Domestic Credit Market and Monetary Policy in a Small Open Economy*

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Abstract

A standard open economy model prescribes that central banks should control producer prices and let exchange rates to float freely, since exchange rate movements are needed to stabilize shocks. This is no longer the optimal policy when the model is augmented including a domestic credit market where assets and liabilities denominated in local and foreign currency are present. Due to its impact on borrower's portfolios, exchange rate volatility also has a negative effect on welfare. Consequently, it is actually optimal to exert some exchange rate control, targeting the Consumer Price Index (CPI) rather than the Producer Price Index. Thus, the framework presented here gives theoretical support to CPI targeting in small open economies.

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1. Introduction

Gali and Monacelli (2005) and Sutherland (2001), amongst others, show that central banks of small open economies should target producer prices, adopting a pure exchange rate floating regime. This policy generates high exchange rate volatility in order to offset nominal rigidities and stabilize shocks[1]. In this paper we extend the simple small open economy model to include a domestic credit market where both local and foreign currency denominated assets are available. The optimal monetary policy under the framework developed here is no longer to target producer prices but to target the consumer price index (CPI), thus exerting some control on exchange rate volatility.

The traditional stabilization motive is still present with exchange rate volatility impacting welfare positively. However, we identify a new effect of exchange rate volatility on welfare when credit markets are incorporated. As the central bank controls only producer prices and leaves exchange rates to float freely, exchange rate variance is at its highest. The resulting high level of exchange rate uncertainty impacts negatively on the borrowers' portfolio position, reducing their expected welfare. Given this new opposing effect it is optimal for the central bank to select a policy that targets the consumer price index, controlling exchange rate movements. Therefore, in addition to supporting CPI targeting, our model provides a theoretical explanation for the so called "fear of floating" phenomenon - the empirical observation that although countries may announce they will allow the exchange rate to float freely, they in fact do not (Calvo and Reinhart (2002)).

This paper relates not only to the new open economy literature but also to more recent contributions on financial dollarization (FD), a common and relevant characteristic of many economies, particularly in Latin America,

[1] This policy prescription does not necessarily hold for economies with incomplete pass-through (see Corsetti and Pesenti (2005)) and for economies facing sector specific shocks (see Tille (2002)).

Eastern Europe and some parts of Asia[2] (see table 3 in the Appendix). Financial dollarization is defined as the holding by residents of a share of their assets and/or liabilities denominated in foreign currency. The theoretical and empirical studies in this literature have concentrated only on explaining the drivers of financial dollarization (e.g. Ize and Levy-Yeyati (2003), Barajas and Morales (2003) and Basso et al. (2007)) or providing empirical analysis on its consequences (e.g. Levy-Yeyati (2006) and Nicolo et al. (2005)). The impact of the domestic portfolio of deposits and loans denominated in foreign currency on optimal monetary policy, which is the focus of this paper, is a question that has not received as much attention in the literature.

The framework here follows the theoretical work on the determinants of asset substitution, particularly Ize and Levy-Yeyati (2003), allowing households to select the optimal portfolio composition of local and foreign currency denominated assets and liabilities. While maximizing portfolio returns and minimizing their variance, households weight the trade-off between the forward looking variances of inflation and real exchange rate, determining the share of assets/liabilities denominated in foreign currency or the level of FD. The portfolio choice is endogenous since these forward looking variances are affected by the expected monetary policy. The portfolio allocation, on the other hand, has an impact on welfare and hence will influence the monetary policy decision.

The closest contribution, within the financial dollarization literature, to our own is Chang and Velasco (2006). They develop a small open economy model where (*i*) firms choose the composition of external debt given the expected monetary policy, (*ii*) central bank sets monetary policy given the debt composition. They find that both floating and fixed exchange rate regimes can emerge as equilibrium outcomes, but the floating regime is Pareto

[2] Although rarely, foreign currency denominated loans also occur in developed economies. In Austria 20% of the total outstanding loans are denominated in foreign currency. This figure increases to 33% when only households are considered. Source: Oesterreichische Nationalbank

superior and hence is the equilibrium under commitment.

Despite giving the important step of incorporating endogenous variance and covariances into the portfolio selection problem, Chang and Velasco (2006) only consider the currency choice of external debt. However, in most cases, countries can only borrow in foreign currency (see Eichengreen et al. (2003)). Furthermore, in the economies where financial dollarization is predominant both households and firms decide to make deposits and loans in foreign currency directly through the domestic banking system, aspect that their modeling approach does not incorporate. Finally, they assume the economy is fully open (households only consume foreign produced goods) and they only consider fixed and pure floating exchange rate regimes.

Our model, building on the new keynesian open economy literature, gives us the flexibility to investigate optimal monetary policy under different levels of openness. More importantly, it does not restrict the central bank choice to fixed and pure floating exchange rate regimes. That turns out to be very important since the optimal monetary policy under our specification is to target the consumer price index, implying a intermediate level of exchange rate control. However, as opposed to theirs, our analysis does not consider the effects of different portfolio positions in the international asset market on monetary policy, focusing only on the domestic asset market.

Another contribution that looks at monetary policy in open economies and endogenous portfolio choice is Devereux and Sutherland (2008). They also find that portfolio positions can influence monetary policy, which is assumed to target the producer price index. Their model is solved using a combination of first order approximation to non-portfolio first order conditions and second order approximation to the portfolio choice equations. That allows then to augment a staggered pricing model with portfolio choice. Our approach follows Obstfeld and Rogoff (2000) more closely considering a full second order approximation that captures the effect of uncertainty in all first order conditions, including price/wage setting. However, we can only analyze a two period economy with varying levels of nominal rigidity.

The remainder of the paper is divided into four sections. Section 2 introduces the model and section 3 presents the equilibrium conditions. In Section 4, we show the main results of the paper, discussing optimal monetary policy under endogenous portfolio choice. Section 5 concludes.

2. Model

We consider a two period small open economy model inhabited by two representative households, $j = \{G, H\}$, two union types $m = \{a, b\}$, each composed of a continuum of unions/labor types $z = [0, 1]$, a representative firm, a representative bank, the central bank and the government. There is perfect competition in the banking sector, hence, banks act only as intermediaries.

We depart from the standard small open economy model incorporating a *domestic* credit market with four assets available, deposits and loans denominated in local and foreign currencies. Following Corsetti and Pesenti (2001) we assume a unit elasticity of substitution between home and foreign goods, ensuring the current account is always in balance. That makes the international asset structure irrelevant, allowing tractable solutions to be obtained from models that take account of the uncertainty in macroeconomic variables as we do.[3]

The rest of the world consumption and prices are exogenously given. Furthermore, the only source of uncertainty is the rest of the world demand for domestically produced goods in period two[4]. Foreign prices (P_i^*) are normalized to one in both periods $i = \{1, 2\}$.

Households select a portfolio of domestically traded assets (deposits and

[3] For a model where this assumption is relaxed see De Paoli (2004).

[4] Although we do not consider other shocks, a home demand shock, e.g. government expenditure shock, or a taste (preference) shock would lead to the same monetary policy response (see Sutherland (2001) for a small open economy model, similar to ours, with such shocks).

loans), supply labor, the only production factor, to the representative firm and consume a composite of foreign and home traded goods. The firm is a price and wage taker, selecting labor demand to maximize profits. Good prices are perfectly flexible in both periods and wages are fully flexible in the first period. In order to introduce nominal rigidity into the model we assume unions of type a set second period wages in period one (before the shock) while type b unions set wages after the realization of the shock. Finally, the central bank can commit and thus, monetary policy is set in period one.

2.1 Households

In the first period, households decide how much deposits and loans they wish to make[5]. Each representative household has a specific discount factor, β_H for household H and $\beta_G < \beta_H$ for household G. The relationship between the interest rate charged by banks and the households' implicit interest rate ($1/\beta_j$) determines whether household $j = H, G$ decides to take a loan or make a deposit. In equilibrium, the impatient household (G) takes a loan while the patient (H) makes a deposit.

Households maximize their expected utility, given their disposal income (wages, profits and transfers), choosing the amount of deposits and loans in local and foreign currency, implicitly determining consumption in each period. Both local and foreign currency denominated assets are risky. While the first might fluctuate due to inflation, the second will fluctuate due to changes in inflation and in the nominal exchange rate, i.e. due to real exchange rate changes.

Households in period one choose the demand for loans, the demand for deposits and the portfolio compositions, or the set (D, L, α_d, α_l), where D = total deposits, L = total loans, α_d = portion of deposits in foreign currency

[5]Although we have not assumed that firms make loans in period one, Basso et al. (2007) show that the portfolio decision of risk neutral firms that can default in their loans is analogous to that of the household.

and α_l = portion of loans in foreign currency [6]. The proportion of assets and liabilities denominated in foreign currency is also called level of financial dollarization of deposits and loans, respectively.

In order to simplify the exposition and the solution of the model each household is split into two units: (*i*) the investor and (*ii*) the fund manager.

The investor solves a certainty equivalent problem selecting D and L, given the expected returns, the portfolio allocations (α_d, α_l), the first period disposal income, $I_{1,j}$, and the expected disposable income in the second period, $I_{2,j}$.[7]

The expected returns are defined as $E[\bar{R}_d] = (1-\alpha_d)R_d + \alpha_d R_d^* - E[P_2 - P_1] + \alpha_d E[S_2 - S_1]$ for deposits and $E[\bar{R}_l] = (1-\alpha_l)R_l + \alpha_l R_l^* - E[P_2 - P_1] + \alpha_l E[S_2 - P_1]$ for loans, where S_i is the nominal exchange rate at period $i = \{1, 2\}$, P_i the price index, R_d (R_l) the local currency deposit (loan) rate and R_d^* (R_l^*) the foreign currency deposit (loan) rate.

