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Financial Dollarization in Emerging Markets: An Insurance Arrangement

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Abstract

Households in emerging markets hold significant amounts of dollar deposits while firms have significant amounts of dollar debt. Motivated by the perceived dangers, policymakers often develop regulations to limit dollarization. In this paper, I draw attention to an important benefit of dollarization, which should be taken into account when crafting regulations. I argue that dollarization represents an insurance arrangement in which the entrepreneurs that own firms provide income insurance to households. Emerging market exchange rates tend to depreciate in a recession so that dollar deposits in effect provide households with income insurance. With their preference for holding deposits denominated in dollars, households effectively starve local financial markets of local currency, which raises local interest rates. By raising local currency interest rates, they cause entrepreneurs to borrow in dollars. Consistent with my argument, countries in which the exchange depreciates in a recession have a higher level of deposit and credit dollarization. In those countries, I verify that the premium of the local interest rate over the dollar interest rate is higher. This premium is the price paid by households for insurance.

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1 Introduction

In many emerging markets, firms borrow large amounts of funds denominated in foreign currency. This phenomenon of "credit dollarization" is typically regarded as a concern for policymakers and regulators, because it creates significant balance-sheet risks. In fact, when the exchange rate depreciates, interest payments on foreign debt rise, but firms' revenues do not, since they are usually denominated in local currency. As a result, firms' balance sheets deteriorate, with negative consequences on investment, production and, ultimately, employment and wages. The typical explanation for the widespread diffusion of credit dollarization is related to the political instability of emerging economies, and the lack of commitment of their central banks, which are responsible for high and volatile domestic interest rates. What is puzzling, however, is that the degree of credit dollarization remains high, despite the fact that macroeconomic conditions have now considerably improved in many of emerging markets (Catao & Terrones (2016)) .

In this paper, I offer a complementary explanation for the prevalence of credit dollarization. In emerging economies, poor economic performance is typically associated with exchange rate depreciations. Savings accounts denominated in foreign currency provide a hedge against domestic income fluctuations because the foreign currency gains in value exactly when domestic economic growth is low. Therefore, households find it optimal to save considerable amounts in foreign currency. The willingness of domestic households to save in foreign currency, however, decreases the supply of local currency to the banking system, which raises domestic interest rates and induces firms to borrow more in dollars. In other words, rather than just entailing risks, a large share of credit dollarization in emerging economies stems from an insurance arrangement in which firms offer households a hedge against income fluctuations in the form of foreign currency borrowing. Firms pay lower foreign currency interest rates to households on average, but, in return, pay a larger amount when the economic performance is poor.

I formalize the idea of dollarization as an insurance agreement in the context of a small open economy model with financial frictions. In the model, households can save by purchasing assets denominated in either local or foreign currency (deposit dollarization). Entrepreneurs are subject to a Costly State Verification financial friction (Townsend (1979); Gale & Hellwig (1985)) and they can borrow either from local or foreign sources (credit dollarization). The model features the main concern about dollarization, i.e. that the balance sheets of entrepreneurs are adversely affected by exchange rate depre-

ciations due to the mismatch between the denomination of revenues and debt (revenues are in local currency, debt is in dollars). At the same time, the model also captures the insurance aspect of dollarization, which is the focus of this paper. Following an exchange rate depreciation, the value of household savings in foreign assets increases, providing insurance against the adverse effects of this depreciation. When households invest more in foreign assets, to capture their hedging benefits, the supply of local funds falls and the spread between local and foreign interest rates endogenously increases. Due to the desire for savings in foreign assets to smooth income fluctuations, households are content to receive lower interest rates on foreign assets because foreign assets provide income in episodes where the consumption is low.

The main source of uncertainty in the model is foreign interest rate shock, which should be interpreted as the international risk-free rate plus the spread emerging market economies face, and is an important driver of emerging markets business cycles (Neumeyer & Perri (2005); Gertler et al. (2007)). An increase in foreign interest rates causes an exchange rate depreciation because of higher demand for foreign assets by households, and lower demand for local source of funding by the entrerpeneurs. Exchange rate depreciation caused by the increase in foreign interest rates adversely affect the economy through raising the cost of capital and deteriorating the balance sheets of entrepreneurs. Entrepreneurs need to pay a larger interest rate cost, which lowers their net worth. Due to the endogenous leverage constraints generated by the financial frictions, lower net worth translates into lower borrowing. Hence, deteriorated balance sheets lead to lower investment and wages, which decrease the household consumption. I show that households can effectively hedge against foreign interest rate risk by saving in foreign assets that provide high return when foreign interest rates increase, which leads to an exchange rate depreciation and increases the value of foreign assets.

The model generates several empirical regularities observed in the data. Credit and deposit dollarization are correlated in the cross section and comove across time. Economies with high dollar credit have also high household dollar savings, and periods with higher deposit dollarization coincide with higher credit dollarization. Higher dollarization is associated with higher interest rate spread both in the cross section and across time. Dollarization is higher in economies where the correlation between consumption and exchange rate movements is negative. I also show that the more negative this correlation is, the more dollarized a country tends to be.

In my model, policies that limit dollarization have overall unfavorable consequences, de-

spite reducing the balance-sheet effects of depreciations. This is because these policies make the economy more vulnerable to foreign interest rate shocks by reducing households‘ insurance. When comparing the baseline to a counterfactual economy where households are forced to only save in local currency, credit dollarization is also substantially lower, but consumption becomes 40 percent more sensitive to foreign interest rate shocks. An alternative policy to reduce dollarization would be to tax foreign borrowing. The advantage of this policy is that it does not take away household insurance through foreign currency saving. However, limits to foreign borrowing decreases investment and production in the long run. For example, I find that a tax that eliminates 50% of foreign currency credit raises real interest rates by 1.4% and causes a decline of 5% in steady state capital.

In this paper, I argue that dollarization has an often neglected benefit as well as known costs. Substantial share of foreign currency credit in the economy is part of a beneficial insurance arrangement between firms and households. Policies to limit dollarization might break this insurance and, hence, the effects of these policies on the economy can be costlier than the policymakers think.

2 Related Literature

Dollarization was on the rise until the late ’90s. Figure 1 shows the historical movement of dollarization. After 2000, there was a notable switch to local currency, even though the use of foreign currency deposit remained significant. This corresponds to a time of stability in emerging market economies. This trend of “dedollarization” was noted by Catao & Terrones (2016), which shows that dollarization declined until the great recession. The use of foreign currency has been attributed to weakness in financial institutions; however, households hold significant amounts of foreign currency even in emerging economies with stable financial systems. I claim that part of dollarization in these emerging economies can be explained by the hedging property of foreign currency accounts. A similar idea has been pursued by Chari & Christiano (2017), where they see commodity futures trading as part of a hedging arrangement.

The earliest work on dollarization is related to the concept of currency substitution. Currency substitution is where households use foreign currency as a medium of exchange or store of value; earlier work focused on how currency substitution can limit the effectiveness of monetary policy (Brillembourg & Schadler (1979); Miles (1978)).

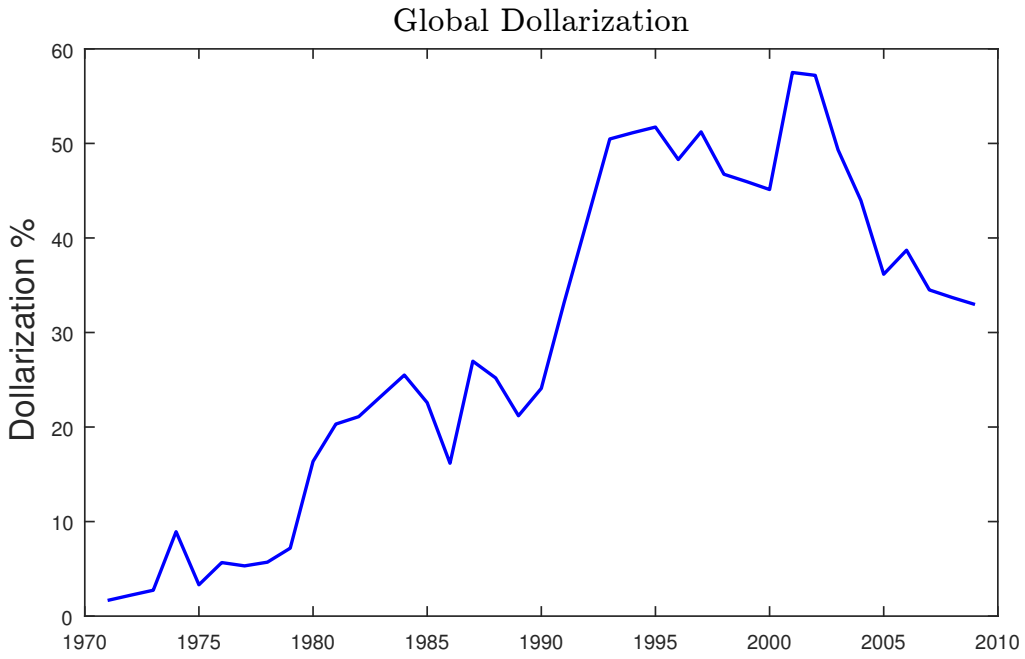


Figure 1: Deposit dollarization in the world
Source: Yeyati (2006), World Bank

Currency substitution is thought to be a problem faced by economies with weak institutions (Giovannini & Turtelboom (1992)), and foreign currency borrowing is thought to be a systemic risk factor. High credit dollarization puts balance sheets of firms and the public sector into exchange risk and limits the ability of conducting monetary policy. Overall, dollarization has been seen as a sign of weakness in financial institutions (Mecagni (2015)). In a seminal paper, Ize & Levy Yeyati (2003) argue that dollarization can arise in economies with sound financial system. Borrowers and lenders with mean-variance utility will compare relative volatilities of real exchange rate and inflation and when the inflation is more volatile than the real exchange rate, depositors find it optimal to invest in foreign currency.

It is thought that credit dollarization has negative externality on the economy. An important channel discussed by Eichengreen et al. (2003) is the moral hazard channel. Given the presence of implicit and explicit[1] government guarantees, firms and banks find it optimal to borrow in foreign currency. Burnside et al. (1999) argue that under implicit government guarantees, banks find it optimal not to hedge their exchange rate

[1]A fixed exchange regime could be thought of as an explicit guarantee where the government promises exhcange rate stability.

exposure. Even under flexible exchange rate regimes, authorities use monetary policy to stabilize the exchange rate in the presence of foreign debt. Calvo & Reinhart (2002) argue that many emerging economies who claim to have a floating exchange rate regime actually use monetary policy to avoid depreciations. In fact, a monetary tightening to avoid a depreciation can be the optimal policy in the presence of balance sheet effects of foreign exchange rate (Braggion et al. (2009); Christiano et al. (2004)). Reinhart & Kaminsky (1999) show that there is a pattern in emerging market crises. Currency crises and banking crises often happen jointly. A fall in the value of currency puts the banking sector under risk, and problems in the banking sector cause further collapse in the value of the currency. Thus, the economy enters into a vicious cycle. Rey (2013) argues that changes in the Federal Funds Rate affect the VIX[2] index, which affects global credit conditions and local interest rates. It then becomes difficult for small open economies to conduct monetary policy independent of global financial conditions. Bruno & Shin (2015) argue that an important channel is through bank capital flows. A fall in US interest rates increases cross border capital flows, which end up in the non-financial sector outside the US. Similarly, Aoki et al. (2016) discuss how monetary policy should respond to global financial shocks in emerging markets with dollar denominated debt.

In a recent work, Dalgic et al. (2017) document firm borrowing behavior in emerging economies. They show that it is mostly larger firms and firms with foreign currency revenue that borrow in foreign currency. These firms are more resilient against exchange rate depreciation even though they incur large financial costs in years where exchange rate depreciates, which, in turn, deteriorates their balance sheets. They show that a simple model where foreign currency borrowing is cheaper but risky due to exchange rate movements fits the borrowing behavior of firms. In my model, interest rate spread is generated endogenously, but the firms face a similar choice. Dalgic et al. (2017) also show that exporting firms borrow mostly in foreign currency. However, firms with significant export revenues do not constitute a large part of the economy. Most foreign currency borrowing is done by large firms without significant exporting revenue. Still, the empirical observation supports the view that foreign currency borrowing/lending is conducted in a manner that takes into account (and minimizes) the balance sheet effects.

There is recent literature about currency choice in sovereign borrowing, which notes the

[2]Implied volatility by S&P 500 options, proxy for stock market expectation of volatility.

countercyclicality of exchange rate in developing economies. Perez & Ottonello (2016) argue that foreign currency borrowing is especially expensive for emerging economies because of the fact that the exchange rate depreciation is associated with recessions, but in the absence of a credible monetary policy, sovereigns are unable to borrow in local currency because of the fear that it will devalue. Du et al. (2016) make a similar argument— foreign currency debt helps as a commitment device against future inflation in emerging economies. Private sector foreign currency debt can also discipline the sovereign against inflating local currency sovereign debt (Schreger & Du (2014)).

Contrary to the prevailing view, literature on firm credit dollarization generally finds that the balance sheet effects of currency depreciation are modest (Bleakley & Cowan (2008); Dalgic et al. (2017)). It is mostly large and exporting firms who borrow in dollars (Alp & Yalcin (2015); Dalgic et al. (2017)). Alp & Yalcin (2015) find that overall, foreign currency borrowing is positively related to firm growth. Ranciere et al. (2010) find that in Eastern Europe, it is the small firms which benefit from the access to foreign currency borrowing. In their framework, firms borrow in foreign currency because of implicit bailout expectations. Liquidity injections by EU and IMF to Eastern European countries confirm this expectation (Ranciere et al. (2010)). In a separate analysis, they find that foreign currency borrowing positively correlates with high GDP growth before the crisis but leads to a sharper contraction in 2008. Hedging behavior of the firms who borrow in foreign currency is not well documented. Many authors assume that in most emerging markets, it is too costly to hedge. Moreover, even if the firms hedge some of their exposures, this hedging is not perfect and leaves the firms vulnerable to large depreciations (Chui et al. (2014)). Forbes (2002) finds that in the aftermath of exchange rate depreciations, firms experience lower net income growth but other performance indicators are not affected.

Interest rate spread between the dollar and emerging market currencies is documented by several papers (Ferreira & Leon-Ledesma (2007); Alper et al. (2009); Banerjee & Singh (2006)). In my model, the source of interest rate spread is the household's desire to hold foreign currency because foreign currency denominated bonds provide insurance against global risks. A similar idea is pursued by Hassan (2013) and Martin (2013). In this context, the US bonds are bought by the investors all around the world. Risk-free US bonds carry a negative premium because it provides insurance against global risks.

One of the crucial assumptions driving the results in this paper is that foreigners do not want to invest in local EM currencies. Recent empirical observation supports this

assumption. Gruić & Wooldridge (2013) show that around 70% of all emerging market international securities are denominated in dollars, whereas the share of local currency is around 10%. Similarly, Maggiori et al. (2017) document using a large data set of securities that there is a strong "currency bias" in international financial flows so that residents of developed economies invest mostly in securities denominated in their currency even if the issuer is from another country. This is related to the dollar's role as a reserve currency (Goldberg (2010); Maggiori & Farhi (2016)). A related idea is the theory of "Original Sin". Developing economies have difficulty issuing debt in domestic currency. Eichengreen et al. (2003) push forward the idea of Original Sin. According to this theory, emerging markets are unable to borrow in their local currency because of reasons that are currently out of their control. Hausmann & Panizza (2003) find that the only variable to explain this phenomenon is the size of the economy, which makes this phenomenon relevant for small open economies. In the last decade, many countries have started borrowing in local currency in small amounts (In the Appendix, I construct the Original Sin index for the last decade.). Still, the magnitudes are small compared to foreign currency issuance. A recent attempt to rationalize Original Sin claims that foreign currency asset prices are driven by default expectations, whereas local currency assets are mainly driven by inflation expectations. This naturally makes sophisticated foreigners refrain from investing in local currency assets (Bassetto & Galli (2017)). The argument that the domestic currency market needs to clear in the country reminds us of the Feldstein-Horioka Puzzle (Feldstein & Horioka (1980a)), which shows that domestic saving and investment are too closely correlated to be explained by a standard international macroeconomic model. If investment is determined by domestic savings, then this means domestic capital markets clear within the borders. The original paper argues that the puzzle can be reconciled with free capital flows. Short term liquid flows get much attention but most of the capital stock in an economy is in fact highly illiquid. Similarly, the currency derivatives market can be used by foreigners to benefit from higher emerging market interest rates. International financial institutions trade high volumes in these markets. However, Gabaix & Maggiori (2015) note that most of these trades are generally very short term. In their model, collateral constraints lead to limited participation of foreign traders in local currency markets and create interest rate spread.

