Escaping the Financial Dollarization Trap: The Role of Foreign Exchange Intervention*

Paul Castillo† Ruy Lama‡ Juan Pablo Medina§

June 2024

Abstract

Financial dollarization is considered a source of macroeconomic instability in many emerging economies. In this paper we evaluate the role of foreign exchange reserves in facilitating macroeconomic stabilization in a financially dollarized economy. We first show empirically that foreign exchange intervention in response to capital outflows can largely reduce the volatility of output and the real exchange rate in dollarized economies. We then develop a small open economy model with foreign currency debt and balance sheets effects. Our quantitative model shows that an active foreign exchange intervention policy is sufficient for offsetting the output volatility associated with financial dollarization. These results can explain the prevalence of low macroeconomic volatility in some dollarized economies (Christiano et al., 2021) and they highlight the role of foreign exchange reserves in reducing the welfare costs of dollarization.

JEL Classification: E58, F31, F41.
Keywords: Foreign Exchange Intervention; Global Financial Cycle; Financial Dollarization; Balance Sheet Effects; Emerging Economies.

*We thank Larry Christiano, Jesper Lindé, Mathias Trabandt, Marcin Kolasa, Nikhil Patel, Sergio García Monroy, Dmitry Plotnikov, Sonia Muñoz, Tomohiro Tsuruga, Julia Otten, and participants at the 27th LACEA Conference and the seminar at the Monetary and Capital Department of the International Monetary Fund (IMF) for helpful comments and suggestions. The views expressed here are ours and do not necessarily represent the views of the Central Bank of Peru, the IMF, its Executive Board, or IMF management. Corresponding author: Ruy Lama (rlama@imf.org)
†Central Bank of Peru. Email: paul.castillo@bcrp.gob.pe
‡International Monetary Fund. Email: rlama@imf.org
§Universidad Adolfo Ibáñez, Chile. Email: juan.medina@uai.cl

1. Introduction

The conventional wisdom among policy makers is that financial dollarization (i.e., private sector borrowing denominated in foreign currency) is a source of macroeconomic volatility and financial instability in emerging economies.[1] In contrast to the standard Mundell-Fleming paradigm, under financial dollarization, the exchange rate is unable to absorb negative external shocks. Instead, an exchange rate depreciation can amplify external shocks by raising the effective cost of borrowing, triggering balance sheet effects and exacerbating a contraction in investment and output growth. Moreover, attempts to fix the exchange rate do not necessarily improve macroeconomic outcomes, as the stabilization of the nominal exchange rate might require a procyclical monetary stance that results in a larger output contraction (Végh et al., 2017). Alternative policies for de-dollarization, such as a higher reserve requirements in foreign currency or limits on bank's foreign exchange positions, could potentially lead to financial disintermediation and lower growth (Catao and Terrones, 2016). In turn, financial dollarization imposes a policy dilemma for central banks, as the available policy options to mitigate its harmful effects in the economy are limited. We refer to this dilemma encountered by many central banks as the financial dollarization trap.

Nevertheless, and contrary to the conventional view, some dollarized countries have been highly resilient to exchange rate depreciations. Recent empirical work shows a weak relationship between dollarization, banking crisis, and macroeconomic volatility. For instance, Christiano et al. (2021) analyze a large panel of firms in Armenia and Peru and do not find that exchange rate depreciations affect investment and employment decisions. They argue that an efficient macroprudential policy could explain the weakness of balance sheet effects. Bleakely and Cowan (2008) find similar results for Latin American countries, where the lack of balance sheet effects could be explained by the fact that liability dollarization is concentrated among export firms that are naturally hedged against exchange rate fluctuations. In this context, our paper focuses on two key policy questions: (i) Can foreign exchange intervention lower macroeconomic volatility under dollarization?; and (ii) How large are the welfare gains from deploying foreign exchange rate intervention policies in economies with financial dollarization? Despite extensive policy debates, these issue are far from settled.

This paper explores the idea that an optimal foreign exchange intervention policy can substantially reduce the welfare costs of financial dollarization while provid-

[1]See, for example, Hausmann et al. (2001), Calvo and Reinhart (2002), Céspedes et al. (2004), Yeyati (2006), and Braggion et al. (2009)

ing the central bank with an additional tool for achieving macroeconomic stability. We develop a small open economy DSGE model with balance sheet effects where, contrary to the Mundell-Fleming paradigm, exchange depreciation generates contractionary effects. In the model, monetary policy has limited power to counteract the balance sheet effects under financial dollarization, as shown by Céspedes et al. (2004). While several papers in the literature assume that the central bank relies solely on the short-term policy rate for macroeconomic stabilization purposes, a more recent strand of the literature considers the more realistic case in which central banks deploy multiple instruments.[2] We follow that avenue and include foreign exchange reserves as an additional policy instrument that could be deployed optimally over the business cycle. We then ask to what extent this additional tool can address the excess macroeconomic volatility induced by financial dollarization.

The first contribution of our paper is to estimate the macroeconomic effects of foreign exchange intervention in dollarized economies. We depart from the standard panel data approach used in the dollarization literature (Levy-Yeyati, 2006; Christiano et. al, 2021) and rely on Vector Autorregresive (VAR) models for quantifying the dynamic effects of foreign exchange intervention in dollarized economies. To overcome endogeneity issues, we quantify the dynamic effects of foreign exchange intervention in response to a shock in global capital flows, following Blanchard et al. (2015). Based on a sample of 45 countries, we show that financial dollarization amplifies the macroeconomic effects of capital flows. Moreover, we find that dollarized economies that engage in sterilized foreign exchange intervention display a more stable path of real exchange rate and output growth, partially offsetting the macroeconomic volatility associated with dollarization.

The second contribution is to show that dollarization drastically changes the transmission mechanism of policy instruments in a small open economy model. In the case of monetary policy, the transmission mechanism becomes weaker, as a policy rate easing induces an exchange rate depreciation and tighter financial conditions in foreign borrowing, partially offsetting the initial monetary stimulus. For foreign exchange intervention, the transmission mechanism under dollarization directly affects not only the exchange rate but also the borrowing costs, increasing the effectiveness of this policy tool for dealing with capital flows and the associated financial stability risks. When we evaluate the optimal policy responses to a capital outflow, monetary policy alone is unable to fully stabilize the economy, and the path of interest rates is consistent with the procyclical monetary policy stance observed in many emerging economies (Végh et al., 2017). This reflects the central bank's attempt to stabilize financial conditions in foreign currency in response to an outflow of capital. Once

[2]See Basu et al. (2020) and Adrian et al. (2020).

foreign exchange reserves becomes part of the central bank's toolkit, the optimal foreign exchange intervention policy stabilizes the cost of borrowing in foreign currency, resulting in lower volatility of consumption, investment, and output. Furthermore, the use of foreign exchange intervention restores monetary policy autonomy and allows the central bank to lower the policy rate in bad times. These theoretical results explain the fact that with appropriate policies in place, some dollarized economies might exhibit low macroeconomic volatility.[3][4][5]

Related literature. This paper relates to the vast literature on monetary policy in small open economies under financial frictions. The key references in the literature for the case of emerging economies are Céspedes et al. (2004) and Gertler et al. (2007), who show that financial dollarization imposes a constraint on monetary policy since a monetary easing and the associated exchange rate depreciation could trigger balance sheet effects and a contraction in investment. Other contributions in the literature include Aghion et al. (2001), Aoki et al. (2021), Braggion et al. (2009), Cavallino and Sandri (2023), Choi and Cook (2004), and Hoffman et al. (2022), who also show that financial dollarization imposes significant trade-offs in monetary policy design. In this paper, in addition to balance sheet effects, we introduce imperfect asset substitution and foreign exchange intervention, which allows us to go beyond the classical dichotomy of flexible and fixed exchange rates. Instead, we focus our analysis on the optimal policy and the associated macroeconomic outcomes in an intermediate regime, where foreign exchange reserves and monetary policy can simultaneously address the policy dilemma imposed by financial dollarization.

This work is also related to studies on the optimal use of foreign exchange intervention, such as Cavallino (2019), Fanelli and Straub (2021), Davis et al. (2021), Gabaix and Maggiori (2015), and Camara et al. (2024). All these papers introduce a portfolio balance channel, where domestic and foreign debt are imperfect substitutes and foreign exchange intervention has real effects in the economy. While we use a similar approach for modeling a portfolio balance channel, our paper focuses on quantifying the effectiveness of foreign exchange intervention for stabilizing an economy with financial dollarization.

[3] See Christiano et al. (2021) for a discussion of dollarization in Armenia and Peru

[4] Our results are consistent with the policy advice by the IMF (2023), which suggests the prudent use of FXI for addressing financial stability risks stemming from financial dollarization (Use case B).

[5] As discussed in the Principles for the Use of Foreign Exchange Intervention (IMF, 2023), there are some circumstances under which FXI polices might be suboptimal. For instance, FXI could hinder the development of the FX market, create moral hazard in the private sector by incentivizing the exposure to foreign currency, create conflicting signals on the goals for monetary policy, or the use of FXI for political or business interests in case the central banks lacks independence.

Another strand of the literature studies foreign exchange intervention in the context of dollarized economies (Bocola and Lorenzoni, 2020; Céspedes et al.,2017). In those papers, the central bank, acting as a lender of last resort, uses foreign exchange reserves to relax borrowing constraints during periods of crisis. Rather than focusing on the lender-of-last-resort role, our paper evaluates more generally the role of foreign exchange intervention over the business cycle in dollarized economies, taking into account a conventional portfolio balance channel and the impact on exchange rate dynamics.

Finally, the paper is also related to the empirical literature on the dynamic effects of foreign exchange intervention as in Blanchard et al. (2015), Kim (2003), and Cavallino (2019). These authors estimate VAR models for quantifying the macroeconomic impact of foreign exchange intervention. This paper contributes to the empirical literature first by analyzing the amplification role of financial dollarization in response to capital flow shocks and second by showing that foreign exchange intervention has a macroeconomic stabilization role in dollarized economies.

Outline. The rest of the paper is organized as follows. Section 2 presents the VAR analysis that describes the macroeconomics effects of the global capital flow shocks. Section 3 describes the small open economy model featuring balance sheet effects and liability dollarization. Section 4 discusses the model calibration strategy. Section 5 presents the response of the model economy to a capital outflow, comparing the outcomes in economies with and without liability dollarization. Section 6 evaluates the welfare gains from deploying foreign exchange intervention and monetary policy optimally in the model economy. Finally, section 7 concludes.

2. Empirical Evidence on Foreign Exchange Intervention in Dollarized Economies

In this section we empirically analyze the macroeconomic effects of foreign exchange (FX) intervention and global capital flow shocks. In particular, we estimate country-specific VAR models with a recursive identification, compute the responses in each country to a global capital flow shock, and report the endogenous response of FX reserves. We rely on quarterly data for a sample of 45 advanced and emerging economies over the period 2000Q1-2018Q4. In the sample we do not consider countries that issue a reserve currency (namely, the United States, the United Kingdom, Japan, Euro area countries, and Switzerland). We are also interested in understanding the macroeconomic effects of a global capital flow shock in the presence of liability dollarization.

Using the database on financial dollarization from Levy-Yeyati (2006), we analyze the impact of global capital flow shocks in dollarized and non-dollarized economies. We define an economy as dollarized when deposit dollarization is equal to or greater than 20 percent and as non-dollarized when this indicator is less than 20 percent.[6] Levy-Yeyati (2006) argues that deposit dollarization can be used as a relevant proxy of loan dollarization, which is the liability dollarization of the corporate sector. This correspondence between deposit and loan dollarization is due to the presence of prudential limits on bank's foreign exchange positions, implying that the exchange rate risk deriving from financial dollarization is mostly absorbed by non-financial firms and households. The sample of countries used in the estimations and their financial dollarization ratios are presented in the appendix A.