The investor's $j = \{H, G\}$ problem is

$$\max_{\{C_{1,j}, C_{2,j}, D, L\}} \frac{C_{1,j}^{1-1/\sigma}}{1-1/\sigma} - \delta\frac{N_{1,j}^{1+1/\gamma}}{1+1/\gamma} + \beta_j\left[\frac{C_{2,j}^{1-1/\sigma}}{1-1/\sigma} - \delta\frac{N_{2,j}^{1+1/\gamma}}{1+1/\gamma}\right]$$

Subject to

$$C_{1,j} = I_{1,j} - D + L + wed_j \quad (1)$$

$$C_{2,j} = I_{2,j} + E[\bar{R}_d]D - E[\bar{R}_l]L \quad (2)$$

$$I_{1,j} = (1-\tau)\frac{W_1}{P_1}N_{1,j} + \Pi_{1,j} + T_{1,j}$$

$$I_{2,j} = E\left[(1-\tau)\frac{W_2}{P_2}N_{2,j} + \Pi_{2,j} + T_{2,j}\right] \quad (3)$$

$$N_{i,j} = \frac{N_i}{2}, \quad \Pi_{i,j} = \frac{\Pi_i}{2} \quad \text{for} \quad j = \{H, G\} \quad (4)$$

[6] Throughout the paper we state that households demand loans and deposits, considering that both are products that banks sell to households. However, deposit "demand" is upward sloping as it represents a supply of funds.

[7] Note that the certainty equivalent assumption allow us to solve the investor problem independently of the portfolio composition decision. Hence, the variance of the return does not affect the total deposit and loan decisions (no precautionary motive). Combining both decisions would increase the complexity of the model without significantly changing the results. See Basso et al. (2007) for details.

The first two equations are the budget constraints for period one and two, respectively. The following two give the disposal income in each period, where τ is the tax/subsidy on labor income and $T_{i,j}$ is a government transfer. Π_i is the firm profits in period i. Finally, N_i is the total labor demand from the representative firm given by a composite index of all union/labor types (this is formally defined in the firm problem below). Hence, both households supply all types of labor, taking the wages set by unions as given and meeting the firm's labor demand.

The variable wed_j represents a difference in wealth between household H and G in the first period, such that $wed = wed_H = -wed_G$. When this wealth wedge is different from zero the size of the credit market is determined by two main elements: (i) the further apart the households' discount factors are, the greater the credit market and (ii) the higher the period one wealth level of the patient household (H) relative to the impatient household (G), the deeper the credit market. An important empirical motivation to include this variable is the evidence presented by Lawrance (1991) that poorer households are more impatient. In models in which capital accumulation is available patient households will hold all capital stock, and hence will be wealthier than impatient households (see Iacoviello (2005)). Given that we are not incorporating capital into the model the variable wed is used here to adjust the model to this empirical evidence.

Consumption in each period, for household j, $C_{i,j}$, is given by

$$C_{i,j} = \frac{C_{i,P,j}^{\omega} C_{i,F,j}^{1-\omega}}{\omega^{\omega} (1-\omega)^{1-\omega}} \quad i = \{1, 2\},$$

a composite index of the consumption of home produced goods $C_{i,P,j}$ and the consumption of foreign produced goods $C_{i,F,j}$. ω determines the bias towards home goods in the household consumption index and is regarded as an inverse measure of the degree of openness of the economy. The higher ω, the lower the degree of openness of the economy.

Given the consumption index, the price index will be

$$P_i = P_{P,i}^{\omega} S_i^{1-\omega} \quad i = \{1, 2\}. \tag{5}$$

The second part of the household, the fund manager, allocates the total deposits (D) and loans (L) determined by the investor into foreign currency denominated deposits and loans (d^*, l^*) and local currency denominated deposits and loans (d, l) to maximize the portfolio return in period two and minimize its variance, where

$$\begin{aligned} D &= d + d^*, \quad d = (1 - \alpha_d)D \quad \text{and} \quad d^* = \alpha_d D \\ L &= l + l^*, \quad l = (1 - \alpha_l)L \quad \text{and} \quad l^* = \alpha_l L \end{aligned}$$

Hence, fund manager's $j = H, G$ problems are, respectively,

$$\begin{aligned} &\max_{\alpha_d} \quad E[\bar{R}_d] - q\frac{\text{VAR}[\bar{R}_d]}{2} \\ &\max_{\alpha_l} \quad E[-\bar{R}_l] - q\frac{\text{VAR}[\bar{R}_l]}{2} \end{aligned}$$

The portfolio decision would then be given by

$$\alpha_d = \frac{R_d^* - R_d + E[S_2 - S_1]}{q\text{VAR}[S_2]} + \frac{\text{COV}[P_2, S_2]}{\text{VAR}[S_2]} \tag{6}$$

$$\alpha_l = \frac{R_l - R_l^* - E[S_2 - S_1]}{q\text{VAR}[S_2]} + \frac{\text{COV}[P_2, S_2]}{\text{VAR}[S_2]} \tag{7}$$

Where q represents how important the variance is relative to the expected returns in the fund managers' portfolio allocation. Thus, the higher the value of q, the lower the sensitivity of the interest rate differential onto the portfolio decision.

An alternative specification for the fund manager problem would be to maximize the expected value of consumption and minimize its variance. If this were to be the case, the households would attempt to maximize the portfolio return and minimize its variance plus adjust the portfolio to hedge against income fluctuations. Income fluctuations, however, result from economy's aggregate shocks and therefore cannot be hedged from borrowing or lending internally. Hence, in this alternative, the resulting portfolio allocations in equilibrium would be the same as the one stated above.

2.2 Unions

There are two types of unions, a and b. The labor market is populated by a continuum of unions $z \in [0,1]$ for each labor type. Type a unions set second period wages before the realization of the shock (in period one), while type b unions set second period wages after the realization of the shock. The proportion of type a unions in the labor market is $\kappa \in [0,1]$, hence, this parameter determines the degree of wage rigidity in the economy[8].

Each union $z \in [0,1]$ of type a and b maximizes its members expected utility selecting wage $w_{i,m}(z)$ for $i = \{1,2\}$ and $m = \{a,b\}$. Although there are two households types (G and H), both supply labor type z to the representative firm and are, therefore, members of union z. Consequently, unions consider the aggregate variables (sum of both households) while measuring the members' expected utility[9].

The union z of type m selects the second period wage as follows

$$\max_{w_{2,m}(z)} E\left[\frac{C_2^{1-1/\sigma}}{1-1/\sigma} - \delta\frac{N_{2,m}(z)^{1+1/\gamma}}{1+1/\gamma}\right]$$

[8]Note that as there are only κ unions of type a and $1-\kappa$ unions of type b, the labor market is in fact composed of a single continuum $z \in [0,1]$, or the normalized size of the labor market is 1 and not 2.

[9]This structure is equivalent to unions setting wages considering the representative member. An alternative, but more complex specification, would be to measure members' utility as a weighted sum of the utility for each member. The main difference is that the dispersion of consumption between the members would affect the wage setting decision in this alternative specification.

subject to

$$
\begin{aligned}
C_2 &= (1-\tau)\frac{w_{2,m}(z)}{P_2}N_{2,m}(z) + \Pi + \bar{R}_d D - \bar{R}_l L + T \\
N_{2,m}(z) &= \left(\frac{w_{2,m}(z)}{W_{2,m}}\right)^{-\varphi} N_{2,m}
\end{aligned}
$$

Where the last equation is the representative firm's demand for labor z of union type m in period 2 (see firm problem below).

The second period wage set by type a unions (before the shock) is

$$
w_{2,a}(z) = \delta\frac{1}{1-\tau}\frac{\varphi}{\varphi-1}\frac{E\left[N_{2,a}(z)^{1+1/\gamma}\right]}{E\left[P_2^{-1}C_2^{-1/\sigma}N_{2,a}(z)\right]} \quad \text{for} \quad z \in [0,1] \tag{8}
$$

The wage set for type b unions (after the shock) is

$$
w_{2,b}(z) = \delta\frac{1}{1-\tau}\frac{\varphi}{\varphi-1}P_2 C_2^{1/\sigma}N_{2,b}(z)^{1/\gamma} \quad \text{for} \quad z \in [0,1] \tag{9}
$$

We assume τ is set such that $\frac{1}{1-\tau}\frac{\varphi}{\varphi-1} = 1$, thus taxes remove the monopoly distortion.

Given that wages are flexible in period one, labor supply is given by $w_{1,a}(z) = w_{1,b}(z) = w_1(z) = \delta P_1 C_1^{1/\sigma} N_1(z)^{1/\gamma}$. As all unions within each type are equal, in equilibrium, $w_{i,m}(z) = W_{i,m}$ for $i = \{1,2\}$ and $m = \{a,b\}$.