Another crucial assumption in this paper is that the banks are required to balance currency denomination of assets and liabilities through the loans they extend. This

rules out currency mismatch in the banking sector. There is ample evidence that in emerging economies, currency denomination of liabilities heavily influences the currency denomination of loan portfolios (Brown et al. (2014); Keller (2017)). Neanidis & Savva (2009) show that the tendency of emerging market banks to match the denomination of deposits and loans creates a correlation between deposit and credit dollarization. In a similar context, Bocola & Lorenzoni (2017) show how currency mismatch in financial sector can lead to self-fulfilling bank runs and financial crisis. In line with their policy recommendation, in most emerging markets, banks are not allowed to have currency mismatch on their balance sheets and household foreign currency deposits are under protection of deposit insurance. Banks can typically match denomination of their assets and liabilities by changing loan composition or using forward markets (Keller (2017)). On the other hand, liquid currency derivative securities are commonly very short term, as opposed to long term loans the banks extend. Banks prefer changing loan composition instead of using derivative securities because hedging using these securities will create maturity mismatch (Borio et al. (2017)).

I discuss how global conditions and risks influence domestic dollarization and interest rates, and I consider the effects of an increase in global risk to an emerging market. The starting point is that households hold foreign currency to hedge their exposure to exchange rate risk. An increase in risk will make households want to hold more foreign currency, which will increase overall dollarization of the economy through firm credit dollarization. In order to consider the effects of an increase in risk, I follow an approach similar to Fernandez-Villaverde et al. (2011) in which they consider impulse responses to a shock to the stochastic standard deviation. In my model, standard deviation of the export shock is stochastic. I find that a positive shock to the standard deviation of the export shock increases both credit and deposit dollarization.

I find that policies to reduce dollarization have unintended consequences. As opposed to conventional thinking, I find that preventing household foreign currency deposits makes the economy more vulnerable to global shocks. Similarly, preventing foreign currency credit reduces investment and capital over long term. I argue that policies to limit dollarization should consider the benefits of dollarization, as well as the cost of these policies.

3 Empirical Facts

In this section, I present certain important facts about dollarization in emerging economies. In these economies, a significant portion of financial intermediation takes place in foreign currency. As Figure 2 indicates, in many countries, close to 50% of credit to non-financial firms is denominated in foreign currency. I am going to show that the source of this credit is household foreign currency savings, and it is the household behavior that drives dollarization in these economies.

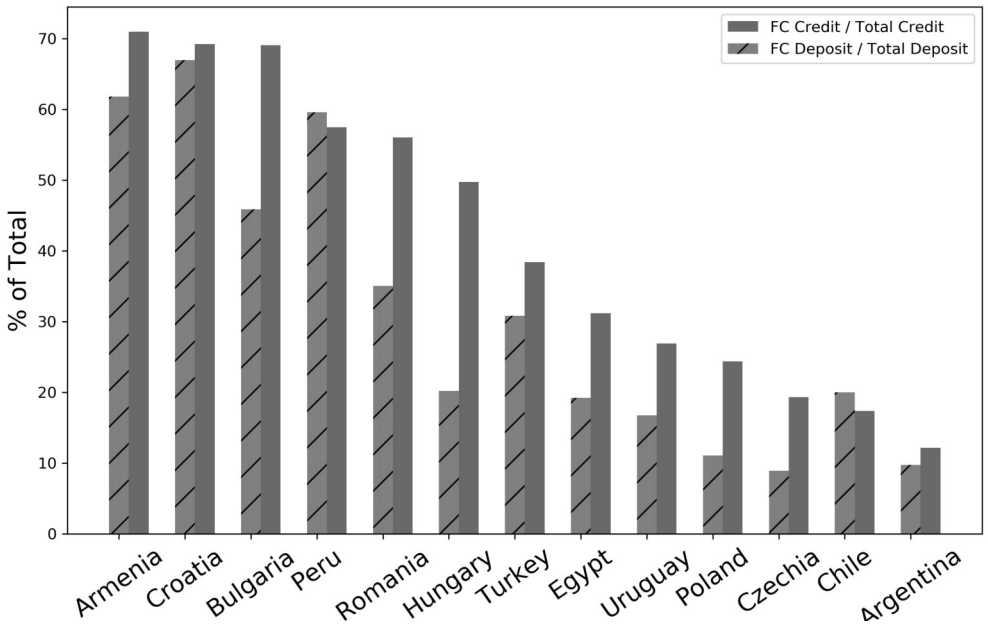


Figure 2: Ratio of FC deposit and credit in the banking system
Source: Individual central banks, ECB

3.1 Deposit and Credit Dollarization are Correlated

Credit and deposit dollarization are positively correlated across countries. Figure 3 shows the average dollarization in emerging economies[3]. In certain economies, more than 50% of financial intermediation takes place in a foreign currency[4].

[3]Monthly averages, from early 2000s to 2016; data obtained from central bank websites.

[4]I replicate this graph for more economies using IMF Financial Soundness Indicators where credit dollarization inlcudes household loans as well as loans to non-financial firms

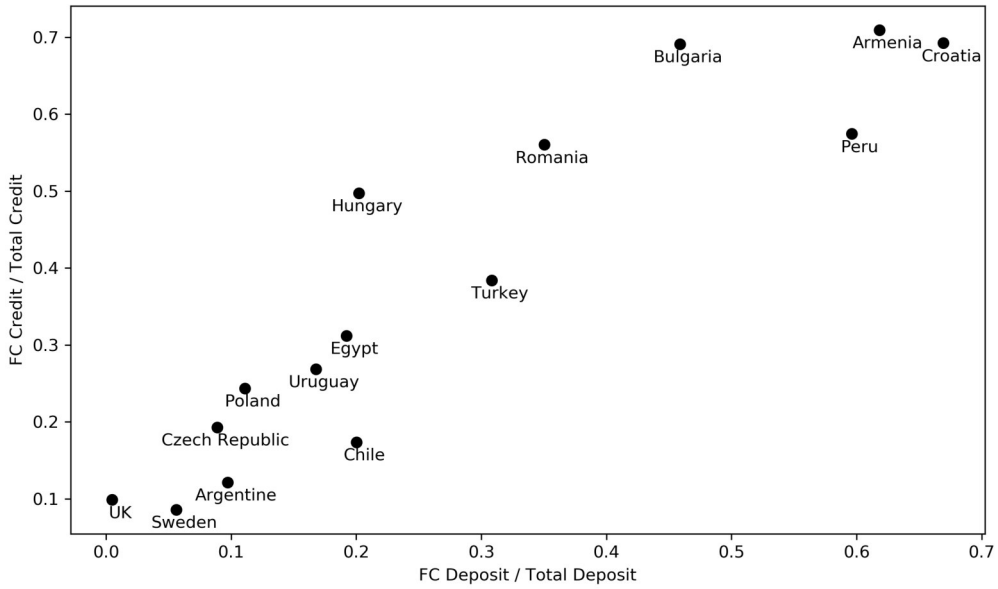


Figure 3: Average credit and deposit dollarization across selected countries
Source: Individual central banks, ECB

3.2 Hedging motive

I argue that one of the underlying reasons behind deposit dollarization is hedging motive. In emerging economies, exchange rate depreciations are associated with lower growth. Figure 4 presents the evidence for this fact. In economies with high dollarization, correlation between real GDP growth and exchange rate[5] depreciations is typically negative. On the other hand, in developed economies where we do not observe dollarization, the covariance is either close to zero or positive[6].

3.3 Interest Rate Spread in Dollarized Economies

The model has a clear implication about interest rate spread. In this section, I provide evidence for high interest rates in dollarized economies. Households hold foreign currency due to hedging motive, which drives up local currency interest rates. Due to

[5]Here, exchange rate is defined as the nominal dollar exchange rate divided by CPI of that economy. This is similar to how I define exchange rate in the model

[6]Inflation volatility has been also suggested as a motive for dollarization. In Appendix, I produce the same graph for inflation and real exchange volatility, see Figure 24

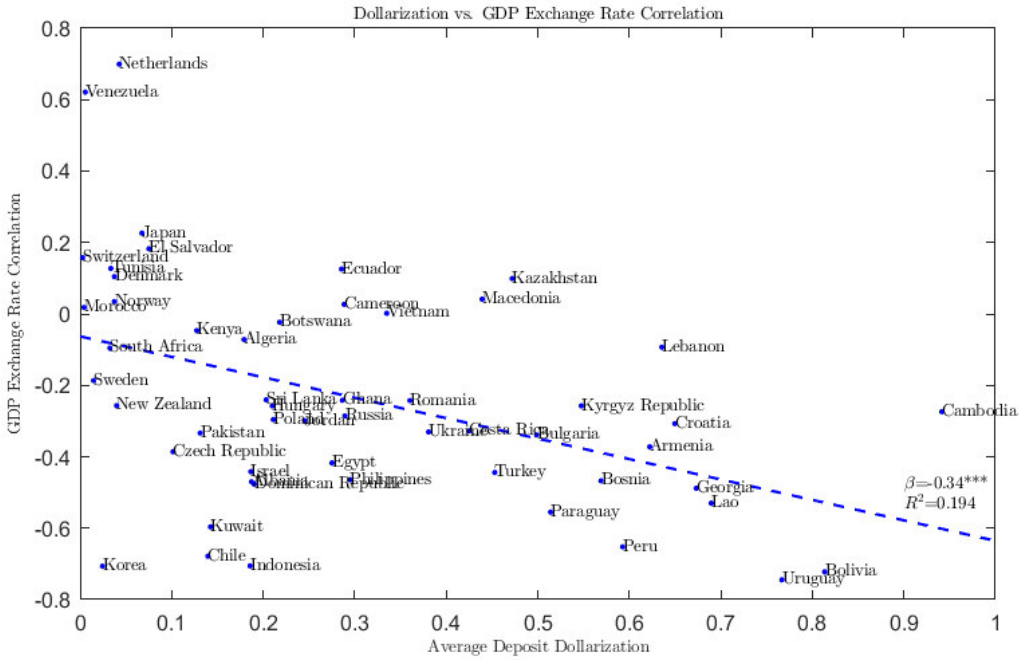


Figure 4: Correlation between change in GDP and exchange rate
Source: World Bank

the interest rate spread in favor of emerging market currencies- investing in currencies of dollarized economies should give on average positive returns. I follow the strategy outlined in Burnside et al. (2011) to check whether emerging economies with higher dollarization yield higher returns. Monthly data covers the period 2004-2017. Data is taken from Reuters/WMR quotes on Datastream and covers the period 2004-2017. For Bulgaria, Croatia, Hungary, Romania, and Poland, the Euro is taken as benchmark; for others USD is the benchmark.

I assume that covered interest rate parity holds[7]. I denote S_t as the spot exchange rate and F_t as the forward rate. Covered interest parity implies that returns domestic interest rate has to be equal to a hedged foreign position.

$$R_t = \frac{F_t}{S_t} R_t^f \tag{1}$$

Return to holding local currency is

[7]Otherwise, there will be an arbitrage opportunity where any investor can invest large amounts and earn essentially riskless profit. On the other hand, some recent literature finds that in the aftermath of recent finanical crisis, violations of covered interest rate parity are observed (Sushko et al. (2016); Amador et al. (2017)).

$$R_t - \frac{S_{t+1}}{S_t} R_t^f$$

Then, replacing R_t, I get that borrowing in foreign currency and investing in local currency yields,

$$x_t^L = \left(\frac{F_t - S_{t+1}}{S_t} \right) R_t^f \tag{2}$$

The evidence suggests that currencies of dollarized economies yield higher returns on average. There is a positive relation between average spread and average dollarization. Figure 5 plots average dollarization and interest rate spread.

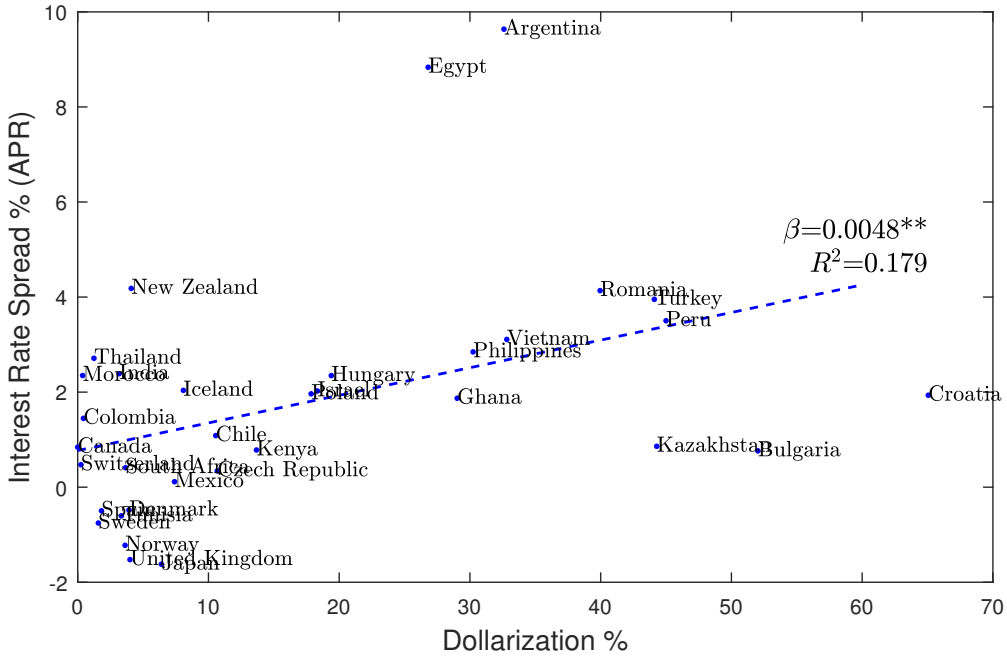


Figure 5: Average Interest Rate Spread and Average Deposit Dollarization

Average interest rate spread can be due to high risk that these emerging markets carry. In Figure 6, I plot Sharpe Ratio[8] instead of average return. Highly dollarized economy local asset returns are higher, even after being standardized by standard deviation.

[8]Average return divided by standard deviation of returns.

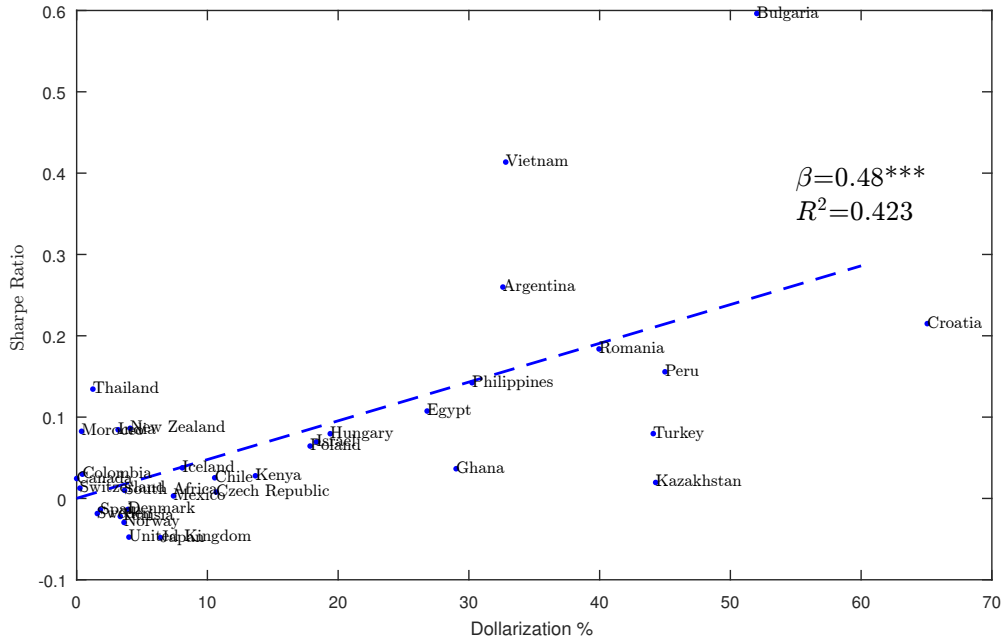


Figure 6: Sharpe Ratio for Interest Rate Spread and Average Dollarization

3.3.1 Interest Rate Spread and GDP Exchange Rate Correlation

Equation 28 implies that interest rate spread is proportional to the covariance between the consumption and exchange rate. In Figure 7, I plot the average interest rate spread and correlation between exchange rate and consumption. In line with the evidence from Figures 4 and 5, a negative correlation between GDP and exchange rate fluctuations are associated with higher interest rate premium.

