Capital controls and foreign currency denomination

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Abstract

This paper studies the effectiveness of capital controls with foreign currency denomination on business cycle fluctuations and the implications for welfare. To do this, we develop a general equilibrium model with financial frictions and banking, in which assets and liabilities are denominated in both domestic and foreign currencies. We propose a non-pecuniary, capital-control policy that limits the gap between foreign-currency denominated loans and deposits to the amount of foreign funds that bankers can borrow from the international credit market. We show that capital controls have a significant impact on the dynamics of assets and liabilities that are denominated in foreign currency. The non-pecuniary capital controls help to stabilize the financial sector, thereby reducing the negative spillovers to the real economy. A more restrictive capital-control policy significantly weakens the welfare effect of the foreign monetary policy and exchange rate shocks.

JEL Classification: E32, E44, E58, F38, F41

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1 Introduction

The increase in foreign currency denominated loans (FCLs) and deposits (FCDs) creates new challenges for the government to manage its capital controls. Large shares of FCLs and FCDs make domestic financial markets more vulnerable to exchange rate risks and foreign monetary policy uncertainties. This, in turn, can have a significant impact on business cycle fluctuations and welfare.

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This paper studies the effectiveness of capital controls with foreign currency denomination[1] on business cycle fluctuations and the implications for welfare. To do this, we develop a small open economy real business cycle model with financial frictions and banking, in which domestic deposits and loans are denominated in both domestic and foreign currencies, and foreign funds are denominated in foreign currency. We propose a non-pecuniary, capital-control policy that limits a fraction of the gap between FCLs and FCDs to the amount of foreign funds that bankers can borrow from the international credit market. We study the transmission mechanisms through which such capital controls with foreign currency denomination affect business cycle fluctuations and welfare.

Over the last few decades, the proportion of FCLs to total loans has increased, reaching significant levels in 2013 (Table 1). In some small open economies[2], such as Romania and Bulgaria, FCLs made up over 60% of total loans. The increasing share of FCLs is not an isolated event, as the share of FCDs has also been increasing significantly in some economies (the second column of Table 1 shows the share of liabilities denominated in foreign currencies).[3] In general, countries that have a high level of FCLs also have a high level of FCDs (Basso et al., 2011).

The general consensus is that the volatility of capital flows can create macroeconomic uncertainties, especially for small open economies. In the aftermath of the recent financial crisis, capital inflows to emerging market economies increased due to the dramatic decline in returns on assets in developed countries. This challenges economists and policy makers to focus, once again, on the effectiveness of capital controls in mitigating the negative external spillovers associated with excessive capital flows. For instance, in 2009, after Brazil's currency appreciated by nearly 40%, its government introduced a 2% levy on foreign investments in certain domestic financial assets in order to restrict capital inflows. In fact, most emerging market economies have introduced various measures of capital controls in the past (Forbes et al., 2015).

The Asian financial crisis (1997–1998) and the recent global financial (2007–2008) crisis reveal the severe impact exchange rate risks can have on the economic growth. Figure 1 plots the growth of real output and real effective exchange rates for some small open economies during these two financial crises. During the Asian financial crisis, South Korea experienced a massive currency depreciation associated with a pronounced reduction in real output growth. Similarly, during the 2007–2008 crisis, most countries suffered a severe currency depreciation and recession. Empirical literature suggests that FCLs exacerbated the spillovers of the Asian crisis (e.g., Eichengreen and Hausmann, 1999). Bordo et al. (2010) show that the risk of having a financial crisis increases if FCLs exceed a certain threshold. As shown in Figure 1, over the past 2–3 years, countries such as Brazil, Hungary, Mexico and South Africa have seen their

[1] This refers to foreign currency denominated borrowings, savings and foreign funds accessed by banks.
[2] These include emerging market economies.
[3] This accounts for deposits in the deposit-taking institutions.

Table 1: Foreign-currency denominated loans and liabilities.

Country	FC loans over total of loans year 2013	FC liabilities over total liabilities year 2013
Austria	18.81	9.96
Brazil	15.24	14.28
Bulgaria	61.16	50.16
Korea	12.84	14.28
Mexico	10.85	12.33
Peru*	40.75	49.60
Poland	28.48	20.19
Romania*	60.92	35.87
South Africa	8.74	6.25
Zambia*	25.73	30.35

Source: International Monetary Fund (IMF), International Financial Statistics, Financial Soundness Indicators. Note: * denotes that the value is taken from the last quarter of the year.

real effective exchange rates depreciated even further than during the 2007–2008 financial crisis. This may be an indication of a potential recession in these economies.

In addition to exchange rate risks, countries with large shares of FCLs and FCDs are also exposed to foreign monetary policy shocks. The empirical literature suggests that borrowers choose FCLs for their relatively lower borrowing costs (e.g., Luca and Petrova, 2008), whereas savers choose FCDs if they expect domestic currency to depreciate in the near future (e.g., Brown and Stix, 2015). Although borrowers and savers choose foreign currencies for different reasons, both are directly exposed to foreign monetary policy shocks. This is simply because the returns on FCLs and FCDs are directly linked to the monetary policy rate of the specific country in whose currency the FCLs and FCDs are denominated (Canova, 2005).

The literature contains very few FCLs- and FCDs- related dynamic stochastic general equilibrium (DSGE) studies. Brzoza-Brzezina et al. (2015) incorporate FCLs (mortgage loans) into a small open economy DSGE model and evaluate its impact on the effectiveness of monetary and macroprudential policies. The authors find that the presence of FCLs weakens the transmission of domestic monetary policy. It has, however, a weakly positive impact on the effectiveness of macroprudential policies – loan-to-value (LTV) ratios and the share of FCLs.

In the literature on capital controls with general equilibrium models, capital controls are mostly modeled as extra pecuniary costs, such as taxes on foreign earnings on domestic bonds (e.g., Jeanne and Korinek, 2010; Bianchi, 2011; Brunnermeier and Sannikov, 2015). For instance, Jeanne and Korinek (2010) show that a time-varying Pigouvian tax on foreign borrowing as a capital-control policy can internalize the external spillovers associated with excessive capital inflows. Chang et al. (2015) use a DSGE model to study the optimal monetary policy and the

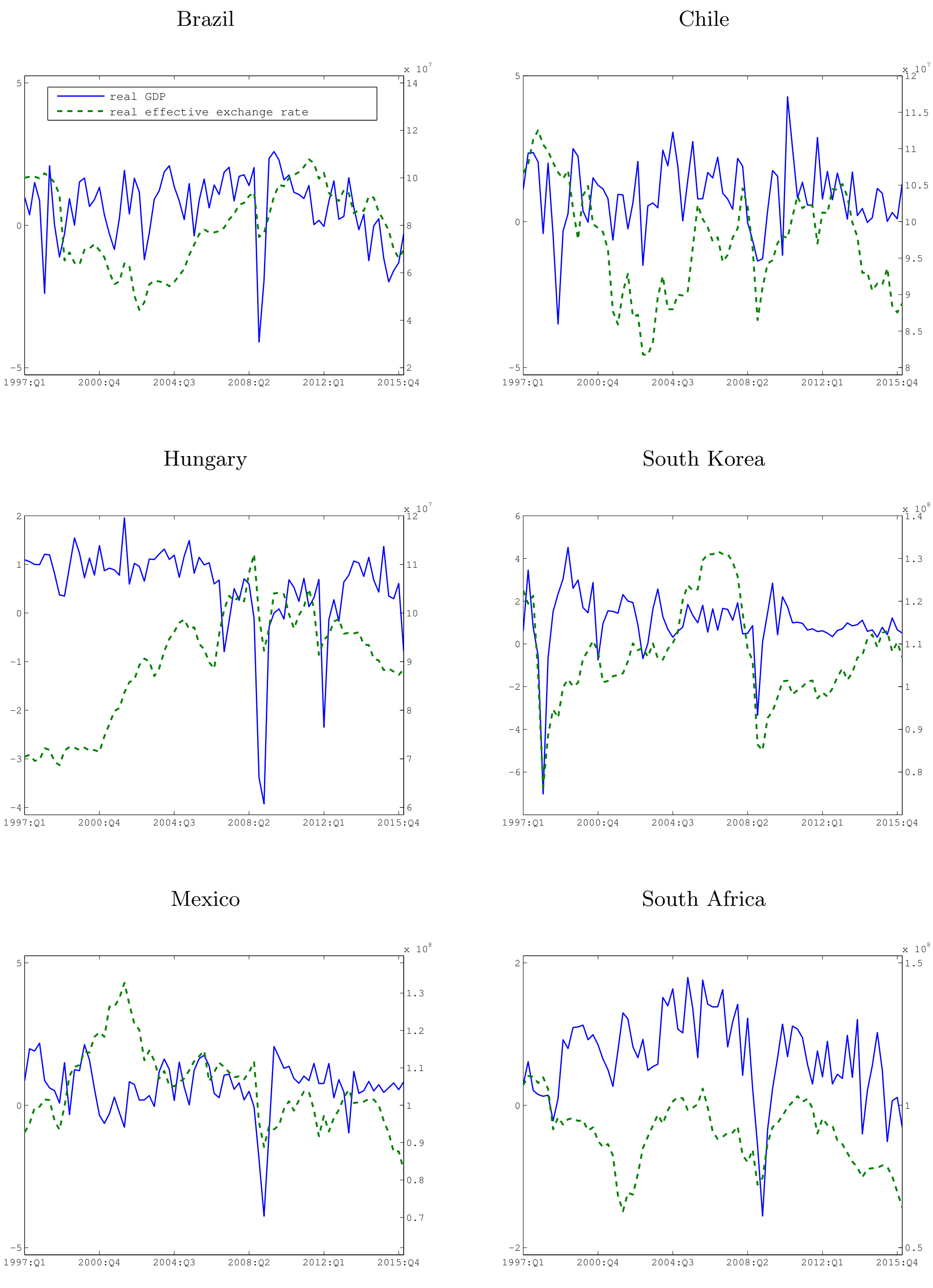

Figure 1: Growth rate of real gross domestic product – solid line (left axis) and real effective exchange rate – dashed line (right axis). Sources: OECD statistics for growth of real gross domestic product (quarterly data, seasonally adjusted) and BIS statistics for real effective exchange rate (local currency against a broad basket of currencies).