2.3 Representative Firm

The firm decides labor demand ($N_{i,m}(z)$) to maximize real profits given wages ($w_{i,m}(z)$) for period $i = \{1,2\}$ and union type $m = \{a,b\}$, thus

$$
\max_{\{N_{i,a}(z),N_{i,b}(z)\}} \frac{P_{P,i}}{P_i}Y_i - \frac{1}{P_i}\int_0^1 w_{i,a}(z)N_{i,a}(z)dz - \frac{1}{P_i}\int_0^1 w_{i,b}(z)N_{i,b}(z)dz
$$

Subject to

$$
\begin{aligned}
Y_i &= N_i^{\eta}, \quad 0 < \eta < 1 \\
N_i &= \frac{N_{i,a}^{\kappa} N_{i,b}^{1-\kappa}}{\kappa^{\kappa}(1-\kappa)^{1-\kappa}} \\
N_{i,a} &= \left[\int_0^1 N_{i,a}(z)^{\frac{\varphi-1}{\varphi}} dz\right]^{\frac{\varphi}{\varphi-1}} \quad \text{and} \quad N_{i,b} = \left[\int_0^1 N_{i,b}(z)^{\frac{\varphi-1}{\varphi}} dz\right]^{\frac{\varphi}{\varphi-1}}.
\end{aligned}
$$

As standard, that would imply the following demand function for labor type z of union $m = \{a, b\}$

$$
N_{i,m}(z) = \left(\frac{w_{i,m}(z)}{W_{i,m}}\right)^{-\varphi} N_{i,m}
$$

and the wage index $W_{i,m} = \left[\int_0^1 w_{i,m}(z)^{1-\varphi} dz\right]^{1/1-\varphi}$

The total labor demand for type $m = \{a, b\}$ union is given by[10]

$$
\begin{aligned}
N_{i,a} &= \left(\frac{W_{i,a}}{W_i}\right)^{-1} N_i, \quad N_{i,b} = \left(\frac{W_{i,b}}{W_i}\right)^{-1} N_i \\
&\text{where} \quad W_i = W_{i,a}^{\kappa} W_{i,b}^{1-\kappa}.
\end{aligned}
$$

The demand for domestically produced goods is given by $\sum_j C_{i,P,j} + \frac{S_i C_i^*}{P_{P,i}}$ where C_i^* is the amount spent by the rest of the world on home produced goods in period $i = 1, 2$. In the first period foreign demand is fixed and equal to $\overline{C^*}$ and in the second, foreign demand is equal to C^*, which is stochastic with mean $\overline{C^*}$ and variance Σ.

2.4 Central Bank and Government

The government taxes labor income and makes a transfer to each household such that $\tau \frac{W_i}{P_i} N_{i,j} = T_{i,j}$, for $j = \{H, G\}$ and $i = \{1, 2\}$.

The central bank maximizes the weighted sum of the welfare of each

[10]Note that given the proportion of type a unions is κ, the total demand for labor for that union type is adjusted, otherwise one would have $N_{i,a} = \left(\frac{W_{i,a}}{\kappa W_i}\right)^{-1} N_i$.

agent. The problem under commitment is

$$\max_{\{\varepsilon\}} \sum_j \zeta_j \left\{ \frac{C_{1,j}^{1-1/\sigma}}{1-1/\sigma} + \beta_j \left[\frac{C_{2,j}^{1-1/\sigma}}{1-1/\sigma} \right] \right\} - \delta \left[\frac{N_1^{1+1/\gamma}}{1+1/\gamma} + (\zeta_H \beta_H + \zeta_G \beta_G) \frac{N_2^{1+1/\gamma}}{1+1/\gamma} \right]$$

Subject to firms, unions and households behaving optimally and

$$P_{P,2}^{\varepsilon} S_2^{1-\varepsilon} = \tilde{\Lambda} \tag{10}$$

where, ε is the monetary policy parameter and $\tilde{\Lambda}$ is the monetary policy target dependent on the level of prices and exchange rate in the first period[11], defined as $\tilde{\Lambda} \equiv P_{P,1}^{\varepsilon} S_1^{1-\varepsilon}$. ζ_j is the weight of each household type in the government utility. We set ζ_H=ζ_G=1/2.

The monetary policy setup does not explicitly selects an instrument allowing the central bank to control directly the relationship of prices and exchange rate, simplifying the exposition. This set up does not restrict the central bank's policy choices. In fact the central bank can select all three main monetary policy settings considered in the literature (e.g. Gali and Monacelli (2005)), namely, targeting the producer prices ($\varepsilon = 1$), the consumer price index ($\varepsilon = \omega$) or the nominal exchange rate ($\varepsilon = 0$) to their period one level. An alternative model specification in which households derive utility from money balances produces the same qualitative results. The central bank would then use money as a instrument to deliver the three different policies. See Srour (2002) for an example of such specification.

3. Equilibrium

As it is standard the model is solved backwards.

Period 2

[11]This target is commonly set to 1, assuming both prices and exchange rates are normalized to one. In the model here producer prices and the exchange rate in period 1 are determined endogenously.

Table 1 shows the solution for consumption, labor, the wage for type b unions, the nominal exchange rate, the producer price and the price index given the external demand shock, the monetary policy (ε) and the first period variables. The results are obtained by combining the households and firm first order conditions, the goods market clearing condition, the balance of payment equality and the wage setting equation for type b unions, see Appendix B for details.

The average rates on total deposits and loans are given by $\bar{R}_d = (1 - \alpha_d)R_d + \alpha_d R_d^* - (P_2 - P_1) + \alpha_d(S_2 - S_1)$ and $\bar{R}_l = (1 - \alpha_l)R_l + \alpha_l R_l^* - (P_2 - P_1) + \alpha_l(S_2 - P_1)$.

Table 1: Solution - Period 2

$$C_{2,H} = \frac{1}{2}\frac{S_2 C^*}{P_2}\frac{1}{1-\omega} + \bar{R}_d D \tag{11}$$

$$C_{2,G} = \frac{1}{2}\frac{S_2 C^*}{P_2}\frac{1}{1-\omega} - \bar{R}_l L \tag{12}$$

$$N_{2,H} = N_{2,G} = \frac{1}{2}\left(\frac{S_2 C^*}{P_{P,2}}\frac{1}{1-\omega}\right)^{1/\eta} \tag{13}$$

$$W_{2,b} = \delta P_2 C_2^{1/\sigma}\left(W_{2,a}^{\kappa} W_{2,b}^{-\kappa} N_2\right)^{1/\gamma} \tag{14}$$

$$S_2 = Z^{\phi_2} W_{2,b}^{\phi_2 \eta (1-\kappa)} C^{*(1-\eta)\phi_2} \tag{15}$$

$$P_{P,2} = Z^{\phi_2 - \phi_3} W_{2,b}^{(\phi_2-\phi_3)\eta(1-\kappa)} \Lambda C^{*(1-\eta)(\phi_2-\phi_3)} \tag{16}$$

$$P_2 = Z^{\phi_2 - \phi_1} W_{2,b}^{(\phi_2-\phi_1)\eta(1-\kappa)} \Lambda^{\omega} C^{*(1-\eta)(\phi_2-\phi_1)} \tag{17}$$

where we define

$$Z = \frac{W_{2,a}^{\kappa\eta}}{\Lambda \eta^{\eta}(1-\omega)^{(1-\eta)}} \tag{18}$$

$$\Lambda = P_{P,1} S_1^{\frac{1-\varepsilon}{\varepsilon}} \tag{19}$$

$$\phi_1 = \frac{\omega}{\eta\varepsilon - 1}, \quad \phi_2 = \frac{\varepsilon}{\eta\varepsilon - 1} \quad \text{and} \quad \phi_3 = \frac{1}{\eta\varepsilon - 1} \tag{20}$$

Using the period 2 solution one can verify that exchange rate volatility, or a monetary policy that controls producer prices leaving exchange rates to float freely, is able to stabilize shocks. In order to obtain analytical results we assume $\kappa = 1$ (full wage rigidity). Then, by substituting the equation for the nominal exchange rate (15) and prices ((16) and (17)) into the solution for labor (13) and disposal income excluding loans and deposits ($I_{2,j}$) and setting ε equal to zero (fixed nominal exchange rate) and one (fixed producer prices), we get the following results

Table 2: Stabilization of Shocks

	Fixed Exchange Rate	Fixed Producer Prices
	$\varepsilon = 0$	$\varepsilon = 1$
Income	$\frac{Z^{-\omega}}{(1-\omega)\Lambda^{\omega}} C^{*1-(1-\eta)\omega}$	$\frac{Z^{-\omega/(1-\eta)}}{(1-\omega)\Lambda^{\omega}} C^{*1-\omega}$
Labor	$\frac{Z^{-1}}{(1-\omega)\Lambda} C^{*\eta}$	$\frac{Z^{-1/(1-\eta)}}{(1-\omega)\Lambda}$

Hence, as the central bank moves ε from zero to one it will manage to stabilize the foreign shock more effectively, i.e. reduce the variability of labor and income, given the variance of the shock (the exponent of C^* is closer to zero). Moreover, under full wage rigidity, when the central bank controls producer prices, it actually makes labor independent from the shock, reducing its variance to zero.

