Financial Dollarization in Emerging Markets: Efficient Risk Sharing or Prescription for Disaster?*

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Abstract

We present data that suggests financial dollarization is primarily a device for reallocating business cycle income risk between different people within emerging market economies, rather than across different countries. Although we identify sources of fragility in some aspects of dollarization, the common view that financial dollarization is a source of fragility is over-stated. We develop a simple model which formalizes the insurance view, which is consistent with the key cross-country facts on interest rate differentials, deposit dollarization and exchange rate depreciations in recessions.

1 Introduction

The recent literature focuses on dollar-denominated financial instruments as a source of risk sharing across countries.[1] We argue here that those instruments may also be an important mechanism for risk sharing among different agents within countries. Using data from 16 EMEs, we find that within-country risk sharing associated with dollar financial instruments is greater than risk sharing between residents and the rest of the world.

The notion that dollar financial assets contribute to risk sharing within emerging markets (EME) is motivated by three observations:

(a) In countries where the share of deposits denominated in dollars ('deposit dollarization') is high, the premium on the domestic interest rate over the exchange rate-adjusted dollar interest rate is also high.[2] Since this premium is the price paid for holding dollar deposits, we infer that a principle source of cross-country variation in deposit dollarization reflects cross-country variations in the demand for dollar deposits.

(b) In countries where deposit dollarization is high, the exchange rate tends to depreciate most in a recession (see Dalgic (2018)). This suggests that the reason for the observed cross country variation in the demand for dollar deposits is cross-country variation in the usefulness of the dollar as a hedge against business cycle income risk.

(c) Non-financial firm dollar borrowing is reasonably similar in magnitude to dollar deposits.

To us, these three observations suggest a particular narrative. Households who denominate their deposits in dollars are purchasing business cycle insurance from the households who own the firms which borrow in dollars. The 'price' paid by the depositors for this insurance is the premium on the local interest rate. The payoff from the insurance is the spike in the dollar return that occurs when the local currency depreciates in a recession. We report empirical evidence on the above three observations. The last section describes a model which formalizes our narrative.

[1] This is a theme that has been advocated particularly forcefully in Gourinchas et al. (2010); Obstfeld et al. (2010); Bernanke (2017).

[2] By 'dollar' assets we mean foreign assets from the perspective of EME's. Although in most EME's these assets are in fact denominated in US dollars, in many cases they are in Euros or, for example, in Swiss Francs. Our definition of 'deposits' follows the convention on Central Bank websites: they include demand deposits and time deposits. Evidence from Peru suggests that deposits are a major form of non-equity financial assets for residents in an EME. Data from Peru indicate that deposits are by far the largest part of non-equity claims by residents on local financial firms. Other claims by domestic residents include bank-issued bonds and commercial paper, but these are a small portion of borrowing by banks from local residents in Peru. We are grateful to Paul Castillo for this information about Peru.

Before turning to the model, we must address the widespread view that financial dollarization imposes a significant cost on EMEs. Under that view, financial dollarization increases vulnerability to financial crisis and makes investment and employment sub-optimally volatile in response to exchange rate fluctuations. If this view were correct, then financial dollarization may on net be welfare-reducing for an EME even if there were some insurance features associated with it. However, we find that the widespread view about the dangers of financial dollarization receives little support in the data. According to our results, the most important variables for forecasting crises in EMEs are the VIX and the total dollar debt borrowed by domestic residents from foreigners. A country's level of deposit dollarization does not significantly improve forecasts of crises once the latter two variables are included. Also, financial dollarization does not appear to create significant over-reaction to exchange rate movements.

It may at first seem puzzling that credit dollarization created by deposit dollarization is not systematically related to crises. For this reason we examine, as a case study, firm-level datasets for Peru and Armenia. These datasets provide information about the assets and liabilities of individual firms, broken down by currency.[3] Both data sets include periods of significant domestic currency depreciation. So, if balance sheet effects of depreciations were important for non-financial firms, that should have been evident in these datasets. That the effects turned out to be small complements similar findings in other research discussed in Section 5. Our data suggest that deposit dollarization does not raise the risk of financial crises because the currency mismatch it creates is in the hands of low-leveraged firms that can handle exchange rate fluctuations.

The preceding analysis leaves open the possibility that while dollarization does not increase the likelihood of crisis, it might nevertheless lead to excess volatility in employment and investment. The firm-level data in Armenia and Peru, as well as the results in Bleakley and Cowan (2008), suggest that the contribution of financial dollarization to volatility is minimal.

Our empirical results are based mostly on data from the 2000s, a period in which macroprudential regulation was taken very seriously. We infer that most of these regulations have been very effective. We conclude that, as long as sensible macro prudential regulations are in place, financial dollarization is less risky than is widely supposed.

We formalize the narrative suggested by findings (a)-(c), in the form of a two-period, small open economy model. Our findings that balance sheet effects appear not to play a first-order role leads us to adopt a model which does not include the possibility of financial crisis. Our narrative divides domestic residents into two groups: (i) worker-households who make deposits in the first period and finance second period consumption using second period income from labor and deposits; and (ii) household-firms that invest in the first period and

[3]We thank Paul Castillo at the Central Bank of Peru for helping us to access these data.

earn income and consume in the second period. For simplicity, we refer to worker-households as *households* and firm-households as *firms*.

Firms and households naturally find themselves on opposite sides of domestic financial markets. In period 1 households supply their savings in the form of deposits, and firms borrow those savings to finance an investment that bears fruit in the second period. Both types of household maximize a mean/variance utility function in second period consumption. Given our assumption about utility, agents' period 1 financial decisions transparently decompose into *speculative* and *hedging* motives. The speculative motive captures an agent's desire to choose a portfolio that has a high expected return. Under the hedging motive, the agent is concerned with choosing a portfolio that has a high payoff in future states of the world in which the agent's other sources of income are low.

Our model has several shocks. However, the principle ones in our narrative are shocks (e.g., an export demand shock) which cause the exchange rate to depreciate when domestic incomes are low in period 2. Hedging considerations motivate households to hold their deposits in an asset (a *dollar asset*) that pays off in terms of foreign goods. Firms' hedging motive, by contrast, makes them want to borrow using an asset (a *peso asset*) that pays off in terms of domestic goods.[4] Financial markets in effect allow these two types of agents to engage in an insurance arrangement. Households receive insurance by saving in dollar deposits.[5] Other things the same, this requires that firms take dollar loans even though they do not naturally want to do so because dollar loans are a bad hedge for them. Market clearing encourages firms to borrow in dollars anyway and they are compensated for doing so by a relatively low average interest rate on dollar assets. That low interest rate is in effect their reward for providing income insurance to households. The relatively low return that households receive on dollar deposits is the price that they pay for the insurance.

In our data, we observe variation in deposit dollarization across countries. We use our model to interpret this as reflecting that different countries face somewhat different patterns

[4] It is sometimes argued that being an exporter provides a firm that borrows in dollars with a 'natural hedge' against depreciations. For such a firm, when there is a depreciation its debt in peso terms goes up, but this is partially offset ('hedged') by a jump in the peso value of what it sells. In our model this logic depends on which shock is responsible for the depreciation. If the depreciation is caused by a negative shock to foreign demand, then the peso value of what the exporter sells to foreigners falls in our model. As a result, being an exporter is not a hedge against the exchange rate risk in a dollar loan when the primary shock driving exchange rates is to export demand.

[5] Our model only includes debt and loan markets in local currency and dollars. In the Online Technical Appendix, we show that this environment is isomorphic to an alternative environment in which dollar debt and loan contracts are not traded in EMEs. Instead, residents and foreign financiers participate in fully collateralized long and short forward contracts in dollars while deposit and debt contracts are denominated in local currency only. We do not emphasize the forward contract interpretation of our model because the evidence suggests that derivative contracts are not generally used in EMEs. Using data from Chile, Alfaro et al. (2021) show that large firms do tend to use derivative instruments to hedge short term trade credit, but they do not hedge FX debt which tends to be longer term.

of shocks.

To verify that our narrative is coherent and does not have hidden counterfactual implications, we introduce additional structure. A reduced form demand curve summarizes foreign demand for the domestic tradable good. To capture the incentives and willingness of foreigners to to trade financial assets with domestic residents we introduce *foreign financiers*.[6] In part, we need to model foreign financiers to ensure that our narrative can plausibly address why foreigners do not enter domestic financial markets to profit from, and thereby eliminate, the premium on peso loans.[7] In our model, foreign financiers are also mean-variance households, and providing peso loans in the domestic financial market is a bad hedge for them. The reason has to do with the primary shock in our model that makes the currency depreciate in a recession. That shock is a disturbance to foreign demand for the period 2 domestically produced tradable good. We interpret that shock as a negative shock to foreign Gross Domestic Product, which is positively correlated with the income of foreign financiers. For this reason, peso loans, though they have a high yield, are a bad hedge for foreigners. In effect, foreigners are averse to lending in local currency markets for the same hedging reason that households are. In our model the level of risk aversion is the same across foreigners and both types of domestic agent. If our financiers did not have a hedging motive, then our model would only be able to explain the high observed local interest rate premia with the assumption that foreigners are extremely risk averse, compared to domestic residents. We are not aware of evidence to support such an assumption, so we conclude that for our narrative to be compelling it is important that local currency assets be a bad hedge for financiers. This view is consistent with a theme that permeates the recent literature on the Global Financial Cycle.[8] The literature documents substantial comovement of asset prices and other variables between EMEs and rich countries.

In short, our narrative treats financial markets as a mechanism by which risk is allocated among agents. Our emphasis is on the risk sharing between agents within an emerging market economy, though we must also incorporate risk sharing between domestic and foreign agents. The framework borrows heavily from Dalgic (2018). The framework also resembles the one in Chari and Christiano (2019). The latter focuses on the role of commodity futures markets as devices for providing insurance both between users and producers of commodities (they

[6]For a discussion of foreign financiers, see Gabaix and Maggiori (Section I, 2015).

[7]Formally, our analysis limits foreigners to providing finance by purchasing debt assets from domestic financial firms. In practice, foreign finance also enters emerging market economies via foreign direct investment. Including foreign direct investment would be a straightforward extension of our model, but would complicate the analysis. Since our empirical analysis does not require examining foreign direct investment we decided that including foreign direct investment in the model would obscure its purpose: to provide a simple, coherent economic interpretation of our empirical findings.

[8]See, *inter alia*, Lustig and Verdelhan (2007), Lustig et al. (2011), Hassan (2013), Bruno and Shin (2015b)), Maggiori (2017), Farhi and Maggiori (2018), Gopinath and Stein (2018), Bahaj and Reis (2020), Miranda-Agrippino and Rey (2020), Gourinchas et al. (2017) and Maggiori et al. (forthcoming).

resemble our households and firms) and outsiders (those resemble our foreign financiers). Our results are also in the spirit of the idea of 'home equity bias', financial asset flows are typically greater within rather across countries (French and Poterba (1991); Carlos Hatchondo (2008)).

The first section below defines the concept of deposit dollarization, and the international data set that we have constructed on that variable. Section 3 presents a key empirical observation that motivates the analysis of this paper: deposit dollarization is greatest in countries where the local currency depreciates most in a recession. We argue that the resulting currency mismatch is largely held by domestic firms. As a result, they are the primary suppliers of the insurance that dollar deposits provide to households. Section 4 examines the evidence that would show a connection between deposit dollarization and financial crises if such a connection were pronounced. Looking at that evidence, we find that there is little statistical relation between deposit dollarization and financial crises (both their incidence as well as their cost if they occur). Section 5 reports our analysis of the Armenian and Peruvian datasets. Section 6 presents our model and Section 7 provides concluding remarks. Details are available in an online Technical Appendix.

2 Some Concepts and Deposit Dollarization Data

Let i denote the risk-free domestic nominal return earned by domestic residents on a local currency bank deposits. Let i^* denote the return, in domestic nominal terms, earned by domestic residents on a risk-free foreign currency bank deposit. In particular, let e denote the beginning-of-period t nominal exchange rate (local currency, per unit of foreign currency). Then, the domestic return on a foreign currency deposit that has one-period gross nominal return, $R^{\$}$, in terms of domestic currency, is

$$i^* \equiv R^{\$} \left(e'/e \right),$$

where e' is the exchange rate at the beginning of the next period. Evidently, if $R^{\$}$ is risk-free then i^* is risky because of the uncertainty about e'.

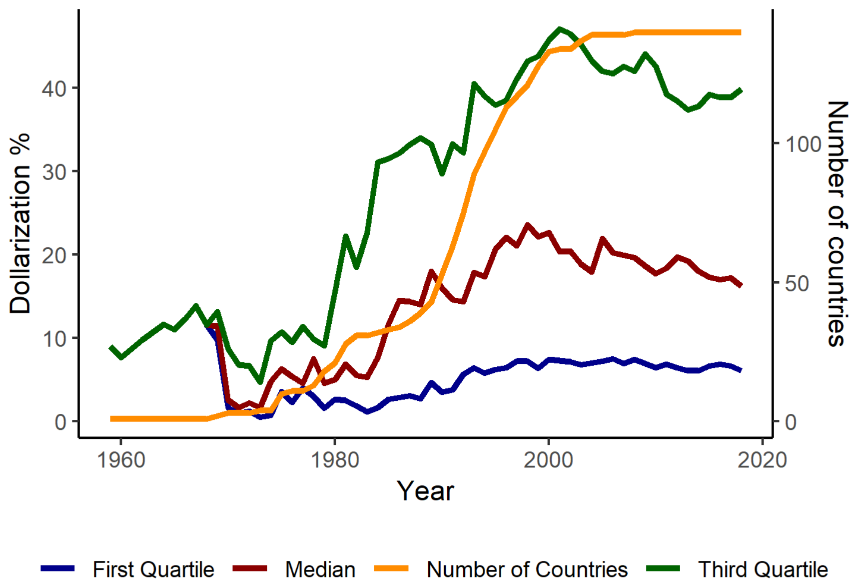
We define *deposit dollarization* for country i and year t, as

$$\phi_{i,t} = \frac{\text{value of dollar deposits held by domestic residents}}{\text{total deposits held by domestic residents}}, \tag{1}$$

where both the numerator and denominator are expressed in local currency units. Our analysis is based on a database that we have constructed which extends the database constructed in Levy-Yeyati (2006). We extend his data to 2018 and expand coverage from 124 to 140 countries using publicly available data. We use 'dollar' as an umbrella term for all the foreign currencies used in financial transactions. Our measure includes dollar deposits in the local banking system (which also includes local subsidiaries of foreign banks). [9]

A summary of our data is provided in Figure 1. The figure describes the median and first and third quartiles for deposit dollarization in the cross-section of countries for which data are available.[10]

Figure 1: Deposit Dollarization Data



A key result from the figure is that though deposit dollarization shows a small tendency to decline in the 2000s, the median remains near 20 percent. The upper quartile shows that there remains a substantial group of countries with significant dollarization. The figure indicates that we have the most coverage for the 2000s.

[9]In practice, 'deposits' are defined as demand deposits plus term deposits. In EMEs, deposits held by domestic residents are by far the major component of non-equity bank liabilities to domestic residents. For example, using data from the website of the Reserve Bank of Peru, we found that in December 2019, soles deposits of Peruvian residents were 159,467 million soles (of which, 18,370 million soles are government deposits). In the same month, resident dollar deposits were \$31,549 million (government deposits were \$613 million). The exchange rate in that month was 3.37 soles per dollar. So, total deposits in that month were 265,787 million soles. Other bank liabilities to residents were 14,253 million soles and \$1,037 million. So, total deposit liabilities held by residents were 94 percent of total liabilities to residents. Using these data, we have that ϕ in equation (1) is 0.40 in Peru for December 2019. We obtained banking data from the website of the Turkish Banking Regulation and Supervision Agency. That website provides information about bank deposit liabilities by currency and residency. This allows us to compute ϕ (this is 0.55 in December, 2020).

[10]The results in Figure 1 includes data for 10 countries that discourage deposit dollarization. These countries are discussed in Subsection 3.1 below (see in particular the countries with blue labels in Figure 2).

3 Key Result

We show that, across countries, deposit dollarization is greatest where the local currency depreciates most in a recession. We show that none of the resulting currency mismatch is held by banks and that roughly all of it is held in the form of dollar loans to domestic non-financial firms. We argue dollar assets are used primarily to shift risk among households in a given EME country, rather than among households across different countries.

3.1 The Insurance Hypothesis

A key result of our paper appears in Figure 2. Each of the 134 country observations in Figure 2 is indicated by the corresponding World Bank country code.[11] The vertical axis depicts the correlation, over the available sample for a particular country, between its real GDP and the domestic good value of foreign currency, S/P, where P is the domestic consumer price index.[12] The horizontal axis corresponds to the country's average deposit dollarization rate defined in equation (1)[13]. For each country the sample used to compute its correlation and dollarization statistic are the same. In almost all cases, the sample is 2000-2018.[14] The codes for 125 countries are in black while the codes for 9 are in blue.[15] The blue codes correspond to countries that, according to Nicolo et al. (2003), restrict residents from holding domestic

[11]We do not include results for 6 countries because we are missing at least one of GDP, CPI and the exchange rate for these. The countries are Anguilla, Antigua, Latvia, Montserrat, Qatar, and Zimbabwe.

[12]We run the following regression for each country $\frac{\Delta GDP_t}{\sigma(\Delta GDP)} = \alpha + \rho_i \frac{\Delta S/P}{\sigma(\Delta S/P)} + \epsilon_t$. Both GDP and S/P are logged. For each country, we divide GDP and S/P by their standard deviations to put each country on a common scale. For the bivariate case, the estimate $\hat{\rho}$ turns out to be the correlation coefficient, which also has the advantage that it is direction free.

[13]By using average dollarization, we abstract from short-term movements in dollarization. Dollarization is typically highly persistent (Kokenyne et al. (2010)), it is unlikely to see large movements in dollarization over the short term. We use market prices to calculate dollarization, which reflects not the total amount of dollar held by residents but the share of dollar asset in their saving portfolios. Since we average over long periods, valuation effects are unlikely to change our results.

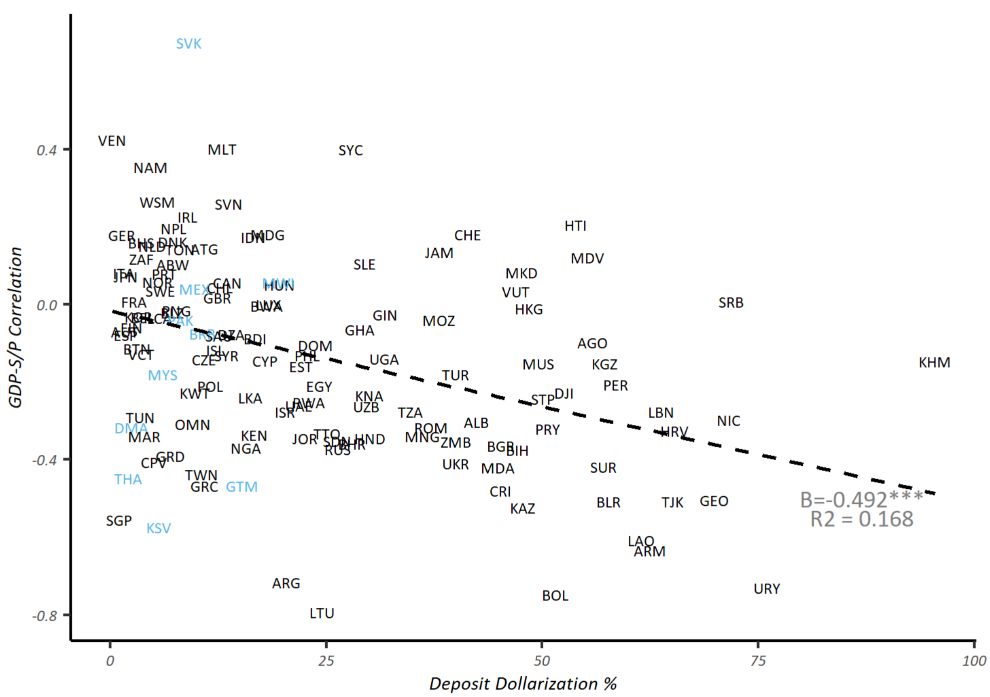
[14]We do not have all the data for 2000-2018 for each of the 134 countries accounted for in Figure 2. The binding constraint for a few countries on data availability is the deposit dollarization rate. But, as we can see in Figure 1, we have data for virtually each country in the case of the sample, 2000-2018. In the few countries for which data for the full sample are not available, we simply use the available data compute those countries' statistics reported in Figure 2.

[15]The nine countries are: Barbados (BRB), Dominica (DMA), Guatemala (GTM), Kosovo (KSV), Mexico (MEX), Malaysia (MYS), Slovakia (SVK), Pakistan(PAK), and Thailand (THA). Being included in this list of countries does not imply that the holding of dollar deposits is entirely forbidden. It may simply be that the rules on holding dollar deposits are very restrictive. For example in Mexico residents may hold dollar deposits, but only if they live within 20 kilometers of the US border. In Malaysia, residents may also hold dollar deposits, but only if they intend to use them to pay dollar debt or things like educational expenses. In Thailand, limits on dollar deposits were lifted in 2008, but we decided to leave Thailand in the list of blue countries anyway. Two countries that Nicolo et al. (2003) characterize as restrictive are Ukraine and Kazakhstan. We nevertheless include these among the black countries because they have credit dollarization in excess of 20%. We infer that the restrictions against dollarized deposits in those countries must not be very severe.

dollarized deposits in 2000. The dashed line is the least squares line through the data with black codes. If the blue-coded data are included, the least squares line changes by only a small amount.

To verify the robustness of the negative relationship in Figure 2, we constructed an alternative version of the figure. In that version, the variables on the vertical and horizontal axes are replaced with their residual after regressing on a set of control variables. The controls include average inflation in the 1990s, as well as the average of several variables in the 2000s: a measure of inequality (Gini coefficient); a World Bank measure of quality of institutions; fuel as a share of exports; central bank reserves as a fraction of GDP; and external debt as a share of GDP. The results, in terms of the slope of the regression line and the R^2, are essentially the same as reported in Figure 3. For the details, see Technical Appendix Section A.1. We infer that the negative relationship in Figure 2 is not an artifact of a country's institutions or its experience with past inflation, or the other variables in our controls.

Figure 2: Countries in which the Currency Depreciates More in a Recession Have Greater Deposit Dollarization



Notes: (i) statistic on vertical axis is correlation between the log difference (in annual data) of real GDP and the log difference of S/P, where S denotes foreign currency per unit of domestic currency and P denotes the domestic consumer price index; (ii) deposit dollarization is defined in equation 1; (iii) codes in the figure correspond to World Bank Country codes; (iv) the sample for all but a few exceptions is 2000-2018 (see Figure 1) and the exceptional cases are missing a some observations in the early 2000s; the country codes indicated in blue indicate countries that restrict deposit dollarization according to Nicolo et al. (2003). See Online Appendix, section E, for a list of the countries for which we have deposit dollarization data. The GDP and S/P data are available from the IMF's database, IFS, for all those countries.

One interpretation of the negative association in Figure 2 is that deposit dollarization drives the correlation on the vertical axis via a balance sheet channel. Countries whose banks have a large amount of dollar liabilities also make a large amount of dollar loans. This can be seen in Figure 3, which displays the average over the 2000s of these variables, scaled by total bank liabilities, in a cross-section of countries.[16] According to *the balance sheet channel*, other things the same, an exchange rate depreciation in a country with a high amount of dollar loans results in lower output as borrowers with unhedged dollar debt are forced to cut back on investment and employment. The expectation, under this hypothesis, is that if regulations to restrict deposit dollarization were exogenously imposed in some country, then exchange rate depreciations should be associated with smaller recessions in that country. Thus, the correlation on the vertical axis of Figure 2 would be expected to be *higher* for that country. But, Figure 2 indicates that that correlation is in fact *lower* than it is in other countries with low dollarization and no restrictions.[17] Perhaps this puzzle can be resolved based on a failure of the exogeneity assumption.[18] Still, Sections 4 and 5 below present more evidence against the balance sheet hypothesis. There, we show that deposit dollarization has no predictive power for financial crises or for the severity of a crisis when it happens. Also, firm-level data suggest that in the wake of a currency depreciation, the response of investment is not very different for firms with and without substantial currency mismatch on their balance sheets. In Section A.2 we show that the relationship is robust when we use nominal exchange rate, or we focus on the period 1995-2018. We also show the relation within each region.

An alternative interpretation of the negative association in Figure 2 receives more support in our analysis. Under that interpretation, it is the correlation on the vertical axis of Figure that drives deposit dollarization. The idea is that in countries where the exchange rate depreciates most in recessions, households hold a larger fraction of their saving in dollars as a hedge against business cycle income risk. There are various reasons why a country's currency might depreciate in recessions. For example, fluctuations in GDP may be dominated by volatility in the demand for exports. Hassan (2013) argues that shocks to large countries can propagate to smaller countries. Similarly, according to Richmond (2019), currencies of countries that are not central to trade networks depreciate druing global downturns. Gopinath et al. (2020); Akinci and Queralto (2018) argue that dollar invoicing contribute to the countercyclical exchange rate by muting the response of exports. Or, government

[16]In Subsection 3.2.1 below, we argue that there is virtually no currency mismatch in banks. Note that the slope in Figure 3, though positive, is less than unity. Evidently, banks with higher dollar deposits back them in part by dollar assets other than loans.

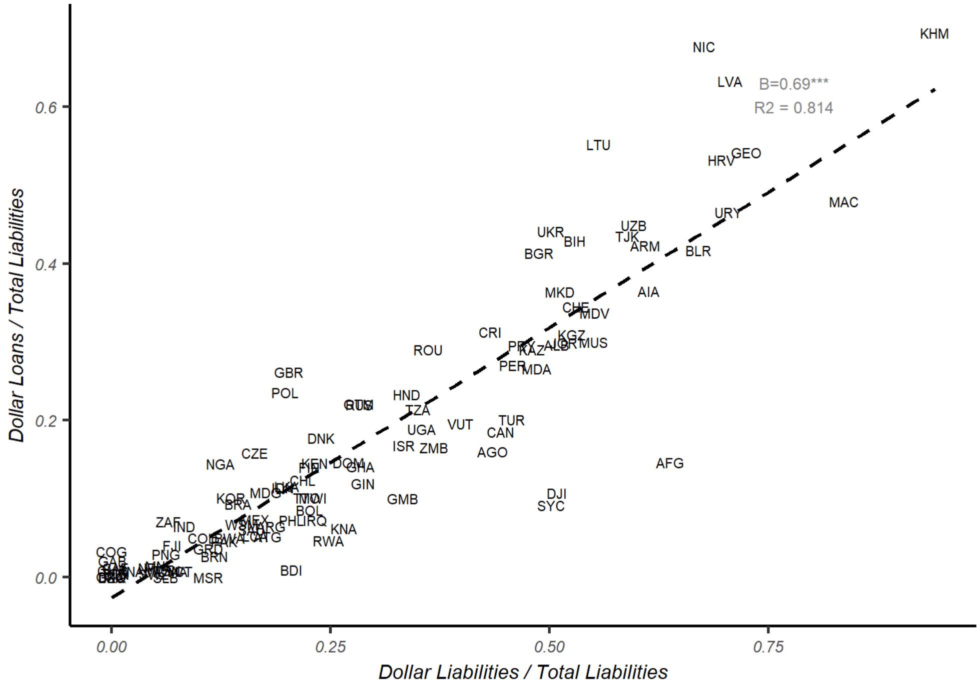
[17]Consider countries with deposit dollarization less than the median of roughly 20 percent. Among the countries without regulatory restrictions on deposit dollarization, the mean correlation is -0.133. The mean correlation among countries without regulatory restrictions, the mean correlation is -0.031.

[18]One would have to argue that countries in which restrictions on deposit dollarization were implemented would otherwise have had extremely low correlation between GDP and S/P.

policy might be inflationary in recessions. A related possibility is that financial disturbances originating in the US (the 2008 financial crisis, or simply a monetary policy tightening) can create a recession in the rest of the world and for safe-haven reasons lead to an appreciation of the dollar (see, for example, Gourinchas et al. (2010); also Bruno and Shin (2015b) on how global deleveraging corresponds to an appreciated USD). It has also been argued that the movements in the US interest rates can generate low growth in the rest of the world combined with an appreciated USD (Bruno and Shin (2015a); Rey (2013); Miranda-Agrippino and Rey (2020)). Bruno and Shin (2021) show that financial conditions in the US affect the international trade via the working capital channel; tight dollar financing conditions lead to an appreciated USD and a decline in trade credit, which reduces exports of developing economies. We are agnostic about the exact shock that generates the observed negative covariance between output and the exchange rate in these economies. In particular, different countries might face different types of shocks that generate a countercyclical exchange rate. From the perspective of an ordinary household, negative covariance between output and the exchange rate means that dollar assets gain in value when the economy is doing poorly; thus provide income insurance. We refer to the hedging interpretation of Figure 2 as *the insurance hypothesis*.

Under the insurance hypothesis the cross-country variation in dollar deposits is driven by demand, and so the price of dollar deposits is expected to covary positively with quantity. Specifically, for emerging market economies (EMEs) in which deposit dollarization is high, the supply of dollars in local lending markets is high relative to the supply of local currency. At the same time, hedging considerations for borrowers in those markets makes them averse to borrowing in dollars. So, clearing in dollar and local currency loan markets requires that the price of holding dollar deposits, $i - i^*$, is high.

Figure 3: Dollar Loans Versus Dollars Liabilities



Notes: Data obtained from International Monetary Fund database, Financial Soundness Indicators. Each country is indicated by its World Bank code and the data represent, for each country, averages over the period, 2000-2018. The numerator variables on the y and x-axes are 'Foreign currency denominated loans' and 'Foreign currency denominated liabilities', respectively. Both variables are expressed as a fraction of 'Total liabilities'. The dashed line is the least squares line fit to the data, where B denotes the slope and $R2$ denotes the R^2. The three stars on B indicates significance at the 1 percent level.

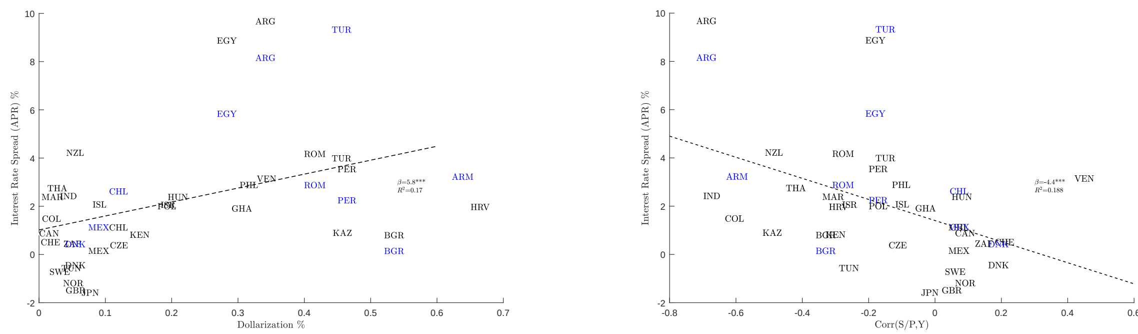
We investigate the implication of the insurance hypothesis that the price of dollar deposits, $i - i^*$, is high in countries where deposit dollarization is high. We use the data on $i-i^*$ constructed by the indirect method in Dalgic (2018) for the 33 countries in our database for which there are futures markets in currencies. The $i - i^*$ data were constructed using the return on a US government security as a measure of the nominal risk-free dollar return. Using the assumption of covered interest parity, Dalgic (2018) combined the dollar interest rate with spot exchange rates and futures rates to compute $i - i^*$.[19] The average for each country of $i - i^*$ over the 2000s are displayed for each of our 33 countries in Figure 4. The first panel contains the scatter plot of $i - i^*$ against deposit dollarization. The second panel displays the scatter of $i - i^*$ against the correlation between S/P and GDP. The latter is the same correlation appearing on the vertical axis in Figure 2.

For 10 of the 33 countries we were also able to obtain direct observations on local currency and dollar deposit rates from Central Bank websites. The spread, $i - i^*$, in these countries appears in the panels of Figure 4 in blue. In one country, Armenia, we do not have the

[19] Our data are annual and we work with averages of $i - i^*$ in the 2000s, so we do not expect the much-discussed deviations from covered interest parity observed at relatively high frequencies to substantially distort our results (see, for example, Du et al. (2018) and Verdelhan (2018)).

futures market-based measure of the local interest rate and so only the blue measure appears. Generally the blue and the black measures are close to each other. Egypt and Turkey are two exceptions. In any case, the least squares (dashed) line drawn through the data is roughly unaffected by whether we use the blue or black variables. This protects us from some, though not all, sources of distortion in our measure of $i - i^*$.

Figure 4: Interest Rate Spreads vs Dollarization and the Correlation between GDP and Exchange Rate



Notes: Data on the horizontal axis correspond to $100 \times \phi$, where ϕ is defined in equation (1). For the observations marked in blue, local deposit rates (local and foreign currency) were obtained from Central Bank websites. In the case of observations marked in black, the local deposit rate was inferred using covered interest parity, local and future's market exchange rates (monthly rates taken from Datastream) as well as dollar risk free rates. In some cases, both measures of the domestic interest rate are available . The line in the figure is the least squares that uses actual local dollar rates when available (blue) and uses derivative-based rates otherwise (black). The least squares line based on the black observations only is not included because it is virtually indistinguishable from the line reported. Data covers the period 2004-2017.

Our direct and indirect measures of $i - i^*$ each have their own potential problems. A problem with direct observations is that, according to anecdotal evidence, deposit maturities and income tax treatments of the earnings on dollar versus domestic deposits vary across countries. Unfortunately, we are not aware of systematic data on either issue. The indirect inference approach does not suffer from the maturity problem, but obviously has the same tax problems as the direct method. We would prefer to have $i - i^*$ after taxes.

A potential distortion for both measures of $i - i^*$ is the impact on interest rate spreads of differential reserve requirements on domestic versus dollar bank deposits. Federico et al. (2014) provide a dataset on reserve requirements by local versus foreign currency deposits in banks. In their sample of 52 countries the average difference in reserve requirements for most countries is small. Exceptions are Peru (26), Honduras (23), Serbia (18) and Uruguay (13), where numbers in parentheses are the difference in the percent reserve requirements.[20] We are cautiously optimistic that differences in reserve requirements across countries do not substantially affect our analysis of interest rate spreads.[21]

[20] There are five other countries were the differences are in single digits and in all other countries the difference is zero.

[21] Federico et al. (2014) discuss the cyclical movements in reserve requirements. These cyclical movements may not affect our analysis which only focuses on first moments of $i - i^*$.

We now turn to the two panels Figure 4 to evaluate the price implications of the insurance hypothesis. The first panel is consistent with that hypothesis' implication that $i - i^*$ is typically higher in countries with deposit dollarization.[22] The second panel is consistent with with the idea that the demand for dollarized deposits is driven by the correlation between the domestic goods value of a dollar, S/P, and GDP.

In this paper, our focus is on domestic dollarization as a determinant of average excess currency returns. The other main determinants of average excess currency returns found in the literature are country size (Hassan (2013)), trade network centrality (Richmond (2019)), external debt (Della Corte et al. (2016)), US Dollar debt (Wiriadinata (2019)). Dalgic and Ozhan (2021) show that the covariance between GDP movements and exchange rate changes is a significant determinant of average excess returns even after controlling for size, centrality and external debt. Lustig and Verdelhan (2007) show that the covariance between US durable consumption and exchange rate movements is a significant determinant of currency returns, in countries where the exchange rate tends to depreciate during US recessions, US investors require a risk premium to invest.