effects of sterilization policies with imperfect asset substitutability for China. In the study, the measure of capital controls is governed by a quadratic adjustment cost when households adjust the portfolio share of their domestic bond holdings.

This paper contributes to the literature from two different perspectives. First, to our knowledge, this is the first time the effectiveness of capital controls with foreign currency denomination is studied using a general equilibrium model. Specifically, we develop a coherent general equilibrium model in which all private agents, households (savers), entrepreneurs (borrowers) and bankers (financial intermediaries) are exposed to foreign currency denominations. That said, all private agents are vulnerable to external uncertainties. We argue that, when studying the effectiveness of capital controls, it is critical to consider how foreign currency denomination affects each agent and the interaction between agents in the model economy. Second, we propose a new approach to using pecuniary costs as measures of capital controls, whereby bankers can only finance a fraction of or the full gap between FCLs and FCDs with foreign funds denominated in foreign currency. In this way, we limit the capital inflows and the external spillovers to the domestic economy that are a result of exposure to foreign currency denomination.

Our results show that capital controls have a significant impact on the dynamics of assets and liabilities that are denominated in foreign currency. In general, a more restrictive capital-control policy weakens the negative effect of a contractionary foreign monetary policy shock and the exchange rate shock (a depreciation of domestic currency). This attenuation effect of capital controls is much more pronounced for the financial sector. That said, capital controls help to stabilize the financial sector, thereby reducing the negative spillovers to the real economy.

A contractionary foreign monetary policy shock reduces social welfare, but this negative effect on welfare is significantly reduced through a more restrictive capital-control policy. In contrast, the exchange rate shock has a positive effect on welfare, whereas a more restrictive capital-control policy reduces the welfare gain from the shock. This result is not surprising as the exchange rate uncertainty (to which all private agents are exposed) is much lower in the case of more restrictive capital controls.

The remainder of the paper is structured as follows. Section 2 describes the theoretical model framework. Section 3 presents parameter values. Section 4 investigates the transmission mechanisms through which capital controls with foreign currency denomination affect business cycle fluctuations, and Section 5 presents the corresponding implication for welfare. Section 6 concludes.

2 The model

In this section, we develop a small open economy real business cycle model in which we augment the credit constraint in the spirit of Kiyotaki and Moore (1997). Specifically, we extend a simplified version of the model developed by Iacoviello (2005) into a small open economy with assets and liabilities that are denominated in both domestic and foreign currencies. The model economy is inhabited by households, entrepreneurs, bankers and a government. Bankers intermediate between savers (households) and borrowers (entrepreneurs). We allow both savers and borrowers to have choices of currency denomination when they make their decisions on saving and borrowing; that is, both deposits and loans can be denominated in either domestic or foreign currencies.[4] In addition, we assume that bankers can access foreign funds denominated in foreign currency. The model is designed so that all private agents in the model economy are exposed to exchange rate risks and foreign monetary policy shocks.

The government implements two regulatory policies. One is a minimum bank capital requirement with different risk-weighted coefficients imposed on loans denominated in domestic and foreign currencies. The other one is capital controls. Contrary to taxation- or adjustment cost-based capital controls in the literature (Jeanne and Korinek, 2010; Chang et al., 2015), we propose a policy that limits the gap between FCLs and FCDs to the quantity of foreign funds, which restricts capital inflows.

2.1 Households

The representative household derives utility from consumption (C_t^h), leisure ($1 - N_t$), and holdings of housing (H_t^h). In each period, the representative household can choose to hold bank deposits (D_t) in either domestic currency (D_t^h) or foreign currency (D_t^f). The representative household's optimization problem is defined as follows:

$$\max_{\left\{C_t^h, D_t^h, D_t^f, H_t^h, N_t\right\}_{t=0}^{\infty}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\log\left(C_t^h - \psi_h C_{t-1}^h\right) + \eta \log\left(H_t^h\right) + \varsigma \log\left(1 - N_t\right)\right], \tag{1}$$

subject to the budget constraint:

$$C_t^h + Q_t\left(H_t^h - H_{t-1}^h\right) + D_t\left(1 + \Phi_{d,t}\right) = R_{t-1}^{d,h} D_{t-1}^h + e_t R_{t-1}^{d,f} D_{t-1}^f + W_t N_t, \tag{2}$$

where the parameters $\beta_h, \psi_h, \eta, \varsigma \in (0,1)$ represent the household's discount factor, the habit persistence in consumption, the utility parameter for housing demand and the utility parameter for leisure. To create a spread between deposits denominated in domestic currency (DCDs) and FCDs, we assume that households need to pay a portfolio adjustment cost ($\Phi_{d,t}$) if they adjust

[4] See, e.g., Klein (1971) and Monti (1972) for the literature on the diversification of bank's assets and liabilities.

their holdings of FCDs. $\Phi_{d,t} \equiv \frac{\phi_d}{2}\left(\frac{e_t D_t^f}{D_t} - \mu_d\right)^2$ represents the quadratic portfolio-adjustment cost, where ϕ_d measures the size of the cost and μ_d denotes the steady-state portfolio share of FCDs in total deposits (D_t). Q_t denotes the real price of housing, and e_t is the real exchange rate. $R_t^{d,h}$ and $R_t^{d,f}$ are the gross real returns on DCDs and FCDs, respectively. N_t and W_t are hours worked and real wage rate, respectively. $\mathbb{E}$ is the expectation operator.

Following Brzoza-Brzezina et al. (2015), we aggregate total deposits in both currencies with the following constant elasticity of substitution (CES) function:

$$D_t = \left[(\chi_h)^{\frac{1}{\nu_d}} \left(D_t^h\right)^{\frac{\nu_d - 1}{\nu_d}} + (1-\chi_h)^{\frac{1}{\nu_d}} \left(e_t D_t^f\right)^{\frac{\nu_d - 1}{\nu_d}} \right]^{\frac{\nu_d}{\nu_d - 1}}, \tag{3}$$

where ν_d is the elasticity of substitution between DCDs and FCDs. So long as ν_d is positive (negative), both types of deposits are substitutes (complements). The parameter χ_h measures the preference of households for DCDs.

Denoting λ_t^h as the Lagrange multiplier for the budget constraint (2), the first-order conditions for the representative household are as follows:

$$H_t^h : \lambda_t^h Q_t = \eta \frac{1}{H_t^h} + \beta_h \mathbb{E}_t \lambda_{t+1}^h Q_{t+1}, \tag{4}$$

$$N_t : \lambda_t^h W_t = \varsigma \frac{1}{1 - N_t}, \tag{5}$$

$$C_t^h : \lambda_t^h = \frac{1}{C_t^h - \psi_h C_{t-1}^h} - \beta_h \psi_h \mathbb{E}_t \frac{1}{C_{t+1}^h - \psi_h C_t^h}, \tag{6}$$

$$D_t^h : \beta_h \mathbb{E}_t \lambda_{t+1}^h R_t^{d,h} = \lambda_t^h \frac{\partial D_t}{\partial D_t^h}\left(1 + \Phi_{d,t}\right) + \lambda_t^h D_t \frac{\partial \Phi_{d,t}}{\partial D_t^h}, \tag{7}$$

$$D_t^f : \beta_h \mathbb{E}_t \lambda_{t+1}^h \frac{e_{t+1}}{e_t} R_t^{d,f} = \lambda_t^h \frac{1}{e_t} \frac{\partial D_t}{\partial D_t^f}\left(1 + \Phi_{d,t}\right) + \lambda_t^h D_t \frac{1}{e_t} \frac{\partial \Phi_{d,t}}{\partial D_t^f}. \tag{8}$$

Equation 4 gives the demand function for the holdings of housing, and Equation 5 gives the optimal condition for labor supply. Equation 6 is the optimal decision for consumption. Equations 7 and 8 give the optimal decisions on DCDs and FCDs, respectively, from which we can derive a generalized uncovered interest parity (UIP) condition in the following form:

$$\beta_h \mathbb{E}_t \frac{\lambda_{t+1}^h}{\lambda_t^h} \left(\frac{e_{t+1}}{e_t} R_t^{d,f} - R_t^{d,h} \right) = \left(1 + \Phi_{d,t}\right) \left(\frac{1}{e_t} \frac{\partial D_t}{\partial D_t^f} - \frac{\partial D_t}{\partial D_t^h} \right) + D_t \left(\frac{1}{e_t} \frac{\partial \Phi_{d,t}}{\partial D_t^f} - \frac{\partial \Phi_{d,t}}{\partial D_t^h} \right). \tag{9}$$

The UIP condition here differs from the standard one because DCDs and FCDs are imperfect substitutes. The spread between the exchange-rate-adjusted FCDs rate and DCDs rate is increasing in the portfolio share of FCDs. In the absence of adjustment costs and the depositors' preference, Equation 9 states that the difference between the returns on FCDs and DCDs equals the expected change of the real exchange rate.