Period 1

The following approximations are used in order to find the first period equilibrium conditions, presented next. This second order approximation is similar to the solution methodology introduced by Obstfeld and Rogoff (2000) where shocks are assumed to be log-normal. Thus, for any generic function $f(x)$, its expectation is equal to the function evaluated at the mean value of x plus a variance adjustment.

$$
\begin{aligned}
E[f(x)] &\approx f(E[x]) + \frac{f''(E[x])}{2}\mathrm{VAR}[x] \\
\mathrm{VAR}[f(x)] &\approx f'(E[x])^2\mathrm{VAR}[x].
\end{aligned}
$$

The relevant first period variables to solve for the equilibrium of this economy are type a wages, total deposits and loans, the rates of interest and the portfolio allocations.

Using the results in table 1 and the unions first order condition (8) give

$$\begin{aligned} W_{2,a}^{1-\Xi_1} &= \Upsilon^{\Xi_4} \frac{E\left[C^{*\Xi_2}\right]}{E\left[C^{*\Xi_3}\right]} \\ &\approx \Upsilon^{\Xi_4} \frac{\left[\overline{C^*}^{\Xi_2} + \Xi_2(\Xi_2-1)\overline{C^*}^{\Xi_2-2}\frac{\Sigma}{2}\right]}{\left[\overline{C^*}^{\Xi_3} + \Xi_3(\Xi_3-1)\overline{C^*}^{\Xi_3-2}\frac{\Sigma}{2}\right]} \end{aligned} \tag{21}$$

where Υ, Ξ_1, Ξ_2, Ξ_3, Ξ_4 are functions of the structural parameters of the model (see Appendix B for details).

The investor part of the households, who decides L and D, sets

$$D = \frac{I_1 - I_2\left(\bar{R}\right)^{-\sigma}\beta_H^{-\sigma}}{1+\left(\bar{R}\right)^{1-\sigma}\beta_H^{-\sigma}} \tag{22}$$

$$L = \frac{I_2\left(\bar{R}\right)^{-\sigma}\beta_G^{-\sigma} - I_1}{1+\left(\bar{R}\right)^{1-\sigma}\beta_G^{-\sigma}} \tag{23}$$

Where $I_{1,j} = I_1 = \frac{S_1 \bar{C}^*}{2(1-\omega)}$. The expected disposable income I_2 is given by

$$I_{2,j} = I_2 = E\left[\frac{1}{2}\frac{S_2 C^*}{P_2}\frac{1}{1-\omega}\right] = \frac{1}{2}\frac{Z^{\phi_1}}{\Lambda^{\omega}(1-\omega)} E\left[W_{2,b}^{\phi_1\eta(1-\kappa)} C^{*(1-\eta)\phi_1+1}\right] \tag{24}$$

Note that the total deposits and loan choices are only affected by the aggregate level of income in each period and the discount factors.

Perfect competition in the banking sector implies that $L = D$ and[12]

$$R_d^* - R_d + E[S_2] - S_1 = R_l - R_l^* - E[S_2] - S_1 = R^* - R + E[S_2] - S_1 = 0 \tag{25}$$

$$\bar{R} = (1-\alpha)R + \alpha R^* - E[P_2] + P_1 + \alpha(E[S_2] - S_1) \tag{26}$$

[12]The expected nominal exchange rate ($E[S_2]$) and the expected price index ($E[P_2]$) are calculated using the same approximation stated above.

The portfolio allocation is given by

$$\alpha = \alpha_d = \alpha_l = \max\left[\frac{\text{COV}[P_2, S_2]}{\text{VAR}[S_2]}, 0\right] \approx \max\left\{\Psi\left[1 - \frac{\phi_1}{\phi_2}\right], 0\right\} \tag{27}$$

where Ψ is a function of the wage set by type a unions, the mean of the shock $\overline{C}^*$ and the structural parameters of the model (See Appendix B for details). The max term is needed since the portfolio allocation must not be smaller than zero[13]. The term inside the square brackets, which effectively controls the sign of the covariance, using the definitions of ϕ_1 and ϕ_2, is equal to $1 - \frac{\omega}{\varepsilon}$. Thus, when the central bank changes ε from zero to one, the covariance will move from minus infinity to roughly $1 - \omega$, being zero when $\varepsilon = \omega$ (CPI targeting).

Therefore given an external shock, the higher the control over the exchange rate relative to producer prices, the lower the proportion of assets/liabilities denominated in foreign currency (α). As mentioned in the introduction this proportion is sometimes refered to the literature as the level of financial dollarization (FD). As Ize and Levy-Yeyati (2003) point it out, the main driver of FD is the exchange rate pass-through. In our model, exchange rate pass-through is at its highest when producer prices are fixed and the consumer price index moves with the nominal exchange rate. Also note that the covariance, and therefore the portfolio allocation, is undefined when $\varepsilon = 0$; in this case both assets have the same riskiness profile.

4. Optimal Monetary Policy

Using the equilibrium conditions, (11)-(27), derived in the previous section, we are now able to evaluate the economy's welfare as a function of the monetary policy parameter (ε), and the structural parameters of the model. The details of the welfare function $U(\varepsilon)$ incorporating these equilibrium con-

[13]Portfolio shares must also be smaller than 1, but this limit is never binding in the model.

ditions can be found in Appendix B.

The optimal monetary policy can, therefore, be characterized as the value of ε that maximizes the welfare function $U(\varepsilon)$. As we cannot obtain simple analytical results we run numerical simulations under different sets of structural parameter values to compute welfare for all values of $\varepsilon \in (0, 1]$.

In order to do so, we need to set values for the main parameters of the model. A discussion on the sensitivity of these parameters is presented at the end of this section. Following Lawrance (1991) and Iacoviello (2005) we set β_H to 0.99 and $\beta_G = 0.95$. The intertemporal elasticity of substitution (σ) is set to 0.7, a rough average for the values used in different studies (for instance De Paoli (2004) sets it to be equal to 1 while Chari et al. (2002) set it equal to 0.2). η is set to 0.65, given that the share of labor income is roughly 65%[14]. We set the aggregate elasticity of labor supply, γ, to 1.5, following Gourio and Noual (2006)[15]. We set δ, the weight on the labor term in the utility function, such that the expected labor demand is around 0.7. Finally we set $\overline{C}^* = 0.5$ and $\Sigma = 0.05$.

Welfare analysis with different values of ω, which determines the level of openness, κ, which determines the degree of nominal rigidity, and wed, the initial wealth wedge between households, are presented in more detail since openness, the degree of wage rigidity and the level of domestic credit (controlled by wed) are the key drivers of the results. Initially, we set $\omega = 0.6$, implying a ratio of imports over output of around 40%, $\kappa = 0.5$, thus half of unions are allowed to change wages in the current period and $wed = 0.2$, implying a Gini income inequality index of 0.23.

In order to obtain a benchmark model that replicates the results obtained by the standard small open economy model (e.g. Gali and Monacelli (2005) and Sutherland (2001)) we consider a small open economy with a domestic

[14]The model does not explicitly include capital, though one can assume it to be fixed in the short term.

[15]That is considerably smaller than the one used by Rotemberg and Woodford (1997) and De Paoli (2004) but still slightly higher than microeconomic based estimates, e.g. Pistaferri (2003), who estimate it to be around 0.7.

credit market where only assets denominated in local currency are available. Thus, we exclude equation (27) from the equilibrium conditions and set α to be equal to zero. Figure 1(a) shows that welfare is maximized when $\varepsilon = 1$, that is when the central bank chooses to target domestic (producer) prices and leaves the nominal exchange rates to float freely. For comparison purposes we also report the ratio of total loans (domestic credit) to output.

[**Insert *Figure 1: Small Open Economy* - $\alpha = 0$ here**]

Firstly, as noted by Corsetti and Pesenti (2001), among others, the central bank, while targeting producer prices, can influence the terms of trade in a way beneficial to domestic consumers, hence the utility from consumption increases with ε.

Secondly, Gali and Monacelli (2005) and Sutherland (2001) show that either fixing the nominal exchange rate or controlling the consumer price index ($\varepsilon = \omega = 0.6$) lead to excess smoothness in the nominal exchange rate resulting in a deviation from the first best allocation (without nominal rigidities). Therefore, controlling producer prices is the best policy to stabilize shocks leading to the highest, but optimal, volatility of the exchange rate. As indicated by Gali and Monacelli (2005) the consumer price index (CPI) targeting is merely a hybrid regime between domestic price targeting and fixed exchange rate regime, given the monotonicity of the welfare function as ε increases.

Targeting producer prices, however, is not optimal when the full model, where the portfolio allocation (α) is optimally selected by both households, is considered. The simulation results presented in figure 2 show that it is now optimal to control the consumer price index (CPI), setting $\varepsilon = \omega = 0.6$, and not the producer prices ($\varepsilon = 1$). Contrary to the conclusion obtained by the standard small open economy models the model here gives theoretical support to CPI targeting, which is commonly used in many small open economies. The main welfare component driving this result is the effect of ε (monetary policy) on the borrower's expected utility.

