Barbados	Brunei Darussalam
Canada	Chile	Croatia	Czech Rep.
Denmark	Hungary	Israel	Rep. of Korea
Norway	Oman	Poland	Qatar
Seychelles	St. Kitts & Nevis	Sweden	Trinidad & Tobago
United Arab Emirates	Uruguay		

Source: Dataset was kindly provided by the authors in Corrales and Imam (2021).

Table A.1. Sample of countries in the analysis

A.2 Peruvian Dataset

We discipline the model to replicate relevant unconditional and conditional moments for the Peruvian economy. We calibrate a subset of the parameters to be consistent with some steady-state targets associated with Peruvian historical averages. We estimate another subset of parameters by using a limited information method based on an impulse response matching function estimator.

Peru is a typical commodity-exporting emerging market economy with inflation targeting, active FX intervention policy, and financial dollarization. Monetary policy in Peru follows an

inflation-targeting scheme adapted to take into account the risks associated with financial dollarization. This framework includes sterilized FX intervention to reduce the volatility of the exchange rate, preventive accumulation of international reserves, and high reserve requirements on foreign currency liabilities to mitigate liquidity risk.

A.2.1 Banking system

Data on the banking system is collected from the Peruvian financial regulator database (In Spanish: Superintendencia de Banca, Seguros y AFP - SBS Peru). We use domestic currency credit for L_t , foreign currency-denominated liabilities for L_t^* , and total banking investments for B_t . We also use banks' net worth for N_t and the sum of foreign currency deposits and external liabilities to measure D_t^* . Moreover, we use the average domestic (foreign) currency prime, corporate, and big company loan's interest rate to measure domestic (foreign) currency lending return. Figure A.1 shows the evolution of the key variables the directly match the ones used in our analysis. Leverage ratios have been steadily increasing in the sample period, while the opposite occurred to dollarization rates. Moreover, we also show the evolution of interest rates and measure of the ex-post UIP deviation based on the safest loan's interest rate return and the LIBOR rate.

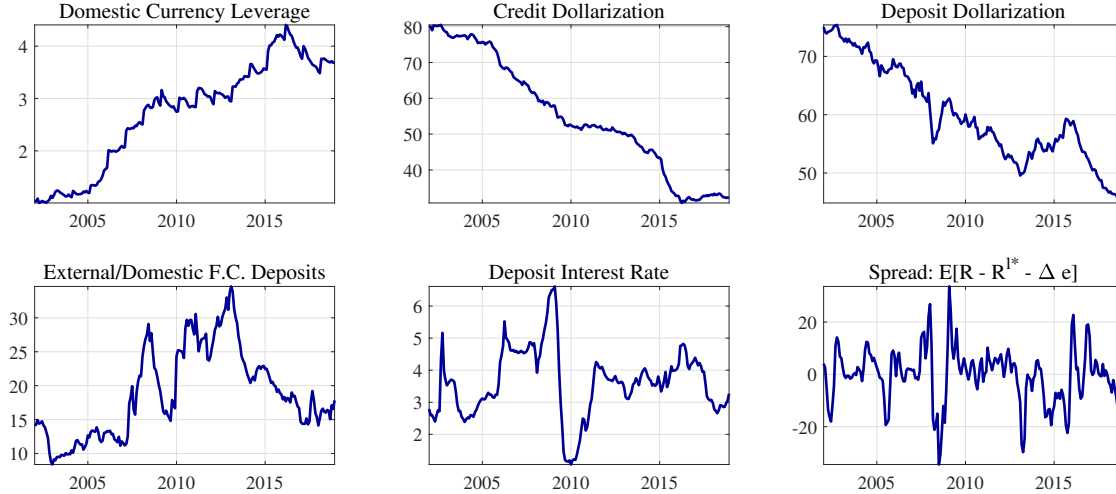


Figure A.1. Bank's balance sheet composition in the Peruvian banking system

Note. We use data on domestic currency credit for L_t , dollar-denominated credit for L_t^* , and total banking investment for B_t . We use data on banks' net worth for N_t and the sum of foreign currency deposits and external liabilities for measuring D_t^* . **Source:** Superintendencia de Banca y Seguros (SBS).

BCRP's de-dollarization programme. The downward trend observed in Figure A.1 is the result of the BCRP's de-dollarization programme. Since 2013, the BCRP has focused on accelerating credit de-dollarization to mitigate risks from sudden depreciation pressures on FX-indebted firms and households. To achieve this, the BCRP introduced additional reserve

requirements (RRRs) on FX liabilities aimed at (i) limiting the growth of USD credit and (ii) promoting a shift toward PEN-denominated debt. These RRRs were triggered when financial institutions failed to meet FX loan targets set by the BCRP, encouraging them to prioritize loans in soles. By making USD credit more expensive, the policy aimed to break habitual lending practices and dispel borrowers' misconceptions about the lower risk of USD loans. See [Velarde and Montoro \(2023\)](#) for further details about the Peruvian experience on managing exchange risks.

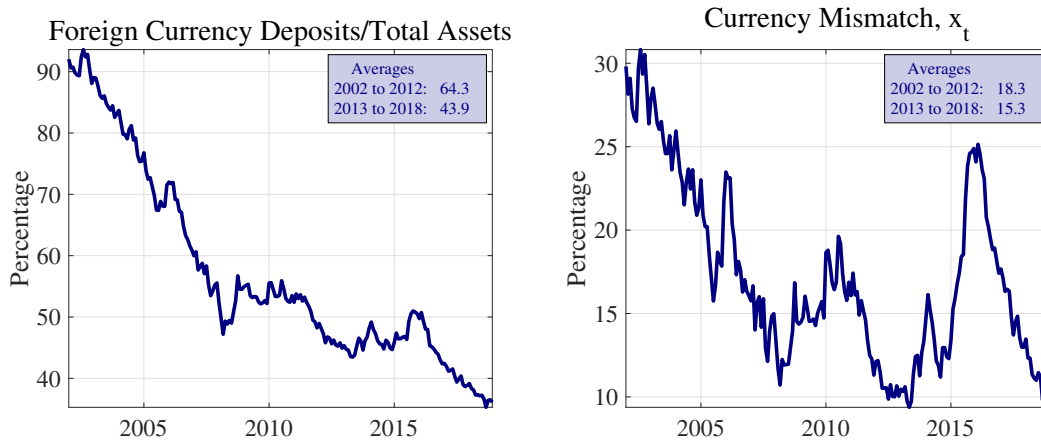


Figure A.2. Foreign deposits and currency mismatch

Source: Superintendencia de Banca y Seguros (SBS).

Currency mismatch. Based on the SBS dataset, [Figure A.2](#) shows the empirical evolution of foreign currency liabilities and the currency mismatch in Peru's banking system, where the latter refers to the FX spot net position excluding FX derivatives. Foreign currency deposits, including external credit lines (banks' foreign borrowing), as a share of total assets, have steadily declined from an average of 64.3% between 2001-2012 to 43.9% between 2009-2018. Similarly, the currency mismatch decreased significantly from 2001 to 2012, averaging 18.3%. From 2009 to 2018, it fluctuated around 15.3% without a clear trend.

A.2.2 Real economy

Data on macroeconomic variables are collected from the Peruvian Central Bank database (In Spanish: Banco Central de Reserva del Peru - BCRP). [Figure A.3](#) presents the aggregate real ratios used to fix the demand side steady state of the economy. The demand side structure of the Peruvian economy is the standard one in many emerging market economies.

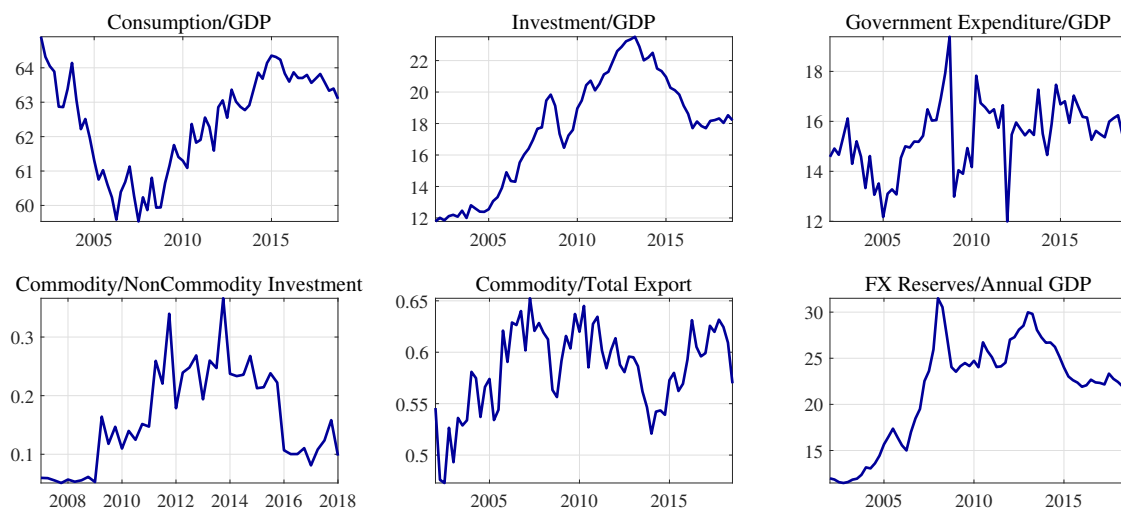


Figure A.3. Real aggregate ratios

Source: Central Reserve Bank of Peru (BCRP).

A.3 FX reserves and intervention

In a partially dollarized economy like Peru, FX intervention (FXI) serves as a complementary tool to inflation targeting, helping to preserve macro-financial stability. In Peru, FXI manages the current risks of dollarization, while the credit de-dollarization program addresses its root causes, both now and in the future. As de-dollarization progresses –especially since the introduction of the program in 2013– the need for FX intervention may diminish. However, this transition will take time.

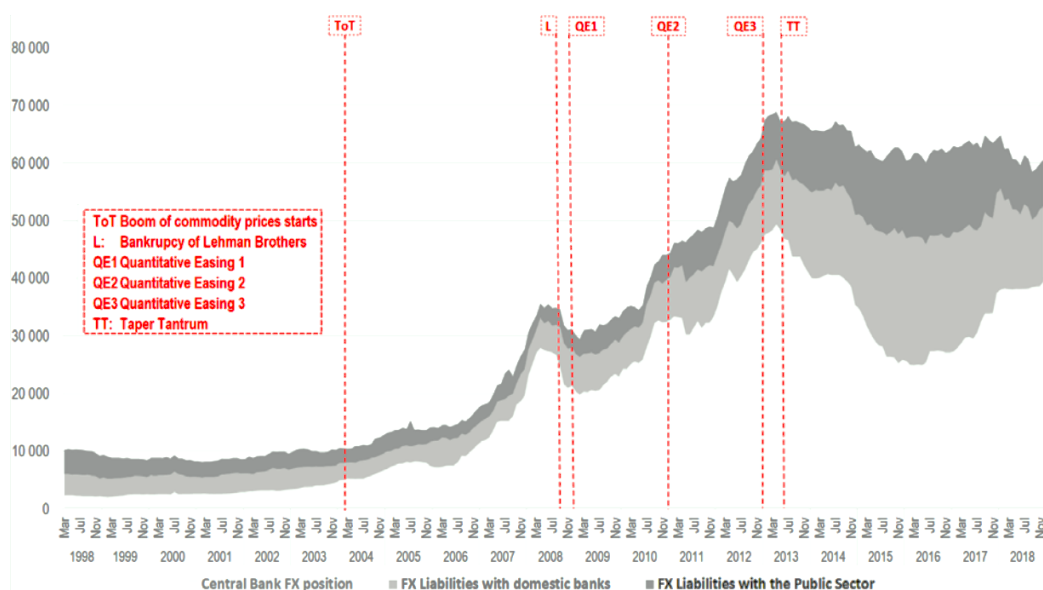


Figure A.4. Source of international reserves (USD millions)

Source: This figure is extracted from [Rossini et al. \(2019\)](#).

International reserves and FX interventions. International reserves come from three sources: (i) the central bank’s own FX position, which is influenced by FX market interventions and returns on reserve investments; (ii) FX liabilities with local banks tied to reserve requirements; and (iii) FX deposits from the Treasury held at the central bank. In [Figure A.4](#), it is shown that reserve accumulation is linked to the central bank’s FX interventions during periods of external shocks affecting the current and capital accounts of the balance of payments. The central bank accumulates reserves to ensure international liquidity and effectively manage sudden stops during periods of heightened volatility in global financial markets. Ample reserves address a key challenge for financially dollarized economies: the absence of a US dollar-based lender of last resort. Additionally, maintaining sufficient reserves enhances the credibility of FX interventions and the central bank’s overall monetary policy.

