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Foreign Exchange Intervention, Capital Flows, and Liability Dollarization

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Abstract

This paper investigates the importance of foreign exchange intervention in dealing with shocks to global capital flows in emerging economies. We show in a VAR analysis that a shock to global capital flows has a sizable effect on economic activity, and this effect is amplified in emerging economies with liability dollarization. However, countries that systematically rely on sterilized foreign exchange intervention in response to movements in global capital flows, display lower output and real exchange rate volatility. Motivated by the empirical evidence, we develop a small open economy model with liability dollarization and balance sheets effects calibrated to an emerging economy. Our quantitative results show that liability dollarization amplifies the effects of fluctuations in capital flows and that foreign exchange intervention can reduce macroeconomic volatility and improve welfare. These results point to the importance of foreign exchange reserves in insulating emerging economies from the global financial cycle.

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

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1. Introduction

Capital flows play a crucial role in emerging economies as they allow less developed economies to finance investment and facilitate the process of economic convergence. (Calvo et al., 1996; Lucas, 1990). At the same time, large and temporary movements of capital flows can be a source of macroeconomic instability. For instance, episodes of capital inflows tend to be associated with periods of output expansion, credit and asset price booms, and real exchange rate appreciation, all of which increase the probability of a financial crisis (Gourinchas and Rogoff, 2012). More recently, the literature has identified that capital flows are preponderantly driven by global factors, implying the existence of a global financial cycle in capital flows (Rey, 2015; Davis et al., 2021). The fact that capital flows respond to global conditions implies that they might not always be appropriate for the cyclical conditions in individual emerging economies, and could induce excessive financial and macroeconomic volatility. In addition, the prevalence of liability dollarization or foreign currency borrowing can further exacerbate the impact of the global financial cycle on the balance sheets of firms and banks (Rajan, 2014; Levy-Yeyati, 2006). During periods of capital inflows, an exchange rate appreciation can improve the balance sheets of the private sector amplifying a credit boom, while during periods of capital outflows an exchange rate depreciation can lead to private sector bankruptcies and insolvencies inducing a severe credit contraction.

The combination of the global financial cycle and liability dollarization poses significant challenges to central banks in emerging economies, as monetary policy might be an insufficient tool to respond to this scenario. Rey (2015) proposes different policy options for dealing with the global financial cycle such as the implementation of macroprudential policies and capital controls. While there are merits in managing the global financial cycle through these instruments, in practice capital controls are acycliclal (Fernandez et al., 2015) and, on average, are not properly calibrated to the magnitude of capital flows. Moreover, while effective, macroprudential instruments might fall short to deal with sizable capital flows during booms (Rajan, 2014). Alternatively, a policy instrument not explicitly discussed by Rey (2015) and that is widely used among emerging economies is Foreign Exchange Intervention (Fratzcher et al., 2019). The goal of the this paper is to analyze the role of Foreign Exchange Intervention (FXI) in dealing with global capital flows shocks, especially in emerging economies experiencing liability dollarization.[1] In particular, our paper is focused on two key questions: (i) Is FXI an effective policy tool for dealing with global capital flows?; and (ii) Is FXI a welfare-improving policy when deployed in response to global capital flows shocks?

In this paper we answer these two questions from an empirical and a theoretical perspective. From the empirical standpoint, we conduct a VAR analysis following the work of Blanchard et al. (2015) and analyze the interaction between the shocks to global capital flows and FXI in economies with liability dollarization. We refer liability dollarization to the fact that a relevant fraction of the loans from the domestic financial and corporate sector are denominated in foreign currency. From the theoretical standpoint, we developed a small open economy DSGE model with balance sheet effects and liability dollarization following the work from Bernanke et al. (1999), Gertler et al. (2007) and Cespedes et al. (2004). The model features imperfect asset substitution between domestic and foreign bonds as in Chang et al. (2015), which allows FXI to have real effects in the economy. Following Miranda-Agrippino and Rey (2020), we assume that the underlying force driving the global financial cycle is U.S. monetary policy shocks, and we simulate in the model a shock to the global risk free rate. In the model simulations we evaluate the macroeconomic effects of shocks to capital inflows in the presence of liability dollarization and to what extent deploying FX intervention in response to this shock is a welfare-improving policy.

Based on a sample of 45 advanced and emerging economies we conduct a VAR analysis and find that shocks to global capital flows have a substantial impact on output, inflation, and the real exchange rate. A positive shock to global capital flows stimulates aggregate demand and inflation, and in addition induces a real exchange rate appreciation. We also find that the effects on output and inflation are amplified in economies featuring liability dollarization. Moreover, these economies tend to intervene systematically as a way to smooth real exchange rate fluctuations and "lean against the wind". We also find evidence that sterilized FXI, i.e., changes in FX reserves that do not lead to change in the monetary policy rate, are highly effective in smoothing the exchange rate and stabilizing aggregate demand in response to the shocks to global capital flows.

[1] The focus of our paper is on the role of sterilized FX interventions. However, in the paper we use interchangeably the terms sterilized FX intervention and FX intervention.

We also find that the quantitative results from the small open economy model support the VAR analysis. Shocks to capital flows have an expansionary effect on economic activity and induce a real exchange rate appreciation. Furthermore, the real effects of capital flows are amplified when the degree of liability dollarization is calibrated to the level observed in emerging economies. We also analyze the welfare implications of deploying FX intervention in response to capital flow shocks. We find that optimal FX reserves accumulation is procyclical and can largely reduce the welfare costs stemmed from capital flow shocks.

In response to capital inflows, it is optimal for the central bank to accumulate reserves in order to "lean against the wind" and limit the extent of the real exchange rate appreciation. Since the real exchange rate is more depreciated relative to the baseline case of no FX intervention, this policy results in tighter financial conditions for the corporate sector as it increases the cost of servicing the debt. This policy reduces macroeconomic volatility as tighter financial conditions partially offset the increase in aggregate demand induced by expansionary capital inflows. We also evaluate the optimal monetary policy response to capital flow shocks. Consistent with the results from Cespedes et al. (2004) we find that a "leaning against the wind" policy based on the policy rate might be ineffective, as smoothing the real exchange rate appreciation with a lower interest rate could result in greater output expansion and an increase in overall volatility. The results from model simulations suggest that the use of FX intervention in response to global capital flows in economies with liability dollarization is a welfare-improving policy.

