POLÍTICA Y ESTABILIDAD MONETARIA EN EL PERÚ

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De-dollarization and financial robustness

*Rocío Gondo and Fabrizio Orrego**

We evaluate the implications of financial de-dollarization on the strength of balance sheet effects in a small open economy following an unanticipated shock to the foreign risk-free interest rate. In particular, we extend the Cespedes, Chang and Velasco (2004) open economy model by allowing entrepreneurs to borrow in both foreign and domestic currency so as to finance firms' capital needs. A real depreciation reduces the value of firms' net worth whenever there is a currency mismatch in their balance sheets. Under flexible exchange rates, a low degree of dollarization lessens the negative impact on output and investment, since there is a small increase in the cost of external borrowing. The quantitative results show that the model is able to account for about 80 percent of the output and investment drops, and 60 percent of the real exchange rate depreciation in Peru following the Russian Crisis. Moreover, de-dollarization would have moderated the decline in output growth by 0.7 percent.

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JEL Classification: F31, F41, G32.

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7.1 Introduction

In recent years, corporate firms in Latin America have been concerned about the currency composition of their debt. Figure 7.1 shows that firms have been re-balancing their debt portfolios so as to reduce the participation of liabilities denominated in foreign currency, particularly since the 1997-98 international financial crisis. Levy-Yeyati (2006) argues that the main disadvantage of this type of dollarization, also known as financial dollarization, is related to the incidence of balance sheet effects in the event of a sharp real exchange rate depreciation, as firms may struggle to service their dollar debt.[1]

A vast literature emerged after that crisis, which provided the theoretical underpinnings on how financial shocks have real effects due to a currency mismatch between assets and liabilities in the balance sheets of firms. Initial developments embedded the financial accelerator mechanism of Bernanke et al. (1999) into small open economy models, as in Cespedes et al. (2003) and especially Cespedes et al. (2004), CCV hereafter. In order to simplify the theory, an assumption in this class of models is that entrepreneurs are fully exposed to currency risk, as they borrow only in foreign currency in an environment in which currency hedging is not available.

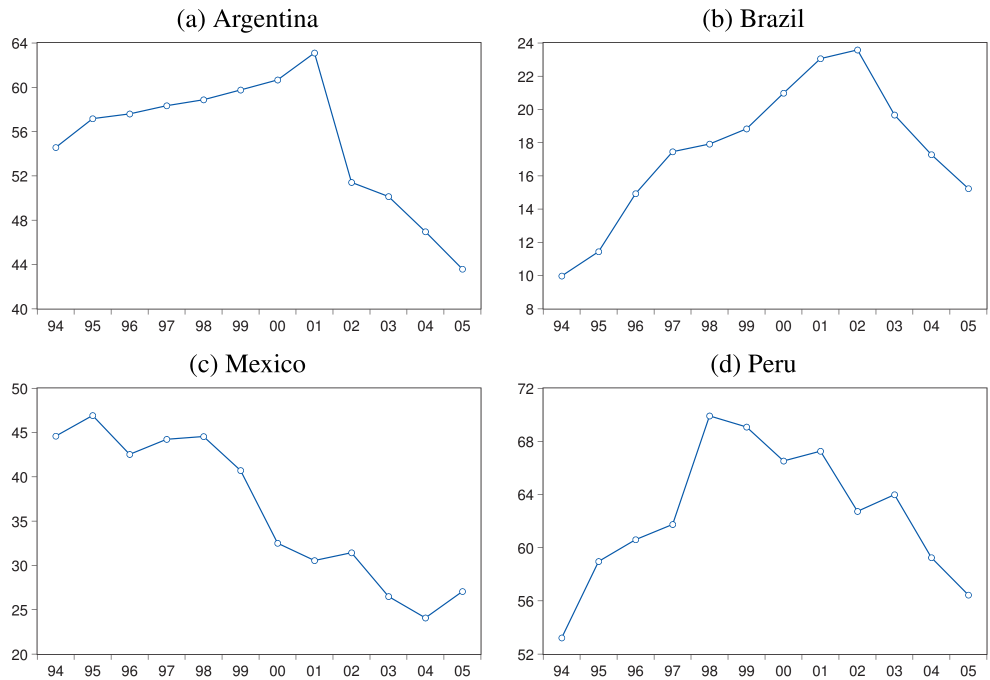
We depart from the standard framework of CCV that features full financial dollarization, and let entrepreneurs borrow in both foreign and domestic currency (*pesos* hereafter) so as to finance firms' capital needs. Then, we evaluate the implications of financial de-dollarization on the strength of balance sheet effects in a small open economy following an unanticipated shock to the foreign risk-free interest rate. To deal with the issue of borrowing in different currencies, we consider two types of entrepreneurs, investors and savers, which for the time being are cataloged exogenously. Both types are endowed in each period with a certain amount of net worth in pesos, but only investors can buy productive capital. Savers, on the other hand, can profit from their net worth by lending their pesos to investors, who can borrow from abroad as well. Thus, the proportion of savers determines the extent of financial dollarization in this economy.

Similarly to CCV, our framework is of flexible exchange rates and flexible prices. More importantly, investors' debt structure will affect the currency mismatch between

[1] The possibility of higher interest rates in the US in the months ahead has revived the debate on the currency composition of debt at the corporate level, as many countries in Latin America have witnessed sharp currency depreciations since the end of the quantitative easing.

expenditures and revenues, which seems plausible because in the data we observe a close relationship between financial dollarization and currency mismatch. Figure 7.2 suggests that in the aftermath of the 1997-98 crisis, corporate firms in Latin America not only reduced their dollar-denominated debt (as observed in Figure 7.1) but also improved their currency mismatch.

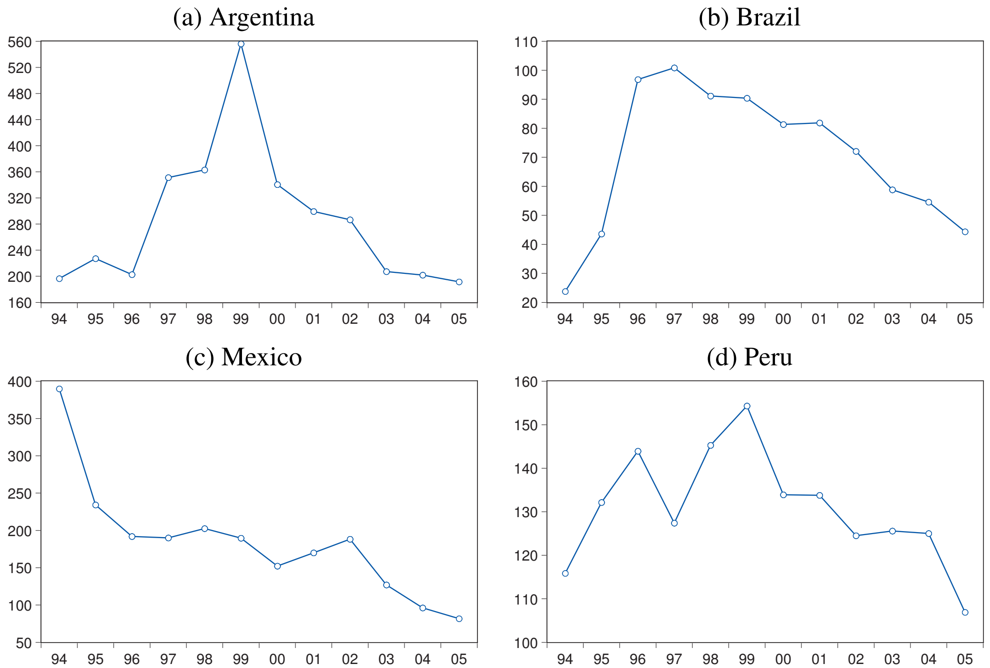
Figure 7.1 *Dollarization of liabilities in the corporate sector in Latin America*



Note: Figures are averages across firms, in percentage points.
Source: Kamil (2012).

At the firm level, Caballero and Krishnamurthy (2003) argue that debt dollarization seems to arise as a response to financial market conditions, in the sense that firms in shallow and illiquid financial markets choose foreign currency as an alternative source of financing. However, the aforementioned evidence suggests that the ability of a firm to contract debt in domestic currency seems to be relevant in practice. Therefore, it seems important to analyze the role of this ability in reducing the exposure of firms to a financial meltdown, and how it can help mitigate the balance sheet channel.