FX intervention and UIP deviations. [Figure A.5](#) illustrates the evolution of currency mismatch in Peru’s banking system alongside UIP deviations from January 2002 to December 2018. From the banks’ perspective, UIP deviations represent the interest rate spread between domestic currency deposits and foreign borrowing. While currency mismatch may be influenced by various economic fundamentals, it shows a positive correlation with UIP deviations. In our model, this correlation arises from the assumption that currency mismatch at the bank level affects the severity of the incentive constraints banks encounter. At a micro level, [di Giovanni et al. \(2017\)](#) provides empirical evidence of this co-movement in emerging markets using Turkish banking data. Notably, our model predicts that this correlation is strong during periods of moderate FX interventions (2013-2018) but weak during periods of FX intervention (2002-2012).

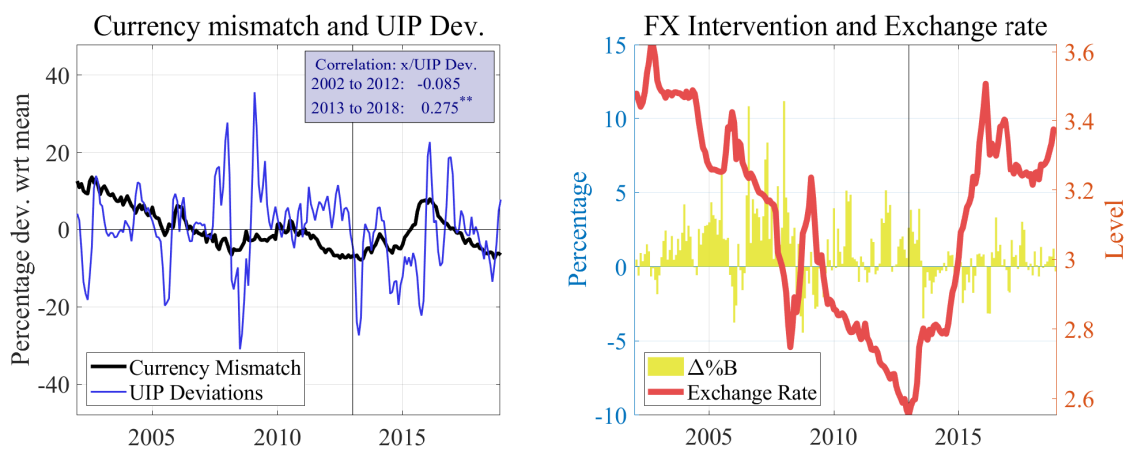


Figure A.5. Currency mismatch, FX intervention and UIP deviation

Source: Central Reserve Bank of Peru (BCRP) and Superintendencia de Banca y Seguros (SBS).

Episodes of accumulation and deaccumulation of FX reserves. Using data from

the Peruvian central bank’s interventions, we construct a time series of FX reserves (B_t in the model) and compare it to the nominal exchange rate in Figure A.6. To facilitate comparison, we normalize both variables to one at the beginning of the sample (2002M1). The figure highlights a negative correlation between FX reserves and the exchange rate.

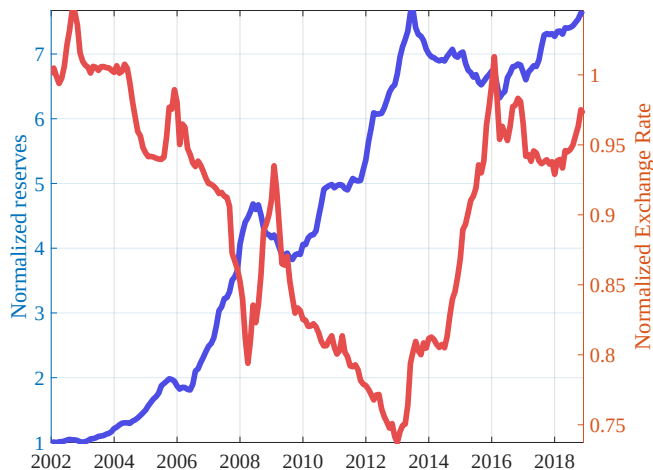


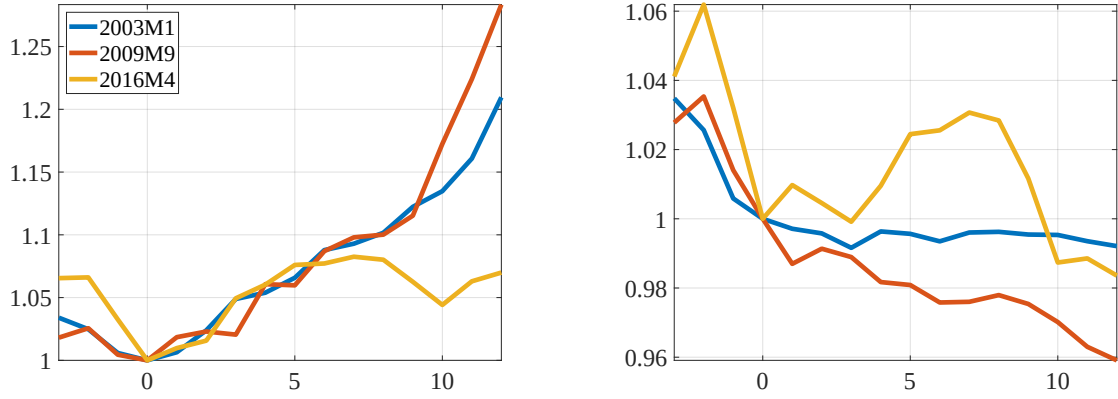
Figure A.6. Normalized FX reserves and exchange rate around Intervention episodes

To analyze FX intervention episodes, we identify the months when a persistent “cycle” of FX reserve accumulation or depletion began. To compare these episodes, we normalize the dynamics of FX reserves and the exchange rate by dividing each series by its value at the start of the cycle. Importantly, we do not attempt to establish causal relationships or the origins of these cycles but instead provide rough estimates of the magnitude of FX interventions and exchange rate movements during “turbulent” periods.

Figure A.7 depicts the evolution of normalized FX reserves and the exchange rate from three months before to twelve months after the start of each cycle. Panels (a) and (b) focus on accumulation episodes, suggesting that the Peruvian central bank responds to exchange rate appreciation pressures by increasing FX reserves. During the first year of an accumulation cycle, FX reserves typically rise by 15% (ranging from 6% to 26%), while the exchange rate declines by about 2% (from 1% to 4%). Although we cannot disentangle the external and domestic shocks driving these movements, it is notable that one episode (starting in 2003M1) coincides with the onset of the commodity supercycle. In this regard, our ballpark calculations align with the quantitative results discussed in Section 5.1.

Panels (c) and (d) show that the Peruvian central bank tends to reduce FX reserves in response to exchange rate depreciation pressures. During the first year of a deaccumulation cycle, FX reserves decline by approximately 12% (ranging from 9% to 15%), while the exchange

(a) FX Reserves around accumulation (b) Exchange rate around accumulation episodes



(c) FX Reserves around deaccumulation (d) Exchange rate around deaccumulation episodes

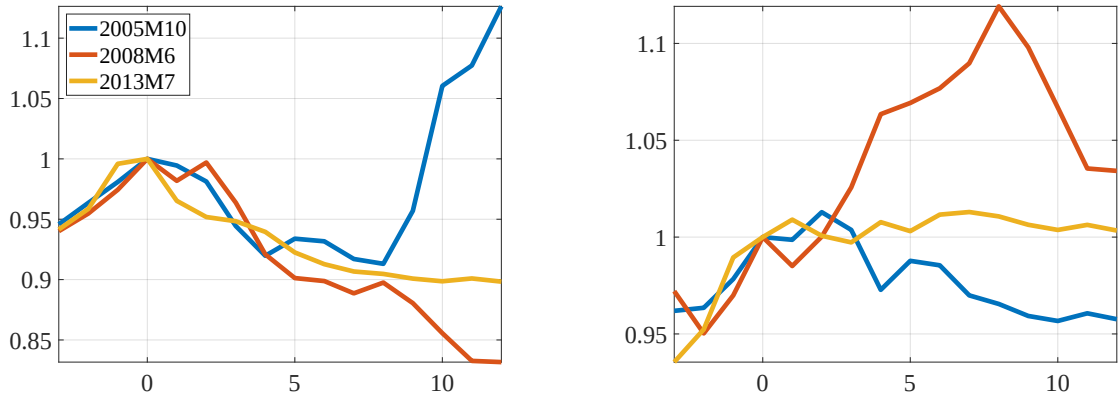


Figure A.7. Normalized FX reserves holdings and exchange rate around intervention episodes

rate appreciates by about 3%. Again, although we cannot distinguish between external and domestic shocks driving these movements, it is notable that one episode (starting in 2013M7) coincides with the Taper Tantrum. Then, the data on FX reserve deaccumulation seems to align with the quantitative results discussed in [Appendix B.2](#).

A.4 Steady-state targets and parameterization

Using this data, we calibrate the model so that the steady-state values of certain variables align with these average ratios. [Table A.2](#) summarizes our parameterization, with target variables listed in the left column and the corresponding parameter values in the right column. Additionally, we distinguish between targets and parameters related to the banking and non-banking sectors.

TARGETS			PARAMETERS		
Description	Variable	Value	Description	Parameter	Value
<i>Banking Sector</i>					
Foreign Interest Rate	R^*	$1.01^{1/4}$	Foreign Rate	R^*	1.01
Domestic Interest Rate	R	$1.04^{1/4}$	Subjective Discount Factor	β	0.99
Domestic C. Loans Return	R^l	$1.06^{1/4}$	Foreign C. Loans Participation	ϖ^*	1.42
Foreign C. Loans Return	R^{l*}	$1.04^{1/4}$	Bonds Loans Participation	ϖ^b	0.21
CB Bond Return	R^b	$1.04^{1/4}$	Banker's Start-up Transfers	ξ	3.36e-04
Foreign Liability to Asset	$\frac{eD^*}{A}$	53.5%	Moral Hazard 1	θ	0.57
Domestic C. Leverage	$\frac{L}{N}$	3.50	Moral Hazard 2	$\varkappa$	7.17
Credit Dollarization	$\frac{eL^*}{L+eL^*}$	42.5%	DC Bias in Loans	δ^f	0.50
<i>Non-Banking Sector</i>					
Capital Return	R^k	$1.08^{1/4}$	Loans Aggregator Scale	A^e	1.99
Worked Hours	H	1/3	Labor Disutility Scale	ζ_0	3.12
Real Exchange Rate	e	1	Foreign Output	Y^*	0.15
Commodity Price	p^{wc}	1	Commodity Price	p^{wc}	1.00
GDP	GDP	1	Non Commodity Productivity	A^{nc}	0.50
Commodity to Total Export	$\frac{Y^{x,c}}{Y^x}$	60%	Commodity Returns to Scale	α^c	0.18
Commodity to Non Commodity Inv.	$\frac{I^c}{I^{nc}}$	20%	Commodity Sector Productivity	A^c	0.22
Share of Capital financed by households	$\frac{S}{K^{nc}}$	20%	Capital Share	α^k	0.29
Share of Foreign FC Deposits	$\frac{D^{f,*}}{D^+}$	20%	Ef. Household's Capital	$\bar{S}$	0.63
Consumption to GDP	$\frac{C}{GDP}$	60%	Ef. Household's FC Deposits	$\bar{D}^{h,*}$	2.75
Investment to GDP	$\frac{I}{GDP}$	18%	Imported Input Share	α^m	0.33
Gov. Purchases to GDP	$\frac{G}{GDP}$	14%	Gov. Expenditure	G	0.14
FX Reserves to GDP - Anual	$\frac{eF}{4 \times GDP}$	22%	CB Bonds	B	0.88

Table A.2. Targeted parameterization

Note. Parameters (right column) are set such that the steady state of some variables (left column) equals their corresponding empirical average.