The recursive VAR model considers the following six variables: a global capital flows series; real gross domestic product (GDP); the consumer price index (CPI); the short-term interest rate; the real effective exchange rate; and the stock of FX reserves. The global capital flow series is country-specific and is constructed following Blanchard et al. (2015). This variable for an individual country i is defined as the ratio of the sum of gross private capital inflows to all non-reserve currency countries divided by the sum of the corresponding nominal GDP expressed in U.S. dollars, but excluding the data from country i. By using this definition, we ensure that the global capital flows are exogenous to each individual economy. Formally, we estimate the following VAR model for country i:

$$\mathbf{X}_{i,t} = \alpha_i + \mathbf{A}_{i,1}\mathbf{X}_{i,t-1} + \cdots + \mathbf{A}_{i,p}\mathbf{X}_{i,t-p} + \mathbf{u}_{i,t}, \tag{1}$$

where the vector $\mathbf{X}_{i,t}$ is given by $\mathbf{X}_{i,t} = [gkf_{i,t}, \Delta y_{i,t}, \Delta p_{i,t}, R_{i,t}, rer_{i,t}, \Delta fx_{i,t}]'$. The variables $\Delta y_{i,t}$ and $\Delta p_{i,t}$, are the first difference of the log of GDP and CPI, respectively, in country i. $R_{i,t}$ is the short-term interest rate, and $rer_{i,t}$ is the logarithm of the real effective exchange rate for country i. The variable $gkf_{i,t}$ is the Blanchard et al. (2015) measure of global capital flows. Finally, $\Delta fx_{i,t}$ is the change in the stock of FX reserves divided by the trend GDP for country i, computed with a Hodrick-Prescott filter with a smoothing parameter of 1,600.[7] All domestic variables are obtained from Haver Analytics.

[6]The main results of the VAR analysis do not change when we use different dollarization thresholds.

[7]The empirical results are robust to alternative definitions of FXI included in the database by Adler et al. (2021). Blanchard et al. (2015) also found that the VAR results are robust to different measures of FXI .

The matrices of coefficients $\mathbf{A}_{i,1}, \cdots, \mathbf{A}_{i,p}$ have a dimension of 6×6 and the vector of coefficients α_i has a dimension of 6×1. The parameter p is the lag-length for the VAR model. The variable $u_{i,t}$ is a 6×1 disturbance vector with mean 0 and a variance-covariance matrix given by $\mathbf{\Omega}_i$.Furthermore, we impose a block exogeneity restriction in the VAR such that domestic variables do not affect global capital flows on impact. This restriction captures the fact that for small open economies, the global capital flows series are exogenous to macroeconomic developments in each economy. This implies that all coefficients that affect the variable $gkf_{i,t}$ are set to zero, except for its own lag. Consequently, the first equation in the VAR model is as follows:

$$gkf_{i,t} = \alpha_{1i} + a_{11} gkf_{i,t-1} + u_{1i,t}. \tag{2}$$

We set $p = 3$ for all the country-specific VARs following Schwarz's Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC). We estimate $\mathbf{A}_{i,1}$, $\mathbf{A}_{i,2}$, $\mathbf{A}_{i,3}$, and $\mathbf{\Omega}_i$ by ordinary least squares (OLS), imposing the block exogeneity restriction in equation (2).

Figure 1 shows the responses of dollarized and non-dollarized economies to a contraction of global capital flows of 2 percent of global GDP.We report the median impulse response functions for dollarized and non-dollarized economies and the 60 percent confidence bands.[8] A negative shock to global capital flows is contractionaty in both types of economy. However, the negative effect on output is amplified in dollarized economies, in line with the conventional wisdom on the macroeconomic impact of dollarization, whereby balance sheet effects are exacerbated in response to a capital outflow. Furthermore, and consistent with the predictions of a standard Phillips curve, the contraction of global capital flows also depresses inflation, with the effects being higher in dollarized economies. As a result, dollarized economies engage in more policy activism in response to capital outflows, as they sell more reserves and increase their policy interest rate more relative to non-dollarized economies. These two policy responses suggest a "leaning against the wind" policy to contain an exchange rate depreciation and the corresponding adverse balance sheet effects when debt is denominated in foreign currency. When we analyze the real rate exchange dynamics, dollarized economies tend to display a more gradual depreciation in the short run, which is consistent with the reaction of the policy rate and foreign exchange intervention. The increase in the policy rate in dollarized economies could potentially also be associated with unsterilized FX interventions that result in a contraction of the money supply.

[8]The 60% confidence bands for the median country were computed using bootstrapping methods.

Figure 2 delves deeper into the interaction between monetary policy and sterilized FX intervention by plotting the responses to a negative global capital flow shock in a sample consisting of only dollarized economies. We split the sample of dollarized economies into two groups, base on whether the interest rate response to the shock is above or below the median. Thus, both groups deploy foreign exchange intervention, but group A has a more active and group B a more stable interest rate. We interpret group B as a case of sterilized FX interventions, since these interventions are not associated with a substantial change in monetary policy. As shown in figure 2, interest rate for group B does not react on impact and is relatively more stable over time than the rate for group A. Interestingly, in the case of group B, the pace of the real exchange rate depreciation is slower relative to group A, consistent with the idea that sterilized foreign exchange has a stronger transmission mechanism relative to unsterilized FX interventions. The larger depreciation observed in group A is consistent with a larger output contraction, as the depreciation increases the cost of borrowing in foreign currency and hence contributes to a larger aggregate demand contraction. In group B, where the exchange rate depreciation is contained in the short run, the response of output to capital flows is moderate. This is also consistent with a balance sheet mechanism, where a less depreciated exchange rate would attenuate the impact of a higher cost of borrowing in foreign currency, offsetting the contractionary effect of capital outflows on output. Finally, inflation is lower in group B, which is consistent with a less-depreciated exchange rate and may reflect the impact of a lower aggregate demand on local consumer prices.

To summarize, the VAR econometric analysis shows that global capital outflow shocks have a sizable effect on output, and this effect is amplified in countries with liability dollarization. Sterilized FX interventions in dollarized economies are helpful in “”leaning against the wind””, resulting in a slower real exchange depreciation and lower output volatility in the context of global capital outflows. Next, we analyze this empirical evidence through the lens of a small open economy DSGE model, and evaluate the welfare implications of FX intervention in response to capital flow shocks.

3. A Small Open Economy Model with Foreign Exchange Intervention

We developed a small open economy model following the work of Christiano et al. (2005), Gertler et al. (2007), and Smets and Wouters (2007). The model considers two goods: domestic and imported. The domestic good is produced by firms that combine capital and labor using a constant-returns-to-scale technology. Entrepreneurs demand capital, and their borrowing transactions are subject to agency costs as in Bernanke et al. (1999). Based on the work of Céspedes et al. (2004) and Gertler et al. (2007), we assume that a fraction of corporate borrowing is denominated in foreign currency. This captures the prevalence of liability dollarization in many emerging economies (Levy-Yeyati, 2006), as well as the fact that the exchange rate fluctuations can adversely affect the balance sheets of corporate borrowers. We also consider imperfect asset substitution as in Chang et al. (2015) and Cavallino (2019). This friction allows sterilized foreign exchange (FX) intervention to have real effects in the economy. In the model, we evaluate the welfare gains from relying on FX intervention in response to capital outflows in the context of liability dollarization.

3.1. Households

The domestic economy is inhabited by a continuum of households indexed by j in the unit interval, $[0, 1]$. The expected present value of the utility of household j is given by:

$$U_t(j) = E_t \sum_{i=0}^{\infty} \beta^i \frac{\left[C_{t+i}(j) - \zeta_L \frac{l_{t+i}(j)^{1+\sigma_L}}{1+\sigma_L}\right]^{\frac{\sigma_C - 1}{\sigma_C}}}{1 - 1/\sigma_C}, \tag{3}$$

where $l_t(j)$ is the labor supply and $C_t(j)$ is consumption. The parameters σ_C and σ_L are the intertemporal elasticity of substitution and the inverse Frisch elasticity of labor supply, respectively; and ζ_L is the weight on the disutility of labor. $C_t(j)$ is defined by a constant-elasticity-of-substitution (CES) aggregator of home and foreign goods:

$$C_t(j) = \left[\gamma_C^{\frac{1}{\eta_C}} C_{H,t}(j)^{\frac{\eta_C - 1}{\eta_C}} + (1 - \gamma_C)^{\frac{1}{\eta_C}} C_{F,t}(j)^{\frac{\eta_C - 1}{\eta_C}}\right]^{\frac{\eta_C}{\eta_C - 1}}, \tag{4}$$

where $C_H(j)$ and $C_F(j)$ are home and foreign goods respectively. γ_C is the share of domestic goods in the consumption basket and η_C is the elasticity of substitution between home and foreign goods. Households have access to the following assets: non-contingent domestic bonds $B_t(j)$, deposits in domestic currency $D_t(j)$, deposits in foreign currency $D_t^*(j)$, non-contingent foreign debt $B_t^*(j)$, and domestic state-contingent bonds $d_{t+1}(j)$. The gross return of the foreign currency deposits in is equal to the risk-free foreign interest rate, R_t^*. Hence, the household budget constraint is given by:

$$
\begin{aligned}
&P_{C,t}C_t(j) + B_t(j) + D_t(j) + D_t^*(j) + E_t[q_{t,t+1}d_{t+1}(j)] - \mathcal{E}_t B_t^*(j)(1+\Theta_t,) = \\
&W_t(j)l_t(j) + R_{t-1}B_{t-1}(j) + R_{D,t-1}D_{t-1}(j) + \mathcal{E}_t R_{t-1}^* D_{t-1}^*(j) \\
&+d_t(j) + \Pi_t(j) + T_t(j) - \mathcal{E}_t B_{t-1}^*(j) R_{t-1}^*,
\end{aligned} \tag{5}
$$

where $\Pi_t(j)$ are the profits received from domestic firms, $W_t(j)$ is the nominal wage set by household j, T_t are net lump-sum transfers from the government, and $\mathcal{E}_t$ is the nominal exchange rate. R_t and R_t^* are the gross interest rate of the non-contingent bonds in domestic and foreign currency, and $R_{D,t}$ is the gross interest rate of the deposits in domestic currency. In equilibrium $R_{D,t} = R_t$. Households choose their optimal consumption and portfolio allocation by maximizing welfare (3) subject to equation (5). By assuming a complete set of state-contingent claims, consumption is equalized across households despite differences in their supply of labor.

Households pay a transaction cost Θ_t per-unit of foreign borrowing they issue. This transaction cost is paid to domestic financial intermediaries as a fee for their service and generates imperfect asset substitution between domestic and foreign assets.[9] This transaction cost for foreign borrowing follows Chen et al. (2012), who introduce a similar cost to generate imperfect substitution between short and long term bonds to quantify the macroeconomic effect of quantitative easing in the US after the global financial crisis. The transaction cost for foreign borrowing also follows the portfolio adjustment cost assumption in Liu and Spiegel (2015) and Chang et al. (2015), where the cost induces a wedge in the uncovered interest parity (UIP) condition. This wedge in the UIP condition makes sterilized FX intervention effective in influencing the real exchange rate through the portfolio balance channel. The exact functional form for $\Theta_t = \Theta(\cdot)$ is discussed in section 3.6.