3.2 Who Supplies Insurance to the Households?

When exchange rates depreciate during a recession, households with dollar deposits in effect receive a transfer, in terms of local currency. Where does that transfer come from? In principle, banks, firms, government and/or foreigners could be the source of this transfer. Evidence from a large IMF database on bank stability indicators suggest that banks have very little currency mismatch in the 2000s, so they do not appear to be the source of insurance payments to households after a depreciation. We have access to a smaller data set for 16 EMEs which do not strongly discourage dollar deposits according to the index in Nicolo et al. (2003). We show that in those countries, dollar borrowing from banks in many cases exceeds the net amount of dollars deposited by residents. This suggests that, to a first approximation, firms are the source of the insurance payments that households with dollar bank deposits receive when the currency depreciates. This is consistent with the idea that financial dollarization plays an important role in risk allocation among different residents within EMEs. In the third section below we make use of a dataset recently produced by Benetrix et al. (2020), which decomposes cross-country financial flows by currency. This data, in conjunction with our deposit dollarization data, allows us to decompose inter- versus intra-national insurance flows. In the data for the two countries that overlap with our dataset, we find that the within country insurance flows are much larger than the cross- country flows.

[22] To gain a better understanding of the magnitude of $i - i^*$, Subsection A.3 in the Online Appendix expresses $i - i^*$ as a tax on depositors.

3.2.1 It is not the Banks

The evidence suggests that there is little currency mismatch in banks, indicating that they are not the ones providing the insurance to households. This is consistent with the view that bank regulators, particularly in the 2000's, have worked to ensure that banks do not have significant currency mismatch on their balance sheets. A relevant statistic is compiled by the International Monetary Fund (IMF). We perform stress tests on the banking system in each of the 115 countries covered by the IMF dataset, by asking what exchange rate depreciation (or, in some cases, appreciation) would be required to wipe out bank equity. We find that, for the overwhelming majority, 93, there is no possible depreciation that would have this effect. For the other countries, the depreciation would have to be truly extreme.[23] We conclude that, especially in emerging markets, there is not a serious currency mismatch in banks.[24] So, it appears that the owners of banks are not the ones providing insurance services to bank depositors.

3.2.2 If it is not the banks, then who?

The results reported in Figure 5 summarize information about borrowing and lending for 16 EMEs which do not discourage dollar deposits according to the index in Nicolo et al. (2003).[25] In all panels of Figure 5, except Panel 5f, the solid line is the median in the cross-section of countries for the indicated year and the specified statistic. The upper and lower dashed lines indicate the boundaries of the upper and lower 25% quartiles. Panel (5f) indicates the number of countries for which we have observations, for each year. The dashed line in that panel indicates the number of countries for which the firm and household components of deposits, reported in panel 5a, are available The solid line indicates the number of countries in the cross-section for all panels apart from Panel 5a. Panel 5f indicates that we have data for a relatively small fraction of our countries before 2010. Also, the number of countries whose data allow us to differentiate between household and firm deposits is always less than 16.[26]

[23]For details, see Section B in the Online Technical Appendix.

[24]It is well known, and internalized in the Basel III reforms (see, for example, https://www.bis.org/basel_framework/), that term mismatch raises the possibility of a rollover crisis. This can suddenly convert a system which appears to have no currency mismatch into one in which currency mismatch is severe. We address this concern in Section 4 below.

[25]The countries are Albania, Armenia, Bulgaria, Croatia, Egypt, Honduras, Hungary, Kazakhstan, Lithuania, Mozambique, Peru, Romania, Russia, Turkey, Uganda and Ukraine. Summary statistics are reported in Table C3 in Section C of the Online Appendix. Column (1) of Table C3 shows that our 16 countries have somewhat higher deposit dollarization rates than the average in our sample.

[26]With one exception, the deposit and bank credit were obtained from central bank websites. The exceptional case is Peru, where the household versus deposit data where kindly provided to us by Paul Castillo. We obtained data on the stock of debt issued by nonfinancial firms in international debt markets from the BIS website, https://stats.bis.org/ . For the reasons given in Shin (2013) and Coppola et al. (2021), we use

Panel (5a) shows that in the median country, most of the deposits (over 60 percent) are held by households.[27] The lower quartile is close to 50 percent, so that in a small number of countries firms hold more dollar deposits than households (Peru is such a country). Panel 5b displays the total dollar debt of firms from all sources (domestic and foreign), scaled by total dollar deposits.[28] The figure shows that the median value of scaled firm dollar debt increased steadily from from 25% to nearly 100% between 2000-2018. It is interesting to note from Panel (5e) that, for the median country, more than 90 percent of firm dollar borrowing is from local banks and relatively little is from international financial markets. This is not the case for all the countries in our sample. The decline in the lower quartile reflects the fact that (see, for example, Shin (2018)) firms in some countries have substantially increased their borrowing in international markets since the 2010s.[29]

Also, in some countries, households borrow dollars back from banks. An example of this is the widely-noted borrowing after 2005 in Eastern European countries of mortgages in foreign currencies (mainly Swiss francs). Panel 5c displays the sum of household and firm borrowing, as a ratio to total deposits. Note the bulge in the upper quartile. This reflects the Eastern European household borrowing just mentioned. Importantly for us, the mean of the ratio in Panel 5c converges to unity in the 2010s. This suggests that household deposits net of household dollar bank credit is on average equal to firm dollar borrowing. That is, in the

the data based on nationality.

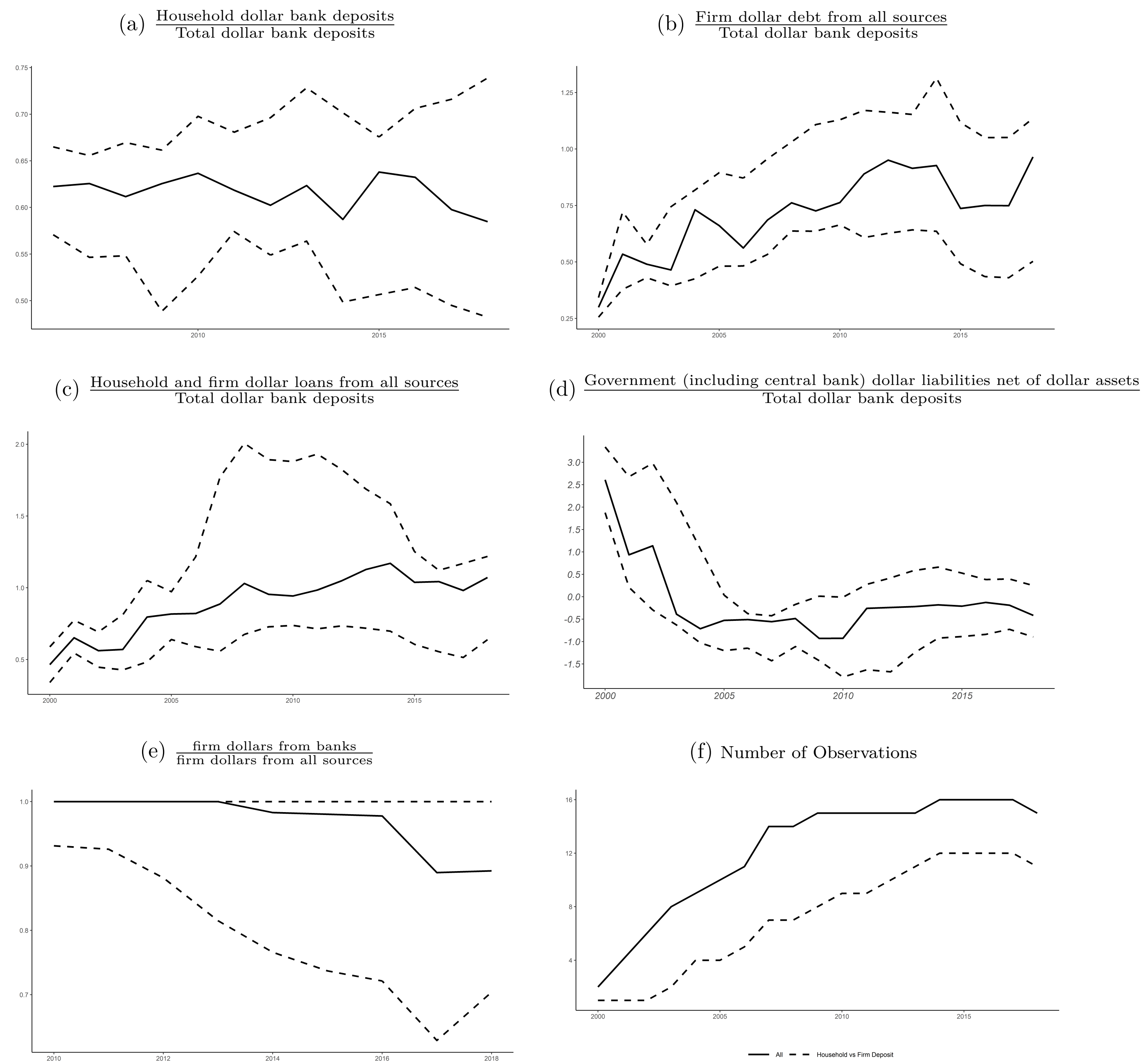
[27] We do not know how the other 40 percent breaks down among firms and government. We also do not have information about possible misclassification. For example, it may be that the deposits of small businesses are classified as 'business deposits', even though those deposits are intermingled with the deposit balances of the household that owns the business.

[28] We do not include foreign direct investment and other portfolio equity investment in firm dollar debt because the rate of return on these assets is not stipulated in dollar terms. These liabilities are not of direct interest to us because our focus is on the insurance implications of international financial instruments whose rate of return is fixed in dollars.

[29] Our results are qualitatively consistent with those in Shin (2018), who stresses the shift from local bank borrowing to bond market borrowing. But there are quantitative differences which reflect our unit of analysis and data sources. In our analysis the unit of observation is a country and we do not differentiate by size. When we recompute the solid line in Panel (5e), taking the ratio of sums rather than the median of ratios, we obtain results that resemble more closely the lower quartile in Panel (5e). In particular, we find that the share of dollar borrowing from domestic banks relative to total dollar borrowing in our sample of 16 countries is 96% in 2009 and fluctuates around 75% after 2013 (for our sample of countries, see Table C3 in Online Appendix Section C). The levels of these numbers are higher than the levels reported in Shin (2018)XXThis discussion is confusing...I thought the point was to explain why Shin gets numbers lower than our solid black line in Figure 5(e). I think we're saying that he computes the ratio of sums, while 5(e) reports the median of country ratios. Is it that when we compute the ratio of sums we're still higher than Shin?XX. Still, they are consistent with his observation that the share of dollar borrowing by non-financial firms from domestic banks has fallen. Indeed, the percentage point fall in our data is roughly twice what it is in Shin (2018)'s data. The set of countries we consider is different from Shin (2018) because we are interested in countries that distinguish between household and firm deposits. Also, our data on non-financial firm dollar borrowing includes borrowing from domestic banks as well as BIS-reported bond issues by domestic residents in international markets. Shin (2018)'s data also includes borrowing from foreign banks. We do not include data on dollar borrowing from foreign banks, unless they are registered in the domestic economy.

median country, non-financial firms are the source of the insurance enjoyed by households when they hold dollar deposits.

Figure 5: Local Firms Appear to Provide the Insurance to Dollar Depositors



Note: Sub-figures (a)-(e): Black line is median, across all 16 countries listed in Footnote 25, of the indicated statistic, for the indicated year. Upper dashed line is upper 25^{th} percentile and lower dashed line is lower 25^{th} percentile. Data were obtained from Central Bank websites. Sub-figure (5f): The dashed line indicates the number of countries for we have data on the composition of deposits in terms of households and firms. The solid line indicates the number of countries for which we have all the other data. In Sub-Figure (a), ϕ_t is the average across all countries, i, of $\phi_{i,t}$ for each t, where $\phi_{i,t}$ is defined in equation (1).

Finally, consider Panel (5d), which indicates that EME governments began to accumulate a substantial amount of dollar assets beginning in the early 2000s.[30] For the median country, the amount of the dollar accumulation by the government is about 1/2 of total dollar deposits. We interpret this accumulation as insurance obtained from foreigners on behalf of all residents, including households and the people that own the firms. How to allocate these insurance benefits across the two types of households is beyond the scope of this paper. Instead, we focus on the insurance obtained by households when they choose the currency composition of their deposits. This represents a lower bound on the insurance that they receive because it abstracts from any insurance received via the fiscal authorities.

3.3 Decomposing International Versus Intra-national Insurance Flows

The evidence in the previous section suggests that at least a substantial portion of the insurance obtained by residents who hold dollars is provided by other residents in the same country. In this section we discuss a decomposition that allows us to quantify all insurance flows associated with dollar borrowing and lending in a particular country. Market clearing requires that the quantity of dollar assets created in the financial market of a particular country must be equal to the quantity of dollar liabilities created in that financial market. That is,

$$d_t^* + d_t^{*,f} = b_t^* + b_t^{*,f}. \tag{2}$$

Here, d and b XXthere are only superscript *, no d and bXXdenotes assets and liabilities, respectively, denominated in local currency. Also, a * indicates that the financial instrument has a dollar denominated return so that in units of the domestic currency the return depends on the future realized exchange rate. In addition, variables without the superscript XXconfusing, been just talking about * isn't that a superscript?XXdenote domestic non-financial residents and variables with superscript, f, denotes foreign residents. We exclude the dollars borrowed and lent by domestic financial institutions because the results in section (3.2.1) suggest that these cancel. Below, we explain how government enters the picture. Equation (2) is the market clearing condition for trade in dollar financial assets between domestic and foreign residents.

After rearranging the terms in equation (2), we obtain:

$$\min\left[d_t^*, b_t^*\right] + \min\left[d^{*,f}, b^{*,f}\right] + |b_t^* - d_t^*| = b_t^* + b_t^{*,f}.$$

[30]By 'government' we mean the consolidated net assets accumulated by the fiscal and monetary authorities. To some extent, the increase in dollar (net) foreign assets may reflect the observation in Du and Schreger (2016a) that many governments have shifted the denomination of their international borrowing from dollars to local currency.

The first and second terms represent the quantity of financial trade between residents and non-residents, respectively. The third term denotes the quantity of financial trade between domestic and foreign residents. Suppose, for example that $d_t^* < b_t^*$. In this case, the quantity of insurance obtained by households is fully provided by private firms.[31] In this case, $b_t^* - d_t^* > 0$ is the component of insurance provided by domestic residents to foreignersXXdoes it make sense that these foreigners are getting 'insurance'?XX. The object on the right of the equality is a measure of the total amount of financial trade. Dividing, we have

$$\overbrace{\frac{\min\left[d_t^*, b_t^*\right]}{b_t^* + b_t^{*,f}}}^{\text{within country insurance}} + \overbrace{\frac{\min\left[d_t^{*,f}, b_t^{*,f}\right]}{b_t^* + b_t^{*,f}}}^{\text{within foreign insurance}} + \overbrace{\frac{\left|b_t^* - d_t^*\right|}{b_t^* + b_t^{*,f}}}^{\text{across country insurance}} = 1. \tag{3}$$

In this way we have an additive decomposition of insurance flows.

We include government trade in assets and liabilities by netting these out of the foreign asset flows. We denote the dollar assets in the consolidated balance sheet of the fiscal and central bank authorities by $d_t^{g,*}$. We denote the corresponding liabilities by $b_t^{g,*}$. We interpret $d^{*,f}$ in equation (3) as $d^{*,f} - b_t^{g,*}$. Also, we interpret $b^{*,f}$ as $b^{*,f} - d_t^{g,*}$. This interpretation does not affect the validity of equation (3).[32]

Data on the currency composition of international financial flows (i.e., $d_t^{*,f}$ and $b_t^{*,f}$) in and out of EMEs are limited. We obtained time series data for Turkey and Peru from Benetrix et al. (2020) and the results of the decomposition are displayed in Figure (6).[33] Equation (3) implies that the data should add to unity at each date. In practice, the data come from different sources or they may be incomplete, and so the identity need not hold. However, the figures indicate that the identity holds approximately for Peru and Turkey, which is consistent with the notion that there is little measurement error in the data. The

[31] There are two channels by which thisXXshouldn't use 'this'XX can occur. The most straightforward is that the households deposit the dollars in a bank and the firms then come to the bank to borrow those dollars. An alternative is that local banks use the dollar deposits to purchase foreign assets and then domestic firms borrow the dollars by issuing dollar bonds in international markets. From the point of view of who receives the insurance payments and who makes them, the two scenarios are the same.

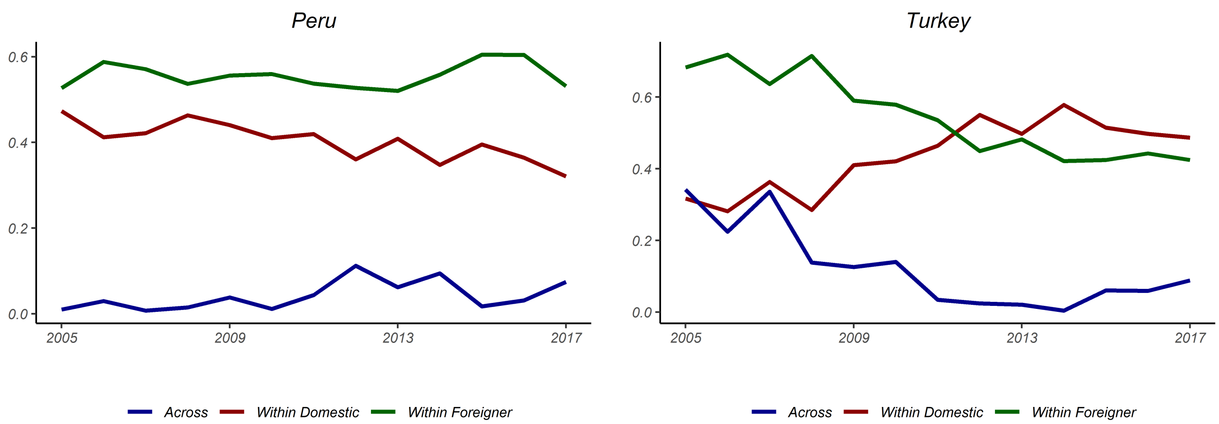
[32] We suspect that most of the dollar debt in $b_t^{g,*}$ is issued by the fiscal authorities. Similarly, we suspect that most of the dollar assets in $d_t^{g,*}$ are owned by the monetary authority. We do not know how much of the monetary authorities' dollar assets are the dollar liabilities issued by the fiscal authorities. If we had data on these objects, we would delete them from both $d_t^{g,*}$ and $b_t^{g,*}$. The principle objects that interest us are the first and third terms in (3) and these are not affected by the considerations discussed here.

[33]

The data from Benetrix et al. (2020) cover 19 EMEs. We did not use their data on Brazil, India and Mexico because those countries sharply limit the amount of deposit dollarization that is allowed. In the case of Hungary, our data sources are incomplete because the sum of the three components in equation (3) is substantially less than unity. In the case of the other countries we have not yet acquired their deposit dollarization data.

key result in the figure is that within-category flows are much larger than across-category flows, especially after 2010 in the case of Turkey.

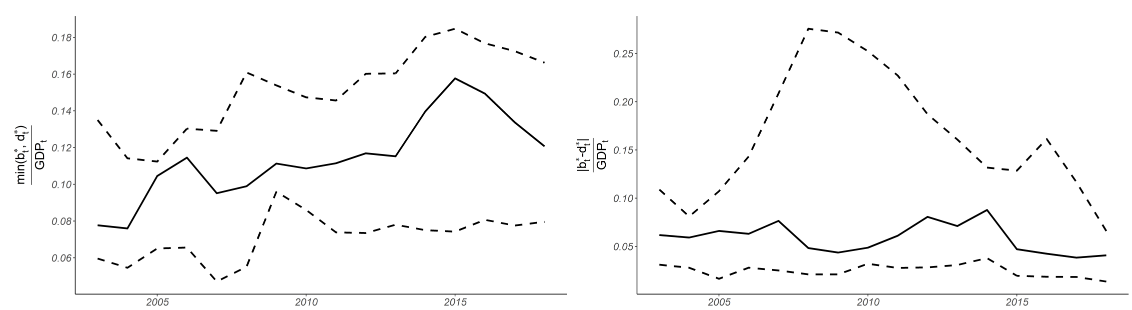
Figure 6: Decomposition of Insurance Flows



Note: These data correspond to the three terms on the left of the equality in equation (3). They represent the share of dollar financial flows between residents of the indicated country ('Within Domestic'), between foreigners ('Within Foreigner') and between residents and foreigners ('Across'). As explained in the text, $d_t^{*,f}$ and $b_t^{*,f}$ are the obtained from Benetrix et al. (2020), net of government dollar liabilities and assets, respectively. Government liabilities The government data were obtained from the BIS (dollar bonds issued by the fiscal authorities in international credit markets were The other data have been described in previous sections.

Figure 7: Intra-national vs International Positions

(a) Intra, $\frac{\min(b_t^*, d_t^*)}{GDP_t}$ (b) Inter, $\frac{|b_t^* - d_t^*|}{GDP_t}$



Notes: Please refer to section 3.2.2 for details of the data. d_t^* and b_t^* refer to dollar deposits and loans respectively. For each country the annual data are averaged over the 2000s. Solid line plots the median across 16 EMEs whereas dashed lines are 25 and 75 percentiles.

Our primary interest is in the within-country resident category versus the across-country category. For this, we do not require the Benetrix et al. (2020) data. We display information about the time series data on a measure of intra-national insurance, $\min(b_t^*, d_t^*)/GDP_t$ versus inter-national insurance, $|b_t^* - d_t^*|/GDP_t$ for our 16 countries in Figure 7. The solid line indicates the median across countries for each year. The dashed lines indicate the 75^{th}

and 25^{th} percentiles.[34] The key result is that the across-country insurance flows are small compared to the within-country flows. The median cross-country flows are on average 55 percent of within-country flows.

4 Banking Crises and Dollarization

There is a persistent view that deposit dollarization is dangerous because it makes a country vulnerable to a systemic banking crisis. This section shows that there is little evidence to support this view. Deposit dollarization also does not appear to exacerbate the economic costs of a financial crisis, if it occurs.

We begin by showing that our conclusion is consistent with a bivariate analysis of the data. However, a bivariate analysis might hide subtle channels by which deposit dollarization actually does destabilize the financial system. So, in the second section below we move to a multivariate analysis that focuses on those channels. Still, we find little evidence of a relationship.

We conclude that dollarization has little to do with systemic banking crisis. The primary driver of financial crisis appears to be a high external debt as well as the Global Financial Factors studied in the literature and sometimes measured by the VIX.[35]

4.1 Bivariate Analysis

We examine data on crises from two sources. Data on systemic banking crises are taken from Laeven and Valencia (2020), while data on sudden stops are taken from Eichengreen and Gupta (2018).

The data on systemic banking crises from Laeven and Valencia (2020) cover the period, 1980-2017, and include 151 systemic banking crises. According to the criteria in Laeven and Valencia (2020), a country experiences a banking crises if it meets two conditions:[36]

- significant banking policy intervention measures are taken in response to significant losses in the banking system,

- the banking system exhibits significant losses, resulting in a share of nonperforming

[34]The bulge in the upper percentile in Figure 7b primarily reflects the much-discussed jump in East European foreign currency mortgage borrowing.

[35]For a general discussion of the impact of Global Financial Factors, see Miranda-Agrippino and Rey (2020). For the importance of the VIX specifically in financial crises, see Forbes and Warnock (2012). For the role of external dollar debt in financial crises see Mendoza and Terrones (2008), Gourinchas and Obstfeld (2012) and Caballero (2016), who emphasize rapid credit expansion financed by capital inflows, i.e., external debt.

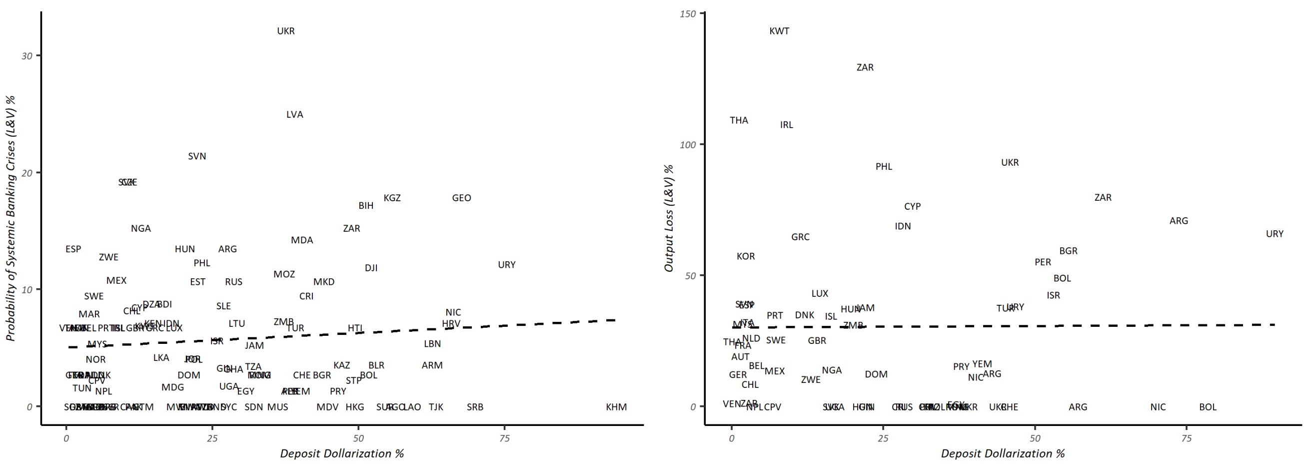
[36]See Laeven and Valencia (2020) for additional details.

loans above 20 percent of total loans, or bank closures of at least 20 percent of banking system assets.

Our data on dollarization come from Levy-Yeyati (2006) as well as from individual central banks and cover the period, 1980-2017. The intersection of the Laeven and Valencia (2020) database with our deposit dollarization data includes 81 banking crises. Figure 8a displays the fraction of years a country is in a banking crisis against the average deposit dollarization in that country over the same years. This Figure shows that there is not a significant relationship between the level of dollarization and the frequency of crises.

Figure 8: Deposit Dollarization versus Frequency and Cost of Laeven and Valencia (2020) Banking Crises

(a) Frequency (b) Cost



Note: The dashed line is the least squares line obtained by regressing the variable on the vertical axis on the variable on the horizontal axis. See

Figure 8b displays the relationship between Laeven and Valencia (2020)'s measure of the cost of a crisis and deposit dollarization.[37] Figure 8b indicates that the cost of a crisis is not significantly related to the level of deposit dollarization.

4.2 Multivariate Analysis

We perform a multivariate analysis to investigate various links between financial dollarization and the stability of the financial system. In the first subsection, we describe the *a priori* considerations about those links which motivate the design of the analysis in the second

[37] Laeven and Valencia (2020) measure the cost of a crisis in, say, year t by the percent of real GDP lost. They compute the HP filter of log real GDP from $t-20$ (or, the first available observation) to $t-1$. They then extrapolate the HP trend into years t to $t+3$. The cost of a crisis is measured by the sum of the deviations between log real GDP and its HP extrapolated trend in periods t to $t+3$. See Laeven and Valencia (2020, p. 326) for more details.

subsection. To avoid over-fitting we restrict ourselves to a variant of the design in Levy-Yeyati (2006), which also has the objective of understanding the links between financial dollarization and financial crisis. The last two subsections describe our results.

4.2.1 A Priori Considerations

Potential Pitfalls of Financial Dollarization

There are at least two ways that financial dollarization might destabilize a country's financial system, while perhaps not leaving a strong footprint in bivariate scatter plots such as Figure 8. A *currency mismatch channel* operates in case deposit dollarization creates substantial unhedged currency mismatch on the balance sheets of borrowers from banks.[38] A large currency depreciation could then damage bank balance sheets by causing these borrowers to stop servicing their debts. A *maturity mismatch channel* operates in case the maturity of banks' dollar assets is substantially longer than the maturity of their dollar liabilities. In this case banks without any apparent currency mismatch on their balance sheets could suddenly have such a mismatch. This would happen if banks encounter difficulties in rolling over short term dollar liabilities and are forced into selling dollar assets at fire-sale prices.

But in theory a large depreciation does not necessarily damage the financial system via the above two *balance sheet effects*. For example, if the *expenditure switching effects* associated with depreciation are large enough then a very different outcome is possible. In this case, a depreciation could strengthen the economy (and, hence, balance sheets) by redirecting foreign and domestic demand towards domestically-produced goods and services.

Which dominates, the balance sheet or expenditure switching effects, has important implications for the desirability of financial dollarization. If balance sheet effects dominate then financial dollarization has costs. Either the incidence of financial crisis is increased, or the central bank is restricted in its ability to stabilize the domestic economy by, say, cutting interest rates in a recession.

Mitigating The Pitfalls

Each of the currency and maturity mismatch channels has the potential to create a dollar shortage in banks and trigger a financial crisis. In principle, there are two complementary ways to preserve the insurance benefits of financial dollarization (see section 3.1) while minimizing the risks of dollar shortage in the financial system. One way is for the central bank to accumulate liquid foreign reserves that can be used to provide limited lender-of-last-resort

[38] Recall from Figure 5e that a substantial portion of dollar deposits are passed on by banks in the form of loans to domestic non-financial firms.

services. A shortcoming of this approach is that it may generate moral hazard problems associated with dollar borrowing and lending (*moral hazard effect*). Another way is to require banks to hold a fraction of their dollar deposit liabilities in the form of liquid foreign financial assets.[39] Either approach could help mitigate the currency and maturity mismatch channels mentioned above.

It is worth noting that for the banks to hold foreign assets as backing for dollar deposits is not inconsistent with the insurance argument developed in section 3.1. Consider two extreme scenarios. In the baseline scenario banks lend out all dollar deposits in the form of dollar loans to domestic firms. In the alternative scenario, banks use the full amount of a dollar deposit to purchase liquid foreign dollar assets.[40] Under the alternative scenario the supply of funds to local firms is restricted, and they are forced to turn to international financial markets for funding.

A substantive difference between the baseline and alternative scenarios is that any risk associated with firm loans is shifted off domestic bank balance sheets and onto the balance sheets of the foreigners that make dollar loans to domestic firms. No doubt borrowing firms would have to pay a premium to cover this risk, but such a premium would also have to be paid to domestic banks in the baseline scenario. The key is that from the insurance perspective the baseline and alternative scenarios are similar. In each case, a recession in which the domestic exchange rate depreciates is an occasion in which firms transfer more, in domestic currency units, to depositors. In the baseline scenario the transfer occurs through the domestic banking system while in the alternative scenario the transfer occurs through the international financial system.

An advantage of the alternative scenario is that the pitfalls of financial dollarization are mitigated. Presumably, the optimum is a combination of the two scenarios because the alternative scenario does not make use of local bank expertise at identifying good lending opportunities and monitoring them. In addition, the alternative scenario in effect taxes dollarization by requiring that reserves be held in low-return, liquid form.

The first two subsections below describe our logit methodology and the results, respectively. The third subsection investigates the relationship between deposit dollarization and the severity of a financial crisis, if it occurs. Taken together, the multivariate analysis con-

[39]Banks could be required to hold liquid foreign assets directly or they could hold them indirectly. They could hold them indirectly by placing the dollar deposits in the central bank which then uses the funds to acquire liquid foreign assets. A small number of central banks impose relatively heavy dollar reserve requirements on dollar deposits. For example, the database constructed in Federico et al. (2014) shows that in the 1990s Peru placed a 45% reserve requirement on dollar deposits. They were again increased sharply in the decade after the Great Financial Crisis in 2008. The Federico et al. (2014) database shows that regulators can impose higher reserve requirements on dollar demand deposits than on dollar deposits of longer duration.

[40]This could be done directly, or indirectly by holding dollar deposits at the central bank which then purchases the foreign assets.

firms the impression conveyed by Figure 8 that there is little relationship between deposit dollarization and the frequency or cost of financial crisis.

4.2.2 Logit Methodology and Data Used in the Analysis

Let $y_{i,t} \in \{0,1\}$, where 1 indicates a Laeven and Valencia (2020) systemic banking crisis in year t, country i. Let $p(x_{i,t};\beta)$ denote the probability that year t is the first year of a Laeven and Valencia (2020) systemic banking crisis for country i. Here, the column vector, $x_{i,t}$, represents a set of year $t-1$ country-specific variables and a year t aggregate variable, while β denotes a conformable set of parameter values.[41] Let

$$y_{i,t} = p(x_{i,t};\beta_0) + \varepsilon_{i,t}, \tag{4}$$

where $\varepsilon_{i,t}$ is a variable that is orthogonal to period $t-1$ information, $p_{i,t}(x_{i,t};\beta_0) = E[y_{i,t}|x_{i,t};\beta_0]$, and β_0 is the true values of β, which must be estimated. We adopt the following functional form:

$$p(x_{i,t};\beta) = \frac{1}{1+e^{-x_{i,t}^T\beta}}, \tag{5}$$

so that the log odds of a crisis is the linear function, $x_{i,t}^T\beta$, where T denotes transposition.[42] Note that by construction, $0 \leq p_{i,t}(x_{i,t};\beta) \leq 1$. By the orthogonality property of $\varepsilon_{i,t}$

$$E\{[y_{i,t} - p(x_{i,t};\beta_0)]\,x_{i,t}\} = 0. \tag{6}$$

This setting satisfies the conditions of the Generalized Method of Moments estimator described in Hansen (1982). Accordingly, we estimate β_0 by choosing the value of β, $\hat{\beta}$, having the property that the sample analog of equation (6) is satisfied. The number of equations in (6) is equal to the number of elements in β, so that the estimator is exactly identified. We follow Petersen (2009) in allowing for correlation in $\varepsilon_{i,t}$ over i for given t and over t for given i.[43]

We include the following variables in $x_{i,t}$, in addition to a constant. Our primary interest is in understanding the impact of deposit dollarization on financial stability, so our first variable in $x_{i,t}$ is the dummy variable, $Dollar\,(20)_{i,t-1}$. $Dollar\,(20)_{i,t}$ is unity for country i and year t if deposit dollarization exceeds 20 percent in year t (in the table, the i and $t-1$

[41] Working in a similar environment, Bussiere and Fratzscher (2006) and Gourinchas and Obstfeld (2012) make a case that more lags are required. Subsection H.4 in the Online Appendix shows that the results we report below are robust to including additional lags.

[42] It is easily verified that, given equation (5), $\ln(p(x_{i,t};\beta)/(1-p(x_{i,t};\beta))) = x_{i,t}^T\beta$.

[43] See Thompson (2011) and Cameron et al. (2012) further discussion. We use STATA to do the calculations. The logit code, logit2.ado, was written by Petersen (2009). As in Hansen (1982), our estimator allows for conditional heteroscedasticity in $\varepsilon_{i,t}$.

subscripts are deleted).[44] Both the use of a dummy variable for deposit dollarization and the one year lag are designed to minimize potential endogeneity distortions in the logit regression. In Online Appendix Subsection H.6 we show that the results are robust to adopting a 10 percent cutoff in our deposit dollarization dummy rather than the 20 percent cutoff reported here. Second, $x_{i,t}$ also includes $\Delta e_{i,t-1}$, the log difference of the previous year's exchange rate, relative to its value in the prior year (this is the variable, Δe, in the table). The nominal exchange rate depreciation is included to assess the because for its potential to for causing the damaging balance sheet effects associated with dollarization discussed in subsection 4.2.1. Third, we also include the period $t-1$ cross-product of the exchange rate change and the dollar dummy in $x_{i,t}$.