3.3.2 Carry Trade

In this section, I am going to replicate the above results from the perspective of US investors. Imagine a US investor who has access to risk-free funding, investing in an emerging market asset currency yields,

$$R_t \frac{S_t}{S_{t+1}} - R_t^f$$

Using equation 1, I can write this difference as

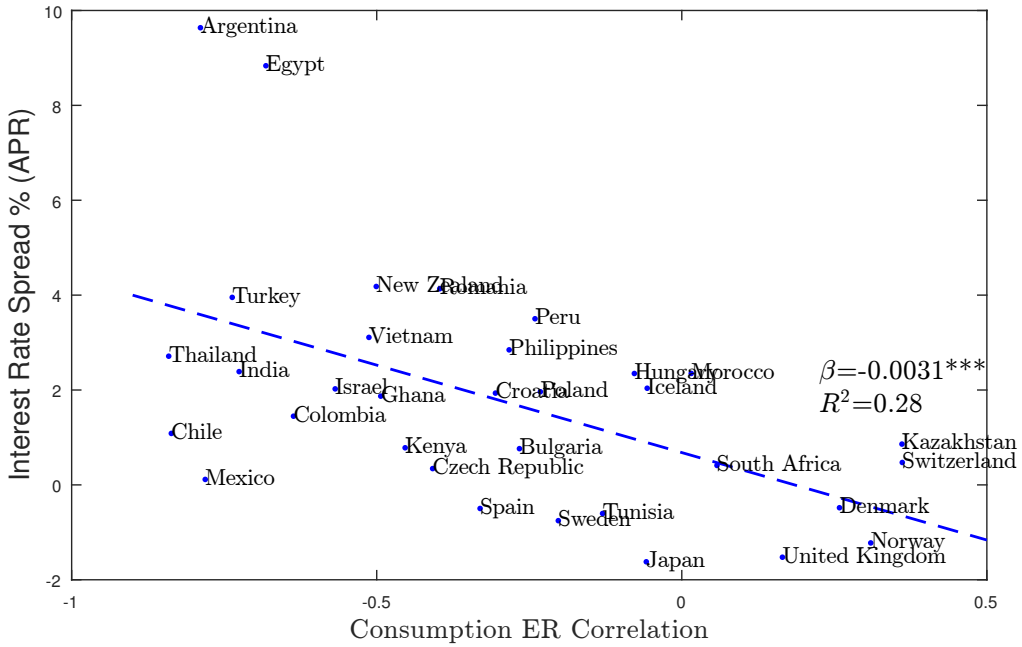


Figure 7: Interest Rate Spread and GDP ER Correlation

$$R_t^f \left(\frac{F_t - S_{t+1}}{S_{t+1}} \right) \tag{3}$$

Equation 3 is very similar to equation 2. Figure 8 shows Sharpe Ratio as a function of average dollarization. Average Sharpe Ratio for emerging economies with dollarization of more than 15% turns out to be 21.19%. I calculate US equity Sharpe Ratio for the same period to be 16.85%[9].

3.4 Interest Rate Spread Comoves with Dollarization

Using central bank survey of expectation data, I calculate the real interest spread between dollar and local currency deposits in Turkey and Chile.

$$\text{Real Spread} = R_t^l \frac{P_t}{P_{t+1}^e} - R_t^f \frac{P_t}{P_{t+1}^e} \frac{S_{t+1}^e}{S_t}$$

where R_t^l and R_t^f are average local currency and foreign currency deposit interest rates, P_t is CPI, S_t is dollar exchange rate. Superscript P_{t+1}^e and S_{t+1}^e denote CPI and ex-

[9]Monthly returns and risk free-rate are taken from Ken French's website.

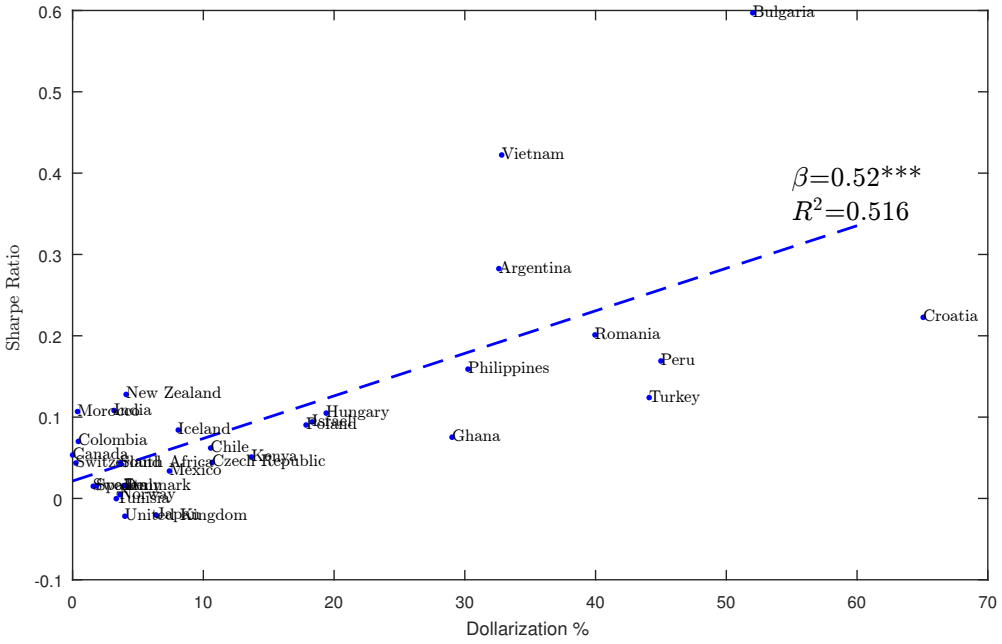
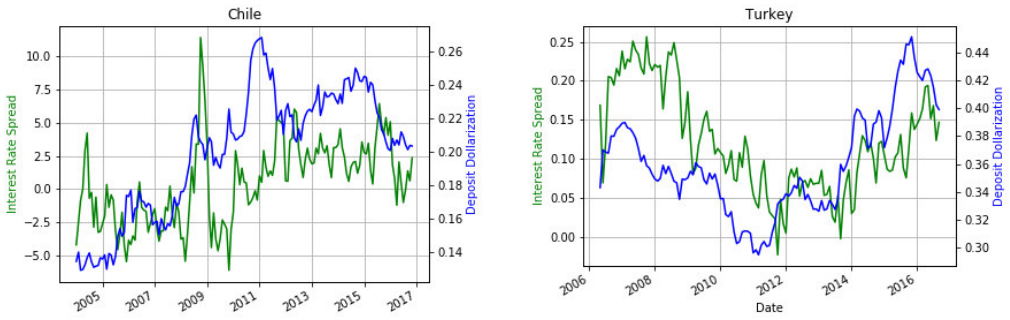


Figure 8: Sharpe Ratio and Average Dollarization

change rate expectations for 12 months ahead respectively. Comovement between credit dollarization and interest rates support the view that firms follow the the cheaper source of funding. On the other hand, when households switch to saving in foreign currency, it coincides with an increase in local interest rates. This lends to the view that the underlying reason for deposit dollarization is not the relative interest rates.



$\rho = 0.47$ $\rho = 0.37$

Figure 9: Deposit dollarization and interest rate spread
Source: Individual central banks, Survey of Expectations

3.5 Deposit and Credit Dollarization Comove

Deposit and credit dollarization also correlate in time series. Figure 10 shows the time series movement of credit and deposit dollarization in example economies[10]. Deposit and credit dollarization comove over long periods[11]. The interest rate spread also follows the same trend, which means that as households and firms switch to foreign currency, local interest rates become more expensive.

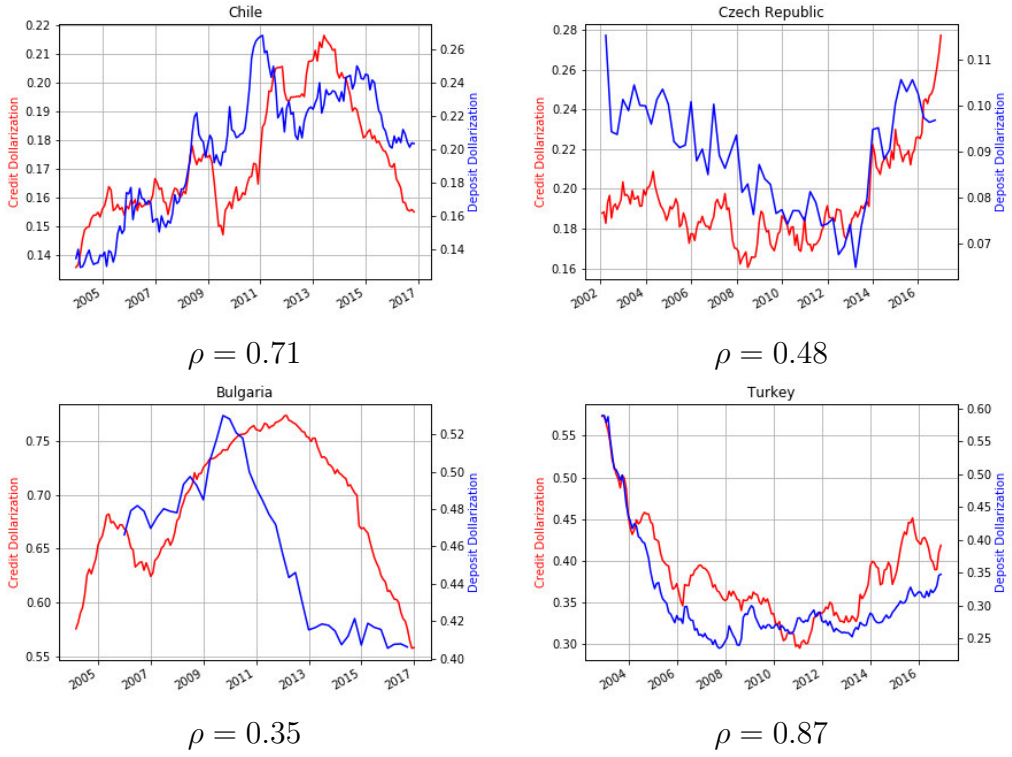


Figure 10: Credit and deposit dollarization in time series
Source: Individual central banks, ECB

4 The Model

The model is based on a standard small open economy model with two goods (home good and foreign good). Exchange rate is determined endogenously through current account identity. Endogenous local interest rates clear local financial markets. In order

[10] In the Appendix, graphs of all countries in the dataset are listed.

[11] In short horizons, exchange rate movements can create a spurious correlation but we observe long periods where deposit and credit dollarizations comove.

to capture balance sheet effects of exchange rate, the model features financial frictions that are based on the Costly State Verification (CSV) mechanism from Gale & Hellwig (1985). Bernanke et al. (1999) use the same structure structure, and it is among the first papers to embed a financial system inside a macroeconomic model. CSV mechanism has also been applied previously in the context of open economies[12]. I allow entrepreneurs in the model to choose endogenously the currency of borrowing. Foreign currency[13] borrowing creates balance sheet effects of exchange rate movements.

4.1 Household

I consider a standard small open economy. Consumption good is a composite good of home good ($c_{h,t}$) and foreign good ($c_{f,t}$).

$$C_t = \left(\omega^{\frac{1}{\sigma}} c_{h,t}^{\frac{\sigma-1}{\sigma}} + (1-\omega)^{\frac{1}{\sigma}} c_{f,t}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{4}$$

with $\omega > 0.5$ representing the home bias and σ is the elasticity of substitution between home and foreign good. Price index of composite good,

$$P_t = \left(\omega p_{h,t}^{1-\sigma} + (1-\omega) S_t^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{5}$$

where price of home good is fixed $p_h = 1$. S_t denotes the relative price of foreign good; I refer to S_t as exchange rate throughout the paper. Households have access to a one period risk-free foreign bond at an exogenous world interest rate R_t^f. f_t denotes household foreign asset holdings in terms of home good; d_t is the amount of local asset holdings that pays local interest rate R_t, which is determined endogenously. Each household is endowed with 1 unit of labor, which he lends to production firms at the competitive wage rate w_t. Representative household maximizes life-time utility subject to the budget constraint,

$$\sum_{t=0}^{\infty} \beta^t \mathbb{E}\left(\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{\xi}{1+\phi} l_{h,t}^{1+\phi}\right) \tag{6}$$

[12]See Christiano et al. (2011) for a review. In particular, Faia (2007) shows that CSV-type financial frictions amplifies comovement between open economies. Similarly, Gertler et al. (2007) show how a small open economy reacts to shocks to interest rate premium under different exchange rate regimes.

[13]This is an abuse of notation. Since this is not a monetary model, any reference to foreign currency means foreign good. Exchange rate refers to relative price of foreign good with respect to home good.

$$P_t C_t + \overbrace{d_t}^{\text{Home Asset}} + \overbrace{f_t}^{\text{Foreign}} = \overbrace{w_t l_{h,t}}^{\text{Labor}} + d_{t-1} \overbrace{R_{t-1}}^{\text{Local Rate}} + f_{t-1} \overbrace{\frac{S_t}{S_{t-1}}}^{\text{ER}} \overbrace{R^f_{t-1}}^{\text{Foreign Rate}} \tag{7}$$

In many emerging economies, households hold savings in both local and foreign currencies; the model captures this behavior by allowing households to hold domestic and foreign assets. I refer to the ratio $\frac{f_t}{f_t+d_t}$ as "deposit dollarization". The first order conditions of household maximization problem are

$$\frac{C_t^{-\gamma}}{P_t} = \beta R_t \mathbb{E}\left(\frac{C_{t+1}^{-\gamma}}{P_{t+1}}\right) \tag{8}$$

$$\frac{C_t^{-\gamma}}{P_t} = \beta R_t^f \mathbb{E}\left(\frac{C_{t+1}^{-\gamma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\right) \tag{9}$$

$$\xi l_{h,t}^{\phi} C_t^{\gamma} = \frac{w_t}{P_t} \tag{10}$$

4.2 Production Firms

Production firms produce home good according to the production function,

$$y_t = z_t K_t^{\alpha} L_t^{1-\alpha} \tag{11}$$

Capital (K_t) is operated by the entrepreneurs, which will be discussed in the next section. z_t is the exogenous productivity process. Firms hires labor (L_t) from both household and entrepreneur; labor is aggregated according to,

$$L_t = l_{h,t}^{\Omega} l_{e,t}^{1-\Omega} \tag{12}$$

where $l_{h,t}$ and $l_{e,t}$ are labor provided by household and entrepreneurs, respectively. Return to capital is given by

$$R_t^k = \mathbb{E}\left(\frac{z_{t+1}\alpha K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} + Q_{t+1}(1-\delta)}{Q_t}\right) \tag{13}$$

which is equal to the marginal product of capital plus the resale price of undepreciated capital divided by the current price of capital. Q_t is the price of capital and δ is the depreciation rate. Capital investment is made by the representative household. Each

period, households buy back the capital from entrepreneurs. Capital evolves according to

$$K_{t+1} = (1-\delta)K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right)K_t \tag{14}$$

with capital adjustment costs $\Phi(\cdot)$.

4.3 Foreign Economy

Foreign economy produces foreign good and this good is traded competitively without trade costs. Foreign good can be exchanged for S_t amount of home good. Foreign households demand a certain amount of home good for consumption (c_{xt}), their consumption demand is given by

$$c_{xt} = S_t^{\varphi} x_t \tag{15}$$

where x_t is an exogenous demand, φ is the elasticity of demand and S_t is the relative price of foreign good. Foreign households own foreign banks, which borrow and lend at the exogenous interest rate R_t^f. Figure 11 summarizes the trade and production in the model.

4.4 Banks

In the model, there are two types of banks: local and foreign. Local banks are owned by households and intermediate local funds. Following Eichengreen et al. (2003), I assume that local banks can only borrow from the household. This means that foreign investors do not have access to financial intermediation in terms of local currency. Recent empirical observation by Maggiori et al. (2017) verifies that this assumption is reasonable. Local financial markets need to then clear within the small open economy[14] through local interest rates R_t. Foreign banks intermediate in terms of foreign currency and are owned by risk neutral foreign investors [15]. They borrow at the exogenous interest rate R_t^f from foreign investors and the local household. Figure 12 shows the financial sector in the economy.

[14]This is similar to Feldstein-Horioka puzzle (Feldstein & Horioka (1980b)).

[15]This assumption is made because lending to entrepreneurs in foreign currency will typically carry aggregate risk.