Our paper is related to theoretical and empirical literature analyzing foreign exchange intervention. Related to the theoretical literature, we follow the work of Cavallino (2019), Gabaix and Maggiori (2015), Chang et al. (2015), Fanelli and Straub (2021), and Fujiwara et al. (2021), by developing a small open economy with imperfect asset substitution which generates deviations from the uncovered interest parity condition and renders FX reserves as an effective policy tool. Related to the empirical literature, we follow Blanchard et al. (2015), Kim (2003), and Cavallino (2019), and conduct a VAR analysis for understanding the systematic response of FX intervention to global capital flows shocks. This paper contributes to the literature by first analyzing the role of liability dollarization in amplifying the global financial cycle, and second the role of FX intervention in supporting macroeconomic stabilization in response to global capital flows shocks. Our paper shows that under liability dollarization, foreign exchange reserves play the role of shock absorber to capital flows shocks. Furthermore, in absence of FX intervention fluctuations in the exchange rate can, indeed, be source of macroeconomic instability.

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 calibration strategy for the model. Section 5 presents the response of the model economy to global financial shocks, comparing the outcomes in economies with and without liability dollarization. Section 6 evaluates the welfare gains from deploying FX intervention optimally in the model economy. Finally, section 7 concludes.

2. Empirical Evidence on Foreign Exchange Intervention and Global Capital Flows Shocks

In this section we analyze empirically the macroeconomic effects of FX intervention and global capital flow shocks. In particular, we estimate country-specific VAR models with a recursive identification and compute the responses in each country to a global capital flows shock and report the endogenous response of FX intervention. We rely on quarterly data in 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 (i.e., US, UK, Japan, Euro area countries, among others). We are also interested in understanding the macroeconomic implications of liability dollarization in response to global capital flows shocks.

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 a dollarized economy when deposit dollarization is equal or greater than 20 percent and non-dollarized economies when this indicator is less than 20 percent.[2] 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

[2]We consider additional thresholds of dollarization and does not change the main results of the VAR analysis.

the bank's foreign exchange positions, implying that the exchange rate risk derived from financial dollarization is mostly absorbed by non-financial firms and households. The sample of countries used in the estimations and their financial dollarization ratio is presented in appendix A.

The recursive VAR model considers the following six variables: a global capital flows series; real GDP; CPI; short-term interest rate; 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 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 corresponding nominal GDP 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:

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

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 the GDP and the 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. $gkf_{i,t}$ is the gross capital flows to other countries, but not country i, divided by the sum of the GDP of the other countries. Finally, variable $\Delta fx_{i,t}$ is the change in stock of FX reserves divided by the trend GDP for country i, computed with a Hodrick-Prescott filter with a smoothing parameter 1600. All domestic variables are obtained from Haver Analytics.

Notice that the matrices of coefficients $\mathbf{A}_{i,1}, \cdots, \mathbf{A}_{i,p}$ have a dimension 6×6 and vector of coefficients $\boldsymbol{\alpha}_i$ has dimension 6×1. The parameter p is the lag-length for the VAR model. The variable $u_{i,t}$ is 6×1 disturbance vector with mean 0 and variance-covariance matrix given by $\boldsymbol{\Omega}_i$.

Futhermore, we impose a block exogeneity restriction in the VAR such that domestic variables do not impact the global capital flows. This restriction captures the fact that for small open economies the global capital flows series are exogenous to macroeconomic developments in each economy. This restrictions 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:

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

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

Figure 1 shows the responses of dollarized and non-dollarized economies to an innovation of global capital flows shocks of 2 percent of global GDP.[3] We report the median impulse response functions for dollarized and non-dollarized economies. A shock to global capital flows is expansionary in both types of economies. However, the expansionary effect on output is magnified in dollarized economies. Consistent with output dynamics, inflation also increases more rapidly in dollarized economies in response to a global capital flow shock. Furthermore, dollarized economies engage in more policy activism in response to capital flows, as they accumulate more reserves and have a lower interest rate than dollarized economies. These two policy responses suggest a "leaning against the wind" policy to prevent an exchange rate appreciation and further amplification of the output expansion potentially cause by balance sheet effect. When we look at the response of the real exchange, we see that in fact dollarized economies tend to achieve a moderate appreciation in the short-run, which is consist with the reaction of the policy rate and foreign exchange intervention. Notice that the decline in the policy rate in dollarized economies could also be associated to non-sterilized FX interventions that results in an expansion of the money supply. Figure 2 delves deeper into the interaction between monetary policy and FX intervention.

Figure 2 plots the responses of only dollarized economies to global capital flow shocks. We split the sample of dollarized economies in two groups of countries, those where the interest rate responses to the shock is larger and lower than the median. The first group is labeled in the figure as "Foreign Exchange Intervention with active interest rate" (group A), and the second one as "Foreign Exchange Intervention with stable interest rate" (group B). We interpret group B as a case of sterilized FX interventions, since these are

[3]The 60% confidence bands computed using bootstrapping methods are available upon request.

FX interventions that are not associated with a substantial change in the monetary policy. Notice that the interest rate for the group B does not react on impact and further it is relatively more stable over time. Interestingly, in the case of group B, foreign exchange intervention is capable of slowing down the pace of real exchange rate appreciation relative to group A. The larger appreciation observed in group A, is consistent with a larger output expansion, as an appreciation of the exchange rate presumably reduces the cost of borrowing in foreign currency and hence contributes to further expansion of aggregate demand. On the contrary, group B, where the exchange rate appreciation is contained in the short-run, it is capable of moderating the response of output to capital flows. This is also consistent with a balance sheet mechanism, where a less appreciated exchange rate would attenuate the reduction in the cost of borrowing in foreign currency, offsetting the expansive effect of capital flows on output. Notice that, consistent with the fact that the exchange rate is less appreciated in group B, inflation in this group of countries is higher, possibly reflecting that unambiguously higher aggregate demand and exchange rate contribute jointly to a rise in local consumer prices.