Fourth, following the analysis in Levy-Yeyati (2006), we also consider the variable, FL/FA, for each country (the country index, i, is dropped for simplicity).[45] Here, FL denotes the dollar liabilities to foreigners of non-central bank domestic financial institutions. We presume that the these liabilities are relatively short-term.[46] Also, FA denotes the dollar claims on foreigners by the same institutions, which we presume are relatively liquid. Our time series on FL/FA are displayed in Figure 9.

[44] See equation (1) for the definition of $\phi_{i,t}$.

[45] For the observations before 2000, we used the FL/FA observations used by Levy-Yeyati (2006), which the author kindly provided to us. Levy-Yeyati (2006) reports that these data were obtained from the IMF. The later observations on FL and FA were obtained from the International Monetary Fund's data base, International Financial Statistics (currently, the pre-2000 data on FL and FA appear not to be reported in the IFS).FL (FA) is defined as liabilities to (claims on) non-residents by other depository corporations. 'Other depository corporations' include commercial banks and excludes the central bank. Specifically, FL (FA) corresponds to the IMF variable, "Monetary and Financial Accounts, Other Financial Corporations, Net foreign Assets, Liabilities to (Claims on) Non-residents, Domestic Currency".

[46] This presumption warrants further investigation. For example, we know that in recent years the duration of FL in Peruvian banks has gotten longer. Pre-2000's data on Peru are consistent with the idea that FL is primarily composed of short term (less than two years) liabilities. But, that component began to fall in the 2000s and is now substantially less than 50%. In particular, data for Peru show that the fraction of FL that was short term was above 90% from 1992 until late 1999 (there was a dip to around 80% from mid-1996 to mid-1997). The fraction of short term borrowing then fell steadily and has been fluctuating in a 13% to 30% range in recent years. This suggests that, at least in the case of Peru, the chances of the type of rollover crisis associated with FL may be relatively small. We are grateful to Paul Castillo for providing us with these numbers.

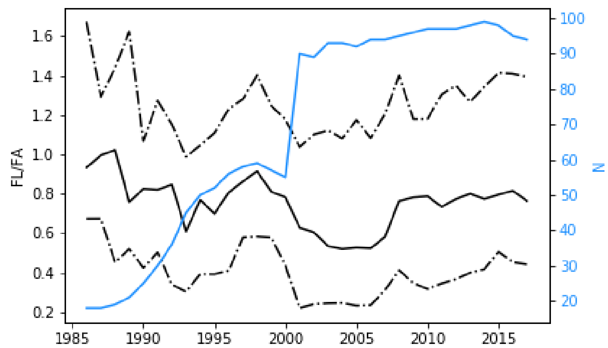


Figure 9: FL/FA

Blue line indicates data availability (right scale). Solid line indicates the median, dashed lines are 25% and 75% percentiles. Source: Levy-Yeyati (2006) (before 2001), IMF IFS (after 2001).

According to Figure 9, the number of countries for which we have data on FL/FA jumps in the 2000s to between 90 and 100. Among the 140 countries for which we have deposit dollarization data, there are a little over 40 for which we do not have data on FL/FA in the 2000s. Our measure 'High FL/FA' is a dummy, which is unity if $FL/FA > 1$ and zero otherwise. According to Figure 9, more than 25% of the countries have high FL/FA. When this ratio is high the absence of currency mismatch in banks suggests $FL - FA > 0$ takes the form of loans to domestic residents. We presume that these loans are relatively long term and illiquid, so that $FL/FA > 1$ corresponds to the dollar maturity mismatch scenario discussed in section 4.2.1. The period $t-1$ value of the dummy variable, High FL/FA, is thus included in $x_{i,t}$ as a potential indicator of dollar maturity mismatch. Because of the symmetry between the High FL/FA and *Dollar* (20) dummies, we also include, as a fifth variable, the period $t-1$ cross-product of the exchange rate change and the High FL/FA dummy in $x_{i,t}$.

As explained in subsection 4.2.1, *a priori* reasoning suggests that the currency and maturity channels are more likely to lead to crisis in case the central bank is low on dollar reserves. So, the sixth variable included in $x_{i,t}$ is the period $t-1$ dummy variable, 'Low Reserves' (again, we drop the index, i). This variable is unity for country i and year t if country i's central bank reserves lie below the median of the the reserves-to-GDP ratio in year t in our sample.[47] The seventh and eighth variables in $x_{i,t}$ are the period $t-1$ value of the cross product between Low Reserves and each of *Dollar* (20) and FL/FA. For example, the coefficient on the first cross product is an answer to the question: "given that a country has high deposit dollarization, what does a high level of foreign reserves do to the odds of a financial crisis?". If the coefficient on the cross product is positive, this suggests that if

[47]The foreign reserves and GDP data were taken from the IMF's International Financial Statistics database, International Financial Statistics.

dollarization is high, then it is wise for the central bank to hold liquid foreign reserves in order to be in a position to offer at least a limited amount of lender-of-last-resort services in dollars.

In principle, high GDP growth could, by lifting balance sheets, have an impact on the probability of a financial crisis. So, the ninth variable in $x_{i,t}$ is a country's one-period lag of real GDP growth.[48] The tenth variable is 'External Debt', which corresponds to interest payments by all residents on foreign debt, divided by GDP.[49] In principle, a high external debt could raise the probability of a domestic banking crisis by a variety of mechanisms. For example, it could do so if borrowers' assets have longer maturity than their external debt and foreigners refuse to roll over. Or, external debt could raise the probability of a financial crisis by damaging firm balance sheets in the event of a depreciation, which in turn could prevent them from servicing local bank loans.

The eleventh variable in $x_{i,t}$, is country i's real exchange rate (relative to dollar) in period $t-1$ minus its value in period $t-2$. [50] We include real exchange rate in order to compare our results with those reported in Gourinchas and Obstfeld (2012), who work with the real exchange rate, Δrer, rather than Δe. Our twelfth and final variable in $x_{i,t}$ is the VIX, the index of financial market volatility produced by the Chicago Board Options Exchange.[51] This is motivated by the findings in Forbes and Warnock (2012) and Miranda-Agrippino and Rey (2020), which suggest that the VIX, as an indicator of global risk appetite, can influence financial conditions in EMEs. Because the VIX is a US variable and no i corresponds to the US, we are relatively unconcerned about endogeneity problems in the case of the VIX. Our principle interest is in EMEs and endogeneity for the VIX seems for these countries seems especially plausible. For this reason, we include the period t value of the VIX variable in $x_{i,t}$ for each i.

Since the analysis investigates the odds of entering the first year of a crisis, we leave out observations on the second and later years of crises. Table 1 reports $t-$statistics for the null hypothesis that the true parameter is zero in parentheses beneath point estimates.

4.2.3 Results of Logit Regressions

We now describe the results of our logit analysis reported in Table 1, which covers the period, 1995-2007. Each column in the table reports results based on a different subset

[48]Source: IMFInternational Financial Statistics

[49]Source: World Bank, International Debt Statistics. The variable used is Interest Payments On External Debt (% Of GNI) https://databank.worldbank.org/reports.aspx?source=14&series=DT.INT.DECT.GN.ZS.

[50]The real exchange rate, $\Delta rer_{i,t}$, corresponds to $\Delta e_{i,t} + \pi_t^* - \pi_{i,t}$, where π_t^* denotes the log difference of the CPI in December of year t minus its value in December of $t-1$. Also, $\pi_{i,t}$ denotes the analogous inflation measure for the the i^{th} economy. Data source: IMF's International Financial Statistics. In the table we delete the $i, t-1$ subscripts on $\Delta rer_{i,t-1}$.

[51]The data are available on the Federal Reserve Bank of St. Louis' website, Fred.

of the variables in $x_{i,t}$. The variables included in each column can be determined from the first column. The variable in the j^{th} row, $j = 1, ..., 12$ in the first column is explained in subsection 4.2.2, where that variable is referred to as the 'j^{th} variable', $j = 1, ..., 12$. Columns labeled (1)-(4) use data for all the countries in our sample while columns (5)-(8) only include EMEs.[52] We also report an R^2 diagnostic for our logit regressions at the bottom of each column.[53] The variable, N, denotes the number of country-year observations used in each of the eight columns of results.

Our sample includes the Asian financial crisis. To verify that our results are not driven by this episode, we redid the analysis using data over the period 2000-2017. The version of Table 1 estimated using this sample appears in Online Appendix, Section H.2. Our basic results using the 1995-2017 sample also hold when we only use the shorter sample. Other robustness checks on the results in Table 1 are also reported in Section in the Online Appendix.

Table 1 allows us ask three types of questions: (i) how does financial dollarization affect the impact of a depreciation on the likelihood of a financial crisis?; (ii) how does the level of central bank foreign reserves affect the likelihood of a financial crisis?; (iii) how do to other variables affect the likelihood of financial crisis?

Consider question (i) first. We have two measures of financial dollarization: deposit dollarization and FL/FA. Consider two economies that are identical in every respect, except that the first one has low deposit dollarization (e.g., $Dollar\,(20) = 0$) and the second one has high deposit dollarization ($Dollar\,(20) = 1$). The (log odds) of the probability of crisis is $\beta_1 + (\beta_2 + \beta_3)\,\Delta e$ for the second economy and $\beta_2 \Delta e$ (we ignore the other parameter which are, by assumption equal across the two economies). impact of the depreciation on the seconddifference in the impact The impact of a given depreciation, $\Delta e > 0$, on the second economy is $\beta_1 + (\beta_2 + \beta_3)\,\Delta e$. these two economies The information in the table tells us that if we have two economies that are equal in all respects except

Consider first the significance of the deposit dollarization dummy in row 1 of Table 1.

[52]The economies that are not included in the last four columns are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom.

[53]Specifically, we report the pseudo-R^2 provided by STATA, $1 - var\,(\hat{\varepsilon}_{i,t})\,/var\,(y_{i,t})$. Here, $\hat{\varepsilon}_{i,t} = y_{i,t} - p\left(x_{i,t}; \hat{\beta}\right)$, where $\hat{\beta}$ is the estimated value of the logit model parameters and $y_{i,t}$ is the Laeven and Valencia (2020) indicator of banking crisis. Also, $var\,(z_{i,t}) = \sum_{i,t} (z_{i,t} - \bar{z})^2\,/N$, where N denotes all country-year observations, the summation is over all i, t for which we have an observation, $z_{i,t}$, and $\bar{z}$ denotes $\left(\sum_{i,t} z_{i,t}\right)/N$, for $z = \hat{\varepsilon}, y$.

Table 1: Probability of Systemic Banking Crisis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dollar (20)	-0.318	-0.362	-0.358	-0.449	0.427	-0.105	-0.455	-1.083*
	(-0.50)	(-0.61)	(-0.53)	(-0.73)	(0.80)	(-0.16)	(-0.76)	(-1.66)
Δe	-0.939*	-2.122	0.710	1.461	0.303	2.620	3.501	4.373
	(-1.90)	(-1.12)	(0.19)	(0.38)	(0.28)	(1.31)	(1.58)	(1.39)
Dollar(20)*Δe	1.628**	2.454	0.780	0.276	0.407	-1.612	-2.431	-3.920
	(2.36)	(1.63)	(0.20)	(0.07)	(0.36)	(-0.66)	(-0.87)	(-0.95)
High FL/FA			1.690***	1.245		1.503**	1.296	0.899
			(2.83)	(1.41)		(2.54)	(1.46)	(0.97)
High FL/FA *Δe			-4.526*	-5.221*		-2.470	-2.693	-4.807*
			(-1.72)	(-1.80)		(-1.42)	(-1.40)	(-1.74)
Low Reserve				-0.872			-1.240	-2.224**
				(-0.88)			(-1.17)	(-2.14)
Dollar(20) * Low Reserves				0.338			1.022	2.448*
				(0.42)			(0.75)	(1.75)
High FL/FA * Low Reserves				1.128			0.580	0.503
				(0.98)			(0.41)	(0.32)
External Debt								0.381***
								(7.37)
Real GDP Growth	-0.0386	-0.0448	0.0334	0.0301	-0.0379	0.0303	0.0269	0.0550
	(-0.99)	(-1.05)	(0.41)	(0.36)	(-0.94)	(0.35)	(0.31)	(0.72)
VIX	0.189***	0.203***	0.155***	0.157***	0.104***	0.124***	0.126***	0.117***
	(2.65)	(2.83)	(3.09)	(3.15)	(2.67)	(3.02)	(3.07)	(2.87)
Δrer		1.211	-0.739	-0.851	-0.0942	-1.411	-1.640	-2.365
		(0.71)	(-0.57)	(-0.72)	(-0.08)	(-1.05)	(-1.12)	(-1.12)
Constant	-8.065***	-8.403***	-8.775***	-8.490***	-6.774***	-8.093***	-7.679***	-7.668***
	(-5.44)	(-5.47)	(-6.13)	(-5.40)	(-6.55)	(-6.80)	(-5.88)	(-5.96)
SumReserve								
Inflation Difference								
N	2258	2244	1554	1540	1901	1475	1461	1201
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	All	All	All	All	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.0551	0.0626	0.0776	0.0750	0.00652	0.0278	0.0293	0.0555

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Notes: There are 12 variables (not including the constant) in the first column. The variable in the j^{th} row, $j = 1, ..., 12$ of the first column is explained in subsection 4.2.2, where the variable is referred to as the 'j^{th} variable', $j = 1, ..., 12$; the 'left hand variable' in the logit regression is the Laeven and Valencia (2020) banking crisis indicator; for the list of countries included in 'All', see Online Appendix section E; the countries in 'EME' include the countries in 'All', excluding the ones listed in footnote 52. Our unbalanced panel covers annual data over the period, 1995-2017. In subsection H.2 in the Online Appendix, we redo the table using the period, 2000-2017. Our conclusions are robust to the change in sample. Other robustness checks are reported in section H in the Online Appendix.

This coefficient indicates that the association between (log odds of) a crisis and high deposit dollarization for countries in which Δe is small and the central bank has a relatively high level of foreign reserves, so that the dummy variable Low Reserves is zero.[54] Note that, with one exception, the coefficient on this variable is not significant. In the exceptional case (see column (8)) it is only marginally significant (t statistic less than 2) but has the 'wrong' sign. So, consistent with the bivariate analysis in section 4.1, high dollarization *per se* does not appear to be associated with an increase in the likelihood of a financial crisis.

Column (1) of Table 1 conveys the kind of result reported in Levy-Yeyati (2006). That column suggests that an exchange rate depreciation is less likely to lead to a systemic crisis if deposit dollarization is low (i.e., $Dollar\,(20)_{i,t-1} = 0$). Levy-Yeyati (2006) interprets the significance of the coefficient on the cross product, $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$, as reflecting that high deposit dollarization causes the balance sheet effects of a depreciation to dominate the expenditure switching effects. Levy-Yeyati (2006) interprets this result as a significant count against financial dollarization.

However, we find that the statistical significance of the cross-product coefficient is not robust. First, our principle interest is in EME's and when we focus only on these countries (see column (4)), then the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ ceases to be significant. Second, when we add the other potentially relevant variables listed in subsection 4.2.2 the significance of the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ also disappears and even has the 'wrong' sign (see columns (2), (3), (4) and (5)). Third, note that the logit regression in column (1) does not include the lagged real exchange rate, Δrer. The results in column (2) indicate that the significance of the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ is also not robust to including the real exchange rate.[55] We conclude that deposit dollarization is not associated with an increased probability of systemic banking crisis, particularly in EME's.

Rows 4 and 5 assess the role of High FL/FA in banking crises. There is little support in these rows for the proposition that financial dollarization increases the probability of crisis. Consider row 4 first. This shows that High FL/FA is significant only if we exclude central bank reserves. In particular, in columns (4) and (8) the coefficient on High FL/FA is not significant. Consider row 5. The point estimates of the interaction of High FL/FA and Δe are the 'wrong' sign from the perspective that financial dollarization destabilizes the financials system. The point estimates indicate that in countries with high FL/FA a depreciation is associated with a reduction in the likelihood of a financial crisis. The latter is consistent with the proposition that the expenditure switching effect from a depreciation in a

[54] Recall, according to subsection 4.2.2 Low Reserves = 0 for i, t in which central bank reserves are below the median across i in year t. Impli

[55] In the Online Appendix Section H.10 we display additional evidence on the lack of robustness in Levy-Yeyati (2006)'s findings that the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ is statistically significant. Levy-Yeyati (2006) kindly shared his computer codes and data with us. The lack of robustness of his results is not just due to our use of data from the 2000s. Using Levy-Yeyati (2006)'s own data, we find that the significance of the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ is not robust to small changes in the cutoff used to define "high deposit dollarization" and to allowing for correlation in $\varepsilon_{i,t}$ for fixed i across t.

crisis is stronger than the balance sheet effect. Thus, it appears that financial dollarization, whether measured by deposit dollarization of FL, is not significantly related to increased vulnerability to a systemic financial crisis.

We now discuss the impact of central bank reserves on the results (see rows (6)-(8)). First, the point estimates in row (6) indicate that low reserves are associated with an elevated level of vulnerability to financial crisis. This is consistent with the moral hazard effect of central bank reserves discussed in subsection 4.2.1. The results in column (4) indicate that the moral hazard effect is not significant for all countries taken together. However, the result in column (8) indicates that when we include all the available data for EMEs, the moral hazard effect is strongly significant when we include external debt in the analysis. We return to this momentarily.

The results in rows (7) and (8) indicate that the interaction of Low Reserves with our two measures of dollar financialization are basically not strongly significant. Some evidence that deposit dollarization is risky when central bank reserves are low appears in column (8), but that coefficient is only marginally significant.

Now consider External Debt. This is a variable that we only have for the EMEs. According to column (8) a high external debt has statistically significant, positive impact on the likelihood of financial crisis. This is consistent with Gourinchas and Obstfeld (2012)'s finding that strong credit growth [56] (we assume this requires high external debt[57]) is associated with an elevated chance of financial of financial crisis. As noted above, the inclusion of external debt also raises the significance of the coefficient indicating a moral hazard effect associated with reserves (see row (6)). The results in the table suggest a simple narrative: low reserves and external debt covary with opposite signs with financial crisis but the two variable move together. Omitted variables bias in column (7) implies that low reserves So, when external debt is excluded from the analysis, low reserves alone have to mimic their direct effect with crisis and, because of the missing external debt numbersthe sign of the relationship between low reserves and financial and external debt have opposite relationship between have opposite effects on table suggests that Among the 50 financial crises in the dataset,

remains strong for EMEs that low reserves are discuss our results for central bank reserves and for external debt. According to Table

It is interesting to relate our findings to those in GO and MR. In the case of GO, they report three findings: a real depreciation, a credit expansion and low international reserves are systematically positively related to a financial crisis. When we estimate our

[56] See also Eichengreen and Arteta. (2000); Schularick and Taylor (2012); Sufi and Taylor (2022)

[57] Richter and Diebold (2021) show that in the post 1980, most credit expansions are financed with external debt. Similarly, Jorda et al. (2021) show that Loan/Deposit ratio tends to increase before crises, which indicates that the increase in loans are not financed by local deposits.

logit regression using the subset of our variables that capture the spirit of their regression over the period, 1970-2017, we obtain similar results (see Online Appendix, section XX for details). However, the results are significantly different when we only include the 2000s. over starting from the same date that they do, 1970, we obtain similar results. These are reported in Online Appendix xx. (We don't have credit.) In this 1970-2017 sample we cannot include deposit dollarization include the version of our logit reAccording to our dataset, the real exchange does not have a significant relationship with financial crisis. In our dataset, the real exchange rate ddepreciation is associated with While some coefficients are statistically significant, they are the wrong sign.

We now use our panel dataset to investigate the relationship between central bank reserves and financial crisis. The results are reported in rows 6-8 in Table 1.

in exploit the cross sectional variation in the data to see whether central bank reserves reduce the risk of financial crisis. investigate whether the apparent lack of association between financial dollarization and crisis reflects the management of central bank reserves. see whether central bank reserves reduce the likelihood of financial crisis in the presence of financial dollarization. Although we find that the overall relation between financial dollarization and crisis to be negligible, this may well be due to policiesBecause financial crises occur in our dataset we can exploit cross sectional variation to gain insight into what policies promote financial stability. The results appear in rows 6-8 of Table 1. determine whether there is evidence it is prudent to it is nevertheless prudent to consider policies that minimize the probability of a dollar financial crisis. The *a priori* considerations in subsection 4.1 suggest requiring banks to either hold international dollar assets directly or indirectly by using dollar deposits to acquire dollar deposits at the central bank. This would reduce, though not eliminate, the role of dollarization in providing insurance across different residents of a country. using shifting dollar borrowing from banks and to international financial markets. This would be the general equilibrium effects of placing reserve requirements on dollar deposits. These reserves could be held in the form of reserves at the central bank (which would use them to buy liquid dollar assets on international markets) or in the form of direct purchases of dollar assets on international markets. reducing banks' role in making dollar loans to riskier borrowers, the ones that are unhedged and/or have high leverage. a trade off: it is wise to shift banks' role in making dollar loans to financial firms less able to the international financial that banks' role in making dollar loans to the private sector should be limited to the most Given that banks have relatively high leverage, it may well be prudent to minimize the role that they play in dollars. As discussed in section what policies minimize any financial instability that may may seem important to minimize risk.

Turning to the role of central bank reserves in rows 6-8, our results present mixed signals. Row 6 indicates that in EMEs economies with low reserves and low dollarization have fewer financial crises. By itself (row 6) central bank reserves appear to have a significant impact only in the case of EME's. Surprisingly, low reserves are associated with a *lower* probability of financial crisis in the next year. One possible explanation features moral hazard: in countries where the central bank has ample reserves, banks understand that central banks have the capacity of to provide dollar assistance in case of crisis and banks may view it as a prudent time to take dollar risks.[58] A the same time Pursuing this result would be of interest, but would take us away from our purpose here. From our perspective here, what is interesting is that among the EME's with high deposit dollarization, low reserves increase the chance of a crisis in the next year. This finding is perhaps a warning that, while there may be insurance benefits associated with dollar deposits.

In the one case (row 5, column 6) of significance, the coefficient is the wrong sign. That coefficient implies that countries whose banks have high net dollar foreign debt are relatively less likely to experience a crisis when there is an exchange rate depreciation. It is tempting to infer that the expenditure switching effects of an exchange rate depreciation are stronger than the balance sheet effects. Weak evidence against this inference appears in row 2 where the point estimates of the coefficient on depreciation are positive, though in most cases not significant.

Note that the VIX plays a significant role in all our results. When it comes to EME's the only two variables that matter significantly for a banking crisis are the VIX and the country's external debt (see column (6)).[59] We only include external debt in our analysis of EME's because our data source does not include non-EME data.

Turning to High FL/FA note that columns (2) and (5) imply that that variable is statistically significant. As explained above, there are *a priori* reasons why $FL/FA > 1$ could make the banking system vulnerable to crisis by creating a dollar shortage in the domestic economy. This suggests that the interaction of the Low Reserves dummy with FL/FA should have a positive and significant coefficient. In fact, column (3), (5), (6) show that the coefficient is negative and not significant. So, the positive coefficient on FL/FA appears to be a puzzle, at least for the classic liquidity crises. An alternative interpretation of the results is suggested by the findings in column (6). When we include External Debt in the equation, then FL/FA ceases to be significant. Taken together, the evidence suggests that the statistical significance of FL/FA only reflects its role as an indicator of external debt, and not that FL/FA per se is necessarily important.

[58] Recall the definition of a Laeven and Valencia (2020) banking crisis in subsection 4.1, according to which a crisis is a time when the central bank offers substantial assistance to banks.

[59] In Subsection H.3 in the Online Appendix we explore alternative measures of uncertainty, but find that the VIX has the biggest $t-$statistic. Two alternative measures of uncertainty that are almost as useful as the VIX are "financial stress" (see Puttmann (2018)) and "exchange rate market volatility" (see Baker et al. (2019)). The Online Appendix also considers the "global financial factor" (see Miranda-Agrippino and Rey (2020)) which turns out not to be significant.

In sum, we find that financial crises are forecastable to some extent, with variables like the VIX and external debt.[60] However, our forecasting exercise provides no support to the idea that there is an association between deposit dollarization and financial crises.

4.2.4 Dollarization and the Severity of Banking Crises

Previous subsections show that there is little evidence that deposit dollarization affects the likelihood of a crisis. Here, we ask a different question: "conditional on a crisis occurring, is the economic cost greater for an economy with high deposit dollarization?". We answer this question using the ordinary least squares results reported in Table 2. In each regression the left-hand variable is the quantity of GDP lost that can be attributed to the crisis, as measured in Laeven and Valencia (2020).[61] The cost of a crisis includes lost output in subsequent years for crises that last more than one year.[62] The number of observations, N, at the bottom of the table is relatively small, reflecting the small number of crises in our data. The country-specific right hand variables in Table 2 include only observations on the year before the first year of a crisis. We do this to mitigate endogeneity problems. The only variable that is not country-specific is the VIX, and we include its contemporaneous value on the right side of the regression. The right hand variables in Table 2 are similar to the right hand variables in Table 1 for the sake of symmetry. As in the logit regressions, we permit heteroscedasticity in the error terms, as well as autocorrelation and cross-country correlations (see Petersen (2009)).

The critical result in the table is that the coefficient on deposit dollarization has the 'wrong' sign, but in any case is never significantly different from zero. Note that the adjusted R^2 is negative in column 4 and 6, consistent with the finding that none of the variables in the associated regression is significant, as well as the fact that N is small. Notably, the VIX is never significant for EMEs, despite the fact that it plays an important role in determining the probability of a crisis (see Table 1). Still, it is interesting that the coefficient on the VIX is always negative, and in one case, when we include advanced economies, it is significant. This is (modest) evidence that when the VIX is high then the output loss from a crisis is small. One interpretation of this is based on the fact that the VIX is the only variable that is common across countries. This may suggest that when the trigger of a crisis is external to a country, then the resulting output loss is less severe than when the cause is internal.

Column 5 adds FL/FA, central bank reserves and real GDP growth in the year before a

[60] Subsection (H.12) in the Online Appendix uses standard metrics to show that the model in column (6) of Table 1 represents an 'acceptable' forecasting model for crises. Consistent with the results in the table, those metrics show that the crucial variables for forecasting crises are the VIX and external debt, while deposit dollarization is not related to crises.

[61] For the measure of the amount of output loss in a crisis, see the discussion in Section 4.1.

[62] Scarring effects which continue after the crisis is over are not included in the cost measure.

crisis. As in Table 1, reserves are not significant. Real GDP growth is significant, suggesting that the cost of crisis is greater if it hits an economy that is already weakening for other reasons. Table 1 indicates that slow GDP growth per se does not raise the probability of a crisis. However, since the cost of a crisis is greater if it hits a slow-growing economy, risk aversion may dictate that policymakers prepare for crisis when GDP growth is low.

The significance of FL/FA in column 5 draws attention to a possible cost of financial dollarization. The significance of FL/FA deserves further study. As discussed above, the evidence in Table 1 on FL/FA as a predictor of crises is somewhat mixed. But, Table 2 suggests that once a crisis is underway, the cost of that crisis is greater if FL/FA is high at the time that the crisis begins. Risk aversion would dictate that policy pay attention to FL/FA whether it increases the probability of a crisis or simply makes a crisis worse once it happens.

For our purposes the main takeaway from Tables 1 and 2 is that deposit dollarization does not increase a country's vulnerability to financial crisis and if one occurs, it does not affect its severity. Our results for FL/FA and external debt do indicate that policy pay attention to dollar borrowing by domestic residents from foreigners. It is possible that our measure of banking crises does not fully reflect the financial vulnerabilities of a dollarized economy. For example, Baron et al. (2020) show that there are several credit crunch episodes not linked with an overall banking crises. In order to adress this issue, in Section 5, we review the evidence whether dollar borrowing firms are adversely affected by a depreciation. Using data from Peru and Armenia, we do not find strong balance sheet effects. In Section I we show that FX loans have lower non-performance overall in Peru; non-performance of FX loans rise following an exchange rate depreciation but to a level close to those of Soles loans.

5 Impact of Financial Dollarization on Transmission of Shocks

Even if deposit dollarization does not increase the probability of crisis or raise the cost of crisis once it occurs, it may still have harmful effects in other ways. In particular, given the relative absence of currency mismatch in banks, deposit dollarization forces currency mismatch onto non-financial firms. For example, when the exchange rate depreciates the banking system may remain stable, but firms with heavy dollar liabilities may be forced to inefficiently pass up on good investment and employment opportunities. This is a *balance sheet channel* associated with a depreciation that is similar to the analogous channel for banks discussed in Section 4.2. In line with other evidence in the literature, our empirical results support the idea that, with sensible prudential policy in place, the balance sheet channel is relatively weak. Sales and GDP appear to be the main drivers of nonfinancial firm investment, not exchange rate fluctuations per se. An exchange rate depreciation could also impact investment activity by an *investment price channel* which raises the local currency price of critical imported investment goods. This expenditure switching-type channel has nothing directly to do with the financial dollarization issues considered in this paper.

Table 2: Output Loss in Banking Crises

	(1)	(2)	(3)	(4)	(5)	(6)
Dollar (20)	-16.07	-27.24	-4.827	-22.72	-21.12	37.46
	(-1.25)	(-1.70)	(-0.20)	(-1.01)	(-1.05)	(0.38)
Δer	-51.62	14.54	95.26	-131.7	86.66	324.7
	(-0.77)	(0.25)	(0.77)	(-1.23)	(0.93)	(0.43)
Dollar(20)*Δer	42.69	74.05	-15.77	119.8	-18.14	-505.4
	(0.66)	(0.92)	(-0.12)	(1.14)	(-0.13)	(-0.95)
VIX	-1.300	-2.972*	-2.753	-1.748	-2.835	-2.999
	(-0.94)	(-2.08)	(-1.67)	(-0.96)	(-1.61)	(-0.59)
High FL/FA		27.96**	51.46		30.25**	102.1
		(2.40)	(1.65)		(2.81)	(0.68)
Reserves/GDP		67.54	75.29		107.0	16.54
		(0.45)	(0.43)		(0.68)	(0.06)
Real GDP Growth		-2.005	-2.279		-2.738**	-1.278
		(-1.61)	(-1.36)		(-2.87)	(-0.46)
High FL/FA * Dollar (20)			-29.93			-93.54
			(-0.74)			(-0.60)
External Debt						-0.0470
						(-0.01)
Constant	72.99*	102.3**	79.01	91.36	90.13**	54.25
	(1.77)	(2.92)	(1.55)	(1.71)	(2.40)	(0.28)
N	41	18	18	25	15	13
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	All	All	All	EMEs	EMEs	EMEs
Adj R2	0.00162	0.360	0.327	-0.0247	0.287	-0.172

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Notes: left hand variable is GDP growth; for list of countries see footnote 52.

[63] In any case, the evidence for an investment price channel is also weak.[64] The point estimates are not significant and they are even have the wrong sign.[65]

[63]There may also be an indirect effect, to the extent that imported inputs require foreign finance. That effect may in fact imply that *looser* regulations on financial dollarization are desired. If domestic residents can denominate their saving in dollars, this could make importers less dependent on (possibly fickle) foreign finance for dollars. So, we view that indirect channel between financial dollarization and the investment price channel as ambiguous.

[64]Alfaro et al. (2018) note heterogenous impact of RER depreciations on the performance of exporting firms. In particular, exporting firms which are more dependent on imported intermediate inputs, do not benefit from RER depreciations. So, our evidence against the investment price channel may reflect lack of power. However, we stress that there is no direct relationship between the investment price channel and financial dollarization and if there is an indirect effect, that appears to be ambiguous (see footnote 63).

[65]See the discussion of the results for the exchange rate depreciation, ΔER, in Table I14 in Subsection I.1.1 of the Oline Appendix.

Our analysis is based on two firm-level datasets for Peru and one dataset for Armenia.[66] The first Peruvian dataset has annual observations for 118 firms over the period, 1999-2014. In any one year, this unbalanced panel includes data for 80-100 firms and was constructed for the research reported in Ramírez-Rondán (2019). This dataset is attractive because it has a relatively large number of observations, it includes information about whether or not a firm is an exporter, and it includes the assets and liabilities of the firms by currency of denomination. Moreover, the firms in the dataset account for most of the dollar borrowing by Peruvian nonfinancial firms. This dataset indicates that a firm's investment response to an exchange rate depreciation is not significantly related to the degree of currency mismatch on its balance sheet. Moreover, among the firms with significant currency mismatch, the response of investment to an exchange rate depreciation is not significantly related to whether or not it is an exporter. Finally, we exploit our observations on assets and liabilities by currency denomination to do stress tests on the firm balance sheets. We infer that the reason depreciations have little impact on firms is that the ones with currency mismatch on their balance sheets have low leverage and can handle the consequences of exchange rate fluctuations.

Our second Peruvian dataset was constructed for the research reported in Humala (2019) and contains a balanced panel for 28 large, publicly traded firms. This dataset has the advantage that it includes the period of the large 30 percent currency depreciation that occurred in Peru over the three years, 2013-2015 (see Figure I17d). While the data do not indicate the extent to which firms are naturally hedged by exports, they do include information about firms' holdings of foreign exchange derivatives. We show that there is no significant relationship between a firm's currency mismatch on its balance sheet on the eve of the depreciation, 2012Q4, and its investment over the subsequent years, 2012Q4 to 2016Q4.

Our firm-level annual Armenian dataset resembles our second Peruvian dataset in that it includes a period of sharp depreciation and its aftermath. The Armenian dataset covers the period, 2014-2017, which allows us to study the impact of the abrupt 17% depreciation in the Dram that occurred in a three-month period starting at the end of 2014. The data merge information on credit data by currency from the Armenian credit registry with assets and investment and other firm variables from the tax authorities. With a minor exception, the results are consistent with our findings for the second Peruvian dataset: the investment in 2015, 2016 and 2017 of firms with substantial currency mismatch on their balance sheets on the eve of the depreciation is statistically similar to investment by firms with little mismatch. The results do not change if we control for whether or not a firm is an exporter.

The exception in our analysis of the Armenian data lies with the firms in the top quartile in terms of leverage. Among these highly-leveraged firms, the ones with a relatively high

[66]We thank Paul Castillo for drawing our attention to the Peruvian datasets.

share of credit in dollars in the pre-shock period invested significantly less in 2015 than did highly-leveraged firms with low credit dollarization. The difference in investment among highly-leveraged firms with high and low credit dollarization was not significant in 2016 and 2017. It is not clear how we should interpret these results. To understand why firms with high leverage cut back on investment in 2015 requires investigating the individual firms, something that we cannot do for confidentiality reasons. Although one might be tempted to infer that the results warrant additional prudential regulations, to reach such a conclusion without further information would be a mistake. For example, a number of firms in the sample have leverage so high that they are technically in default.XXexplain how this is even possible in principle...the example in the next sentence involves negative net worthXX There are even some firms whose dollar debt alone exceeds the value of their total assets. Perhaps the leverage of these firms is mis-measured in the sense that assets are measured at historical rather than market value. Or, perhaps these firms have a lot of intangible capital that is not fully reflected in their total asset data.