3.1.1. Wage Setting and Labor Supply

Each household j is a monopolistic supplier of a differentiated labor service $l_t(j)$. There is a set of perfectly competitive labor service assemblers that hire labor from each household and combine it into an aggregate labor service unit l_t. Aggregate labor is defined as:

$$
l_t = \left(\int_0^1 l_t(j)^{\frac{\epsilon_L - 1}{\epsilon_L}} dj \right)^{\frac{\epsilon_L}{\epsilon_L - 1}}, \tag{6}
$$

[9]This transaction cost also induces stationarity in the model in the context of a small open economy (Schmitt-Grohé and M. Uribe, 2003). The financial intermediaries are assumed to distribute their profits to households.

where ϵ_L is the elasticity of substitution of the variety j of household labor supply. The optimal composition of this labor service unit is obtained from the cost minimization problem of the assembler. The resulting demand for the labor service provided by household j is given by:

$$l_t(j) = \left(\frac{W_t(j)}{W_t} \right)^{-\epsilon_L} l_t, \tag{7}$$

where $W_t(j)$ is the wage rate set by household j and W_t is an aggregate wage index defined as $W_t = \left(\int_0^1 W_t(j)^{1-\epsilon_L} dj \right)^{\frac{1}{1-\epsilon_L}}$. Following Erceg et al. (2000), we assume a wage setting process à la Calvo (1983). In each period, each household faces a constant probability $(1 - \phi_L)$ of being able to re-optimize its nominal wage. Once a household has decided on a wage, it must supply the labor service demanded at that wage rate.

3.2. Capital Producers

We assume a continuum of capital goods producers who operate in a perfectly competitive market. Aggregate investment (I_t) consists of a CES aggregation of home ($I_{H,t}$) and foreign ($I_{F,t}$) investment goods:

$$I_t = \left[\gamma_I^{\frac{1}{\eta_I}} I_{H,t}^{\frac{\eta_I - 1}{\eta_I}} + (1 - \gamma_I)^{\frac{1}{\eta_I}} I_{F,t}^{\frac{\eta_I - 1}{\eta_I}} \right]^{\frac{\eta_I}{\eta_I - 1}},$$

where η_I is the elasticity of substitution between home and foreign investment goods, and γ_I is the share of domestic investment goods. The law of motion of physical capital is given by:

$$K_{t+1} = (1 - \delta) K_t + S\left(\frac{I_t}{I_{t-1}} \right) I_t,$$

where K_t is the stock of capital and $S(.)$ is the investment adjustment cost.[10] The capital goods producers then sell the capital goods at a price Q_t to the entrepreneurs, who earn the rental rate of capital and the value of undepreciated capital as income.

3.3. Entrepreneurs

The financial accelerator mechanism follows the work of Bernanke et al. (1999) where the external finance premium depends positively on the entrepreneurs' leverage ratio.

[10]The adjustment cost of investment satisfies: $S(1) = 1$, $S'(1) = 0$, $S''(1) = -\mu_S < 0$ (see Altig et al. (2011)).

In addition, we assume that a fraction of the debt portfolio is denominated in foreign currency. The model considers a continuum of risk-neutral entrepreneurs. In period t, entrepreneurs finance the purchase of physical capital K_{t+1} with net worth N_t and loans from financial intermediaries such that the following constraint holds:

$$N_t + B_{e,t} + \mathcal{E}_t B^*_{e,t} = Q_t K_{t+1}, \tag{8}$$

where $B_{e,t}$ is the loan in domestic currency and $B^*_{e,t}$ is the loan in foreign currency. Following Aoki et al. (2021), we assume that a fraction ϕ of the loan is denominated in domestic currency and $1-\phi$ is denominated in foreign currency. Therefore, $B_{e,t} = \phi \bar{B}_{e,t}$ and $\mathcal{E}_t B^*_{e,t} = (1-\phi)\bar{B}_{e,t}$, where $\bar{B}_{e,t}$ is the total value of the loan and $1-\phi$ is the degree of liability dollarization.

Entrepreneurs rent capital to the firms and sell the undepreciated capital to capital goods producers in period $t+1$. Each entrepreneur faces an idiosyncratic shock ω that affects the effective amount of capital available in $t+1$, which is denoted $\omega_{t+1}K_{t+1}$. Following Bernanke et al. (1999), we assume that $\log(\omega_{t+1})$ follows a normal distribution with mean $-\sigma^2_\omega/2$ and standard deviation equal to σ_ω. This last assumption implies that $E_t\omega_{t+1} = 1$. The ex-post return in period $t+1$ for the entrepreneur is given by:

$$\omega_{t+1} R^K_{t+1} = \omega_{t+1} \frac{Z_{t+1} + (1-\delta)Q_{t+1}}{Q_t}, \tag{9}$$

where Z_{t+1} is the rental rate of effective capital in period $t+1$. There is asymmetric information between entrepreneurs and financial intermediaries. Entrepreneurs observe the realization of ω_{t+1} while financial intermediaries can only verify the value of ω_{t+1} after incurring monitoring costs. The monitoring costs are proportional to investment income: $\mu\omega_{t+1}R^K_{t+1}Q_tK_{t+1}$, with $\mu \in (0,1)$. An optimal financial contract will be incentive-compatible and will provide incentives for entrepreneurs to reveal the realization of ω_{t+1} to the financial intermediary. In particular, the debt contract is structured as follows. For every state with associated return on capital $\omega_{t+1}R^K_{t+1}$, entrepreneurs have to either repay their debt or incur in default. The interest rate on domestic and foreign currency debt is given by $R_{L,t+1}$ and $R^*_{L,t+1}$, respectively. The effective interest rate for the debt portfolio $\bar{R}_{L,t+1}$ is defined as:

$$\bar{R}_{L,t+1} = \phi R_{L,t+1} + (1-\phi)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} R^*_{L,t+1}. \tag{10}$$

When entrepreneurs default, the financial intermediary seizes their revenue and pays a fraction μ of that revenue for the monitoring process. Therefore, entrepreneurs will always have incentives to pay the loan if the return $\omega_{t+1}R^K_{t+1}$ is high enough to do so. This logic implies that there will be a cutoff value for the realization of the idiosyncratic risk, $\bar{\omega}_{t+1}$, which satisfies:

$$\bar{\omega}_{t+1}R^K_{t+1}Q_tK_{t+1} = \bar{R}_{L,t}\bar{B}_{e,t} = \bar{R}_{L,t+1}(Q_tK_{t+1} - N_t). \tag{11}$$

If $\omega_{t+1} < \bar{\omega}_{t+1}$, the entrepreneur defaults and the financial intermediary recovers a fraction $1-\mu$ of the revenue. This debt contract captures the information asymmetries between lenders and borrowers that can only be circumvented with a costly state verification mechanism. The optimal debt contract maximizes the net expected benefits for entrepreneurs subject to the zero profit condition for financial intermediaries. The net expected benefits for entrepreneurs are:

$$\begin{aligned}
&\int_{\bar{\omega}_{t+1}}^{\infty} \omega R^K_{t+1}Q_tK_{t+1}f(\omega)d\omega - \bar{R}_{L,t}\bar{B}_{e,t}\int_{\bar{\omega}_{t+1}}^{\infty} f(\omega)d\omega \\
&= \int_{\bar{\omega}_{t+1}}^{\infty} \omega R^K_{t+1}Q_tK_{t+1}f(\omega)d\omega - \bar{\omega}_{t+1}R^K_{t+1}Q_tK_{t+1}\int_{\bar{\omega}_{t+1}}^{\infty} f(\omega)d\omega \\
&= \left[\int_{\bar{\omega}_{t+1}}^{\infty} \omega f(\omega)d\omega - \int_{\bar{\omega}_{t+1}}^{\infty} \bar{\omega}_{t+1}f(\omega)d\omega\right] R^K_{t+1}Q_tK_{t+1} = \Lambda(\bar{\omega}_{t+1})R^K_{t+1}Q_tK_{t+1}.
\end{aligned} \tag{12}$$

Since financial intermediaries are perfectly competitive, they obtain zero profits in equilibrium. The risky loans to entrepreneurs should have an expected return equal to the opportunity cost of the funds. Hence, the zero profit condition for financial intermediaries becomes:

$$\begin{aligned}
&\left(\phi R_t + (1-\phi)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}R^*_t\right)(Q_tK_{t+1} - N_t) = \\
&\bar{R}_{L,t}\bar{B}_{e,t}\int_{\bar{\omega}_{t+1}}^{\infty} f(\omega)d\omega + (1-\mu)R^K_{t+1}Q_tK_{t+1}\int_0^{\bar{\omega}_{t+1}} f(\omega)d\omega = \\
&\left[\bar{\omega}_{t+1}\int_{\bar{\omega}_{t+1}}^{\infty} f(\omega)d\omega + (1-\mu)\int_0^{\bar{\omega}_{t+1}} f(\omega)d\omega\right] R^K_{t+1}Q_tK_{t+1} = \\
&\Gamma(\bar{\omega}_{t+1})R^K_{t+1}Q_tK_{t+1}.
\end{aligned} \tag{13}$$

The optimal debt contract will maximize profits (12) subject to equation (13) which implies the following condition:

$$\begin{aligned}
sp_{t+1} &= \frac{R^K_{t+1}}{Q_t(\phi R_t + (1-\phi)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}R^*_t)} = \rho(\bar{\omega}_{t+1}), \\
\rho(\bar{\omega}_{t+1}) &= (\Gamma(\bar{\omega}_{t+1}) - \Lambda(\bar{\omega}_{t+1})\frac{\Gamma'(\bar{\omega}_{t+1})}{\Gamma(\bar{\omega}_{t+1})})^{-1},
\end{aligned} \tag{14}$$

where sp_{t+1} is a measure of the credit spread of the return to capital relative to the risk-free rate or what Bernanke et al. (1999) call the external finance premium. Using this last expression and condition (13), Bernanke et al. (1999) show that a log-normal distribution for ω_{t+1} implies an increasing relationship between the credit spread, sp_{t+1}, and the leverage of entrepreneurs ($\frac{Q_t K_{t+1}}{N_t}$), defined by :

$$sp_{t+1} = \Psi(\frac{Q_t K_{t+1}}{N_t}), \;\; \Psi'(\cdot) > 0 \tag{15}$$

A fraction γ_e of entrepreneurs survives in each period, while the remaining fraction exits the market and consumes all their wealth. The entrepreneurs who exit the market are replaced by a new cohort that enters and receives an initial wealth w_e, an amount that surviving entrepreneurs also receive. Thus, the entrepreneurs' net worth evolves according to:

$$N_t = \gamma_e \Lambda(\bar{\omega}_t) R_t^K Q_{t-1} K_t + w_e, \tag{16}$$

and the aggregate consumption of entrepreneurs is:

$$C_{e,t} = \frac{(1-\gamma_e)\Lambda(\bar{\omega}_t) R_t^K Q_{t-1} K_t}{P_{C,t}}. \tag{17}$$

3.4. Firms

The model considers three types of firms: intermediate good producers which have monopoly power and set their prices in a staggered fashion á la Calvo (1983); perfectly competitive retailers of home good, which assemble the differentiated intermediate goods and sell them in domestic and foreign markets; and importers, which purchase homogeneous goods from abroad, differentiate them, and set their prices in domestic currency á la Calvo (1983).