To summarize, the VAR analysis shows that global capital flow shocks have a sizable effect on output, and this effect is amplified in countries with liability dollarization. Sterilized FX intervention in dollarized economies are helpful in "leaning against the wind", resulting in a slower pace of real exchange appreciation and lower output volatility in response to global capital flow shocks. Next, we analyze this empirical evidence through the lens of a 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 goods 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 emerging economies (Levy-Yeyati, 2006), and the fact 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 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 inflows 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. ζ_L is the weight on the disutility from labor. $C_t(j)$ is defined by a 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 returns of the deposits in foreign currency is equal to risk-free foreign interest rate, R_t^*. Hence, the household budget constraint is given by:

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

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. Foreign borrowing pays a premium (Θ_{t-1}) over the risk-free foreign rate and households do not internalize the effects of their borrowing decisions on the premium.[4] 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 (3) subject to (5). By assuming a complete set of state-contingent claims, consumption is equalized across households despite differences in their supply of labor.

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:

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

[4] This premium is introduced to model imperfect asset sustitutability and induce stationarity in the model. The exact functional form for $\Theta_t = \Theta(\cdot)$ will be discussed in section 3.6. See Chang et al. (2015) and Cavallino (2019) for alternative approaches for modeling imperfect asset substitution.

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 a wage, she 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.[5] 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.

[5]The adjustment cost of investment satisfies: $S(1) = 1$, $S'(1) = 0$, $S''(1) = -\mu_S < 0$ (see Altig et al. (2005)).

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. In addition, we assume that a fraction of debt portfolio is denominated in foreign currency. We assume a continuum of risk-neutral entrepreneurs in the economy. In period t, entrepreneurs finance the purchase 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. In order to simplify the portfolio choice of currency composition of the loan, 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 in period $t+1$ to capital goods producers. Each entrepreneur faces an idiosyncratic shock ω affecting the effective amount of capital available in $t+1$. The effective capital of entrepreneur in period $t+1$ is $\omega_{t+1}K_{t+1}$. 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 in 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 process of monitoring. 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, $\bar{\omega}_{t+1}$, that 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:

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

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

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

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) calls 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 a increasing relationship of the credit spread, sp_{t+1}, and the leverage of entrepreneurs defined by $\frac{Q_t K_{t+1}}{N_t}$:

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

We consider that a fraction γ_e of entrepreneurs survives in each period, while the remaining fraction exit the market and consume all their wealth. The entrepreneurs who exit the market are replaced by a new cohort that enters and receive 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. First, the intermediate good producers. Each of these firms has monopoly power and set their prices in a staggered fashion á la Calvo (1983). Second, perfectly competitive retailers of home goods that assemble the differentiated intermediate goods and sell them in domestic and foreign markets. Third, the importers that purchase homogenous 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 $Y_{H,t}\left(z_H\right)$ 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. The capital share in the production function is denoted by α. Intermediate good producers set their prices á la Calvo (1983).[6]

3.4.2. Retailers of intermediate home goods

Retailers of intermediate goods operate in a perfectly competitive market. In order 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 consists of a continuum of firms that buy a homogenous good in the foreign market and turn it into differentiated ones. Competitive as-

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

semblers 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. The imported 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 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 foreign interest rate (R^*_t) from their steady state levels. We also allow for interest rate smoothing such that the interest rate rule has the following specification:

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

where φ_R, φ_π, φ_y, and φ_{R^*} are the weights of interest rate smoothing, inflation, GDP, and foreign interest rate in the monetary policy rule. Notice that 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 rate, 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 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 the foreign exchange reserves, θ_{R^*} governs the intensity in 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 banks adjusts the stock 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 by 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 for 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.[7]

3.6. Aggregation and Equilibrium Conditions

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

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

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 equilibrium in the labor and capital markets are given by:

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

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

$$K_t = \int_0^1 K_t(z_H) dz_H. \quad (26)$$

The equilibrium conditions for the final home good is:

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

$C^*_{H,t}$ corresponds to the volume of export of final home goods:

$$C^*_{H,t} = \zeta^* \left(\frac{P_{H,t}}{\mathcal{E}_t P^*_t} \right)^{-\eta^*} C^*_t, \quad (28)$$

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:

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

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

$$\mathcal{E}_t(F^*_t - B^*_t) \;=\; R^*_{t-1} \left(\mathcal{E}_t F^*_{t-1} - \Theta_t \mathcal{E}_t B^*_{t-1} \right) + X_t - M_t \quad (30)$$

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 Chang et al. (2015), the risk premium Θ_t determines the the degree of asset substitution between domestic and foreign bonds and the strength of the transmission mechanism of sterilized FX interventions.[8] As indicated in equation (22), an accumulation of FX reserves is financed by increasing the supply of domestic bonds which are purchased by households. When there is perfect asset substitution ($\Theta_t = 1$), households will respond to this excess of supply of bonds by borrowing from the rest of the world,

[8] Yakhin (2020) 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.

fully offsetting the impact of FX reserves accumulation.[9] Thus, in order to have real effects from sterilized FXI, we will 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 will 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 $\beta = 0.995$ to be 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 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 IMF WEO database for the period 2000-2018 (27 percent).

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, 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 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.

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

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 b/w H and F in consumption
γ_I	0.30	Share of imported goods in investment
η_I	0.5	Substitution elasticity b/w 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 SS
$4 \times F(\bar{\omega})$	0.03	Default premium in annual terms in the SS
$\bar{Q}\bar{K}/\bar{N}$	2.00	Capital-Net worth ratio of entrepreneurs in the SS
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 SS
$(\bar{X}-\bar{M})/\bar{Y}$	0.0	Net export-output ratio in the SS
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 of shocks to the foreign interest rate are set to $\rho_{R^*} = 0.95$. Section 6 discusses the selection of φ_{R^*}, ρ_{fx}, and θ_{R^*} in the context of optimal policy rules.