Figure 7.2 *Dollar debt as a share of natural currency hedges in Latin America*



Note: Figures are medians across firms, in percentage points.
Source: Kamil (2012).

We first provide a qualitative link between debt dollarization and financial fragility. Throughout this chapter, as in Morón and Winkelried (2005), financial fragility (robustness) means that the elasticity of the risk premium with respect to the real exchange rate is positive (negative). We show that under flexible exchange rates, the lower the degree of the currency mismatch, the smaller the drop in output following an unanticipated increase in the world interest rate. In the extreme case in which investors borrow only in pesos, the economy is always financially robust, because there is no exposure to currency mismatch.

Since borrowing is subject to agency costs, we characterize the standard debt contract between investors and lenders. Because of informational asymmetries, borrowing is subject to frictions that give rise to a wedge between the expected return to investment and the cost of borrowing in dollars and pesos. Similarly to CCV, we conclude that the risk premium is an increasing function of leverage. Hence, a shock that affects the investors' net worth will self-perpetuate. This is the basic financial accelerator theory put forth by Bernanke et al. (1999).

We also calculate the effects of an unanticipated increase in the world risk free interest rate on real aggregates in the Peruvian economy under the financial conditions faced during the period prior to the Russian crisis, and ask ourselves to what extent de-dollarization helps reduce the impact of an exogenous shock on the real economy. The quantitative analysis suggests that de-dollarization would have moderated the effect of an unanticipated increase in the foreign interest rate on output by 0.7 percentage points. Similar effects are obtained in other variables such as investment (1.6 percentage points) and real depreciation (1.8 percentage points). Intuitively, financial de-dollarization rules out the complications derived from currency mismatches. When a bad financial shock hits the economy, the absence of currency risk reduces the probability of default, so that lenders have less incentives to go through the costly state verification process, which translates into a small risk premium.

We further simulate the model and compute the equivalent variation as a measure of welfare. Our results show that dollarization is welfare reducing, as the equivalent variation is 0.0053% under full dollarization, but only 0.0038% in the case of zero dollarization.

Our chapter contributes to several strands of the literature. Firstly, there are several papers on the quantitative implications of the financial accelerator mechanism, but they typically study firms with fully dollarized liabilities (see, inter alia, Gertler et al., 2007 and Tovar, 2005).

Secondly, we show that the endogenous amplification mechanism caused by the currency mismatch coupled with the financial accelerator (which occurs due to asymmetric information) is worth studying in open economy models, in line with Gertler et al. (2007) who introduce both variable capital utilization (along with fixed operating costs) and the financial accelerator mechanism in a model with nominal price rigidities and a fixed exchange rate regime. They argue that their model is able to account for the roughly 12 percent drop in Korean output in the 1997-98 financial crisis. However, we show that the amplification solely induced by the financial accelerator is somewhat negligible, in agreement with Kocherlakota (2000) and Cordoba and Ripoll (2004) who find that financial frictions under standard parameter values do not create large amplifications.[2] The fact that the quantitative effects of this type of frictions are mild has already been pointed out in closed economy models by Bernanke et al. (1999) and Christensen and Dib (2008).

Regarding the effects of financial fragility, there is empirical evidence that high dollarization and the resulting currency mismatch between assets and liabilities increases the solvency risk of debtors, which makes the financial system more fragile. For instance, De Nicoló et al. (2003) find that dollarization arises as an alternative source of financing in countries that lack macroeconomic stability. Highly dollarized countries are more exposed to currency mismatches that undermine the quality of their loan portfolio when large depreciations take place, which boost solvency risk as measured by the Z-index and the ratio of non-performing loans. Even though our framework abstracts from the existence of a banking system, we are able to show that dollarization leads to financial fragility.

The results presented in this chapter are also consistent with empirical studies that show that the degree of currency mismatch in highly leveraged firms strengthens the impact of exchange rates on the behavior of real aggregates. Levy-Yeyati (2006) demonstrates that exchange rate fluctuations have significant effects on crisis propensity in the presence of financial dollarization, compared to non-dollarized economies. Firms without full hedge on the currency composition of their liabilities face a sharp drop in investment and output when facing currency depreciations during financial crises. Aguiar (2005) shows that partially hedged Mexican firms faced a reduction in net worth and a sharp drop in investment during the Tequila crisis. Forbes (2002) presents evidence on a set of emerging markets, where after large currency depreciations, highly leveraged firms have lower net income growth. In the model presented in this chapter, when a bad interest rate shock hits the economy, the currency mismatch amplifies the increase in the cost of borrowing due to financial frictions, with more severe drops in investment, output and consumption, harsher severe capital account reversals and larger real exchange rate depreciations. Therefore, high dollarization would be reflected in frequent sudden stop episodes, as defined by Calvo et al. (2008).

[2] Kocherlakota (2000) finds that exogenous borrowing constraints do not create amplification. Nevertheless, when financial constraints depend on the value of collateral, amplification may be important for certain parameter values. Cordoba and Ripoll (2004) additionally consider the general equilibrium effects on the interest rate in a closed economy model. Under standard assumptions, large amplification of exogenous shocks is a cutting edge result.

The rest of this chapter is organized as follows. Section 7.2 introduces the model. Section 7.3 discusses the qualitative results of a change in the currency composition of liabilities under flexible exchange rate regimes, when the economy is either financially robust or financially vulnerable. Section 7.4 presents a quantitative analysis of the balance sheet channel in the case of Peru during the Russian Crisis. Section 7.5 concludes. The appendices contain algebraic details, and formal proofs of our main propositions are available upon request.

7.2 The Model

We lay out a general equilibrium framework in the spirit of the recent open macroeconomics literature. Sections 7.2.1, 7.2.2 and the financial contract in Section 7.2.3 borrow from CCV.

7.2.1 Firms

There is a continuum of firms indexed in the [0, 1] interval, which produce a single good in a competitive environment. They all have access to a common technology which exhibits constant returns to scale:

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha}, \tag{7.1}$$

where K_t denotes capital input, L_t labor input, Y_t home output, A is a positive time-invariant total factor productivity parameter, and $0 < \alpha < 1$ is the output elasticity of capital. The market for labor is characterized by monopolistic competition, since labor services offered by workers are heterogeneous. Using a Dixit-Stiglitz aggregator, we let L_t be the aggregate of the services of the different workers in the economy:

$$L_t = \left[\int_0^1 L_{it}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \tag{7.2}$$

where L_{it} is the demand for worker i's labor and $\sigma > 1$ is the elasticity of demand for worker i's services. Firms' profits are defined as follows:

$$P_t Y_t - R_t K_t - \int_0^1 W_{it} L_{it} di, \tag{7.3}$$

where P_t represents the price of the home good, R_t is what firms pay in exchange for capital usage and W_{it} is worker i's wage, all expressed in pesos.

Firms maximize profits (7.3) subject to equations (7.1) and (7.2). For simplicity, capital fully depreciates in each period, so the solution to this problem becomes standard. On the one hand, first order conditions show that:

$$R_t K_t = \alpha P_t Y_t \,, \tag{7.4a}$$

$$W_t L_t = (1-\alpha) P_t Y_t \,, \tag{7.4b}$$

where

$$W_t = \left[\int_0^1 W_{it}^{1-\sigma} di\right]^{\frac{1}{1-\sigma}} \tag{7.5}$$

denotes the minimum cost of one unit of L_t, expressed in pesos. On the other hand, the demand for worker i's labor is:

$$L_{it} = \left(\frac{W_{it}}{W_t}\right)^{-\sigma} L_t \,. \tag{7.6}$$

7.2.2 Households

Preferences of household i can be represented by the expected utility function:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\ln C_{it} - \left(\frac{\sigma-1}{\sigma}\right) \frac{L_{it}^{\tau}}{\tau} \right] \right\} , \tag{7.7}$$

where $\tau > 1$ governs the curvature of labor supply, $0 < \beta < 1$ is the subjective discount factor and $\mathbb{E}_t\{x\}$ is the expected value of x conditional on information available at time t. We assume additive separability between consumption and labor as well as a logarithmic utility function for tractability. As usual, C_{it} is a composite consumption index of the home good (C_{it}^H) and the imported good (C_{it}^F):

$$C_{it} = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} (C_{it}^H)^{\gamma} (C_{it}^F)^{1-\gamma} \,, \tag{7.8}$$

where $0 < \gamma < 1$ measures the participation of home goods in the consumption index. The price of the imported good is normalized to one and the price of one unit of imports in pesos is equal to the nominal exchange rate of S_t pesos per dollar, because the Law of One Price is assumed to hold. For later reference, let $E_t \equiv S_t / P_t$ be the prevailing real exchange rate.