2.2 Entrepreneurs

The representative entrepreneur maximizes her expected life-time utility:

$$\max_{\{C_t^e, H_t^e, L_t^h, L_t^f, N_t\}_{t=0}^{\infty}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \log\left(C_t^e - \psi_e C_{t-1}^e\right), \tag{10}$$

subject to the budget constraint (11) and the borrowing constraint (12):

$$C_t^e + Q_t\left(H_t^e - H_{t-1}^e\right) + R_{t-1}^{l,h} L_{t-1}^h + e_t R_{t-1}^{l,f} L_{t-1}^f + W_t N_t = L_t\left(1 - \Phi_{l,t}\right) + Y_t, \tag{11}$$

$$R_t^{l,h} L_t^h + \mathbb{E}_t e_{t+1} R_t^{l,f} L_t^f \leq \gamma\left(\mathbb{E}_t Q_{t+1} H_t^e - W_t N_t\right). \tag{12}$$

$\beta_e, \psi_e \in (0,1)$ are the discount factor and habit persistence parameters for entrepreneurs. C_t^e represents entrepreneurial consumption. Entrepreneurs produce output (Y_t) using a standard Cobb-Douglas function, $Y_t \equiv \left(H_{t-1}^e\right)^{\alpha} \left(N_t\right)^{1-\alpha}$, where H_{t-1}^e is the entrepreneurial housing and $\alpha \in (0,1)$ is the share of entrepreneurial housing in production.

We assume that entrepreneurs can access bank loans that are denominated either in domestic currency (DCLs) or in foreign currency. Like for deposits, total loans are aggregated with the following CES function:

$$L_t = \left[\left(\chi_e\right)^{\frac{1}{\nu_l}} \left(L_t^h\right)^{\frac{\nu_l - 1}{\nu_l}} + \left(1 - \chi_e\right)^{\frac{1}{\nu_l}} \left(e_t L_t^f\right)^{\frac{\nu_l - 1}{\nu_l}}\right]^{\frac{\nu_l}{\nu_l - 1}}, \tag{13}$$

where ν_f is the elasticity of substitution between DCLs (L_t^h) and FCLs (L_t^f). A positive (negative) value of ν_l implies both types of loans are substitutes (complements). χ_e measures the preference of entrepreneurs for DCLs. $\Phi_{l,t} \equiv \frac{\phi_l}{2}\left(\frac{e_t L_t^f}{L_t} - \mu_l\right)^2$ represents the quadratic adjustment cost of changing the portfolio share of FCLs in total loans (L_t). μ_l is the steady-sate portfolio share of FCLs in total loans and ϕ_l measures the size of the cost.

The borrowing constraint (12) states that entrepreneurs can only borrow up to a fraction γ of the expected value of housing minus the wage bill,[5] where γ can be regarded as the LTV ratio. $R_t^{l,h}$ and $R_t^{l,f}$ are the gross real returns on DCLs and FCLs, respectively.

Denoting λ_t^e and λ_t^f as the Lagrange multipliers of constraints (11) and (12), the first order

[5] The borrowing constraint here is similar to that in Neumeyer and Perri (2005) and Iacoviello (2015), where the authors assume that entrepreneurs must pay a fraction of wage bill in advance.

conditions are as follows:

$$C_t^e : \lambda_t^e = \frac{1}{C_t^e - \psi_e C_{t-1}^e} - \beta_e \psi_e \mathbb{E}_t \frac{1}{C_{t+1}^e - \psi_e C_t^e}, \tag{14}$$

$$H_t^e : \lambda_t^e Q_t = \mathbb{E}_t \left(\gamma \lambda_t^f + \beta_e \lambda_{t+1}^e \right) Q_{t+1} + \alpha \beta_e \mathbb{E}_t \lambda_{t+1}^e \frac{Y_{t+1}}{H_t^e}, \tag{15}$$

$$L_t^h : (\lambda_t^f + \beta_e \mathbb{E}_t \lambda_{t+1}^e) R_t^{l,h} = \lambda_t^e \left(1 - \Phi_{l,t}\right) \frac{\partial L_t}{\partial L_t^h} - \lambda_t^e L_t \frac{\partial \Phi_{l,t}}{\partial L_t^h}, \tag{16}$$

$$L_t^f : \mathbb{E}_t \left(\lambda_t^g + \beta_e \lambda_{t+1}^e \right) \frac{e_{t+1}}{e_t} R_t^{l,f} = \lambda_t^e \left(1 - \Phi_{l,t}\right) \frac{1}{e_t} \frac{\partial L_t}{\partial L_t^f} - \lambda_t^e L_t \frac{1}{e_t} \frac{\partial \Phi_{l,t}}{\partial L_t^f}, \tag{17}$$

$$N_t : \left(\lambda_t^e + \gamma \lambda_t^f \right) W_t = (1 - \alpha) \lambda_t^e \frac{Y_t}{N_t}. \tag{18}$$

Equation 14 is the optimal decision for entrepreneurial consumption; Equation 15 is the demand function for entrepreneurial housing; and Equation 18 is the demand for labor. Equations 16 and 17 give the optimal returns on DCLs and FCLs, from which we can derive the UIP condition in terms of the two loan rates:

$$\mathbb{E}_t \frac{\left(\lambda_t^f + \beta_e \lambda_{t+1}^e \right)}{\lambda_t^e} \left(R_t^{l,h} - \frac{e_{t+1}}{e_t} R_t^{l,f} \right) = \left(1 - \Phi_{l,t}\right) \left(\frac{1}{e_t} \frac{\partial L_t}{\partial L_t^f} - \frac{\partial L_t}{\partial L_t^h} \right) - L_t \left(\frac{1}{e_t} \frac{\partial \Phi_{l,t}}{\partial L_t^f} - \frac{\partial \Phi_{l,t}}{\partial L_t^h} \right). \tag{19}$$

The implications are similar to (9) and, in the absence of the portfolio-adjustment cost and borrowers' preference to the currency in which loans are denominated, the interest rate differential between the two loan rates should equal the expected change in the real exchange rate.

2.3 Bankers

In the model economy, bankers intermediate between borrowers and savers. In addition to FCDs and FCLs, we further assume that bankers can access foreign funds (B_t) that are also denominated in foreign currency. This assumption serves two purposes. First, it allows us to propose a capital-control policy that limits the gap between FCLs and FCDs to the quantity of foreign funds (capital inflows). Second, it provides a monetary transmission from the foreign economy to the domestic economy, through which the foreign monetary policy shock hits the financial sector directly and passes on the external spillovers to the real sector.

The representative banker maximizes her expected life-time utility:

$$\max_{\left\{C_t^b, D_t^h, D_t^f, L_t^h, L_t^f\right\}_{t=0}^{\infty}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \log \left(C_t^b - \psi_b C_{t-1}^b \right), \tag{20}$$

subject to the budget constraint (21), the minimum of bank capital requirement (22), the capital-control constraint (23) and the non-negativity constraint on foreign funds (24):

$$C_t^b + e_t R_{t-1}^b B_{t-1} + R_{t-1}^{d,h} D_{t-1}^h + e_t R_{t-1}^{d,f} D_{t-1}^f + L_t^h + e_t L_t^f = \tag{21}$$

$$e_t B_t \left(1 - \Phi_{b,t}\right) + D_t^h + e_t D_t^f + R_{t-1}^{l,h} L_{t-1}^h + e_t R_{t-1}^{l,f} L_{t-1}^f,$$

$$e_t \left(B_t + D_t^f\right) + D_t^h \leq (1 - \kappa\phi_h) L_t^h + \left(1 - \kappa\phi_f\right) e_t L_t^f, \tag{22}$$

$$\sigma e_t \left(L_t^f - D_t^f\right) \leq e_t B_t, \tag{23}$$

$$B_t \geq 0, \tag{24}$$

where $\beta_b, \psi_b \in (0, 1)$ are the discount factor and the habit persistence parameter for bankers, respectively. C_t^b is the banker's consumption. R_t^b is the return on foreign funds, which is the foreign monetary policy rate. $\Phi_{b,t} \equiv \frac{\phi_b}{2}\left(\frac{e_t B_t}{e_{t-1}B_{t-1}} - 1\right)^2$ represents the adjustment cost of varying the holdings of foreign funds, where $\phi_{b,t}$ measures the size of the cost.