Table 1 (continued): Baseline Calibration

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/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 in order to guarantee stationarity of the model. Second, we calibrate ϱ_2 based on the empirical evidence of Bayoumi et al. (2015), who find that an increase of 1 percent of GDP in the stock of foreign reserves improves the current account balance 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.

To gain intuition on the transmission mechanism of FX intervention, figure 3 shows the macroeconomic effects of a one percent exogenous increase in the stock of FX reserves. FXI results in a gradual improvement in the trade balance up to 0.3 percent of GDP and a real exchange depreciation of 2 percent. Liability dollarization induces a rise in the credit spread due to the depreciation of the currency and a contraction of output around 0.4 percent. At the same time, consumption and labor decline, whereas inflation and the monetary policy rate increases in response to the exchange rate depreciation.

5. Macroeconomic Effects of Global Capital Flows

In this section analyze through the lens of the small open economy model the macroeconomic effects of global capital flows. We follow Miranda-Agrippino and Rey (2020), and consider that a key driver of the global financial cycle is the US monetary policy. In particular, we model a shock to global capital flows as a reduction of one percentage point in the foreign interest rate R_t^*. Since we are interested in understanding how liability dollarization amplifies the effects of global capital flows, we simulate the model under two scenarios: (i) without liability dollarization ($1 - \phi = 0$); and (ii) with liability dollarization ($1 - \phi = 0.50$). We assume that the central bank operates under a pure floating regime ($\varphi_{R^*} = 0$) and reserves are constant ($\theta_{R^*} = \rho_{fx} = 0$).[10]

Figure 4 plots the impulse response function to one percentage point decline in the foreign interest rate in models calibrated with and without liability dollarization. The model dynamics broadly reproduce the findings from the VAR analysis, and shows that the expansionary effects of capital inflows on output are larger in dollarized economies relative to non-dollarized economies. In our model, this effect is mainly driven by the balance sheet effects. As result of an exchange rate appreciation induced by capital inflows, the leverage ratio of entrepreneurs decline as the value of foreign currency debt declines in terms of local currency. This generates a large decline in the external finance premium, and a subsequent expansion in credit to finance investment. Hence, capital flows are more expansionary in terms of GDP and employment in countries experiencing liability dollarization. In addition, we observe a decline in inflation in dollarized and non-dollarized economies. Furthermore, the trade balance deficit is larger and the policy rate is higher in dollarized economies as a result of a larger expansion in output.

Given how liability dollarization amplifies the macroeconomic effects of capital flows, a key question is to what extent 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 at the same time can increase macroeconomic volatility in the presence of the financial accelerator.

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

For instance, in our scenario, a lower nominal interest rate can depreciate the currency offsetting the expansionary effects of capital inflows, but lower interest rates can also rise the price of capital, reducing the leverage ratio and the credit spread, leading to a further expansion 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 leads to effects that are opposite to capital inflows, i.e. exchange rate depreciation, higher inflation, and a contraction of output and consumption. Intuitively, one can interpret FX intervention as official capital outflows. In that sense, they have the potential to counteract the effects from private capital inflows. In the next section, we characterize the optimal use of FX intervention in response to capital inflows.

6. Optimal Foreign Exchange Intervention in Response to Global Capital Flows

In this section we evaluate alternative policy options for dealing with the global capital flows in a model economy featuring liability dollarization ($1 - \phi = 0.5$). Similar to the previous section, we model a shock to global capital flows as one percentage point decline in the foreign interest rate. We consider three types of policy regimes. First, we evaluate the case where the central bank responds to capital inflows by adjusting the policy rate ($\varphi_{R^*} < 0$) but keeping FX reserves constant ($\theta_{R^*} = \rho_{fx} = 0$). Second, the central bank deploys a FX intervention rule in response to capital inflows (ρ_{fx}, $\theta_{R^*} > 0$) but 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 for dealing with capital flows ($\varphi_{R^*} < 0$ and ρ_{fx}, $\theta_{R^*} > 0$). For each of these regimes, the coefficients of the interest rate and 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.

Table 2: Optimized parameters for alternative policy regimes

	Optimized φ_{R^*}	Optimized FXI rule	Joint optimization 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), with an optimized coefficient φ_{R^*}, and with an optimized FX intervention rule. The optimal response of the policy rate ($\varphi_{R^*} = -0.39$) is an initial monetary policy tightening followed by a subsequent loosening of the policy rate.[11] This monetary policy tightening moderates the expansion in credit and investment. However, the contractionary monetary policy leads to a larger exchange rate appreciation, and a sharp reduction in output, employment, and inflation in the first quarter. In subsequent quarters, monetary policy is not very effective in moderating the expansionary effects of capital inflows. In contrast, the optimized FX intervention rule can largely reduce macroeconomic volatility. It moderates the extent of real exchange appreciation, resulting in a compression of the credit spread and a more moderate expansion in output, consumption and employment. Also the fall in the inflation rate is smaller than in the baseline model, and the nominal interest rate declines largely tracking the response of the Taylor-type rule to inflation.

Figure 6 plots the model dynamics when the central bank jointly deploys the policy rate and FX intervention in response to capital inflows. The impulses responses from this regime are similar to the case where only the optimized FX intervention rule is implemented, suggesting small additional welfare gains from optimally using both FX intervention and the monetary policy rule. Notice that some substitution of instruments seems to take place when the monetary authority decides to deploy them in an optimal fashion. Relative to the regime where only the FX intervention rule is optimized, in this scenario we find that the monetary authority prefers to accumulate more FX reserves and a larger reduction in the policy rate.