As in CCV, we assume that households cannot save and hence labor income is the only source of earnings. That is, they are hand-to-mouth individuals. The associated budget constraint is given by:

$$W_{it}L_{it} = P_t C_{it}^H + S_t C_{it}^F \,. \tag{7.9}$$

The household maximizes the expected utility (7.7) subject to (7.6), (7.8) and (7.9), which implies, in a symmetric equilibrium, that:

$$Q_t C_t = W_t L_t \,, \tag{7.10}$$

where the minimum cost of consumption is given by:

$$Q_t = P_t^{\gamma} S_t^{1-\gamma} \,. \tag{7.11}$$

Households set their wages at the beginning of each period, before main aggregate variables are observed. As wages are set in advance, it must be the case that:

$$\mathbb{E}_{t-1}\left\{L_t^{\tau}\right\} = 1 \,. \tag{7.12}$$

7.2.3 Entrepreneurs

7.2.3.1 Distribution of entrepreneurs

There is a continuum of risk-neutral entrepreneurs indexed by i in the [0, 1] interval, who are initially allocated a positive net worth in domestic currency. We assume there is an exogenous time-invariant threshold π in the distribution of entrepreneurs that gives rise to two different types of entrepreneurs, namely savers and investors.

Savers are restricted from buying physical capital.[3] However, investors use their initial net worth to finance capital acquisitions for the next period. Should they fall short of money, they may borrow additional resources in either foreign or domestic currency, that is, $D_{i,t+1}^*$ or $D_{i,t+1}$, respectively. The former is provided by the world capital market at the risk-free interest rate given by ρ_{t+1}^*, whereas the latter is provided by savers, who transform costlessly their endowments into bonds and charge an interest rate in domestic currency equal to ρ_{t+1}. As in Aghion et al. (2000), we argue that for

[3] Aghion et al. (1999) discuss a number of reasons why not all savers are also investors in the sense of being able to invest in physical capital.

reasons that reflect the level of financial development in domestic currency, savers are unwilling to lend more than $D_{i,t+1}$ to investors at each period. Consequently, the rest of the funding, $D^*_{i,t+1}$, comes from abroad and is denominated in foreign currency. Following Caballero and Krishnamurthy (2003), we can interpret the location of the threshold as the depth of the domestic capital market.

We assume that there is a fictitious risk-neutral mutual fund that pools resources from foreign lenders and savers, and then engage in credit activities with investors. This financial intermediary makes zero profits. Since the value of π determines the currency composition of the fund, then π measures the separation between dollar loans $D^*_{i,t+1}$ and peso loans $D_{i,t+1}$. Put differently, the ratio of dollarization (i.e. debt issued in foreign currency to total debt) is driven by the position of the threshold π. Investors' portfolios are consistent with the ratio of dollarization. Given that they are risk neutral, the uncovered interest rate parity is a by-product of the investors' problem:

$$(1 + \rho_{t+1}) = (1 + \rho^*_{t+1})\mathbb{E}_t \left\{ \frac{S_{t+1}}{S_t} \right\} . \tag{7.13}$$

We acknowledge that even though the mutual fund can lend in the world market, it will not pursue that avenue in equilibrium, because it would get the same expected payout from lending to local investors.

7.2.3.2 Financial contract

We consider the contracting problem between a single investor i and the mutual fund in any period t. At the time of contracting, i's net worth $P_t N_{it}$, the dollar interest rate ρ^*_{t+1}, the peso interest rate ρ_{t+1} and prices in period t are known. However, since S_{t+1} is unknown, the period $t+1$ rental rate on capital in dollars, R_{t+1}/S_{t+1}, is also unknown.

Investors and the mutual fund are all risk neutral. Their joint problem is in choosing a level of investment $K_{i,t+1}$, a loan from the mutual fund (the value of π determines the separation between dollar loans $D^*_{i,t+1}$ and peso loans $D_{i,t+1}$) and a repayment schedule so as to maximize the expected return to investors, so that the mutual fund is paid at least the opportunity cost of funds.

Investment in t, $K_{i,t+1}$, yields $\omega_{i,t+1}K_{i,t+1}R_{t+1}/S_{t+1}$ dollars next period, where $\omega_{i,t+1}$ is an *iid* random shock across i and t with $\mathbb{E}_t\{\omega_{i,t+1}\} = 1$. We assume that $\omega_{i,t+1}$ is freely observed by the investor, but its realization cannot be observed by the mutual fund, unless it pays a proportional monitoring cost of $\zeta\omega_{i,t+1}K_{i,t+1}R_{t+1}/S_{t+1}$.

Under similar conditions, provided that the financial contract is written in terms of non-state contingent repayment, CCV argues that a standard debt contract arises, which stipulates a fixed repayment, say of $B^*_{i,t+1}$ dollars and $B_{i,t+1}$ pesos. Furthermore, if the investor cannot pay, the mutual fund monitors the outcome and seizes it all. Monitoring happens whenever $\bar{\omega}$ is above $\omega_{i,t+1}$, where $\bar{\omega}$ is such that $B^*_{i,t+1} + B_{i,t+1}/S_{t+1} = \bar{\omega}K_{i,t+1}(R_{t+1}/S_{t+1})$.

Since investors must pay the expected cost of debt service, after borrowing $D^*_{i,t+1}$ and $D_{i,t+1}$ from the mutual fund, the following condition must hold:

$$\begin{aligned} R_{t+1}K_{i,t+1}\left[\bar{\omega}(1-H(\bar{\omega})) + (1-\zeta)\int_0^{\bar{\omega}} \omega_{i,t+1} dH(\omega_{i,t+1})\right] \\ = \mathbb{E}_t\left\{(1+\rho^*_{t+1})S_{t+1}D^*_{i,t+1} + (1+\rho_{t+1})D_{i,t+1}\right\} \\ = \mathbb{E}_t\left\{(1+\rho^*_{t+1})\frac{S_{t+1}}{S_t}(Q_tK^j_{t+1} - P_tN_{it})\right\}, \quad (7.14) \end{aligned}$$

where $H(\cdot)$ denotes the cdf of $\omega_{i,t+1}$, and $H(\bar{\omega})$ is the probability of bankruptcy. The left hand side of equation (7.14) gives the expected dollar yield on investment. With probability $1 - H(\bar{\omega})$, the investor does not go bankrupt and receives $\bar{\omega}$ times the return on investment. Conversely, with probability $H(\bar{\omega})$ the investor goes bankrupt, and lenders seize what is left after paying monitoring costs. The right hand side gives the opportunity cost of loans $D^*_{i,t+1}$ and $D_{i,t+1}$. The expression on the right hand side of the second equality sign simply reflects the fact that borrowing must equal the value of investment minus the investor's net worth.

As in the original CCV, the optimal contract maximizes the investor's utility:

$$\left[\int_{\bar{\omega}}^{\infty} \omega_{i,t+1} dH(\omega_{i,t+1}) - \bar{\omega}(1-H(\bar{\omega}))\right] R_{t+1}K_{i,t+1} \quad (7.15)$$

subject to the participation constraint for the mutual fund, as given by equation (7.14), which once simplified yields:

$$\kappa_{it}\left[\bar{\omega}(1-H(\bar{\omega})) + (1-\zeta)\int_0^{\bar{\omega}} \omega_{i,t+1} dH(\omega_{i,t+1})\right](1+\eta_{t+1}) = \kappa_{it} - 1\,, \quad (7.16)$$

where:

$$\kappa_{it} = Q_tK_{i,t+1}/P_tN_{it}\,,$$

is the ratio of the value of investment to net worth, and:

$$1 + \eta_{t+1} \equiv \frac{\mathbb{E}_t \{R_{t+1} K_{t+1}/S_{t+1}\}}{(1 + \rho^*_{t+1}) Q_t K_{t+1}/S_t} , \tag{7.17}$$

is the risk premium or the external finance premium as introduced by Bernanke et al. (1999). The risk premium arises because of the costly state verification problem of savers and foreign lenders, which in turn introduces a wedge between the expected return to investment and the cost of borrowing in dollars. Needless to say, this wedge is an endogenous variable whose properties would be derived subsequently.