We assume that bankers are subject to a minimum capital requirement with different risk-weighted coefficients on DCLs and FCLs. That is, $BK_t \geq \kappa\left(\phi_h L_t^h + \phi_f e_t L_t^f\right)$, where $\kappa \in (0, 1)$ is the required capital-asset ratio and, ϕ_h and ϕ_f are the risk-weighted coefficients on DCLs and FCLs, respectively. Bank capital is defined as $BK_t = L_t^h + e_t L_t^f - e_t B_t - D_t^h - e_t D_t^f$.

Equation 23 is the proposed capital-control policy that limits the gap between FCLs and FCDs to the quantity of foreign funds, which restricts capital inflows. Under the case of $\sigma = 1$, the difference between FCLs and FCDs is funded completely by foreign funds. We define it as the *full-cover foreign currency denomination* case, which is a less restrictive capital control regulation. Under the case of $0 < \sigma < 1$, capital controls become more restrictive as capital inflows can fund only a fraction of the gap between FCLs and FCDs. We define it as the *partial-cover foreign currency denomination* case.[6]

A non-negativity constraint of foreign funds (24) implies that the economy is a net borrower in the international credit market, which is the case for most small open economies. In addition, it implies that the gap between FCLs and FCDs is already positive.

Denoting λ_t^a, λ_t^b, λ_t^c and λ_t^d as the Lagrange multipliers for constraints (24), (21), (22) and

[6] We only consider that $0 < \sigma \leq 1$. This implies that bankers are not allowed to use foreign funds to finance assets other than the gap between FCLs and FCDs.

(23), the first-order conditions are as follows:

$$C_t^b : \lambda_t^b = \frac{1}{C_t^b - \psi_b C_{t-1}^b} - \beta_b \psi_b \mathbb{E}_t \frac{1}{C_{t+1}^b - \psi_b C_t^b}, \tag{25}$$

$$B_t : \lambda_t^a + \lambda_t^b \left(1 - B_t \frac{\partial \Phi_{b,t}}{\partial B_t} - \Phi_{b,t}\right) - \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} B_{t+1} \frac{\partial \Phi_{b,t+1}}{\partial B_t} - \lambda_t^c + \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^b, \tag{26}$$

$$D_t^h : \lambda_t^b - \lambda_t^c = \beta_b \mathbb{E}_t \lambda_{t+1}^b R_t^{d,h}, \tag{27}$$

$$D_t^f : \lambda_t^b - \lambda_t^c + \sigma \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^{d,f}, \tag{28}$$

$$L_t^h : \lambda_t^b - (1 - \kappa \phi_h) \lambda_t^c = \beta_b \mathbb{E}_t \lambda_{t+1}^b R_t^{l,h}, \tag{29}$$

$$L_t^f : \lambda_t^b - \left(1 - \kappa \phi_f\right) \lambda_t^c + \sigma \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^{l,f}. \tag{30}$$

Equation 25 is the optimal decision for bankers' consumption. Equation 26 gives the optimal return on foreign funds.[7] Using (27) and (28), we can derive the interest rate differential between the returns on FCDs and DCDs:

$$\beta_b \mathbb{E}_t \lambda_{t+1}^b \left(\frac{e_{t+1}}{e_t} R_t^{d,f} - R_t^{d,h}\right) = \sigma \lambda_t^d. \tag{31}$$

The spread between deposits denominated in foreign and domestic currencies is found to be increasing in σ. Under the *partial-cover foreign currency denomination* case, the more restrictive the capital-control policy is, the smaller the spread is. In steady state, so long as the budget and capital-control constraints are binding ($\lambda^b, \lambda^d > 0$), the spread is always positive in the presence of capital controls ($\sigma > 0$).

Similarly, combining (29) and (30) gives the spread between the returns on DCLs and FCLs:

$$\beta_b \mathbb{E}_t \lambda_{t+1}^b \left(R_t^{l,h} - \frac{e_{t+1}}{e_t} R_t^{l,f}\right) = \kappa \left(\phi_h - \phi_f\right) \lambda_t^c - \sigma \lambda_t^d. \tag{32}$$

The spread depends positively on the capital-asset ratio (κ) and the difference between the corresponding risk-weighted coefficients (ϕ_h and ϕ_f) for DCLs and FCLs. In contrast, it is negatively related to capital controls. In steady state, with the presence of both bank capital requirement and capital controls ($\kappa, \sigma > 0$), this spread will always be positive if $\kappa \left(\phi_h - \phi_f\right) \lambda^c > \sigma \lambda^d$. Otherwise, the spread will be negative, implying that FCLs are more expensive than DCLs ($R_t^{l,f} > R_t^{l,h}$).

The spread between returns on FCLs and foreign funds can be derived by combining (26)

[7] One implicit assumption here is that foreign funds are demand driven, whereas the supply of foreign funds is inelastic.

and (30):

$$\beta_b \mathbb{E}_t \lambda^b_{t+1} \frac{e_{t+1}}{e_t} \left(R^{l,f}_t - R^b_t\right) = \kappa \phi_f \lambda^c_t - (1-\sigma)\lambda^d_t + \lambda^b_t \left(B_t \frac{\partial \Phi_{b,t}}{\partial B_t} + \Phi_{b,t}\right) + \beta_b \mathbb{E}_t \lambda^b_{t+1} \frac{e_{t+1}}{e_t} B_{t+1} \frac{\partial \Phi_{b,t+1}}{\partial B_t} - \lambda^a_t, \tag{33}$$

which shows that the spread depends positively on the demand of foreign funds. In steady state, Equation 33 becomes:

$$R^{l,f} - R^b = \left[\kappa \phi_f \lambda^c - (1-\sigma)\lambda^d - \lambda^a\right] / \beta_b \lambda^b. \tag{34}$$

In the presence of bank capital requirements and capital controls, the higher the parameters κ, ϕ_f and σ are, the higher the spread is.

From condition (34) we can define the condition for the non-negative foreign funds:[8]

$$R^{l,f} - R^{d,f} = \kappa \phi_f \lambda^c / \beta_b \lambda^b. \tag{35}$$

That is, the return on FCLs needs to be greater than the return on FCDs, which is the case in reality. Otherwise, $B = 0$, when $R^{d,f} > R^{l,f}$.

By combining (26) and (28), we can express the spread between the rates of foreign funds and of the FCDs:

$$\beta_b \mathbb{E}_t \lambda^b_{t+1} \frac{e_{t+1}}{e_t} \left(R^b_t - R^{d,f}_t\right) = \lambda^a_t + (1-\sigma)\lambda^d_t - \lambda^b_t \left(B_t \frac{\partial \Phi_{b,t}}{\partial B_t} + \Phi_{b,t}\right) - \beta_b \mathbb{E}_t \lambda^b_{t+1} \frac{e_{t+1}}{e_t} B_{t+1} \frac{\partial \Phi_{b,t+1}}{\partial B_t}, \tag{36}$$

which indicates that the spread depends negatively on the demand of foreign funds. In steady state, this spread becomes:

$$R^b - R^{d,f} = \left[\lambda^a + (1-\sigma)\lambda^d\right] / \beta_b \lambda^b. \tag{37}$$

It indicates that the spread is always positive in the presence of capital controls and the binding constraints of (21), (23) and (24). Moreover, a more restrictive capital control (a smaller value of σ) increases the spread.

An additional condition for a non-negative value of foreign funds arises from (37):

$$R^b - R^{d,f} \geq (1-\sigma)\lambda^d / \beta_b \lambda^b. \tag{38}$$

That is, with the binding constraint of capital controls, the return on FCDs ($R^{d,f}$) cannot be greater than the return on foreign funds (R^b). Intuitively, foreign funds are a more expensive resource than deposits denominated in both domestic and foreign currencies.

[8] This is obtained by equalizing $\lambda^a = \left[\kappa \phi_f \lambda^c - (1-\sigma)\lambda^d - \beta_b \lambda^b \left(R^{l,f} - R^b\right)\right]$ from (34) with the solution of λ^a from (36): $\left[\kappa \phi_f \lambda^c - (1-\sigma)\lambda^d - \beta_b \lambda^b \left(R^{l,f} - R^b\right)\right] = \beta_b \lambda^b \left(R^b - R^{d,f}\right) - (1-\sigma)\lambda^d$.