Although our analyses are (to the best of our knowledge) novel, they complement similar findings for other countries, which already exist in the literature. As a result, we have put the details of our analysis in Section I.1.1 in the Online Appendix.

Regarding the existing literature, Kim et al. (2015) show that small firms in Korea with dollar debt decreased investment following the Asian crises but the effect is negligible (or even positive) for large firms with dollar debt. Hardy (2018) shows similar results for Mexico, small firms with FX mismatch suffer following a depreciation but large firms are able to sustain investment using peso loans. Aguiar (2005) finds that firms with a high amount of short-term dollar debt decreased investment after the exchange rate shock in 1994. However, Aguiar (2005)'s data show that most of the dollar debt issued by firms in Mexico is long-term.[67] Moreover, he finds that the response of investment to an exchange rate depreciation is small for firms that issue longer-maturity debt. In Pratap et al. (2003)'s analysis of Mexican data they report strong balance sheet effects following the 1994 crisis but not in the 1998 crisis. They interpret the difference as reflecting better management of exchange rate risk. Their results are consistent with the view that sound prudential policy is important, but that financial dollarization *per se* is not a problem. Finally, Bleakley and Cowan (2008) study 450 firms in 5 Latin American countries and they find that balance sheet effects are relatively modest.[68] That is, they conclude "...firms holding more dollar debt do not invest less than their peso-indebted counterparts following a depreciation."[69]

[67] See Subsection I.2 in the Online Appendix.

[68] Bleakley and Cowan (2008) using data from Argentina, Brazil, Colombia, Chile, and Mexico.

[69] Casas et al. (2020) report an interesting study of Colombia, but the relevance of that analysis for our investigation is not clear. They find that in Colombia, non-exporter firms with dollar mismatch decreased their imports significantly following an exchange rate depreciation, via the investment price channel. This may reflect an efficient expenditure switching response to a depreciation rather than a problem with dollarization.

In sum, our results and those in the existing literature suggest that the role of balance sheet effects in exchange rate changes is relatively modest in EMEs. Of course, most of this evidence is drawn from post-2000s, a period in which regulatory authorities have been attentive to prudential policy. For example, we show in Figure I15 that dollar default rates are lower than Soles default rates in Peru. But the picture actually shows that dollar default rates have been coming down from a large level. In some cases, there may be a case for strengthening such policies. For example, the evidence from Mexico might warrant making sure firms do not take out too much short term dollar debt and the Armenian data may suggest (subject to the measurement issues raised above) keeping a watchful eye on high-leverage firms that borrow dollars. Similarly, results by Gyongyosi et al. (2022) highlight the results of households mortgage borrowing in foreign currencies.

At the same time, it is important to bear in mind that it is not the purpose of prudential policy to eliminate private sector risk-taking altogether. Risk taking (which by definition means encountering the possibility of failure and even ruin) is in many ways the driving force of innovation and economic growth. The purpose of prudential policy is to prevent firms from making risky decisions in cases where the consequences of those risks are born by others without their consent or knowledge. For example, if firms which look technically bankrupt are nevertheless able to receive dollar loans because of implicit government guarantees, then those loans put taxpayers at risk and such firms may well warrant prudential scrutiny. Similarly, firms in systemically critical positions may also warrant prudential oversight.

The principle in the previous paragraph suggests that banks should not be permitted to have large currency mismatch on their balance sheets.[70] Banks typically have a much higher level of leverage than nonfinancial firms, and so they cannot handle substantial currency depreciation. This is especially so because central banks in EMEs have at best only a limited capacity to act as lenders of last resort when there is a dollar liquidity problem. Because a large part of bank liabilities serve as the medium of exchange for transactions in goods and services, if banks fail because of an exchange rate depreciation, the consequences are felt by a wide range of people who took no part in the bank's currency portfolio decisions. Fortunately, these views are widely understood and, as we show in Subsection 3.2.1, regulators in the 2000s appear to have successfully acted to prevent currency mismatch in their national banking systems.[71]

[70] It is also important that term mismatch in dollar assets and liabilities be avoided. When long-term illiquid dollar assets (e.g., loans to nonfinancial firms) are financed by short-term dollar liabilities, a failure of creditors to roll over the dollar liabilities could quickly result in dollar mismatch as assets have to be sold at fire-sale prices (see, e.g, Gertler and Kiyotaki (2015)).

[71] Another example of dollarization where prudential regulation is warranted is the large increase in foreign-currency denominated mortgages taken by households in Eastern Europe, which is an exampleof highly levered borrowing. Presumably, a number of factors contributed to this phenomenon. Among these is a moral hazard problem when a large group of people undertake a correlated risk (e.g., acquire foreign

What is important for our analysis is that, overall, most firms with dollar mismatch do not appear to cut back on investment after a depreciation. We conclude that, with sensible prudential policy in place, the dollar mismatch pushed onto non-financial firms by households that choose to hold dollar deposits does not appear to impose substantial economic disruption on EME economies.[72]

6 Model

Following is our two-period model designed to interpret the results reported in previous sections. We interpret the model as capturing a 'representative year' in a typical EME, though we parameterize it using data from Peru. In the model we think of 'Period 1' as the point at the end of that period, after worker-household consumption has occurred and their consumption saving decision is a state variable. The only decision for the worker-household in Period 1 is a portfolio decision about how to allocate saving between local currency and foreign currency deposits. These deposits, as well as potential finance from abroad, are used to finance period 1 capital investment by a firm-household which has no resources of its own. The model continues into period 2 when production and consumption occurs. We use this interpretation of the model as a guide for choosing reasonable parameters. Still, the model is highly stylized to maximize transparency of the analysis.

6.1 Worker-Households

Households have claims on Y units of the *domestic good*, at the start of period 1. They sell all the goods in the period 1 domestic goods market and deposit the corresponding credits in a domestic bank. The bank offers two types of deposits, d and d^*, both denominated in units of the period 1 domestic good. The first type of deposit, d, offers a state non-contingent claim on dr period 2 final domestic consumption goods. The second type of deposit, d^* offers a state non-contingent claim on d^*r^* period 2 foreign goods. We denote r as the 'peso interest rate' and r^* as the 'dollar interest rate'. Similarly, we refer to d as 'peso deposits' and d^* as 'dollar deposits'. These must be chosen before the household knows the realization

currency-denominated liabilities). In this case, members of the group may, knowing that many others are undertaking the same risk, believe that the government (e.g., other tax payers) will come to the rescue in case things go awry and there is a substantial appreciation in the currency in which the debt is taken. Fortunately, regulators are now well aware of this risk and are taken suitable measures. Gyongyosi et al. (2022) show that households with FX mortgage debt decreased consumption in Hungary following the depreciation in 2008; still they find that mortage default rates were well below 1% for FX loans.

[72] In principle, dollarization can also interfere with monetary policy, which we abstract from in this paper. Camara et al. (2021) explore unconventional monetary tools in dollarized economies.

of the period 2 shocks, subject to:

$$d + d^* = Y. \tag{7}$$

The household's period 2 budget constraint is:

$$c_2^{house} = dr + d^* r^* e_2 + w_2 l_2 = (e_2 r^* - r)\, d^* + w_2 + Yr, \tag{8}$$

after substituting out for d using equation 7. Here c_2^{house} and w_2 denote period 2 consumption and labor earnings, respectively. They are denominated in terms of the period 2 final consumption good. In (8), e_2 denotes the real exchange rate in period 2. That is, one unit of period 2 foreign good can be purchased with e_2 units the period 2 final consumption good. The restriction, $c_2^{house} \geq 0$, for all realizations of period 2 shocks restricts the household's d^* decision in period 1. Finally, we have imposed the assumption that households supply one unit of labor in period 2 inelastically.[73]

The problem of the household is to choose d^* to solve

$$\max_{d^*} Ec_2^{house} - \frac{\lambda}{2} var\left(c_2^{house}\right), \tag{9}$$

subject to the second restriction in (8). The solution to a problem with these mean-variance preferences is standard:[74]

$$d^* = -\frac{E\,(r - e_2 r^*)}{\lambda var\,(r^* e_2)} - \frac{cov\,(r^* e_2, w_2)}{var\,(r^* e_2)}. \tag{10}$$

Here, E, cov and var are the expectation, covariance and variance operators, conditional on period 1 information. The first term reflects the household's *speculative motive* for holding deposits and the second term reflects the worker-household's *hedging motive*. For the model to be empirically interesting, it must be that in equilibrium there is a premium on pesos, that is, $E\,(r - e_2 r^*) > 0$. The speculative motive alone would then imply that the household wants to go short on dollars and set $d^* < 0$. Of course, in the data we observe $d^* > 0$. This can be an equilibrium in an empirically plausible version of our model if the household has

[73]The model with peso and dollar deposits is isomorphic to a model with no dollar deposits and a futures market in dollars. For the details, see the Online Appendix. The observation is perhaps already obvious from the second equality in equation (8). Note that $(e_2 r^* - r)\, d^* = (e_2 r^* - F)\, L$ where $L = r^* d^*$ and $F = r/r^*$. Here, L denotes the number of long futures contracts acquired in period 1 to take delivery of a dollar in period 2. The object, F is the number of pesos to be paid in period 2 for one futures contract. Under this alternative arrangement, all deposits are made in pesos in period 1, so that earnings from deposits in period 2 correspond to Yr. Under the futures contract, the household receives a payment of $(e_2 - F)\, L$ pesos from the futures exchange in period 2 if $(e_2 - F) > 0$. Otherwise, $(e_2 - F)\, L$ is a payment made by the household to the futures exchange. In principle, the household could go long or short (i.e., $L < 0$) in dollars, though in the empirically relevant range $L > 0$. Our requirement, $c_2^{house} \geq 0$ in all period 2 states of nature means that the household can guarantee payment to the exchange by putting up its period 2 income as collateral.

[74]For details, see the Online Appendix, section J.1.1.

the right hedging motive.

By equation (10), having the right hedging motive means that the covariance term must be sufficiently large and negative. Put differently, it must be the case that e_2 depreciates in states of the world when w_2 is low. We assume that in period 2, production occurs using a Cobb-Douglas production function, so that the workers' earnings, w_2, are proportional to period 2 GDP. So, the worker 'has the right hedging motive' if the exchange rate depreciates in a recession.

6.2 Firm-Households and Period 2 Domestic Output

Identical, competitive local firms are on the other side of the period 1 lending market. The representative firm needs period 1 resources to produce capital, K. Capital is used, in combination with the labor of the household, to produce a period 2 tradable good.

The firm produces K in period 1 using domestic, k_h, and foreign, k_f, inputs using the following production function:

$$K = k_h^{\omega} k_f^{1-\omega}. \tag{11}$$

Conditional on producing a given amount of K, cost minimization leads the usual constant expenditure share expressions:

$$e_1 k_f = (1-\omega)\, p^K K,\ k_h = \omega p^K K, \tag{12}$$

where $e_1 k_f$ is the domestic period 1 goods value of k_f and e_1 is the period 1 exchange rate. Also, p^K denotes the marginal cost of producing K:

$$p^K = \left(\frac{e_1}{1-\omega}\right)^{1-\omega} \left(\frac{1}{\omega}\right)^{\omega}, \tag{13}$$

which is exogenous to the firm. We refer to p^K as the shadow price of capital.[75]

The firm must issue debt, b, b^*, into the period 1 domestic financial market in order to produce K, subject to

$$p^K K = b + b^*. \tag{14}$$

Here, b and b^* denote peso and dollar loans, which must be repaid at interest r and r^*, respectively, in period 2. These loans are denominated in units of the period 1 domestic good. The model does not include foreign direct investment (FDI). In part, this is because FDI plays no role in our empirical analysis.[76]

[75]The marginal cost expression in equation (13) is the standard one for the Cobb-Douglas production function in equation (11). For further discussion see subsection J.1.2 in the Online Appendix.

[76]We leave the introduction of FDI to future work. One way to introduce FDI into the model is to allow

Capital is used by the firm to produce the period 2 tradable good, Y_2^h, as follows:

$$Y_2^h = (AK)^\alpha l_2^{1-\alpha}, \tag{15}$$

where l_2 denotes the quantity of labor hired in period 2 and A denotes a technology shock realized in period 2. All shocks, including A, are modeled as the realization of a binomial distribution of the following form: $A \in (\mu_A (1-\sigma_A), \mu_A (1+\sigma_A))$, with probability 1/2 for each possible realization. In this way, the mean of A is μ_A and its standard deviation is $\mu_A \sigma_A$. Approximately, σ_A is the standard deviation of $\ln A$.

Conditional on the realization of A and its period 1 chosen value of K, the firm chooses l_2 in period 2 to optimize earnings from K, $p_2^h Y_2^h - w_2 l_2$. Here, p_2^h denotes the number of period 2 final consumption goods needed to purchase a unit of the period 2 tradable good. The optimized earnings of the firm correspond to $\alpha p_2^h Y_2^h$. It is convenient to write this as $r_2^K K$, where r_2^K is the marginal contribution to earnings of a unit of capital:

$$r_2^K = \alpha p_2^h Y_2^h / K. \tag{16}$$

Because the firm is competitive and K/l_2 is a function of p_2^h, w_2 and A, we treat the marginal earning on capital as exogenous to the firm.

The firm's consumption of final period 2 consumption goods, c_2^{firm}, must satisfy its budget constraint,

$$c_2^{firm} = r_2^K K - (br + b^* r^* e_2) = \left(R_2^K - r\right) p^K K - b^* \left(e_2 r^* - r\right), \tag{17}$$

where the second equality follows by substituting out for b using equation (14).[77] Also, the rate of return on capital, R_2^k, is the marginal earnings on capital, divided by its shadow price:

$$R_2^K = \frac{r_2^K}{p^K}. \tag{18}$$

We assume that in period 1 the firm chooses K and b^* to maximize the following mean-variance objective:

$$\max_{b^*, K} E(c_2^{firm}) - \frac{\lambda}{2} var(c_2^{firm}), \tag{19}$$

foreign financiers to come into the country and build K in period 1 and reap the rewards in period 2, just like our firm-households. A difference is that the foreign financiers' preferences are in terms of the dollar good (see Equation (28) below), while the firm-household preferences are in terms of the domestic good (see equation (9)).

[77] In terms of the futures market in footnote (73), with $b^* > 0$ the firm in effect goes long on $b^* r^*$ futures contracts in dollars.

subject to (17) and $c_2^{firm} \geq 0$ in each period 2 state of nature. Optimization of b^* implies:

$$b^* = \frac{E(r - e_2 r^*)}{var(e_2 r^*)\lambda} + \frac{cov\left(e_2 r^*, r_2^K\right)}{var(e_2 r^*)}. \tag{20}$$

Note that, like the household's d^* decision, the firm's b^* decision decomposes into a speculative and a hedging component. If the exchange rate depreciates (e_2 high) in states of nature in which the firm's income is low (i.e., r_2^K is low) then the hedging motive makes the firm averse to borrowing in dollars. By equation (16), r_2^K, is proportional to $p_2^h Y_2^h$. Below, (see equation (41)) we show that $p_2^h Y_2^h$ corresponds to period 2 GDP. Thus, the hedging motive of the firm is the same as it is for the household, so that makes the firm averse to borrowing in dollars. However, the firm can be induced to borrow in dollars anyway by the speculative motive if there is a sufficiently high premium on the domestic interest rate (i.e., $E(r - e_2 r^*) > 0$).

Finally, optimization of K leads to the following solution:

$$p_1^K K = \frac{E\left(R_2^K - r\right)}{var(R_2^K)\lambda} + \frac{cov\left(e_2 r^*, R_2^K\right)}{var(R_2^K)} b^*. \tag{21}$$

6.3 Foreign Financiers

There is a representative and competitive foreign financier that also participates in domestic financial markets. Analogous to the other agents in the model, the financier has mean-variance preferences over period 2 foreign consumption. In period 1 financier borrows b^f in the foreign financial market, where b^f is denominated in foreign goods. The financier must pay back $b^f r^\$$ in period 2, where $r^\$$ is period 2 foreign goods per period 1 foreign good borrowed in the foreign market. In equilibrium,

$$e_1 r^* = r^\$, \tag{22}$$

for otherwise the financier would have an arbitrage opportunity. The financier uses the borrowed 'dollars' to make loans in the domestic credit market. Of these loans, $x^\$$ is the quantity of dollar loans and x^D is the quantity of peso loans. Both $x^\$$ and x^D are in units of foreign goods, so that the foreign financiers' financial constraint is:[78]

$$x^\$ + x^D = b^f. \tag{23}$$

[78]Here, we adopt an important simplification, that foreigners do not do direct investment (see Footnote 7).

The foreign financier has other exogenous income, Y_2^f, in period 2, in foreign goods. This other income is imperfectly correlated with the period 2 foreign demand shifter, which we denote by Y_2^*. In particular,

$$Y_2^* = \xi + \nu, \tag{24}$$

where ξ and ν are independent random variables which are realized in period 2. We model these variables in the same way as A. Thus, ξ and ν each have a binomial distribution with mean μ_ξ and μ_ν, respectively. Similarly, they have standard deviations, $\mu_\xi \sigma_\xi$ and $\mu_\nu \sigma_\nu$. We assume that the financier's period 2 other income has the following form:

$$Y_2^f = s\nu, \tag{25}$$

where s is a parameter that is known in period 1 before the financier solves its problem. Thus,

$$cov\left(Y_2^f, Y_2^*\right) = s \times \sigma_\nu^2. \tag{26}$$

The financier's consumption is the foreign consumption good value of its period 2 earnings:

$$x^\$ e_1 r^* + \frac{x^D e_1 r}{e_2} - b^f e_1 r^* + Y_2^f, \tag{27}$$

where we have substituted out $r^\$$ using the arbitrage condition, equation (22). After substituting out for b^f from 23, the financier's consumption of period 2 foreign goods is, after rearranging:

$$\left(r - r^* e_2\right) x^D \frac{e_1}{e_2} + Y_2^f. \tag{28}$$

According to this equation, foreign financier's only choice is x^D. We assume the foreign financier has mean-variance preferences with parameter λ^f, so that optimization leads to:

$$x^D = \frac{E\frac{e_1}{e_2}\left(r - e_2 r^*\right)}{var\left(\frac{e_1}{e_2} r\right)\lambda^f} - \frac{cov\left(\frac{e_1}{e_2} r, Y_2^f\right)}{var\left(\frac{e_1}{e_2} r\right)}, \tag{29}$$

after using the no-arbitrage condition, equation (22). We have stressed that an empirically plausible model of an EME will have the property that there is a premium on the local currency. Equation (29) implies that, other things the same, this motivates foreign financiers to lend in terms of domestic currency. Of course, if they actually did this to a sufficient extent, then in equilibrium there could be no premium on the domestic interest rate. However, the foreign financiers also have a hedging motive. Suppose that in states of the world when the exchange rate depreciates (i.e., e_2 is high) their other sources of income, Y_2^f, are low. In that case, their hedging motive makes foreign financiers averse to lending in domestic currency, even in the presence of a local premium[79]. This aversion to investing in domestic assets endogenously generates limited participation of foreign investor in our model[80]. The covariance between the exchange rate and foreign income can be motivated by global financial cycle (Miranda-Agrippino and Rey (2020); Bruno and Shin (2015a); Gourinchas et al. (2010)), that whenever the world economy as a whole goes into trouble, USD tends to appreciate. It is Similarly, Lustig and Verdelhan (2007) and Lustig et al. (2011) highlight the common risk exposures faced by world currencies. Hofmann et al. (2022) show how EM currencies tend to move together during global turmoils so that it is hard to diversify EM currency risk.

6.4 Final Consumption Good Production in Period 2

The final good is produced in period 2 by combining the domestically produced period 2 good, c_2^h, with an imported period 2 foreign good, c_2^f. We model this as being accomplished by a zero-profit, representative competitive good firm. The firm's CES production function is:

$$c_2 = \mathbb{A}\left[\omega_c^{\frac{1}{\delta}}\left(c_2^h\right)^{\frac{\delta-1}{\delta}} + (1-\omega_c)^{\frac{1}{\delta}}\left(c_2^f\right)^{\frac{\delta-1}{\delta}}\right]^{\frac{\delta}{\delta-1}}, \quad \mathbb{A} = \omega_c^{\omega_c}\left(1-\omega_c\right)^{1-\omega_c}\ 0 < \delta \leq 1. \tag{30}$$

The firm solves

$$\max_{c_2, c_2^h, c_2^f} c_2 - p_2^h c_2^h - e_2 c_2^f, \tag{31}$$

subject to the production function. Optimization leads to the following conditions:

$$c_2^h = c_2 \omega_c \mathbb{A}^{\delta-1}\left(p_2^h\right)^{-\delta},\ c_2^f = c_2\left(1-\omega_c\right)\mathbb{A}^{\delta-1} e_2^{-\delta}. \tag{32}$$

It is well known that with linear homogeneity in production and perfect competition, equilibrium requires that the factor prices (expressed in units of the output good) satisfy a simple relation. We obtain this relation by substituting (32) into the production function

[79] In practice, we refer to $E\left(r - e_2 r^*\right)$ as 'the local premium'. This takes the perspective of the local lenders. Foreigners will view the local premium in foreign units, $E\frac{e_1}{e_2}\left(r - e_2 r^*\right)$. In principle, these are two different objects. Below, we will see that they are roughly the same in the data, as well as in our calibrated model.

[80] Home bias in equity investments is also noted by French and Poterba (1991)). In this paper we focus on the hedging motive, which limits the foreign participation. As an alternative channel, Albuquerque et al. (2009) argue that local investors might have informational advantage over global investors in domestic markets.

and rearranging, to obtain:

$$p_2^h = \begin{cases} \left[\frac{A^{1-\delta}-(1-\omega_c)(e_2)^{1-\delta}}{\omega_c}\right]^{\frac{1}{1-\delta}} & 0 < \delta < 1 \\ (e_2)^{-\frac{1-\omega_c}{\omega_c}} & \delta = 1 \end{cases}.$$

6.5 Market Clearing, Balance of Payments and GDP

This section describes the goods and financial market clearing conditions in periods 1 and 2.

6.5.1 Period 1

The market clearing condition in the period 1 goods market is given by

$$c_1^* + k_h = Y. \tag{33}$$

Here, Y is the period 1 endowment of domestic goods, which is supplied to the goods market. The demand for domestic period 1 goods is the sum of the demand by firms, k_h, and the demand by foreigners, c_1^*. We assume that foreigners' demand for domestic goods is given by:

$$c_1^* = \omega e_1^\eta Y_1^*,\ \eta > 0, \tag{34}$$

where η denotes the elasticity of demand for exports and Y_1^* denotes the foreign demand shifter, in units of foreign goods.

There are clearing conditions in each of the two financial markets in period 1. The supply of peso loans is $d + x^D e_1$ and the demand for those loans is b. Clearing requires:

$$d + x^D e_1 = b. \tag{35}$$

Similarly, clearing in the period 1 market for dollar loans requires

$$d^* + x^\$ e_1 = b^*. \tag{36}$$

The balance of payments in period 1 requires that the receipts for exports net of imports, $c_1^* - e_1 k_f$, equals assets acquired by domestic residents, $d + d^*$, net of liabilities issued by domestic residents, $b + b^*$:

$$c_1^* - e_1 k_f = d + d^* - (b + b^*). \tag{37}$$

6.5.2 Period 2

The market clearing condition in the period 2 domestic tradable goods market is given by

$$Y_2^h = c_2^h + c_2^*, \tag{38}$$

where c_2^* denotes exports. Although the firm is competitive and takes the price of the tradable good, p_2^h, as given, the tradable good is specialized on international markets and therefore has the following demand curve:

$$c_2^* = \left(\frac{e_2}{p_2^h}\right)^\eta Y_2^*. \tag{39}$$

Here, Y_2^* denotes foreign GDP in period 2 and e_2/p_2^h is the period 2 relative price of the foreign good relative to the domestic, tradable good. The market clearing condition for period 2 final consumption goods is given by:

$$c_2 = c_2^{house} + c_2^{firm}.$$

Domestic GDP in period 2 is defined as the sum of consumption and exports net of imports:

$$GDP_2 = c_2 + p_2^h c_2^* - e_2 c_2^f. \tag{40}$$

Using the zero profit condition for final good producers (the maximized value of the objective in (31) is zero) as well as market clearing, (38), we find that GDP_2 in equation (40) can be expressed in value-added terms as follows:

$$GDP_2 = p_2^h Y_2^h. \tag{41}$$

So, by equation (16) and its analog for w_2 :

$$r_2^K = \alpha GDP_2/K, \; w_2 = (1-\alpha) \, GDP_2, \tag{42}$$

where we have used the fact that equilibrium employment is unity in period 2.

The balance of payments in period 2, in units of final consumption goods, requires that the receipts for net exports, $p_2^h c_2^* - e_2 c_2^f$, must equal net foreign asset accumulation. Because period 2 is the last period, net asset accumulation in period 2 results in a zero stock of net assets at the end of period 2. For example, if the net asset position at the end of period 1 were positive, then net asset accumulation in period 2 would be negative and the trade surplus would be negative as well.

On the asset side, recall that net asset accumulation by domestic residents in period 1 is

$d + d^* - (b + b^*)$, in units of period 1 domestic goods. The period 2 net earnings on those assets, in period 2 final consumption units, is

$$dr + d^* r^* e_2 - (br + b^* r^* e_2).$$

So, the balance of payments requires:

$$p_2^h c_2^* - e_2 c_2^f = br + b^* r^* e_2 - (dr + d^* r^* e_2). \tag{43}$$

That is, net exports must be positive in period 2 if interest obligations to foreigners exceed their obligations to domestic residents.

6.6 Model Results

In effect, our model provides a narrative motivated by the data that we study. In the first section we consider a special case for which we obtain a simple analytic result that illustrates that narrative. After that, we assign values to the model parameters and then explore the model's implications in greater detail. The section below describes the calibration of the model, which uses data from Peru. We then discuss the ability of our model to reproduce the key features of the Peruvian data.

6.6.1 Analytics: the Simple Narrative in the Model

The core hypothesis of this paper is that within country insurance flows are important and perhaps of even greater magnitude than inter country flows. In the extreme case, all insurance in the domestic economy is between residents ('intra-national') and none is international. This is the case, $b = b^*$ (see equation (3)). Then, equating d^* from (10) with b^* from (20) and rearranging, we obtain:

$$E(r - e_2 r^*) = -\frac{\lambda}{2} cov\left(r^* e_2, w_2 + r_2^K K\right) = -\frac{\lambda}{2} cov\left(r^* e_2, GDP_2\right). \tag{44}$$

Here, the second equality uses equation (41). According to this expression, there is a positive premium on peso deposits if the exchange rate depreciates when GDP is low. This expression is consistent with the very simple intuition in the introduction, in which we (temporarily) disregarded the role of foreigners in domestic credit markets.

This makes households averse to lending in local currency and drives them to hold dollars. The effect is to create a premium on the domestic interest rate to encourage local firms to borrow in dollars. Foreign financiers could in principle come in and wipe out the domestic currency premium. They don't do so because they have the same hedging motive to avoid lending in domestic currency units that households have. Although we do not describe the world economy, we have in mind that EME exchange rate uncertainty is a bad hedge for developed-country suppliers of finance.

6.6.2 Calibration

We simply set $r^{\$} = \delta = 1$, and $\omega_c = 0.75$, $\omega = 0.65$. The latter two values ensure home-bias in the production of period 2 consumption goods and period 1 capital goods (see equations (30) and (11)). All three shocks are iid with the given standard deviations. For simplicity we assumed each random variable can take 2 values with equal probability. Overall, we have 8 possible realizations of the three shocks in period 2.We use the Peruvian data to calibrate the following remaining model parameters:

$$\sigma_A, \mu_A, \sigma_\eta, \mu_\eta, \sigma_\xi, \mu_\xi, s, \alpha, \lambda, \lambda^f, \eta, Y_1^*, Y_1.$$

In our baseline calibration we impose that the foreign financiers have the same risk aversion parameter as domestic agents, $\lambda^f = \lambda$. We choose the 12 free parameters to get as close as possible to 10 calibration targets, which correspond to the 10 numbers in column (d) in Table 4. Each calibration target is an average of annual data covering period in the 2000's indicated in the note to Table 4. We choose the parameters to optimize a metric which, roughly, minimizes a weighted sum of the squared deviations between the variables in the 'model' column of Table 4 and the 'Peru' column, when both are available.[81]

Our calibration targets are constructed from averages of annual Peruvian data covering the period, 2000-2018. The results are reported in Table 4. Data from the Central Bank of Peru (CBP) website suggests $d^*/(d + d^*) \simeq .44$, where d^* denotes dollar by residents in local banks and d denotes their local currency deposits. Data from the CBP and the Bank for International Settlements (BIS) suggests that $b^*/(b + b^*) \simeq 0.40$, where b^* denotes dollar loans to non-financial firms plus dollar bonds issued in international financial markets.[82] In the Peruvian data, $(d^* - b^*)/d^* = -0.07$. The fact that d^* is similar in magnitude to b^* indicates that exchange rate fluctuations reallocate funds among Peruvians, and only to a much smaller extent between Peruvians and foreigners. In particular, inter-country insurance due to dollar debt in the calibrated model is 7% of the insurance flowing between households and firms within the country. This result for Peru is somewhat less than what we found for the median country in our dataset (see Figure 7).

[81] With one exception, we assign unit weight to each square deviation. The exception, the scaled trade deficit, receives a weight of 100. We found it helpful to initiate calculations using the additional convex and differentiable penalty that is non-zero when any of the following variables are negative: $E(r - r^* e_2)$, $d - b$, $1.05 - r$, $\alpha - 0.36$. Note from the results in the table that these constraints are non-binding.

[82] As noted above, we do not consider equity investment or foreign direct investment by foreigners.

Not surprisingly, the local interest rate premium in Peru is quite high, a little over 2 percent, which is also roughly the average over the premia for the 10 EMEs in Figure 4. Our 2 percent number is reasonably close to the roughly 3.5 percent premium reported in Gourinchas et al. (2010).[83] This premium represents a tax on holding dollar deposits rather than soles deposits and our model takes the position that holders of dollar deposits do so because of its insurance value. To be specific about this, it is useful to combine our solution to the household's dollar deposit decision (see equation (10)) with equation (40) and other equilibrium conditions. In particular the Cobb-Douglas assumption about production in equation (15) implies that the wage bill, w_2, is proportional, to GDP_2, $w_2 = \alpha GDP_2$. Substituting this into the household deposit decision we obtain:

$$d^* = -\frac{E\left(r - e_2 r^*\right)}{\lambda var\left(r^* e_2\right)} - (1-\alpha)\frac{cov\left(r^* e_2, GDP_2\right)}{var\left(r^* e_2\right)}. \tag{45}$$

One of our calibration targets is the correlation between the Peruvian goods value of a dollar and Peruvian GDP, which is -0.20 (see Table 4). This maps into a negative value for the covariance term in equation (45), explaining why $d^* > 0$ even though households lose money on average holding dollars.

Note that the share of borrowing in dollars by firms is relatively large. In the Peruvian data the number is 40 percent and in our model it is 60 percent. Given the relatively low interest rate on dollars, why don't firms denominate 100 percent of their debt in dollars. The reason is the mirror image of why households prefer to lend in dollars rather than local currency. To see this, combine the firm's borrowing rule, equation (20), with equation (40) to obtain:

$$b^* = \frac{E\left(r - e_2 r^*\right)}{var\left(e_2 r^*\right)\lambda} + \alpha\frac{cov\left(e_2 r^*, GDP_2\right)}{var\left(e_2 r^*\right)K}.$$

Note that the covariance terms are identical across firms and households, except for the sign. So, firms don't do all their borrowing in dollars because that is a bad hedge for them.

We now turn to the foreign financiers. In our Peruvian dataset, only about 1 percent of non-financial firm local currency borrowing is financed by foreign financiers (i.e., $100 \times (b-d)/b \cong 1$).[84] Why don't foreigners' exploit this apparent profit opportunity by lending local currency in large quantities and thereby erase the interest rate premium? The answer in our model is that foreigners have the same hedging motive to avoid local currency assets

[83] The premium in our model and in the Gourinchas et al. (2010) analysis are not completely comparable. First, theirs is an average over all non-US countries. Second, as Gourinchas et al. (2010) point out, their interest rate spreads compare the return on foreign assets with risky payoffs held by US residents against relatively risk free liabilities issued to foreigners by US residents. Our model abstracts from uncertainty in asset payoffs. The only uncertainty for agents to consider in the choice of financial instruments has to do with the exchange rate in period 2.

[84] Recall, from equation (35), that $x^D e_1/b = (b-d)/b$.

that local residents have. In particular, the dominant shocks in the model are the shocks to foreign demand, Y_2^*, and when $s > 0$ the income of foreign financiers is positively correlated with those shocks[85]. So, when domestic GDP_2 is low and e_2 is high, local residents are happy to have dollar deposits rather than domestic deposits and foreign financiers feel the same way. Thus, if we ignore the hedging motive in foreign financiers' demand for local currency deposits and only include the speculative motive, they would attempt to lend 540% of $(b-d)/b$, rather than 1 percent. Another way to see this point is to recompute the model equilibrium setting $s = 0$, so that foreign financiers have no hedging motive. The model equilibrium for that case is reported in column (e) of Table 4. We can see that the domestic premium falls by one percentage point. This reflects that firms substantially increase their lending in local currency (note the jump in $(b-d)/b$) and households greatly increase their holdings of dollar deposits. Indeed, households borrow local currency to finance their dollar borrowing.[86] So, the hedging motive of foreigners plays an important role in our model calibration. In column (f) we show what happens when we raise λ^f (holding other parameters at their calibrated values) by enough to hit the target on the local interest rate premium. To do this, we have to raise λ^f all the way to 45. Note that with one exception, the model continues to hit the targets. The exception is that foreigners now play a bigger role in financing local firms' peso debt. Even though foreign financiers are now more risk averse, the absence of the hedging motive causes them to still lend a lot in domestic currency. We take it as given that foreign financiers' risk aversion is not an order of magnitude higher than that of domestic residents. We conclude that, conditional on our model, the hedging motive of foreign financiers plays a crucial role in quantifying basic features of the data. In many ways, our model resembles the models used in the literature, (e.g., Gabaix and Maggiori (2015) and Bruno and Shin (2015b)). This literature typically abstracts from this hedging motive (see Lustig and Verdelhan (2007) for the importance of the hedging motive).

[85] As we discuss in Section 3.1, many shocks can be behind the negative covariance between income and the exchange rate. For simplicity, we focus on export demand shock in the model. Obstfeld (2022) argues that trade fluctuations are important drivers of business cycles, especially for more open EMEs. Further, it has been suggested that export demand shocks can explain negative covariance between income and the exchange rate in small countries (Hassan (2013)); countries that are away from the center of trade networks (Richmond (2019)). It has also been suggested that dollar invoicing could contribute to the negative covariance by muting expenditure switching channel (Gopinath et al. (2020); Akinci and Queralto (2018); Camara et al. (2021); Dalgic and Ozhan (2021)). Another related mechanism could be related to global value chains (GVC, Antràs and Chor (2013)); export demand is less elastic in industries that are more upstream in the GVC (Fadinger et al. (2022)) so that countries that are dominated by upstream industries might face muted response of exports to exchange rate changes.

[86] Because $d^*/(d+d^*) > 1$ in column (e) of Table 4, it follows that $d < 0$.