A.5 VAR specification

We consider an SVAR model with two recursive blocks similar to [Canova \(2005\)](#), [Cushman and Zha \(1997\)](#), and [Zha \(1999\)](#). Let $\mathbf{X}_t$ denote the vector of foreign variables and $\mathbf{D}_t$ the vector of domestic variables. Following [Canova \(2005\)](#), the baseline specification considers $\mathbf{X}_t$ as an exogenous block, with no feedback dynamics from the domestic block, $\mathbf{D}_t$, at any point in time. Like much of the related literature, the main identification assumption is that an emerging small open economy takes as given world prices and quantities. Therefore, we consider an SVAR in levels with zero restrictions between blocks and a linear time trend to capture the SOE assumption of the Peruvian economy, as well as to control for time trends, respectively. Shocks within each block are identified recursively with zero contemporaneous restrictions. Formally, consider the following restricted block VAR model with deterministic

trend:

$$\begin{bmatrix} \mathbf{X}_t \\ \mathbf{D}_t \end{bmatrix} = \begin{bmatrix} \Phi_X \\ \Phi_D \end{bmatrix} G(t) + \begin{bmatrix} \Phi_{XX}^1(L) & \mathbf{0} \\ \Phi_{DX}^1(L) & \Phi_{DD}^1(L) \end{bmatrix} \begin{bmatrix} \mathbf{X}_{t-1} \\ \mathbf{D}_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{v}_t^X \\ \mathbf{v}_t^D \end{bmatrix}$$

where $G(t)$ measures a deterministic time trend.¹ Φ_X, Φ_D are vectors of ones, $\mathbf{v}_t^X \sim \mathcal{N}(0, \Sigma_{\mathbf{v}^F})$ and $\mathbf{v}_t^D \sim \mathcal{N}(0, \Sigma_{\mathbf{v}^D})$. Hence, the underlying SVAR model is

$$\begin{bmatrix} \Theta_{XX}^0 & \mathbf{0} \\ \Theta_{DX}^0 & \Theta_{DD}^0 \end{bmatrix} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{D}_t \end{bmatrix} = \begin{bmatrix} \Theta_X \\ \Theta_D \end{bmatrix} G(t) + \begin{bmatrix} \Theta_{XX}^1(L) & \mathbf{0} \\ \Theta_{DX}^1(L) & \Theta_{DD}^1(L) \end{bmatrix} \begin{bmatrix} \mathbf{X}_{t-1} \\ \mathbf{D}_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{u}_t^X \\ \mathbf{u}_t^D \end{bmatrix}$$

We use quarterly data, covering from 2002Q1 to 2018Q4 for the domestic block and from 1980Q1 to 2018Q4 for the foreign block. Following [Fernández et al. \(2017\)](#), we first estimate the foreign block separately and impose the corresponding estimated parameters in the estimation of the domestic block.

¹Like the SVAR model, the DSGE model considers deterministic time trends that are removed before the matching procedure.

B Additional figures

B.1 Exogenous FX Intervention in General Equilibrium

Based on our quantitative framework, we numerically examine the broader general equilibrium effects of a 1% increase in FX reserves. As shown in Figure B.1 the buildup of FX reserves triggers a real exchange rate depreciation which reduces banks' net worth and heightens the currency mismatch at the outset (FX channel). Additionally, the sterilization operation modifies the composition of banks balance alters banks' balance sheets by increasing the share of central bank bonds while reducing lending (BS channel). As a result, the FX intervention shock leads to lower consumption and production, higher interest rate spreads, and greater deviations from UIP.

Initially, the marginal benefit of lending in domestic currency rises, causing a slight increase in the leverage ratio immediately after the impact. However, the leverage ratio subsequently declines, with this drop being only partially offset by a gradual recovery in banks' net worth. This dynamic ultimately reduces bank intermediation and aggregate credit. In summary, the buildup of FX reserves causes real exchange rate depreciation, pushing the economy into a credit crunch and recession. As emphasized, the interaction between banks' net worth, leverage ratio, and balance sheets is central to the transmission mechanisms of FX interventions.

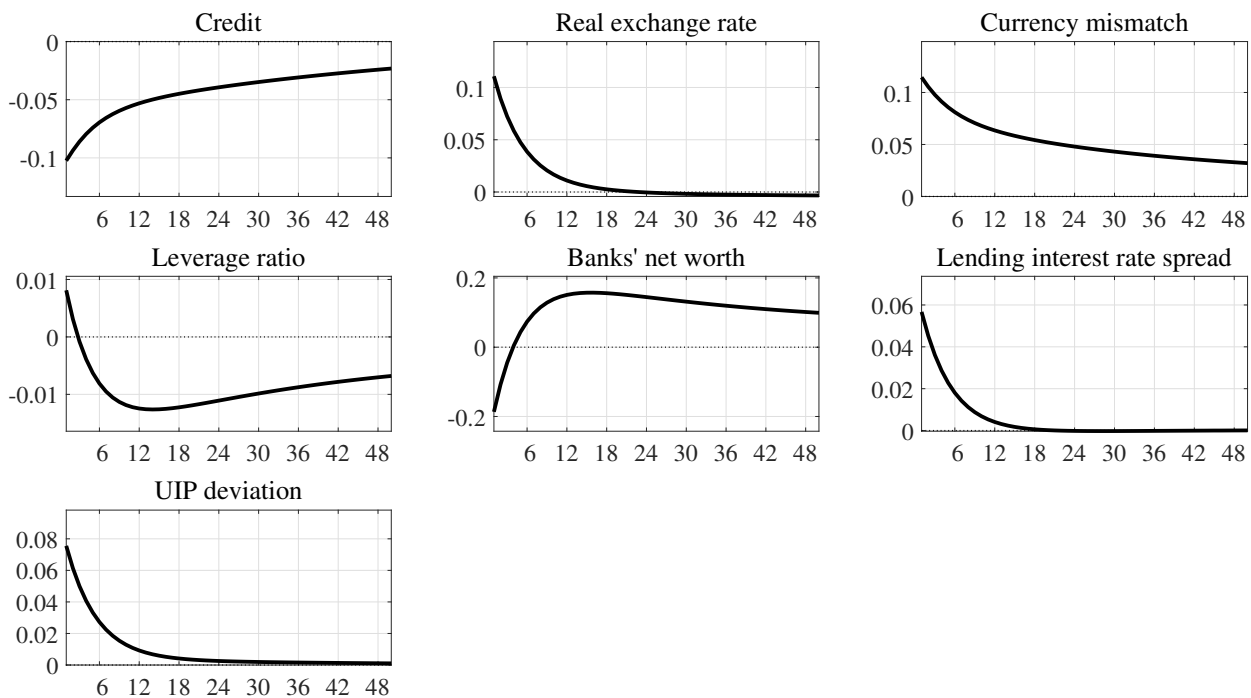


Figure B.1. Response to a purchase of FX reserves

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

B.2 Impulse response for foreign aggregate demand and foreign interest rate shocks

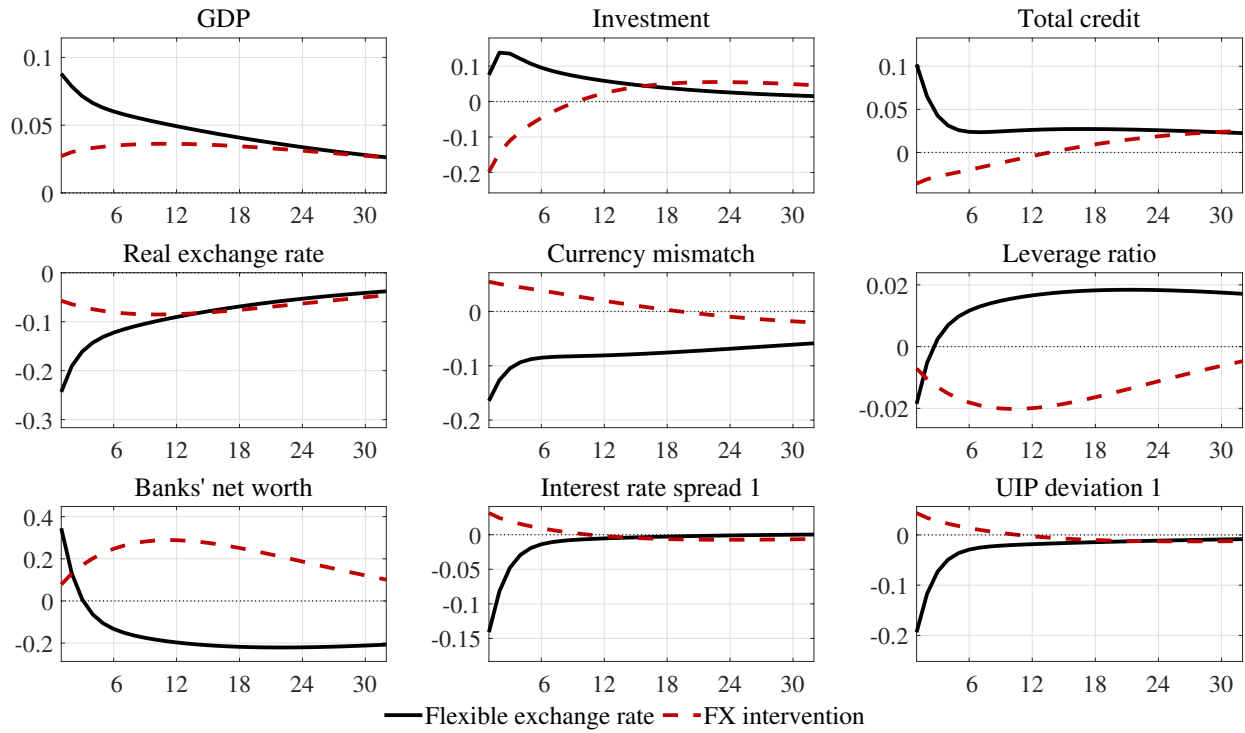


Figure B.2. Responses of financial variables to a foreign demand shock

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

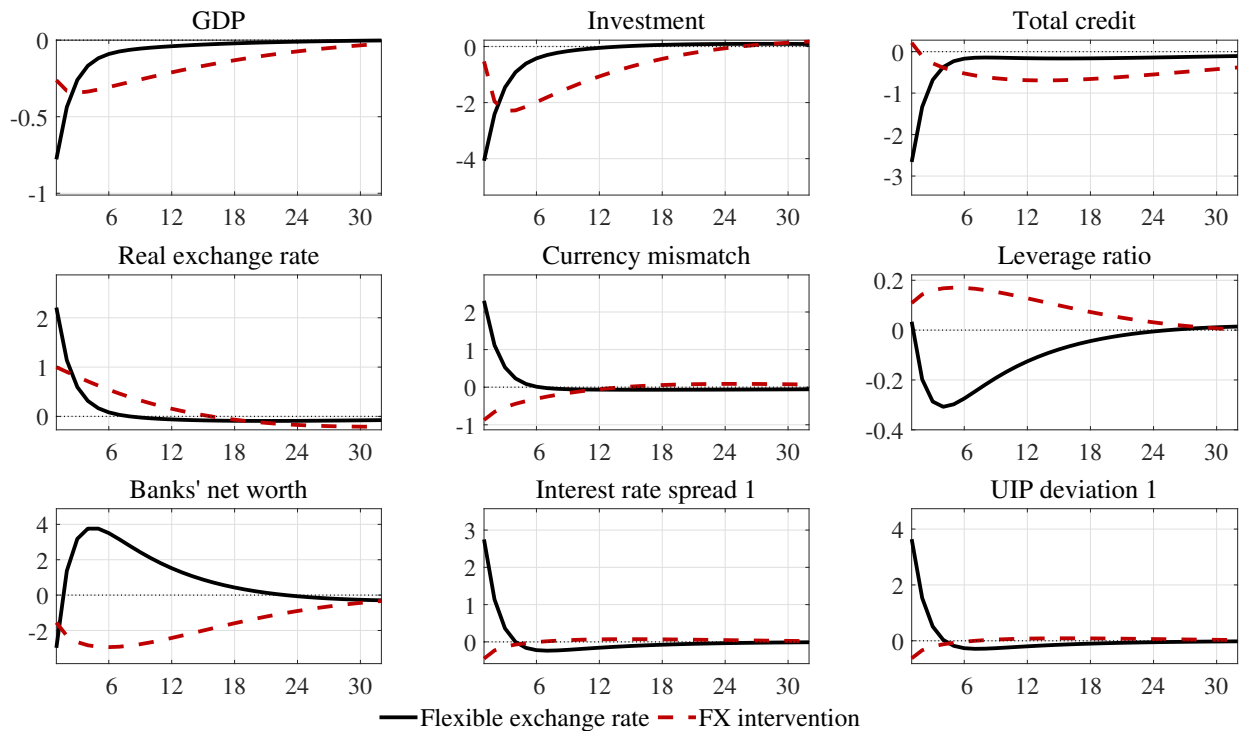


Figure B.3. Responses of financial variables to a foreign interest rate shock

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

C Robustness exercises

We examine the effectiveness of FX interventions as a response to external shocks under more general assumptions (“Case”). The first four cases induce a change in the steady state of the model which are reported in Table C.1. We discuss the volatility and welfare implications of these cases.