Based on the steady-state conditions discussed above, the relationship between the interest rates is summarized as follows:

$$R^{l,h} \lesseqgtr R^{l,f} > R^b \geq R^{d,f} \geq R^{d,h}. \tag{39}$$

2.4 Government

The government implements two regulatory policies: a minimum bank-capital requirement and capital controls. For the former, the government implements a minimum capital requirement in the banking sector, with an additional restriction of different risk weights on loans denominated in domestic and foreign currencies (22). For the latter, bankers can only finance a fraction of or the gap between foreign currency denominated loans and deposits with capital inflows (23).

2.5 Foreign sector

The foreign sector in the model is considered to be exogenous. For the sake of simplicity, we assume the foreign funds rate is equivalent to the foreign monetary policy rate. The foreign interest rate evolves as a logarithmic AR(1) process:

$$\log\left(R_t^b\right) = (1-\rho_r)\log\left(R^b\right) + \rho_r \log\left(R_{t-1}^b\right) + \xi_{r,t}, \tag{40}$$

where ρ_r is the persistence coefficient and $\xi_{r,t}(0, \sigma_r^2)$ is the foreign interest rate shock.

We also assume that the exchange rate follows a logarithmic AR(1) process:

$$\log\left(e_t\right) = (1-\rho_e)\log\left(e\right) + \rho_e \log\left(e_{t-1}\right) + \xi_{e,t}, \tag{41}$$

where ρ_e is the persistence coefficient and $\xi_{e,t}(0, \sigma_e^2)$ is the exchange rate shock.

2.6 Market clearing

The following two equations summarizes the market-clearing conditions. The housing market is closed as follows:

$$H_t^e + H_t^h = H, \tag{42}$$

whereas, the aggregate resource condition is given by:

$$Y_t = e_t\left(R_{t-1}^b B_{t-1} - B_t\right) + C_t^b + C_t^e + C_t^h + \Phi_{b,t} + \Phi_{d,t} + \Phi_{l,t}. \tag{43}$$

3 Parameter values

This section presents the parameter values used in our analysis. The model's time period is a quarter. The discount factors for households, entrepreneurs and bankers are set at $\beta_h = 0.99$, $\beta_e = 0.945$ and $\beta_b = 0.962$, respectively. The preference coefficient for housing (η) in utility is set at 0.075, and the share of housing in production (α) is set at 0.04. These parameter values yield an annualized real state value-to-output ratio of 2.2650, which is midway between 1.36 in Iacoviello and Neri (2010) and 3.1 in Iacoviello (2015). The leisure parameter in utility, $\varsigma = 1.8$, implies a labor supply close to 40%. The LTV ratio (γ) is set at 0.9. Following the real business cycle literature, the habit persistence parameters for households, entrepreneurs and bankers are all set at 0.7, $\psi_b = \psi_e = \psi_h = 0.7$.

For the substitution parameter of loans denominated in different currencies, ν_l is set at 6, which is the same as in Brzoza-Brzezina et al. (2015). By assigning a positive value of ν_l, we assume that loans denominated in different currencies are substitutes.[9] We set the same value at the substitution parameter of deposits denominated in different currencies.[10] In addition, we want to characterize an economy where domestic-currency denomination is preferred. For this, both $\chi_e = \chi_h = 0.52$, which yields an approximate 10% preference for domestic currency denomination over foreign currency (home bias). The parameter that measures the size of the portfolio-adjustment cost for FCLs is $\phi_l = 0.8$. This is based on the study by Chang et al. (2015) that finds an estimated portfolio-adjustment cost parameter for DCLs of 0.22 for 22 emerging market economies. For simplicity, we set parameters that measure the size of adjustment costs for FCDs and foreign funds, $\phi_b = \phi_d = 1$. Based on our simulation results, the steady-state portfolio shares for FCDs (μ_d) and FCLs (μ_l) are 0.47 and 0.48, respectively, which are close to the average values for the selected countries reported in Table 1.

We set a 10% minimum of bank capital requirement ($\kappa = 0.10$), which is in line with the value established by the Basel Accord and the literature (e.g., Van den Heuvel, 2008). The risk-weighted coefficient for DCLs (ϕ_h) is set at 1.02, approximately 2% higher than that for FCLs, $\phi_f = 1.005$. This implies that the regulatory authority views FCLs as being less risky than DCLs. Together with the calibrated parameter values in (32), we have the scenario that the return on FCLs is lower than that on DCLs, which is along the lines of empirical literature (e.g., Luca and Petrova, 2008; Basso et al., 2011). For capital controls, in the baseline case we consider that bankers can use foreign funds to finance only half of the gap between FCLs and DCLs, that is $\sigma = 0.5$.

It is important to mention that the parameter values are chosen so that spreads between foreign funds, domestic- and foreign-currency denominated loans and deposits exist. Nonetheless, the parameter values chosen are in line with the literature. The assigned parameter values

[9] The size of ν_l does not affect the quality of our results.

[10] Here we want to characterize deposits are substitutes, the same as loans.

discussed above result in annualized returns of 4.04% and 5.23% on DCDs and DCLs, respectively. In steady state, the relation between the interest rates in (39) can be summarized as follows:

$$R^{l,h} > R^{l,f} > R^{b} > R^{d,f} > R^{d,h}. \tag{44}$$

Table 2: Parameter values.

Parameter	Value	Description
α	0.04	Housing share in production
β_b	0.962	Discount factor for bankers
β_e	0.945	Discount factor for entrepreneurs
β_h	0.99	Discount factor for households
η	0.075	Coefficient for housing in utility
χ_e	0.52	Preference parameter for DCLs
χ_h	0.52	Preference parameter for DCDs
γ	0.9	Loan-to-value ratio
H	1	Total of housing
κ	0.10	Minimum bank capital requirement ratio
ν_d	6	Elasticity of substitution for deposits
ν_l	6	Elasticity of substitution for loans
ς	1.8	Coefficient for leisure in utility
σ	0.5	Parameter for capital controls (baseline)
ϕ_b	1	Adjustment cost parameter for foreign funds
ϕ_d	1	Adjustment cost parameter for FCDs
ϕ_l	0.8	Adjustment cost parameter for FCLs
μ_l	0.48	Steady-state portfolio share for FCLs
μ_d	0.47	Steady-state portfolio share for FCDs
ϕ_h	1.02	Risk-weighted coefficient for DCLs
ϕ_f	1.005	Risk-weighted coefficient for FCLs
ψ_b	0.7	Habit persistence parameter for bankers
ψ_e	0.7	Habit persistence parameter for entrepreneurs
ψ_h	0.7	Habit persistence parameter for households
ρ_e	0.7	Persistence coefficient for exchange rate shock
ρ_r	0.7	Persistence coefficient for foreign monetary policy shock

4 Capital controls with foreign currency denomination

Foreign currency denominated borrowings and savings make private agents more vulnerable to exchange rate risks and foreign monetary policy uncertainties, which in turn can have a significant impact on business cycle fluctuations. It also creates challenges for government to manage its capital controls. In this section, we study the transmission mechanisms through which capital controls with foreign currency denomination affect business cycle fluctuations. We consider cases of *partial-cover foreign currency denomination* ($\sigma = 0.5, 0.75$) and the case of *full-cover foreign currency denomination* where $\sigma = 1$. Section 4.1 discusses business cycle fluctuations in response to a foreign monetary policy shock, while section 4.2 discusses the model dynamics in response to an exchange rate shock.[11]

4.1 Foreign monetary policy shock

Figures 2 and 3 plot the impulse response functions (IRFs) of the key macroeconomic and financial variables to an unexpected contractionary foreign monetary policy shock (of one percent). We first look at the baseline case – *partial-cover foreign currency denomination* capital controls with $\sigma = 0.5$ (solid line), which implies that bankers use foreign funds to finance up to half of the gap between FCLs and FCDs. We then compare the dynamics of the baseline case with varying levels of capital controls.

A contractionary foreign monetary policy shock results in a decline in aggregate consumption, housing prices, entrepreneurial housing and foreign funds. The foreign monetary policy shock affects the domestic economy through the following transmission mechanisms. The increased foreign funds' rate decreases the demand for foreign funds, which limits the bankers' capacity to supply FCLs and, in turn, increases the FCL rate. The higher FCL rate discourages entrepreneurs from borrowing, while also increasing their financing costs. At the same time, entrepreneurs face a rising wage bill. Entrepreneurs are forced to sell their housing holdings, which results in a decline in the housing price. This deteriorates entrepreneurs' collateral value and causes a further decline in the demand for loans denominated in both domestic and foreign currencies.

To meet the regulation of capital controls (23), bankers need to adjust their portfolios – the decline in both foreign funds and FCLs requires bankers to reduce their holdings of FCDs. In addition, given the binding bank capital requirement constraint (22), DCDs have to fall as well. Another force also drives DCDs to fall. Given the aggregation of housing in our model setup, households need to increase their housing holdings because entrepreneurs are selling houses in response to the shock. This results in a decline in DCDs even though the spread between the

[11] Notice that the spreads displayed in the figures are defined as follows. The spread for deposits: $R_t^{d,f} - R_t^{d,h}$; the spread for loans: $R_t^{l,h} - R_t^{l,f}$.

returns on DCDs and FCDs increases after the shock. These findings are consistent with those of Ostry et al. (2012) whose empirical study finds that capital controls can help reduce lending in foreign currencies and lower the associated risk.