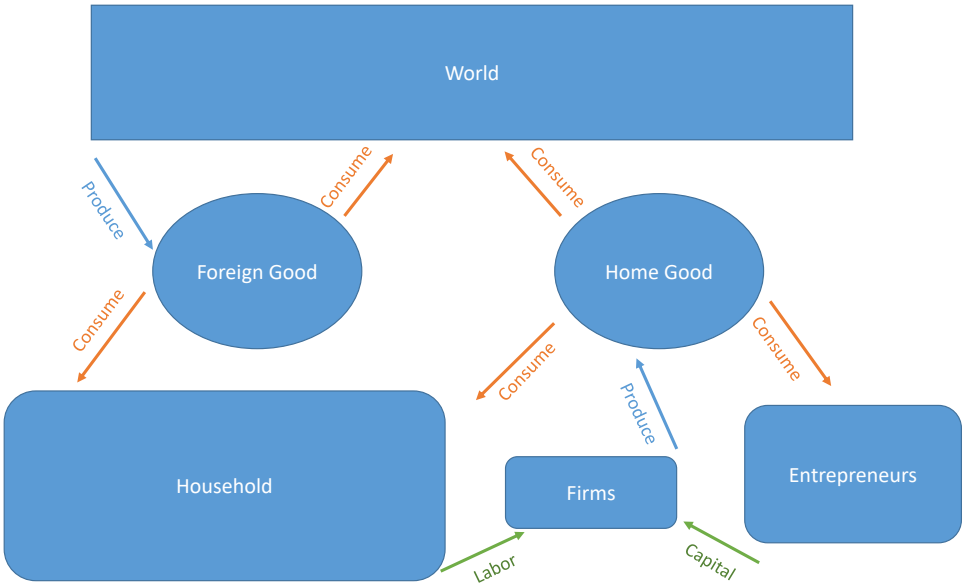


Figure 11: Goods market

Another important assumption is that the banks cannot have currency mismatch; they need to match denomination of their liabilities and loans. Many studies verify that emerging market banks do not carry currency mismatch due to regulation or risk management (Dalgic et al. (2017); Keller (2017); Brown et al. (2014)). I also assume that the banks are totally separate and they do not insure each other; the implication is that each loan has to satisfy bank zero profit condition separately, which means that banks do not extend loans they know they would make a loss from.

4.5 Entrepreneurs

Following Bernanke et al. (1999), entrepreneurs are modeled as separate households. They are risk neutral and maximize life time income[16]. Entrepreneurs operate the capital in the economy. Even though all entrepreneurs are ex-ante identical, each entrepreneur operates capital with efficiency ω_i. Given the return to capital R_t^k, an entrepreneur gets a return of $\omega_i R^k$. The realization of ω_i depends on the distribution function $\omega_i \sim F(\omega)$ where $\mathbb{E}(\omega_i) = 1$.

Each entrepreneur has net worth N_i, which can be used as collateral to borrow more.

[16]For simplicity, they only consume home good.

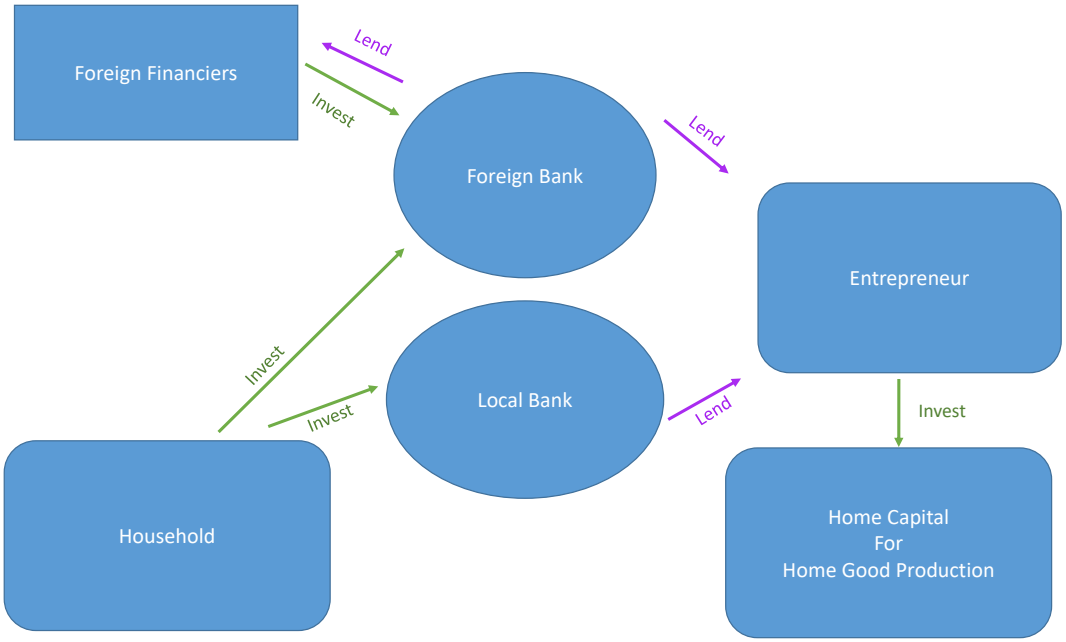


Figure 12: Financial markets in the model

They are subject to a particular financial friction, Costly State Verification, introduced by Townsend (1979). In particular, banks can observe efficiency ω_i only after paying a monitoring cost μ of total assets of the entrepreneur. Gale & Hellwig (1985) show that the optimal contract in this environment is a debt contract and the entrepreneur is monitored only if he declares bankruptcy. The bank offers a menu of contracts that specify an interest rate and leverage. The interest rate offered by the bank carries a risk premium reflecting the likelihood of default. The interest rate offered by the foreign bank reflects the exchange rate risk. An entrepreneur picks the contract to maximize expected profit. In the model, there are two sources of borrowing, which means there will be two endogenous bank interest rates $(R^f_{b,t}, R^l_{b,t})$ and two leverages(L^f_t, L^l_t) for foreign and local borrowing, respectively, which become two equilibrium contracts offered by banks $(R^l_{b,t}, L^l_t)$ for local and $(R^f_{b,t}, L^f_t)$ for foreign borrowing. Given the level of leverage, the interest rate uniquely determines default cutoff for two types of borrowing $(\bar{\omega}^l_t, \bar{\omega}^f_t)$, where the entrepreneur defaults if the realization of individual efficiency is less than the cutoff. Finally, entrepreneurs decide how to divide their net worth between two sources of borrowing.

Entrepreneur Choice and Capital

Details and equations for entrepreneurs are in the Appendix. Entrepreneurs maximize expected profit,

$$\max_{\theta_t,\bar{\omega}_t^l,\bar{\omega}_t^f} R_t^k N_t \left(\left[1 - \Gamma^l(\bar{\omega}_t^l)\right] L_t^l(1-\theta_t) + \theta_t \mathbb{E}\left[1 - \Gamma^f(\bar{\omega}_t^f \frac{S_{t+1}}{S_t})\right] L_t^f \right) \tag{16}$$

$R_t^k \left[1 - \Gamma(\cdot)\right]$ denotes the expected return to the entrepreneur of borrowing and $\Gamma(\cdot)$ is the expected payment to the bank given the default cutoff[17]. Since the bank interest rate uniquely determines a default cutoff, entrepreneurs choose,

- $(R_{b,t}^l, L_t^l)$ Interest rate and leverage for local borrowing
- $(R_{b,t}^f, L_t^f)$ Interest rate and leverage for foreign borrowing
- θ_t amount of net worth used as collateral for foreign borrowing

where, $N_t(1-\theta_t)(L_t^l - 1)$ is the amount raised through local sources and $N_t\theta_t(L_t^f - 1)$ through foreign sources. Similar to deposit dollarization, I denote "credit dollarization" as the portion of credit funded by foreign sources. Credit dollarization in the model is equal to

$$\frac{N_t\theta_t(L_t^f - 1)}{N_t\theta_t(L_t^f - 1) + N_t(1-\theta_t)(L_t^l - 1)} \tag{17}$$

Then, the entrepreneur buy capital with the fund they raised,

$$Q_t K_{t+1} = N_t\theta_t L_t^f + N_t(1-\theta_t)L_t^l \tag{18}$$

Since entrepreneurs are risk neutral, in equilibrium they are indifferent between borrowing in either source. First order condition for the entrepreneur maximization problem with respect to θ_t implies[18],

$$\left[1 - \Gamma(\bar{\omega}_{lt})\right] L_{lt} = \mathbb{E}\left[1 - \Gamma\left(\bar{\omega}_{ft}\frac{S_{t+1}}{S_t}\right)\right] L_{ft} \tag{19}$$

[17]This function is explicitly defined in the Appendix

[18]Two other first order constraints are derived in the Appendix

Foreign Borrowing and Balance Sheet Effects

In the model, entrepreneurs are free to borrow from either local or foreign banks by choosing the amount of net worth to allocate to each type of borrowing. Foreign borrowing is subject to exchange rate risk since return to capital is in terms of local good. A depreciation will increase the default rates and the payments of the entrepreneurs who borrowed form the foreign bank. This will decrease net worth of the entrepreneurs and decrease the amount of investment and production. Households will be affected through a decrease in wages. Due to limited liability, entrepreneurs are only liable to the amount that they pledge to the bank. In case the entrepreneur defaults on his foreign loan, a foreign bank does not have the right to liquidate the investment financed by local funds.

4.6 Saving and Debt Denomination

In the model, two equations determine the choice of denomination and the interest rate spread, Euler equations, and the entrepreneur choice.

$$R_t \mathbb{E}\left[\frac{u'(C_t)/P_t}{u'(C_{t+1})/P_{t+1}}\right] = R_t^f \mathbb{E}\left[\frac{u'(C_t)/P_t}{u'(C_{t+1})/P_{t+1}}\frac{S_{t+1}}{S_t}\right] \tag{20}$$

The deviation in expected interest rates will come from the covariance between expected exchange rate depreciation and marginal utility. An increase in the covariance between marginal utility and the exchange rate will be reflected as the widening in the interest rate spread that the entrepreneurs will face when borrowing. In the equilibrium, entrepreneurs are indifferent between borrowing in two sources.

$$\left[1 - \Gamma(\bar{\omega}_{lt})\right] L_{lt} = \mathbb{E}\left[1 - \Gamma\left(\bar{\omega}_{ft}\frac{S_{t+1}}{S_t}\right)\right] L_{ft} \tag{21}$$

Where $[1 - \Gamma(\cdot)]$ is the share of gross earnings kept by the entrepreneur net of expected interest expenses and default costs. An increase in the interest rate spread will be reflected in the interest cost. Even though the entrepreneurs are risk neutral, financial frictions prevent them from erasing the interest rate difference. Higher risk means that the probability of default goes up and expected monitoring costs rise. Since the banks operate on zero profit condition, expected monitoring costs are reflected to the contract that the entrepreneurs face, which makes the function $(1-\Gamma(\cdot))L(\cdot)$ concave. Concavity

of the objective function makes risk neutral entrepreneurs act as if they are risk averse. In equilibrium, a higher interest spread leads firms to borrow more from foreign sources.

4.7 Equilibrium Conditions

Exchange rate (S_t) and local interest rate (R_t) is determined endogenously with three equilibrium conditions[19].

- Local bank needs to clear borrowing and lending within the small open economy, which means that local borrowing needs to be equal to household local savings

$$d_t = N_t(1-\theta_t)\left(L_t^l - 1\right) \tag{22}$$

- Current account identity implies that trade surplus needs to be equal to the change in net investment position (Current Account - Capital Account = 0),

$$\text{Current Account}: \frac{c_{xt}}{S_t} - c_{ft} \tag{23}$$

$$\text{Capital Account}: \underbrace{\left(\frac{f_t}{S_t} - \frac{f_{t-1}}{S_{t-1}}R_t^f\right)}_{\text{Household net foreign investment}} - \underbrace{\left[\theta_t \frac{N_t}{S_t}(L_t^f - 1) - \theta_{t-1}\frac{N_{t-1}}{S_{t-1}}(L_{t-1}^f - 1)R_{t-1}^f\right]}_{\text{Entrepeneur net foreign borrowing}} - \underbrace{\Pi_t^b}_{\text{Foreign Bank Profit}} \tag{24}$$

Default rates change with exchange rate movements, which affect the payments received by foreign banks.

- Market clearing for home good

$$c_{h,t} + c_{e,t} + c_{x,t} + I_t + M_t + \Pi_t^b S_t = z_t K_t^\alpha L_t^{1-\alpha} \tag{25}$$

$c_{h,t}\, c_{e,t}$, $c_{x,t}$ are home good consumption demand by the household, entrepreneurs and foreigners, respectively. M_t is the default costs given by

$$M_t = R_{t-1}^k N_{t-1}\left(\mu G(\bar{\omega}_{l,t-1})L_{t-1}^l(1-\theta_{t-1}) + \mu G(\bar{\omega}_{f,t-1}\frac{S_t}{S_{t-1}})L_{t-1}^f\theta_{t-1}\right) \tag{26}$$

[19]Due to Walras' Law, financial market clearing and current account identity implies market clearing for home good.

4.8 Shocks in the model

The economy is subject to the following shocks:

- Technology shock, z_t, mainly works through increasing marginal product of capital. An increase in productivity increases wages and profits. Due to the income effect, households increase consumption, which drives up the relative price of foreign good. Hence, a positive technology shock is associated with increased consumption and exchange rate depreciation.

- Export demand shock, x_t, affects the economy through current account equation. An increased foreign demand increases the amount of foreign good in the economy and decreases the price of foreign good. Since households are net buyers of foreign good, this increases consumption. Hassan (2013) and Martin (2013) discuss how this shock could generate interest rate spread between emerging markets and developed economies.

- Foreign interest rate shock, R_t^f, can also be considered as external premium shock similar to Gertler et al. (2007). Neumeyer & Perri (2005) claim that foreign interest rate shock is an important driver of emerging economy business cycles. I argue that households can protect themselves from foreign interest rate shock by holding foreign assets.

- Foreign interest rate shock is subject to stochastic volatility (σ_{Rt}), as in Fernandez-Villaverde et al. (2011). An increase in the standard deviation of foreign interest rate increases macroeconomic uncertainty. I show that households shift their portfolios to foreign currency in response to increased uncertainty.

5 Model Parameterization

5.1 Small Open Economy

I use quarterly discount factor $\beta = 0.9923$, which corresponds to a 3% steady state annual interest rate. Elasticity of intertemporal substitution is 0.2, which implies $\gamma = 5$. Home bias in consumption is set $\omega = 0.7$, which is the roughly average import/consumption ratio in emerging economies. Elasticity of intratemporal substitution is set to $\sigma = 1.5$ (Faia (2007), Backus et al. (1993)). In a similar model, Christiano et al.

(2011) estimates inverse elasticity of labor $(1+\phi) = 7.7$. This number is pretty high compared to estimates from the US economy; a low elasticity is thought to give a more realistic reaction of hours to interest rate shocks in developing economies (Fernandez-Villaverde et al. (2011)). ξ is set such that the labor in the non-stochastic steady state is equal to unity. Elasticity of export demand is equal to unity $\varphi = 1$ and the mean export demand is set such that the non-stochastic steady state exchange rate is equal to 1 ($S = 1$), which implies that the price index equal to 1 as well ($P = 1$).

5.2 Finance and Investment

Steady state capital return spread is set $\frac{R^k}{R} = 1.0045$, which targets the steady state level of leverage of 2.04 — the average leverage of nonfinancial firms calculated by Dalgic et al. (2017). Share of capital in production is $\alpha = 0.36$. Depreciation rate is $\delta = 0.025$, and investment is subject to quadratic capital adjustment costs $\Phi(\cdot)$. I borrow standard parameters used in the literature using the CSV framework[20]. Entrepreneur efficiency follows lognormal distribution with standard deviation $\sigma_e = 0.26$, and the losses in case of bankruptcy is $\mu_e = 0.12$ (Gertler et al. (2007); Faia (2007)). Entrepreneurs retire with rate $(1-\gamma_e) = 0.0333$; entrepreneur labor share is set to $(1-\Omega) = 0.09$.

5.3 Shocks

All shocks follow AR(1) process. I use $\sigma_R = 0.0025$ as the standard deviation of interest rate shock. This number is very similar to the estimated values in the literature (Neumeyer & Perri (2005); Fernandez-Villaverde et al. (2011)). I set $\rho_R = 0.96$, which is roughly the number estimated by above papers and my own estimates. I use the VIX index as a proxy for uncertainty shock. I estimate an AR(1) process on the log of VIX index; I estimate, $\rho_\sigma = 0.72$ and $\sigma_\sigma = 0.25$. The standard deviation I estimated is very close to the ones in Fernandez-Villaverde et al. (2011).