3.4.1. Intermediate Home Good Producers

Intermediate good producers can produce $Y_{H,t}(z_H)$ of a particular variety z_H, relying on constant returns to scale technology:

$$Y_{H,t}(z_H) = A_{H,t} \left(l_t(z_H)\right)^{1-\alpha} \left(K_t(z_H)\right)^{\alpha},$$

where $l_t(z_H)$, $K_t(z_H)$, and $A_{H,t}$ represents the labor input, stock of physical capital, and the productivity level common to all firms, respectively. The capital share in the production function is denoted by α. Intermediate good producers set their prices á la Calvo (1983).[11]

3.4.2. Retailers of intermediate home goods

Retailers of intermediate goods operate in a perfectly competitive market. To produce $Y_{H,t}$ units of home goods, they combine domestically produced intermediate varieties according to a constant elasticity of substitution function:

$$Y_{H,t} = \left[\int_0^1 Y_{H,t}(z_H)^{\frac{\epsilon_H - 1}{\epsilon_H}} dz_H \right]^{\frac{\epsilon_H}{\epsilon_H - 1}}, \tag{18}$$

where $Y_{H,t}(z_H)$ is the quantity of intermediate variety z_H used for final domestic goods and ϵ_H is the elasticity of substitution among varieties.

3.4.3. Importers

The importers consist of a continuum of firms that buy a homogeneous good in the foreign market and turn it into differentiated goods. Competitive assemblers combine this continuum of differentiated imports into a final import good Y_F according to the following technology:

$$Y_{F,t} = \left[\int_0^1 Y_{F,t}(z_F)^{\frac{\epsilon_F - 1}{\epsilon_F}} dz_F \right]^{\frac{\epsilon_F}{\epsilon_F - 1}}, \tag{19}$$

where $Y_{F,t}(z_F)$ is the quantity of a differentiated import z_F used by the assemblers and ϵ_F is the elasticity of substitution among differentiated imported goods. Importers purchase foreign goods at a price $P^*_{F,t}$ abroad in foreign currency. Each importer has monopoly power over a variety of imported good. We assume local currency price stickiness of the differentiated imported good á la Calvo (1983).

3.5. Monetary and Foreign Exchange Policy

The monetary authority controls the short-term interest rate and the stock of FX reserves. The short-term interest rate is set according to a Taylor-type rule. According to the policy rule, the interest rate adjusts in response to deviations of CPI inflation (π_t), GDP (Y_t), and the foreign interest rate (R^*_t) from their steady state

[11] The assumption of Calvo price setting determines that inflation in home goods responds to real marginal costs according to a New Keynesian Phillips curve.

levels. We also allow for interest rate smoothing, such that the interest rate rule has the following specification:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\varphi_R} \left(\frac{1+\pi_t}{1+\bar{\pi}}\right)^{(1-\varphi_R)\varphi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{(1-\varphi_R)\varphi_y} \left(\frac{R_t^*}{\bar{R}^*}\right)^{(1-\varphi_R)\varphi_{R^*}}, \tag{20}$$

where φ_R, φ_π, φ_y, and φ_{R^*} are the weights of interest rate smoothing, inflation, GDP, and the foreign interest rate in the monetary policy rule. If $\varphi_{R^*} > 0$ this rule will stabilize the nominal exchange rate. The larger the coefficient φ_{R^*}, the smaller the difference between the domestic and foreign interest rates, resulting in a smaller expected exchange rate depreciation according to the uncovered interest rate parity condition. The central bank follows a FX intervention policy rule that "leans against the wind" and is designed to counteract the effects of capital flows:

$$\frac{F_t^*}{\overline{F}^*} = \left(\frac{F_{t-1}^*}{\overline{F}^*}\right)^{\rho_{fx}} \left(\frac{R_t^*}{\bar{R}^*}\right)^{\theta_{R^*}}, \tag{21}$$

where F_t^* is the stock of foreign exchange reserves, $\overline{F}^*$ is the steady state values of foreign exchange reserves, θ_{R^*} governs the intensity with which FX interventions respond to fluctuations in the foreign interest rate, and ρ_{fx} defines the persistence of the stock of FX reserves. When $\theta_{R^*} < 0$, the central bank adjusts the stock of FX reserves to offset the associated capital flows induced by the interest rate differential between domestic and foreign assets (i.e., a decline in the foreign interest rate is associated with capital inflows and an increase in FX reserves). Changes in the stock of FX reserves satisfy the central bank's budget constraint :

$$\mathcal{E}_t F_t^* - B_t = \mathcal{E}_t F_{t-1}^* R_{t-1}^* - B_{t-1} R_{t-1} - T_t. \tag{22}$$

Sterilized FX interventions are conducted through the issuance of domestic bonds B_t and the accumulation of foreign reserves F_t^* by the central bank. Each period, the central bank earns interest payments net of valuation effects of foreign reserves from the previous period, equal to $\mathcal{E}_{t-1} F_{t-1}^* \left(R_{t-1}^* \mathcal{E}_t / \mathcal{E}_{t-1} - 1\right)$. The central bank also pays interests on the stock of domestic bonds from last period, equal to $B_{t-1}(R_{t-1} - 1)$. The net profits derived from FX transactions are rebated to households through lump-sum transfers T_t.[12]

[12]In the simulations the costs of sterilized foreign exchange intervention are of second order importance, and are summarized by the lump-sum transfers.

3.6. Aggregation and Equilibrium Conditions

In each period, markets for assets, labor, capital, and domestic and foreign goods clear. For assets, we express the aggregate holdings of deposits, domestic bonds, and foreign debt as follows:

$$D_t = \int_0^1 D_t(j), \;\; D_t^* = \int_0^1 D_t^*(j), \;\; B_t = \int_0^1 B_t(j), \;\; B_t^* = \int_0^1 B_t^*(j). \tag{23}$$

Given the balance sheet of financial intermediaries, in equilibrium:

$$D_t = B_{e,t} \text{ and } D_t^* = B_{e,t}^*, \tag{24}$$

where $B_{e,t} = \phi \bar{B}_{e,t} = \phi(Q_t K_{t+1} - N_t)$ and $\mathcal{E}_t B_{e,t}^* = (1-\phi)\bar{B}_{e,t} = (1-\phi)(Q_t K_{t+1} - N_t)$.

The equilibria in the labor and capital markets are given by:

$$l_t = \left(\int_0^1 l_t(j)^{\frac{\epsilon_L - 1}{\epsilon_L}} dj \right)^{\frac{\epsilon_L}{\epsilon_L - 1}} = \int_0^1 l_t(z_H) dz_H, \tag{25}$$

$$K_t = \int_0^1 K_t(z_H) dz_H. \tag{26}$$

The equilibrium condition for the final home good is:

$$Y_{H,t} = C_{H,t} + C_{e,H,t} + I_{H,t} + C_{H,t}^* + \mu \left(\int_0^{\bar{\omega}_{t+1}} f(\omega) d\omega \right) R_{t+1}^K Q_t K_{t+1}. \tag{27}$$

$C_{H,t}^*$ corresponds to the volume of exports of final home goods:

$$C_{H,t}^* = \zeta^* \left(\frac{P_{H,t}}{\mathcal{E}_t P_t^*} \right)^{-\eta^*} C_t^*, \tag{28}$$

where ζ^* corresponds to the share of domestic goods in the consumption basket in the rest of the world and η^* is the price elasticity of this demand.

The equilibrium for the foreign goods market is:

$$Y_{F,t} = \left(\int_0^1 Y_{F,t}(z_F)^{\frac{\epsilon_F - 1}{\epsilon_F}} dz_F \right)^{\frac{\epsilon_F}{\epsilon_F - 1}} = C_{F,t} + C_{e,F,t} + I_{F,t}. \tag{29}$$

Combining the households', entrepreneurs', and government budget constraints, we obtain the balance of payments identity that describes the dynamics of net foreign assets:

$$\mathcal{E}_t(F_t^* - B_t^*) = R_{t-1}^* \left(\mathcal{E}_t F_{t-1}^* - \mathcal{E}_t B_{t-1}^* \right) + X_t - M_t, \tag{30}$$

where X_t and M_t are exports and imports, respectively. They are given by $X_t = P_{H,t} C^*_{H,t}$ and $M_t = \mathcal{E}_t P^*_{F,t} \int_0^1 Y_{F,t}(z_F) dz_F$.

Similar to Liu and Spiegel (2015) and Chang et al. (2015), the transaction costs for foreign borrowing Θ_t determines the degree of asset substitution between domestic and foreign bonds and the strength of the transmission mechanism of sterilized FX interventions.[13] As indicated in equation (22), an accumulation of FX reserves is financed by increasing the supply of domestic bonds that are purchased by households. When there is perfect asset substitution ($\Theta_t = 1$), households will respond to this excess supply of bonds by borrowing from the rest of the world, fully offsetting the impact of FX reserve accumulation.[14] Thus, to have real effects from sterilized FXI, we assume that Θ_t depends on the stock of foreign and domestic bonds expressed in foreign currency: $\Theta_t = \Theta\left(B^*_t, B_t/\mathcal{E}_t\right)$. For this specification, we define two key elasticities that determine the degree of imperfect asset substitution:

$$\frac{\partial \Theta}{\partial B^*_t} \frac{B^*_t}{\Theta\left(B^*_t, B_t/\mathcal{E}_t\right)} = \varrho_1,$$

$$\frac{\partial \Theta}{\partial B_t/\mathcal{E}_t} \frac{B_t/\mathcal{E}_t}{\Theta\left(B^*_t, B_t/\mathcal{E}_t\right)} = \varrho_2.$$

4. Calibration

The model is calibrated at a quarterly frequency to match key features of a representative emerging economy. We set the discount factor to $\beta = 0.995$, consistent with a steady state risk-free rate of 2 percent. Household preferences have a unitary intertemporal substitution elasticity ($\sigma_C = 1$) and a Frisch elasticity of the labor supply equal to 1/2 ($\sigma_L = 2$). The share of imported goods in consumption and investment is set to 30 percent and the elasticity of substitution between domestic and imported goods is 0.5. The implied ratio of imports to GDP broadly coincides with the observed value for an average of 155 emerging and developing countries in the International Monetary Fund (IMF) World Economic Outlook (WEO) database for the period 2000-2018 (27 percent).

[13] Yakhin (2022) shows that up to a first order approximation an endogenous risk premium is equivalent to alternative formulations in Gabaix and Maggiori (2015) and Fanelli and Straub (2021) that generate deviations in the UIP condition.

[14] This is similar to the assumption of "Wallace neutrality", where open market operations are ineffective under frictionless financial markets. See Wallace (1981) and Curdia and Woodford (2011).

The financial accelerator block of the model is calibrated following Bernanke et al. (1999) and Gertler et al. (2007) and is consistent with a credit spread of 3 percent in annual terms, an annual default rate of 3 percent, a capital-net worth ratio of 2, and a survival rate of entrepreneurs of 97.5 percent. The degree of liability dollarization is set to $1 - \phi = 0.5$ in the benchmark calibration, which broadly matches the empirical value for the median emerging economy in the Levy-Yeyati (2006) database.

The capital share α is set to 0.35. The depreciation rate δ is consistent with an investment-to-GDP ratio of 20 percent. ζ^* is chosen to have net exports equal to zero at the steady state. The stock of FX reserves at the steady state $\bar{F}^*$ is equal to 25 percent of GDP.