[**Insert *Figure 2: Welfare Analysis - Full Model* here**]

Another way of interpreting this new result is to follow Gali and Monacelli (2005) and translate it into the optimal level of exchange rate volatility. As $\varepsilon* < 1$, it is now optimal to exert some exchange rate control. Controlling exchange rate becomes optimal since when the monetary authority sets $\varepsilon = 1$, controlling producer prices only, the nominal exchange rate exhibits the highest variance. This leads to a sharp increase in the nominal exchange rate risk premium[16] (figure 2(e)). Given that the borrower increases the share of foreign currency denominated loans as ε approaches one (see figure 2(f)), the expected loan payment in period two also increases sharply with ε. That leads to a decrease in the borrower's expected utility from consumption when $\varepsilon > \omega = 0.6$ (dotted line in figure 3). Therefore, increasing ε above ω results in a sharp increase in the cost of hedging against portfolio fluctuations for borrowers. This effect was not in place when the portfolio selection was not endogenous and only local currency assets were available. In this case, $\alpha = 0$ for all ε (continuous line in figure 3), loan payments do not increase sharply and the kink observed in the borrower's utility does not arise[17]. [**Insert *Figure 3: New effect of exchange rate volatility* here**]

In addition note that the welfare function is no longer monotonically increasing in ε. The evolution of welfare when monetary policy moves from fixed exchange rate towards CPI targeting ($0 < \varepsilon < \omega$) and from CPI towards domestic price targeting ($\omega < \varepsilon < 1$) is essentially different. On one hand exchange rate volatility stabilizes shocks and tends to increase welfare. On the other hand, high levels of exchange rate volatility lead to a decrease in borrowers' utility. While the first effect is present as ε increase from zero to one, the second is present only in the interval $\omega < \varepsilon < 1$. Therefore,

[16] The exchange rate risk premium (ERP) is defined as the difference between the expected nominal exchange rate and the nominal exchange rate evaluated when the shock is equal to its mean value. Note that this risk premium reflects the impact of uncertainty on asset prices and is entirely different from the risk premium commonly used to model departures from Uncovered Interest Rate Parity.

[17] Note that the increase in loan payment is not due to an increase in the ratio of domestic credit over GDP. That remains roughly the same, at around 14%, in both cases.

the difference arises due to the effect of the share of foreign denominated liabilities in the domestic asset market (or the level of financial dollarization) and the variance of nominal exchange rate on the welfare of borrowers, since that share is different than zero only when $\varepsilon > \omega$.

4.1 Credit Market Size

As observed from the results in the previous section the impact of exchange rate volatility on the domestic liabilities denominated in foreign currency is an important factor determining the optimal monetary policy in small open economies. Hence, the size of these liabilities with respect to the level of output in the economy is relevant to determine if the new effect of exchange rate volatility on welfare is relevant for monetary policy making.

The size of the credit market depends on how far apart β_H and β_G are and most importantly the initial welfare difference between patient and impatient households, wed. The ratio of domestic credit (total loans) over output under our initial parametrization is around 14% (see figure 2 (d)), well below the one observed in the data (see table 3). Furthermore, the wealth differential introduced ($wed = 0.2$) also leads to low levels of income inequality comparing to the data. Therefore, the welfare function is also obtained for a higher level of wed, setting it equal to 0.3. This implies a Gini index of 33% and a ratio of total loans to GDP of around 25%, both still below the average in the data[18]. For completeness we also show the results for a lower level of wed.

[Insert *Figure 4: Varying Credit Market Size* here]

As expected, the higher the credit market the stronger the negative effect of exchange rate volatility on the economies welfare as ε increases above ω. When $wed = 0.1$ the domestic credit is quite thin, only 7% of output, and the

[18]Our model does not incorporate capital investment, which would increase the return on lending, leading to an increase in credit market depth. Incorporating this feature would bring the model close to the data, possibly reinforcing the liability effect over the stabilization effect.

stabilization effect is stronger than the liability effect such that it is optimal to set $\varepsilon* > \omega$.

4.2 Level of Openness

Another important parameter that we kept constant so far is the level of openness of the economy. Although we set the ratio of imports over GDP to roughly 40% ($\omega = 0.6$) in our model, the data from the main emerging markets economies show it can be considerably higher than that. The average for the countries in table 3 is 55%. Figure 5 shows how welfare changes with monetary policy for $\omega = 0.3$ under low and high levels of credit. Even for low levels of credit the optimal monetary policy is still to target CPI (note that CPI targeting is now achieved when $\varepsilon = \omega = 0.3$). This is so because financial dollarization or the share of liabilities denominated in foreign currency is higher than zero for lower levels of ε, where the stabilization effect is mild, and the consumption basket is heavily biased towards foreign goods.

[**Insert *Figure 5: Welfare - Higher Openness (*$\omega = 0.3$*)* here**]

4.3 Degree of Nominal Rigidity

Varying κ, the proportion of the unions in the labor market that set wages one period in advance, allow us to investigate the effects of different degrees of nominal rigidity on the optimal monetary policy. The analysis done so far only considered an intermediate degree of wage rigidity, setting $\kappa = 0.5$.

Figure 6 shows the welfare for different levels of κ [19]. The central bank finds it optimal to exert less control over the nominal exchange rate, the greater the rigidity of nominal wages. The higher the proportion of unions that can not adjust wages in the second period, the greater the relevance of using exchange rate movements to stabilize the shocks, correcting for the nominal distortion in the economy, and hence the greater the gain from

[19]The other parameter are set as in the benchmark case: $\omega = 0.6$ and $wed = 0.2$.

controlling producer prices and letting the exchange rate to float freely.

[**Insert *Figure 6: Varying the degree of wage rigidity* here**]

Note that with high levels of rigidity and $wed = 0.2.$, figure 6 (c), CPI is no longer the optimal policy. However, when credit market depth increases (higher wed) the optimality of CPI targeting obtains even for high levels of nominal rigidity.

4.4 Sensitivity Analysis

Changing the other parameters of the model does not alter the qualitative results discussed above[20].

Lower values of γ, the elasticity of labor supply, make the households more averse to the volatility of labor and therefore strengthen the welfare gains from exchange rate movements as a stabilization mechanism in relation to the losses due to the liability effect. As η, the exponent of labor on the production function, decreases, type b wages become less responsive to an external shock. That implies lower wage dispersion, decreasing the need to use exchange rate movements as a stabilization mechanism. Finally, an increase in Σ, the variance of the external shock strengthens the potential welfare loss from exchange rate volatility, because its impact on the exchange rate risk premium is stronger than its impact on the variance of labor and income.

The effect of changing σ, the elasticity of intertemporal substitution and measure of risk aversion, on ε or the optimal monetary policy is not monotonic as observed for the other variables. Decreasing σ from a high value towards 0.7 (our benchmark parametrization) leads to more risk aversion, which lowers the amount of credit and increases the expected welfare losses due to the variance of consumption. These effects strengthen the welfare gain from exchange rate movements as a stabilization mechanism in relation to the

[20]Simulation results are presented in a technical appendix available from the author upon request.

loss due to the liability effect. However as σ becomes too small, the households utility function displays a high degree of curvature such that income dispersion between borrowers and lenders is very detrimental to welfare. In that case the liability effect is strengthened.

4.5 Impact of Regulation on Foreign Currency Denominated Assets

A common regulatory policy used to promote de-dollarization or control the share of deposits and loans denominated in foreign currency in the domestic market is to prevent or prohibit agents from making these deposits and loans. This type of policy is in place in some emerging market countries (e.g. Brazil). The framework developed in this paper can be employed to analyze the welfare consequences of implementing such a policy.

The implementation of the policy in our setting is equivalent to solving the model when only local currency denominated assets are available, or setting $\alpha = 0$. Although the economy's welfare increases only borrowers benefit from the change; lenders are worse-off, thus the policy implementation is not Pareto improving. The main drivers of this result are: (*i*) the variance of the total income of lenders is increasing in ε due to inefficient portfolio allocation and (*ii*) since without FD the exchange rate premium bears no impact on the expected loan payment, this payment does not rise as sharply as before. Figure 7 shows the results (unconnected dotted line shows the equilibrium after the implementation of the policy). The other parameter for these simulations are $\omega = 0.6$, $\kappa = 0.5$ and $wed = 0.2$.

[**Insert *Welfare effects of Policy preventing Financial Dollarization* here**]

Once again note that under the new policy the difference between the evolution of welfare when moving monetary policy from the regime with fixed exchange rate towards consumer price targeting ($0 < \varepsilon < \omega$) and from

CPI towards producer price targeting ($\omega < \varepsilon < 1$) does not exist (no kink at $\varepsilon = \omega$). CPI becomes again a simple hybrid regime between these two extreme policies.

5. Conclusion

This paper analyzes monetary policy in a small open economy with a domestic credit market where both local and foreign currency denominated assets are available. Given that variances are crucial for the determination of asset allocation, we employ a methodology, similar to the one introduced by Obstfeld and Rogoff (2000), that takes explicit account of economic uncertainty and its impact on macroeconomic variables.

Gali and Monacelli (2005) and Sutherland (2001) show that monetary policy in a small open economy is isomorphic to close economies, prescribing a domestic price targeting. Such a policy produces enough exchange rate volatility to stabilize the external shock reducing the variance of labor and income. However, when agents can trade both local and foreign currency denominated assets and liabilities, exchange rate volatility can have a negative effect on welfare. Taking that into account the optimal monetary policy is to control the consumer price index (CPI), thus, exerting some control over exchange rate movements. Under producer price control, exchange rate volatility is at its highest leading to a high exchange rate premium. Given that the share of foreign currency denominated liabilities is also at its highest, a high exchange rate premium makes the borrowers worse off, reducing welfare.

Therefore, the model presented gives theoretical support to CPI targeting and shows that the "fear of floating" observed in many emerging economies is in fact an optimal response of the central bank when agents are allowed to accumulate domestic liabilities in foreign currency. Although Chang and Velasco (2006) also present a framework with this feature, they only model the currency choice of external debt. However, for most small open economies, the international credit market is only available in foreign currency ("original sin") and furthermore, as Honig (2005) points out, domestic liability dollarization plays a central role in producing a "fear of floating".