Next, we quantify the welfare costs á la Lucas (1987) for each policy regime r by calculating the fraction of steady state consumption λ_r that

[11] Similar non-monotonic dynamics for optimal monetary policy in response to a sudden stop episode is obtained by Braggion et al. (2009).

households are willing to give up in order to eliminate macroeconomic volatility. Formally, for regime 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 labor supply. Table 3 shows the welfare losses for each regime, measured by the compensation λ_r. In the baseline scenario, were the central bank implements a Taylor-type rule that depends on output and inflation, the welfare costs are 0.29 percent from lifetime consumption, about three times the valued obtained by Lucas (1987) for the US business cycles. The welfare costs obtained 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 is not effective in dealing with shocks to capital flows. 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 flows. Finally, considering a regime where the policy rate and FX intervention are jointly optimized provides even lower welfare costs, but the marginal gain from optimizing the coefficient φ_{R^*} is fairly small. In sum, the welfare cost analysis suggests significant welfare gains from deploying an FX intervention rule in response to the global financial cycle.

Table 3: Welfare losses of fluctuations in global financial conditions

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 evaluate from an empirical and a theoretical perspective the role of foreign exchange intervention in dealing with shocks to global capital flows. We focus our analysis on economies with liability dollarization, a feature that is widespread among emerging economies. In a VAR analysis we find that a positive shock to global capital flows has an expansionary effect in output, and this is exacerbated in countries experiencing liability dollarization. Furthermore, sterilized foreign exchange intervention can largely insulate emerging economies from global capital flow shocks, by stabilizing output and the real exchange rate. We also develop a small open economy with balance sheets effects and liability dollarization that broadly replicates the empirical facts. In the model, liability dollarization amplify the expansionary effects of capital inflows and foreign exchange intervention is highly effective in stabilizing the economy. In addition, we show that deploying FX intervention in response to capital flow shocks is a welfare-improving policy. These results highlight the role of foreign exchange intervention for dealing with the global financial cycle, and rationalize the practice by many emerging economies of actively intervening in the foreign exchange market.

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Appendix A: Sample of countries used in the VAR estimation

Table A: List of countries

Country	Financial dollarization 1995-2004	Type of economy
Australia	0.0%	Non-dollarized
Azerbaijan	69.1%	Dollarized
Bolivia	90.1%	Dollarized
Brazil	0.0%	Non-dollarized
Bulgaria	50.0%	Dollarized
Canada	0.0%	Non-dollarized
Chile	7.9%	Non-dollarized
China, P.R.: Mainland	7.9%	Non-dollarized
Colombia	0.4%	Non-dollarized
Costa Rica	42.5%	Dollarized
Croatia	68.6%	Dollarized
Czech Republic	11.0%	Non-dollarized
Denmark	3.8%	Non-dollarized
Egypt	26.4%	Dollarized
Estonia	27.2%	Dollarized
Georgia	70.1%	Dollarized
Guatemala	0.8%	Non-dollarized
Hungary	21.3%	Dollarized
India	0.0%	Non-dollarized
Indonesia	19.8%	Non-dollarized
Israel	18.4%	Non-dollarized
Jamaica	25.4%	Dollarized
Kazakhstan	48.6%	Dollarized
Korea, Republic of	2.7%	Non-dollarized
Latvia	44.9%	Dollarized
Lithuania	36.7%	Dollarized

Table A: List of countries (cont.)

Country	Financial dollarization 1995-2004	Type of economy
Malaysia	2.7%	Non-dollarized
Mexico	8.3%	Non-dollarized
Moldova	39.4%	Dollarized
New Zealand	3.5%	Non-dollarized
Norway	3.7%	Non-dollarized
Paraguay	54.5%	Dollarized
Peru	67.2%	Dollarized
Philippines	30.8%	Dollarized
Poland	19.3%	Non-dollarized
Qatar	25.3%	Dollarized
Romania	39.9%	Dollarized
Russia	32.8%	Dollarized
South Africa	3.2%	Non-dollarized
Sri Lanka	20.0%	Non-dollarized
Sweden	1.4%	Non-dollarized
Thailand	1.0%	Non-dollarized
Turkey	48.8%	Dollarized
Ukraine	34.7%	Dollarized
Uruguay	82.5%	Dollarized

Figure 1: Comparing responses to global capital flow shock between Dollarized and Non-Dollarized Economies