So far we have shown that there is a unique participation constraint and consequently a unique risk premium. This is so because the financial intermediary receives exactly the same payouts in case of default. If we had not assumed the existence of the risk-neutral mutual fund, we would have to deal with two separate participation constraints for both local savers and foreign lenders. Furthermore, we abstract from additional implications of having different degrees of enforcement of domestic and foreign contracts, which would lead to differentiated risk premia for each currency. In our model, both $D^*_{i,t+1}$ and $D_{i,t+1}$ have the same level of seniority, because investors (or firms, to a large extent) ultimately borrow from the mutual fund in the domestic financial market.[4]

Now we further write the investor's objective function in terms of κ_{it} and $\bar{\omega}$:

$$\left[\int_{\bar{\omega}}^{\infty} \omega_{i,t+1} dH(\omega_{i,t+1}) - \bar{\omega}(1 - H(\bar{\omega})) \right] \kappa_{it} .$$

It is clear that the analysis laid out here is close to that of CCV. Specifically, CCV shows that under suitable conditions the optimal cutoff $\bar{\omega}$ is both orthogonal to i's net worth and increasing in the risk premium η_{t+1}, which is a parameter of the investor's problem, or in its inverse form:

$$1 + \eta_{t+1} = \Delta(\bar{\omega}) , \tag{7.18}$$

[4] We acknowledge that the assumption of a unique participation constraint may not be innocuous, but the payoff is that the model may accommodate different degrees of dollarization much easily. In the absence of the mutual fund, we would need to introduce two participation constraints, one for foreign lenders and one for local lenders, because foreign lenders have probably less experience than domestic lenders in recovering investors assets, as pointed out by Iacoviello and Minetti (2006). We believe this second route may introduce additional issues beyond the scope of this chapter. Despite this limitation, we show that the evolution of the risk premium is an increasing function of the dollarization ratio, which means that higher dollarization ratios go along with higher financial frictions.

where $\Delta(\cdot)$ is an increasing and differentiable function in the $(0, \omega^*)$ domain, and ω^* is the maximizing value of $\bar{\omega}(1 - H(\bar{\omega})) + (1 - \zeta) \int_0^{\bar{\omega}} \omega_{i,t+1} dH(\omega_{i,t+1})$. Additionally, CCV argue that the optimal investment/net worth ratio κ_{it} is also a function of $\bar{\omega}$:

$$\kappa_{it} = \Psi(\bar{\omega}) ,$$

where $\Psi(\cdot)$ is increasing and differentiable in the $(0, \omega^*)$ domain. Given the independence of $\bar{\omega}$ and i, so that κ_{it} is the same for all i, aggregation over i is possible:

$$\frac{Q_t K_{t+1}}{P_t N_t} = \Psi(\bar{\omega}) . \tag{7.19}$$

If equations (7.18) and (7.19) are combined, it is straightforward to get the risk premium as a function of the value of total investment relative to total net worth, as shown by equation (17).

$$1 + \eta_{t+1} = \Delta \left[\Psi^{-1} \left(\frac{Q_t K_{t+1}}{P_t N_t} \right) \right] \equiv F \left(\frac{Q_t K_{t+1}}{P_t N_t} \right), \quad F(1) = 1, \quad F'(\cdot) > 0 . \tag{7.20}$$

In other words, the risk premium is an increasing function of leverage. For the calibration exercise, we will assume that the function $F(\cdot)$ takes the following form:

$$F(\cdot) = \left(\frac{Q_t K_{t+1}}{P_t N_t} \right)^{\mu} , \tag{7.21}$$

where μ is the elasticity of the risk premium with respect to leverage.

7.2.3.3 Further results

Now, if Q_t is the price of capital, investors' budget constraint can be written as:[5]

$$P_t N_t + D_{t+1} + S_t D^*_{t+1} = Q_t K_{t+1} , \tag{7.22}$$

where D_{t+1} and D^*_{t+1} denote the amount borrowed in pesos and dollars, respectively, $P_t N_t$ represents investors' net worth, K_{t+1} accounts for the investment in $t + 1$ capital, and S_t is the nominal exchange rate.

[5] For simplicity, we assume that capital goods are made up of the same composition of domestic and foreign goods as consumption goods.

At the end of each period, investors collect the income from capital and repay domestic and foreign debt. They consume a portion $1-\lambda$ of the remainder and only consume imports. Thus, their net worth is:

$$P_t N_t = \lambda \left[R_t K_t - \Phi_t \alpha P_t Y_t - (1+\rho_t^*) S_t D_t^* - (1+\rho_t) D_t \right] . \qquad (7.23)$$

where $R_t K_t$ is aggregate capital income; $\Phi_t \alpha P_t Y_t$ accounts for monitoring costs paid in period t, while the terms $(1+\rho_t^*) S_t D_t^*$ and $(1+\rho_t) D_t$ refer to debt repayments in foreign and domestic currency, respectively. Put differently, equation (7.23) states that investors exit the economy with probability $(1-\lambda)$. On the other hand, savers are relatively patient (in the sense that they do not discount the future), and consequently they sell off their accumulated capital at the end of each period, consume imported goods with the proceeds and leave the economy. In order to keep the population of entrepreneurs fixed, the exiting entrepreneurs are replaced by new ones (see Carlstrom and Fuerst, 1997 for a related exposition).

7.2.4 Equilibrium and dynamics

The full description of a competitive equilibrium is standard. However, for later use we stress that because domestic production is absorbed by both residents and non-residents, the market for home goods is in equilibrium when:

$$P_t Y_t = \gamma Q_t (K_{t+1} + C_t) + S_t X , \qquad (7.24)$$

where the left hand side is the nominal output, C_t is aggregate consumption and X stands for total exports.

Now we study the dynamics of the model by log-linearizing the equilibrium equations around the non-stochastic steady state (lowercase letters denote percentage deviations from the non-stochastic steady state). We outline all log-linearized expressions in Appendix B, as they are fairly standard in the literature.

To begin with, the monetary authority, though not formally modeled, operates in an environment of flexible exchange rates, as described in the following definition:

Definition 1 (Flexible exchange rates). *A regime of flexible exchange rates is one in which the monetary authority lets the nominal exchange rate s_t adjust to market conditions. In particular, monetary policy is conducted such that $p_t = \mathbb{E}_{t-1}\{p_t\} = 0$ for all t. An implication of a flexible exchange rate regime is that it delivers the outcome that would prevail if there were no nominal wage rigidities: $l_t = 0$ for all t.*

We now manipulate the log-linearized equations from the entrepreneurs' problem and derive the law of motion for the risk premium:

Proposition 1 (Risk premium). *The first-order backward-looking difference equation that describes the dynamics of the risk premium is:*

$$\eta'_{t+1} - \phi\eta'_t = \mu \left[\left(\frac{1-\chi}{\chi} \right) (y_t - e_t) \right] + \cdots$$
$$\cdots + \mu\psi^*\lambda(1+\rho^*) \left[(1-\pi)\left(e_t - \mathbb{E}_{t-1}\{e_t\}\right) - \left(y_t - \mathbb{E}_{t-1}\{y_t\}\right) \right] , \quad (7.25)$$

where χ is the share of investment demand in total non-consumption demand for home goods, ψ^* is the steady state debt to net worth ratio, μ is the elasticity of the risk premium with respect to leverage, ϕ is a coefficient that depends on the debt contract and $(1-\pi)$ represents the steady state dollarization ratio.