For productivity and export shocks, I use an autocorrelation coefficient of 0.92. I use $\sigma_z = 0.08$ and $\sigma_x = 0.04$ to target output volatility of 3% and real exchange rate volatility of 3.8%, which are approximately the quarterly volatility of industrial output and real exchange rate observed in emerging markets.

[20] See Bernanke et al. (1999); Gertler et al. (2007); Faia (2007)

5.4 Solution

I use third order perturbation to solve the model. Fernandez-Villaverde et al. (2011) show that this method works to analyze the effects of uncertainty shocks. In order to ensure stationarity, I use quadratic portfolio adjustment costs, which is standard in the literature[21]. This requires me to set deposit and credit dollarization in the non-stochastic steady state; I set 25% deposit dollarization and 25% credit dollarization. As I show under results, these numbers change endogenously in the stochastic steady state.

6 Results

6.1 Deposit dollarization, credit dollarization and interest rate spread move together in time series

The model is able to match the empirical regularities about dollarization in emerging economies. In the model, deposit and credit dollarizations comove like in the data, and the interest rate spread moves with them. Figures 13 and 14 show an example simulation where deposit and credit dollarizations move together. Higher expected interest rate spread is associated with a higher dollarization. Note that the simulations look remarkably similar to the data in Figure 10 and Figure 9.

	Turkey(2006-2016)	Chile(2006-2016)	Model
Corr(FC Deposit, FC Credit)	0.43	0.71	0.58
Corr(FC Deposit, Spread)	0.37	0.47	0.71

Table 1: Correlations between deposit and credit dollarization and interest rates

[21] I use adjustment cost parameter $\epsilon = 1e-3$. See Schmitt-Grohe & Uribe (2003) for a review of other means to ensure stationarity.

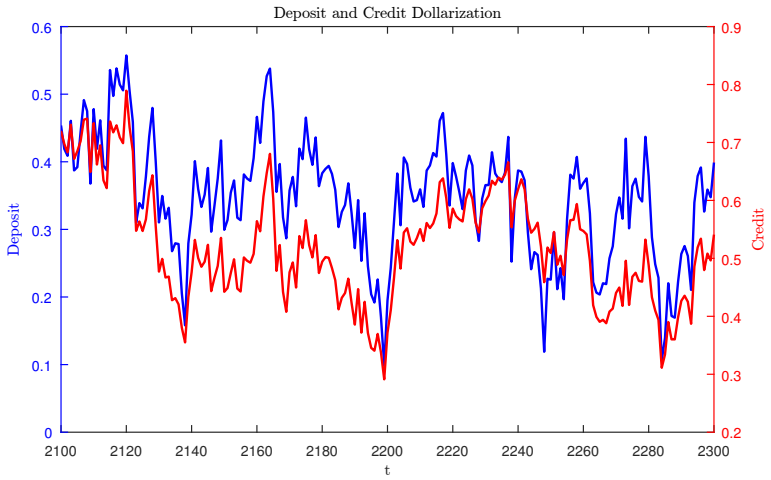


Figure 13: Simulated credit and deposit dollarization

6.2 Deposit dollarization moves negatively with the correlation between consumption and exchange rate

The model is able to match the empirical observation that household dollarization exists in economies in which exchange rate depreciations are associated with a recession. Here, I want to move the covariance between consumption and exchange rate to see whether the model responds as predicted. In order to change the covariance between consumption and exchange rate, I change the volatility of the foreign interest rate $\sigma_R \in [0, 0.005]$[22]. I interpret foreign interest rate not as US interest rates but as dollar interest rates in emerging markets. Similar to the literature, this offers the interpretation that foreign interest rates in the model capture not only the movements in US interest rates but also the risk premia emerging markets face. Increased uncertainty about the interest rates creates consumption risk, which the household uses foreign currency savings to hedge. Figure 15 shows the relation between consumption and exchange rate covariance and dollarization. The model is able to capture the main trend in the data.

[22]The results do not rely on the particular shock that I use, any shock which moves the covariance will yield the same results.

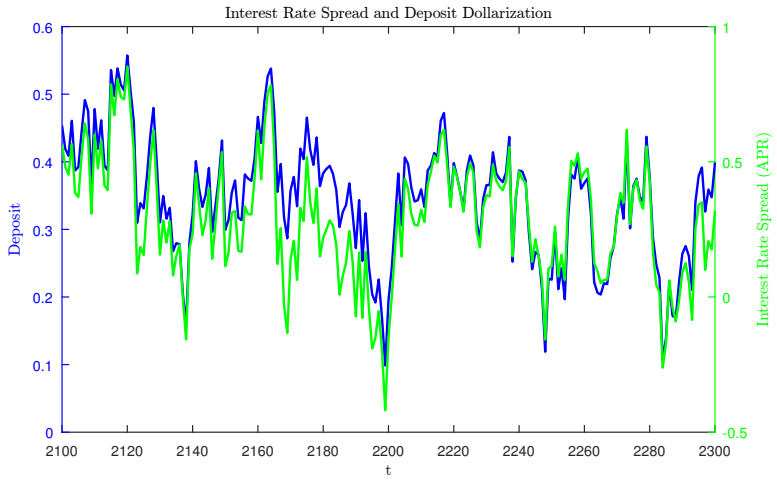


Figure 14: Simulated deposit dollarization and expected interest rate spread

6.3 Credit and deposit dollarization are linked

In the model, steady state deposit and credit dollarizations are linked. Figure 16 shows the relationship in the stochastic steady state. Increased uncertainty pushes households to invest in foreign assets; through higher interest rate spreads, entrepreneurs are pushed to borrow from foreign banks.

6.4 Interest Spread is related to consumption-exchange rate correlation

The model generates endogenous interest spread that is related to the covariance between consumption and exchange rate movements. Figure 17 shows the steady state interest rate spread as a function of consumption-exchange rate correlation. Unfortunately, the model cannot deliver the high spreads that we observe in the data even though it captures the essence (compare to Figure 7)

6.5 Macroeconomic uncertainty increases dollarization through household hedging motive

In the model, the source of deposit dollarization is hedging against uncertainty coming from outside shocks. In the following exercise, I shock the economy with increased uncertainty. The shock is similar to the one employed by Fernandez-Villaverde et al.

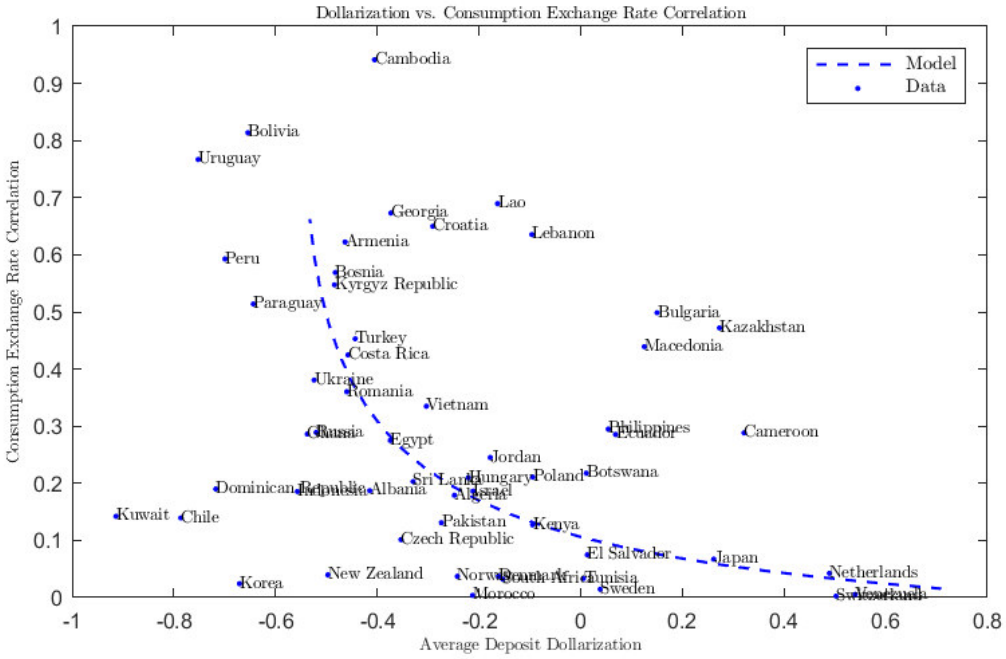


Figure 15: Deposit dollarization and correlation between consumption and exchange rate

(2011), and it is an increase in the standard deviation of the international interest rate process. With no deposit dollarization, the shock does not affect the portfolio composition of the economy . On the other hand, in the benchmark economy, households shift its portfolio from local assets to foreign assets, which provide hedging in the presence of increased uncertainty. Credit dollarization increases only when households can invest in foreign assets.

7 Mechanism

International interest rate risk has been noted to be an important driver of emerging market business cycles (Neumeyer & Perri (2005); Gertler et al. (2007)). Foreign currency deposits can hedge households against this risk by providing higher income when international interest rates are high. On the other hand, by holding foreign currency accounts, households decrease local currency supply in the banking system. This raises the local interest rates and pushes firms to borrow in foreign currency. Thus, indirectly, firms are providing insurance for households against currency risk. In turn, high foreign

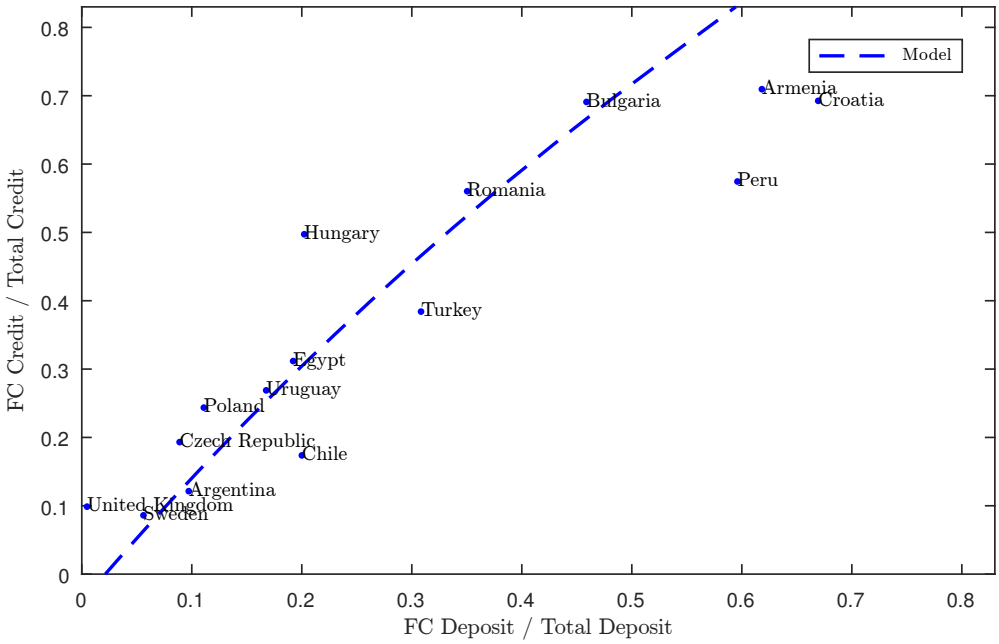


Figure 16: Deposit and credit dollarization in the steady state

currency credit creates balance sheet risks, which makes households save even more in foreign currency.

An increase in foreign interest rates causes a Dornbusch-like depreciation in the local exchange rate. In a classical model where UIP holds, depreciation comes from the parity condition. In this model, equation 20 and 21 have a similar purpose. Even in the absence of deposit dollarization, foreign currency credit channel causes a depreciation via equation 21[23]. Entrepreneurs are indifferent between borrowing from either sources. An increase in foreign interest rates does not have a first order effect on local currency borrowing, but it increases the cost of funds from abroad. In order for the equation to hold, the exchange rate depreciates. Equation 27 shows the two effects of exchange rate depreciation on the household. Cost of imported goods increases, which increases the price level (trade). An increase in relative price of foreign good is bad for the household because households are net buyers of foreign good and net seller of home good. The other channel is through balance sheet effects. In the aftermath of a depreciation, entrepreneurs face higher interest rate costs if they borrowed in foreign currency. Lower

[23]The case where both foreign currency credit and deposit are not allowed is not discussed because in this case, foreign interest rate becomes irrelevant and the economy has to balance trade every period.

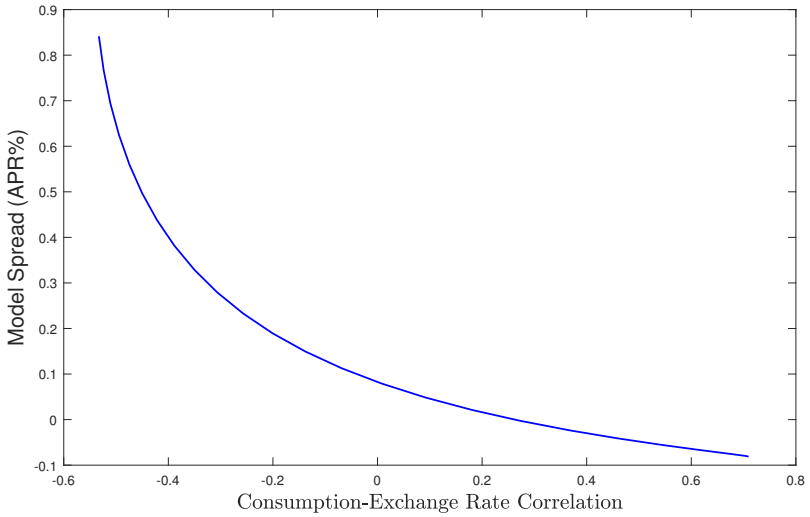


Figure 17: Spread and thecorrelation between consumption and exchange rate

net worth leads to lower investment and lower production and wages.

$$\overbrace{P_t}^{\text{Trade}\uparrow} C_t + d_t + f_t = \overbrace{w_t l_{h,t}}^{\text{Balance Sheet}\downarrow} + d_{t-1}R_{t-1} + f_{t-1}\overbrace{\frac{S_t}{S_{t-1}}R^f_{t-1}}^{\text{Insurance}\uparrow} \tag{27}$$

Foreign currency deposits provide a perfect hedge against foreign interest rate risk because its returns are high when the exchange rate depreciates. At the same time, households benefits from increased foreign interest rates. As Figure 21 shows, households do not decrease consumption as much and is able to increase savings after an increase in foreign interest rates.

In order to see how an increase in uncertainty affects interest rate spread, let's rewrite Euler equations

$$\begin{aligned}
R_t\mathbb{E}\left[\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t}\right] &= R^f_t\mathbb{E}\left[\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t}\frac{S_{t+1}}{S_t}\right] \\
&= \mathbb{E}\left[\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t}\right]\mathbb{E}\left[R^f_t\frac{S_{t+1}}{S_t}\right] + \text{cov}\left(\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t},\, R^f_f\frac{S_{t+1}}{S_t}\right) \\
\mathbb{E}\left[R_t - R^f_t\frac{S_{t+1}}{S_t}\right] &= \text{cov}\left(\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t},\, R^f_f\frac{S_{t+1}}{S_t}\right)/\mathbb{E}\left[\frac{u'(C_{t+1})/P_{t+1}}{u'(C_t)/P_t}\right]
\end{aligned} \tag{28}$$

Expected interest spread is related to the covariance between marginal utility and

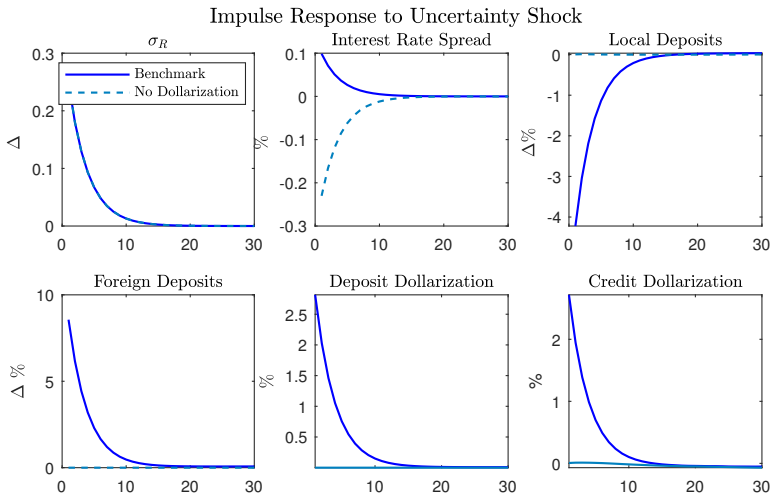


Figure 18: Impulse response to uncertainty shock

exchange rate. An increase in the uncertainty increases the covariance and leads to expected interest rate difference. Later, I am going to verify whether increased dollarization is actually related to interest rate spread.