Another relevant policy question investigated in this paper is the welfare impact of introducing a regulation to prevent agents from making deposits and loans in foreign currency. This regulation is actually in place in some countries. We find that the introduction of such a policy leads to an increase in welfare, although it is not Pareto improving as lenders are worse-off.

The analysis here identifies a relevant effect of exchange rate volatility on welfare that can influence the optimal monetary policy in an small open economy. Although our model embeds many important characteristics of small open economies, we have assumed unitary intertemporal elasticity of substitution, implying no trade imbalances. We also restricted our analysis to monetary policy responses to an external demand shock. Finally, we only consider a two period economy.

Hence, an important topic of future research is to incorporate different shocks, adopt a more flexible consumption index, and extend our framework to an infinity horizon economy. The extended framework would then provide a more realistic representation of the monetary policy trade-offs faced by small open economies, allowing a more accurate analysis of the importance of domestic asset holdings on monetary policy.

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Appendix A

Table 3: Financially Dollarized Small Open Economies

Country	Openness	Imports	Domestic Credit	Loan Dollarization	Deposit Dollarization	Gini Index	IMF de facto Exch. Rate Regime 2006
Albania	63%	43%	0%	68%	31%	26	Floating
Armenia	71%	45%	8%		75%	37	Managed Floating
Azerbaijan	100%	51%	10%	62%	59%	36	Crawling Peg
Belarus	132%	68%	21%		57%	29	Fix Peg
Bosnia and Herzagovina	89%	62%	41%	39%	52%	26	Currency Board
Bulgaria	125%	68%	30%	41%	50%	31	Currency Board
Croatia	103%	56%	64%	78%	65%	29	Managed Floating
Czech Republic	135%	68%	46%	14%	11%	26	Managed Floating
Estonia	162%	84%	54%	80%	30%	34	Currency Board
Georgia	76%	46%	21%	83%	94%	40	Managed Floating
Hungary	138%	70%	57%	35%	17%	28	Pegged within Horizontal Band
Israel*	80%	41%	83%		19%	38	Floating
Kazakistan	98%	46%	19%	57%	51%	30	Managed Floating
Latvia	99%	56%	50%	64%	40%	37	Fix Peg
Lithuania	112%	59%	28%	61%	41%	36	Currency Board
Macedonia	97%	57%	18%	20%	48%	39	Fix Peg
Moldova	191%	120%	29%	72%	50%	33	Managed Floating
Poland	69%	36%	34%	16%	17%	36	Floating
Romania	76%	42%	0%	59%	44%	31	Managed Floating
Slovak Republic	156%	80%	50%	18%	15%	26	Pegged within Horizontal Band
Slovenia	121%	61%	56%	25%	33%	24	Pegged within Horizontal Band
Turkey*	61%	33%	60%		58%	43	Floating
Ukraine	110%	53%	31%	43%	35%	31	Fix Peg
Cambodia*	126%	68%	7%		95%	41	Managed Floating
Hong Kong*	334%	163%	1%		45%	53	Fix Peg
Indonesia*	61%	27%	50%		20%	36	Floating
Korea*	78%	38%	94%		4%	35	Floating
Malaysia*	218%	99%	141%		4%	46	Managed Floating
Philippines*	102%	52%	54%		31%	45	Floating
Thailand*	132%	64%	121%		1%	42	Managed Floating
Argentina†	36%	15%	42%	62%	65%	49	Managed Floating
Bolivia†	56%	28%	55%	97%	93%	59	Fix Peg
Chile†	69%	31%	72%	14%	8%	54	Floating
Costa Rica†	96%	49%	39%	50%	49%	49	Crawling Peg
Dominican Republic†	77%	41%	28%	24%	23%	51	Managed Floating
Haiti†	54%	40%	35%	39%	32%	59	Managed Floating
Honduras†	96%	56%	29%	24%	28%	53	Fix Peg
Jamaica†	98%	58%	65%	20%	28%	45	Managed Floating
Nicaragua†	77%	52%	90%	82%	70%	43	Crawling Peg
Paraguay†	84%	43%	26%	50%	65%	56	Managed Floating
Peru†	38%	18%	21%	82%	77%	52	Managed Floating
Uruguay†	50%	25%	57%	87%	92%	45	Managed Floating
Mean	103%	55%	44%	51%	43%	40	

Source: IFS, WEO and CIA Factbook. Dollarization data: * from Nicolo et al. (2005) referring to levels in 2001, † from Barajas and Morales (2003), referring to levels in 2001 and the remaining countries from Basso et al. (2007), referring to averages from 2000 to 2006.
Note: Openness = (Imports + exports)/GDP. Imports, Domestic Credit and Net Foreign Assets in the Banking Sector are shown as percentage of the GDP. Loan (deposit) dollarization is shown as percentage of total loans (deposits).

Appendix B

A.1 Equilibrium Solution - Main Model

The firm's first order conditions and goods market clearing condition are (time subscripts have been omitted for simplicity):

$$\frac{W}{P} = \frac{P_P}{P}\eta\frac{Y}{N} \tag{A.1}$$

$$\Pi = (1-\eta)\frac{P_P}{P}Y \tag{A.2}$$

$$Y = C_{P,H} + C_{P,G} + \frac{SC^*}{P_P} \tag{A.3}$$

$$Y = N^\eta \tag{A.4}$$

Using (A.4) into (A.1) gives

$$P_P = \frac{1}{\eta}WY^{(1-\eta)/\eta} \tag{A.5}$$

The Household first order conditions and the balance of payment condition are the budget constraint (2), the price index (5) and

$$C_{P,H} = \frac{P_P^\omega S^{1-\omega}\omega C_H}{P_P}, \quad C_{F,H} = \frac{P_P^\omega S^{1-\omega}(1-\omega)C_H}{S} \tag{A.6}$$

$$C_{P,G} = \frac{P_P^\omega S^{1-\omega}\omega C_G}{P_P}, \quad C_{F,G} = \frac{P_P^\omega S^{1-\omega}(1-\omega)C_G}{S} \tag{A.7}$$

$$C^* = C_{F,G} + C_{F,H} \tag{A.8}$$

Using (A.6), (A.7) and (A.8) into (A.3) gives

$$Y = \frac{SC^*}{P_P}\frac{1}{1-\omega} \tag{A.9}$$

Using (A.1), (A.2) and (A.9) into (2) and using (A.9) into (A.4) gives equations (11) - (13) into the main text.

Using (A.9) into (A.5) gives

$$P_P = \frac{W^\eta}{\eta^\eta}\left[\frac{SC^*}{1-\omega}\right]^{1-\eta} \tag{A.10}$$

Combining the result with the monetary policy rule (10), the wage index ($W = W_a^{\kappa} W_b^{1-\kappa}$) and the price index (5) give equations (15)-(20) into the main text (time subscripts should be replaced).

The period two wage set by type b unions, using the solutions for P_2, C_2 and N_2 in table 1, is given by

$$W_b = \delta P_2 C_2^{1/\sigma} N_b{}^{1/\gamma} = \delta P_2 C_2^{1/\sigma} \left(\frac{W_2 N_2}{W_b} \right)^{1/\gamma} = Q_a (C^*)^{\psi_2} \qquad \text{(A.11)}$$

where

$$\begin{aligned}
Q_a &= \Upsilon^{\frac{1}{\psi_3}} W_a^{\frac{\kappa(\eta\psi_1 + 1/\gamma)}{\psi_3}} \\
\psi_1 &= \left(\phi_2 + \frac{\phi_3}{\gamma\eta} + \phi_1 \left(\frac{1}{\sigma} - 1 \right) \right) \\
\psi_2 &= \frac{(1-\eta)\psi_1 + 1/\sigma + 1/(\gamma\eta)}{\psi_3} \\
\psi_3 &= 1 - (1-\kappa)(\eta\psi_1 + 1/\gamma) + 1/\gamma \\
\Upsilon &= \frac{\delta}{(1-\omega)^{1/\sigma + 1/\gamma\eta}} \left[\frac{1}{\Lambda \eta^{\eta} (1-\omega)^{1-\eta}} \right]^{\psi_1} \left[\Lambda^{\omega - \omega/\gamma - 1/\gamma\eta} \right]
\end{aligned}$$

Given that prices are flexible in the first period, then one can set $P_1 = 1$, and use the same first order conditions stated above (adjusting for the time subscript) to find that $C_1 = C_{1,H} + C_{1,G} = I_1 = \frac{S_1 \bar{C}^*}{(1-\omega)}$. Using the price index one finds that $P_{P,1} = S_1^{\frac{\omega-1}{\omega}}$. Using this result into the equivalent equation (A.10) for period one and the first period wage setting equation we find the solution for the nominal exchange rate, stated below.

$$S_1 = \frac{\delta}{\eta}^{\frac{\eta\omega\gamma\sigma}{\eta\omega\gamma(\sigma-1) - \sigma(1+\gamma)}} \frac{\bar{C}^*}{1-\omega}^{\frac{\eta\omega(\omega-1)(\gamma+\sigma)}{[\eta\omega\gamma(\sigma-1) - \sigma(1+\gamma)](\eta\omega-1)} + \frac{(1-\eta)\omega}{\eta\omega-1}}$$