Table 3: Calibrated Model Parameter Values

Parameter	Description	Value
α	Capital Share, 15	0.38
λ	Risk aversion, domestic residents, 9, 19	1.55
λ^f	Foreign Financier Risk aversion, 29	1.55
η	Elasticity of demand for exports, 34, 39	3.28
Y^*	Period 1 trade demand, 34	1.35
s	Covariance parameter, financier income, 26	3.82
Y	Period 1 GDP, 7	3.17
μ_ν	Mean, ν shock to foreign demand, 24	2.97
μ_A	Mean productivity, 15	7.85
μ_ξ	Mean, ξ shock to foreign demand, 24	7.16
σ_A	Std dev, log productivity, 15	$0.22\mu_A$
σ_ξ	Std dev, log ξ shock to foreign demand, 24	$0.68\mu_\xi$
σ_ν	Std dev log u shock to foreign demand, 24	$0.22\mu_\nu$

Note: model parameters selected to optimize a penalty function based on discrepancy between the entries in the 'Peru' and 'Model' columns in Table 4

6.7 Results

Correlation between GDP and Exchange Rate vs Dollarization

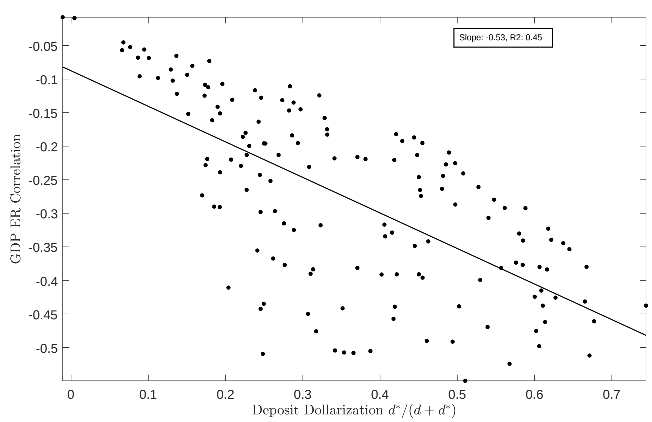
Figure 10 replicates figure 2 using model simulations. The model is simulated using different values for standard deviations of trade, foreign income, productivity shocks. Note that the model can get the basic correlation right and it is flexible enough to allow for dispersion.

Table 4: Endogenous Variables and Corresponding Values for Peru[1]

Variable	Description	Model	Peru	$s=0$ no adj.	$s=0$ adj. λ^f only
(a)	(b)	(c)	(d)	(e)	(f)
$\frac{b+b^*}{d+d^*}$	$\frac{\text{Total domestic borrowing}}{\text{Total domestic lending}}$	1.02		1.04	1.02
$100\times(r-1)$	Domestic Rate	-0.3%	-0.3%	-0.2%	-0.3%
$E(e_2r^*)$	Expected Dollar Rate	0.975		0.975	0.975
$100\times E(r-e_2r^*)$	Spread (domestic agents)	2.24%	2.20%[6]	1.19	2.20%
$100\times E(\frac{r}{e_2}-r^*)$	Spread (financier)	2.50%		1.38%	2.46%
$d^*/(d^*+d)$	Deposit Dollarization	0.60	0.44[2]	1.26	0.62
$\frac{b-d}{b}$	Foreign Source of Peso Credit	0.04	0.01[3]	1.22	0.16
$\frac{d^*-b^*}{d^*}$	Foreign Absorption of Dollar Deposits	-0.00	-0.07[3]	1.14	0.08
$b^*/(b+b^*)$	Credit Dollarization	0.59	0.40[3]	-0.17	0.56
$\frac{c_1^*-e_1k_f}{Y}$	Scaled Trade Surplus	-0.02	-0.02[4]	-0.04	-0.02
$100\times\frac{E(r-r^*e_2)}{r}\frac{d^*}{d^*+d}$	Implicit tax on dollar deposits	1.3%	1.5%[5]	1.5%	1.4%
ρ	Correlation, e_2, GDP	-0.23	-0.20[7]	-0.19	-0.23
$std(log(e_2))$	Standard Deviation, e_2	0.04	0.03[8]	0.04	0.04

Notes: (1) Columns (a) and (b) - model variables and description, respectively; column (c) - model steady state at calibrated parameter values reported in Table (3); column (d) - model steady state with $s=0$ and all other parameter values kept at their calibrated values; column (e) - model steady state with $s=0$ and λ^f is adjusted so that $100\times(r-e_2r^*)=2.20$, requiring $\lambda^f=45$. (2) d^* denotes the foreign currency deposits of residents, measured in soles and d denotes the domestic currency deposits of residents, and the ratio is an average over 2000-2016 (source: CBP). (3) b (b^*) denotes soles (dollar) borrowing by non-financial firms from Peruvian banks (source: CBP) plus international securities issued by nonfinancial corporations in soles (dollars) (source: BIS); ratios are averages over the period, 2000-2016. (4) Average of scaled trade surplus, over 2000-2017, scaling in model by Y and in the data by GDP (source: World Bank, World Development Indicators). (5) The implicit tax is based on the domestic interest rate inferred by covered interest parity and US/soles forward rates. (6) Here, r and r^*e_2 are measured as the real return, in units of Peruvian CPI goods, associated with soles deposits (r) and dollar deposits (r^*e_2) in Peruvian banks over 2004-2014 (source: CBP). (7) Correlation based on S/P (S denotes soles per dollar, P denotes Peruvian CPI) and Peruvian real GDP, where both variables were log, first differenced, covering the period 2000-2018. (8) 'standard deviation' corresponds to standard deviation of error term in AR(1) representation fit to annual data on log Real Broad Effective Exchange Rate for Peru, 2001-2020.

Figure 10: GDP ER Correlation vs Dollarization in the Model



Prohibiting Deposit Dollarization

Several emerging market economies (Mexico, Brazil, India etc) do not allow residents to hold dollar accounts. In this section, we evaluate the consequences of such a policy using our model. Table 5 shows that the utility of both workers and firms go down. Workers lose their means of insurance whereas firms end up borrowing at high local interest rates. Interest rate spread declines as households are forced to save in pesos but the exchange rate becomes more volatile, which reduces investment. Foreigners slightly gain from the policy as they sell peso assets short to gain insurance against consumption fluctuations coming from their exogenous income.

Table 5: Consequences of Prohibiting Deposit Dollarization

$\Delta Spread$	$\Delta\sigma_{e_2}$	ΔU_{HH}	ΔU_{Firm}	ΔU_{For}
-0.23%	0.07%	–0.07%	-0.98%	0.01%

7 Concluding remarks

We provide evidence that financial dollarization in emerging markets is mostly a within-country risk sharing arrangement. Exchange rates often depreciate in recessions, setting off a transfer of local currency from domestic borrowers to domestic lenders.In principle, another hypothesis could be at work. The desire for local lenders to denominate their deposits in dollars may reflect their fear of a financial crisis which then becomes self fulfilling because of the resulting currency mismatch. We find no evidence that deposit dollarization has any association with financial crisis and so this alternative hypothesis seems implausible.

With these considerations in mind, we construct a simple two-period model which captures what we find to be the key features of the data. This type of exercise is in effect an important 'reality check' on the impressions we draw from our empirical analysis. For example, the notion that there is a premium on (risk free) domestic interest rates because domestic residents prefer dollars for insurance reason leads to an important question: 'why don't foreigners step in and make more domestic currency loans?' Our model must address this question. In effect, we take the position that the risk in emerging market economies is not diversifiable by foreign financiers and they have hedging reasons for not lending in domestic currency because their other sources of income tend to drop too, when a recession occurs. Foreigners obviously do in effect make domestic currency 'loans' in the form of foreign direct investment and equity purchases. Our model is consistent with this observation. They do make local currency loans, but they require a premium to do so to compensate them for the fact that local currency loans are a bad hedge for them.

Our work highlighs some not well-known benefits of financial dollarization; we also find that the cost of dollarization in terms of financial stability is not large. There could possibly be other dangers of dollarization we could not model but the main takeaway from our analysis is that policy makers should consider the benefits we highlight.

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Online Appendix to 'Financial Dollarization in Emerging Markets: Efficient Risk Sharing or Prescription for Disaster?'

Lawrence J. Christiano, Husnu Dalgic and Armen Nurbekyan

A The Insurance Hypothesis

A.1 Figure 2 After Removing Controls

Here, we construct versions of Figure 2 in Subsection 3.1 after controlling for other variables. Table A1 reports the results of regressing deposit dollarization over the period 2000-2018 on our controls. The first column shows what happens when we include only the correlation term in Figure 2, and shows that that variable is highly significant. That is what we expect given the results in Figure 2. Importantly, both the numerical value and the (high) statistical significance of the coefficient on the cyclical behavior of the exchange rate remain highly significant when we also include the other controls, in columns (2)-(5). Other variables are also important for deposit dollarization. In particular, countries that experienced high inflation in the 1990s tend to have higher deposit dollarization in the 2000s. Similarly countries with 'better' institutions according to the World Bank also have lower deposit dollarization.

Table A1: Determinants of Dollarization

	Dependent variable:				
	Dollarization				
	(1)	(2)	(3)	(4)	(5)
Corr($\Delta GDP, \Delta S/P$)	−34.161***	−30.287***	−35.402***	−35.254***	−24.122**
	(6.843)	(7.976)	(8.256)	(8.332)	(9.707)
Av Inflation		0.027***	0.026***	0.026***	0.023***
		(0.005)	(0.005)	(0.005)	(0.005)
Gini			0.187	0.256	0.096
			(0.213)	(0.214)	(0.240)
Commodity Export			−0.051	−0.045	−0.062
			(0.066)	(0.066)	(0.062)
Reserves/GDP			0.028*	0.024	−0.001
			(0.016)	(0.016)	(0.014)
Institutions				−0.234*	−0.056
				(0.138)	(0.151)
External Debt					0.276***
					(0.078)
Constant	21.429***	20.462***	9.917	8.305	8.498
	(1.882)	(2.194)	(7.866)	(7.710)	(12.489)
Observations	121	112	90	84	57
R^2	0.168	0.232	0.352	0.399	0.399
Adjusted R^2	0.161	0.218	0.314	0.352	0.313
Residual Std. Error	19.592 (df = 119)	19.197 (df = 109)	17.559 (df = 84)	17.051 (df = 77)	16.298 (df = 49)
Note:					*p<0.1; **p<0.05; ***p<0.01

Dependent variable is the average dollarization between 2000-2018. Right hand variables are average inflation in the 90s ('Av Inflation'); average Gini index in the sample, 2000-2018, ('Gini'); fuel exports (as a share of total exports) in the sample, 2000-2018, ('Fuel Export'); Central Bank reserves (as a share of GDP) in the sample, 2000-2018, ('Reserves/GDP'); Political institutions ('Institutions') are proxied by "Constraints on the Executive Authority", 2000-2018, provided by Polity V database provided by Center for Systemic Peace ("https://www.systemicpeace.org/inscrdata.html"); External Debt (as a share of GDP), in the sample 2000-2018, ('External Debt'). Heteroskedasticity consistent standard errors appear in parentheses.

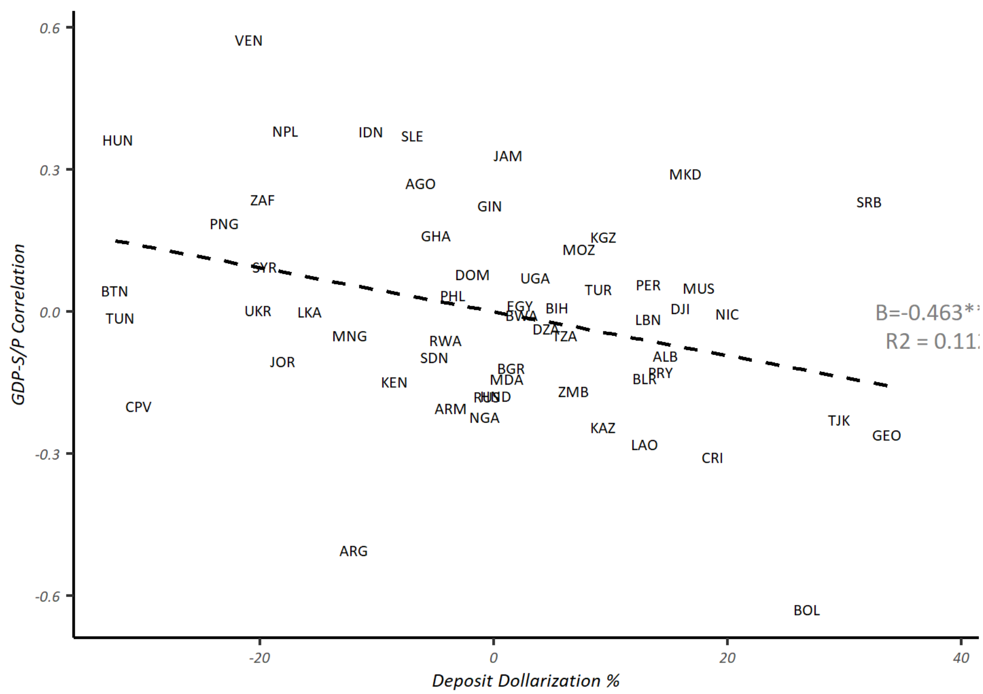
That inflation in the 1990s is important for deposit dollarization in the 2000s is not surprising. Figure A1 shows that countries which experienced high inflation in the 1990s (vertical axis) had high average levels of deposit dollarization in the 2000s (horizontal axis). It is also not surprising that countries with weak institutions would have high deposit dollarization, perhaps because these countries are more likely to turn to inflation finance in a recession.

Figure A1: Inflation vs Dollarization

We find the insignificantly-different-from zero coefficient on dollar reserves in columns (3)-(5) in Table A1 somewhat surprising. In effect, dollar reserves held by the government represent insurance for all the people in the country, households as well as the owners of firms. Governments holding a high amount of dollar reserves in countries in which the exchange rate depreciates in a recession are able to reduce spending cutbacks and tax hikes at such a time, both of which represent a form of insurance to citizens. We expect that, other things the same, households in a country with high dollar reserves would hold lower dollar deposits so that the coefficient on reserves should be negative and significant from the insurance point of view. The fact that the coefficient is insignificantly zero is also a puzzle from the point of view of the alternative hypothesis about Figure 2. That is the 'reverse causality' hypothesis associated with the balance sheet channel under which causality goes from deposit dollarization to the correlation on the vertical axis.

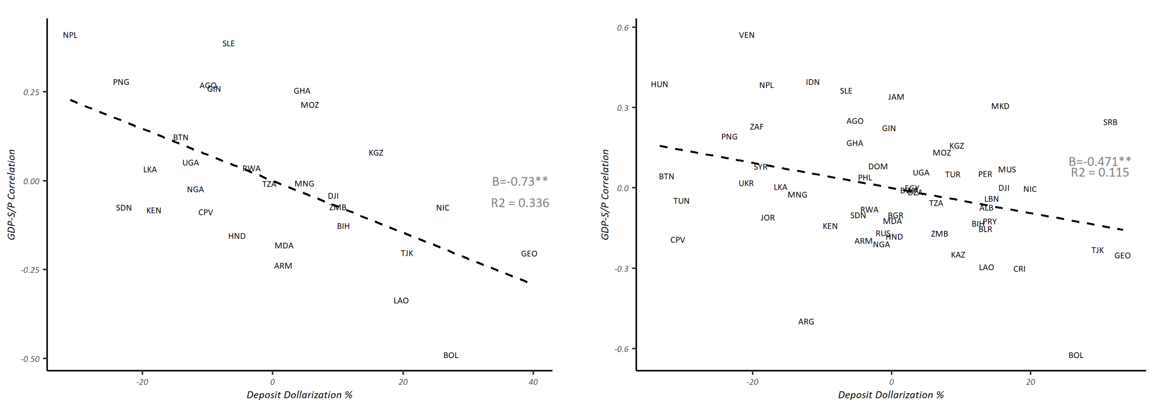
Notice in Table A1 that the number of countries for which we have evidence for all our controls is sharply limited. So, we construct three different versions of Figure 2. They differ according to which set of controls are removed from the cross-country data displayed in the figure. Figure A2 is the scatter of the error in the correlation (vertical axis) against the error in deposit dollarization (horizontal axis), after regressing on the controls in column (3) of Table A1. Note that the R^2, the slope coefficient and its significance level coincide roughly with what is reported in Figure 2. The results using the controls in columns (4) and (5) appear in the first and second panels of Figure A3, respectively. The number of countries included in the latter two data sets is sharply reduced. Still, the results display a similar pattern: the correlation on the vertical axis has a statistically significant negative relationship with deposit dollarization.

Figure A2: Countries in which the Currency Depreciates More in a Recession Have Greater Deposit Dollarization even after controlled for other determinants



Notes: x-axis and y-axis variables are the residuals from regressing the variables on the x and y axes in Figure (2) on the variables in Table A1, column 3. See figure 2 for details.

Figure A3: Countries in which the Currency Depreciates More in a Recession Have Greater Deposit Dollarization even after controlled for other determinants



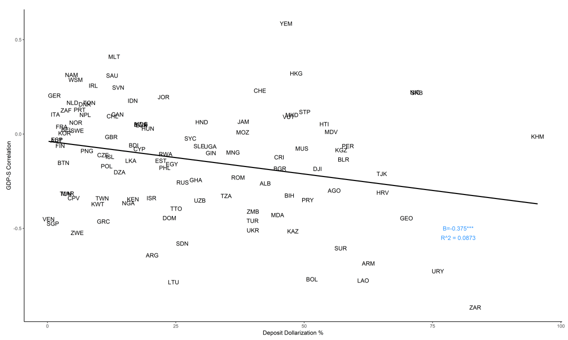
Notes: x-axis and y-axis variables are the residuals from regressing the variables on the x and y axes in Figure (2) on the variables in Table A1, column 4 and 5 . See figure 2 for details.

A.2 Figure 2 Robustness

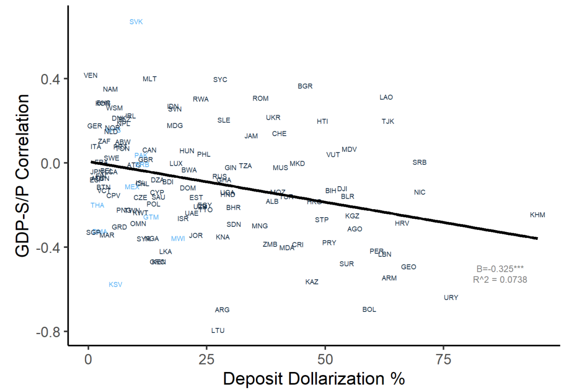
In Figure A4, we replicate Figure 2 using nominal exchange rate and using the period 1995-2018. In both cases, the significance remains strong.

Figure A4: Figure 2 Robustness

(a) 1995-2018



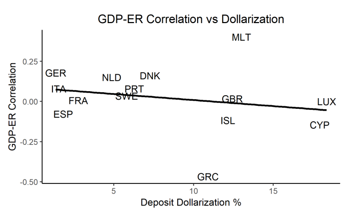
(b) Nominal Exchange Rate-GDP Correlation



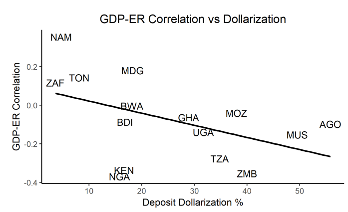
Notes: Left figure plots replicates Figure 2 using data between 1995-2018, right figure plots 2000-2018 correlation vs dollarization using nominal exchange rate fluctuations. See the footnote of Figure 2 for details

In Figure A5, we replicate Figure 2 for different regions. Our effect is highly significant for Latin American and African countries and somewhat significant for Eastern Europe.

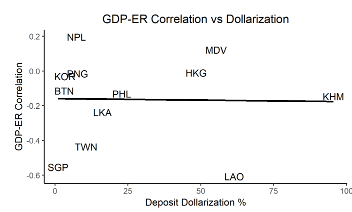
Figure A5: Figure 2: Differnet Regions



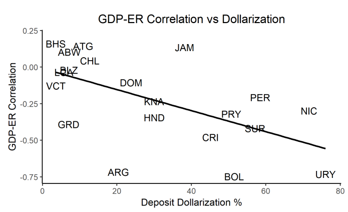
Advanced Economies



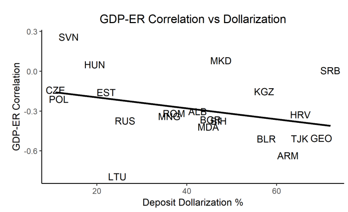
Africa



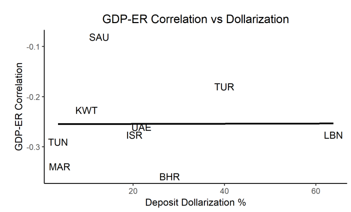
Asia



Latin America



Eastern Europe



Middle East

A.3 The Interest Rate Spread, $i - i^*$, as a Tax

Here, we express $i - i^*$ in the form of a tax, τ, on dollar balances. To measure that tax, consider households' total deposit earnings:

$$i^* \overbrace{d^*}^{\text{dollar deposits in local currency units}} + i \overbrace{d}^{\text{local deposits}}. \tag{A.1}$$

On average, these earnings are less than what the household would get if it were to place all its deposits in local currency units. In that case, they would earn $(d^* + d)\, i$. The amount it loses by holding dollar deposits defines the tax:

$$(d^* + d)\, i\, (1 - \tau) = d^* i^* + di,$$

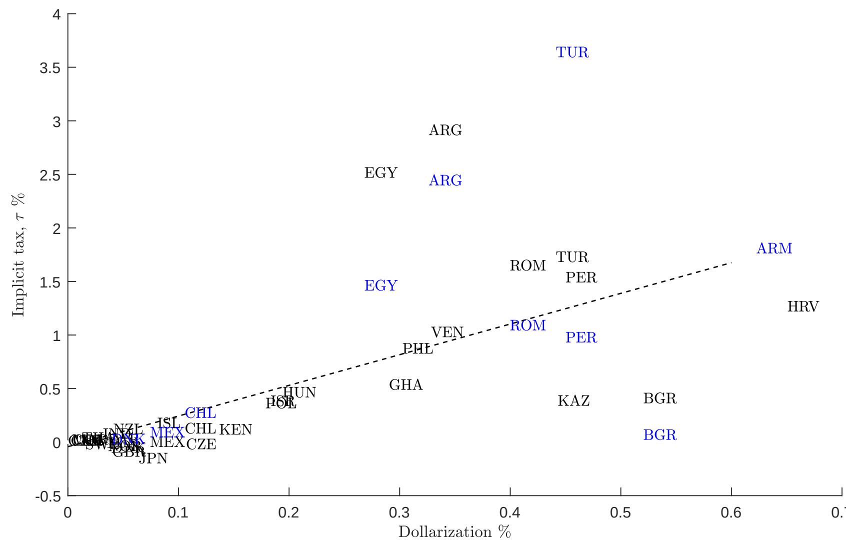
where τ denotes the tax rate. Solving,

$$\tau = \frac{i - i^*}{i} \phi, \tag{A.2}$$

where $\phi \equiv d^* / (d^* + d)$ denotes deposit dollarization (see equation (1)). Under the hedging hypothesis, τ is the 'premium' paid for the hedging services provided by dollar deposits. In countries where households want more of those services, i.e., where there is greater deposit dollarization, we expect the premium to be higher.

We display the scatter plot of τ against deposit dollarization in Figure A6.

Figure A6: Implicit Tax on Dollar Deposits versus Deposit Dollarization



Notes: τ denotes the implicit tax for denominating deposits in dollars rather than in domestic currency. See text for construction. Data on the horizontal axis correspond to $100 \times \phi$, where ϕ is defined in equation (1). For the observations marked in blue, local deposit rates were obtained from Central Bank websites. In the case of observations marked in black, the local deposit rate was inferred using covered interest parity, local and future's market exchange rates (taken from Datastream) as well as dollar risk free rates. In some cases, both measures of the domestic interest rate are available . The line in the figure is the least squares that uses actual local dollar rates when available (blue) and uses derivative-based rates otherwise (black). The least squares line based on the black observations only is not included because it is virtually indistinguishable from the line reported.

Figure A6 suggests two things. First, the positive relationship between the price, τ, paid by households for dollarized deposits, and the quantity of those deposits suggests that variations in deposits across countries primarily reflect variations in demand by households. This is consistent with the insurance hypothesis. Second, for countries with substantial deposit dollarization (say, 40-50 percent), the price is in a range of 0.5-1.5 percent. To interpret this magnitude, it is interesting to note that the price is reasonably close to the fees earned by hedge fund managers.[87].

B The Absence of Currency Mismatch in Country Banking Systems

IMF Financial Soundness Indicators (FSI) report 'net open position in foreign exchange to capital' (NOPFxCapital) for 115 countries and the results suggest that currency mismatch in banks (deposit-taking institutions) is very low.[88] We define the IMF statistic as follows.

[87] See https://www.investopedia.com/terms/t/two_and_twenty.asp .

[88] For a precise definition of a 'bank' used in the data, see IMF (2006, Section 2). Data on the ratio of the net open position in foreign exchange divided by capital can be found in http://data.imf.org/regular.aspx?key=61404590. The data are an unbalanced panel. The IMF actually

Let a and a^* denote the domestic and foreign assets of banks, respectively, each measured in local currency units. Similarly, let b and b^* denote banks' domestic and foreign liabilities. In principle, a^* and b^* should not include the portion of assets or liabilities in which exchange rate risk has been removed with the use of hedging instruments.[89] Then, NOPFxCapital corresponds to $m(s)$ for $s = 1$:

$$m(s) = \frac{(a^* - l^*)\, s}{(a^* - l^*)\, s + a - l}, \tag{B.1}$$

where the numerator, $a^* - l^*$ represents the net unhedged banks' foreign asset position and the denominator is bank net worth.[90] The statistics, for $s = 1$, are reported in the first column of Table B2. To give $m(1)$ an economic interpretation, we compute the magnitude of the depreciation, s, which would wipe out bank equity:

$$s = -\frac{a - l}{a^* - l^*} = 1 - \frac{1}{m(1)}.$$

Evidentially, when $m(1) < 0$ then $s > 1$, so it takes a depreciation to wipe out bank equity. If $1 > m(1) > 0$, so that $a > l$, then there is no depreciation that could wipe out bank equity. That is, even in the extreme case, $s = 0$, when all net foreign assets are lost, bank equity remains positive. Finally, if $m(1) > 1$ then $a < l$ and $1 > s > 0$, so that there is a appreciation that will wipe out bank equity.

reports results for 119 entities. However, three - Anguilla, Macao and Montserrat - are not sovereign countries, so we do not use these data. Also, the Eastern Caribbean Currency Union (ECCU) is dropped because it includes countries included elsewhere in the dataset (ECCU also includes Anguilla).

[89]The IMF data document, IMF (FSI, Chapter 6, part (vii), 2006), Paragraph 6.37, explains NOPFxCapital. Reporting countries have the option to produce one of two versions of NOPFxCapital: a narrow one, IMF (FSI, Table 6.2, line 49, 2006) and a broader one, IMF (FSI, Table 6.2, line 50, 2006). The two versions differ according to how much detail is provided about the reporting bank's derivative operations to hedge foreign exchange risk. Obviously, the broader one includes more such information. In many cases, notes on the data provided to the IMF on their financial stability indicators are provided on the IMF website, folder labeled 'table 3', indicator S230.

[90]Details about the composition of bank assets and liabilities (including derivatives) can be found in IMF (2006, Table 4.1, page 31)). The denominator of $m(1)$ is positive for each of our observations.

Table B2: Currency Mismatch

Country	exchange depreciation, s, to wipe out bank assets	$m(1) = \frac{\text{Open FX Position}}{\text{Equity}}$
Norway	2.71	-0.37
Israel	2.99	-0.33
Switzerland	3.10	-0.32
Botswana	3.14	-0.31
Denmark	3.46	-0.28
Kazakhstan	15.15	-0.07
Central African Rep	17.81	-0.06
Bolivia	18.13	-0.06
Uganda	35.62	-0.03
Armenia	39.20	-0.02
Turkey	79.68	-0.01
Slovak Republic	96.80	-0.01
Rwanda	98.74	-0.01
Burundi	211.04	-0.00
Chad	358.86	-0.00
Nicaragua	0.01	1.00
St. Kitts and Nevis	0.34	1.50
Congo	0.38	1.61
St. Lucia	0.43	1.74
Grenada	0.50	2.00
Dominica	0.75	4.00

Notes: (i) Numbers have been rounded. Countries are ranked by NOPFxCapital, which appears in the right column. (ii) Data source: IMF.

For the 115 countries in the IMF dataset, the overwhelming majority, 93, have $0 < m(1) < 1$, and so they have zero foreign exchange (FX) risk according to the NOPFxCapital index.[91] That fact alone is an important indicator of the absence of currency mismatch in banks. The data on the remaining 22 countries are reported in Table B2. To understand the numbers in this table it is useful to look at particular cases. For example, in Nicaragua the IMF data indicate that NOPFxCapital is 1.0060 (rounded to 1). According to (B.1) with $s = 1$, Nicaraguan banks' net assets are nearly completely in dollars, i.e., $a-l$ is negative but essentially zero. If the assets were fully in dollars, bankruptcy would be impossible but given that $a - l$ is slightly negative, it would take a whopping 99% appreciation in the exchange rate for bank equity to be wiped out.

The countries in Table B2 are ordered in terms of NOPFxCapital from smallest to largest. The countries with the largest apparent exposure to foreign exchange risk (i.e., the most negative $m(1)$) are Israel, Norway, Denmark and Switzerland. In the case of Israel, notes on the IMF website indicate that the Israeli NOPFxCapital index does not fully reflect all foreign exchange hedging commercial banks. Furthermore, Bank of Israel (Statistical Bulletin, Part 1, section d, Figure 4.13, 2018) documents that once bank hedging is taken into account, there is essentially no foreign exchange risk on commercial banks' balance

[91] Two of the countries that we designate as having zero foreign exchange risk are Algeria and Comoros. In both cases the IMF reports zero foreign currency assets and liabilities in the years for which they report data. For the data sourse, see footnote 88.

sheets.[92] So, the large of NOPFxCapital in the case of Israel greatly overstates their banks' exposure to foreign exchange risk, which appears to actually be minimal. It is possible that the situation in Norway, Denmark and Switzerland is similar. The key point is that even if we take the statistics pertaining to the most risky 5 countries at face value, those countries have only a small amount of foreign exchange risk since their exchange rates would have to more than double for bank equity to be seriously at risk. The next group of 10 countries would require depreciations by factors of 10 or even over 100 for equity to be at risk. The final 6 countries have positive net foreign assets, $a^* > l^*$, with $m(1) > 1$ so that $a < l$. So, their exchange rates would have to appreciate to create a risk to the banking system. For the most part these appreciations would have to be very large.

[92]We are grateful to Nitzan Tzur-Ilan's help in this matter.

C Firms are the Source of Household Insurance

Because our panel is unbalanced, the statistics in Table C3 cover only the period 2010-2019.

(1) Country	(2) $\phi = \frac{dollar\,deposits}{total\,deposits}$	(3) $\frac{household\,(hh)\,dollar\,deposits}{total dollar\,deposits}$	(4) $\frac{firm\,dollars\,from\,banks}{firm\,dollars\,from\,everywhere}$	(5) $\frac{hh\,dollar\,borrowing\,from\,banks}{total\,dollar\,deposits}$	(6) $\frac{total\,dollar\,borrowing,\,firms}{total\,dollar\,deposits}$
Croatia	0.67		0.48	0.00	0.16
Armenia	0.59	0.74	1.00	0.31	1.07
Kazakhstan	0.52	0.66	0.42	0.15	1.93
Albania	0.51	0.86	1.00	0.15	0.47
Peru	0.48		0.77	0.17	1.01
Ukraine	0.44	0.64	0.76	0.13	1.26
Bulgaria	0.41		0.86	0.17	0.53
Uganda	0.36		1.00	0.02	0.64
Turkey	0.36	0.57	0.97	0.00	1.06
Romania	0.34	0.72	0.98	0.77	0.76
Russia	0.31	0.45	0.61	0.02	1.09
Mozambique	0.30	0.32	1.00	0.03	0.54
Honduras	0.29	0.54	1.00	0.19	0.87
Egypt	0.22	0.66	1.00	0.01	0.51
Hungary	0.21	0.38	0.83	0.43	1.43
Lithuania	0.16	0.60	0.77	0.82	1.05
Mean	0.38	0.59	0.84	0.21	0.90
Median	0.36	0.62	0.91	0.15	0.94

Table C3: Decomposition of Dollar Borrowing and Lending

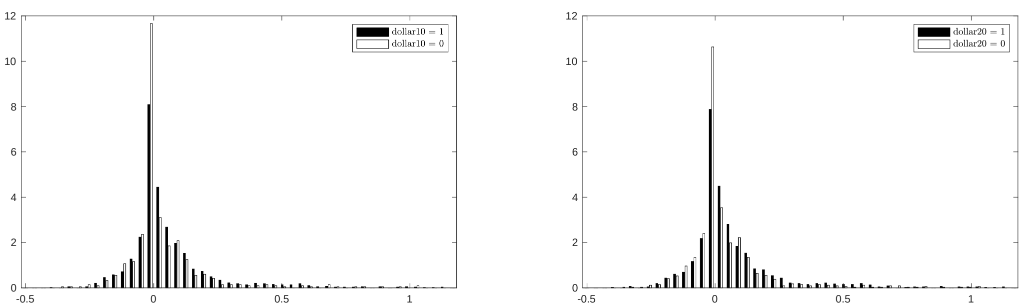
Notes: With one exception, local residents' dollar deposits in banks and dollar credit from banks to local residents was collected from individual central bank websites. The exception is Peru, where the end-of-year data were kindly provided by Paul Castillo of the Peruvian Central Bank, for the period 2010-2019. For BIS reporting countries, dollar denominated securities issued by nonfinancial corporations are included in the column, 'NFC share'. Government share is calculated using dollar denominated securities issued in international markets for BIS reporting countries; for the remaining countries (Armenia, Albania, Honduras, Mozambique, Uganda), government share is calculated using external government debt collected from individual central bank websites. Total reserves (obtained from World Bank) is subtracted from government debt. Foreign share is 1 minus the rest combined. The data is a balanced panel covering the period 2010-2018. We begin the data in 2010 to miss the downward trend in dollar borrowing documented in Du and Schreger (2016b). In the row, 'Average for high-dollarized', we report averages for countries where deposit dollarization exceeds 0.20.

D Is High Deposit Dollarization Less or More Likely to Be Followed by Currency Depreciation in the Next Year?

We pooled all our annual data on deposit dollarization. Figure D7 displays the distribution of exchange rate depreciations, conditional on whether deposit dollarization was high or low in the previous year. Figure D7a uses a cutoff of 10% to identify high rates of deposit dollarization. Figure D7b uses a cutoff of 20%. We normalize the height of the bars, so that the product of their sum and the width of the bars is unity. Thus, the bars are an estimate of the underlying density function. In addition, to improve readability of the graphs, we dropped the smallest observation, as well as the largest 21 observations in the data.[93]

Figure D7: Exchange Rate Depreciations And Dollarization

(a) Average Deposit Dollarization Above 10% (b) Average Deposit Dollarization Above 20%



Note: these figures display the empirical distribution of exchange rate appreciations when deposit dollarization is above 10% and 20%, as indicated. The data correspond to our annual data and treat each observation (year, country) symmetrically.