8 Policy Experiments

8.1 Preventing Foreign Currency Deposits

Household dollarization acts as a hedge against exchange rate risks but dollar savings by households create mismatch in the non-financial system. Here, I evaluate the effects of a tax on dollar savings. Table 2 summarizes the nature of dollarization in both economies. As a comparison, I also include an economy where risk neutral international investors can invest in local assets directly. In this 'International Investors' economy, uncovered interest rate parity holds ($R_t = R_t^f \mathbb{E}\left(\frac{S_{t+1}}{S_t}\right)$).

When international investors lend to local banks in pesos, the link between credit and deposit dollarization is broken. In Appendix, I characterize the portfolio choices of both Households and Entrepreneurs when international investors invest freely in the economy. Households will save everything in dollars to achieve a better hedge (measured as the change in the correlation between consumption and exchange rate). Credit dollarization disappears since entrepreneurs can have access to cheap peso funding from abroad.

	Benchmark	Tax on Dollar Deposits	International Investors
Deposit Dollarization	33%	5.2%	100%
Credit Dollarization	40%	14.5%	0%
ΔWelfare (In C-units)	-	-0.5%	0.84%
$\%\Delta\lvert\text{cov}(\Delta C, \Delta S)\rvert$	-	39.35%	-96.3%

Table 2: Dollarization parameters in two economies

As a comparison, tax on dollar deposits in the benchmark economy significantly reduce both credit and deposit dollarization. Households convert dollar savings into pesos which is channeled to the entrepreneurs. Households are worse off after the tax because they lose access to the asset that provides income insurance. To compensate, households save more in pesos due to precautionary saving motive. However, the precautionary motive is dampened by the fact that the peso bond is now riskier. Euler equation in Eq 29 shows that as households lose access to dollars, covariance between consumption and price level (due to exchange rate) becomes more negative, which means that households demand higher yield to carry the exchange rate risk.

$$\beta^{-1}R_t^{-1} = \overbrace{\underbrace{\mathbb{E}\left(\frac{u'(C_{t+1})}{u'(C_t)}\right)}_{\text{Precautionary Motive}}}^{\uparrow\uparrow} \mathbb{E}\left(\frac{P_t}{P_{t+1}}\right) + \overbrace{\underbrace{cov\left[\frac{u'(C_{t+1})}{u'(C_t)}, \frac{P_t}{P_{t+1}}\right]}_{\text{Price level risk}}}^{\downarrow\downarrow} \tag{29}$$

An additional force which raises interest rates is that firms increase their demand for peso loans as household lose access to dollar accounts. Households get insurance from dollarization by selling dollars as a response to external shocks, which stabilizes the exchange rate and helps entrepreneurs borrow in dollars cheaper. Figure 19 shows that higher household dollars as a share of firm dollar credit is associated with lower exchange rate volatility.

In equilibrium, local interest rates increase to induce households to save more pesos. Higher interest rates lead to a decline in investment, capital and production and wages. Lower wages lead to lower income for both entrepreneurs and households. Table 4 summarizes the changes in the new steady state whereas Figure 20 shows the response of the economy in the short run.

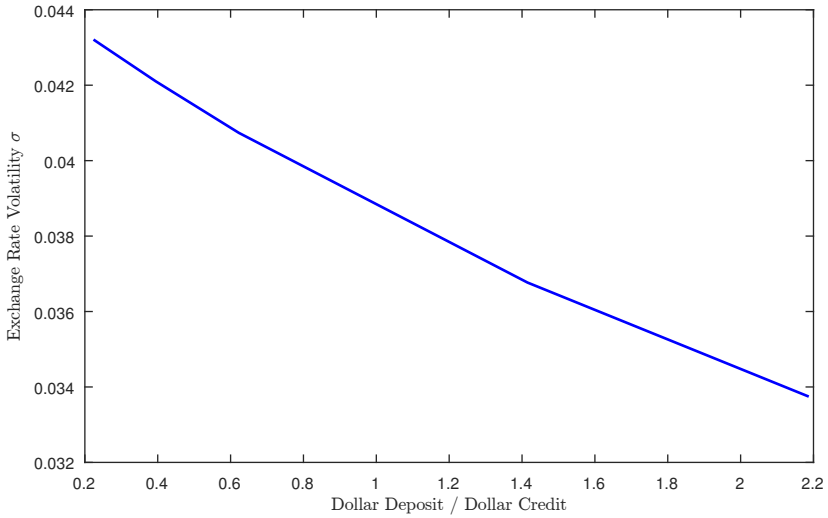


Figure 19: Exchange rate volatility and household dollarization

	Δ
HH Welfare (In C-units)	-0.8%
Entrepreneur Net Worth	-1.98%
Interest Rate (APR)	0.26%
Capital	-0.57%

Table 3: Welfare gains of preventing foreign currency deposits

8.2 Balance Sheet Effects

Deposit dollarization, dollar savings by households, has two opposing effects on household budget. Direct effect is that after a depreciation, dollar savings gain in value and raise household income. However, by saving in dollars, households indirectly generate credit dollarization, which creates balance sheet effects following a depreciation. I show that in the steady state preventing dollarization decrease welfare, which implies that the insurance effect dominates the balance sheet effects. Here, I take two economies in the previous section and show the effect of an increase in foreign interest rates. Neumeyer & Perri (2005) argue that movements in international interest rates are an important source of volatility in emerging economies. An increase in foreign interest rates leads to a decline in consumption and exchange rate depreciation in both economies. The net worth of entrepreneurs in the economy with high dollarization collapses, but the consumption does not decrease much because exchange rate depreciation leads to gains

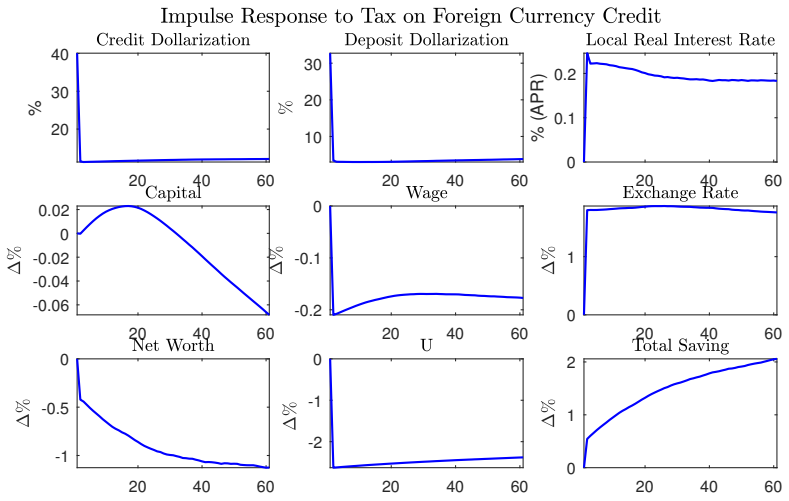


Figure 20: Impulse response to tax on FC deposit

to household wealth due to foreign currency savings. The decline in net worth becomes less crucial because as seen in Figure 21, households can afford to save more to recapitalize the entrepreneurs, which results in higher leverage offered by the banks in the benchmark economy.

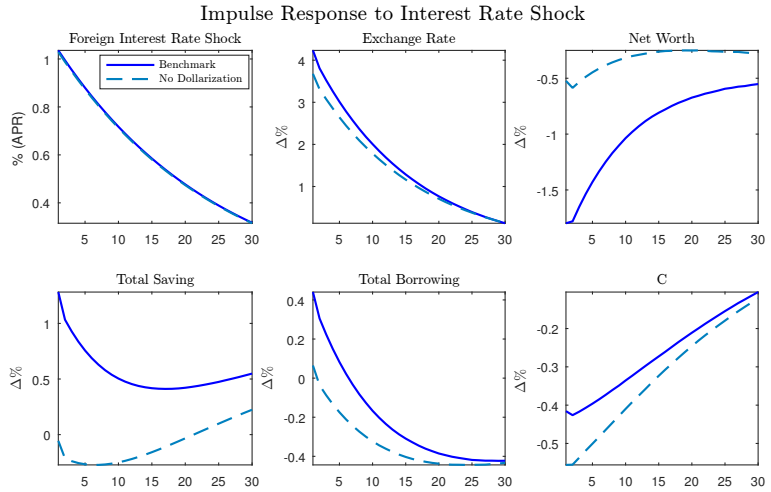


Figure 21: Impulse response to foreign interest rate shock

Next, I am going to do a simple calculation to quantify insurance and balance sheet

effects. Assume that the household saves a unit more in dollars and less in pesos. For simplicity, I am assuming that this extra saving has no effect on prices. Household wealth,

$$\overbrace{w_t l_{h,t}}^{\text{Labor}} + d_{t-1} \overbrace{R_{t-1}}^{\text{Local Rate}} + f_{t-1} \overbrace{\frac{S_t}{S_{t-1}}}^{\text{ER}} \overbrace{R^f_{t-1}}^{\text{Foreign Rate}}$$

Following a 5% exchange rate depreciation, the increase in household wealth resulting from the extra unit of dollar saving is the extra revenue coming from the depreciation minus the cost of saving in dollars, the interest rate spread.

$$\Delta W = \overbrace{\frac{S_t}{S_{t-1}}}^{\text{ER}} \overbrace{R^f_{t-1}}^{\text{Foreign Rate}} - \overbrace{R_{t-1}}^{\text{Local Rate}}$$

$$\underbrace{\Delta W}_{0.04637} = \underbrace{0.05 \underbrace{R^f}_{1.0074}}_{\text{benefit of insurance}} - \underbrace{\underbrace{\text{spread}}_{0.004}}_{\text{cost of insurance}}$$

Assume that following a unit increase in dollar savings by household is followed by a unit increase in one unit of dollar by entrepreneurs. Following a 5% depreciation, interest rate paid on dollars increase. This has to be balanced against domestic interest rate and cost of extra collateral. Since dollar borrowing is risky, banks require higher collateral to lend dollars. An extra dollar borrowing leads to around 2.4% decline in net worth following a 5% depreciation. This is in line with the estimates in Dalgic et al. (2017), where they estimate around 6% decline in corporate equity following a 12% depreciation in 2011.

$$\underbrace{\Delta N}_{-0.0239} = \gamma \left(\underbrace{\overbrace{\Gamma^l(\bar{\omega}^l)}^{\text{Domestic rate}}}_{0.5252} - \underbrace{\overbrace{\Gamma^f(\bar{\omega}^f 1.05)}^{\text{Dollar rate}}}_{0.5117} - \underbrace{\text{Cost of Collateral}}_{0.0382} \right)$$

The decline is multiplied γ because $(1-\gamma)$ of the entrepreneurs retire. The decline in net worth leads to a decline in Capital and production.

$$\underbrace{\Delta K}_{-0.0490} = \underbrace{\Delta N}_{-0.0239} \underbrace{\left(\theta L^f + (1-\theta)L^l\right)}_{2.0539}$$
$$\underbrace{\Delta Y}_{-0.0177} = \alpha \Delta K$$

The decrease in total production is much less than the extra income the household gets. Note that the magnitude of the decline in capital and production depend crucially on the leverage. Non financial system is typically not highly leveraged. Several papers document that the balance sheet effects in the non financial firms following a depreciation are not high in line with the prediction of the model.[24]

8.3 Preventing Foreign Currency Credit

A standard response to high credit dollarization is a tax on foreign currency borrowing. In Figure 22, I show that a tax on foreign currency borrowing is similar to a sudden stop. When firms are forced to borrow in local currency, they raise local interest rates. Lower foreign currency credit and high local interest rates push household to switch to local currency. However, the decrease in deposit dollarization is not big because households still want to keep foreign currency for insurance purpose. The end result is higher interest rates and lower investment. This result is supported by the evidence in Maggiori et al. (2017) where they find that firms who are unable to borrow in foreign currency face higher cost of capital. Eventually, the drop in consumption recovers but in the new steady state, the level of net worth, capital, and investment is lower. Household saving is high in the new equilibrium, which supports the level of consumption even though the production is low.

[24]In the case where leverage is too high, the model does not have a unique equilibrium. If balance sheet effects dominate the insurance effect, an extra unit of dollar saving actually makes the covariance between consumption and exchange rate more negative, which creates more demand for dollar saving. Then the economy potentially has multiple equilibria, good equilibrium with low dollarization and bad dollarized equilibria. for a treatment.

	Δ
Consumption	0.7%
Real Interest Rates	1.4%
Net Worth	−4.5%
Capital	−5%

Table 4: Welfare gains of preventing foreign currency credit

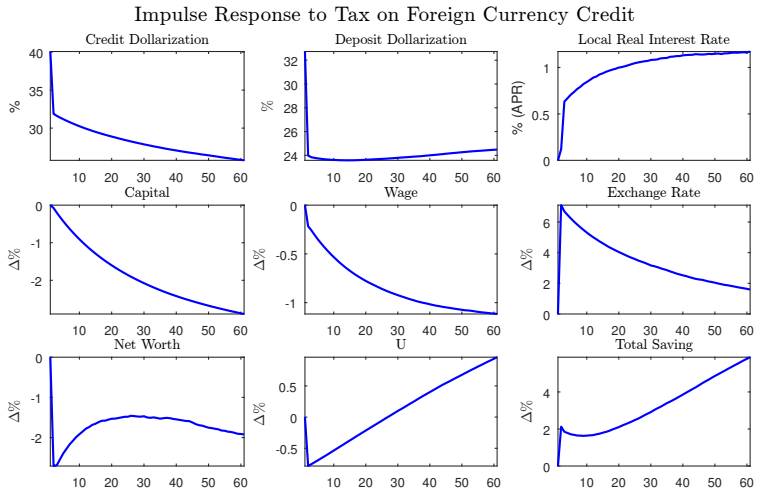


Figure 22: Impulse response to tax on FC credit

9 Conclusion

A Significant amount of financial intermediation in emerging economies takes place in foreign currency, and this has been thought of as a source of fragility in the financial system. In this paper, I show that part of foreign currency use can be explained by the hedging properties of foreign currency accounts. Household deposit dollarization increases interest rate spread in the economy and pushes firms to borrow in foreign currency. I think of this as a hedging arrangement between the household and non-financial sector, where non-financial firms provide households with hedging in exchange for lower foreign interest rates. Macroeconomic uncertainty increases dollarization through household hedging motive. Dollarization increases currency mismatch in the non-financial sector and creates balance sheet effects after exchange rate movements. Increased currency mismatch coincides with periods of higher exchange rate uncertainty. Nevertheless, foreign currency accounts provide households with hedg-

ing against foreign interest rate risk, which is an important source of uncertainty in emerging economies. Combined with the observation that emerging economies have difficulty attracting local currency foreign investment, policies to reduce dollarization have counterproductive results. In particular, preventing household FC deposits makes the economy more vulnerable to foreign interest rate shocks, and preventing FC credit reduces investment. Policymakers should be aware of the costs of macroprudential reforms to limit dollarization.

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A Appendix

A.1 Deposit and Loan Dollarization

I replicate Figure 3 using Loan Dollarization data from IMF Financial Soundness Indicators data where each country reports the ratio of foreign currency loans in the banking system. This includes loans extended to households as well as to non-financial firms (it also includes loans extended across borders but this should be negligible in emerging economies).