VARIABLE	BASE	Case 1A $\delta^f, D^{*,h} = 0$	Case 1B $\downarrow R^*$	Case 2A $\downarrow \kappa_{D^*}$	Case 2B $x^{\text{IND.}}$	Case 3 $\mathcal{H} = 0$	Case 4 $\varpi^b, \varpi^* = 1$
Financial System Rates							
<i>Capital return</i>	8.0	8.2	7.8	8.0	8.0	8.0	7.5
<i>DC loan's return</i>	6.0	6.1	5.9	6.0	6.0	6.0	6.0
<i>FC loan's return</i>	4.0	4.1	3.7	4.0	4.0	4.0	3.0
<i>FX bonds return</i>	4.0	3.9	3.9	4.0	4.0	4.0	6.0
<i>Foreign interest rate</i>	1.0	1.0	0.7	1.0	4.0	1.0	1.0
<i>Deposit interest rate</i>	4.0	4.0	4.0	4.0	4.0	4.0	4.0
<i>Bank leverage in B</i>	1.1	1.3	1.1	1.1	1.1	0.8	1.1
<i>Bank leverage in L</i>	3.0	6.7	3.0	3.0	3.0	3.1	3.1
<i>Bank leverage in eL*</i>	3.0	0.0	3.0	3.0	3.0	3.1	3.1
<i>Currency mismatch</i>	17.7	20.9	19.2	17.7	17.7	17.1	18.6
<i>Credit dollarization</i>	50.0	0.0	50.0	50.0	50.0	50.0	50.1
<i>Deposit dollarization</i>	65.0	0.0	66.4	64.5	65.0	68.7	64.9
<i>RER</i>	1.0	1.0	1.0	1.0	1.0	1.5	1.0
Sectoral Rates							
<i>Commodity/total exp.</i>	60.0	59.9	60.2	60.0	60.0	70.1	60.5
<i>Commodity/total inv.</i>	16.7	16.8	16.6	16.7	16.7	19.7	16.4
Stock Rates							
<i>NC capital/GDP</i>	1.9	1.8	1.9	1.9	1.9	1.9	1.9
<i>C capital/GDP</i>	1.3	1.3	1.3	1.3	1.3	1.3	1.3
<i>Stock of capital/GDP</i>	1.8	1.8	1.8	1.8	1.8	1.8	1.8
<i>Foreign reserves/GDP</i>	22.0	21.9	21.9	22.6	22.0	15.8	21.8
Aggregate Demand Rates							
<i>Investment/GDP</i>	18.0	17.7	18.1	18.5	18.0	17.8	18.4
<i>Public consumption/GDP</i>	14.0	13.9	14.0	14.4	14.0	10.0	13.9
<i>Consumption/GDP</i>	60.0	60.3	59.8	58.9	60.0	62.8	59.6
<i>Current account/GDP</i>	-0.0	0.1	-0.0	-0.0	-0.2	-0.0	0.0
<i>Trade balance/GDP</i>	8.0	8.1	8.1	8.2	8.0	9.3	8.1

Table C.1. Steady state equilibrium

Note. The values of variables at the steady state equilibrium for each parameterized model that are analyzed in the main text.

Case 1: Increased currency mismatch

Intermediate goods producers borrow from banks only in domestic currency, while households cannot hold deposits in dollars.² In this case, international borrowing is the only source of dollar funds for the banking system. In the steady state, the deposit dollarization rate is revised from

²This case attempts to extend our results for a typical emerging market economy without financial dollarization such as Chile, Colombia, Mexico, etc.

	Baseline		Case 1A		Case 1B		Case 2A		Case 2B		Case 3		Case 4		Case 5	
	FXI	FER	FXI	FER	FXI	FER	FXI	FER	FXI	FER	FXI	FER	FXI	FER	Weak	Strong
Interest Rate Spread 1	0.91	4.63	0.53	0.69	1.01	7.25	0.04	0.13	0.23	0.39	1.02	5.82	1.15	8.57	3.39	2.02
Interest Rate Spread 2	0.19	0.99	0.11	0.15	0.21	1.54	0.01	0.03	0.00	0.00	0.22	1.24	1.15	8.57	0.72	0.43
UIP Deviation 1	1.28	6.16	0.78	0.84	1.45	9.98	0.06	0.12	0.00	0.00	1.41	7.74	1.51	10.59	4.51	2.64
UIP Deviation 2	0.91	4.24	0.56	0.55	1.03	6.97	0.05	0.07	0.23	0.39	0.98	5.33	1.51	10.59	3.11	1.80
Real exchange rate	2.07	5.48	1.72	3.60	2.16	5.88	1.96	2.06	1.88	1.87	2.98	6.18	1.58	5.22	3.80	1.22
Total Credit	1.04	3.88	1.35	1.89	1.01	4.88	0.52	0.68	1.45	2.28	1.05	3.66	0.61	3.31	3.46	2.69
Investment	5.03	10.31	3.80	8.95	5.30	9.98	4.16	4.80	4.09	5.32	3.98	7.00	3.86	8.18	13.88	20.83
Consumption	0.71	0.94	0.52	0.72	0.74	0.96	0.35	0.40	0.19	0.20	1.58	2.14	0.64	0.93	0.93	0.92
GDP	0.86	1.91	0.63	1.42	0.90	1.99	0.71	0.85	0.65	0.79	1.15	2.20	0.70	1.71	1.80	1.47
Inflation	0.34	0.74	0.29	0.46	0.36	0.77	0.26	0.29	0.24	0.22	0.34	0.67	0.26	0.72	0.11	1.94
Labor	0.40	0.51	0.40	0.42	0.40	0.58	0.26	0.27	0.29	0.20	0.46	0.56	0.31	0.69	0.58	1.89

Table C.2. Aggregate volatility conditional on external shocks

Note. Standard deviations for major aggregate variables. FXI and FER denote Foreign Exchange Intervention and Flexible Exchange Rate policy regimes, respectively. Moreover, “Weak” is the alternative Taylor rule regime with $\omega_e = 0.1$ and $v_e = 0$, while “Strong” refers to the alternative Taylor rule with $\omega_e = 1$ and $v_e = 0$. The computation considers the external block as the only source of aggregate volatility. Results are based on 2500 replications of 120 periods of simulated trajectories.

69.8 percent in the baseline calibration to 23.9 percent. Additionally, the aggregate currency mismatch increases from 17.7 percent to 20.9 percent as there is no credit dollarization. These changes leave the banking system more vulnerable to exchange rate fluctuations. The aggregate volatility under exchange rate flexibility for an economy consistent with Case 1 is lower than in our baseline economy (see Table C.2). Notably, the volatility of financial variables such as currency mismatch and total credit is reduced by around 80 and 45 percent, respectively. The volatility of macroeconomic aggregates such as investment and GDP drop significantly as well. Consequently, domestic financial dollarization under exchange rate flexibility exacerbates the impact of external shocks, inducing more aggregate volatility to business-cycle fluctuations in EMEs.

In this scenario, FX intervention continues to effectively reduce the real exchange rate and macroeconomic volatility. Table C.2 shows that the real exchange rate volatility in Case 1 is reduced by around 52 percent when FX interventions are active. This real exchange rate volatility decline is lower than the 62 percent drop obtained in our baseline case. Likewise, the reduction in volatility under active FX interventions is carried through total credit, investment, and GDP. Notably, the volatility of the currency mismatch increases under the FX policy regime. The only source of foreign currency funding for banks is borrowing from abroad, which is more sensitive to FX operations (see Figure 6), implying that currency mismatch absorbs all the volatility associated with it.

$\omega_\pi \setminus v_e$	0.0	2.5	5.0	9.71	20.0	30.0	50.0	100.0
Case 1A: No financial dollarization								
1.25	-8.6	-7.2	-6.1	-4.4	-2.1	-1.1	-0.7	-1.1
1.50	-1.5	-0.9	-0.5	0.0	0.5	0.5	0.0	-1.0
2.00	0.6	0.9	1.0	1.2	1.2	0.9	0.2	-1.0
3.00	1.1	1.3	1.5	1.5	1.4	1.0	0.2	-1.0
5.00	1.3	1.5	1.6	1.6	1.4	1.0	0.2	-1.0
Case 1B: Cheaper foreign debt								
1.25	-16.6	-12.0	-9.7	-6.2	-1.9	-0.4	0.3	-0.0
1.50	-5.3	-2.4	-1.3	0.0	1.2	1.4	1.0	0.1
2.00	-1.4	0.6	1.2	1.8	2.0	1.8	1.2	0.1
3.00	-0.2	1.4	1.9	2.2	2.2	1.9	1.2	0.1
5.00	0.2	1.7	2.1	2.3	2.3	1.9	1.2	0.1

Table C.3. Case 1: Welfare gains/losses of Taylor rule and FX policy rule

Note. The parameter ω_π measures the interest rate response to fluctuations in inflation, while v_e measures the response of FX interventions to real exchange rate deviations. For each combination of (ω_π, v_e) we compute ς which is defined above and report $\varsigma \times 100\%$. Only external shocks are considered in this simulation.

Case 2: UIP conditions holds

To examine the role of the real exchange-rate-smoothing channel, we separately modify two assumptions that influence deviations from the UIP condition. First, when households are allowed to engage in frictionless arbitrage between domestic and foreign currency bank deposits, there are no endogenous excess returns in equilibrium. We approximate this economy by setting κ_{D*} at a sufficiently small but positive number. Then, the UIP condition for households holds with a constant premium with no endogenous deviations from it. Table C.2 reports that FX interventions do not reduce real exchange rate volatility relative to the flexible exchange rate regime: the real exchange rate smoothing channel is muted. FX interventions affect aggregate volatility only via the balance-sheet substitution (crowding-out) channel. In particular, the volatility of total credit is reduced by around 23 percent, while GDP and investment volatility are reduced by 17 and 13 percent, respectively. Even though the incentive compatibility constraint for banks remains binding, indicating the existence of endogenous deviations from the bank's UIP condition, its quantitative significance diminishes when households can freely arbitrage without incurring any costs.

The second case (Case 2B) is one where the size of the currency mismatch affecting bankers' ability to divert funds is an aggregate measure of the banking system. Therefore, $\Theta(x)$ is taken as given at the individual bank level. The severity of the moral hazard problem in the bank system depends on an aggregate currency mismatch measure. Banks do not internalize the effects of dollar borrowing on the agency problem. In terms of the (11), this assumption implies $d\Theta(x)/dx = d\Theta(x^{industry})/dx^{bank} = 0$. Consequently, banks are indifferent between domestic

and dollar borrowing, and the UIP condition holds. Even though the incentive constraint binds, the response of the real exchange rate to external shocks is similar under the FXI and FER regimes.³ In this case, FX interventions do not reduce the volatility of the real exchange rate (see Table C.2). Consistently, the reduction of credit, GDP, and investment volatility (by about 36, 18, and 23 percent, respectively) emerges mainly from the balance sheet substitution (crowding-out) channel. In other words, in this case, the interest rate spreads between lending returns and funding costs still experience an upward response, albeit at a lower rate than the baseline scenario.

$\omega_\pi \setminus v_e$	0.0	2.5	5.0	9.71	20.0	30.0	50.0	100.0
Case 2A: UIP holds - Frictionless household's arbitrage								
1.25	-3.2	-3.0	-2.7	-2.4	-2.1	-2.1	-2.8	-4.8
1.50	-0.2	-0.1	-0.0	0.0	-0.2	-0.7	-2.0	-4.9
2.00	0.7	0.7	0.7	0.7	0.3	-0.2	-1.7	-4.9
3.00	0.9	0.9	0.9	0.8	0.5	-0.1	-1.6	-4.8
5.00	1.0	1.0	1.0	0.9	0.5	-0.0	-1.6	-4.7
Case 2B: UIP holds - Frictionless bank's arbitrage								
1.25	-2.6	-2.6	-2.6	-2.5	-2.5	-2.6	-2.7	-2.3
1.50	-0.0	-0.0	-0.0	0.0	-0.0	-0.1	-0.2	0.1
2.00	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.8
3.00	0.8	0.8	0.8	0.8	0.8	0.8	0.7	1.0
5.00	0.8	0.8	0.9	0.9	0.9	0.8	0.8	1.1

Table C.4. Case 1: Welfare gains/losses of Taylor rule and FX policy rule

Note. The parameter ω_π measures the interest rate response to fluctuations in inflation, while v_e measures the response of FX interventions to real exchange rate deviations. For each combination of (ω_π, v_e) we compute ς which is defined above and report $\varsigma \times 100\%$. Only external shocks are considered in this simulation.

Case 3: Absence of habit formation

We explore the effects of removing habit formation, setting $\mathcal{H} = 0$, from household consumption decisions, a feature that can influence the quantitative implications of the FX intervention regime on macroeconomic volatility and welfare relative to exchange rate flexibility. Habit formation typically has two opposing effects: it increases the persistence of shocks while dampening their immediate impact, leading to an overall ambiguous effect on volatility that must be evaluated quantitatively. Our numerical results suggest that macroeconomic volatility remains largely unchanged. However, the welfare gains diminish, since our welfare measure is closely tied to this parameter.: The benchmark welfare gain of 4% falls to 2.8% when habit formation is excluded.

³Assuming that the agency problem does not depend on any currency mismatch measure (i.e., $\Theta(x)$ is constant) leads to similar qualitative results. Results are available upon request.