The first term on the right hand side of equation (7.25) is interpreted as follows. A high level of output requires capital input that must be financed through debt. Therefore the lender charges a high risk premium because of the increasing leverage. The first component of the second term captures the effect of the currency denomination of debt. An unexpected devaluation boosts the investors' debt burden, which in turn reduces their net worth and consequently the market charges a high risk premium. The second component of the second term is related to the effect of an unexpected fall in output. It implies that low unexpected output reduces the reward for capitalists from previous investment regardless of the currency denomination of debt. This results in low net worth and high risk premium.

At the end of the day, the first and last terms show us that the presence of asymmetric information and imperfect capital markets require agency costs to create the incentives that guarantee debt repayment, regardless of the currency denomination of debt. Therefore, even under zero dollarization, the risk premium would still be affected by changes in output.

7.3 Qualitative analysis

In this section we study the effects of an unanticipated shock to the world interest rate on investment and the real exchange rate from a qualitative perspective. To this purpose we derive two curves in the (k_{t+1}, e_t) space, namely IS_π and BP_π, which summarize the equilibria in the goods and loan markets, respectively. In this exercise, we assume that starting from the steady state, there is a shock to the world safe interest rate at $t = 0$, whose effects disappear from $t = 1$ onwards, because the economy settles again on the saddle path in the long run. The equations that characterize the IS_π and BP_π curves in this economy are contained in Proposition 2:

Proposition 2 (IS_π and BP_π curves). *Under flexible exchange rates, the IS_π curve is downward sloping:*

$$k_1 = -\left(\frac{1-\chi\gamma}{\chi}\right) e_0 \tag{7.26}$$

and the BP_π curve is:

$$k_1 = \left[\gamma - (1-\zeta)\,\varepsilon_\pi\right] e_0\,, \tag{7.27}$$

where $\zeta < 0$ is the saddle-path coefficient in the linear relationship $y_t - e_t = \zeta\eta_t'$ and $\varepsilon_\pi \equiv \mu\left[\psi^*\lambda\,(1+\rho^*)\,(1-\pi) - (1-\chi)/\chi\right]$ is the elasticity of the risk premium with respect to a change in the real exchange rate. When we include the effect of the unanticipated increase in the foreign interest rate, the BP_π curve becomes:[6]

$$k_1 = \left[\gamma - (1-\zeta)\,\varepsilon_\pi\right] e_0 - \tilde{\rho}_1^*\,. \tag{7.28}$$

The sign of the elasticity ε_π determines whether an economy is financially robust ($\varepsilon_\pi < 0$) or financially vulnerable ($\varepsilon_\pi > 0$). We argue that this elasticity has two major building blocks. The first element, $\mu\psi^*\lambda(1+\rho^*)(1-\pi)$, is related to the debt deflation channel of foreign liabilities. An exchange rate depreciation increases the value of dollar denominated liabilities in terms of pesos and creates higher incentives for investors to default. Therefore, the risk premium increases to compensate for the higher risk of default. The second component, $-\mu(1-\chi)/\chi$, represents an investment demand effect. An exchange rate depreciation increases the price of capital goods and reduces investment demand. Financing a lower level of investment reduces leverage and therefore decreases the risk premium.

Now we analyze, by means of the IS_π-BP_π diagram, the effects of an unanticipated increase in the foreign interest rate on investment and the real exchange rate when the

[6] Before the shock, we know from equations (7.26) and (7.27) that both curves intersect at the origin. Nevertheless, when the shock is taken into account it is straightforward to see from equations (7.26) and (7.28) that the coordinate pair (e_0, k_1) satisfies:

$$(k_1, e_0) = \left(\frac{(\chi\gamma-1)\,\tilde{\rho}_1^*}{\chi\,(\zeta-1)\,\varepsilon_\pi + 1}, \frac{\chi\tilde{\rho}_1^*}{\chi\,(\zeta-1)\,\varepsilon_\pi + 1}\right).$$

economy is either robust or vulnerable. At the same time, in order to grasp what the benefits of de-dollarization are, we will examine two types of dollarization, namely full dollarization with $(1 - \pi) = 1$ and partial dollarization with $(1 - \pi) < 1$.

7.3.1 The financially robust economy

Let ε be the elasticity of the risk premium with respect to the real exchange rate that would prevail in a world with full dollarization, that is when $(1-\pi) = 1$. Let BP be the associated curve that clears the loan market. From equation (7.26), we know that IS_π does not depend on the ratio of dollarization $(1 - \pi)$, and hence its slope is invariant to changes in π. From equations (7.27) or (7.28), we also know that the slope of BP_π does depend on $(1 - \pi)$ through the elasticity of the risk premium with respect to the real exchange rate. Actually, BP_π is flatter than BP since $\varepsilon > \varepsilon_\pi$.

In the case of a financially robust economy, it is clear from (7.28) that both BP and BP_π shift to the left after an unanticipated increase in the foreign interest rate. The impact on both the real exchange rate and capital is less intense with partial dollarization, that is when $(1 - \pi) < 1$, as shown in Figure 7.3.

7.3.2 The financially vulnerable economy

In the case of a financially vulnerable economy, it is possible to deal with a downward sloping BP_π under certain parameter configurations, as depicted in Figure 7.4. Since net worth effects matter in this case, both investment and the real exchange rate fall more on impact than in the financially robust case. In this context, the effects of an unanticipated increase in the foreign interest rate on both investment and the real exchange rate are less sharp with partial dollarization.

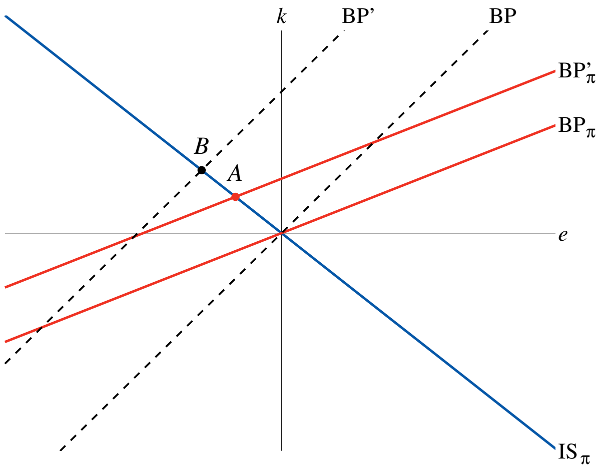
Recall from section 7.2.3 that π is a by-product of the depth of the domestic capital market in domestic currency. In this regard, the results shown in Figures 7.3 and 7.4 suggest that a financially vulnerable economy would find it beneficial to develop the market for domestic debt, and consequently reduce the size of the balance sheet effect:

Proposition 3 (Threshold level of dollarization). *Let*

$$1 - \pi^T \equiv \frac{1 - \chi}{\chi\psi^*\lambda(1 + \rho^*)}$$

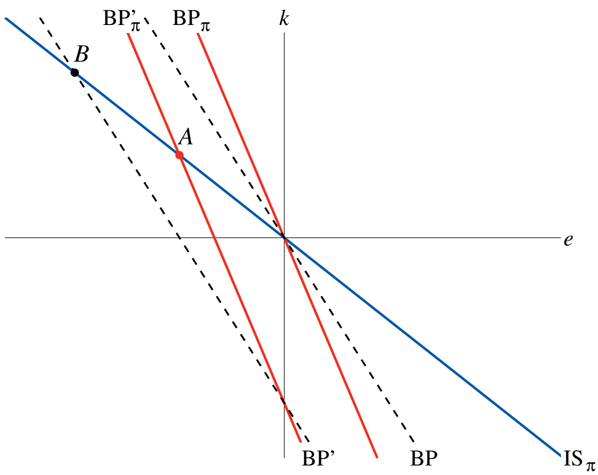
be such a threshold. The economy is financially robust if $(1-\pi) < (1-\pi^T)$. *Otherwise, the economy is financially vulnerable.*

Figure 7.3 *Financially robust economy*



Notes: Initially BP_π and IS_π intersect at the origin. After an unanticipated increase in the foreign interest rate, BP_π shifts to BP'_π. The new intersection occurs at $A = (e_{0\pi}, k_{1\pi})$. Under full dollarization, the upward sloping BP would shift to BP′ and the intersection with IS_π would occur at $B = (e_0, k_1)$.
Source: Authors' own elaboration.