Figure D7 examines the empirical density of exchange rate depreciations, $\Delta e_{i,t} = \ln(e_{i,t}/e_{i,t-1})$, where $e_{i,t}$ denotes the domestic currency price of a unit of foreign currency in year t and country i. The median value of $\Delta e_{i,t}$ in the entire sample is roughly zero and the mean is 0.074. The first panel, Figure D7a, reports the empirical density for all $\Delta e_{i,t}$ corresponding to t, i with low levels of dollarization, $\phi_{i,t-1} \leq .10$ (black bars) versus $\Delta e_{i,t}$ in which $\phi_{i,t-1} > .10$ (white bars).[94] The second panel is the same as the first, except that we compare i, t with

[93] The computations were done in MATLAB and the 'edges' on the horizontal axis are a grid with 50 equally-spaced points, where the first point is -0.5 and the last is 1.2. The observation 1.2 means that $e_t/e_{t-1} = 1.2$, where e_t denotes the year t exchange rate.

[94] See equation (1) for the definition of $\phi_{i,t}$. We use $\phi_{i,t-1}$ rather than $\phi_{i,t}$ to minimize potential distortions from an 'automatic' effect of exchange rate depreciation that raises deposit dollarization, holding the quantity of dollar deposits and domestic deposits fixed. This effect is at best marginal because it only matters for the (presumably) small number of countries which jump deposit dollarization bins when the exchange changes. In any case, we repeated the histogram for $\Delta e_{i,t}$ and $\phi_{i,t}$ and found little difference in the results. That is, we find that the empirical density does not reveal a systematic pattern of fewer depreciations in deposit

$\phi_{i,t-1} \leq 0.20$ against $\phi_{i,t-1} > .20$. The key thing to note is that, if anything, there is a slight shift towards larger depreciations, $\Delta e_{i,t} > 0$, when dollarization is high. If deposit dollarization made balance sheet effects important, we might expect monetary authorities to see this and to respond by reducing the likelihood of large depreciations. In fact, the depreciations are slightly skewed to the right, consistent with the idea that deposit dollarization does not magnify balance effects.

E Dataset: Country-year availability and crises

The countries for which we have deposit dollarization data (i.e., those referred to in Figure 4.2.2 and used in Table 1) appear in the following table.

dollarized economies.

Table E4: Country-year availability and years of crises

Country	Crisis1	Crisis2	Crisis3	First Year	Last Year	Country	Crisis1	Crisis2	Crisis3	First Year	Last Year
Albania				1995	2017	Malawi				1995	2017
Algeria				2000	2017	Malaysia	1997			1997	2017
Angola				1996	2017	Maldives				1995	2017
Anguilla				2001	2017	Malta				2004	2017
Antigua and Barbuda				1995	2017	Mauritius				1995	2017
Argentina	1995	2001		1995	2017	Mexico				1995	2017
Armenia				1995	2017	Moldova	2014			1995	2017
Aruba				2005	2017	Mongolia	2008			1995	2017
Austria	2008			1999	2017	Montserrat				2001	2017
Bahamas				1995	2017	Morocco				2002	2017
Bahrain				1995	2017	Mozambique				1995	2017
Barbados				1995	2017	Namibia				2004	2017
Belarus	1995			1995	2017	Nepal				1995	2017
Belgium	2008			2000	2017	Netherlands	2008			1995	2017
Belize				1995	2017	Netherlands Antilles				1995	2017
Bhutan				1995	2017	Nicaragua	2000			1995	2017
Bolivia				1995	2017	Nigeria	2009			1995	2017
Bosnia and Herzegovina				1998	2017	Norway				1997	2017
Botswana				1996	2017	Oman				1995	2017
Bulgaria	1996			1995	2017	Pakistan				1995	2017
Burundi				2009	2017	Papua New Guinea				1995	2017
Cambodia				1995	2017	Paraguay	1995			1995	2017
Canada				1995	2017	Peru				1995	2017
Cape Verde				1995	2015	Philippines	1997			1995	2017
Chile				1995	2017	Poland				1995	2017
Congo Dem Rep				1995	2017	Portugal	2008			1995	2017
Costa Rica				1995	2017	Qatar				1995	2017
Croatia	1998			1995	2017	Romania	1998			1995	2017
Cyprus	2011			1995	2017	Russia	1998	2008		1995	2017
Czech Republic	1996			1995	2017	Rwanda				1995	2016
Denmark	2008			1995	2017	Samoa				2001	2017
Djibouti				1995	2017	Sao Tome and Principe				1996	2017
Dominica				1995	2017	Saudi Arabia				1995	2017
Dominican Republic	2003			1997	2017	Serbia				2000	2017
Egypt				1995	2017	Seychelles				2004	2017
Estonia				1995	2017	Sierra Leone				1995	2017
Finland				1997	2017	Singapore				1995	2017
France	2008			2000	2017	Slovak Republic	1998			1995	2017
Georgia				1997	2017	Slovenia	2008			1995	2017
Germany	2008			2000	2017	South Africa				1995	2017
Ghana				1996	2017	Spain	2008			1995	2017
Greece	2008			1995	2017	Sri Lanka				1996	2017
Grenada				1995	2017	St. Kitts and Nevis				1995	2017
Guatemala				1998	2017	St. Lucia				1995	2017
Guinea				1995	2017	St. Vincent and the Grenadines				1995	2017
Haiti				1997	2017	Sudan				1995	2017
Honduras				1995	2017	Suriname				1999	2017
Hungary	2008			1995	2017	Sweden	2008			1995	2017
Iceland	2008			1995	2017	Switzerland	2008			1997	2017
Indonesia	1997			1995	2016	Syria				1995	2012
Ireland	2008			2003	2017	Taiwan				1995	2017
Israel				1995	2017	Tajikistan				1997	2017
Italy	2008			2000	2017	Tanzania				1995	2017
Jamaica	1996			1995	2017	Thailand	1997			1995	2017
Japan				1999	2017	Tonga				1995	2017
Jordan				1995	2017	Trinidad and Tobago				1995	2017
Kazakhstan	2008			1999	2017	Tunisia				1995	2017
Kenya				1996	2017	Turkey	2000			1995	2017
Korea	1997			1995	2017	Uganda				1995	2017
Kosovo				2005	2017	Ukraine	1998	2008	2014	1995	2017
Kuwait				1995	2017	United Arab Emirates				1995	2017
Kyrgyz Republic				1997	2017	United Kingdom	2007			1995	2017
Lao PDR				1995	2017	Uruguay	2002			1995	2017
Latvia	1995	2008		1995	2017	Uzbekistan				1998	2017
Lebanon				1995	2017	Vanuatu				1995	2017
Lithuania	1995			1995	2017	Venezuela				1995	2017
Luxembourg	2008			2000	2017	Yemen	1996			1995	2016
Macedonia, FYR				1996	2017	Zambia	1995			1995	2017
Madagascar				2001	2017	Zimbabwe	1995			1995	2017

Notes: Table lists the countries in our dataset, years of banking crises and the first and the last observations.

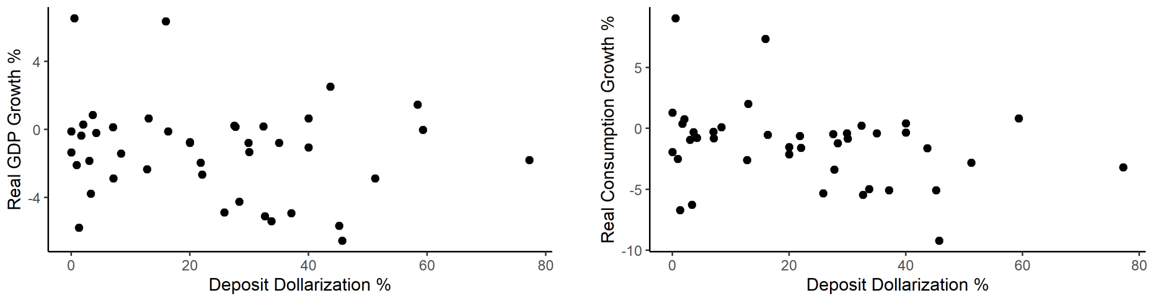
F Bivariate Analysis: Sudden Stops

To investigate the robustness of the results in section4 , we use the Eichengreen and Gupta (2018) data on sudden stops. There are 34 countries that intersect with the 66 countries in the Eichengreen and Gupta (2018) dataset and the 124 countries in our dataset on deposit dollarization. There are 43 sudden stops in the data that we analyze. Figure F8 indicates that there is little relationship between the probability of a sudden stop and deposit dollarization. Figure F9 shows that there is little relationship between the cost of a sudden stop (measured in a decline of GDP growth or consumption growth) and deposit dollarization. Again, with this different measure of crisis we come a way with the same conclusion: there does not seem to be a systematic relationship between the probability of a crisis, or its cost if there is one, and deposit dollarization.

Figure F8: Eichengreen and Gupta (2018) Frequency of Sudden Stops versus Dollarization

Note: Based 34 countries' data, the intersection of 66 Eichengreen and Gupta (2018) countries with the 124 Levy-Yeyati (2006) countries. Each point corresponds to a country. There are 43 sudden stops in the period 1990-2014.

Figure F9: Cost of Eichengreen and Gupta (2018) Severity of Sudden Stop and Deposit Dollarization



Note: See note to Figure F8 for data on sudden stops. Real GDP and consumption growth is calculated by taking the difference between average growth rate during the sudden stop and the decade average around the sudden stop.

We conclude that both datasets analyzed above indicate very little relationship between deposit dollarization and the likelihood or cost of crisis.

G Bootstrap Analysis of Logistic Regression

Table G5 provides more direct evidence on the relationship between crisis and dollarization, allowing for the possible role of exchange rates. First, the overall frequency of Laeven and Valencia (2020) crises, unconditional on the level of dollarization, is 1.8 percent in our sample of 2,281 observations. Second, if we consider just the subset of 1,690 observations in which $\phi_{i,t} > 0.10$, the probability of Laeven and Valencia (2020) crisis is 2.01 percent. Even for the 1,340 observations in which $\phi_{i,t} > 0.20$ the probability of crisis is 1.87 percent.[95] These observations are consistent with our bivariate analysis in Section (4.1), though here it is based on data at a more temporally disaggregated level.

Table G5 also allows us to focus a question that involves trivariate relationships. The table arranges our data in a way that we can ask, using minimal econometric structure, the following question. 'Is a big exchange rate depreciation more likely to lead to a crisis when the level of deposit dollarization is high?' The answer is 'no', according to the results in the table.

The table organizes the data according to six exchange rate depreciation intervals (see columns (1) and (2)). The first and sixth intervals are 'very large' appreciations and depreciations. The second and fifth intervals are 'large', and so on. The lower bound on the first interval and the upper bound on the sixth interval are the smallest depreciation and largest depreciation, respectively, in the dataset. The depreciations, -6.0 and 20.8 are the 10^{th} and

[95]With a little work, the 2 percent results can be recovered from Table G5 from the entries in columns (3), (4) and (5). In each of the six panels, take the product of the probability (the number not in brackets or parentheses) and the number of observations (the number in parentheses) and sum across all six panels.

90^{th} percentiles of the depreciation rates. The mean depreciation rate is 7.4 and we also include 7.4/2 as boundaries for our six depreciation intervals. There are 365 observations on the median exchange rate depreciation, which is zero. All these observations are included in the third depreciation interval.

Each of the six panels corresponding to a depreciation range is composed of two rows. The first row of each panel in column (3) indicates the frequency of Laeven and Valencia (2020) crises, conditional on depreciation being in the interval defined in columns (1) and (2).[96] The first row of each panel in Columns (4)-(6) report the frequency of crisis conditional on that panel's depreciation interval, and conditional on the level of dollarization indicated in the column's header. The numbers in parentheses in columns (3), (5) and (6) indicate the quantity of observations in which the depreciation rate lies in the range specified in columns (1) and (2) and the deposit dollarization rate lies in the range indicated in the column heading.[97] Our depreciation intervals were designed in part to ensure roughly similar-sized samples in each interval.[98] The numbers in square brackets in columns (5) and (6) indicate the fraction of observations in the associated depreciation range that have deposit dollarization rates in excess of 10 percent and 20 percent, respectively.[99] Consistent with the evidence in Figure 1, the numbers in square brackets in columns (5) and (6) indicate that the fraction of our sample with deposit dollarization 10 (20) percent and higher is around 70 percent (60 percent). Moreover, the results indicate that these fractions rise with the exchange rate.

The numbers in the second row of each of the six panels in Table G5 are p-values. In columns (3) and (4) the p-value is the probability that the frequency estimator exceeds its estimated value in the first row, under our null hypothesis: (a) the Laeven and Valencia (2020) crisis indicator is independent of both the depreciation rate and the level of deposit dollarization and (b) the joint density of deposit dollarization and the exchange rate is what we see in the data.[100] Note that the p-values are all well above the usual 1 and 5 percent cutoff values, 0.01 and 0.05. The table provides no evidence against the null hypothesis.

The p-values in columns 5 and 6 go directly to the question raised above: whether a crisis is more likely if an exchange rate depreciation occurs when deposit dollarization is high. We find no such evidence. Specifically, the p-value in column j reports the probability, under

[96] The frequency in column (3) unconditional, in that does not condition on any particular value of deposit dollarization.

[97] There is no number in parentheses in column (4), because the number of observations in that category is just the number in parentheses in column (3), minus the number in parentheses in column (5).

[98] The relatively large number of observations associated with the 0-3.7 interval reflects that we include the 365 zero observations in that interval.

[99] There is no square bracketed number in column (4), because that would just be unity minus the number in square brackets in column (5).

[100] For details of the bootstrap procedure we use to compute the p-values, see the notes to Table G5.

the null hypothesis, that the estimated jump in frequency, from column $j-1$ to column j, is larger than its estimated value, for $j=5,6$. For example, given the third depreciation range, $0-3.7$, the jump in crisis frequency for observations with $\phi_{t,i}<0.10$ (column (4)) to what that frequency is for observations with $\phi_{t,i}>0.10$ (column (5)) is 1.8-0.8, or 1 percentage point. Bootstrap simulations indicate that under the null hypothesis, (a) and (b) stated above, the probability of getting an even higher jump is 16 percent. As noted above, that probability would have to be 1 or 5 percent to reject the null hypothesis in standard practice. Note that 16 percent is the minimum p-value in columns (5) and (6).

In sum, the simple frequency analysis in Table G5 provides no evidence that deposit dollarization makes a country vulnerable to a Laeven and Valencia (2020) crisis.

Table G5: Relation Between Exchange Rate Depreciation and Crisis, Conditional on Dollarization

Depreciation (%) bins		Frequency (%) of crisis conditional on:			
lower bound	upper bound	unconditional	dep. doll. $<$ 10%	dep. doll. $>$ 10%	dep. doll. $>$ 20%
(1)	(2)	(3)	(4)	(5)	(6)%
-274.3	-6.0	1.3, (228)	0.0	0.3, (2), [159.00]	0.7, (0), [120.00]
0.5		1.00	0.16	0.99	
-6.0	-0.0	2.0, (346)	3.3	1.6, (254), [0.73]	1.5, (206), [0.60]
		0.35	0.15	0.85	0.65
-0.0	3.7	1.4, (763)	0.8	1.8, (507), [0.66]	1.8, (379), [0.50]
		0.76	0.90	0.16	0.44
3.7	7.4	1.1, (281)	0.0	1.3, (235), [0.84]	1.6, (189), [0.67]
		0.81	1.00	0.33	0.25
7.4	20.8	3.0, (435)	2.0	3.3, (335), [0.77]	3.0, (264), [0.61]
		0.04	0.40	0.20	0.76
20.8	359.0	1.8, (228)	0.0	2.0, (200), [0.88]	2.2, (182), [0.80]
		0.49	1.00	0.23	0.22

Note: Analysis is based on 2,281 annual observations on Laeven and Valencia (2020) crisis indicators, exchange rate changes and indices of deposit dollarization drawn from an unbalanced panel of emerging market economies. The table is composed of six panels. Each panel has two rows, and we begin by explaining the first row in a panel. The exchange rate depreciation bins in the first two columns were constructed as follows. A depreciation in year i, x_i, is defined as $x_i = 100\ln\left(e_i/e_{i-1}\right)$. The smallest and largestx_i's in our sample, -264.3 and 359.0, provide the lower and upper bounds of the first and sixth bins, respectively. The depreciations, -6.0 and 20.8 correspond to the 10th and 90th percentile values of the x_i's in our sample, while 7.4 is the sample mean of thex_i's. Finally, 3.7=7.4/2. The 365 $x_i = 0$ are included the third bin, 0-3.7. In the first row of each panel, column (3) contains a number and a number in parentheses. Columns (4)-(6) contain, in addition, a number in square brackets. The number in column (3) is the frequency (in percent) that a Laeven-Valencia crisis occurs when x_i lies in the interval defined in the entries in columns (1) and (2). The numbers in columns (4) and (5) are the frequency of Laeven-Valencia crises that occur when the exchange rate lies in the interval defined by columns (1) and (2) and the economy is characterized by the level of dollarization indicated at the top of the relevant column. The numbers in parentheses in columns (4)-(5) are the number of observations in our sample in which x_i lies in the interval defined in columns (1) and (2), and the level of dollarization is as reported at the top of the column. The numbers in square brackets is the fraction of observations in which the exchange rate lies in the bin indicated in columns (1) and (2) which have the level of dollarization indicated in the top of the column We now explain the entry in the second row in each panel. These are p-values under the null hypothesis that Laeven and Valencia crises are independent of x_i and the level of deposit dollarization. To understand our bootstrap procedure for computing the p-values, let X denote the 2281 by 4 matrix, where the first column contains the data on x_i and the other three columns contain 0,1 dummies: one that indicates a Laeven and Valencia crisis, and two which indicate whether deposit dollarization is above 10 percent, or 20 percent, respectively. To do the bootstrap we constructed 100,000 artificial datasets, $X(1), ..., X(100,000)$. For the jth data set we randomly drew two sets of integers of length 2281, with replacement, from [1,...,2281]. Then, $X(j)$ was constructed by reordering the rows of the first column of X using the first set of random indices and reordering the rows in columns (2)-(4) with the second set of indices. In this way, we capture the null hypothesis that crises are independent of exchange rates and deposit dollarization. At the same time, our bootstrapped data preserve the empirical covariation between exchange rates and deposit dollarization. Using the artificial $X(j)$'s we compute 100,000 statistics corresponding to the statistics (the numbers without parentheses or brackets) based on X that appear in the first row, columns (3)-(5), in each panel. In column (3) of the second row of each panel we report the number of times that the simulated statistic exceeds its empirical analog in the first row. In the case of columns (4) and (5), the entry is a p-value for the increment in the probability of a crisis over its probability in the previous column. The p-value was computed across our 100,000 simulated datasets.

H Appendix Logistic Regression Tables

H.1 Replicating Gourinchas and Obstfeld (2012)

Gourinchas and Obstfeld (2012) find that rapid credit growth (which is typically financed by borrowing from abroad) and real exchange rate appreciations predict banking crises. In Table H6, we replicate Table 1 without Dollarization and interaction variables. We find that high foreign liabilities in the banking system, nominal depreciations and real appreciations predict banking crises.

$$\Delta rer =$$

$$rer = \frac{SP^*}{P} \rightarrow \Delta rer = \Delta er - (\pi - \pi^*)$$

It appears that when $er \uparrow \rightarrow p \uparrow$

Table H6: Probability of Systemic Banking Crisis Using without Dollarization

	(1)	(2)	(3)	(4)	(5)	(6)
Δe	0.522		0.726		1.102**	
	(0.85)		(1.29)		(1.97)	
Δrer	-2.540*	-3.112***	-1.907**	-2.729***	-2.095*	-3.407***
	(-1.95)	(-3.79)	(-2.03)	(-3.78)	(-1.84)	(-4.24)
High FL/FA	1.630***	1.614***	1.455**	1.443***	1.265**	1.217**
	(2.66)	(2.68)	(2.55)	(2.59)	(2.20)	(2.19)
Reserves/GDP	-4.813**	-5.238**	-4.020	-4.677*	-2.461	-3.285
	(-2.53)	(-2.44)	(-1.59)	(-1.70)	(-1.19)	(-1.36)
External Debt					0.281***	0.264***
					(4.31)	(4.20)
Real GDP Growth	-0.0173	-0.0318	-0.0172	-0.0381	0.0406	0.00424
	(-0.32)	(-0.68)	(-0.29)	(-0.80)	(0.96)	(0.09)
VIX	0.130**	0.128**	0.102**	0.0995**	0.101**	0.0960**
	(2.54)	(2.53)	(2.45)	(2.45)	(2.24)	(2.17)
Constant	-7.262***	-7.081***	-6.632***	-6.369***	-7.514***	-7.021***
	(-4.98)	(-4.67)	(-5.21)	(-5.00)	(-5.65)	(-4.89)
N	1618	1618	1537	1537	1256	1256
Years	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017
Countries	All	All	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.0517	0.0474	0.0326	0.0211	0.0470	0.0302

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Notes: see notes to Table 1. The results here are based on the period, 1970-2017.

H.2 Limiting the Observations to the 2000s

We recomputed the results in Table 1 using only data for 2000-2017. The results are reported in Table H7. Our conclusions based on Table 1 are robust to the use of the shorter dataset.

Table H7: Probability of Systemic Banking Crisis Using only 2000s Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dollar (20)	-0.595	-0.437	0.0787	-0.0348	0.783	0.392	-0.0399	-0.804
	(-0.88)	(-0.81)	(0.09)	(-0.04)	(1.13)	(0.46)	(-0.04)	(-0.81)
Δe	-1.094**	-7.590	-6.177	-4.697	-0.890	-1.444	-1.294	2.519
	(-2.07)	(-1.57)	(-0.95)	(-0.69)	(-0.58)	(-0.23)	(-0.19)	(0.44)
Dollar(20)*Δe	1.431*	4.524**	7.318	6.533	1.247	3.599	3.876	0.537
	(1.64)	(2.49)	(1.35)	(1.14)	(1.42)	(0.61)	(0.53)	(0.11)
High FL/FA			1.716**	1.194		1.461**	1.105*	0.727
			(2.27)	(1.03)		(2.17)	(1.69)	(0.66)
High FL/FA *Δe			-3.852	-4.631		-2.434	-6.000*	-6.451
			(-0.95)	(-0.98)		(-0.73)	(-1.68)	(-1.31)
Low Reserve				-1.261				-16.48***
				(-0.83)				(-15.05)
Dollar(20) * Low Reserves				0.342				16.14***
				(0.67)				(8.67)
High FL/FA * Low Reserves				1.495				1.077
				(0.85)				(0.42)
External Debt							0.270*	0.296*
							(1.80)	(1.93)
Real GDP Growth	-0.0703	-0.0667	0.0366	0.0312	-0.0552	0.0362	0.105***	0.0966***
	(-1.36)	(-1.27)	(0.63)	(0.54)	(-0.95)	(0.55)	(3.13)	(2.71)
VIX	0.280***	0.296***	0.199***	0.200***	0.160***	0.154***	0.139**	0.141**
	(2.92)	(3.04)	(2.81)	(2.92)	(2.83)	(2.64)	(2.40)	(2.48)
Δrer		6.609	0.848	0.279	-0.309	-1.703	-2.397	-3.168
		(1.39)	(0.17)	(0.06)	(-0.20)	(-0.34)	(-0.53)	(-0.67)
Constant	-10.61***	-10.95***	-10.53***	-10.13***	-8.784***	-9.563***	-9.498***	-8.715***
	(-4.62)	(-4.55)	(-4.76)	(-4.25)	(-6.40)	(-5.47)	(-5.25)	(-4.65)
— Inflation Difference								
N	1902	1895	1383	1369	1585	1317	1087	1073
Years	2000-2017	2000-2017	2000-2017	2000-2017	2000-2017	2000-2017	2000-2017	2000-2017
Countries	All	All	All	All	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.111	0.135	0.123	0.117	0.0107	0.0407	0.0744	0.0803

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Notes: see notes to Table 1. The results here are based on the period, 2000-2017.

H.3 Different Measures of Uncertainty

Table H8: Different Measures of Uncertainty

	(1)	(2)	(3)	(4)	(5)	(6)
Δer	2.341	2.628*	2.818**	2.696*	1.951	2.713
	(1.59)	(1.70)	(2.27)	(1.89)	(1.25)	(1.56)
Dollar (20)	-1.012*	-0.880*	-0.915	-0.873*	-1.004*	-0.831*
	(-1.80)	(-1.77)	(-1.63)	(-1.79)	(-1.83)	(-1.66)
Dollar(20)*Δer	-2.202	-2.412	-2.829	-2.394	-2.027	-2.854
	(-0.88)	(-1.05)	(-1.23)	(-1.11)	(-0.81)	(-1.21)
High FL/FA	0.899	0.987	0.992	0.982	0.929	0.790
	(0.96)	(1.07)	(1.04)	(1.02)	(1.00)	(0.88)
High FL/FA *Δer	-6.157**	-8.109***	-5.166**	-7.372***	-6.604***	-9.351***
	(-2.50)	(-3.28)	(-2.11)	(-3.28)	(-2.84)	(-6.38)
Low Reserve	-2.190**	-1.996*	-2.283**	-2.053*	-2.132*	-2.254**
	(-2.07)	(-1.78)	(-2.10)	(-1.78)	(-1.95)	(-2.04)
Dollar(20) * Low Reserves	2.400*	2.160*	2.443*	2.214*	2.391*	2.346**
	(1.78)	(1.71)	(1.87)	(1.67)	(1.77)	(1.97)
High FL/FA * Low Reserves	0.545	0.404	0.551	0.441	0.493	0.673
	(0.35)	(0.25)	(0.35)	(0.28)	(0.32)	(0.40)
Real GDP Growth	0.0579	0.0880	0.0410	0.0760	0.0721	0.0793
	(0.73)	(1.24)	(0.54)	(1.06)	(0.93)	(1.06)
External Debt	0.379***	0.421***	0.311***	0.405***	0.391***	0.380***
	(6.73)	(5.54)	(6.52)	(4.58)	(5.78)	(4.29)
VIX	0.120***					
	(2.88)					
Global Factor		-0.288				
		(-0.61)				
Financial Stress			1.176**			
			(2.07)			
Mon Pol Uncertainty				0.00446		
				(0.29)		
Financial Uncertainty					4.013**	
					(2.43)	
ExcangeRate Market Vol						1.686**
						(2.09)
Constant	-7.692***	-5.237***	-124.2**	-5.657***	-8.930***	-5.819***
	(-5.87)	(-7.52)	(-2.14)	(-3.95)	(-4.89)	(-6.92)
N	1204	1204	1144	1204	1204	1204
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	EMEs	EMEs	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.0521	0.0241	0.0563	0.0223	0.0451	0.0226

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Note: Global Factor is taken from Miranda-Agrippino and Rey (2020). The rest of the uncertainty measures are downloaded from Economic Policy Uncertainty https://www.policyuncertainty.com. Financial Stress measures financial stress based on major US newspapers (Puttmann (2018)). Monetary Policy Uncertainty and Economic Policy Uncertainty measure policy uncertainty in the US (Baker et al. (2016)). Similarly, Exchange Rate Market Volatility tracks volatility in exchange rate markets (Baker et al. (2019)). Financial Uncertainty is from Jurado et al. (2015)

H.4 Adding Second lag

	(1)	(2)	(3)	(4)	(5)	(6)
Δer	-0.910*	0.266	0.334	0.488	2.240*	2.528*
	(-1.85)	(0.09)	(0.11)	(0.70)	(1.80)	(1.76)
Dollar (20)	-0.587	-1.011	-1.095	-0.388	-1.377	-1.787
	(-0.67)	(-0.65)	(-0.74)	(-0.38)	(-0.87)	(-0.98)
Dollar(t-2) (20)	0.180	0.779	0.754	0.749	1.109	0.932
	(0.28)	(0.56)	(0.54)	(0.72)	(0.69)	(0.49)
Dollar(20)*Δer	3.085**	1.971	1.733	1.584	0.500	-1.068
	(2.54)	(0.62)	(0.49)	(0.99)	(0.23)	(-0.43)
High FL/FA		1.689***	1.693***		1.243	0.837
		(2.81)	(2.84)		(1.40)	(0.88)
High FL/FA *Δer		-4.475*	-4.557*		-2.958	-5.449**
		(-1.74)	(-1.68)		(-1.54)	(-2.48)
Low Reserve		0.123	0.00552		-1.217	-2.173**
		(0.38)	(0.01)		(-1.13)	(-2.07)
Dollar(20) * Low Reserves			0.248		0.962	2.355*
			(0.30)		(0.72)	(1.78)
High FL/FA * Low Reserves					0.666	0.585
					(0.48)	(0.38)
Real GDP Growth		0.0363	0.0351		0.0349	0.0636
		(0.45)	(0.42)		(0.39)	(0.76)
External Debt						0.373***
						(6.83)
VIX	0.169**	0.156***	0.157***	0.0787*	0.127***	0.119***
	(2.56)	(3.12)	(3.12)	(1.92)	(3.13)	(2.85)
Dollar(20)(t-1)*(t-2)*Δer	-1.921*	-1.157	-1.059	-1.896	-2.140	-1.565
	(-1.72)	(-0.69)	(-0.60)	(-1.52)	(-1.05)	(-0.57)
Constant	-7.614***	-8.906***	-8.861***	-6.155***	-7.825***	-7.764***
	(-5.22)	(-6.03)	(-5.93)	(-5.53)	(-5.93)	(-6.04)
N	2255	1540	1540	1914	1462	1203

H.5 Adding Interaction Terms

Table H9: Interaction terms

	(1)	(2)	(3)	(4)	(5)	(6)
Dollar (20)	0.0543	-0.0584	1.114	1.205	0.226	2.249
	(0.10)	(-0.09)	(0.55)	(0.60)	(0.23)	(1.25)
Δer	-0.0370	-0.0705	-0.101	-0.116	-1.559	-1.351
	(-0.02)	(-0.03)	(-0.05)	(-0.06)	(-0.32)	(-0.31)
Dollar(20)*Δer	-0.930	-0.912	-1.039	-0.939	-0.610	-0.849
	(-0.28)	(-0.28)	(-0.35)	(-0.32)	(-0.10)	(-0.15)
High FL/FA	1.466**	0.0229	1.413**	0.0420	1.061	-0.341
	(2.08)	(0.01)	(2.23)	(0.03)	(1.57)	(-0.23)
VIX	0.129***	0.0937**	0.157***	0.122**	0.123***	0.139**
	(2.91)	(1.97)	(2.70)	(1.97)	(2.80)	(2.08)
External Debt					0.438**	0.443**
					(1.99)	(2.02)
Reserves/GDP	-2.786	-2.900	-2.839	-2.860	-1.874	-1.871
	(-1.24)	(-1.30)	(-1.26)	(-1.27)	(-1.02)	(-0.98)
Real GDP Growth	0.0342	0.0306	0.0326	0.0335	0.0567	0.0596
	(0.38)	(0.35)	(0.38)	(0.37)	(0.71)	(0.72)
FL/FA * Dollar (20)	-0.0600			-0.0579		-0.0422
	(-0.57)			(-0.54)		(-0.41)
VIX * High FL/FA		0.0553		0.0578		0.0603
		(0.92)		(0.98)		(1.07)
VIX * Dollar (20)			-0.0460	-0.0468		-0.0786
			(-0.71)	(-0.70)		(-1.12)
External Debt* Dollar (20)					-0.196	-0.203
					(-0.68)	(-0.70)
Constant	-7.713***	-6.752***	-8.363***	-7.542***	-8.231***	-8.735***
	(-5.56)	(-5.55)	(-4.57)	(-4.22)	(-6.12)	(-5.34)
N	1464	1464	1464	1464	1204	1204
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	EMEs	EMEs	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.0230	0.0227	0.0239	0.0238	0.0398	0.0479

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

H.6 10% Cutoff

	(1)	(2)	(3)	(4)	(5)	(6)
Δer	-0.804**	-1.533	-0.994	0.243	1.439	1.765**
	(-2.12)	(-0.40)	(-0.27)	(0.51)	(1.59)	(2.48)
High FL/FA		1.693***	1.244		1.467**	1.270
		(2.81)	(1.43)		(2.49)	(1.46)
High FL/FA *Δer		-4.654*	-5.027**		-2.620	-2.880
		(-1.88)	(-2.05)		(-1.36)	(-1.32)
Low Reserve			-0.419			-0.682
			(-0.46)			(-0.73)
Dollar(20) * Low Reserves			-0.389			0.141
			(-0.49)			(0.13)
High FL/FA * Low Reserves			1.105			0.552
			(0.99)			(0.38)
Real GDP Growth	-0.0459	0.0196	0.0233	-0.0317	0.0257	0.0263
	(-1.08)	(0.27)	(0.29)	(-0.79)	(0.34)	(0.32)
External Debt						
VIX	0.188***	0.154***	0.154***	0.0930**	0.125***	0.125***
	(2.61)	(3.11)	(3.17)	(2.28)	(3.14)	(3.14)
Dollar (10)	0.0331	0.415	0.574*	1.231	0.887	0.847
	(0.06)	(0.76)	(1.71)	(1.27)	(0.95)	(1.27)
Dollar(10)*Δer	1.145*	2.517	2.421	0.340	-0.792	-0.795
	(1.66)	(0.66)	(0.70)	(0.51)	(-0.80)	(-0.54)
Constant	-8.179***	-9.145***	-9.058***	-7.257***	-8.790***	-8.540***
	(-5.86)	(-6.59)	(-6.02)	(-5.19)	(-6.24)	(-5.95)
—						
Dollar (20)						
Dollar(20)*Δer						
N	2258	1557	1543	1915	1478	1464

H.7 Level of Dollarization

Table H10: Level of Dollarization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Crisis							
Δer	-0.795	-4.424	-4.424	0.681*	-1.660	-1.961	0.283
	(-1.39)	(-1.55)	(-1.55)	(1.67)	(-0.81)	(-0.68)	(0.46)
High FL/FA		1.542**	1.543*		1.544*	1.138	
		(2.19)	(1.71)		(1.79)	(1.26)	
Dollar	-0.0104	-0.00981	-0.00981	0.000471	-0.00710	-0.0113	-0.00143
	(-0.85)	(-0.77)	(-0.75)	(0.06)	(-0.59)	(-0.92)	(-0.15)
Dollar*Δer	0.0246*	0.0723	0.0723	-0.000323	0.0287	0.0111	0.000949
	(1.87)	(1.40)	(1.40)	(-0.03)	(0.79)	(0.16)	(0.08)
VIX	0.164**	0.167***	0.167***	0.0758*	0.133***	0.127***	0.103**
	(2.49)	(3.01)	(3.01)	(1.78)	(2.94)	(2.68)	(2.02)
Reserves/GDP		-3.142**	-3.148		-3.168	-2.203	-2.919
		(-2.27)	(-1.11)		(-1.04)	(-0.89)	(-1.62)
Real GDP Growth		0.0272	0.0272		0.0242	0.0606	-0.0335
		(0.38)	(0.38)		(0.31)	(0.86)	(-0.78)
High FL/FA * Low Reserves			-0.00218		-0.468	-0.453	
			(-0.00)		(-0.70)	(-0.55)	
External Debt						0.288***	0.313***
						(4.14)	(4.18)
Constant	-7.413***	-8.358***	-8.357***	-5.876***	-7.492***	-7.761***	-6.518***
	(-5.16)	(-5.26)	(-5.28)	(-5.36)	(-5.81)	(-5.77)	(-5.68)
$\overline{\text{D}}$ollar (20)							
Dollar(20)*Δer							
N	2262	1524	1524	1919	1445	1186	1542
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	All	All	All	EMEs	EMEs	EMEs	EMEs
Pseudo R2	0.0473	0.0811	0.0811	0.00358	0.0283	0.0425	0.00895

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

H.8 Exchange Rate Regimes

Here, we control for exchange rate regimes as determined by Ilzetzki et al. (2019). Freely-float regimes is dropped as there were not observed any crisis in that regime. The exchange rate regime with the highest probability of crisis is the "Freely Falling", which means the inflation is higher than 40% for 12 consecutive months.