Labor at period one is given by

$$N_1 = \frac{\delta}{\eta}^{\frac{\gamma\sigma}{\eta\omega\gamma(\sigma-1) - \sigma(1+\gamma)}} \frac{\bar{C}^*}{1-\omega}^{\frac{(\omega-1)(\gamma+\sigma)}{[\eta\omega\gamma(\sigma-1) - \sigma(1+\gamma)](\eta\omega-1)} + \frac{\omega-1}{\eta\omega-1}}$$

The second period wage set by type a union (before the shock) is given by

$$
\begin{aligned}
W_{2,a} &= W_{2,a}^{\kappa(\eta\psi_1+1/\gamma)-1/\gamma}\Upsilon\frac{E\left[W_{2,b}^{(1-\kappa)(\phi_3+1)(1+1/\gamma)}C^{*\Psi_1}\right]}{E\left[W_{2,b}^{(1-\kappa)(\eta(\phi_1(1-1/\sigma)-\phi_2+\phi_3/\eta)+1)}C^{*\Psi_2}\right]}\\
W_{2,a}^{1-\Xi_1} &= \Upsilon^{\Xi_4}\frac{E\left[C^{*\Xi_2}\right]}{E\left[C^{*\Xi_3}\right]} \qquad \text{(A.12)}
\end{aligned}
$$

where

$$
\begin{aligned}
\Psi_1 &= \left((1-\eta)\phi_3+1\right)(1+1/\gamma)(1/\eta)\\
\Psi_2 &= (1-\eta)\left(-\phi_2+\frac{\phi_3}{\eta}-\phi_1\left(\frac{1}{\sigma}-1\right)\right)-\frac{1}{\sigma}+\frac{1}{\eta}\\
\Xi_1 &= \kappa(\eta\psi_1+1/\gamma)\left(1+\frac{(1-\kappa)(\eta\psi_1+1/\gamma)}{\psi_3}\right)-1/\gamma\\
\Xi_2 &= \Psi_1+\psi_2(1-\kappa)(\phi_3+1)(1+1/\gamma)\\
\Xi_3 &= \Psi_2+\psi_2(1-\kappa)(\eta(\phi_1(1-1/\sigma)-\phi_2+\phi_3/\eta)+1).\\
\Xi_4 &= \left(1+\frac{(1-\kappa)(\eta\psi_1+1/\gamma)}{\psi_3}\right).
\end{aligned}
$$

In order to set total loans and deposits households must know their expected income in the second period $I_{2,j}$. That is given by

$$
\begin{aligned}
I_{2,j}=I_2 &= E\left[\frac{1}{2}\frac{S_2C^*}{P_2}\frac{1}{1-\omega}\right]=\frac{1}{2\Lambda^\omega}\frac{Z^{\phi_1}}{1-\omega}E\left[W_{2,b}^{\phi_1\eta(1-\kappa)}C^{*(1-\eta)\phi_1+1}\right]\\
&\approx \frac{1}{2\Lambda^\omega}\frac{Z^{\phi_1}Q_a^{\eta(1-\kappa)\phi_1}}{1-\omega}\left[\overline{C^*}^{\Xi_5}+\Xi_5(\Xi_5-1)\overline{C^*}^{\Xi_5-2}\frac{\Sigma}{2}\right] \qquad \text{(A.13)}
\end{aligned}
$$

where $\Xi_5=(1-\eta)\phi_1+1+\psi_2\eta(1-\kappa)\phi_1$.

Finally in order to obtain the portfolio allocations we need to calculate the $\mathrm{COV}(P_2,S_2)$ and the $\mathrm{VAR}(S_2)$. Using (A.11), (15) and (17) we get

$$
\begin{aligned}
\mathrm{COV}(P_2,S_2) &= Z^{2\phi_2-\phi_1}Q_a^{\eta(1-\kappa)(2\phi_2-\phi_1)}\Lambda^\omega \mathrm{COV}(C^{*x},C^{*y})\\
&= Z^{2\phi_2-\phi_1}Q_a^{\eta(1-\kappa)(2\phi_2-\phi_1)}\Lambda^\omega (E(C^{*xy})-E(C^{*x})E(C^{*y}))
\end{aligned}
$$

Where $x=(1-\eta)(\phi_2-\phi_1)+\psi_2\eta(1-\kappa)(\phi_2-\phi_1)$ and $y=(1-\eta)(\phi_2)+\psi_2\eta(1-\kappa)\phi_2$

Using a second order approximation to the expectations and excluding the terms with order higher than VAR$(C^*) = \Sigma$ we obtain

$$\mathrm{COV}(P_2,S_2)=Z^{2\phi_2-\phi_1}Q_a^{\eta(1-\kappa)(2\phi_2-\phi_1)}\Lambda^{\omega}\overline{C^*}^{xy-2}\Sigma(xy) \qquad \text{(A.14)}$$

The variance of the nominal exchange rate is given by

$$\mathrm{VAR}(S_2) = Z^{2\phi_2}Q_a^{\eta(1-\kappa)(2\phi_2)}\overline{C^*}^{y}\Sigma\left(y^2\right)$$

.

The ratio of these two results gives the solution for the term used into the portfolio solution ((27)) in the main text.

$$\frac{\mathrm{COV}[P_2,S]}{\mathrm{VAR}[S]} \approx \Psi\left[1-\frac{\phi_1}{\phi_2}\right]$$

where $\Psi = Z^{-\phi_1}Q_a^{-\eta(1-\kappa)\phi_1}\Lambda^{\omega}\overline{C^*}^{-\phi_1((1-\eta)+\psi_2(1-\kappa)\eta)}$

A.2 The Welfare Functions

The economy's welfare can be divided into five parts, the utility from consumption for both households in each period and the disutility of labor. Using the basic model equilibrium conditions (11)-(27) the economy's welfare can be written as

$$
\begin{aligned}
U(\varepsilon) &= E[(A_1+A_2)+(A_3+A_4)-A_5] \\
\text{where} \quad A_1 &= \frac{\left(\frac{S_1\bar{C}^*}{2(1-\omega)} - D + wed\right)^{1-1/\sigma}}{2(1-1/\sigma)}, \\
A_2 &= \frac{\beta_H}{2(1-1/\sigma)}\Bigg[\frac{1}{2}\frac{Z^{\phi_1}W_{2,b}^{\eta\phi_1(1-\kappa)}}{\Lambda^{\omega}(1-\omega)}C^{*(1-\eta)\phi_1+1} \\
&+D((1-\alpha)R+\alpha R^* - P_2 + 1 + \alpha(S_2-S_1)\Bigg]^{1-1/\sigma}, \\
A_3 &= \frac{\left(\frac{S_1\bar{C}^*}{2(1-\omega)} + L - wed\right)^{1-1/\sigma}}{2(1-1/\sigma)}, \\
A_4 &= \frac{\beta_G}{2(1-1/\sigma)}\frac{1}{2}\Bigg[\frac{Z^{\phi_1}W_{2,b}^{\eta\phi_1(1-\kappa)}}{\Lambda^{\omega}(1-\omega)}C^{*(1-\eta)\phi_1+1} \\
&-L((1-\alpha)R+\alpha R^* - P_2 + 1 + \alpha(S_2-S_1)\Bigg]^{1-1/\sigma}, \\
A_5 &= \frac{\delta N_1^{1+1/\gamma}}{1+1/\gamma} + \frac{\beta_H+\beta_G}{2}\frac{\delta}{1+1/\gamma}\left(\frac{Z^{\phi_3}W_{2,b}^{\eta\phi_3(1-\kappa)}}{\Lambda(1-\omega)}C^{*(1-\eta)\phi_3+1}\right)^{\frac{1+1/\gamma}{\eta}},
\end{aligned}
$$

$S_2 = Z^{\phi_2}W_{2,b}^{\eta\phi_2(1-\kappa)}C^{*(1-\eta)\phi_2}$, $P_2 = Z^{\phi_2-\phi_1}W_{2,b}^{\eta(\phi_2-\phi_1)(1-\kappa)}\Lambda^{\omega}C^{*(1-\eta)(\phi_2-\phi_1)}$, $W_{2,b} = Q_a C^{*\psi_2}$, and $Z = \frac{W_{2,a}^{\eta\kappa}}{\Lambda\eta^{\eta}(1-\omega)^{(1-\eta)}}$. Finally, $W_{2,a}$ is given by (21) and L, D, R and R^* are such that (22), (23) and (26) hold.