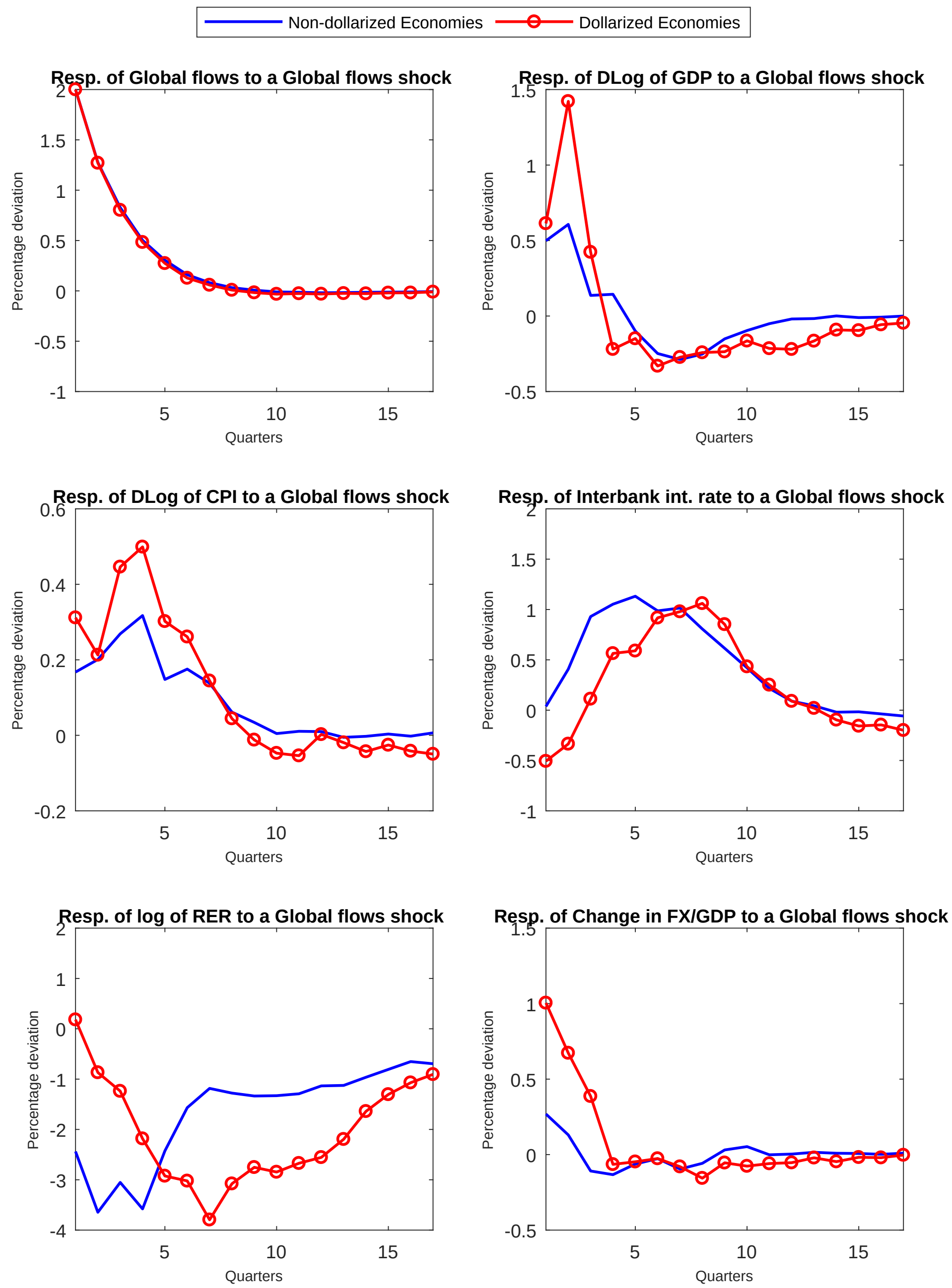

Figure 2: Role of FXI and interest rate reaction in the transmission of global capital flow shock in dollarized economies