Table 1: Baseline Calibration

Parameter	Value	Description
β	0.995	Discount factor
σ_C	1.00	Intertemporal substitution elasticity
σ_L	2.00	Inverse of the labor supply elasticity
γ_C	0.30	Share of imported goods in consumption
η_C	0.5	Substitution elasticity between H and F in consumption
γ_I	0.30	Share of imported goods in investment
η_I	0.5	Substitution elasticity between H and F in investment
μ_S	2.5	Parameter for adjustment cost in investment
$\bar{sp}^4$	1.035	Credit spread in annual terms in the steady state
$4 \times F(\bar{\omega})$	0.03	Default premium in annual terms in the steady state
$\bar{Q}\bar{K}/\bar{N}$	2.00	Capital-Net worth ratio of entrepreneurs in the steady state
γ_e	0.975	Survival rate of entrepreneurs
$1 - \phi$	$0, 0.50$	Degree of financial dollarization
α	0.35	Capital share in domestic production
$\bar{I}/\bar{Y}$	0.20	Investment-output ratio in the steady state
$(\bar{X} - \bar{M})/\bar{Y}$	0.0	Net export-output ratio in the steady state
η^*	0.5	Price elasticity of exports

We use standard parameter values found in the literature for calibrating price and wage rigidities. We set the Calvo pricing parameters consistent with an average price duration of 4 quarters ($\phi_H = \phi_F = 0.75$). For the wage-setting process, we assume an average duration of 8 quarters ($\phi_L = 0.875$). The monetary policy rule has standard values: $\varphi_R = 0.70$, $\varphi_\pi = 1.5$, and $\varphi_y = 0.5/4$. The persistence of shocks to the foreign interest rate is set to $\rho_{R^*} = 0.95$. In section 6, we discuss the selection of φ_{R^*}, ρ_{fx}, and θ_{R^*} in the context of optimal policy rules.

Table 1: Baseline Calibration (continued)

Parameter	Value	Description
ϕ_L	0.875	Calvo parameter in wages
ξ_L	0.5	Indexation to past inflation in wages
ϵ_L	6.0	Substitution elasticity across labor varieties
ϕ_H	0.75	Calvo parameter in the prices of H goods
ξ_H	0.5	Indexation to past inflation in prices of H goods
ϵ_H	11.0	Substitution elasticity across H varieties
ϕ_F	0.75	Calvo parameter in the prices of F goods
ξ_F	0.5	Indexation to past inflation in prices of F goods
ϵ_H	11.0	Substitution elasticity across F varieties
φ_R	0.70	Smoothing of the monetary policy rule
φ_π	1.50	Reaction to inflation in the monetary policy rule
φ_y	0.50/4	Reaction to output in the monetary policy rule
ρ_{R^*}	0.95	Persistence coefficient of foreign interest rate shocks
ϱ_1	0.001	External risk premium elasticity to B^*
ϱ_2	0.013	External risk premium elasticity to $B_t/\mathcal{E}_t$

For calibrating the parameters governing the risk premium, Θ_t, we proceed as follows. First, as in Schmitt-Grohé and Uribe (2003) we calibrate $\varrho_1 = 0.001$. We set a value close to zero to ensure stationarity of the model. Second, we calibrate ϱ_2 based on the empirical evidence of Bayoumi et al. (2015), who find that an increase in the stock of foreign reserves equivalent to 1 percent of GDP improves the current account balance by around 0.4 percent of GDP. Consistent with this evidence we set $\varrho_2 = 0.030$. Table 1 summarizes the parameter values of the model calibration.

5. Inspecting the Transmission Mechanism in Dollarized Economies

In this section we explore the transmission mechanism in dollarized economies. We focus our analysis on how liability dollarization modifies the transmission mechanism of FX intervention, monetary policy, and capital flows shocks. This provides intuition on how dollarization affects the trade-offs faced by policymakers and how it influences the optimal policy response to capital outflows in dollarized economies.[15]

Figure 3 compares a tightening of the policy rate of 1 percentage point and an accumulation of FX reserves of 1 percentage point of GDP for two alternative scenarios: (i) No liability dollarization; and (ii) 50 percent liability dollarization. To better understand the transmission mechanism, we only evaluate shocks to the relevant policy instruments used by the central bank and abstract from any other fundamental shocks affecting the economy. As is standard in the financial accelerator model without dollarization, a higher policy rate leads to a higher real interest rate, a real exchange rate appreciation, and an increase in the external finance premium. This last effect generates a decline in investment and asset prices, with a subsequent deterioration in the balance sheet position of firms. How does financial dollarization modify the transmission mechanism of monetary policy? Since the effective cost of borrowing depends on the nominal exchange rate, the appreciation results in lower financial costs for corporate firms, inducing a milder increase in the external finance premium. Dollarization generates a weaker transmission channel of monetary policy to the external financial premium, rendering monetary policy less effective in stabilizing the economy in response to external shocks.

In the second column of figure 3 we repeat the exercise for an accumulation of FX reserves equivalent to 1 percent of GDP. Consistent with the traditional portfolio balance channel under no dollarization, the FX intervention policy induces a depreciation of the real exchange rate. As the exchange rate depreciates and CPI inflation increases, an interest rate policy rule consistent with the Taylor principle generates an increase in the real interest rate that peaks in the fifth quarter. This increase in the real interest rate induces a modest and temporary increase in the external finance premium. With dollarization, since borrowing costs also depend on the nominal exchange rate, the impact of the FX intervention on the premium is amplified resulting in much tighter financial conditions for the corporate sector. This has two important implications on how the transmission mechanism of FX intervention is modified in dollarized economies. First, the transmission mechanism to financial conditions becomes stronger under dollarization, as FX intervention has a greater impact on the external finance premium. Second, FX intervention has the potential to work as a macroprudential instrument in dollarized economies to the extent that can influence the corporate sector's borrowing costs and financial conditions via the exchange rate.

Next we discus how capital outflow shocks are transmitted in partially dollarized

[15] In the next section we focus on the optimal use of FX intervention in response to shocks to global capital flows.

and non-dollarized economies in the absence of FX intervention and assuming that the central bank follows an interest rate rule. We follow Miranda-Agrippino and Rey (2020), in considering that U.S. monetary policy is a key driver of the global financial cycle. In particular, we model a shock to global capital flows as a 1 percentage point increase in the foreign interest rate R_t^*. Figure 4 plots the corresponding impulse response functions in models calibrated with and without liability dollarization. The model dynamics broadly reproduce the findings from the VAR analysis, showing that the contractionary effects of capital outflows on output are larger in dollarized economies than in non-dollarized economies. In our model, this effect is mainly driven by the balance sheet effects. As result of an exchange rate depreciation induced by capital outflows, the corporate sectors' leverage ratio increases as the value of foreign currency debt rises in local currency terms. This generates a large increase in the external finance premium, and a subsequent contraction in credit to finance investment. Hence, capital flows are more contractionary in terms of GDP and investment in countries with liability dollarization. In addition, we observe a rise in inflation in both dollarized and non-dollarized economies. Finally, the trade balance adjustment is larger in dollarized economies as a result of a larger contraction in output and domestic demand.

Given that liability dollarization amplifies the macroeconomic effects of capital outflows, a key question is the extent to which macroeconomic policies can improve outcomes in response to global capital flow shocks. One option is to implement a monetary policy that "leans against the wind" to prevent an exchange rate appreciation. However, as discussed by Céspedes et al. (2004), while a policy rate can smooth the exchange rate, it can also increase macroeconomic volatility in the presence of financial dollarization. For instance, in our scenario, a higher nominal interest rate can appreciate the currency offsetting the contractionary effects of capital outflows, but a higher interest rates can also lower the price of capital, increasing the leverage ratio and the credit spread and thus leading to a further contraction of investment and output. An alternative option, which is the main focus of the paper, is to rely on FX intervention in response to global capital flows. As shown in figure 3, FX intervention directly affects not only the level of the exchange rate but also financial conditions for the corporate sector. Intuitively, one can interpret FX intervention as an alternative macroprudential policy that could offset the impact of capital outflows.[16] In the next section, we characterize the optimal use of FX intervention in response to capital inflows.

[16] A similar point was made by Arce et al. (2019).

6. Optimal Foreign Exchange Intervention in Dollarized Economies

In this section we evaluate alternative policy strategies for dealing with capital outflows in a model economy featuring liability dollarization ($1 - \phi = 0.5$). As in the previous section, we model a shock to global capital flows as a one percentage point increase in the foreign interest rate. We consider three types of policy regimes. First, we evaluate the case where the central bank responds to capital outflows by adjusting the policy rate ($\varphi_{R^*} < 0$) while keeping FX reserves constant ($\theta_{R^*} = \rho_{fx} = 0$). Second, the central bank deploys a foreign exchange intervention rule in response to capital outflows (ρ_{fx}, $\theta_{R^*} > 0$) while following a Taylor-type rule geared towards domestic objectives ($\varphi_{R^*} = 0$). Finally, in the third regime, the central bank relies on both the short-term policy rate and FX intervention to deal with capital outflows ($\varphi_{R^*} < 0$ and ρ_{fx}, $\theta_{R^*} > 0$). For each of these regimes, the coefficients of the interest rate and the FX intervention rule (φ_{R^*},ρ_{fx}, θ_{R^*}) are chosen to maximize the second-order approximation of households' welfare. The value of the optimized parameters for these regimes are shown in table 2.[17]

Table 2: Optimized Parameters for Alternative Policy Regimes

Parameter	Optimized φ_{R^*}	Optimized FXI rule	Joint opt. of φ_{R^*} and FXI rule
φ_{R^*}	-0.39	–	-0.29
θ_{R^*}	–	-0.99	-1.42
ρ_{fx}	–	0.95	0.93

Figure 5 shows the impulse response function of the baseline model with liability dollarization (shown in figure 4), and two additional regimes: (i) with an optimal monetary policy rule (dotted black line); and (ii) with an optimal FX intervention rule and a calibrated policy rate rule (red dashed line). The optimal response of the policy rate for the first regime ($\varphi_{R^*} = -0.39$) is an initial monetary policy loosening followed by a subsequent tightening of the policy rate. The initial monetary policy loosening helps to stabilize the external finance premium relative to the baseline scenario. However, a persistent decline in real rates would lead to an exchange rate depreciation and a further increase in the cost of foreign borrowing and the

[17] We follow the approach by Schmitt-Grohé and Uribe (2007) and focus our analysis in simple implementable rules. The fact that the optimal rules generate very small welfare costs, suggests that the rules induce an allocation that is very close to the one under the Ramsey policies.

external finance premium. Hence, the optimal policy rate shifts in subsequent periods to a contractionary stance generating a continuous appreciation and a decline in the external finance premium. This non-monotonic path of real rates is a direct consequence of the "financial dollarization trap", where the central bank faces a trade-off for stabilizing the economy. While there are merits to temporarily lowering the rates, the constraint imposed by dollarization results in a subsequent procyclical stance of monetary policy to prevent a larger exchange rate depreciation and balance sheet effects in the corporate sector. Despite being procyclical over the medium-term, this monetary policy leads to a slight reduction in macroeconomic volatility. As shown in the first and second rows of figure 5, the optimal policy rule results in a lower contraction of consumption, investment, and GDP and a smaller adjustment in the trade balance.

For the optimal foreign exchange intervention regime ($\theta_{R^*} = -0.99, \rho_{fx} = 95$), we observe a gradual decline in FX reserves that bottoms out near 0.4 percent of GDP in fifteenth quarter. This intervention cuts the real exchange rate depreciation in half (from 3 to 1.5 percentage points), inducing a sharp reduction in the external finance premium. This policy strengthens entrepreneurs' balance sheet relative to the scenario of no FX intervention, resulting in a stronger stabilization of domestic demand (consumption and investment) and the trade balance.[18] However, although the FX intervention policy is successful in dealing with capital outflows in a context of liability dollarization, the fact that monetary policy is set according to a calibrated rule means that it is still procyclical over the medium term and thus suboptimal.