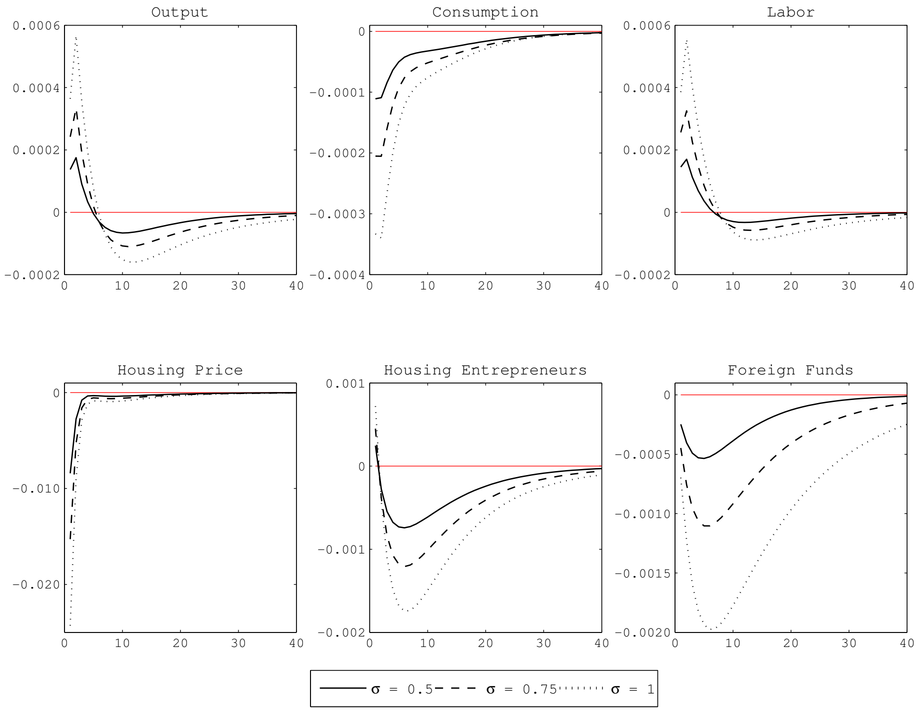

Figure 2: IRFs to a foreign interest rate shock: Selected variables under different values of σ.

The negative effect of the shock on the financial sector passes onto the real economy, resulting in a decline in aggregate consumption and output. An open economy with exposure to foreign currency denomination is vulnerable to foreign monetary policy shocks. However, in the first two periods after the shock, output increases temporarily but then declines persistently. This is a result of the increased hours worked in response to the shock and a relative high labor-output share (0.96) in the production function, compared to a labor-output share of 0.6–0.7 in the real business cycle literature, where a standard production function inlcudes the inputs of physical capital and labour.

Keeping in mind the baseline case analysis, we now explore how the tightness of capital controls affects business cycle fluctuations. In figures 2 and 3, the dashed line represents less restrictive capital controls ($\sigma = 0.75$) compared to the baseline, whereas the dotted line represents the *full-cover foreign currency denomination* case ($\sigma = 1$). In general, a more restrictive capital-control policy (smaller value of σ) weakens the negative effect of the foreign monetary policy shock. This weakening effect of capital controls is more pronounced for the financial sector. From the responses of the financial variables, we can see that a more restrictive capital-control policy helps to stabilize the financial sector and so reduces the negative spillovers

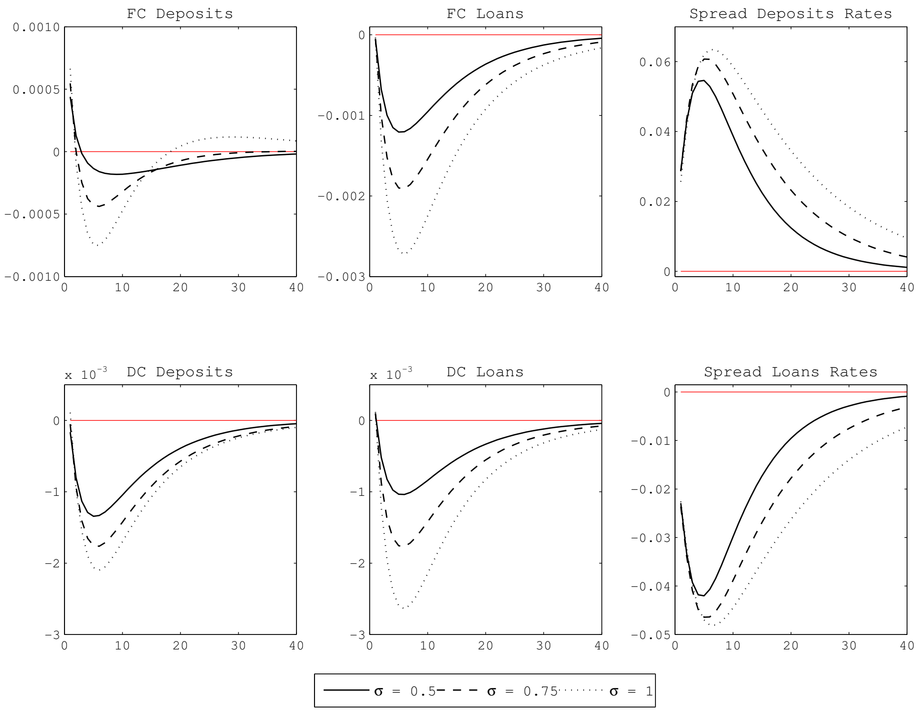

Figure 3: IRFs to a foreign interest rate shock: Financial variables under different values of σ.

to the real economy.

4.2 Exchange rate shock

We now turn to exchange rate risks. As discussed before, the model assumes that bankers can access foreign funds denominated in foreign currency, and so borrowers, savers and financial intermediaries are directly exposed to exchange rate risks. Figures 4 and 5 plot the IRFs of the main variables in response to a one percent increment in the exchange rate.

The shock affects households and entrepreneurs differently. Under the baseline case ($\sigma = 0.5$), the appreciation of the foreign currency raises the value of FCDs in domestic currency. This positive wealth effect decreases the hours worked and increases leisure time. However, the shock increases entrepreneurs' financing costs for FCLs, resulting in a decrease in the demand for FCLs, while the decrease in the loan spread makes DCLs more attractive to entrepreneurs. In addition, the decrease in their wage bill enables entrepreneurs to demand more DCLs through the collateral constraint channel. These two factors contribute to the increase in DCLs.

Capital controls have a significant impact on the dynamics of assets and liabilities denominated in foreign currency. The exchange rate shock affects the spreads of deposits and loans differently. The appreciation of foreign currency decreases the spread between DCLs and FCLs, which increases the demand for DCLs, as they are relatively cheaper than FCLs. In contrast, the shock increases the spread between FCDs and DCDs, making FCDs more attractive, but FCDs decrease in response to the shock (Figure 5) because the appreciation of foreign currency makes foreign funds cheaper than before. Bankers increase the holdings of foreign funds. To ensure the capital control constraint is satisfied, the decrease in FCDs must be greater than the decrease in FCLs. Indeed, our results confirm this transmission mechanism, through which capital controls have a significant impact on dynamics of FCDs and FCLs.

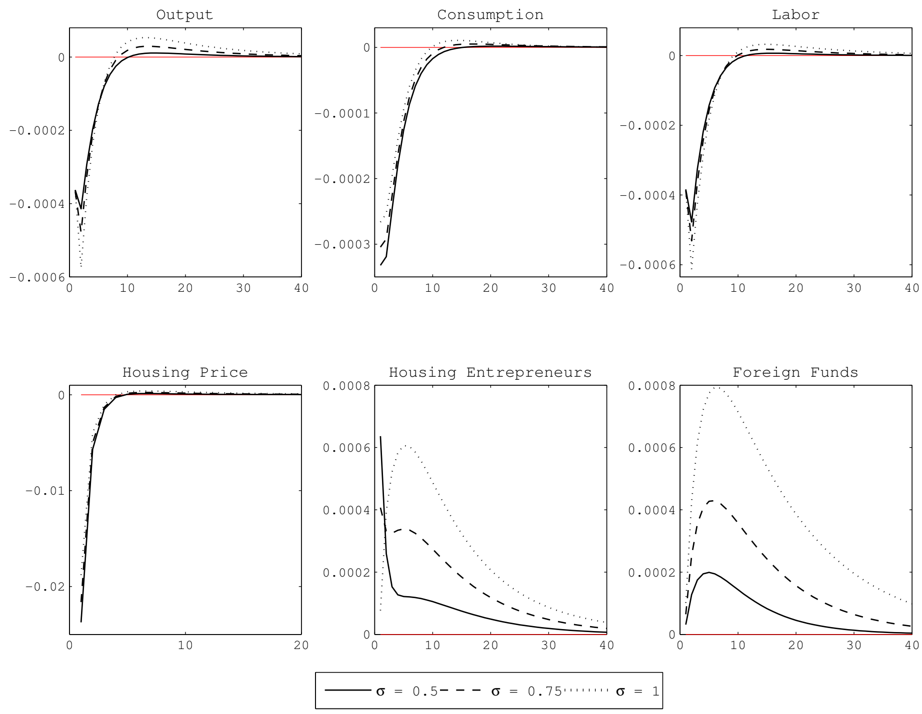

Figure 4: IRFs to an exchange rate shock: Selected variables under different values of σ.