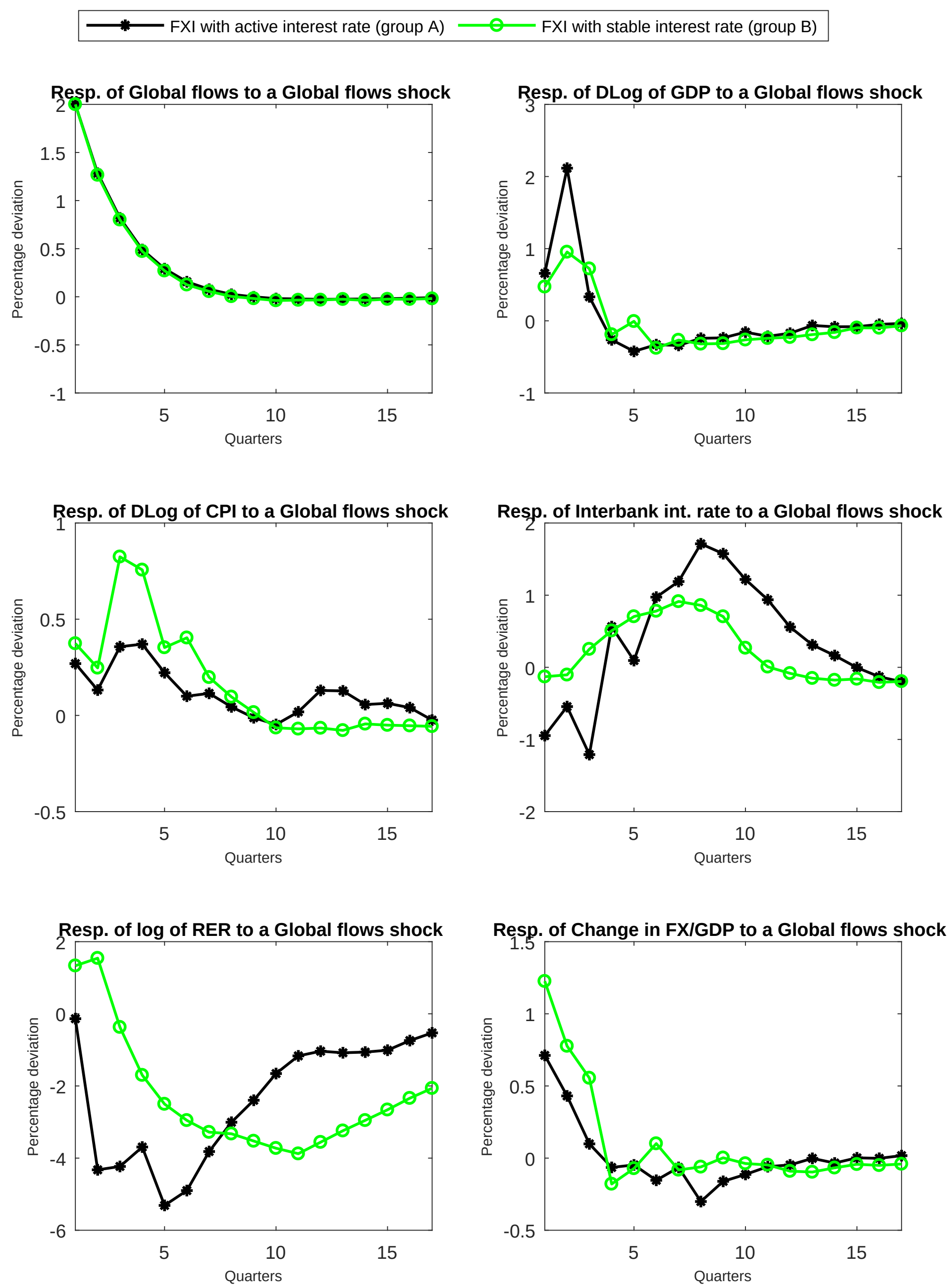

Figure 3: Transmission of exogenous FX Intervention

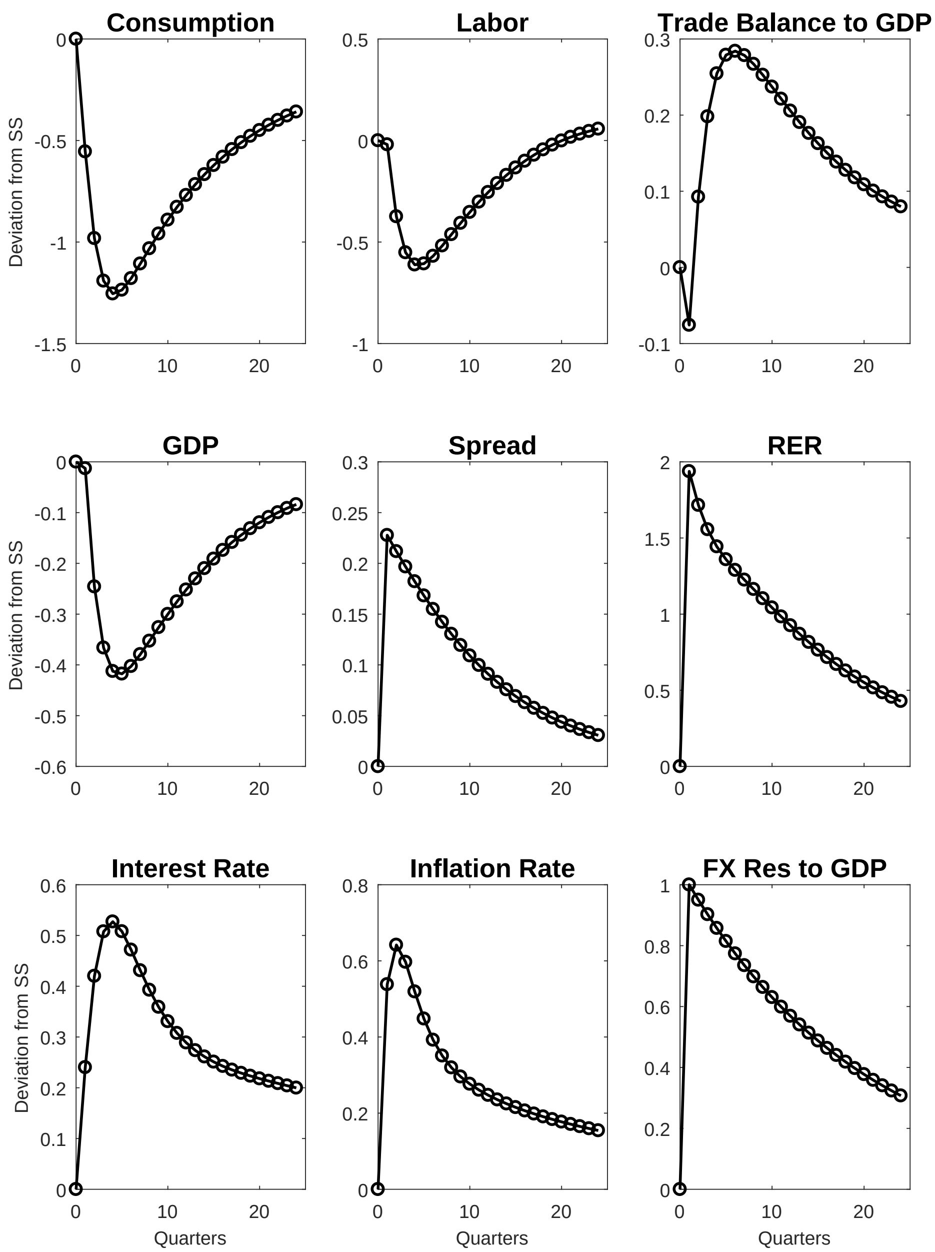

Figure 4: Amplification role of dollarization with constant FX reserves in the model