Figure 6 considers the case in which the central bank deploys both optimal FX intervention and monetary policy rules ($\varphi_{R^*} = -0.29, \theta_{R^*} = -1.42, \rho_{fx} = 0.93$). In this regime, the dynamics of the policy instruments change drastically. First, the sale of FX reserves is more aggressive and front-loaded, peaking at 1 percent in the first period. Second, the monetary policy rates switches from procyclical to countercyclical. As a result of this combination, the central bank is capable of achieving a lower external finance premium and lower overall macroeconomic volatility. The optimal deployment of FX intervention and the policy rate is consistent with the principle of effective market classification proposed by Mundell (1960), according to which policy instruments should be assigned to objectives according to which they have the most influence. Under optimal policy rules, FX intervention is focused on external variables (the real exchange rate) and monetary policy on domestic ones (output and inflation), making it possible for the central bank to restore monetary policy independence and circumvent the constraint imposed by financial dollariza-

[18]Adrian et al. (2021), Davis et al. (2021), and Lama and Medina (2020) show that Capital Flow Measures (CFM) could fully replicate the same allocation obtained under FXI policies.

tion. Furthermore, to the extent that the exchange rate directly affects the financial conditions of the corporate sector, foreign exchange intervention becomes a *de facto* macroprudential instrument. By stabilizing the real exchange rate, FX intervention directly compresses the external finance premium, improving the corporate sector's borrowing conditions in periods of capital outflows and preventing larger balance sheet effects.

Next, we quantify the welfare costs á la Lucas (1987) of each policy regime r by calculating the fraction of steady state consumption λ_r that households are willing to give up in order to eliminate macroeconomic volatility. Formally, for each regime r, we compute the second order approximation of the household utility, $\mathcal{W}_r$ and obtain λ_r such that:

$$\frac{\left[\bar{C}(1-\lambda_r) - \zeta_L \frac{\bar{l}^{1+\sigma_L}}{1+\sigma_L}\right]^{\frac{\sigma_C - 1}{\sigma_C}}}{1 - 1/\sigma_C} = (1-\beta)\mathcal{W}_r$$

where $\bar{C}$ and $\bar{l}$ are the steady state levels of consumption and the labor supply. Table 3 shows the welfare losses for each regime, measured by the compensation rate λ_r. In the baseline scenario, where the central bank implements a Taylor-type rule that depends on output and inflation, the welfare costs are 0.29 percent of lifetime consumption, about three times the value obtained by Lucas (1987) for US business cycles. The results for each of the policy regimes are consistent with the impulse response functions reported in figures 5 and 6. In the model specification with the optimized coefficient φ_{R^*}, there is a small reduction in welfare costs, suggesting that monetary policy has limited power to deal with capital outflows in a dollarized economy. Under the regime with an optimized FX intervention rule, the welfare costs are reduced significantly to 0.04 percent of lifetime consumption, suggesting that the FX intervention rule is highly successful in responding to global capital outflows. Finally, the regime in which the policy rate and FX intervention are jointly optimized provides even lower welfare costs. In sum, the welfare cost analysis suggests significant welfare gains from deploying an FX intervention rule in a dollarized economy. In contrast, monetary policy alone has limited power to reduce the welfare costs of business cycles under dollarization.

Table 3: Welfare Losses from Fluctuations in Global Capital Flows

Regime	Welfare loss
Baseline	0.29%
Optimized φ_{R^*}	0.26%
Optimized FXI rule	0.04%
Joint Optimization of φ_{R^*} and FXI rule	0.03%

7. Conclusions

In this paper we empirically and theoretically evaluate the role of foreign exchange intervention in facilitating macroeconomic stabilization in dollarized economies. We focus our analysis on a shock to global capital flows, given its relevance for driving business cycles in emerging economies. In a VAR analysis we find that a global capital outflow shock has a contractionary effect on output, which is exacerbated in countries characterized by liability dollarization. Furthermore, sterilized foreign exchange intervention can largely insulate emerging economies from capital outflows, by stabilizing output and the real exchange rate. We also develop a small open economy model with balance sheets effects and liability dollarization that broadly replicates the empirical facts. In the model, liability dollarization amplifies the contractionary effects of capital outflows and foreign exchange intervention is highly effective in stabilizing the economy. We show that the welfare gains from relying on an optimal monetary policy rule under dollarization are nil. In contrast, the optimal deployment of FX intervention in a dollarized economy generates larger welfare gains, allowing the central bank to escape the financial dollarization trap. These results can rationalize the prevalence of low macroeconomic volatility in some dollarized economies (Christiano et. al, 2021) and highlights the role of foreign exchange reserves in reducing the welfare costs of dollarization.

References

[1] Adler, G., R. Mano, K. S. Chang, and Y. Shao, 2021, "Foreign Exchange Intervention: A Dataset of Public Data and Proxies". *International Monetary Fund* Working Paper No. WP/21/047.

[2] Adrian, M. T., C.J. Erceg, M. Kolasa, J. Lindé, and P. Zabczyk, 2021, "A Quantitative Microfounded Model for the Integrated Policy Framework. *International Monetary Fund* Working Paper No. WP/21/292.

[3] Aghion, P., P. Bacchetta, P., and A. Banerjee, 2001, "Currency Crises and Monetary Policy in an Economy with Credit Constraints," *European Economic Review*, vol. 45(7), 1121-1150.

[4] Altig, D., L.J. Christiano, M. Eichenbaum, and J. Linde, 2011, "Firm-specific Capital, Nominal Rigidities and the Business Cycle," *Review of Economic Dynamics*, vol. 14(2), 225-247.

[5] Aoki, K., G. Benigno, and N. Kiyotaki, 2021, "Monetary and Financial Policies in Emerging Markets," mimeo, Princeton University.

[6] Arce, J. Bengui, and J. Bianchi, 2019, "A MAcroprudentail Theory of Foreign Reserve Accumulation". *National Bureau of Economic Research* Working Paper No. 26236.

[7] Basu, M. S. S., M. E. Boz, M. G. Gopinath, F. Roch, and M. F. D. Unsal, 2020, "A Conceptual Model for the Integrated Policy Framework". *International Monetary Fund* Working Paper No. WP/20/121.

[8] Bayoumi, T., J. E. Gagnon, and C. Saborowski, 2015, "Official Financial Flows, Capital Mobility, and Global Imbalances," *Journal of International Money and Finance* vol. 52, 146-174.

[9] Bernanke, B., M. Gertler, and S. Gilchrist, 1999, "The Financial Accelerator in a Quantitative Business Cycle Framework," In *Handbook of Macroeconomics*, edition 1, volume 1, chapter 21, edited by J.B. Taylor and M. Woodford, 1341-1393.

[10] Blanchard, O., G. Adler, and I. de Carvalho Filho, 2015. "Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?" *NBER* Working Papers No. 21427.

[11] Bleakley, H. and K. Cowan, 2008, "Corporate Dollar Debt and Depreciations: Much ado About Nothing?," *The Review of Economics and Statistics*, vol. 90(4), 612-626.

[12] Bocola, L. and G. Lorenzoni, 2020, "Financial Crises, Dollarization, and Lending of Last Resort in Open Economies." *American Economic Review*, vol. 110 (8): 2524-57.

[13] Braggion, F., L. Christiano, and J. Roldos, 2009, "Optimal Monetary Policy in a Sudden Stop," *Journal of Monetary Economics* vol. 56, 582-595.

[14] Calvo, G., 1983, "Staggered prices in utility-maximizing framework," *Journal of Monetary Economics* vol. 12, 383-98.

[15] Calvo, G. and C. M. Reinhart, 2002, "Fear of Floating," *The Quarterly Journal of Economics*, vol. 117(2), 379-408.

[16] Camara, S., L. Christiano, and H. Dalgic, 2024, "The International Monetary Transmission Mechanism," *NBER Macroeconomics Annual 2024*, vol. 39.

[17] Catão, M. L., M. M. Terrones, 2016, "Financial De-dollarization: A Global Perspective and the Peruvian Experience," *International Monetary Fund* Working Paper No. WP/16/97.

[18] Cavallino, P., 2019, "Capital Flows and Foreign Exchange Intervention," *American Economic Journal: Macroeconomics*, vol. 11(2), 127-170.

[19] Cavallino, P. and D. Sandri, 2023, "The Open-economy ELB: Contractionary Monetary Easing and the Trilemma," *Journal of International Economics*, vol. 140, 103691.

[20] Céspedes, L.F., R. Chang, and A. Velasco, 2004, "Balance sheets and exchange rate policy," *American Economic Review* vol. 94, 1183-1193.

[21] Céspedes, L. F., R. Chang, and A. Velasco, 2017, "Financial Intermediation, Real Exchange Rates, and Unconventional Policies in an Open Economy," *Journal of International Economics*, vol. 108, S76-S86.

[22] Chang, C., Z. Liu, and M. Spiegel, 2015, "Capital Controls and Optimal Chinese Monetary Policy," *Journal of Monetary Economics*, vol. 74(1), 1-15.

[23] Chen, H., V. Cúrdia, and A. Ferrero, 2012, "The Macroeconomic Effects of Large-scale Asset Purchase Programmes, *The Economic Journal* 122, 289-315.

[24] Choi, W. G. and D. Cook, 2004, ”Liability Dollarization and the Bank Balance Sheet Channel,” *Journal of International Economic*, vol. 64(2), 247-275.

[25] Christiano, L. J., M. Eichenbaum, and C. L. Evans, 2005, “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy,” *Journal of Political Economy* vol. 113, 1-45.

[26] Christiano, L. J., H. Dalgic, and A. Nurbekyan, 2021, “Financial Dollarization: Efficient Intranational Risk Sharing or Prescription for Disaster,” *NBER* Working Papers No. 29034.

[27] Cúrdia,V. and M. Woodford, 2011. ”The central-bank balance sheet as an instrument of monetarypolicy,” *Journal of Monetary Economics*, vol. 58(1), 54-79.

[28] Davis, J. S., I. Fujiwara, and K. Huang, 2021. ”Foreign exchange reserves as a tool for capital account management,” *Journal of Monetary Economics*, vol. 117(C), 473-488.

[29] Erceg, C. J., D. W. Henderson, and A. T. Levin, 2000, ”Optimal Monetary Policy with Staggered Wage and Price Contracts,” *Journal of Monetary Economics*, vol. 46(2), 281-313.

[30] Fanelli, S. and L. Straub, 2021, ”A Theory of Foreign Exchange Interventions,” *Review of Economic Studies*, 2021.

[31] Gabaix, X,. and M. Maggiori, 2015. “International Liquidity and Exchange Rate Dynamics,” *The Quarterly Journal of Economics* vol. 130(3), 1369-1420.

[32] Gertler, M., S. Gilchrist, F. Natalucci, 2007, “External Constraints on Monetary Policy and the Financial Accelerator,” *Journal of Money, Credit and Banking* vol. 39(2-3), 295-330.

[33] Hausmann, R., U. Panizza, and E. Stein, 2001, ”Why do Countries Float the Way they Float?,” *Journal of development economics*, vol. 66(2), 387-414.

[34] Hofmann, B., N. Patel, and S.P. Yeun Wu, 2022, ”Original sin redux: a model-based evaluation,” *Bank for International Settlements Working Paper* No. 1004.

[35] International Monetary Fund, 2013, ”Integrated Policy Framework—Principles for the Use of Foreign Exchange Intervention,” *IMF Policy Paper*, No. 2023/061.

[36] Kim, S., 2003. "Monetary policy, foreign exchange intervention, and the exchange rate in a unifying framework," *Journal of International Economics*, vol. 60(2), 355-386.