Figure 7.4 *Financially vulnerable economy*



Notes: Initially BP_π and IS_π intersect at the origin. After an unanticipated increase in the foreign interest rate, BP_π shifts to BP'_π. The new intersection occurs at $A = (e_{0\pi}, k_{1\pi})$. Under full dollarization, the downward sloping BP would shift to BP′ and the intersection with IS_π would occur at $B = (e_0, k_1)$.
Source: Authors' own elaboration.

The threshold level of dollarization is the dollarization ratio at which the effect of a real exchange rate depreciation on the financial burden of dollar-denominated debt completely offsets the effect on investment demand. On the one hand, the threshold depends negatively on both the leverage ratio, ψ^* and the foreign gross interest rate that affects the debt service, $\lambda(1 + \rho^*)$. Therefore, when investors hold few shares of dollar-denominated debt, the threshold is high and hence it is more likely for the economy to be financially robust. In other words, a non-negligible proportion of peso-denominated debt allows an economy to display a large leverage ratio without becoming financially vulnerable. On the other hand, the threshold depends negatively on the share of investment demand in total non-consumption demand for home goods, χ. When the participation of foreign inputs in the composite capital index is important, investment demand shrinks following an exchange rate depreciation as the price of capital goes up. In this case, the threshold is also high and again it is more likely for the economy to achieve financial robustness.

If the economy succeeds in fostering financial de-dollarization, such that $(1 - \pi) < (1 - \pi^T)$, then financial unsoundness is no longer a feasible outcome. In particular, Proposition 3 says that if debt is contracted only in domestic currency, then the economy is robust. This is the basis of the following corollary:[7]

Corollary 1 (Zero dollarization). *If debt is contracted only in domestic currency, which implies in the limit that* $(1 - \pi) = 0$*, the economy is financially robust.*

7.4 Quantitative analysis

In the spirit of the previous section, we compute the effects of an unanticipated increase in the world risk free interest rate on real aggregates under the financial conditions faced during the period prior to the Russian crisis. We ask to what extent de-dollarization helps to reduce the impact of currency depreciations on the real economy. To answer this question, we compute numerically a log-linear approximation of the decision rules for the variables in the model, following Klein (2000) and Sims (2002). Using the policy rules, we calculate the impulse response functions of both real and financial variables to a shock on the foreign risk-free interest rate.

[7] According to the parameter values in Table 7.1 below, the threshold level of dollarization in Peru is approximately 0.3 around the time of the Russian Crisis. Since the observed dollarization ratio is close to 0.7 (see Figure 7.1), Peru qualifies as a financially vulnerable economy.

7.4.1 Calibration

We calibrate the parameter values to the Peruvian economy using annual national account data with the base year 2007. The steady state world risk free rate is set at 4 percent, a standard value in small open economy models, which is consistent with a discount factor β of 0.96. The home good share in consumption γ is set at 0.8, in line with Elekdag et al. (2006).[8] The capital share in the production of the home good α is set at 0.45, following the Quarterly Forecasting Model of the Central Bank of Peru. The parameter ν comes from the optimal debt contract and is set at 0.3.[9] For the value of λ, the fraction of entrepreneurs' net income that goes to net worth, we use the value from Cespedes et al. (2000) of 0.92.

We calibrate the key parameters of the financial sector to match the financial environment of the Peruvian economy during the onset of the Russian Crisis. The calibrated parameters are the elasticity of the risk premium with respect to the leverage ratio μ, and the steady state value of the risk premium η. For the risk premium, we target a 5 percent premium under full dollarization, consistent with an average EMBI index of 500 basis points in the period prior to the crisis, as documented by Castillo and Barco (2009). The leverage ratio is targeted to 2.2, in line with Loveday et al. (2004), who estimate the average leverage ratio for a sample of two thousand non-financial firms in Peru. Table 7.1 summarizes all this information.

7.4.2 Impulse-response analysis

We simulate the model for three different scenarios: full dollarization, zero dollarization, and without financial frictions. The first two scenarios feature dollarization ratios equal to 1 and 0, respectively. The third case not only features 0 dollarization, but also shuts off the costly state verification problem (and hence the endogenous amplification mechanism). According to Figure 7.1, for Peru about 65 percent of debt was denominated in units of foreign currency. Consequently, in our benchmark scenario we assume full financial dollarization.

[8] Elekdag et al. (2006) use Bayesian methods to show that the median of the parameter is between 0.6 and 0.8 for Korea. On the other hand, Lewis (1999) finds that the parameter is located between 0.6 and 0.99 for advanced economies.

[9] The value of this parameter affects the persistence of the risk premium, in the sense that the higher the elasticity, the more persistent the risk premium. We perform robustness checks for different values of this parameter and argue that the quantitative results are not significantly altered.

Table 7.1 *Parameter values in the benchmark calibration*

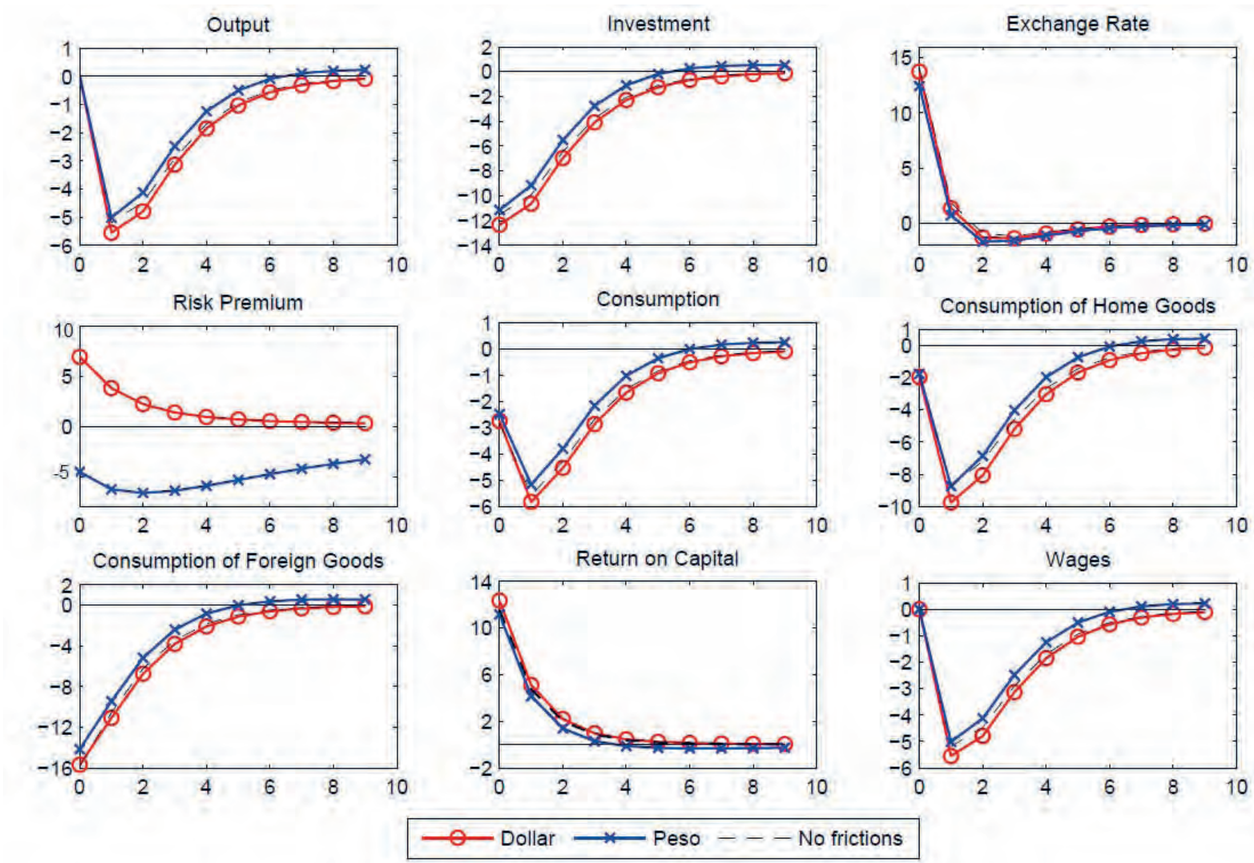
Parameter	Value	Definition
ρ	0.04	Risk free interest rate
γ	0.80	Home goods share in consumption
α	0.45	Capital share in home good production
β	0.96	Discount factor
λ	0.92	Entrepreneurs' saving rate
ν	0.30	Parameter from optimal contract
ε_{Δ}	1.00	Parameter from optimal contract
η	0.05	Steady state risk premium
μ	0.042	Elasticity of risk premium with respect to leverage
$\tilde{\rho}$	0.50	Persistence AR(1) process
$\sigma_{\tilde{\rho}}$	0.25	Standard deviation AR(1) process

Source: Authors' own calculations.