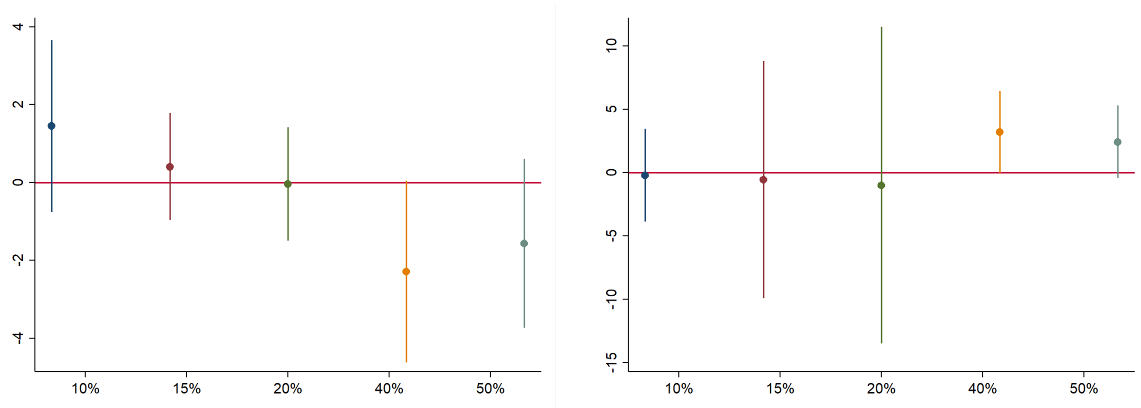
Table H11: Exchange Rate Regimes

	(1)	(2)	(3)	(4)	(5)	(6)
Δer	-0.851**	0.0440	0.0244	-0.390	2.936*	3.093
	(-2.30)	(0.01)	(0.01)	(-1.05)	(1.76)	(1.55)
Dollar (20)	-0.548	-0.661	-0.647	-0.740***	-0.572	-1.150
	(-1.62)	(-1.14)	(-0.85)	(-2.58)	(-0.81)	(-1.59)
Dollar(20)*Δer	1.312	0.682	0.711	1.195**	-2.148	-2.755
	(1.50)	(0.20)	(0.19)	(2.05)	(-0.92)	(-0.93)
High FL/FA		1.883***	1.881***		1.325**	0.831
		(3.34)	(3.34)		(2.01)	(1.18)
High FL/FA *Δer		-4.913	-4.889		-4.004	-8.305***
		(-1.58)	(-1.45)		(-1.39)	(-3.09)
Low Reserve		-0.151	-0.136		-2.071	-3.054*
		(-0.31)	(-0.21)		(-1.39)	(-1.95)
Dollar(20) * Low Reserves			-0.0384		0.684	2.081
			(-0.03)		(0.55)	(1.38)
High FL/FA * Low Reserves					1.472	1.731
					(0.93)	(0.97)
Real GDP Growth		0.0854	0.0857		0.0922	0.130***
		(1.38)	(1.37)		(1.43)	(2.86)
External Debt						0.438***
						(3.41)
VIX	0.168***	0.155***	0.155***	-0.198***	0.123***	0.115***
	(4.74)	(3.73)	(3.67)	(-12.20)	(3.23)	(2.75)
Peg	-7.370***	-9.240***	-9.244***		-8.270***	-8.363***
	(-8.26)	(-7.11)	(-7.14)		(-6.78)	(-7.13)
Crawling peg	-7.791***	-8.671***	-8.676***		-7.463***	-7.773***
	(-8.05)	(-6.47)	(-6.48)		(-6.26)	(-6.29)
Managed float	-7.587***	-9.332***	-9.336***		-8.122***	-8.252***
	(-8.04)	(-7.39)	(-7.44)		(-7.75)	(-7.82)
Freely float	0	0	0		0	0
	(.)	(.)	(.)		(.)	(.)
Parallel mkts.	-6.861***	-7.533***	-7.532***		-6.191***	-6.214***
	(-5.40)	(-4.29)	(-4.30)		(-3.62)	(-3.90)
Freely Falling	-4.220***	-2.367	-2.355		-0.417	-0.326
	(-4.41)	(-1.59)	(-1.51)		(-0.18)	(-0.13)
N	2108	1432	1432	1919	1365	1120
Years	1995-2017	1995-2017	1995-2017		1995-2017	1995-2017
Countries	All	All	All	EMEs	EMEs	EMEs
Pseudo R2						

t statistics in parentheses
* p<0.1, ** p<0.05, *** p<0.01

H.9 Different Cutoffs

In Table H12, we plot dollarization and exchange rate interaction coefficients for different dollarization cutoffs. As the cutoff increases, dollarization coefficient becomes more negative whereas the interaction term becomes more positive, while they are still not statistically significant at 5% level. In Figure H12 we plot AUC-ROC curves for 40% cutoff. Dollarization itself has poor prediction and it does not contribute much to the performance on top of VIX and External Debt.



Dollarization coefficients

Dollarization$\times ER$ coefficients

Table H12: Coefficients of logistic regression for different dollarization cutoffs, lines represent 95% confidence interval

Coefficients are obtained by running the logistic regression in Table 1, column 6. The results based on other columns are similar.

H.10 Levy-Yeyati (2006) Evidence

Levy-Yeyati (2006) is an influential paper often citing by authors that consider deposit dollarization as a source of financial fragility. Using his own dataset, we replicate his results and show that they are highly fragile. Column 1 of H13 replicates table 5, column 6 in Levy-Yeyati (2006). The inference in column 2 allows $\varepsilon_{i,t}$ in equation (4) to be be correlated across countries or across time using the approach in Petersen (2009). Columns 3 and 4 uses 15% and 20% dollarization cutoffs respectively. Finally, column 5 uses post 1990 data. Note that the dollarization loses significance at 5% when the correct standard errors are used. In all other columns, dollarization variables are not statistically significant.

Table H13: Levy-Yeyati (2006) Replication

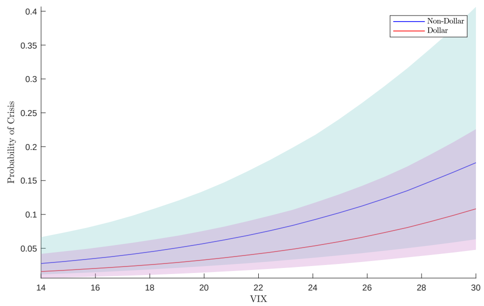
	(1)	(2)	(3)	(4)	(5)
Crisis					
Dollar(10)	0.411	0.411			0.794
	(0.92)	(0.63)			(0.99)
Dollar(10)*Δer	3.196**	3.196*			2.274
	(2.39)	(1.69)			(0.90)
Dollar(15)			0.234		
			(0.47)		
Dollar(15)*Δer			1.208		
			(1.22)		
Dollar(20)				0.0388	
				(0.08)	
Dollar(20)*Δer				1.436	
				(1.46)	
Δer	-2.321	-2.321	-0.567	-0.730	-1.084
	(-1.50)	(-1.02)	(-0.44)	(-0.51)	(-0.46)
FL/FA	0.00698	0.00698	0.00444	0.00479	0.00332
	(1.42)	(1.47)	(1.64)	(1.34)	(1.62)
FL/FA * Δer	0.146	0.146	0.0963*	0.104	0.0709
	(1.53)	(1.57)	(1.77)	(1.48)	(1.44)
Δp	-1.092	-1.092	-0.628	-0.648	-1.490
	(-0.93)	(-0.81)	(-0.50)	(-0.52)	(-1.18)
Δtt	0.0112	0.0112	0.0106	0.0112	0.00556
	(0.86)	(0.73)	(0.66)	(0.69)	(0.27)
realint	-0.000000817**	-0.000000817	-0.000000782**	-0.000000774**	-0.000000672*
	(-2.40)	(-1.62)	(-2.37)	(-2.30)	(-1.71)
M2/reserves	-0.00600	-0.00600	-0.00595	-0.00623	-0.0171
	(-0.36)	(-0.38)	(-0.38)	(-0.41)	(-0.93)
gdppc_i	0.000000564**	0.000000564*	0.000000504	0.000000510	0.000000539
	(2.25)	(1.85)	(1.62)	(1.61)	(1.42)
Δ gdp	-0.00105	-0.00105	-0.00000944	-0.0000249	0.0338
	(-0.03)	(-0.03)	(-0.00)	(-0.00)	(0.68)
private credit/gdp	0.795	0.795	0.896	0.959	1.000
	(0.59)	(0.45)	(0.53)	(0.60)	(0.43)
cash/assets	-0.922	-0.922	-0.962	-0.979	-0.276
	(-0.69)	(-0.80)	(-0.74)	(-0.75)	(-0.23)
capital flows/gdp	-0.575	-0.575	-0.501	-0.570	-1.233
	(-0.37)	(-0.44)	(-0.36)	(-0.41)	(-0.59)
composite_avg	-0.671*	-0.671	-0.692*	-0.723**	-0.711
	(-1.93)	(-1.59)	(-1.78)	(-1.99)	(-1.40)
sudden stop	-0.243	-0.243	-0.217	-0.206	-0.208
	(-0.27)	(-0.26)	(-0.22)	(-0.21)	(-0.23)
currency crisis	1.109*	1.109*	0.924	0.936	0.825
	(1.80)	(1.81)	(1.40)	(1.40)	(1.57)
Constant	-2.912***	-2.912***	-2.847***	-2.749***	-3.264***
	(-5.87)	(-6.76)	(-5.78)	(-5.85)	(-6.00)
N	483	483	483	483	343
Years	1976-2003	1976-2003	1976-2003	1976-2003	1990-2003
StDev Cluster	Country	Country-year	Country-year	Country-year	Country-year
Cutoff	10%	10%	15%	20%	10%

t statistics in parentheses
* p<0.1, ** p<0.05, *** p<0.01

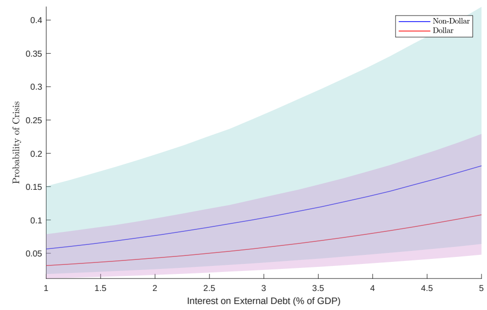
H.11 Implied Probabilities from the Logistic Regression

Figure H10 plots the implied probability of a banking crises using the results under the column 6 of table 1 along with one standard deviation confidence intervals. In a relatively calm period (VIX=14), a country with high external debt has a probability of a systemic banking crises around 2% while the probability rises to around 10% when there is high global uncertainty (VIX=30). Similarly, a country with low external debt has a probability of a systemic banking crises around 5% when VIX is very high; this probability rises to 10% when the interest on external debt rises to 5% of GDP.

Figure H10: Implied Probability of Systemic Banking Crisis



(a) Variations in VIX, for Country with Relatively High External Debt Burden



(b) Variations in External Debt Burden, Holding VIX fixed at High Value

Note: Vertical axis shows the response of the systemic crisis probability to variations in the variable in figure title. In each panel probabilities are reported for the case in which the deposit dollarization dummy is unity ("Dollar") and zero ("Non-Dollar"). In first panel, external debt interest costs are fixed at 5 percent of GDP. In the second panel the VIX is held fixed at 30. In both panels the other variables are fixed at roughly their average values: $\Delta er = 0$, $FL/FA = 1$, $\Delta GDP = 0$, $Reserve/GDP = 0.1$. Computations for the graphs are based on regression results in column 6 of table 1.

H.12 Diagnostics for the Logit Regression

The logit regression results suggest that deposit dollarization does not increase vulnerability to crisis, while the VIX and external debt does. Our conclusions rest on the validity of the (classic) statistical inference that we use, as well as on the validity of the linearity assumption about the log odds of crisis. The fact that crises are low probability events makes us particularly concerned, and so here we turn to some standard informal diagnostics as a check on our analysis. These diagnostic provide support for the idea that our logit specification provides a useful device for forecasting crisis and also support or our inference about the role of deposit dollarization, the VIX and external debt.

The diagnostic device that we use takes into account the two desiderata when forecasting a binary event. We want to maximize the frequency of true positives and minimize the frequency of false negatives. We apply a procedure designed to take these desiderata into account (see, e.g., Fuster et al. (2017); Suss and Treitel (2019)). We define the True Positive Rate (TPR) as follows:

$$TPR\left(\overline{p}\right) = \frac{\text{Number of crises correctly predicted}}{\text{Number of all crisis observations}},$$

where $\overline{p}$ denotes a cutoff such that if $p\left(x_{i,t};\hat{\beta}\right) > \overline{p}$, we say that a crisis is predicted. Obviously, the true positive rate can be set to its highest possible value of unity, simply by setting $\overline{p} = 0$. This is why we also measure the False Positive Rate (FPR):

$$FPR(\overline{p}) = \frac{\text{Number of false crisis predictions}}{\text{Number of all non-crisis observations}}.$$

Here, we see the problem with $\overline{p} = 0$. That would give us a 100 percent false positive rate. We compute $TPR(\overline{p})$ and $FPR(\overline{p})$ for a grid of values of $\overline{p}$ over the unit interval. Our results are presented in Figure H11, where each point on the solid line is $g(\overline{p})$, where

$$g(\overline{p}) \equiv (TPR(\overline{p}), FPR(\overline{p})), \ \overline{p} \in [0,1]. \tag{H.1}$$

The graph of $g(\overline{p})$ is referred to as the Receiver Operating Characteristics (ROC) (see Hosmer et al. (2013, Chapter 5)). The 45 degree line is a benchmark which represents what the ROC curve, g, would look like if $p\left(x_{i,t}; \hat{\beta}\right)$ were simply drawn independently over all i and t from a uniform distribution and the sample were infinite. There is a different g function corresponding to different specifications of $p\left(x_{i,t}; \hat{\beta}\right)$. We do not include this dependence of g on the specification of p in order to keep the notation simple.

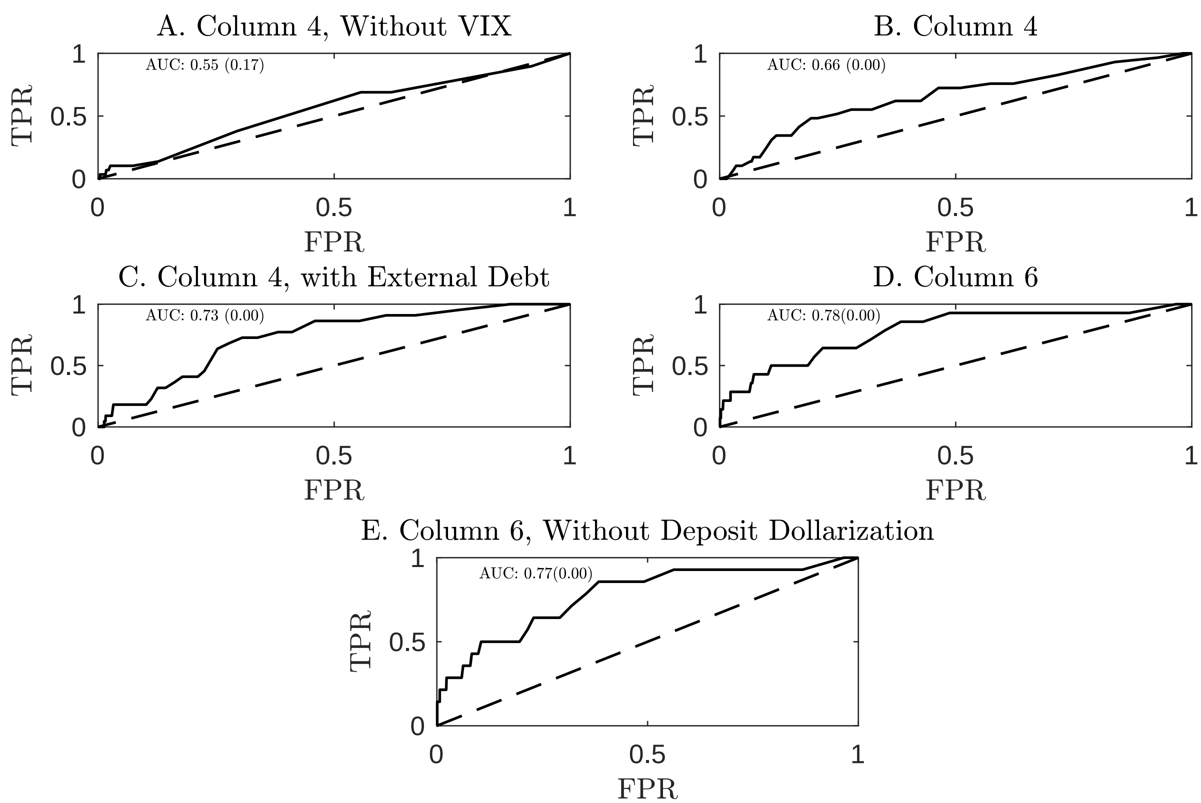
Panel A of Figure H11 graphs $g(\overline{p})$ for the specification of p underlying the results in column 4 of Table 1, except that the VIX is not included in the logit regression when it is estimated. This is a forecasting model that only uses exchange rate depreciations, deposit dollarization and the interaction between the two variables to forecast systemic banking crises. Note that $g(\overline{p})$ is very close to the 45 degree line. The integral of g over $\overline{p} \in (0,1)$ is referred to as the Area Under the ROC curve (AUC). is reported to be 0.55, slightly higher than what it would be if g were exactly the 45 degree line. In fact, g is not statistically significantly different from the 45 degree line. We determined this based on a particular bootstrap exercise. First, we computed the integral underneath the solid line, AUC=0.55. We then computed an artificial AUC by replacing the crisis probabilities, $p\left(x_{i,t}; \hat{\beta}\right)$, for each i, t with an independent draw from a uniform distribution. We repeated the latter exercise 5,000 times. The number in parentheses in Panel A of Figure H11 displays the fraction of times that artificial AUC's exceed the empirical AUC=0.55. The result $p-$value is 0.17 and is indicated in Panel A. That is, the simple logit crisis forecasting model underlying Panel A is not significantly better than a random forecasting model. This is consistent with our conclusion that deposit dollarization is not helpful for forecasting crises.

Panel B of Figure H11 graphs the ROC, $g(\overline{p})$, when the underlying forecasting model is exactly the one in column 4 of Table 1, so that it includes the VIX. Note that now the $p-$value now is zero. So, comparing Panels A and B we see that the VIX does help significantly in crises. Still, according to Hosmer et al. (2013, page 177) and AUC of 0.66 is really only a little better than a random forecasting model. Panel C works with a version of the logit model in column 4 which is estimated with External Debt also included. Adding this variable improves the forecasting model as shown by the fact that the AUC jumps to 0.73.

Hosmer et al. (2013, page 177) argues that this value of AUC constitutes an ‘acceptable’ forecasting model. In panel D we report the ROC when the underlying forecasting model is the estimated one in column 6. The AUC increases with the additional variables, but not very much. For example, Hosmer et al. (2013, page 177) argues that with this value for AUC the model is still only ‘acceptable’ and not ‘excellent’. Finally, Panel E shows the ROC when we re-estimate the column 6 model, leaving out variables pertaining to deposit dollarization. Panel E reports that dropping deposit dollarization leave the AUC of the model virtually unchanged.

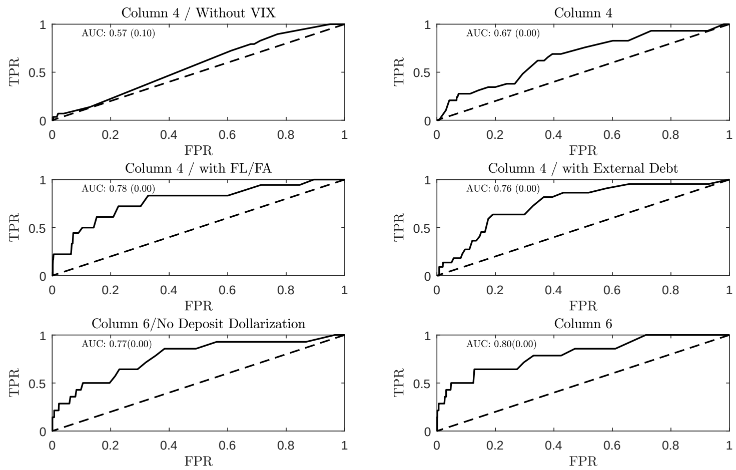
In sum, we find that out logit model is in a sense an ‘acceptable’ model for forecasting crises. The analysis here suggests that the important variables for forecasting crises are the VIX and external debt. Deposit dollarization is not related to crises.

Figure H11: The Information Content For Financial Crises in Deposit Dollarization, the VIX and External Debt



Note: The solid lines correspond to the function, g, defined in equation (H.1). The title of each panel defines the logit regression underlying the g function in each panel. Column 4 and 6 refer to columns in Table (**??**). In Panel A, g is based on an estimated logit regression that corresponds to the one in column 4 in which the VIX has been removed. Panel B uses the logit function reported in column 4. In Panel C, g is based on an estimated logit regression that corresponds to the one in column 4 in which the External Debt has been included. Panel D uses the logit function reported in column 6. In Panel E, g is based on an estimated logit regression that corresponds to the one in column 6 in which the deposit dollarization variables (variables 1 and 3 in Table (**??**)) are removed . See the text for the definition of AUC and for a discussion of the $p-$ values in parentheses.

Figure H12: The Information Content For Financial Crises in Deposit Dollarization (40% cutoff), the VIX and External Debt



Note: The solid lines correspond to the function, g, defined in equation (H.1). The title of each panel defines the logit regression underlying the g function in each panel. Column 4 and 6 refer to columns in Table (1). In Panel A, g is based on an estimated logit regression that corresponds to the one in column 4 in which the VIX has been removed. Panel B uses the logit function reported in column 4. In Panel C, g is based on an estimated logit regression that corresponds to the one in column 4 in which the External Debt has been included. Panel D uses the logit function reported in column 6. In Panel E, g is based on an estimated logit regression that corresponds to the one in column 6 in which the deposit dollarization variables (variables 1 and 3 in Table (1)) are removed. See the text for the definition of AUC and for a discussion of the $p-$ values in parentheses.

I Balance Sheet Effects

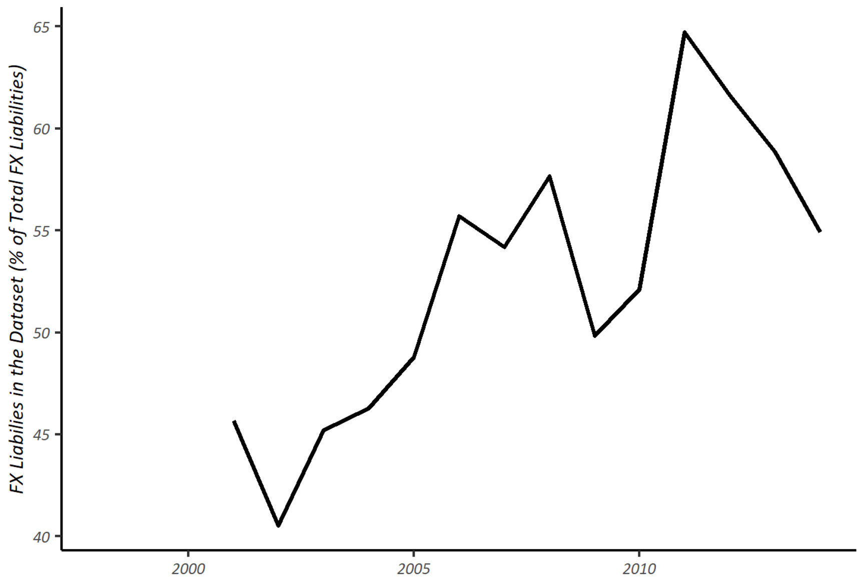
I.1 Analysis of Firm-Level Data in Peru and Armenia

This subsection provides the analysis summarized in Section 5 of the paper. We first describe our analysis of two Peruvian datasets. We then discuss the Armenian dataset.

I.1.1 The Ramírez-Rondán (2019) Dataset

We use the Ramírez-Rondán (2019) data to investigate investment effects of an exchange rate depreciation. After 2006, these data account for well over 50% of all dollar borrowing by non-financial firms in Peru (see Figure I13).

Figure I13: Total Dollar Borrowing in Panel Data Set, Divided by Total Dollar Borrowing by All Non-financial Firms



Note: ratio, total dollar liabilities in Ramírez-Rondán (2019) dataset to total dollar borrowing by Peruvian nonfinancial firms, as reported in the Central Bank of Peru online data and by the BIS. For further discussion, see text.

Table I14 displays our ordinary least squares regression results. The evidence suggests that sales growth and GDP growth are the main drivers of investment and currency mismatch on firm balance sheets is relatively unimportant. Figure I13 shows that total borrowing in the Ramírez-Rondán (2019) dataset encompasses the majority of borrowing by non-financial firms in Peru, at least beginning in 2006.

The left hand variable in our regression is the i^{th} firm's investment in year t. We measure investment by the change in the log of the i^{th} firm's fixed assets.[101] In addition to a constant term, there are two types of right-hand variables: those that pertain to the i^{th} firm as well that those that pertain to the economy as a whole. Firm-level variables include sales/total assets, leverage, and log assets. The last column in Table I14 also uses the firm-level dummy variable, $Large$. That variable is unity for firm i in year t if the i^{th} firm's assets are in the top quartile of firm assets in year t. We also include the dummy variable, $Mismatch$. This variable takes on a value of unity for firm i in year t if the firm's net dollar assets, scaled by its total assets, are less than the median value of that ratio across all firms in year t.[102] We also include a dummy variable, $Exporter$, which is unity for firms whose exports are on

[101] The Ramírez-Rondán (2019) dataset also includes a variable, expenditures on fixed assets, which could be used to measure investment. When we used this variable as the left-side variable in our regressions we obtained results very similar to what is reported in Table I14. These results can be provided on request by the authors.

[102] The median cutoff is negative in each year. Our data on firms' net dollar asset position does not include derivatives.

average more than 20 percent of sales, and zero for the other firms. The firm-level dummy variable, *Non-Exporter* is simply 1-*Exporter*. We differentiate between exporters and non-exporters to help us identify balance sheet effects, if they exist. Assuming non-exporters cannot easily hedge currency mismatch balance sheet effects of exchange depreciations should be most evident for firms like this. All firm-level variables are lagged by one year to minimize simultaneity bias.

The aggregate variables in our regression are not lagged and they include GDP growth, inflation, the VIX and exchange rate depreciation. We include the VIX here because of the importance of that variable in explaining financial crises, in Table 1. As it turns out, the VIX plays no significant role in explaining firm-level investment. Standard errors are reported in parentheses and we take into account clustering in $\epsilon_{i,t}$ by firm and by year (see Petersen (2009)).

Consider column 1 in Table I14, which includes both firm and year fixed effects. The coefficient on $Mismatch \times \Delta ER$ indicates that when there is a nominal depreciation, firms with high currency mismatch tend to cut back on investment in the subsequent year but the coefficient is not significantly different from zero. Column 2 adds aggregate variables instead of year fixed effects. Here, two things are worth noting. First, the coefficient on ΔER indicates that when there is a nominal depreciation, firms tend to cut back on investment in the subsequent year. The second row of column 2 indicates that the subset of firms with currency mismatch cut back on investment a little more, in the wake of a depreciation. Critically, the coefficients in both cases are not significantly different from zero. Second, note that sales and GDP growth are the only significant explanatory variables for investment. Columns 3 includes additional controls and do not significantly change the picture that emerges in column 2. Interestingly, the coefficient on *Large* is positive and modestly significant, while the coefficient on $\log(Assets)$ is negative, though not significant. This suggests that investment is not strongly related to firm size over most of the range of sizes, but is increasing for very large firms. Column 3 also includes a binary variable for Exporters. We find that the exporters invest relatively less after a depreciation but is estimate is not statistically different from zero. Overall, the point estimates in all columns suggest the balance sheet channel is negligible.

Column 2 adds additional aggregate variables. Here, two things are worth noting. First, coefficients on variables also included in column 1 are essentially unchanged in column 2. Second, note that sales and GDP growth are the only significant explanatory variables for investment.

Columns 3, 4 and 5 include additional controls and do not significantly change the picture that emerges in column 2. Interestingly, column 5 shows that the coefficient on *Large* is positive and modestly significant, while the coefficient on $\log(Assets)$ is negative, though not significant. This suggests that investment is not strongly related to firm size over most of the range of sizes, but is increasing for very large firms.

Table I14: Balance Sheet Effects in Peru

	(1)	(2)	(3)	(4)
Mismatch	4.540	2.705	1.481	2.671
	(3.428)	(3.221)	(2.387)	(2.733)
Mismatch * ΔER	-0.0386	-0.0736	-0.0837	-0.114
	(0.202)	(0.192)	(1.580)	(1.582)
ΔER		0.224	0.545	0.525
		(0.438)	(0.525)	(0.568)
log(Assets)	-11.00	2.164	-0.274	-1.939
	(7.098)	(4.460)	(0.870)	(1.379)
Leverage	0.457	0.240	0.148	0.154
	(0.458)	(0.453)	(0.532)	(0.496)
Sales/Assets	19.72**	30.12***	5.941**	5.884**
	(9.723)	(9.695)	(2.902)	(2.955)
GDP		1.464*	2.103**	2.109*
		(0.807)	(1.019)	(1.082)
Mismatch * Non Exporter * ΔER			-0.0425	0.0608
			(1.743)	(1.722)
VIX			0.417	0.404
			(0.293)	(0.310)
Exporter			-0.866	-0.502
			(3.136)	(3.062)
Exporter * ΔER			-0.302	-0.253
			(0.834)	(0.819)
Large				8.456
				(5.196)
Large * Mismatch				-1.355
				(4.936)
Large * Mismatch * ΔER				-0.102
				(0.851)
N	1316	1316	1275	1275
R2	0.174	0.128	0.0256	0.0299
firm fe	yes	yes	no	no
year fe	yes	no	no	no

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Note: Left hand variable is firm-level investment; data are provided by Ramírez-Rondán (2019) and Paul Castillo; data covers 118 firms over 1999-2014.

For our purposes the critical finding in Table I14 is that balance sheet effects on non-financial firm investment appear to be negligible in this data set. This is so, even for firms which we might expect ex ante to exhibit substantial balance sheet effects: the firms that have substantial currency mismatch and are not exporters.

How can it be that the balance sheet effects of exchange rate depreciations are so small for these firms? A direct examination of the balance sheets suggests that foreign exchange exposure is concentrated among firms that have the capacity to withstand large depreciations. To see this let $NetFX$ denote the local currency value of a firm's net foreign exchange position:

$$NetFX = Assets^{\$} - Liabilities^{\$},$$

where $Assets^{\$}$ and $Liabilities^{\$}$ denote dollar assets and liabilities, respectively. Let S denote the actual exchange rate and let S' denote a counterfactual exchange rate. If the exchange rate were S' rather S, a firm's net assets, $NetAssets$, would, in domestic currency units, be:

$$NetAssets + \Delta S \left(Assets^{\$} - Liabilities^{\$} \right),$$

where $\Delta S = S'/S - 1$. The value of ΔS for which the above expression is zero is the depreciation that, if it occurred, would bankrupt the firm. Let $\chi_i(\Delta S)$ denote the function indicating whether firm i is bankrupt, or not:

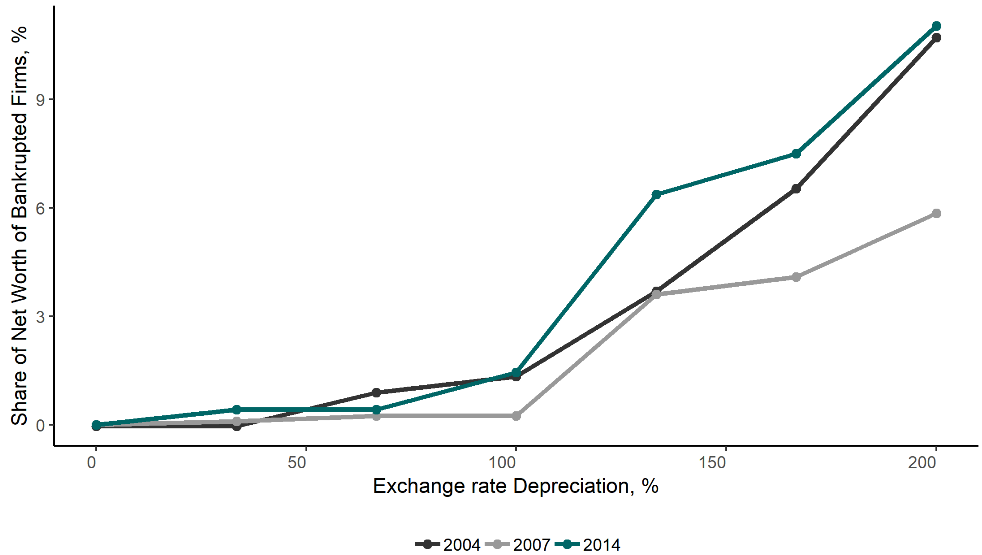
$$\chi_i(\Delta S) = \begin{cases} 1 & NetAssets_i + \Delta S \times NetFX_i < 0 \\ 0 & \text{Otherwise} \end{cases}$$

The fraction of firms (weighted by net assets) that would be bankrupt if the exchange rate depreciated by ΔS is:

$$Default(\Delta S) = 100 \frac{\sum_i \chi_i(\Delta S) \times NetAssets_i}{\sum_i NetAssets_i}.$$

Figure I14 plots the fraction of defaulting firm net worth, $Default$, against counterfactual exchange rate depreciations for three years. Note that even with a 200% exchange rate deprecation, less than 10% of the total firm equity goes bankrupt.

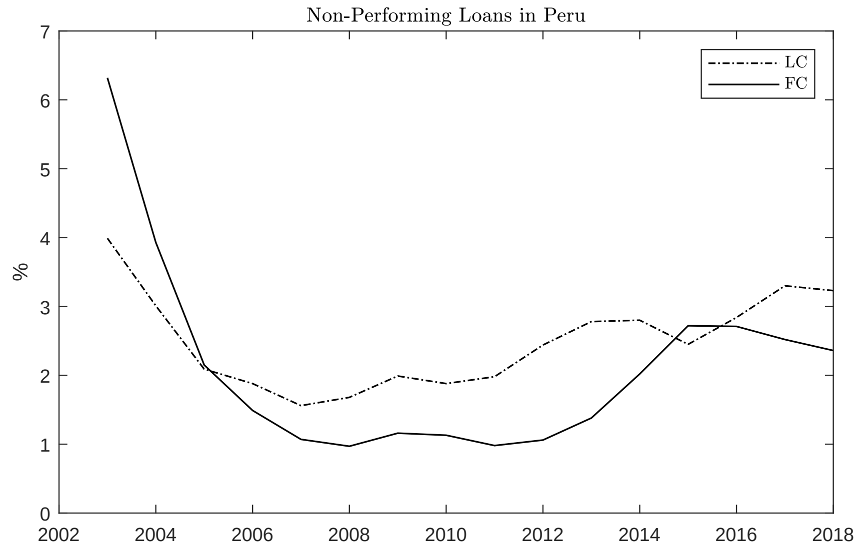
Figure I14: Fraction of Defaulting Firm Net Worth



Our measure attempts to isolate the balance sheet effects of a currency depreciation *per se*. Of course, the effect of a depreciation on a firm's balance will in part reflect the shock that caused the depreciation in the first place. Our results suggest that whatever that shock is, balance sheet effects do not play an important role in its propagation. So, if the depreciation is due to an expansion action by the central bank, then we expect the expenditure switching effects to dominate the balance sheet effects. Similarly, if the depreciation is due to a decline in the demand for exports we expect that balance sheet effects will not amplify the effects of that that shock.