In order to obtain a solution for the expected welfare dependent only on the average and variance of the shock (C^*), a second order approximation of the welfare equation is considered

The terms A_1 and A_3 do not depend on the shock (C^*) but only on its expected value, thus we only need to obtain an approximation for $E[A_2]$, $E[A_4]$ and $E[A_5]$.

$$
\begin{aligned}
E[A_2] &= \frac{\beta_H}{1-1/\sigma} E[f(C^*)^{1-1/\sigma}] \\
&\approx \frac{\beta_H}{1-1/\sigma} \left[f(\bar{C}^*)^{1-1/\sigma} + \frac{\Sigma}{2} \frac{\partial^2 f(C^*)^{1-1/\sigma}}{\partial {C^*}^2} \Big|_{C^*=\bar{C}^*} \right] \\
\text{where} \qquad f(C^*) &= \left[\frac{1}{2} \frac{Z^{\phi_1} W_{2,b}^{\eta\phi_1(1-\kappa)}}{\Lambda^{\omega}(1-\omega)} C^{*(1-\eta)\phi_1+1} \right. \\
&\left. + D((1-\alpha)R + \alpha R^* - P_2 + 1 + \alpha(S_2 - S_1) \right]^{1-1/\sigma}
\end{aligned}
$$

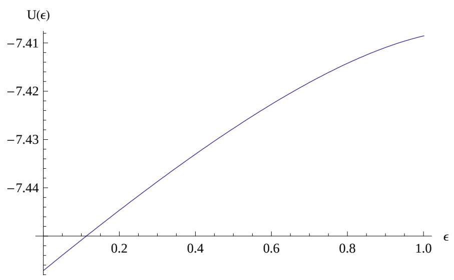
The same approximation is done for $E[A_4]$. $E[A_5]$ is given by

$$
E[A_5] = \frac{\delta}{1+1/\gamma} N_1^{1+1/\gamma} \quad + \quad \frac{\delta(\beta_H+\beta_G)}{2(1-1/\gamma)} \left(\frac{Z^{\phi_3} Q_a^{\eta\phi_3(1-\kappa)}}{\Lambda(1-\omega)} \right)^{\frac{1+1/\gamma}{\eta}} E\left[(C^{*\psi_2\eta\phi_3(1-\kappa)+((1-\eta)\phi_3+1)})^{\frac{1+1/\gamma}{\eta}} \right]
$$

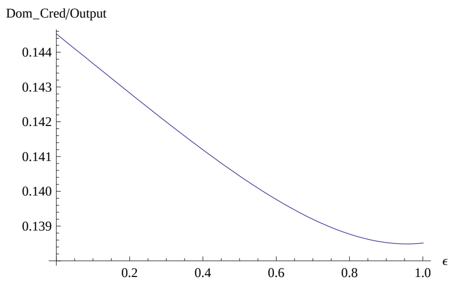
where the last term expectation can be approximated to

$$
\approx \overline{C^*}^{\zeta} + \frac{\Sigma}{2} \zeta(\zeta-1) \left[\overline{C^*}^{\zeta-2} \right]
$$

For $\zeta = (\psi_2\eta\phi_3(1-\kappa) + ((1-\eta)\phi_3+1))(\frac{1+1/\gamma}{\eta})$.

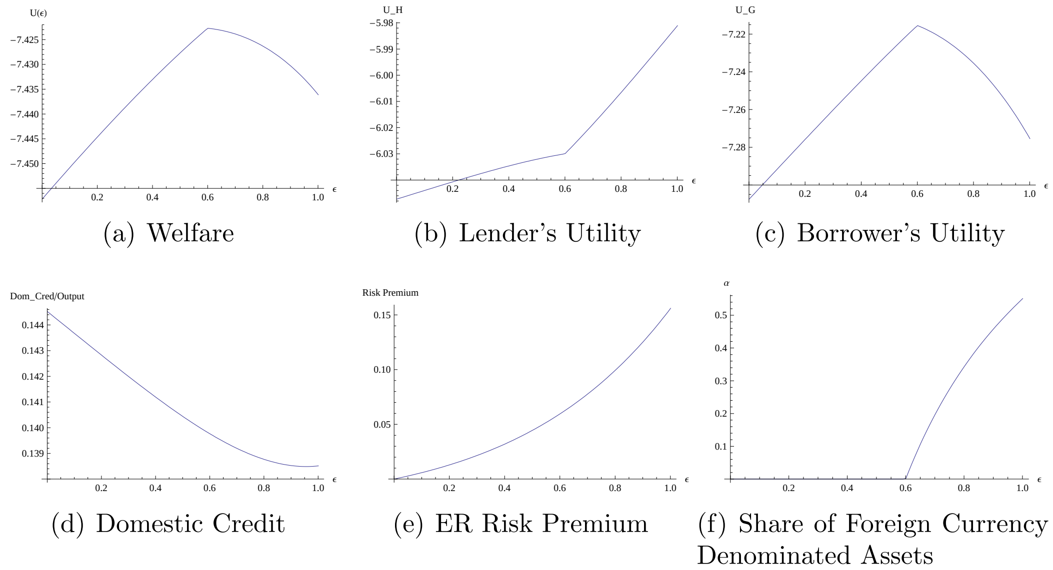


(a) Welfare



(b) Domestic Credit

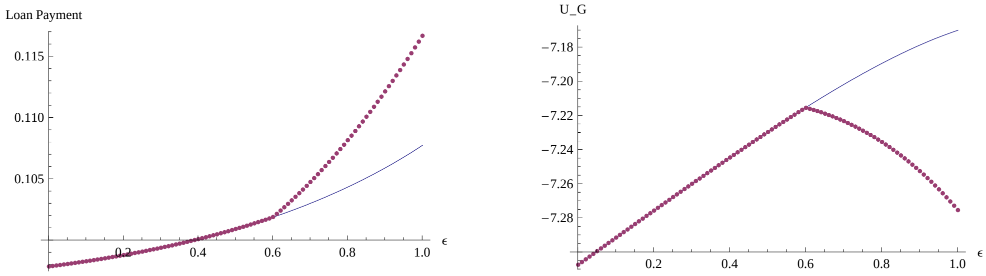
Figure 1: Small Open Economy ($\alpha = 0$)



(a) Welfare (b) Lender's Utility (c) Borrower's Utility

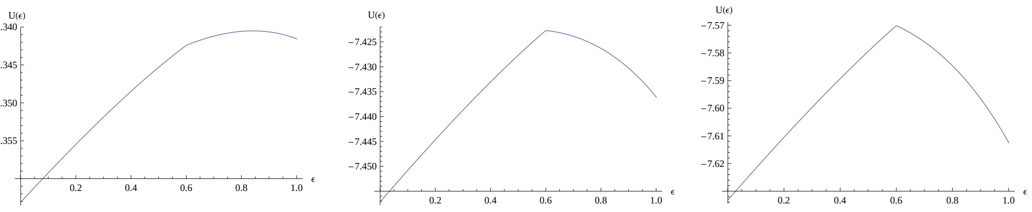
(d) Domestic Credit (e) ER Risk Premium (f) Share of Foreign Currency Denominated Assets

Figure 2: Welfare Analysis - Full Model



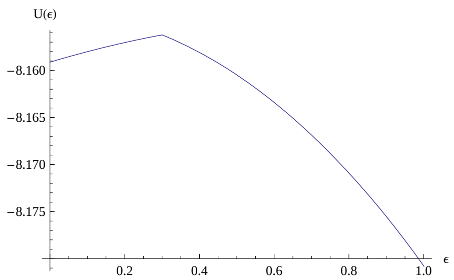
(a) Loan Payment (b) Borrower's Utility

Figure 3: New effect of exchange rate volatility

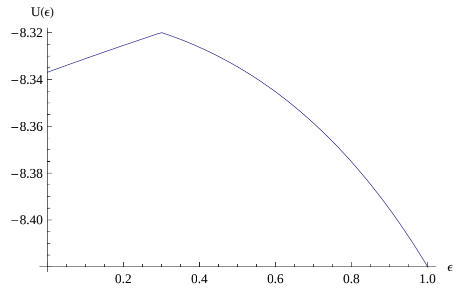


(a) Welfare $wed = 0.1$ (b) Welfare $wed = 0.2$ (c) Welfare $wed = 0.3$

Figure 4: Varying Credit Market Size

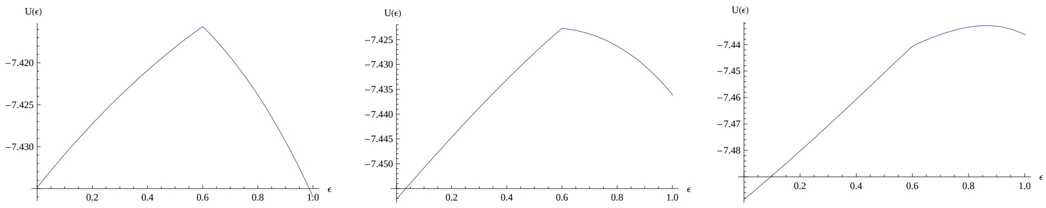


(a) Low Credit Depth - $wed = 0.1$



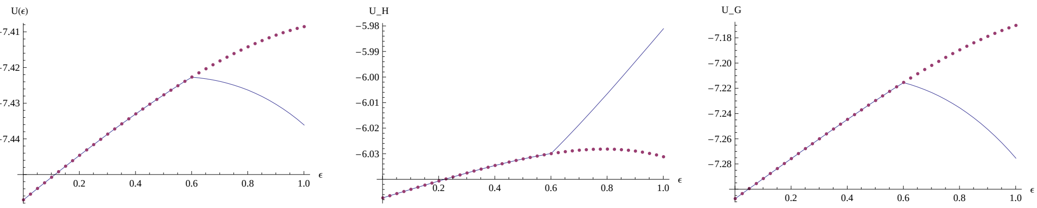
(b) High Credit Depth - $wed = 0.2$

Figure 5: Welfare - Higher Openness ($\omega = 0.3$)



(a) Welfare ($\kappa = 0.25$) (b) Welfare ($\kappa = 0.5$) (c) Welfare ($\kappa = 0.75$)

Figure 6: Varying the degree of wage rigidity



(a) Welfare (b) Lender's Utility (c) Borrower's Utility

Figure 7: Welfare effects of Policy preventing Financial Dollarization