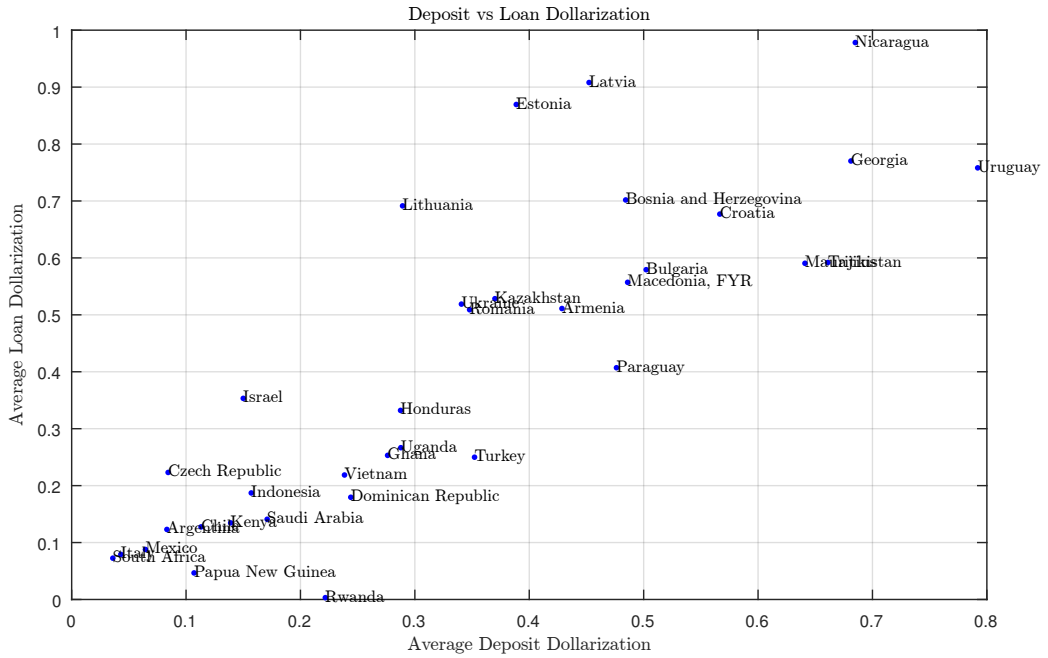


Figure 23: Average Deposit and Loan Dollarization (2004-2008)

A.2 Dollarization vs Inflation and RER Volatility

A.3 Financial Frictions

Here I describe the financial frictions and entrepreneur problem in detail. I provide details for foreign borrowing. For the local borrowing, the equations are identical when the exchange rate is assumed to be constant. In the spirit of CSV, there is a continuum of entrepreneurs. Each entrepreneur can operate capital. K with efficiency ω. ω is distributed according to cdf $F(\omega)$.

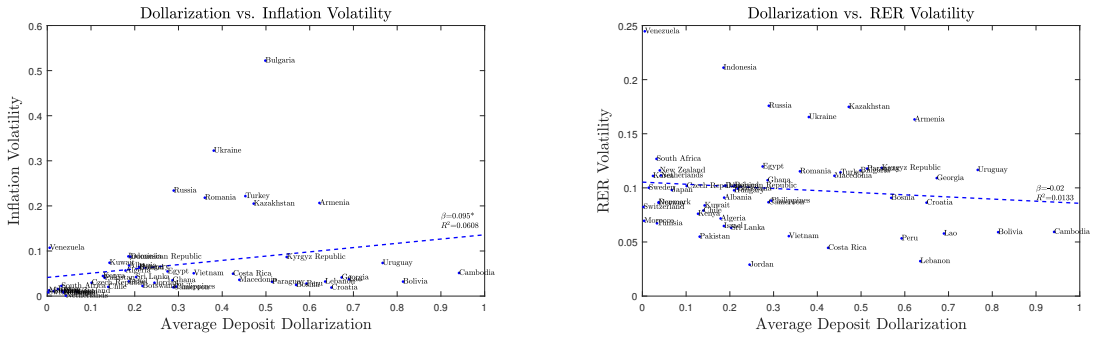


Figure 24: Dollarization vs Inflation and RER Volatility

A.3.1 Entrepreneur Problem

Consider, gross return to capital R_t^k and the risk free foreign interest rate R_t^f. Entrepreneur with net worth N_t borrows B_t at interest rate R_t^b to form assets A_t. He defaults is $\omega < \bar{\omega}$, where $\bar{\omega}$ is characterized by,

$$R^k A_t \hat{\omega} = R_t^b B_t \frac{S_{t+1}}{S_t}$$
$$\hat{\omega} = \frac{R_t^b B_t D_{t+1}}{R^k A_t} = \bar{\omega} D_{t+1}$$

Where $\frac{S_{t+1}}{S_t} = D_{t+1}$ is the depreciation. Similarly,

$$\bar{\omega} = \frac{R_t^b}{R^k} \frac{L_t - 1}{L_t}$$

$$\mathbb{E}\left[\frac{\int_{\bar{\omega}D}^{\infty} R^k A_t \omega - R_t^b B_t D_{t+1} dF(\omega)}{N_t R_t^f \mathbb{E}\left(D_{t+1}\right)}\right]$$

$$\mathbb{E}\left[\frac{\int_{\bar{\omega}D}^{\infty} R^k A_t \omega - R^k A_t \bar{\omega} D_{t+1} dF(\omega)}{N_t R_t^f \mathbb{E}\left(D_{t+1}\right)}\right]$$

$$\mathbb{E}\left[\frac{\int_{\bar{\omega}D}^{\infty} (\omega - \bar{\omega} D_{t+1}) R^k A_t dF(\omega)}{N_t R_t^f \mathbb{E}\left(D_{t+1}\right)}\right]$$

$$\mathbb{E}\left[\int_{\bar{\omega}D}^{\infty} (\omega - \bar{\omega} D_{t+1}) dF(\omega)\right] \frac{R^k}{R_t^f \mathbb{E}\left(D_{t+1}\right)} L_t$$

$$\mathbb{E}\left([1-\Gamma(\bar{\omega}D_{t+1})]\right)\frac{R^k}{R_t^f\mathbb{E}\left(D_{t+1}\right)}L_t$$

$$\max_{\bar{\omega}_F}\mathbb{E}\left(1-\Gamma(\bar{\omega}^f D_{t+1})\right)R^k L^f$$

A.3.2 Foreign Bank

Foreign bank intermediates foreign loans. The bank collects deposits from the household and the rest of the world and it lends to entrepreneurs. It is owned by foreign investors who have deep pockets.

$$\mathbb{E}\left[\frac{1}{S_{t+1}}\left((1-F(\bar{\omega}D_{t+1}))R_t^b B_t D_{t+1}+(1-\mu)\int_0^{\bar{\omega}D}\omega dF(\omega)R^k A_t\right)\right]$$
$$=\mathbb{E}\left[\frac{1}{S_{t+1}}R_t^f B_t D_{t+1}\right]$$

$$\mathbb{E}\left[\frac{1}{S_{t+1}}\left((1-F(\bar{\omega}D_{t+1}))R^k A_t\bar{\omega}D_{t+1}+(1-\mu)\int_0^{\bar{\omega}D}\omega dF(\omega)R^k A_t\right)\right]=\mathbb{E}\left[\frac{1}{S_{t+1}}R_t^f B_t D_{t+1}\right]$$

$$\mathbb{E}\left[\frac{1}{S_{t+1}}\left((1-F(\bar{\omega}D_{t+1}))\bar{\omega}D_{t+1}+(1-\mu)\int_0^{\bar{\omega}D}\omega dF(\omega)\right)\right]=\mathbb{E}\left[\frac{R_t^f B_t}{R^k S_t A_t}\right]$$

$$\frac{\mathbb{E}\left[\frac{S_t}{S_{t+1}}\left((1-F(\bar{\omega}D_{t+1}))\bar{\omega}D_{t+1}+(1-\mu)\int_0^{\bar{\omega}D}\omega dF(\omega)\right)\right]}{\frac{R_t^f}{R^k}}=\frac{L_t^f-1}{L_t^f}$$

$$L_t^f=\frac{1}{1-\frac{R^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)}$$

A.3.3 Entrepreneur Choice

$$\mathbb{E}\left([1-\Gamma(\bar{\omega}D_{t+1})]\right)\frac{R^k}{R_t^f\mathbb{E}\left(D_{t+1}\right)}\frac{1}{1-\frac{R^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)}$$

$$\max \mathbb{E}\left([1-\Gamma(\bar{\omega}D_{t+1})]\right)\frac{1}{1-\frac{R_t^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)}$$

$$\mathbb{E}\left(\left(1-F(\bar{\omega}D_{t+1})\right)D_{t+1}\right)\frac{1}{1-\frac{R_t^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)}=$$
$$\mathbb{E}\left([1-\Gamma(\bar{\omega}D_{t+1})]\right)\frac{\frac{R_t^k}{R_t^f}\mathbb{E}\left[\left(1-F(\bar{\omega}D_{t+1})\right)-\mu\bar{\omega}F'(\bar{\omega}D_{t+1})\right]}{\left[1-\frac{R_t^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)\right]^2}$$

$$\frac{\mathbb{E}\left(\left(1-F(\bar{\omega}D_{t+1})\right)D_{t+1}\right)}{\mathbb{E}\left([1-\Gamma(\bar{\omega}D_{t+1})]\right)}=\frac{\frac{R_t^k}{R_t^f}\mathbb{E}\left[\left(1-F(\bar{\omega}D_{t+1})\right)-\mu\bar{\omega}F'(\bar{\omega}D_{t+1})\right]}{\left[1-\frac{R_t^k}{R_t^f}\mathbb{E}\left(\frac{1}{D_{t+1}}\left(\Gamma(\bar{\omega}D_{t+1})-\mu G(\bar{\omega}D_{t+1})\right)\right)\right]}$$

A.3.4 Equilibrium borrowing

Each entrepreneur decides how to allocate his net worth as collateral to each type of borrowing. In the end, he maximizes expected return,

$$\max_{\theta} R_t^k N_t\left(\left[1-\Gamma^d(\bar{\omega}^d)\right]L_t^d(1-\theta)+\theta\mathbb{E}\left[1-\Gamma^f(\bar{\omega}^f D_{t+1})\right]L_t^f\right)$$

Now, it is apparent that the entrepreneur will choose a corner solution unless in equilibrium both options yield the same revenue. Then the local interest rate will adjust to make sure that happens. In the equilibrium calibaration, dollar borrowing will have lower interest rate with lower leverage (higher collateral).

A.3.5 Risk Aversion

Entrepreneurs are by nature risk neutral. However, due to the nature of the contract that they face, they care about risk. In particular, the objective function that they maximize, $[1-\Gamma(\bar{\omega})]\,L$, is concave. For an individual entrepreneur, higher risk means that she is more likely to default, which means more monitoring costs paid ny banks in expectation. Since banks operate on zero profit condition, expected monitoring costs are charged back to the entrepreneur. Then, in order to take on exchange rate risk by borrowing in dollars, entrepreneurs require an interest rate spread. Figure 25 shows

the required interest rate spread for dollar borrowing as a function of the volatility of exchange rate.

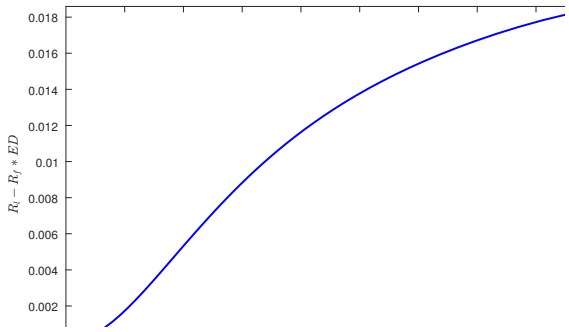


Figure 25: Interest rate spread entrepreneurs require to borrow in dollars as a function of the volatility of exchange rate

A.4 International Investors

I relax the 'Original Sin' assumption and allow risk-neutral international investors with deep pockets to invest in local assets directly. The interest spread basically disappears $\left(R_t = R_t^f \mathbb{E}\frac{S_{t+1}}{S_1}\right)$ since any expected spread will attract more investment until the spread disappears. In 28, I show that interest spread is a function of the covariance between consumption and exchange rate. If the spread is zero, household will invest only in dollars unless the covariance is zero. Since entrepreneurs reqiore interest rate spread to borrow in dollars, they will only borrow in pesos in the absence of a spread.