We now look at how the tightness of capital controls affects business cycle fluctuations under the case of exchange rate shocks. Even though changes in the tightness of capital controls do not have a significant impact on the spreads (both deposits and loans), they do have a significant impact on the quantitative financial variables, deposits and loans denominated in domestic and foreign currencies and foreign funds. In contrast to foreign monetary policy shocks, the significant impact of capital controls on FCDs and FCLs works directly through the capital-control constraint on quantitative financial variables, not through the spreads. In general, the more restrictive the capital-control policy is, the less volatile the responses of the quantitative financial variables are. In addition, with a more restrictive capital-control policy, such as *partial-cover foreign currency denomination* ($\sigma = 0.5$), the financial sector stabilizes much quicker than otherwise. This finding contradicts the empirical evidence found by Glick and Hutchison (2005), whereby countries with less restrictive capital controls tend to be less

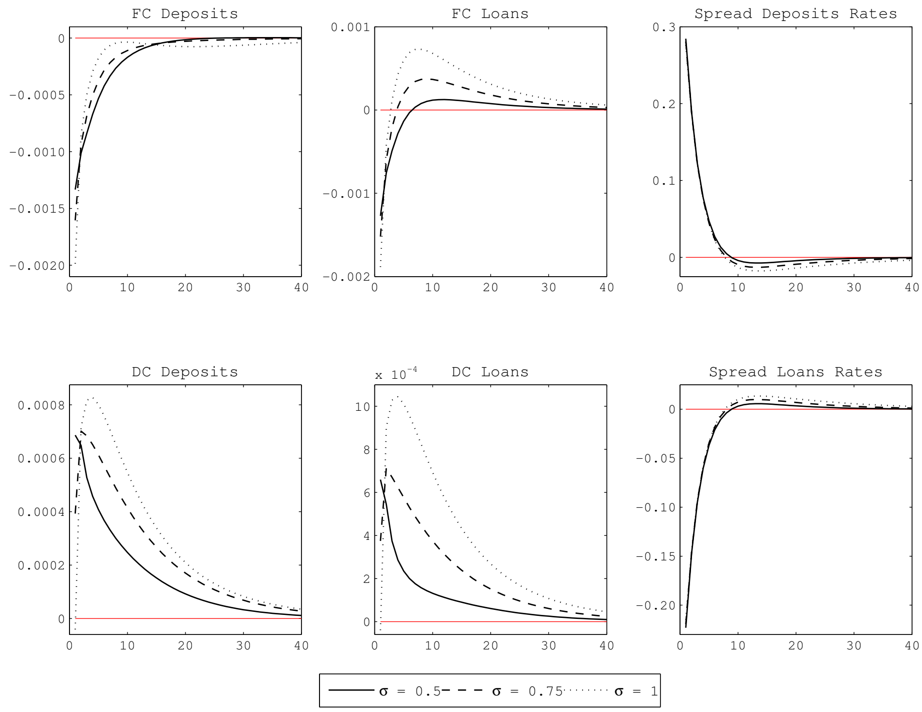

Figure 5: IRFs to an exchange rate shock: Financial variables under different values of σ.

prone to speculative currency attacks.[12] For the exchange rate shock, the conclusion is the same as for the foreign monetary policy shock: a more restrictive capital-control policy helps to stabilize the financial sector and reduce the negative effect of the shock on the real economy. It is worth pointing out that this attenuation effect is much weaker in the case of exchange rate shock, especially for the real sector. As shown in Figure 4, the differences are extremely marginal between the IRFs of output, consumption and hours worked in cases of *full-cover foreign currency denomination* and *partial-cover foreign currency denomination*.

5 Welfare analysis

We conduct the welfare analysis on capital controls with foreign currency denomination. Following Mendicino and Pescatori (2007) and Rubio (2014), we define each agent's welfare as follows:

[12]Notice that our study is not looking at the case of currency crisis as in Glick and Hutchison (2005).

$$W_t^h \equiv \sum_{t=0}^{\infty} \beta_h^t \left[\log\left(C_t^h - \psi_h C_{t-1}^h\right) + \eta \log\left(H_t^h\right) + \varsigma \log\left(1 - N_t\right)\right], \tag{45}$$

$$W_t^e \equiv \sum_{t=0}^{\infty} \beta_e^t \left[\log\left(C_t^e - \psi_e C_{t-1}^e\right)\right], \tag{46}$$

$$W_t^b \equiv \sum_{t=0}^{\infty} \beta_b^t \left[\log\left(C_t^b - \psi_b C_{t-1}^b\right)\right], \tag{47}$$

where the social welfare is the weighted sum of the individual agent's welfare:

$$SW_t = \left(1 - \beta_h\right) W_t^h + \left(1 - \beta_e\right) W_t^e + \left(1 - \beta_b\right) W_t^b. \tag{48}$$

Figure 6 plots the dynamics of social welfare in response to the foreign monetary policy shock (left panel) and the exchange rate shock (right panel) with different levels of capital controls. A contractionary foreign monetary policy shock reduces social welfare, and a more restrictive capital-control policy significantly attenuates the shock's negative effect on welfare. The exchange rate shock (the depreciation of domestic currency) has a positive effect on welfare, whereas a more restrictive capital-control policy reduces the welfare gain from the shock.[13]

A foreign policy rate hike hits the financial sector directly – deposits and loans denominated in both domestic and foreign currencies decline, and so do foreign funds. The shrunken bank balance sheet not only reduces bankers' consumption (hence welfare), but also deteriorates the bankers' ability to extend credits to entrepreneurs. Subsequently entrepreneurs' consumption declines. Households' welfare decreases due to the decline in both consumption and leisure. Therefore, the negative spillovers of the foreign monetary policy shock result in a significant deterioration in social welfare.

A more restrictive capital-control policy mitigates the foreign monetary policy shock's negative effect on welfare. As shown in figures 2 and 3, a more restrictive capital-control policy reduces the shrinkage of the bank balance sheet and attenuates the negative effect on households' consumption and leisure. Social welfare, therefore, declines less when the capital-control policy is more restrictive than when it is less, such as *partial-cover foreign currency denomination* ($\sigma = 0.75$) and *full-cover foreign currency denomination* ($\sigma = 1$).

In contrast to the foreign monetary policy shock, the exchange rate shock has a positive effect on welfare, which is mainly due to the increase in bankers' consumption and households' leisure, despite a decline in aggregate consumption.[14]

As in the case of the foreign monetary policy shock, a more restrictive capital-control policy

[13] See Section 4 for a detailed discussion on the transmission mechanisms of how shocks affect both the financial sector and the real sector.

[14] For the sake of space the IRFs of individual agent's consumption is not reported in the paper, but available upon request.

mitigates the exchange rate shock's effect on welfare, but in the opposite direction – it reduces the welfare gain from the shock. This result is not surprising, as with more restrictive capital controls, all private agents are exposed to much lower exchange rate uncertainty.

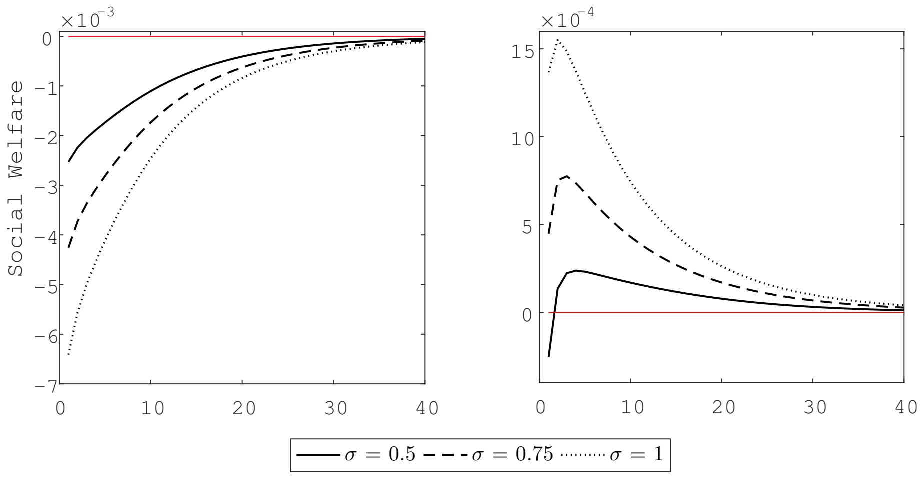

Figure 6: Social welfare dynamics (left: foreign monetary policy shock; right: exchange rate shock).