$\omega_\pi \setminus v_e$	0.0	2.5	5.0	9.71	20.0	30.0	50.0	100.0
Case 3: No habit formation								
1.25	-9.9	-7.5	-6.2	-4.6	-2.4	-1.5	-1.1	-2.0
1.50	-2.8	-1.3	-0.6	0.0	0.5	0.4	-0.2	-1.7
2.00	-0.4	0.7	1.1	1.3	1.2	0.8	-0.0	-1.7
3.00	0.3	1.2	1.5	1.6	1.4	0.9	0.0	-1.7
5.00	0.5	1.4	1.6	1.7	1.4	1.0	-0.0	-1.7
Case 4: Only one domestic spread								
1.25	-15.6	-11.3	-8.5	-4.6	-1.1	-0.1	0.4	0.4
1.50	-5.4	-2.5	-1.3	0.0	1.0	1.1	1.0	0.6
2.00	-2.0	0.1	0.7	1.3	1.6	1.4	1.1	0.6
3.00	-1.0	0.8	1.3	1.6	1.7	1.5	1.1	0.6
5.00	-0.6	1.0	1.4	1.7	1.7	1.5	1.1	0.6

Table C.5. Case 3 and 4: Welfare gains/losses of Taylor rule and FX policy rule

Note. The parameter ω_π measures the interest rate response to fluctuations in inflation, while v_e measures the response of FX interventions to real exchange rate deviations. For each combination of (ω_π, v_e) we compute ς which is defined above and report $\varsigma \times 100\%$. Only external shocks are considered in this simulation.

Case 4: Uniformly divertible bank assets

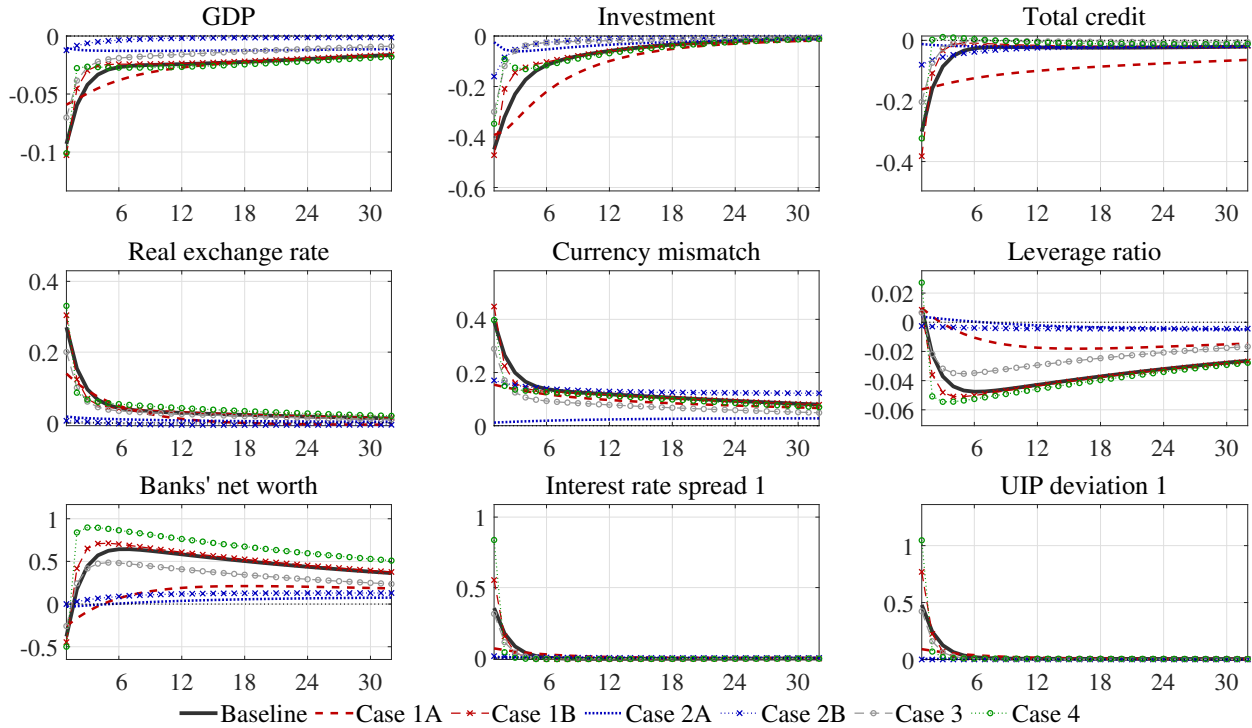


Figure C.1. Responses to a Persistent Purchase of FX Reserves under different generalizations

Note. All variables are presented as percentage deviations from their steady state, except for interest rates, spreads, and the leverage ratio, which are displayed as deviations from their respective steady states.

Figure C.1 displays the responses to a persistent, unanticipated purchase of official FX reserves for each case. In Case 1A and Case 1B, the real exchange rate and aggregate variables respond significantly but less than in our baseline case. In contrast, Case 2A and Case 2B show

practically no real exchange rate response and small effects on the other aggregate variables such as credit, GDP, investment, and inflation. In line with our discussion in [Section 5.4](#), when households or banks can engage in unrestricted arbitrage between domestic and foreign currency-denominated assets or liabilities, FX interventions have very limited power to affect the real exchange rate, real interest rate spreads, and the overall equilibrium of the economy.

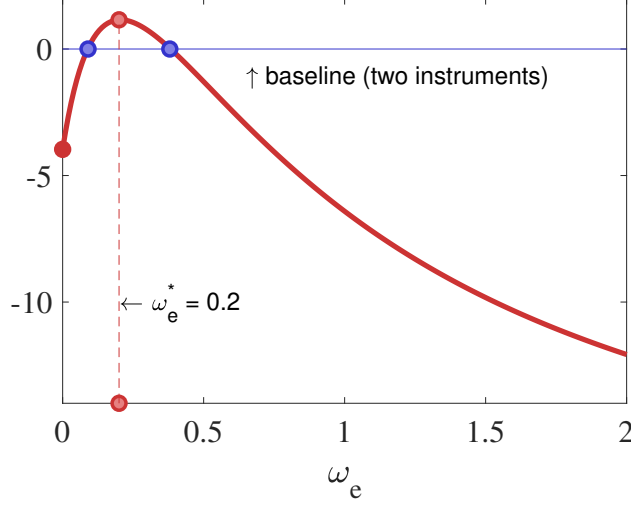


Figure C.2. Welfare gain of extended Taylor rule

Note. The welfare gain associated with the extended-Taylor regime (with $\omega_e \geq 0$ and $v_e = 0$) is compared to the baseline FXI regime (with $\omega_e = 0$ and $v_e = 9.71$).

Case 5: Alternative Taylor rule policies

Consider now a monetary Taylor rule following:

$$i_t - i = \rho_i(i_{t-1} - i) + (1 - \rho_i) \left[\omega_\pi \pi_t + \omega_y \ln \left(\frac{\text{GDP}_t}{\text{GDP}} \right) + \omega_e (\ln e_t - \ln e) + \omega_{\Delta^*} (\Delta_t^* - \Delta^*) \right].$$

Smoothing exchange rate dynamics via the monetary policy rate. Suppose $\omega_{\Delta^*} = 0$. We compare the performance of two policy regimes implementing managed floating for a SOE: i) Our baseline policy regime with two monetary instruments, B_t and i_t , determined by (18) and (19), and ii) an alternative policy regime with i_t as the only monetary instrument following the extended Taylor rule that responds to deviations of the real exchange rate from its steady state value, $\omega_e > 0$.

[Table C.2](#) reports the macroeconomic volatility under both policy regimes and FER, considering $\omega_e \in \{0.1, 1\}$ while keeping the rest of the parameterization as in the baseline model. The two managed-float regimes successfully reduce the exchange rate volatility conditional to external shocks. When the central bank uses two instruments, as in our baseline model, the

exchange rate volatility is reduced from 5.5 percent (under exchange rate flexibility) to 2.1 percent. On the other hand, when the central bank operates with the extended Taylor rule, the decline in the exchange rate volatility depends on ω_e , potentially reaching a lower standard deviation than in the FXI regime. Under the extended Taylor rule, however, the monetary policy interest rate partially absorbs the volatility of the real exchange rate, which ultimately is transmitted to investment and labor volatility. Moreover, the conditional volatility for GDP, consumption, and total credit is lower under the FXI regime than under the extended Taylor rule regime.

The increment in the volatility of aggregate labor accompanied by a slight reduction in consumption volatility may lead to significant welfare losses under the extended Taylor rule regime. To inspect this possibility, [Fig. C.2](#) shows the welfare gains from increasing ω_e but keeping the inflation response on its baseline level $\omega_\pi = 1.5$. In this case, the extended Taylor regime increases welfare whenever ω_e lies between 0.09 and 0.38; otherwise, the extended Taylor rule regime leads to significant welfare losses.

Does this result suggest that the extended Taylor regime can be a good substitute for the baseline regime? Not necessarily. Keeping $\omega_\pi = 1.5$, the maximum welfare gain under the extended Taylor regime is 1.15 of consumption which is attained at $\omega_e = 0.2$. In contrast, the maximum welfare gain under the FXI regime is 1.2 of consumption, attained at $v_e = 28.1$ (see [Section 5.3](#)). Hence, while the extended Taylor regime may potentially improve welfare compared to our baseline two-instrument regime, it cannot do better than the optimal FX intervention rule. Moreover, the interval in which the extended Taylor rule outperforms the baseline regime is narrow enough to raise concerns about the practical implementation of this regime within that interval. Specifically, if there is a non-zero probability of central bank mistakes, the extended Taylor regime is more likely to result in welfare losses compared to the optimal FX intervention rule regime. However, we believe this question is important and deserves more discussion in future research.

Smoothing UIP deviations via the monetary policy rate. If the central bank aims to stabilize UIP deviations through conventional monetary policy, i.e., $\omega_{\Delta^*} > 0$ and $\omega_e = 0$, we compare this approach with our baseline results in [Figure C.3](#).⁴ We consider two calibrations: a "Low" rule with $\omega_{\Delta^*} = 0.5$ and a "High" rule with $\omega_{\Delta^*} = 5$. As in our previous discussion, these rules effectively stabilize the real exchange rate but at the cost of increasing credit and economic activity volatility. [Figure C.4](#) and [Figure C.5](#) extend this analysis to foreign interest rate and foreign demand shocks, yielding similar conclusions.

⁴In this comparison, we also include the previous exchange-rate-smoothin Taylor rule with $\omega_e = 0.5$.

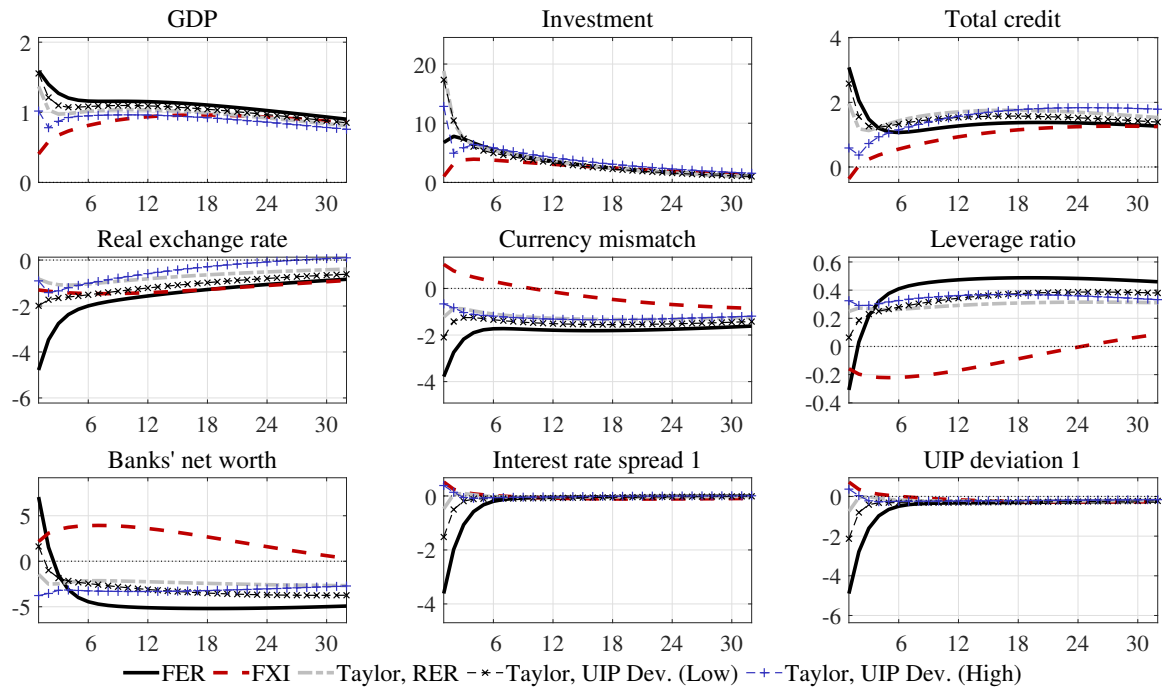


Figure C.3. Commodity price shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