[37] Levy-Yeyati, E., 2006, "Financial dollarization: evaluating the consequences," *Economic Policy* vol. 21(45), 61-118.

[38] Liu, Z. and M. Spiegel, 2015, "Optimal Monetary Policy and Capital Account Restrictions in a Small Open Economy," *IMF Economic Review*, vol. 63(2), 298-324.

[39] Lucas, R., 1987, "Models of Business Cycles," Oxford : Blackwell.

[40] Miranda-Agrippino, S. and H. Rey, 2020. "U.S. Monetary Policy and the Global Financial Cycle," *Review of Economic Studies*, vol. 87(6), 2754-2776.

[41] Mundell, R. A, 1960, "The Monetary Dynamics of International Adjustment under Fixed and Flexible Exchange Rates," *The Quarterly Journal of Economics*, vol. 74(2), 227-257.

[42] Rajan, R., 2015, "Competitive Monetary Easing - Is It Yesterday Once More?" *Macroeconomics and Finance in Emerging Market Economies* 8(1-2): 5-16.

[43] Schmitt-Grohé, S., and M. Uribe, 2003, "Closing Small Open Economy Models," *Journal of International Economics* vol. 61, 163-185.

[44] Schmitt-Grohé, S., and M. Uribe, 2007, "Optimal simple and implementable monetary and fiscal rules," *Journal of Monetary Economics* vol. 54(6), 1702-1725.

[45] Smets, F., and R. Wouters, 2007, "Shocks and Frictions in the US Business Cycles: A Bayesian DSGE Approach," *American Economic Review* vol. 97, 586-606.

[46] Végh, C. A., L. Morano, L., D. Friedheim, and D. Rojas, 2017, "Between a Rock and a Hard Place: The Monetary Policy Dilemma in Latin America and the Caribbean." Washington, DC: *World Bank*.

[47] Wallace, N., 1981. "A Modigliani-Miller Theorem for Open-Market Operations," *American Economic Review*, vol. 71(3), 267-274.

[48] Yakhin, Y., 2022, "Breaking the UIP: A Model-Equivalence Result," *Journal of Money, Credit and Banking*, vol. 54(6), 1889-1904.

Appendix: Sample of Countries used in the VAR estimation

Table A1. List of Countries

Dollarized		Non-dollarized	
Country	Financial dollarization 1995-2004 (%)	Country	Financial dollarization 1995-2004 (%)
Azerbaijan	69.1	Australia	0.0
Bolivia	90.1	Brazil	0.0
Bulgaria	50.0	Canada	0.0
Costa Rica	42.5	Chile	7.9
Croatia	68.6	China	7.9
Egypt	26.4	Colombia	0.4
Estonia	27.2	Czech Republic	11.0
Georgia	70.1	Denmark	3.8
Hungary	21.3	Guatemala	0.8
Jamaica	25.4	India	0.0
Kazakhstan	48.6	Indonesia	19.8
Latvia	44.9	Israel	18.4
Lithuania	36.7	Korea, Republic of	2.7
Moldova	39.4	Malaysia	2.7
Paraguay	54.5	Mexico	8.3
Peru	67.2	New Zealand	3.5
Philippines	30.8	Norway	3.7
Qatar	25.3	Poland	19.3
Romania	39.9	South Africa	3.2
Russia	32.8	Sri Lanka	20.0
Turkey	48.8	Sweden	1.4
Ukraine	34.7	Thailand	1.0
Uruguay	82.5		

Figure 1: Responses to Global Capital Outflow Shocks in Dollarized and Non-dollarized Economies

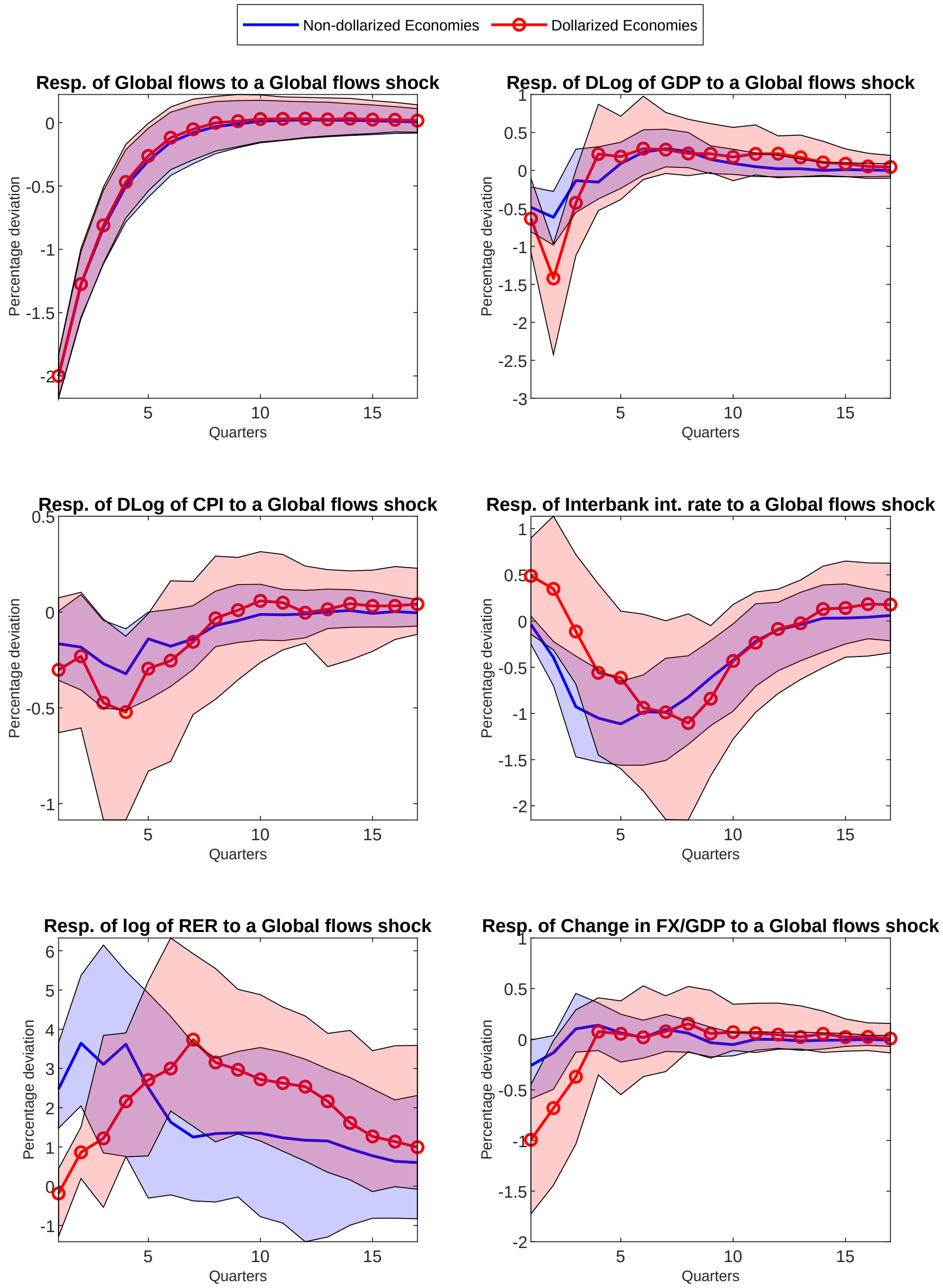

Figure 2: Role of FXI and Interest Rate Reaction in the Transmission of Global Capital Outflow Shocks in Dollarized Economies