Figure 7.5 shows the impulse response functions of real and financial variables to an increase in the world interest rate consistent with a 600 basis point increase in country risk (the exact increase in Peru's EMBI index during the Russian Crisis). Each period corresponds to one year and the response of each variable is measured as percentage deviations from the steady state. The impulse response functions for the scenario with full dollarization are labeled as "dollar". The calibration used to match the average risk premium and leverage ratio prior to the Russian crisis in the case with full dollarization is consistent with a financially vulnerable economy, as the elasticity of the risk premium with respect to the exchange rate is positive. The predictions for this baseline dollarization ratio suggest a negative impact on investment, output, and real exchange rates of 12.9 percentage points, 5.8 percentage points, and 14.3 percentage points, respectively. In the data, on the other hand, we observe the growth rate of investment in Peru declined from 15.6 percent in 1997 to −0.3 percent in 1998, whereas the output growth rate decreased from 6.5 percent in 1997 to −0.4 percent in 1998. The real exchange rate depreciated 22 percent in 1998 in the aftermath of the crisis. Therefore, the model accounts for approximately 80 percent of the output and investment drops and 60 percent of the real depreciation.[10]

[10] The model focuses on the balance sheet channel, and we must stress that empirical work on the effects of financial crises in Peru shows that there was a severe credit crunch during the Russian Crisis (agents were not able to access external financing, regardless of the cost of borrowing). The introduction of this salient channel should help account for even larger output and investment drops.

Figure 7.5 *Impulse response to a world interest rate shock*



Notes: The shock is consistent with a 600 basis point increase in EMBI on impact. Years after the shock are depicted on the horizontal axis.
Source: Authors' own calculations.

The mechanism in the model works as follows. In a financially vulnerable economy, an increase in the world interest rate depreciates the exchange rate, which reduces the investors' net worth and increases the debt burden in terms of home output. Due to imperfect capital markets, lenders ask for a higher risk premium to compensate for the higher debt burden. Therefore, the risk premium increases along with an unexpected currency depreciation.

The sharp fall in investment reflects the increase in the cost of borrowing, through the effects of both a high world interest rate and a high risk premium. Scarce investment reduces the production possibilities of firms, and hence output in the following period. Consequently, it affects the payment to factors of production in $t = 1$ onwards, as a low capital-to-labor ratio implies low wages for workers in equilibrium. Nevertheless, the rental rate of capital goes up given the low capital-to-labor ratio (and this in turn makes each unit of capital more valuable for investors).

From the households' perspective, aggregate income falls due to low wages under flexible prices, which directly implies low consumption, since there are no savings in this model. We identify two effects in the analysis of consumption of home goods and imported goods. On impact (at $t = 0$), there is a reduction in consumption of foreign goods, as the real exchange rate depreciates. In the next period (at $t = 1$), there is an additional effect through a reduction in the consumption of home goods. Given the functional form of aggregate consumption, households' expenditure on domestic goods is a fraction γ of their income. As labor income falls, the consumption of home goods decreases as well.

The impulse response functions for the scenario with zero dollarization are labeled as "peso". In this scenario, the economy is financially robust in the other two cases, because debt is contracted only in pesos (i.e. Corollary 1 holds). After an unanticipated increase in the foreign interest rate, there are negative impacts on investment, output, and real exchange rate of 11.3 percentage points, 5.1 percentage points, and 12.5 percentage points, respectively. Overall, these results confirm that de-dollarization weakens the real effects of an unanticipated foreign shock, which is consistent with the empirical literature that points out that low dollarization leads to less frequent financial crisis and small balance sheet effects.

In this scenario, the economic intuition is as follows. An unanticipated increase in the world interest rate depreciates the exchange rate. If all debt is denominated in pesos, the valuation of debt in terms of the home good does not change. Output falls by a small magnitude, given that it faces a high domestic interest rate but a low risk premium. This second effect is related to Corollary 1, in the sense that an economy with only peso-denominated debt always faces a negative elasticity of the risk premium with respect to the real exchange rate. Therefore, even though there are still negative effects on real variables, these are quantitatively smaller than under full dollarization. Intuitively, given the negative elasticity of the risk premium, an increase in the world interest rate reduces the risk premium, which partially offsets the increase in borrowing costs due to an increase in the interest rate. Therefore, a small increase in borrowing costs implies slight drops in investment and output.[11]

The impulse responses in Figure 7.5 suggest that the impact of de-dollarization is non-trivial but moderate. Since the response on impact to the interest rate shock is -5.8 percent under full dollarization, but only -5.1 percent under zero dollarization, then de-dollarization by itself explains up to 0.7 percentage points of the output fall.

Finally, we also simulate the model with both zero dollarization and no financial frictions, by eliminating the wedge between the interest rate and the return on capital (and therefore a zero risk premium at all times). The results are shown in Figure 7.5 by the lines labeled as "no frictions". An increase in the world interest rate by one standard deviation leads to an output drop of 5.2 percent. The wedge between "peso" and "no frictions" indicates the strength of the endogenous amplification mechanism solely induced by the costly state verification problem.[12] According to Figure 7.5, the effects of this problem per-se are negligible, since the output drop in the case of zero dollarization is 5.1 percent. These results are in line with Kocherlakota (2000) and Cordoba and Ripoll (2004), where the endogenous amplification effect induced by financial frictions is very small under standard parameter values.

7.4.3 A digression on consumption and welfare

In this subsection we numerically evaluate the effect "on impact" of an unanticipated shock to the foreign risk-free interest rate on consumption, investment and output, using a discrete grid of values of the dollarization ratio. Put differently, we are only

[11] The effects on the payments to factors of production are mild as well. A reduction in the capital-to-labor ratio reduces wages and increases the rental rate of capital, but the magnitudes are smaller than in the fully-dollarized case. Consumption also falls, but the drop is less intense, as there is a lukewarm reduction in labor income and a small increase in the price of consumption goods due to a less severe exchange rate depreciation.

[12] We should bear in mind that the asymmetric information problem remains even with zero dollarization, and therefore there is a non-negative wedge between the interest rate and the return on capital.

interested in the effect at the time of the shock. In Table 7.2 we present different values for the dollarization ratio, including the two extreme cases, namely zero dollarization and full dollarization. We also present the threshold level of dollarization $(1 - \pi^T)$, in which π^T is defined as in Proposition 3. From Figure 7.7, we know that the greater the depth of financial dollarization, the stronger the deviation at time zero of real variables such as consumption, investment and output with respect to the steady state values.[13] We confirm in Table 7.2 that the strength of the effect is increasing weakly in the dollarization ratio.

Table 7.2 *Dollarization and welfare costs of business cycles*

	Dollarization ratio $(1 - \pi)$						
	0.0	0.2	$1 - \pi^T$	0.4	0.6	0.8	1.0
Consumption	−5.2	−5.2	−5.2	−5.3	−5.4	−5.7	−6.0
Output	−5.1	−5.3	−5.4	−5.4	−5.5	−5.7	−5.8
Investment	−11.3	−11.7	−11.9	−12.0	−12.3	−12.5	−12.9
RER	12.5	13.1	13.3	13.3	13.7	13.9	14.3
Welfare cost (%)	0.00381	0.00412	0.00433	0.00442	0.00473	0.00503	0.00532

Notes: Response of real variables after an unanticipated shock to the risk-free interest rate, and welfare cost of business cycles for a range of dollarization ratios. First four rows measure the response of consumption, output, investment, and real exchange rate at time zero. Last row measures the welfare cost of business cycles (in percentage). Notice that $(1 - \pi^T) \simeq 0.3$.
Source: Authors' own calculations.