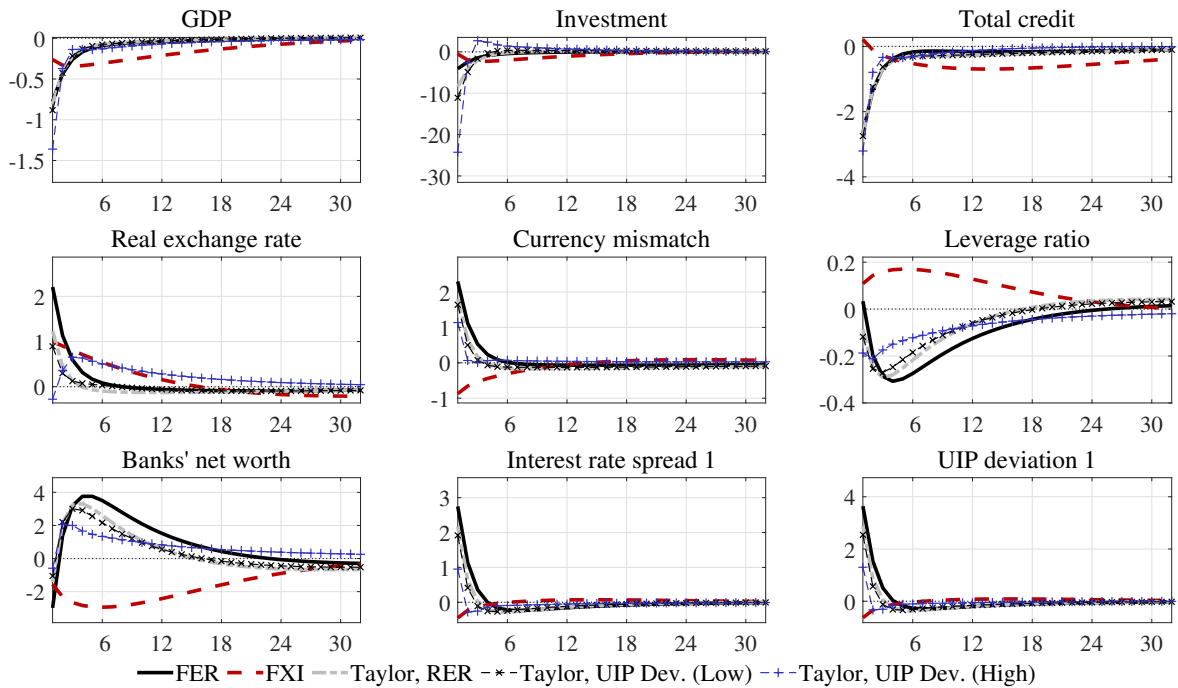


Figure C.4. Foreign interest rate shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

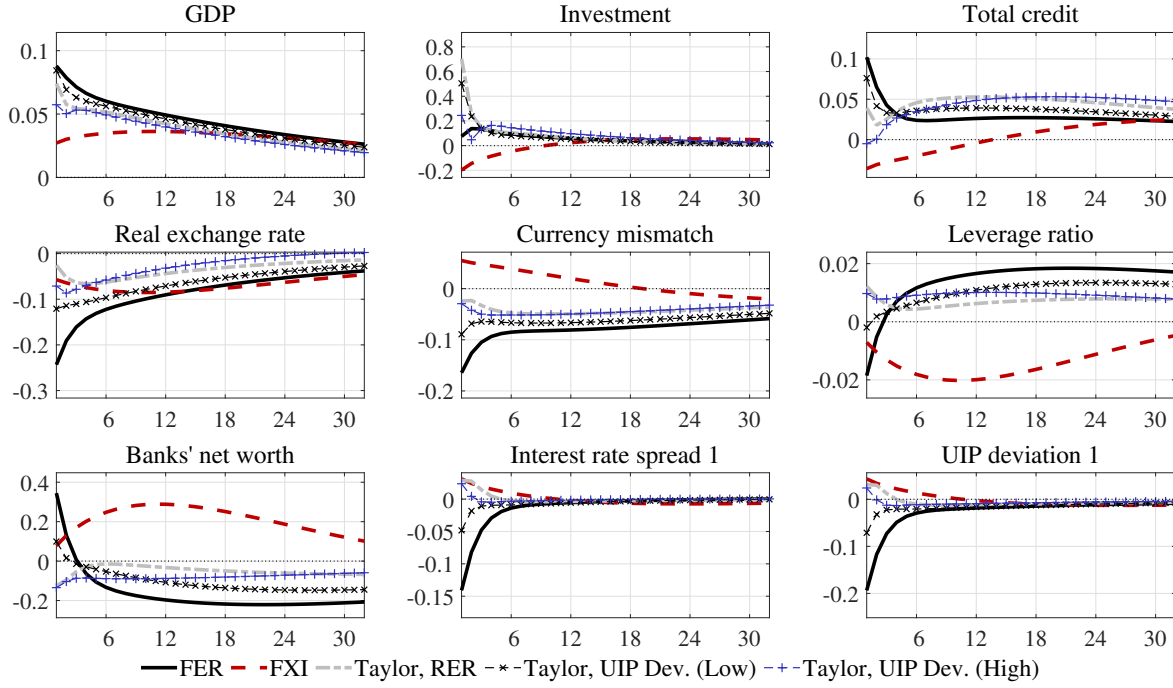


Figure C.5. Foreign output shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

Case 6: Incorporating sterilization operational costs

Addressing the optimal FX policy response to external shocks is challenging since it involves various aspects of official FX reserve management that may not be explicitly considered in our framework. To account for these other aspects of FX policies, we suppose that the central bank incurs adjustment costs when conducting sterilization operations. This extension allows us to incorporate the associated costs and constraints of sterilization operations, which can have implications for the optimal FX policy response to external shocks.

Assuming these adjustment costs are proportional to CB_t , the central bank's quasi-fiscal deficit is

$$\widehat{CB}_t = e^{\tau^{fx}(B_t - B)} CB_t = e^{\tau^{fx}(B_t - B)} \left(R_t^b - \frac{e_t}{e_{t-1}} R_t^* \right) B_{t-1}.$$

Adjustment costs arise when the central bank FX sterilization operations deviate from B at t , while CB_t is a function of past intervention decisions (and current real interest rates).⁵ In the aggregate, the central bank's adjustment cost takes the form of an inefficiency cost since a

⁵We interpret τ^{fx} as the partial elasticity of CB_t/B_{t-1} with respect to B_t . Let $S_t \equiv \frac{CB_t}{B_{t-1}} = \exp(\tau^{fx}(B_t - B)) [R_t^b - \frac{e_t}{e_{t-1}} R_t^*]$, then we have $\tau^{fx} = \frac{1}{S_t} \frac{\partial S_t}{\partial B_t}$.

fraction of non-commodity output is allocated to fund it:

$$Y_t^{nc} - REST_t - \left(e^{\tau^{fx}(B_t - B)} - 1 \right) CB_t = C_t + G_t + I_t^{nc} + I_t^c + Y_t^{x,nc}.$$

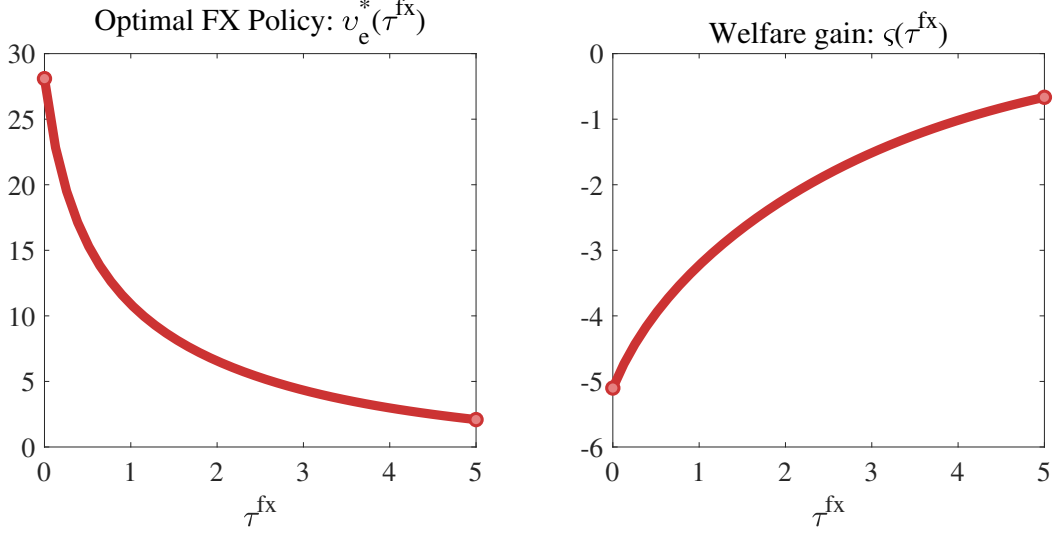


Figure C.6. Optimal FX intervention rule

Note. $v_e^*(\tau^{fx})$ represents the optimal endogenous response in the FX policy rule, which maximizes households' welfare, as a function of the sterilization procedure costs (captured by τ^{fx}). $\zeta(\tau^{fx})$ indicates the welfare gain associated with the FER regime compared to a regime where the FX policy rule is calibrated using $v_e^*(\tau^{fx})$.

The parameter τ^{fx} measures how costly deviations of B_t from its steady-state level are in terms of aggregate non-commodity output. We study the optimal FX intervention rule when τ^{fx} takes values between 0 and 5. For each τ^{fx} , we calculate the optimal FX policy response, $v_e^*(\tau^{fx})$, and compute the welfare cost of the FER regime relative to this optimized FX rule regime, $\zeta(\tau^{fx})$. That is, the reference policy regime varies with τ^{fx} (and is associated with $v_e^*(\tau^{fx})$), while the alternative regime represents the case where $v_e = 0$. We keep the Taylor rule coefficients as in our baseline parameterization.

For each $\tau^{fx} \in [0, 5]$, Panel A of Figure C.6 displays the optimal FX intervention policy coefficient while Panel B shows the welfare cost of implementing a flexible exchange rate regime. The optimized FX policy coefficient decreases monotonically with τ^{fx} , from 28.1 to 3.5. Consistently, the welfare cost of implementing a flexible exchange rate regime decreases with τ^{fx} . Particularly, Panel B of Figure C.6 shows that the welfare cost of exchange rate flexibility varies from 5 percent to 1.5 percent of consumption relative to each optimized FX intervention regime. Hence, exchange rate flexibility could generate substantial welfare losses compared to the optimized FX policy regime.

Case 7: Exploring Alternative FX Intervention Rules

We show responses to external shocks when the central bank FXI rule respond to the real exchange depreciation and/or UIP deviations, obtaining similar results as in our main text analysis. We argue that an FXI rule concerning interest rate spreads is not as implementable as an FX intervention rule responding to exchange rate deviations. In particular, consider the following FX intervention rule:

$$\ln B_t = (1 - \rho_B) \ln B + \rho_B \ln B_{t-1} - v_e(\ln e_t - \ln e) - v_{\Delta e} \Delta e_t - v_{\Delta*}(\Delta_t^* - \Delta^*). \quad (1)$$

In Figure C.7-Figure C.9, we argue that when the central bank intervenes to mute exchange rate depreciation, $v_{\Delta e} > 0$, with a high enough persistent in ρ_B , keeping $v_e = v_{\Delta*} = 0$, the responses are similar to our baseline rule. Moreover, we show the impulse response of the main macroeconomic variables when the central bank intervenes to mute UIP deviations, $\omega_{\Delta*} > 0$ keeping $v_e = v_{\Delta e} = \rho_B = 0$. In particular, we show two different calibration: $\omega_{\Delta*} = 1$ (High FXI) and $\omega_{\Delta*} = 40$ (High FXI). Although the responses under these rules are not close to the responses under our baseline FXI rule, qualitatively the responses are similar. A more detailed exploration for the differences in the response under each rule is out of the scope of this paper.