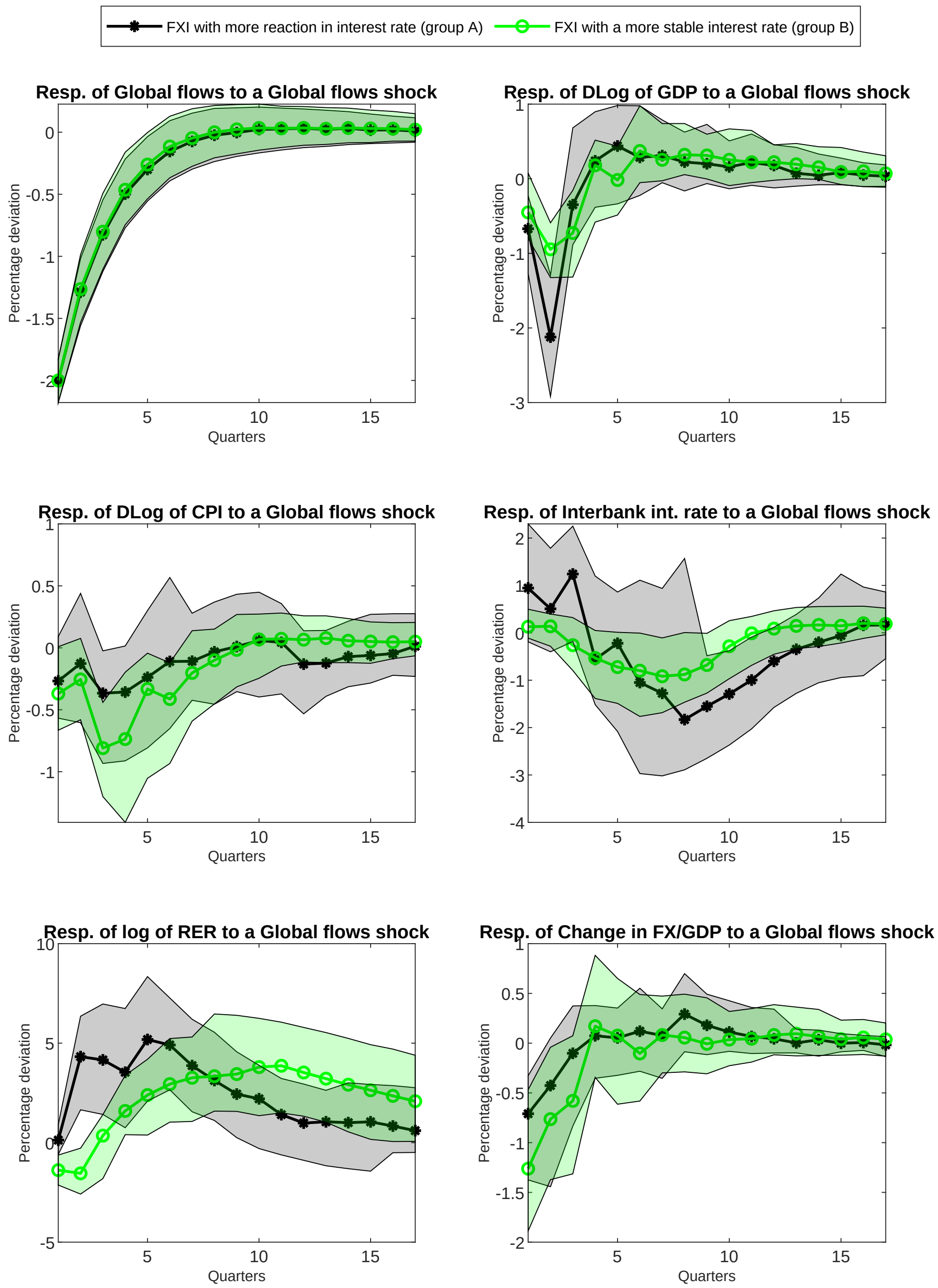

Figure 3: Transmission of Monetary Policy Rate and FX Intervention

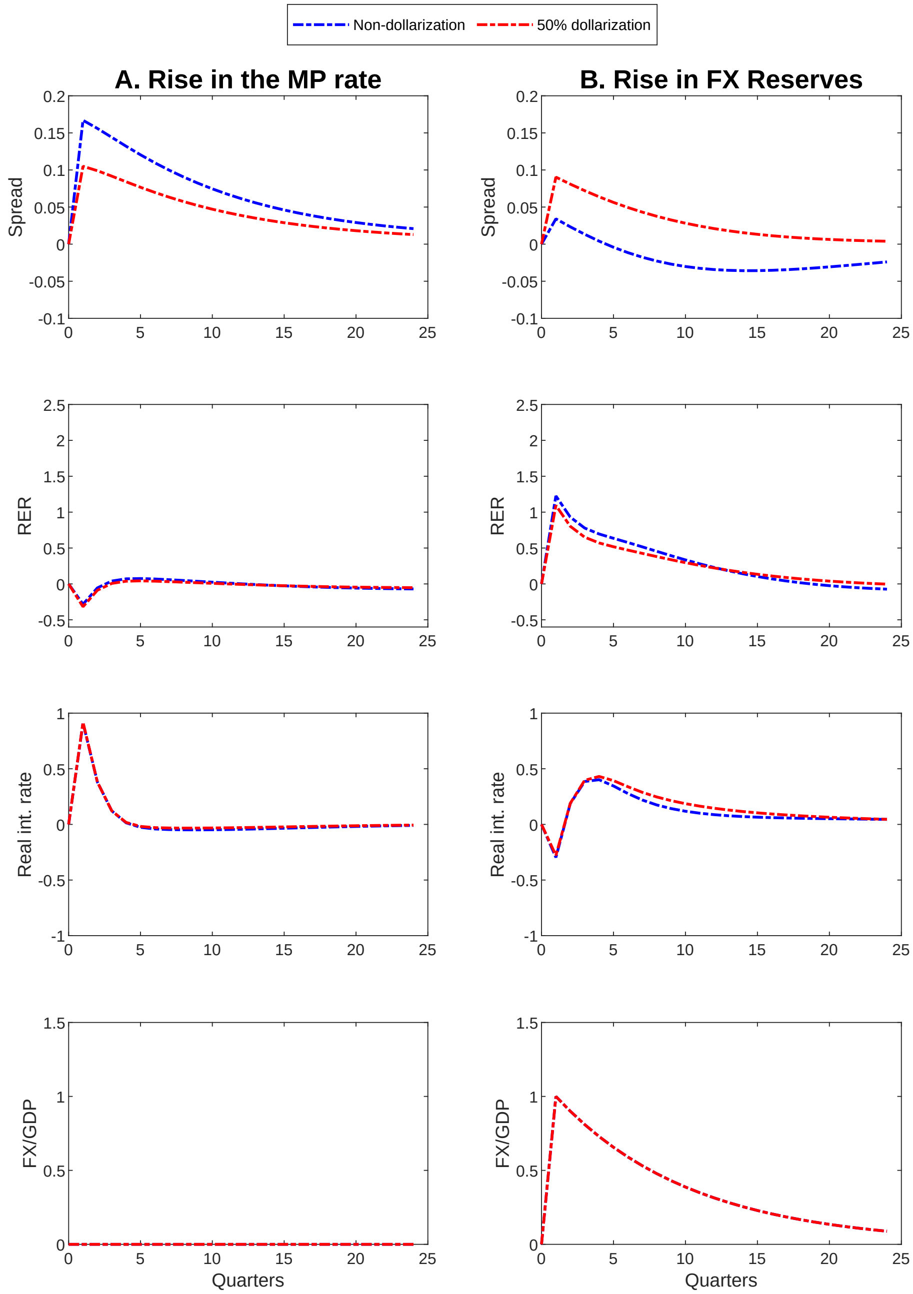

Figure 4: Amplification Role of Dollarization with Constant FX reserves

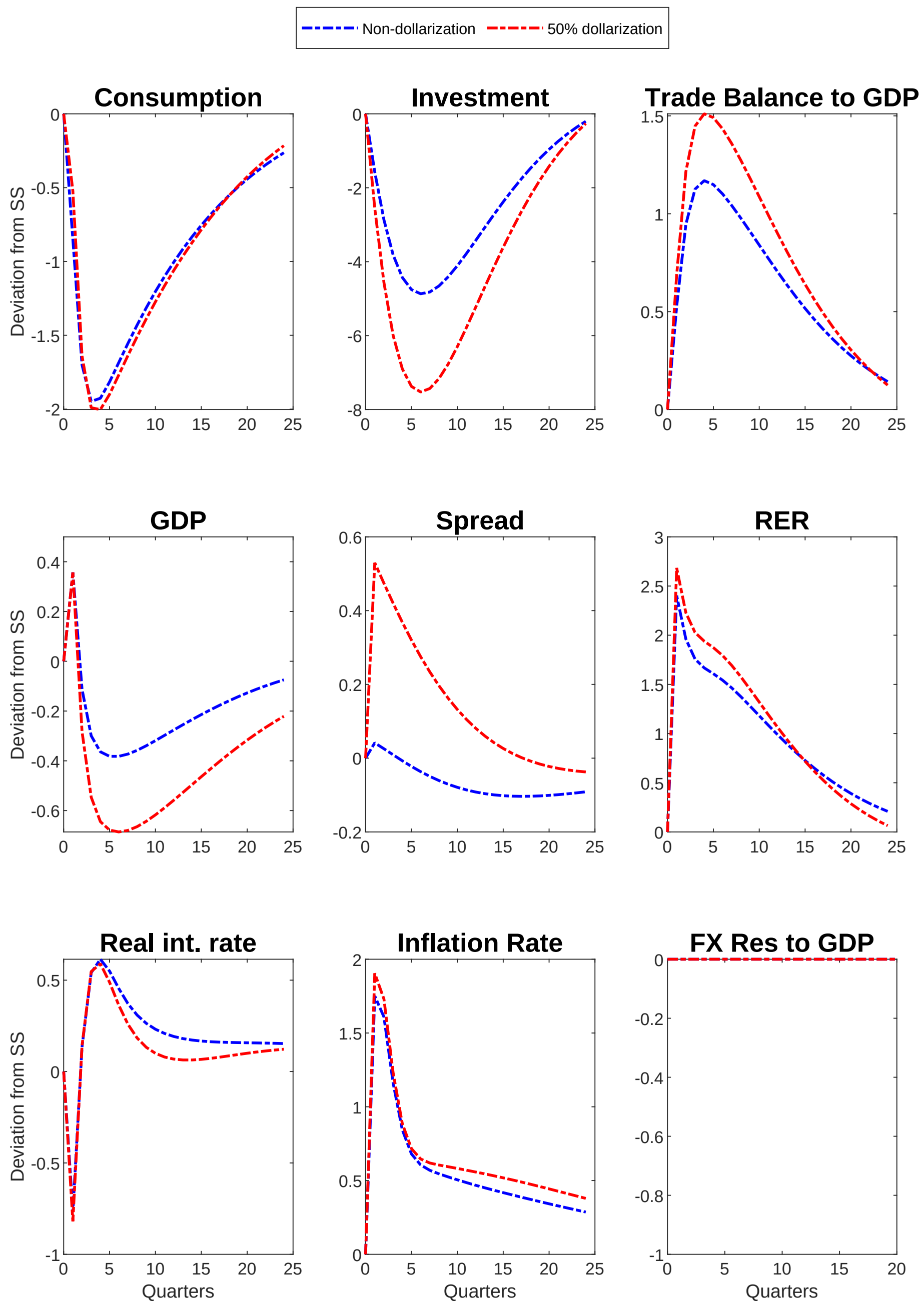

Figure 5: Comparison of Policy Regimes with 50 percent of Dollarization

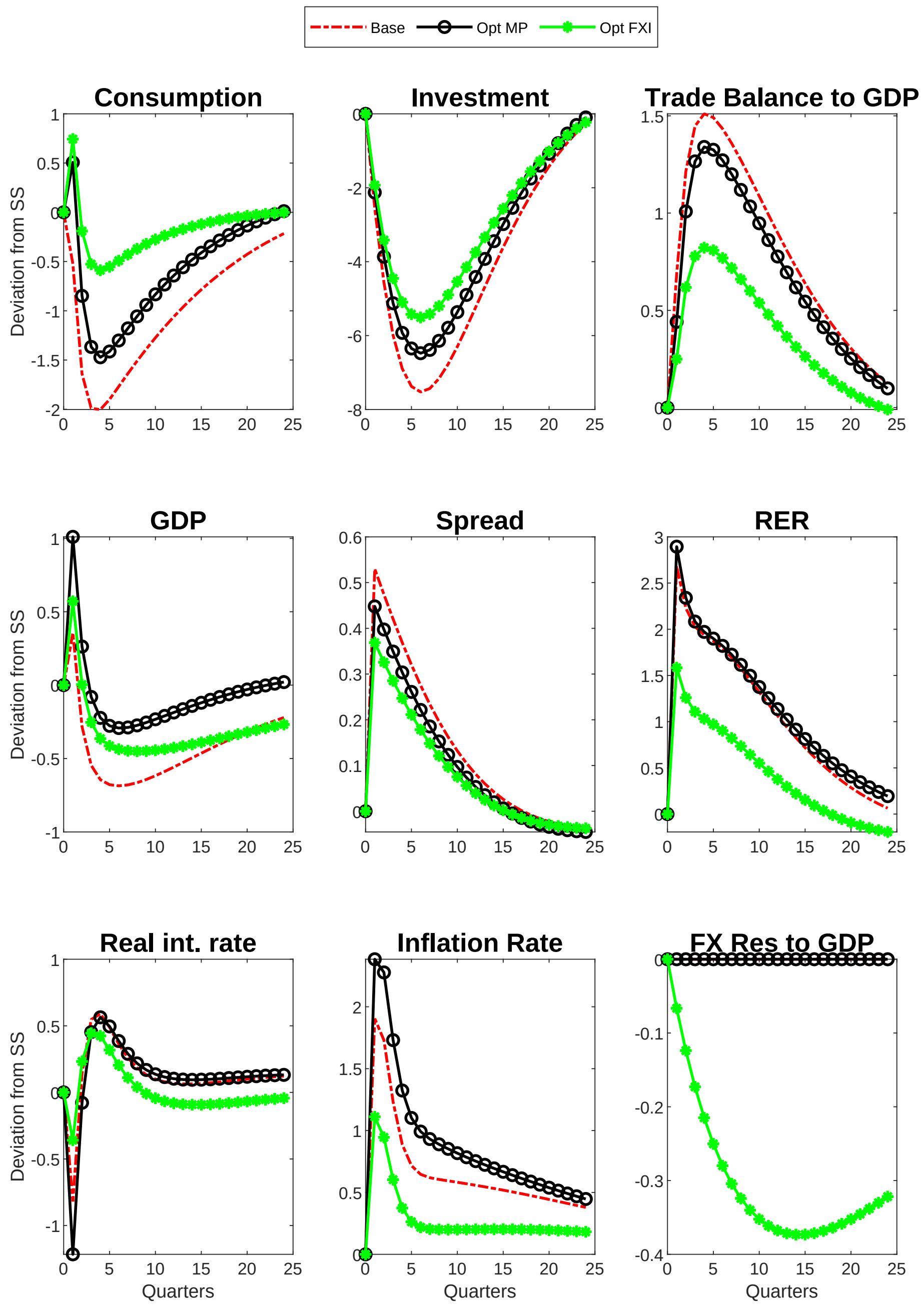

Figure 6: Comparison of Policy Regimes with 50 percent of Dollarization: Joint Optimization