In Table 7.2 we also deal with the welfare cost of business cycles in the spirit of Lucas (1987). The question we ask is somewhat standard: What is the cost, defined as the percentage reduction in steady-state consumption, that the representative agent is willing to pay to move from the fluctuating economy to the deterministic (non-fluctuating) economy, for a given level of financial dollarization?

In order to calculate the expected utility in the fluctuating economy, we first numerically solve the model up to a second-order approximation, as in Schmitt-Grohé

[13] The results in Table 7.2 capture several stylized facts obtained in the empirical literature on the effects of debt dollarization on output and financial fragility. High debt dollarization leads to high output volatility, in line with Reinhart et al. (2003), as the cost of borrowing becomes more volatile due to the effects of currency mismatch.

and Uribe (2004).[14] Consequently, the second-order approximation of equation (7.7) can be written as:

$$\mathbb{E}\{U\} = \bar{U} + \mathbb{E}\{c\} - \left(\frac{\sigma - 1}{\sigma}\right)\bar{L}^{\tau}\mathbb{E}\{l\} + \cdots$$
$$\cdots - \frac{1}{2}\mathbb{V}\{c\} - \frac{1}{2}\left(\frac{\sigma - 1}{\sigma}\right)(\tau - 1)\bar{L}^{\tau}\mathbb{V}\{l\} + O(\|\xi\|^3), \quad (7.29)$$

where uppercase letters with bars denote non-stochastic steady state values, $\mathbb{E}\{x\}$ is the unconditional expected value of the random variable x, and $\mathbb{V}\{x\}$ is the unconditional variance of x; $\xi > 0$ is a scalar, and $O(\cdot)$ follows the standard big-O notation.

We simulate the economy 10,000 times, and compute the expected utility using the simulated series. Similar to Elekdag and Tchakarov (2007), this measure of welfare loss captures the effect of uncertainty on both the mean of consumption and the variance of consumption (a first-order approximation of the solution to the model would only yield the effect of uncertainty on the variance of consumption).

Since utility is separable in consumption and leisure, we follow Otrok (2001) and decompose the welfare cost into the fraction due to consumption volatility and the fraction due to leisure volatility. In order to make our results comparable to Otrok (2001), we only report the former in Table 7.2 (assuming $\tau = 0.3$, as in Céspedes and Rendón, 2012). Hence, the welfare cost of all consumption volatility in Peru is only 0.00381% when there is zero financial dollarization. This number increases to 0.00532% in the presence of full liability dollarization. Clearly, debt dollarization is welfare reducing, though it effects on welfare are rather small.

7.5 Final remarks

We evaluate the equilibrium properties of a version of the model presented originally by CCV. Under the assumptions addressed here, de-dollarization reduces the effect of real exchange rate depreciations on investment and production decisions under a flexible exchange rate regime. Actually, Corollary 1 states that if debt is contracted only in domestic currency, the economy is always financially robust. The model is able to account for around 70 percent of the output and investment drops and 60 percent of

[14] The unique non-stochastic steady state of the model is analytically solved (see Appendix A), and then the second order approximation of the model, together with the stochastic simulations, are computed in DYNARE, which is available at http://www.cepremap.cnrs.fr/dynare.

the real exchange depreciation in the aftermath of the Russian Crisis. De-dollarization would have moderated the decline in output growth by 0.7 percentage points.

We treat the currency composition of debt as exogenous, contrary to Chang and Velasco (2006) among others, who claim that dollarization has endogenous roots that may be dependent on the exchange rate regime expected to prevail in the economy. These authors argue that investors should borrow in domestic currency when they expect flexible exchange rates. We can certainly reconcile our framework with their findings. Consider for instance a small open economy with a given underdeveloped or poorly functioning capital market in domestic currency. Investors in this context find that a shallow capital market may imply a shortage in the supply of peso-denominated debt. In a flexible exchange rate regime, investors borrow as much as possible in domestic currency, which would be consistent with Chang and Velasco (2006) and others. If the supply of resources in pesos is enough to finance capital acquisitions, then π would be endogenously equal to 1, otherwise investors would also need to borrow from abroad and π would be endogenously less than 1.

Further work should include other channels that are highly relevant for the behavior of output and investment, such as the impact of terms of trade shocks on the Peruvian economy. During the financial crisis analyzed in this chapter, exports were severely affected through the worsening of terms of trade, which further impaired output and investment.

7.A Appendix: Non-stochastic steady state

To simplify expressions, we define the following parameters in terms of steady state values: $\pi = D/(D+SD^*)$, $\psi^* = (D+SD^*)/N$ and $\mu = (F'(\cdot)/F(\cdot))(QK/N)$. The equations that characterize the non-stochastic steady state of the model are:

$$Y = AK^{\alpha}\,, \quad Q = S^{1-\gamma}\,, \quad \rho = \rho^*\,, \quad \frac{\alpha Y}{QK} = (1+\rho^*)(1+\eta)\,, \quad 1+\psi^* = \frac{QK}{N}$$

$$1 = \frac{\delta\alpha Y}{N}(1-\Phi) - \delta(1+\rho^*)\psi^*\,, \quad \text{and} \quad Y = \gamma\left[(1-\alpha)Y + QK\right] + SX\,.$$

These equations are the steady state versions of equations (7.1), (7.11), (7.13), (7.17), (7.22), (7.23) and (7.24), respectively. Together with π and the value of $\bar{\omega}$ from the optimal debt contract, they form a system of nine equations in nine unknowns, namely Y, S, K, Q, N, D, D^*, ρ and η, which can be solved easily.

7.B Appendix: Log-linearized system of equations

The log-linearization of equations (7.1), (7.11), (7.13), (7.17) and (7.24) around the non-stochastic steady state yield, respectively:

$$y_t = \alpha k_t + (1-\alpha) l_t\,, \quad q_t = (1-\gamma) e_t\,, \quad \tilde{\rho}_{t+1} = \tilde{\rho}^*_{t+1} + \mathbb{E}_t\left\{e_{t+1} - e_t\right\}\,,$$
$$\tilde{\rho}^*_{t+1} = -\eta'_{t+1} + \mathbb{E}_t\{y_{t+1}\} - q_t - k_{t+1} - \mathbb{E}_t\left\{e_{t+1} - e_t\right\}\,,$$
$$\text{and} \quad \frac{y_t}{\chi} - \left(\frac{1-\chi}{\chi}\right) e_t = q_t + k_{t+1}\,.$$

These equations, which already incorporate the monetary policy rule for flexible exchange rates ($p_t = 0$), characterize the behavior of y_t, q_t, k_t, e_t and ρ_t. The behavior of η_t is described by equation (7.25).

Additionally, we use the log-linearization of equations (7.4b), (7.21), (7.22) and (7.23) around the non-stochastic steady state to pin down the dynamics of d_t, d^*_t, n_t and w_t. Respectively,

$$w_t - y_t = -l_t\,, \quad n_t = q_t + k_{t+1} - \frac{1}{\mu}\eta'_{t+1}\,,$$
$$n_t = (1+\psi^*)(q_t + k_{t+1}) - \psi^*(s_t + d^*_{t+1}) - \frac{D}{N}(d_{t+1} - d^*_{t+1} - s_t)\,,$$
$$\text{and} \quad n_t = \frac{\delta\alpha Y}{N} y_t - \frac{\delta\alpha Y}{N}\Phi\left(\frac{\nu}{\varepsilon_\Delta}\eta'_t + y_t\right) + \cdots$$
$$\cdots + \frac{1}{\psi^*}\left[1 - \frac{\delta\alpha Y}{N}(1-\Phi)\right]\left[\psi^*\left(\tilde{\rho}^*_t + e_t + d^*_t\right) + \frac{D}{N}\left(d_t + \tilde{\rho}_t + \tilde{\rho}^*_t - e_t - d^*_t\right)\right]\,,$$

where, as shown in Appendix B of CCV, ν is the elasticity of $\int_0^{\bar{\omega}} \omega dH(\omega)$ with respect to $\bar{\omega}$ and ε_Δ is the elasticity of the Δ function in equation (7.18).

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