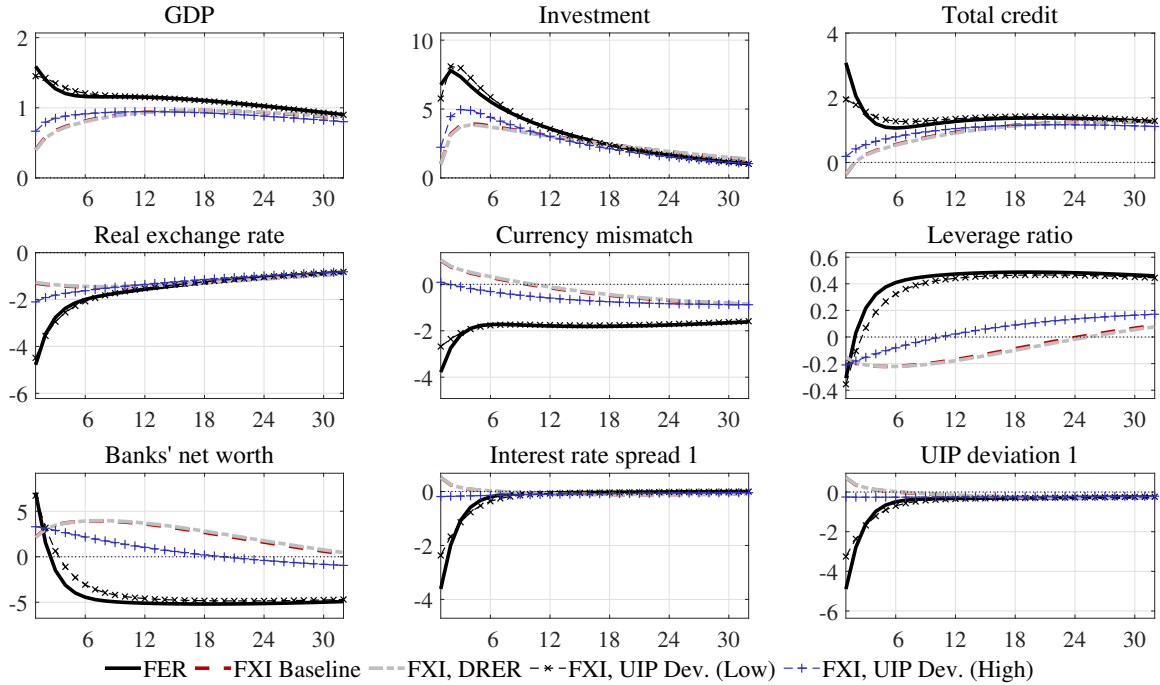


Figure C.7. Commodity price shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

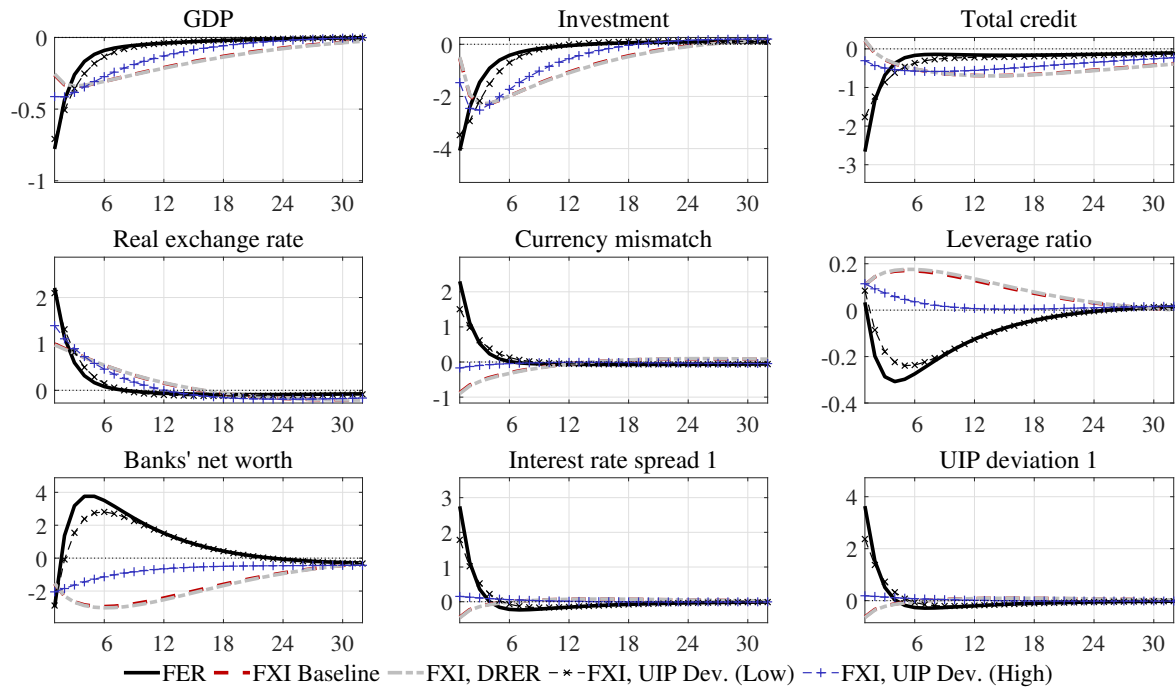


Figure C.8. Foreign interest rate shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

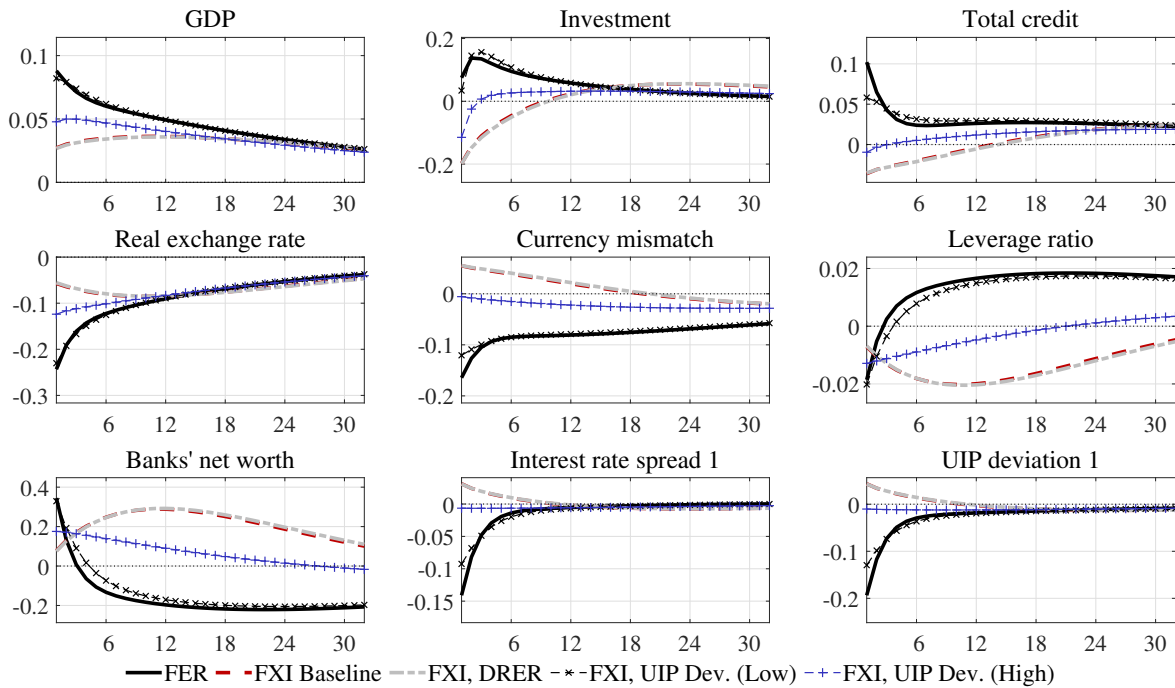


Figure C.9. Foreign output shock

Note. The response of each quantity or index variable is presented as percent deviation from its steady state, while the response of any rate variable is displayed in percentage-point deviations from its steady state.

D Additional derivations and analysis

D.1 Individual bank's problem

Recursive version of banks' problem:

$$V_t = \max_{l_t, l_t^*, b_t, d_t, d_t^*} \mathbb{E}_t [\Lambda_{t,t+1} \{(1 - \sigma)n_{t+1} + \sigma V_{t+1}\}]$$

subject to:

$$\begin{aligned} l_t + e_t l_t^* + b_t &= n_t + d_t + e_t d_t^* \\ n_{t+1} &= R_{t+1}^l l_t + R_{t+1}^{l*} e_{t+1} l_t^* + R_{t+1}^b b_t - R_{t+1} d_t - e_{t+1} R_{t+1}^* d_t^* \\ x_t &= \frac{e_t d_t^* - e_t l_t^*}{l_t + e_t l_t^* + b_t} \\ V_t &\geq \Theta(x_t) [l_t + \varpi^* e_t l_t^* + \varpi^b b_t] \end{aligned}$$

Let $\psi_t = \frac{V_t}{n_t}$, $\phi_t^l = \frac{l_t}{n_t}$, $\phi_t^{l*} = \frac{e_t l_t^*}{n_t}$, and $\phi_t^b = \frac{b_t}{n_t}$, then the objective function can be rewritten as

$$\psi_t = \mathbb{E}_t \left[\Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1}) \frac{n_{t+1}}{n_t} \right]$$

Using the law of motion for a bank's net worth, we have

$$\begin{aligned} \frac{n_{t+1}}{n_t} &= R_{t+1}^l \frac{l_t}{n_t} + R_{t+1}^{l*} \frac{e_{t+1}}{e_t} \frac{e_t l_t^*}{n_t} + R_{t+1}^b \frac{b_t}{n_t} - R_{t+1} \frac{d_t}{n_t} - R_{t+1}^* \frac{e_{t+1}}{e_t} \frac{(l_t + e_t l_t^* + b_t)}{n_t} \frac{(e_t d_t^* - e_t l_t^* + e_t l_t^*)}{l_t + e_t l_t^* + b_t} \\ &= R_{t+1}^l \phi_t^l + \frac{e_{t+1}}{e_t} (R_{t+1}^{l*} - R_{t+1}^*) \phi_t^{l*} + R_{t+1}^b \phi_t^b \\ &\quad - R_{t+1} \left[\phi_t^l + \phi_t^b - 1 - [\phi_t^l + \phi_t^{l*} + \phi_t^b] x_t \right] - \frac{e_{t+1}}{e_t} R_{t+1}^* [\phi_t^l + \phi_t^{l*} + \phi_t^b] x_t. \end{aligned}$$

Hence, we have

$$\begin{aligned} \frac{n_{t+1}}{n_t} &= [R_{t+1}^l - R_{t+1}] \phi_t^l + \left[\frac{e_{t+1}}{e_t} (R_{t+1}^{l*} - R_{t+1}^*) \right] \phi_t^{l*} \\ &\quad + [R_{t+1}^b - R_{t+1}] \phi_t^b + \left[R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right] (\phi_t^l + \phi_t^{l*} + \phi_t^b) x_t + R_{t+1} \end{aligned} \quad (2)$$

Alternatively, (2) can be expressed as

$$\begin{aligned} \frac{n_{t+1}}{n_t} &= \left[R_{t+1}^l - \left\{ (1 - x_t) R_{t+1} + x_t \frac{e_{t+1}}{e_t} R_{t+1}^* \right\} \right] \phi_t^l \\ &\quad + \left[\frac{e_{t+1}}{e_t} R_{t+1}^{l*} - R_{t+1}^l + R_{t+1} - \left\{ (1 - x_t) R_{t+1} + x_t \frac{e_{t+1}}{e_t} R_{t+1}^* \right\} + R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right] \phi_t^{l*} \\ &\quad + \left[R_{t+1}^b - \left\{ (1 - x_t) R_{t+1} + x_t \frac{e_{t+1}}{e_t} R_{t+1}^* \right\} \right] \phi_t^b + R_{t+1} \end{aligned} \quad (3)$$

Using (2), bank's problem can be rewritten as the following form:

$$\psi_t = \max_{\phi_t^l, \phi_t^{l*}, \phi_t^b, x_t} \mu_t^l \phi_t^l + (\mu_t^{l*} + \mu_t^{d*}) \phi_t^{l*} + \mu_t^b \phi_t^b + \mu_t^{d*} (\phi_t^l + \phi_t^{l*} + \phi_t^b) x_t + v_t \quad (4)$$

subject to $\psi_t - \Theta(x_t) [\phi_t^l + \varpi^* \phi_t^{l*} + \varpi^b \phi_t^b] \geq 0$, where

$$\begin{aligned} \mu_t^l &= \mathbb{E}_t [\Omega_{t+1} (R_{t+1}^l - R_{t+1})] \quad \text{and} \quad \mu_t^{l*} = \mathbb{E}_t \left[\Omega_{t+1} \left(\frac{e_{t+1}}{e_t} R_{t+1}^{l*} - R_{t+1} \right) \right] \\ \mu_t^b &= \mathbb{E}_t [\Omega_{t+1} (R_{t+1}^b - R_{t+1})] \quad \text{and} \quad \mu_t^{d*} = \mathbb{E}_t \left[\Omega_{t+1} \left(R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right) \right], \end{aligned}$$

$v_t = \mathbb{E}_t [\Omega_{t+1} R_{t+1}]$ and $\Omega_{t+1} = \Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1})$. Let λ_t^b be the Lagrange multiplier of the associated incentive restriction, then the problem becomes:

$$\begin{aligned} \mathcal{L}_t &= \max_{\phi_t^l, \phi_t^{l*}, \phi_t^b, x_t} (1 + \lambda_t^b) [\mu_t^l \phi_t^l + (\mu_t^{l*} + \mu_t^{d*}) \phi_t^{l*} + \mu_t^b \phi_t^b + \mu_t^{d*} (\phi_t^l + \phi_t^{l*} + \phi_t^b) x_t + v_t] \\ &\quad - \lambda_t^b \Theta(x_t) (\phi_t^l + \varpi^* \phi_t^{l*} + \varpi^b \phi_t^b) \end{aligned}$$