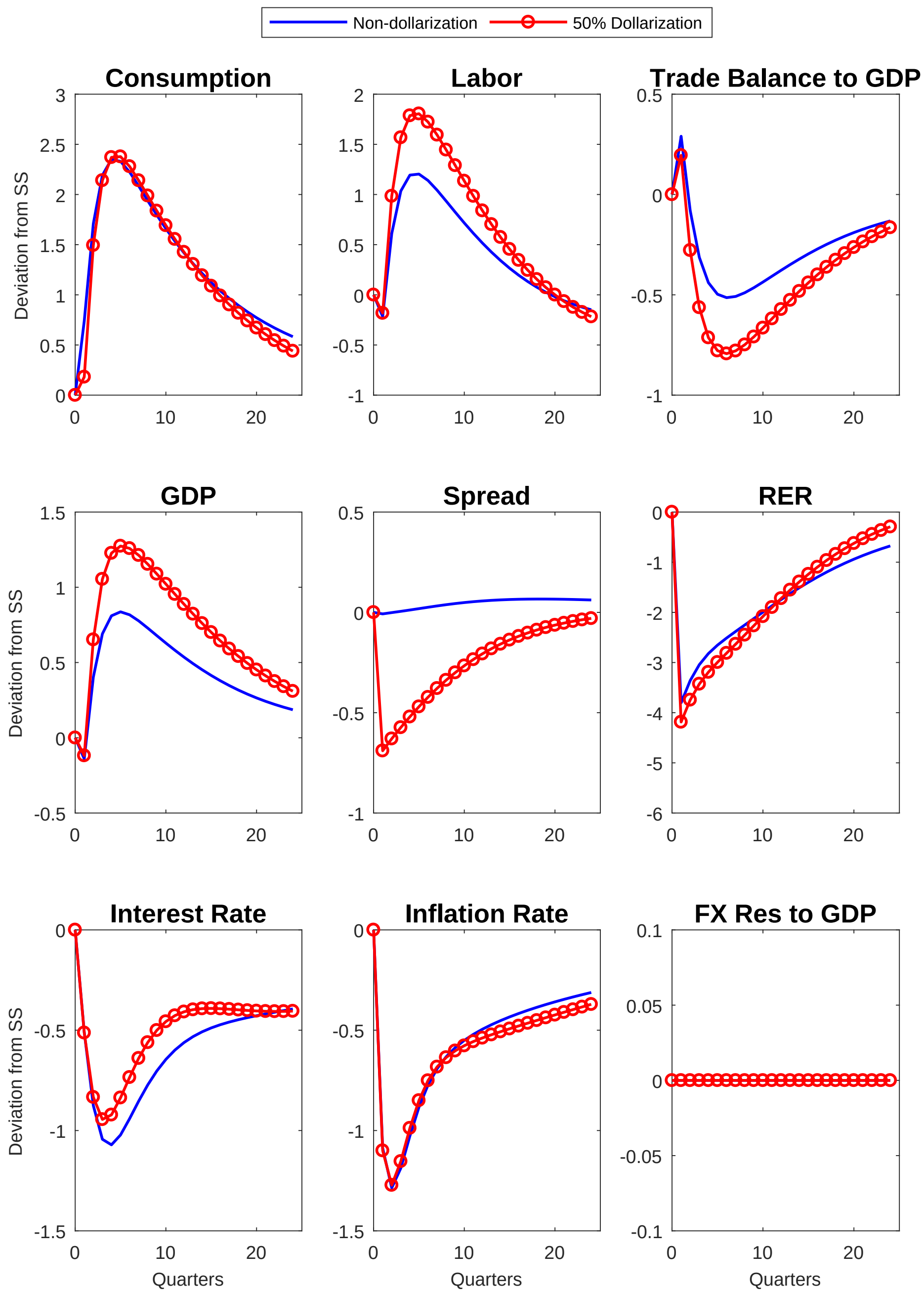

Figure 5: Comparison of policy regimes in the model with 50 percent of dollarization I

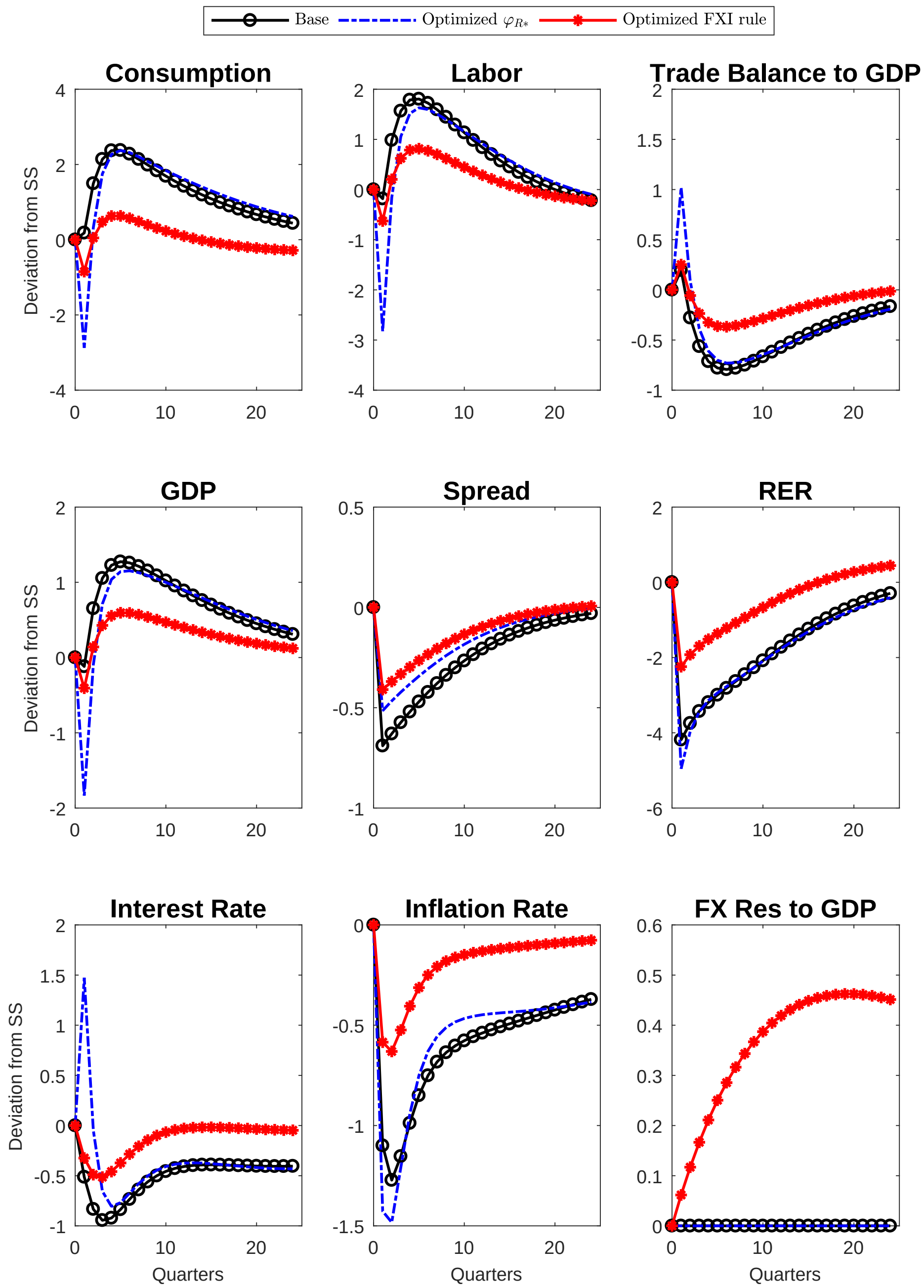

Figure 6: Comparison of policy regimes in the model with 50 percent of dollarization II