A.5 Impulse Response to Shocks

A.5.1 Positive Technology Shock

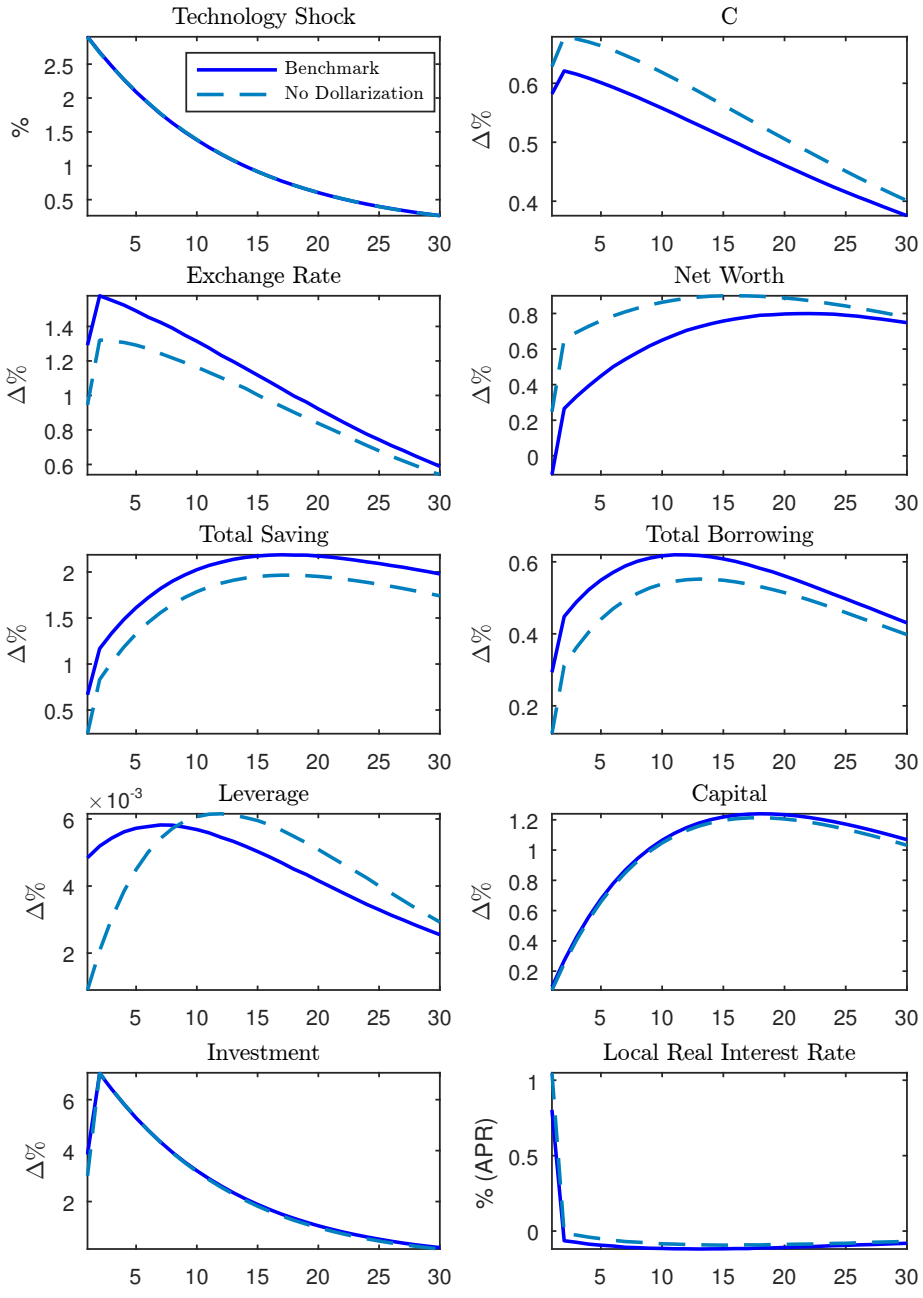


Figure 26: Impulse response to technology shock

A.5.2 Positive Export Shock

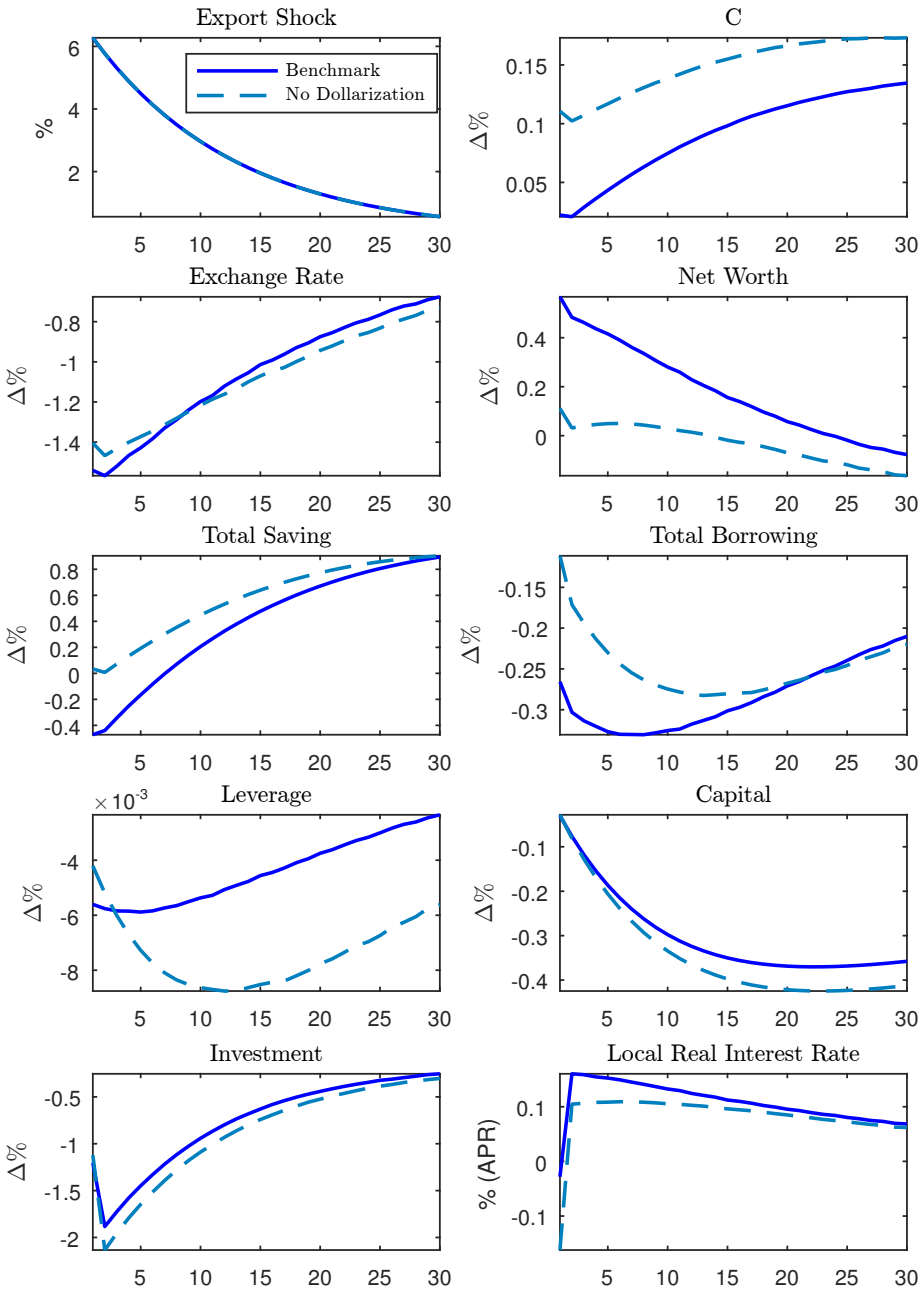


Figure 27: Impulse response to export shock

A.5.3 Uncertainty Shock

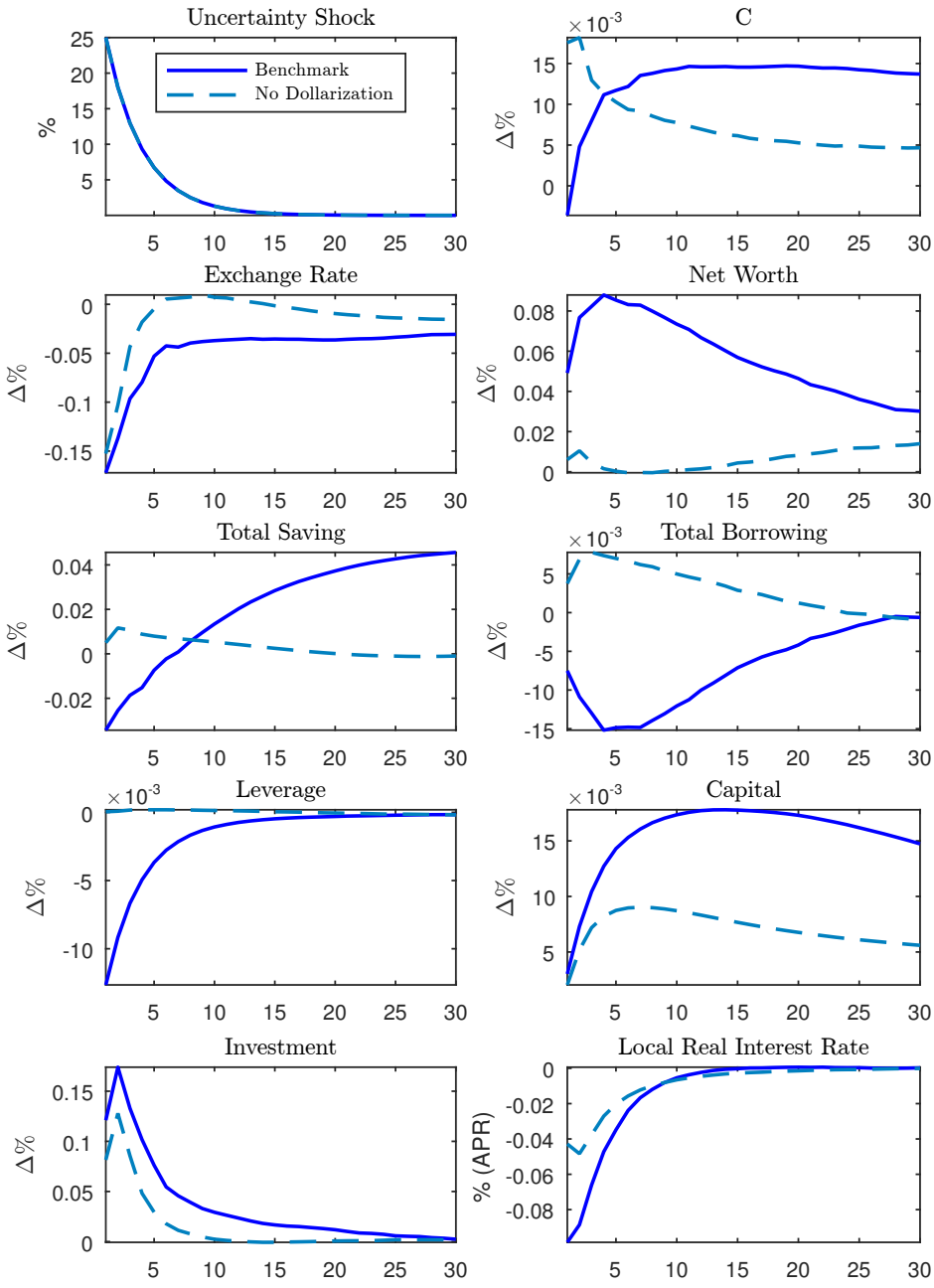


Figure 28: Impulse response to export shock

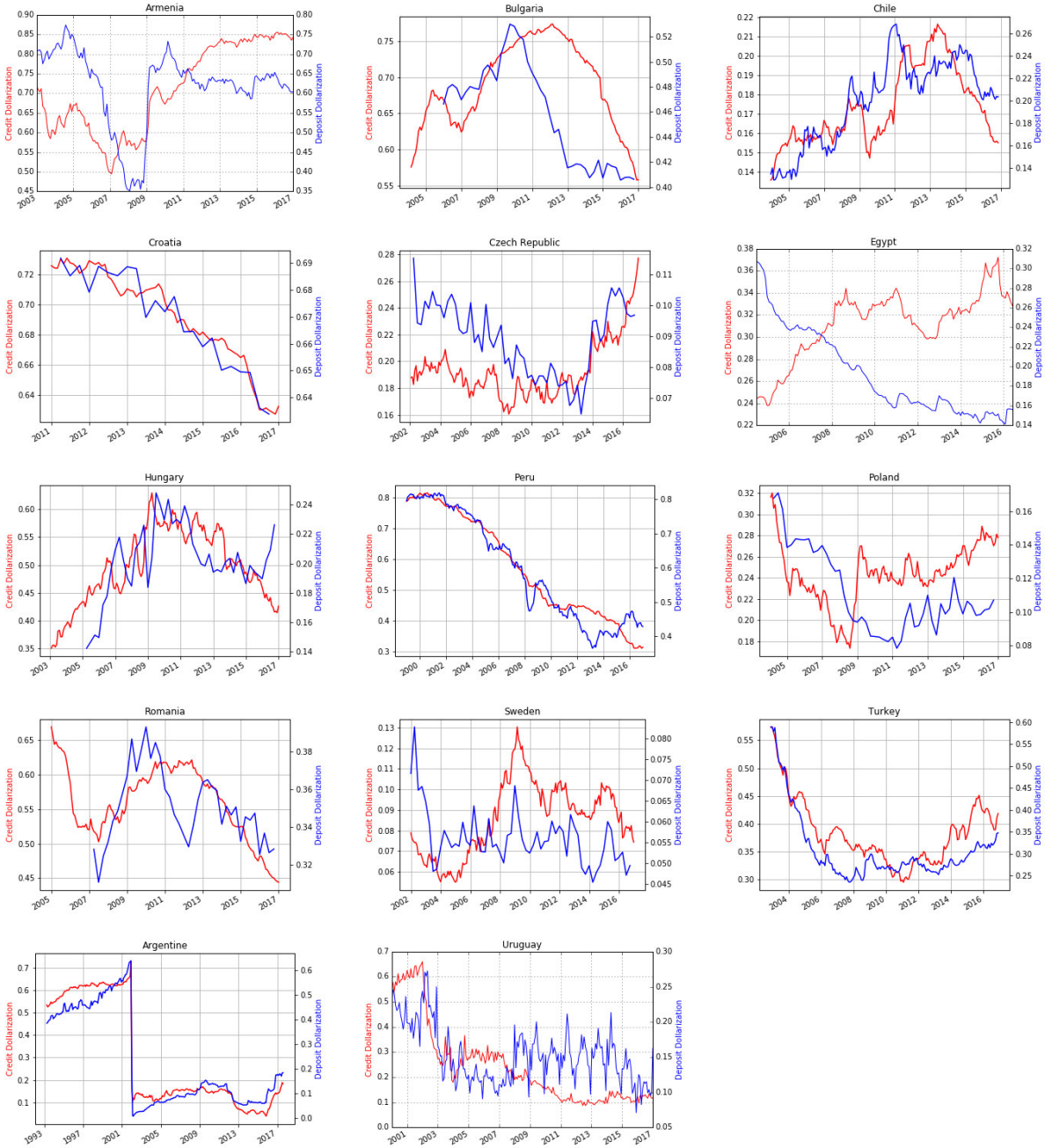
A.6 Data Sources

Time series data for dollarization and interest rates come from central bank websites. For the European economies, the source is ECB. Annual data for deposit dollarization is coming from Yeyati (2006)[25]. World Bank data is used for real GDP, nominal exchange rate and CPI. For the real exchange rate, BIS data is used. If BIS data is not available, World Bank data is used.

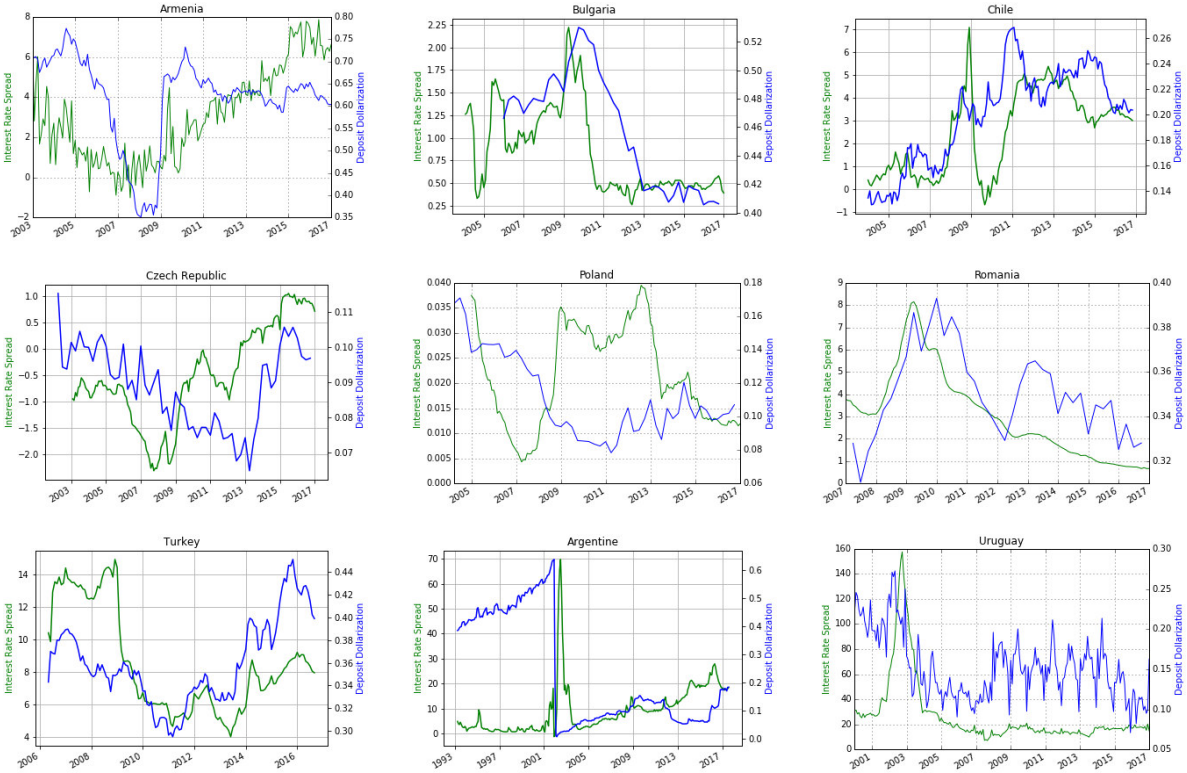
[25]Kindly provided by the author.

A.7 Appendix Graphs

A.7.1 Credit and Deposit Dollarization



A.7.2 Deposit Dollarization and Interest Rates



A.8 Average Currency Returns

Country	Mean	Sharpe Ratio
Argentina	0.80%	25.99%
Egypt	0.74%	10.75%
Turkey	0.64%	14.81%
New Zealand	0.35%	8.63%
Romania	0.34%	18.38%
Peru	0.29%	15.57%
Vietnam	0.26%	41.36%
Philippines	0.24%	14.23%
Thailand	0.23%	13.44%
India	0.20%	8.45%
Morocco	0.20%	8.26%
Hungary	0.20%	7.96%
Iceland	0.17%	3.76%
Israel	0.17%	6.95%
Poland	0.16%	6.44%
Croatia	0.16%	21.49%
Ghana	0.16%	3.65%
Colombia	0.12%	2.98%
Chile	0.09%	2.54%
Kazakhstan	0.07%	1.96%
Canada	0.07%	2.45%
Kenya	0.07%	2.79%
Bulgaria	0.06%	59.63%
Switzerland	0.04%	1.27%
South Africa	0.03%	1.00%
Czech Republic	0.03%	0.78%
Mexico	0.01%	0.31%
Denmark	-0.04%	-1.35%
Greece	-0.04%	-1.40%
Italy	-0.04%	-1.40%
Spain	-0.04%	-1.40%
Tunisia	-0.05%	-2.22%
Sweden	-0.06%	-1.86%
Norway	-0.10%	-2.95%
United Kingdom	-0.13%	-4.75%
Japan	-0.14%	-4.81%

A.9 Model Parameters

Parameter	Value	Explanation	
β	$(1.03)^{-1/4}$	Discount factor	Steady state 3% annual rate
R	$1/\beta$	Steady state interest rate	
ω	0.7	Home Bias	Import/Consumption
σ	1.5	CES elasticity	Faia (2007), Backus et al. (1993)
γ	5	Risk aversion	Neumeyer & Perri (2005) Fernandez-Villaverde et al. (2011)
$\phi - 1$	7.7	Inverse Frisch elasticity	Christiano et al. (2011)
$\bar{d}$	13.3	SS level of local assets	Deposit dollariztion: 33%
$\bar{f}$	4.45	SS level of foreign assets	Credit dollarization: 41%
$L^f = L^l$	2.04	Steady state leverage	Dalgic et al. (2017)
α	0.36	Capital Share	
φ	1	Elasticity of export demand	Gertler et al. (2007); Aoki et al. (2016)
σ_e	0.26	Entrepreneur cross section sdev	Faia (2007); Gertler et al. (2007)
μ	0.12	Monitoring cost	Faia (2007); Gertler et al. (2007)
$F(\cdot)$	Lognormal	Entrepreneur distribution	Faia (2007); Gertler et al. (2007) Christiano et al. (2011)
ρ_R	0.96	Interest rate shock persistency	Data, Fernandez-Villaverde et al. (2011)
σ_R	0.0025	Interest rate shock	Fernandez-Villaverde et al. (2011)
σ_z	0.08	Technology shock	Output Volatility 3%
σ_x	0.04	Export shock	RER Volatility 3.8%
$\sigma_{\sigma R}$	0.25	Interest rate volatility shock	VIX Index
$\rho_{\sigma R}$	0.72	Volatility shock persistence	VIX Index