Thus, the optimal conditions for the bank's optimization problem are

$$\begin{aligned} \mu_t^l + \mu_t^{d*} x_t &= \frac{\lambda_t^b}{1 + \lambda_t^b} \Theta(x_t) \\ \mu_t^{l*} + \mu_t^{d*} (1 + x_t) &= \frac{\lambda_t^b}{1 + \lambda_t^b} \varpi^* \Theta(x_t) \\ \mu_t^b + \mu_t^{d*} x_t &= \frac{\lambda_t^b}{1 + \lambda_t^b} \varpi^b \Theta(x_t) \\ \mu_t^{d*} &= \frac{\lambda_t^b}{1 + \lambda_t^b} \left(\frac{\phi_t^l + \varpi^* \phi_t^{l*} + \varpi^b \phi_t^b}{\phi_t^l + \phi_t^{l*} + \phi_t^b} \right) \partial_x \Theta(x_t). \end{aligned}$$

We can rewrite the optimal conditions in terms of interest rate spreads as

$$\begin{aligned} \mathbb{E}_t \Omega_{t+1} (R_{t+1}^l - R_{t+1}^{fund}) &= \frac{\lambda_t^b}{1 + \lambda_t^b} \Theta(x_t) \\ \mathbb{E}_t \Omega_{t+1} (R_{t+1}^b - R_{t+1}^{fund}) &= \frac{\lambda_t^b}{1 + \lambda_t^b} \varpi^b \Theta(x_t) \\ \mathbb{E}_t \Omega_{t+1} \left(R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right) &= \frac{\lambda_t^b}{1 + \lambda_t^b} \left(\frac{\phi_t^l + \varpi^* \phi_t^{l*} + \varpi^b \phi_t^b}{\phi_t^l + \phi_t^{l*} + \phi_t^b} \right) \partial_x \Theta(x_t) \\ \mathbb{E}_t \Omega_{t+1} \left(R_{t+1}^l - \frac{e_{t+1}}{e_t} R_{t+1}^{l*} \right) &= \frac{\lambda_t^b}{1 + \lambda_t^b} (1 - \varpi^*) \Theta(x_t) + \mathbb{E}_t \Omega_{t+1} \left(R_{t+1} - \frac{e_{t+1}}{e_t} R_{t+1}^* \right) \end{aligned}$$

where $R_t^{fund} = (1 - x_{t-1}) R_t + x_{t-1} \frac{e_t}{e_{t-1}} R_t^*$. Equation (3) indicates that this set of interest rate spreads is sufficient to track the value of a bank ψ_t .

The aggregation of financial variables is simple since banks' optimal decisions are the same for all banks. Then, we can define the aggregate banks' composition as

$$\phi_t^l \equiv \frac{L_t}{N_t}, \phi_t^{l*} \equiv \frac{e_t L_t^*}{N_t}, \phi_t^b \equiv \frac{B_t}{N_t} \quad \text{and} \quad x_t \equiv \frac{e_t D_t^* - e_t L_t^*}{L_t + e_t L_t^* + B_t}$$

Since the aggregate level of sterilized bonds, B_t , is determined by the monetary authority, and N_t is a state variable, then, in the whole financial system, ϕ_t^b is given. However, (R_t^l, R_t^{l*}, R_t^b) is not given for the banking system. The equilibrium interest rates are determined by the aggregated bank's net worth and credit demand functions. The aggregate net worth of banks evolves according to

$$N_{t+1} = \sigma (R_{t+1}^l L_t + R_{t+1}^{l*} e_{t+1} L_t^* + R_{t+1}^b B_t - R_{t+1} D_t - e_{t+1} R_{t+1}^* D_t^*) + \xi (R_{t+1}^l L_t + R_{t+1}^{l*} e_{t+1} L_t^* + R_{t+1}^b B_t)$$

or rearranging,

$$N_{t+1} = (\sigma + \xi) (R_{t+1}^l L_t + R_{t+1}^{l*} e_{t+1} L_t^* + R_{t+1}^b B_t) - \sigma R_{t+1} D_t - \sigma e_{t+1} R_{t+1}^* D_t^* \quad (5)$$

D.2 Inspecting the mechanism

The main simplifying assumptions in this section are as follows: There is no domestic financial dollarization (i.e., $L_t^* = D_t^{*,h} = 0$ for all t), and bank assets are equally weighted in their incentive constraint (i.e., $\varpi^b = \varpi^* = 1$). Additionally, there are no government expenditures, no habits in consumption, full depreciation of capital after production, no adjustment costs of investment, no commodity sector, and fixed prices. To ensure tractability, we assume no aggregate uncertainty and focus on the temporary equilibrium under perfect foresight for credit and FX asset markets taking expectations as given.

Currency mismatch Under the maintained assumptions, the nominal interest rates for loans and central bank bonds are equalized, $i_t^l = i_t^b$ while the optimal currency mismatch of the economy, denoted by $x_t(e_t, i_t^l)$ and defined by $e_t d_t^* / (l_t + b_t)$, is determined by the following equation:

$$i_t^l - i_t = \frac{2 - \kappa x_t^2(e_t, i_t^l)}{2\kappa x_t(e_t, i_t^l)} \left(1 + i_t - \frac{e_{t+1}}{e_t} (1 + i_t^*) \right).$$

The above equation demonstrates that $x_t(e_t, i_t^l)$ increases as the real exchange rate rises, implying that a higher e_t corresponds to a lower expected real depreciation and an increased affordability of external funds relative to domestic funds. As a result, currency mismatch escalates and the banks' borrowing constraint tightens. Conversely, when the return on loans increases, $x_t(e_t, i_t^l)$ decreases, indicating that loans become more profitable with higher i_t^l , and currency mismatches decline while the borrowing constraint loosens for banks.

Credit market. When banks' borrowing constraint binds, the aggregate credit supply is a multiple of banks' net worth: $\Phi_t N_t = L_t + B_t$. The credit supply function is

$$\mathcal{S}_t^L(e_t, i_t^l) \equiv \Phi_t(x_t(e_t, i_t^l), e_t, i_t^l) [J_{t-1} - \sigma e_t (1 + i_{t-1}^*) D_{t-1}^*] - B_t$$

where $\Phi_t(x, e, i^l)$ denotes the leverage ratio as a function of the aggregate currency mismatch, real exchange rate, and loan's return, and J_{t-1} is the fraction of banks' net worth denominated in domestic currency.⁶ Then, the return on loans and real exchange rate affect the economy's credit supply direct and indirectly (through effects on currency mismatch). An increase in the return on loans raises the marginal benefits of loans and reduces the currency mismatch, leading to an unambiguous loosening of the borrowing constraint and credit supply expansion. In contrast, the real exchange rate generates potentially ambiguous effects on the credit supply shown in the following equation:

$$\frac{\partial \mathcal{S}_t^L(e_t, i_t^l)}{\partial e_t} = \overbrace{-\sigma \Phi_t R_t^* D_{t-1}^*}^{\text{Net worth effect}} + N_t \left(\overbrace{\frac{\partial \Phi_t}{\partial e_t}}^{\text{Direct effect}} + \overbrace{\frac{\partial \Phi_t}{\partial x_t} \frac{dx_t}{de_t}}^{\text{Indirect effect}} \right)$$

By reducing the banks' net worth, an increment in the real exchange rate tightens the credit limit. But the real exchange rate movements also generate a direct and indirect effect on banks' leverage ratio. On the one hand, a higher real exchange rate raises the banks' lending profitability through its effect on the expected real depreciation (given by e_{t+1}/e_t) and the increase affordability of external funds (Direct effect). On the other hand, the currency mismatch rises after a rise in the real exchange rate, generating an ambiguous effect (Indirect effect). In this subsection, we focus on the case in which these effects are such that $\partial \mathcal{S}_t^L(e_t, i_t^l)/\partial e_t < 0$ (as it turns out to be in the baseline calibration).

The demand for credit in the economy is driven by intermediate good producers' need for capital. By combining the necessary conditions for cost minimization with the aggregate production function, we can derive the aggregate demand function for credit:

$$\mathcal{D}_t^L(e_t, i_t^l) \equiv \alpha \frac{Y_{t+1}}{A_{t+1}^{nc}} \left(\frac{e_{t+1}}{1 + i_t^l} \right)^{1-\alpha}$$

The cost of credit, which is given by $1 + i_t^l$, has a negative impact on this function. The aggregate demand for credit is heavily influenced by future projections of output, productivity, and real exchange rates since loans are used to purchase the next period's capital stock. Hence, the demand for credit is independent of the current level of the real exchange rate.

Net foreign asset market. The aggregate supply of foreign assets in the economy is determined by adding the current account balance and the net foreign asset position (NFAP) at the beginning of the period and is given by:

$$\mathcal{S}_t^{FX}(e_t, i_t^l) \equiv e_t^\varphi Y_t^* - \frac{1-\alpha}{\alpha} (1 + i_{t-1}^l) K_{t-1} + e_t (1 + i_{t-1}^*) \text{NFAP}_{t-1}$$

⁶That is, $J_{t-1} \equiv (\sigma + \xi)(1 + i_{t-1}^l)(L_{t-1} + B_{t-1}) - \sigma(1 + i_{t-1})D_{t-1}$.

where the value of imports is replaced by firms' demand for inputs. An upward-sloping supply of foreign assets is observed with respect to e_t as long as the real exchange rate improves the trade balance and/or revalues the net foreign asset position.

The net demand for foreign assets in the economy (i.e., aggregate external assets minus external liabilities with the rest of the world) is defined as the difference between the central bank's demand for foreign assets ($e_t F_t = B_t$) and banks' aggregate demand for external funds ($e_t D_t^* = x_t \Phi_t N_t$). Then, the aggregate net demand function of foreign assets is:

$$\mathcal{D}_t^{FX}(e_t, i_t^l) \equiv B_t - x_t(e_t, i_t^l) \Phi_t(x_t(e_t, i_t^l), e_t, i_t^l) [J_{t-1} - \sigma e_t (1 + i_{t-1}^*) D_{t-1}^*].$$

As with the credit supply, an increase in the real exchange rate can have an ambiguous effect on the net demand for foreign assets due to the aggregate external liabilities response which are given by banks' demand for external funds. The opposite effects are due to the responses of banks' aggregate net worth and leverage ratio to changes in the real exchange rate, which in this case are further scaled by a factor represented by x_t . An increase in the real exchange rate increases the currency mismatch, leading to a further effect on $\mathcal{D}_t^{FX}(e_t, i_t^l)$ that is not present in the aggregate credit supply case. As a result, banks may increase their external foreign currency funding, which in turn lowers the aggregate demand for net foreign assets. In this subsection, we focus on the scenario where $\partial \mathcal{D}_t^{FX}(e_t, i_t^l) / \partial e_t < 0$, as this is what we observe in our baseline calibration. The corresponding slopes for the supply of net foreign assets and the demand for credit

Equilibrium and analysis. Given an initial aggregate capital stock (K_s) and banks' portfolio, an exogenous path for $\{A_s^{nc}, Y_s^*, i_s^*\}_{s \geq t}$ and a sequence of policy instruments $\{i_s, B_s\}_{s \geq t}$, a temporary equilibrium is an allocation $\{L_s, D_s^*\}_{s \geq t}$ and a price system $\{i_s^l, e_s\}_{s \geq t}$ such that, for all $s \geq t$, $K_s = \mathcal{S}_s^c = \mathcal{D}_s^c$ and $B_t - e_s D_s^* = \mathcal{S}_s^{fx} = \mathcal{D}_s^{fx}$ and the good's market clears.⁷

The market equilibrium for net foreign assets and aggregate credit is depicted in [Figure 3](#). Notice that the demand for net foreign assets (D_t^{FX}) and the supply for credit (S_t^L), influenced by banks' portfolio decisions are split into two regions. In the first region, when the credit supply is low or the desired net foreign asset is high (with low foreign currency deposits), banks' borrowing constraint does not bind, and both curves remain flat. This means that there are no interest rate spreads ($i_t^l - i_t = 0$) and no deviations from uncovered interest rate parity arise (UIP), as the exchange rate (e_t) is determined by the UIP. In the second region, when the size of banks' balance sheet (determined by either L_t or D_t^*) is large enough, banks'

⁷ $Y_s = C_s(\{i_k, Y_k\}_{k \geq s}) + K_s + e_s^\varphi Y_s^*$ for all $s \geq t$, where $C_s(\cdot)$ is the consumption demand function.

borrowing constraints bind and the interest rate spread together with UIP deviations emerge. This indicates that the banking sector is non-neutral, and both curves show their corresponding slopes, which have been discussed above: $\partial \mathcal{D}_t^{FX}(e_t, i_t^l)/\partial e_t < 0$ and $\partial \mathcal{S}_t^L(e_t, i_t^l)/\partial i_t^l > 0$. Finally, it should be noted that the slopes for S^{FX} and D^L remain unaffected by banks' borrowing constraints.