6 Concluding remarks

We develop a general equilibrium model with financial frictions and banking, in which assets and liabilities are denominated in both domestic and foreign currencies. We propose a non-pecuniary cost approach of capital controls with foreign currency denomination. We argue that capital controls have a significant impact on the dynamics of assets and liabilities that are denominated in foreign currency. In general, a more restrictive capital-control policy weakens the negative effect of a contractionary foreign monetary policy shock and the exchange rate shock (a depreciation of domestic currency). This attenuation effect of capital controls is more pronounced for the financial sector. That said, capital controls help to stabilize the financial sector and, hence, reduce the negative spillovers to the real economy. A more restrictive capital-control policy significantly attenuates the welfare effects of the foreign monetary policy and exchange rate shocks.

This paper serves as a starting point for investigating the effectiveness of capital controls with foreign currency denomination, where all private agents, households (savers), entrepreneurs (borrowers) and bankers (financial intermediaries) are affected. It is for this reason that we opt for a real business cycle model in the current study. One possible extension of the current study is to extend the model to a monetary business cycle model, to study topics such as how foreign currency denomination affects the optimal monetary policy and capital controls, the coordination of monetary and capital control policies, and corresponding welfare implications.

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A Appendix: System of equations representing the model economy:

$$C_t^h + Q_t \left(H_t^h - H_{t-1}^h\right) + D_t + D_t \Phi_d = R_{t-1}^{d,h} D_{t-1}^h + e_t R_{t-1}^{d,f} D_{t-1}^f + W_t N_t, \tag{A.1}$$

$$\lambda_t^h = \frac{1}{C_t^h - \psi_h C_{t-1}^h} - \beta_h \psi_h \mathbb{E}_t \frac{1}{C_{t+1}^h - \psi_h C_t^h}, \tag{A.2}$$

$$\lambda_t^h \frac{\partial D_t}{\partial D_t^h} \left(1 + \Phi_d\right) + \lambda_t^h D_t \frac{\partial \Phi_d}{\partial D_t^h} = \beta_h \mathbb{E}_t \lambda_{t+1}^h R_t^{d,h}, \tag{A.3}$$

$$\lambda_t^h \frac{\partial D_t}{\partial D_t^f} \left(1 + \Phi_d\right) + \lambda_t^h D_t \frac{1}{e_t} \frac{\partial \Phi_d}{\partial D_t^f} = \beta_h \mathbb{E}_t \lambda_{t+1}^h \frac{e_{t+1}}{e_t} R_t^{d,f}, \tag{A.4}$$

$$\lambda_t^h Q_t = \eta \frac{1}{H_t^h} + \beta_h \mathbb{E}_t \lambda_{t+1}^h Q_{t+1}, \tag{A.5}$$

$$\lambda_t^h W_t = \varsigma \frac{1}{1 - N_t}, \tag{A.6}$$

$$D_t = \left[\left(\chi_h\right)^{\frac{1}{\nu_d}} \left(D_t^h\right)^{\frac{\nu_d - 1}{\nu_d}} + \left(1 - \chi_h\right)^{\frac{1}{\nu_d}} \left(e_t D_t^f\right)^{\frac{\nu_d - 1}{\nu_d}} \right]^{\frac{\nu_d}{\nu_d - 1}}, \tag{A.7}$$

$$C_t^e + Q_t \left(H_t^e - H_{t-1}^e\right) + R_{t-1}^{l,h} L_{t-1}^h + e_t R_{t-1}^{l,f} L_{t-1}^f + W_t N_t = L_t - L_t \Phi_l + Y_t, \tag{A.8}$$

$$R_t^{l,h} L_t^h + \mathbb{E}_t e_{t+1} R_t^{l,f} L_t^f = \gamma \left(\mathbb{E}_t Q_{t+1} H_t^e - W_t N_t\right), \tag{A.9}$$

$$Y_t = \left(H_{t-1}^e\right)^{\alpha} \left(N_t\right)^{(1-\alpha)}, \tag{A.10}$$

$$\lambda_t^e = \frac{1}{C_t^e - \psi_e C_{t-1}^e} - \beta_e \psi_e \mathbb{E}_t \frac{1}{C_{t+1}^e - \psi_e C_t^e}, \tag{A.11}$$

$$\lambda_t^e Q_t = \mathbb{E}_t \left(\gamma \lambda_t^f + \beta_e \lambda_{t+1}^e\right) Q_{t+1} + \alpha \beta_e \mathbb{E}_t \lambda_{t+1}^e \frac{Y_{t+1}}{H_t^e}, \tag{A.12}$$

$$\lambda_t^e \left(1 - \Phi_l\right) \frac{\partial L_t}{\partial L_t^h} - \lambda_t^e L_t \frac{\partial \Phi_l}{\partial L_t^h} = \lambda_t^f R_t^{l,h} + \beta_e \mathbb{E}_t \lambda_{t+1}^e R_t^{l,h}, \tag{A.13}$$

$$\lambda_t^e \left(1 - \Phi_l\right) \frac{1}{e_t} \frac{\partial L_t}{\partial L_t^f} - \lambda_t^e L_t \frac{1}{e_t} \frac{\partial \Phi_l}{\partial L_t^f} = \mathbb{E}_t \left(\lambda_t^g + \beta_e \lambda_{t+1}^e\right) \frac{e_{t+1}}{e_t} R_t^{l,f}, \tag{A.14}$$

$$\left(\lambda_t^e + \gamma \lambda_t^f\right) W_t = (1-\alpha)\, \lambda_t^e \frac{Y_t}{N_t}, \tag{A.15}$$

$$L_t = \left[(\chi_e)^{\frac{1}{\nu_l}} \left(L_t^h\right)^{\frac{\nu_l - 1}{\nu_l}} + (1-\chi_e)^{\frac{1}{\nu_l}} \left(e_t L_t^f\right)^{\frac{\nu_l - 1}{\nu_l}} \right]^{\frac{\nu_l}{\nu_l - 1}}, \tag{A.16}$$

$$\begin{aligned} C_t^b + e_t R_{t-1}^b B_{t-1} + R_{t-1}^{d,h} D_{t-1}^h + e_t R_{t-1}^{d,f} D_{t-1}^f + L_t^h + e_t L_t^f = \\ e_t B_t (1-\Phi_b) + D_t^h + e_t D_t^f + R_{t-1}^{l,h} L_{t-1}^h + e_t R_{t-1}^{l,f} L_{t-1}^f, \end{aligned} \tag{A.17}$$

$$e_t \left(B_t + D_t^f\right) + D_t^h = (1-\kappa\phi_h)\, L_t^h + \left(1-\kappa\phi_f\right) e_t L_t^f, \tag{A.18}$$

$$\sigma e_t \left(L_t^f - D_t^f\right) = e_t B_t, \tag{A.19}$$

$$\lambda_t^a e_t B_t = 0,$$

$$BK_t = L_t^h + e_t L_t^f - e_t B_t - D_t^h - e_t D_t^f, \tag{A.20}$$

$$\lambda_t^a + \lambda_t^b \left(1 - B_t \frac{\partial \Phi_{b,t}}{\partial B_t} - \Phi_b\right) - \beta_b \lambda_{t+1}^b \frac{e_{t+1}}{e_t} B_{t+1} \frac{\partial \Phi_{b,t+1}}{\partial B_t} - \lambda_t^c + \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^b, \tag{A.21}$$

$$\lambda_t^b = \frac{1}{C_t^b - \psi_b C_{t-1}^b} - \beta_b \psi_b \mathbb{E}_t \frac{1}{C_{t+1}^b - \psi_b C_t^b}, \tag{A.22}$$

$$\lambda_t^b - \lambda_t^c = \beta_b \mathbb{E}_t \lambda_{t+1}^b R_t^{d,h}, \tag{A.23}$$

$$\left(\lambda_t^b - \lambda_t^c\right) + \sigma \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^{d,f}, \tag{A.24}$$

$$\lambda_t^b - (1-\kappa\phi_h)\, \lambda_t^c = \beta_b \mathbb{E}_t \lambda_{t+1}^b R_t^{l,h}, \tag{A.25}$$

$$\lambda_t^b - \left(1-\kappa\phi_f\right) \lambda_t^c + \sigma \lambda_t^d = \beta_b \mathbb{E}_t \lambda_{t+1}^b \frac{e_{t+1}}{e_t} R_t^{l,f}, \tag{A.26}$$

$$H_t^e + H_t^h = H, \tag{A.27}$$

$$\log\left(R_t^b\right) = (1-\rho_r)\log\left(R^b\right) + \rho_r \log\left(R_{t-1}^b\right) + \xi_{r,t}, \tag{A.28}$$

$$\log\left(e_t\right) = (1-\rho_e)\log\left(e\right) + \rho_e \log\left(e_{t-1}\right) + \xi_{e,t}. \tag{A.29}$$