It is possible that the data analysis above is distorted by a kind of survival bias. One piece of evidence which suggests this is not the case can be found in data on non-performing loans for Peru and Turkey (see Figure I15). The figures distinguish between foreign currency and domestic currency loans to non-financial business and households. In Peru, the thing to note is that these rates are roughly the same. One period that is of particular interest to us is 2013-2015, when the large depreciation occurred. Note that the non-performance rate on foreign currency loans did rise then. However, it simply rose up to the rate on domestic currency loans. We view this evidence as complementary to the other evidence displayed in this section which suggests that the balance sheet effects on non-financial firms of exchange rate depreciation are not large.

Figure I15: Non-performing Loans



Source: Respective Central Bank Websites. Here, LC denotes Local Currency loans and FC denotes Foreign Currency loans. Non-Performance is measured as Non-performing FC (LC) Loans / Total FC (LC) Loans

I.1.2 The Humala (2019) Dataset

Following a period of relative calm, Peru experienced a sharp, three-year depreciation starting in 2013. The PEN depreciated around 30%. We use the quarterly balance sheet data from 28 largest firms in Peru studied in Humala (2019) to see what sort of foreign exchange losses they experienced and how their investment responded.[103]

Figure I16a plots cumulative foreign exchange losses during the period covered by the two vertical lines in Figure I17d against currency mismatch in 2012Q4.[104] Each observation has a number attached, so that it is possible to compare observations across figures. The losses and mismatch in Figure I16a are expressed as a ratio of their 2014Q2 equity.[105] The data set does not include information about whether a firm has 'natural hedges' in the form of revenues from exports. Figure I17d shows a positive relationship between currency mismatch and foreign exchange losses. Interestingly, there are two firms, 7 and 20, that are outliers in terms of the magnitude of their foreign exchange losses. There is one firm, 10, that is an outlier in terms of initial currency mismatch.

Figure I16b displays total investment for each firm during the period of the depreciation,

[103] The raw data source is the Superintendency of the Securities Markets in Peru.

[104] Our cumulative data go one year beyond the period over which the depreciation occurred, in order to capture its full effects.

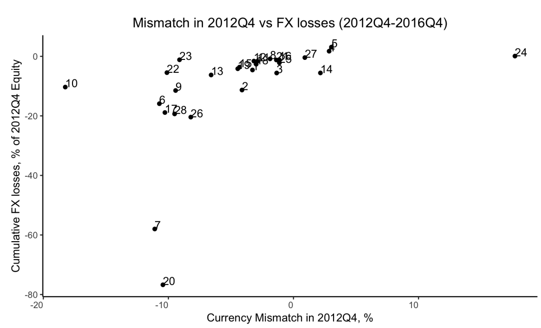
[105] Currency mismatch is defined as the (Dollar Assets - Dollar Liabilities + Net Derivative Position)/Total Assets. Equity is total assets minus total liabilities. All these data, plus the foreign exchange losses analyzed below, are reported by the firms to the Peruvian government agency, the Superintendency of the Securities Markets, which in turn is the data source for the dataset constructed in Humala (2019).

against currency mismatch on the eve of the depreciation. A firm's total investment is the log of the ratio of total assets in 2016Q4 to total assets in 2012Q4. The key finding is that investment is not significantly related to mismatch at the start of the depreciation. Firm 10, which had the most mismatch in the initial period, also had the lowest level of investment. That single observation suggests a link between the two variables. However, taking into account all 28 observations there does not appear to be a link. Figure I16b displays two regression lines, one that uses the firm 10 observation and the other that does not. Both of those lines are roughly the same and essentially flat.

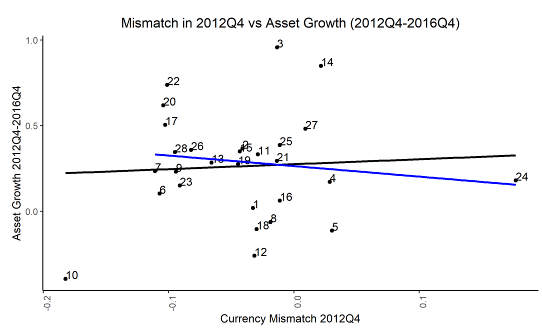
The channel by which currency mismatch might affect investment should operate through foreign exchange losses. So, Figure I17c plots investment against foreign exchange losses. The two outliers in Figure I16a, firms 7 and 20, are apparent in this figure. Note that their levels of investment are at the mean or above the mean of the other firms. The figure displays two least squares regression lines, one with and one without the outliers. In both cases, the point estimates indicate, if anything that investment is higher the bigger are the foreign exchange currency losses.

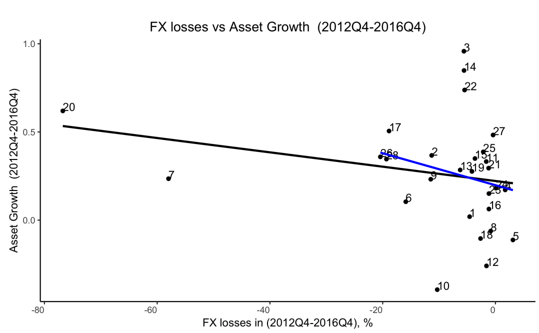
Figure I16: Currency Mismatch, Foreign Exchange Losses and Credit Growth 2012Q2-2016Q4

(a) Currency Mismatch, Foreign Exchange Losses

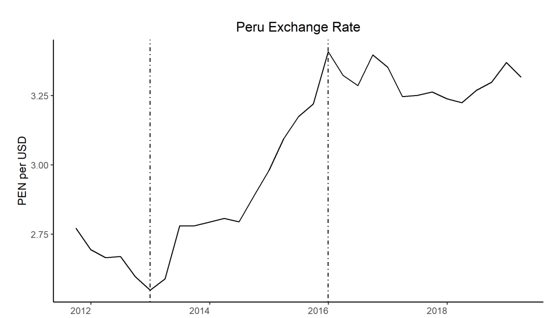


(b) Credit Dollarization vs Asset Growth 2012Q2-2016Q4





(c) FX Losses and Credit Growth 2012Q2-2016Q4



(d) Nominal Exchange Rate in Peru

Note: tick marks refer to exchange rate in the 4^{th} quarter of the preceding year. First and second vertical lines correspond to 2012Q4 and 2015Q4, respectively. Source: average of bid and ask exchange rates used in Humala (2019).

We take the evidence in the figures as indicating that there is no substantial relationship between currency mismatch and investment during the period in which Peru experienced a substantial depreciation. This complements the evidence in Subsection I.1.1 which suggests that exchange rate depreciations, even for firms with currency mismatch and little exports have a statistically negligible impact on firm investment.

I.1.3 Armenia Dataset

Armenia experienced a substantial 17% depreciation between early November 2014 and the end of February 2015 (see figure I17). We study how non-financial firm investment in 2015, 2016 and 2017 is associated with the level of a firm's dollar debt before the depreciation. Our data are annual and end-of-year. We obtain end-of-2013 firm-level data on dollar debt from the Credit Registry of the Central Bank of Armenia.[106] Our credit dollarization variable is a firm's dollar debt divided by its total credit. We also analyze a firm's dollar debt scaled by total assets (financial and fixed), both at end of 2013 (our pre-depreciation observation). Our credit dollarization measure as well as scaled dollar credit are both in percent by multiplying by 100. Asset data were obtained from Armenia's State Revenue Committee and matched with the corresponding credit registry data.[107] Our measure of investment is 100 times $\Delta Capital_t$ the log level of the firm's fixed assets (e.g., structures and equipment) at the end of year t minus that level at the end of year $t-1$, for $t = 2015, 2016, 2017$.

Table I15 displays the results of regressing firm-level investment on credit dollarization. According to the first three columns of row (1), firms with large and small credit dollarization before the depreciation invested about the same amount after the depreciation. This can be seen from the fact that the parameter estimates in row (1) corresponding to 2015, 2016 and 2017 are small and statistically insignificant. In addition, in the 2015 result the sign of the parameter is even 'wrong' from the perspective of the balance sheet effect.

Row (2) in the second three columns of the table investigate a related, but more nuanced, question. We construct a dummy that allows our regression results to focus on firms that are highly levered. We ask whether, among these firms, the ones with high credit dollarization before the depreciation cut back more on investment after the depreciation. To construct our dummy variable, we compute (Total Credit)/(Total Assets) for each firm in our sample in the pre-depreciation period. We rank these numbers from lowest to highest in or order to determine the upper 25% percentile cutoff for (Total Credit)/(Total Assets). A given firm has a dummy, $d = 1$, if its (Total Credit)/(Total Assets) exceeds the cutoff in the period before the depreciation and zero otherwise. The second set of three columns reports the

[106]This dataset contains the universe of all loans in Armenia.

[107]This dataset contains asset and investment information the firms which file corporate tax reports. This tends to be larger firms in Armenia. Smaller companies in Armenia file tax reports which are not required to include asset and investment information.

result of adding this dummy, as well as its interaction with the firm's credit dollarization in the pre-depreciation period. In all three years, we find that the dummy as well as credit dollarization are not statistically different from zero. However, we find that the interaction term is significantly negative in 2015. The evidence from this year suggests that among firms that that were highly levered, those with high credit dollarization cut back significantly on investment relative to those who were not highly levered. At the same time, it is important to note that these effects are only significant in 2015 and that all credit dollarization seems not to have a significant effect on investment in those years.

We interpret our findings as indicating that credit dollarization does not significantly impact a firm's response to an exchange rate depreciation, as long as it is not too highly levered. To the extent that firms are highly levered, credit dollarization can lead to a cutback in investment (and, presumably, employment) if there is a big depreciation. Our interpretation of these results is that it is wise for prudential policy to pay attention to the leverage of firms and households that borrow dollars. Firms and households that are highly levered may not be assessing the risks of exchange volatility properly. An example is the explosion of household foreign-currency borrowing in Eastern Europe prior to mid-January, 2015. At that point the Swiss Frank suddenly appreciated, roiling Eastern European financial institutions.

The parameter, N, in the bottom row of Table I15 indicates the number of firms in the dataset. Note that the value of N declines as we go from 2015 to 2016 and 2017. We investigated whether the decline in N might have been caused by firms experiencing severe balance sheet effects because of the depreciation. If that were true, then our results for 2016 and 2017 in Table I15 would be distorted by selection effects. In fact, we found that the pre-depreciation level of credit dollarization for firms that do not appear in the 2016 and 2017 tax data does not differ substantially from the average credit dollarization of all the firms in our dataset.[108]

We redid the regressions in the first three columns of Table I15, including a dummy variable that indicates whether a firm is an exporter or not. We interacted the dummy variable with the credit variable and found that the resulting coefficient is not significantly different from zero, although we lose a substantial number of observations when want to know if a firm is an exporter or not.[109] This finding is similar to the one reported above for Peru as well as the one found in Bleakley and Cowan (2008). A firm with substantial dollar debt appear to have the same investment response to a depreciation shock whether the firm

[108]We compared the average of our end-of 2013 credit dollarization measures for firms that appear in the 2016 and 2017 data with the average for firms that disappear from either or both of those two years and these averages are not significantly different.

[109]The number of firms for which the export status is reported is about 1/6 of the number of firms in our dataset.

is an exporter or not.

Figure I17: Nominal Exchange Rate in Armenia

Source: IMF International Financial Statistics. Each observation denotes the end of quarter value of the nominal exchange rate.

Table I15: Balance Sheet Effects in Armenia

		2015	2016	2017	2015	2016	2017
$\frac{\text{Dollar Credit}}{\text{Total Credit}}_{2013}$	(1)	0.0329	-0.0299	-0.0104	0.0749	-0.0227	-0.0139
		(0.76)	(-0.87)	(-0.15)	(0.81)	(-0.86)	(-0.14)
High Leverage$_{2013}$	(2)				12.54	4.601	21.06
					(1.17)	(0.50)	(0.71)
$\frac{\text{Dollar Credit}}{\text{Total Credit}}_{2013}$ × High Leverage$_{2013}$	(3)				-0.258**	-0.0420	-0.119
					(-2.21)	(-0.39)	(-0.34)
Age	(4)	0.0754	-0.0120	-0.364	0.0854	0.0484	-0.255
		(0.20)	(-0.04)	(-0.66)	(0.23)	(0.16)	(-0.45)
Employees	(5)	0.00726	0.00453	0.00158	0.00675	0.00423	0.00187
		(1.64)	(1.23)	(0.30)	(1.48)	(1.45)	(1.03)
Constant	(6)	1.221	-2.555	13.92	-0.289	-3.959	10.91
		(0.23)	(-0.59)	(1.57)	(-0.06)	(-0.84)	(1.04)
N		679	609	327	671	594	321

Notes: ; t statistics in parentheses

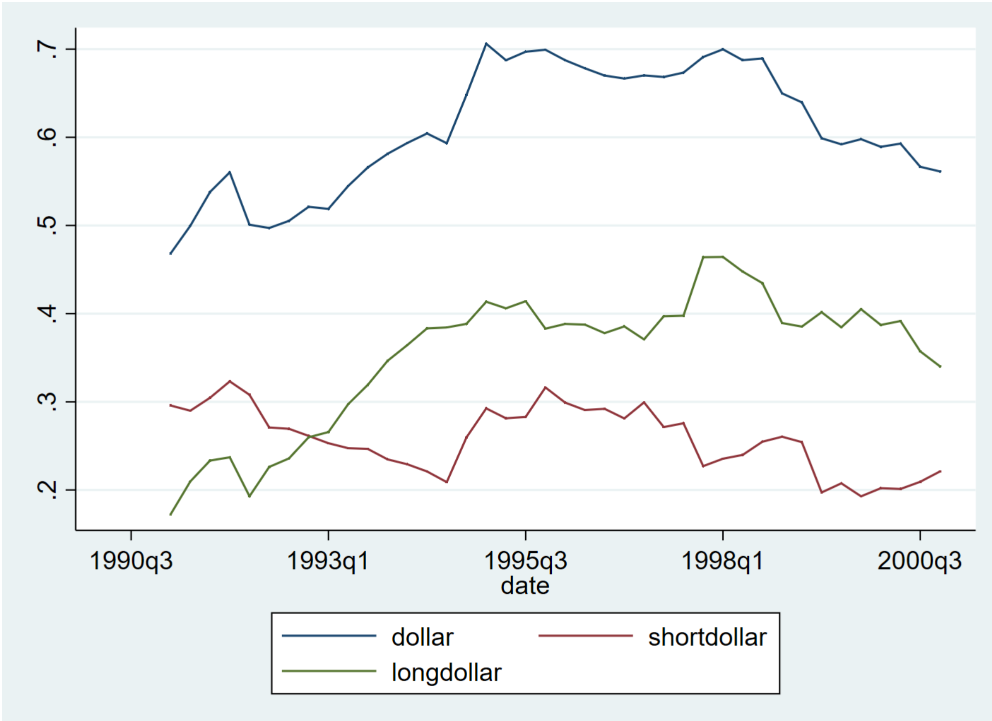
* p<0.1, ** p<0.05, *** p<0.01

Notes: left-hand variable is 100 × $\Delta Capital$; sources: Armenian credit registry and corporate tax reports.

I.2 Dollar Borrowing in Mexico

Figure I18 shows total dollar credit as well as short term and long term credit to non-financial firms in Mexico. The data are scaled by total firm credit. So, the total dollar credit data are the sum of the short-term and long-term data. Note that most dollar credit is long-term.

Figure I18: Dollar Credit to Non-Financial Firms, by Currency, in Mexico



Notes: Here, 'dollar' denotes the ratio of dollar credit to total credit; 'shortdollar' denotes the ratio of short term dollar credit to total credit; 'longdollar' denotes the ratio of long-term dollar credit to total credit. Data used in Aguiar (2005) and kindly provided to us by Mark Aguiar.

J Model Analysis

The first section below describes our model. The second section shows that the model provides a reasonable framework for organizing our empirical results. That section also relates our model to other analyses. Section J.2.1 relates the results of our model to the empirical findings in Miranda-Agrippino and Rey (2020). We show that an exogenous increase in the dollar rate of interest leads to an appreciation of the dollar, a reduction of capital flows in 'the rest of the world', which we assume is composed of small open economies like our model. Although we imagine those economies are somewhat different from each other, they are not sufficiently different to represent a diversifiable risk to our foreign financiers. In addition, we show that the variance of the rate of return on assets (all rates of return are converted into dollar units) increase when the dollar rate increases, suggesting that a measure of the VIX rises in our model after an increase in the dollar interest rate. These results are consistent with the results reported in Miranda-Agrippino and Rey (2020). Our results also can be compared with Ilzetzki and Jin (2020). They report, using 1990-2009 data, that a rise in the dollar interest rate leads to a depreciation in the exchange rate and a rise in foreign output. Ilzetzki and Jin (2020) conjecture that a simultaneous change in risk aversion can account for these results. We explore the impact of changing the risk aversion parameter for foreign financiers in section J.2.1. We show (see Figure J.2.1) that with a decline in risk aversion, foreign (US) financiers make more loans in foreign currency in order to take advantage of the interest premium in the domestic economy. As they acquire foreign currency to lend in the local currency market, the exchange value of the dollar depreciates. In addition, the local interest rate premium falls and local firms borrow more. This borrowing finances investment and higher GDP in the next period. These effects are consistent with the conjectures in Ilzetzki and Jin (2020) about the effects of risk averse

J.1 The Model

The first, second and third subsections below describe our households, firms and foreign financiers, respectively. The final subsections describe the production of final period 2 consumption goods, as well as the economy-wide aggregate conditions. The latter include the market clearing conditions, the balance of payments and domestic GDP. Finally, we define the equilibrium, and summarize the equations and unknowns.

J.1.1 Worker-Households

Household Deposit Decision Households are endowed Y units of *domestic good*, in period 1. They sell all the goods in a period 1 domestic goods market and deposit the corresponding credits in a bank. The bank offers two types of deposits, d and d^*, both denominated in units of the period 1 domestic good. The first type of deposit, d, offers a state non-contingent claim on dr period 2 final domestic consumption goods. The second type of deposit, d^* offers a state non-contingent claim on d^*r^* period 2 foreign goods. We refer to d as 'peso deposits' and d^* as 'dollar deposits'. The household's financial constraint in period 1 is:

$$d + d^* = Y. \tag{J.1}$$

The household's period 2 budget constraint is:

$$c_2^{house} = dr + d^*r^*e_2 + w_2l_2, \tag{J.2}$$

where c_2^{house} and w_2 are denominated in terms of the period 2 final consumption good and wage rate of the household in period 2. The subscript, 2, on a variable indicates that it is contingent on the realization of period 2 shocks. All the variables in (J.3) are denominated in period 2 final consumption goods. In (J.3), e_2 denotes the real exchange rate in period 2. That is, one unit of period 2 foreign goods can be exchanged for e_2 units of period 2 final consumption good. It is useful to substitute out for d in (J.2) using (J.1):

$$c_2^{house} = (e_2 r^* - r)\, d^* + w_2 + Yr. \tag{J.3}$$

Thus, c_2^{house} is the level of consumption the household enjoys if all of Y is deposited into peso accounts, plus the adjustment to consumption that occurs if $d^* \neq 0$. Technically, there is an upper bound on d^* implied by the non-negativity constraint on c_2^{house} . That upper bound can be backed out of equation (J.6) by setting e_2 to the lower bound of its support. In practice, we ignore this constraint.

The problem of the household is to choose d, d^* subject to (J.1) to solve

$$\max_{d^*} Ec_2^{house} - \frac{\lambda}{2} var\left(c_2^{house}\right), \tag{J.4}$$

subject to (J.3) and $0 < l_2 \leq 1, c_2^{house} \geq 0$. With a little algebra it is easy to establish that[110]

$$\begin{aligned} var\left(c_2^w\right) &= \left[d^* - \frac{-Cov\left(r^* e_2, w_2\right)}{var\left(r^* e_2\right)}\right]^2 var\left(r^* e_2\right) \\ &+ \left(1-\rho^2\right) var\left(w_2\right), \end{aligned} \tag{J.5}$$

where

$$\rho = \frac{Cov\left(e_2, w_2\right)}{\sqrt{var\left(e_2\right) var\left(w_2\right)}}.$$

In the special case, $\lambda = \infty$, the household seeks only to use dollars to hedge (or, acquire insurance on) its period 2 income, $w_2 + Yr$. It is clear from (J.5) that with only a hedging motive, the household chooses d^* to set the object in square brackets in (J.5) to zero. In that case, the variance of c_2^w is

$$\left(1-\rho^2\right) var\left(w_2\right) \geq 0,$$

[110]Taking into account that Yr and d^* are not random, we have, $var\left(c_2^w\right) = var\left[d^* e_2 r^* + w_2\right]$. Denoting $s \equiv e_2 r^*, Q = w_2$,

$$\begin{aligned} var\left[d^* s + Q\right] &= E\left[d^*\left(s - Es\right) + Q - EQ\right]^2 \\ &= \left(d^*\right)^2 var\left(s\right) + 2d^* Cov\left(s, Q\right) + var\left(Q\right) \\ &= \left(d^*\right)^2 a + b\left(d^*\right)^2 + c = a\left[\left(d^*\right)^2 - \frac{-b}{2a}\right]^2 + c - \frac{b^2}{4a}. \end{aligned}$$

where

$$a = var\left(s\right), b = 2Cov\left(s, Q\right), c = var\left(Q\right).$$

Equation (J.5) follows by simple rearrangement.

because $\rho \in [-1, 1]$. If $E(e_2 r^* - r) \neq 0$ and the household's risk aversion is finite ($\lambda < \infty$) then it has a speculative motive in addition to the hedging motive for choosing d_1^*. So, for dollar deposits to provide 'perfect' consumption insurance it must be that the correlation between the exchange rate and period 2 is exactly ± 1. The solution to (J.4) is:

$$d^* = -\overbrace{\frac{E(r - e_2 r^*)}{\lambda var(r^* e_2)}}^{\text{speculative motive}} - \overbrace{\frac{cov(r^* e_2, w_2)}{var(r^* e_2)}}^{\text{hedging motive}}. \tag{J.6}$$

The first term reflects the household's *speculative motive* for holding deposits and the second term reflects the worker-household's *hedging motive*. If e_2 depreciates in a recession, when w_2 is low, then dollar deposits are a hedge against income uncertainty. Other things the same, the household would want $d^* > 0$. Of course, if there is a big enough premium on the domestic rate of interest, $r > Ee_2 r^*$, this would drive the household to want to hold less d^*. Note that equation J.6 exhibits a standard feature of mean-variance preferences, namely that a marginal increase in initial wealth (here, Y_1) is allocated totally to the risk free asset, d. This is considered an unrealistic implication of this type of preferences.

The Household Deposit Decision as a Futures Contract In the previous section, we obtained a linear decomposition of the household deposit decision into a speculative and a hedging component. Our use of this language reflects that there is a isomorphism between forward contracts and dollar deposits, which we explain formally in this subsection.

Suppose that in period 1 the household purchases L long contracts to buy dollars with pesos in period 2. The price, F, which specifies the number of pesos the household must pay per dollar in period 2 is determined in period 1 by the requirement that the number of long contracts must equal the number of short contracts. Under the contract, the household receives a payment of $(e_2 - F)L$ pesos from the exchange in period 2. (If this quantity is negative, then the payment goes from the household to the exchange.) So, now the household's period 2 budget constraint is

$$c_2^{house} = (e_2 - F)L + w_2 + Yr. \tag{J.7}$$

We assume that F must be consistent with covered interest parity, so that

$$r = Fr^*. \tag{J.8}$$

There is no current exchange rate in this expression because our definition of r^* is the number of claims on foreign goods in period 2 per domestic goods in period 1 (recall the discussion before equation (J.1)). Using equation (J.8) to substitute out for F in equation (J.7) and rearranging, we obtain:

$$c_2^{house} = (e_2 r^* - r)\frac{L}{r^*} + w_2 + Yr. \tag{J.9}$$

Comparing the latter expression with equation (J.7), we see that with

$$\frac{L}{r^*} = d^* \tag{J.10}$$

the two equations are identical. This establishes that dollar deposits, d^*, in our previous discussion, can be interpreted as long forward contracts on dollars, with $d^* = L/r^*$. Division by r^* converts the future L dollars into period 1 pesos (recall, d^* is measured in pesos). In equation (J.9) the lower bound on the support on e_2 places an upper on L and the upper bound on the support of e_2 places a lower bound on L. The value, $L = 0$, is always feasible but the household can choose L positive or negative, subject to satisfying the budget constraint and $c_2^{house} \geq 0$ with probability 1. The household could guarantee payment to the exchange by putting up claims against its period 2 income as collateral.

In principle, the discussion in this section draws attention to one way that we could be misinterpreting observed dollar deposits. We interpret countries with low dollar deposits as having a low demand for income insurance that derives from covariation of the exchange rate and income. That would not be correct if in those countries, households had access to forward markets. In fact, very few emerging markets appear to have well-developed forward markets in their own exchange rates, and even where those markets are available we assume that households do not have easy access to them.

J.1.2 Firm-Households and Period 2 Domestic Output

The Firms' Decision in the Model Identical, competitive firms are on the other side of the period 1 lending market. Such a firm needs period 1 resources to invest in capital, K. Capital is used, in combination with the labor of the household, to produce domestic output in period 2.

The firm builds K in period 1 using domestic, k_h, and foreign, k_f, inputs using the following production function:

$$K = k_h^{\omega} k_f^{1-\omega}. \tag{J.11}$$

For a given amount of K, the firm's cost minimization problem solves

$$\min_{k_h, k_f} e_1 k_f + k_h + p^K \left[K - k_h^{\omega} k_f^{1-\omega} \right], \tag{J.12}$$

where p^K denotes the Lagrange multiplier on the constraint. Also, e_1 denotes the period 1 real exchange rate: it is the amount of the domestic period 1 good required to purchase 1 unit of the period 1 foreign good. The solution to the firm's cost minimization problem is:

$$k_f = \left(\frac{\omega}{1-\omega}e_1\right)^{-\omega} K,\ k_h = \left(\frac{\omega}{1-\omega}e_1\right)^{1-\omega} K,\ p^K = \left(\frac{\omega}{1-\omega}e_1\right)^{1-\omega} \frac{1}{\omega}, \tag{J.13}$$

where the multiplier, p^K, is the firm's (shadow) marginal cost of building K.

The firm has no resources of its own in period 1, so on net it issues debt, b, b^*, into the period 1 domestic financial market. Here, b and b^* denote borrowing in pesos and dollars, respectively, in period 1. The interest rates on the two assets, r and r^*, are the same rates faced by the household. The firm uses the resources borrowed in period 1 to purchase domestic goods, k_h, and foreign goods, k_f, subject to the financing constraint, $e_1 k_f + k_h = b + b^*$. Substituting out for k_f and k_h in the last expression using (J.13), the financing constraint reduces to:

$$p^K K = b + b^*, \tag{J.14}$$

where the firm treats p^K as an exogenous (shadow) price (see equation (J.13)).[111]

Capital, K, is used by the firm to produce the period 2 domestic good, Y_2^h, using labor:

$$Y_2^h = (AK)^\alpha l_2^{1-\alpha}, \tag{J.15}$$

where l_2 denotes labor hired in period 2 and A denotes a technology shock realized in period 2. Optimization leads to

$$p_2^h Y_2^h - w_2 l_2 = r_2^K K, \tag{J.16}$$

where

$$r_2^K = \alpha p_2^h A \left[\frac{1-\alpha}{w_2/p_2^h}\right]^{\frac{1-\alpha}{\alpha}},\ w_2 = (1-\alpha)\, p_2^h \,(AK)^\alpha,$$

[111] A simple envelope argument establishes p^K is the marginal cost to the firm of K. An interior solution to the minimization problem sets the first order optimality conditions for k_h and k_f to zero and satisfies the complementary slackness conditions: $p^K\left[K - k_h^\omega k_f^{1-\omega}\right] = 0$ and $p^K \geq 0, K - k_h^\omega k_f^{1-\omega} \leq 0$. Because the prices of k_f and k_h are positive, we know that the constraint is binding, so that $K - k_h^\omega k_f^{1-\omega} = 0$ is part of the solution. At the optimum, the inputs are functions, $k_f(K), k_h(K)$ of K. Thus the minimized cost, $C(K)$, is $C(K) = e_1 k_f(K) + k_h(K) + p^K\left[K - (k_h(K))^\omega (k_f(K))^{1-\omega}\right]$. Differentiating with respect to K, we obtain

$$\begin{aligned} C'(K) = &\left[e_1 - p^K(1-\omega)(k_h(K))^\omega (k_f(K))^{-\omega}\right] k_f'(K) + \left[p^K \omega (k_h(K))^{\omega-1}(k_f(K))^{1-\omega}\right] k_h'(K) \\ &+ p^K + p^{K'}\left[K - (k_h(K))^\omega (k_f(K))^{1-\omega}\right] = 0 \end{aligned}$$

so that $C'(K) = p^K$ because all other terms disappear by the first order optimality conditions, including the complementarity conditions assuming the constraint is binding.

so that

$$r_2^K = \alpha p_2^h A \left[\frac{1-\alpha}{(1-\alpha)(AK)^{\alpha}} \right]^{\frac{1-\alpha}{\alpha}} = \alpha p_2^h A^{\alpha} K^{\alpha-1} = \alpha \frac{p_2^h Y_2^h}{K}.$$

Here, we have used the fact that in equilibrium, $l_2 = 1$. Also, w_2 denotes (J.15) the competitive wage rate in units of the final consumption good. Finally, p_2^h denotes number of period 2 final consumption goods needed to purchase a unit of the domestic period 2 output good.

The firm's consumption of final period 2 consumption goods, c_2^{firm}, must satisfy its budget constraint,

$$c_2^{firm} = r_2^K K - (br + b^* e_2 r^*),$$

and its financing constraint, (J.14). Using the financing constraint, equation (J.14), to substitute out for b, the firm's period 2 consumption is given by:

$$c_2^{firm} = \left(r_2^K - p^K r \right) K - b^* \left(e_2 r^* - r \right). \tag{J.17}$$

According to this expression, the marginal return to the firm of a unit of capital is given by $r_2^K - p^K r$ in case all the firm's borrowing in period 1 is in pesos. The expression also shows how consumption is affected in case $b^* \neq 0$.

We define the rate of return on capital in the usual way (payoff on one unit of K, divided by the price of one unit of K:

$$R_2^K = \frac{r_2^K}{p^K}. \tag{J.18}$$

We assume that the firm chooses K and b^* to maximize the following mean variance objective:

$$\max_{b^*, K} E(c_2^{firm}) - \frac{\lambda}{2} var(c_2^{firm}), \tag{J.19}$$

subject to (J.17). Optimization of b^* implies (as in the discussion of section (J.1.1)):

$$b^* = \frac{E(r - e_2 r^*)}{var(e_2 r^*)\lambda} + \frac{cov\left(e_2 r^*, r_2^K\right)}{var(e_2 r^*)} K \tag{J.20}$$

The key thing to note is that the hedging term in (J.20) has the opposite sign from what it is in (J.6). If the exchange rate depreciates when the firm's income is low then, other things the same, the firm does not want to borrow in dollars. Of course, the speculative motive could induce the firm to borrow in dollars after all, even if the exchange rate depreciates in a recession. That would require that there be a premium on the peso interest rate. Finally, optimization of K leads to the following solution:

$$p_1^K K = \frac{E\left(R_2^K - r\right)}{var\left(R_2^K\right)\lambda} + \frac{cov\left(e_2 r^*, R_2^K\right)}{var\left(R_2^K\right)} b^*. \tag{J.21}$$

Again, this has the standard structure of a decision that optimizes a mean-variance objective. Since the firm is a borrower, its hedging incentive goes in the opposite direction from the household's incentive. In particular, if the exchange rate depreciates when their income is low, then their hedging motive drives them to reduce b^*. It is important to note that the solution to this problem has the classic mean-variance property that the risky investment is a function only of variables that are exogenous to the decision maker (in this case, the firm). Equations (J.20) and (J.21) jointly determine the entrepreneur's risky decisions as a function of market prices alone. It is important for our analysis that $c_2^{firm} \geq 0$ in all states of nature. For a computed equilibrium to be an actual equilibrium requires verifying this non-negativity constraint.

Firm Dollar Loans Interpreted as Futures Contracts Suppose that when the firm borrows, it borrows only in pesos. It can participate in futures markets for currency on an exchange. In particular, the firm purchases S short contracts on dollars in an exchange in period 2. It agrees to sell dollars in period 2 at a price of F pesos per contract, i.e., FS. Under the contract, the firm receives $(F - e_2)\,S$ pesos from the exchange in period 2. If $F < e_2$ then the firm receives a negative amount, i.e., it must make a payment to the exchange. The firm's period 2 budget constraint is:

$$c_2^{firm} = \overbrace{\left(r_2^K - p^K r\right) K}^{\text{revenues net of borrowing costs}} + \overbrace{(F - e_2)\,S}^{\text{revenues from future's exchange}}$$

$$c_2^{firm} = r_2^K K + (F - e_2)\,S - p^K r K$$

Under $\delta = 1$ we have the following (mysterious!) equilibrium condition

$$p_2^h = e_2^{\frac{\omega_c}{\omega_c - 1}}$$

$$r_2^K = \alpha p_2^h A \left[\frac{1-\alpha}{(1-\alpha)(AK)^\alpha}\right]^{\frac{1-\alpha}{\alpha}} = \alpha p_2^h A^\alpha K^{\alpha-1} = \alpha e_2^{\frac{\omega_c}{\omega_c-1}} A^\alpha K^{\alpha-1}$$

$$c_2^{firm} = \left(r_2^K - p^K r\right) K + (F - e_2)\left(s + \frac{r_2^K}{e_2} K\right)$$

$$r_2^K K = e_2 S$$

Using the arbitrage constraint in equation (J.8), $r = Fr^*$

$$c_2^{firm} = \left(r_2^K - p^K r\right) K + (r - e_2 r^*) \frac{S}{r^*}.$$

This budget constraint is identical to the firm's budget constraint when has access to loan markets in dollars as well as pesos, as long as we interpret

$$b^* = \frac{S}{r^*}. \tag{J.22}$$

Since we can expect $cov\left(e_2 r^*, r_2^K\right) < 0$, equation (J.20) suggests that firms' hedging motive wants them to go long, not short. To be induced to go long, a premium will be required on the peso interest rate, r.

J.1.3 Foreign Financiers

The Financiers' Decision A third category of participants in domestic financial markets is foreign financiers. These are foreigners who also have mean-variance preferences and who have the ability to borrow and lend in the domestic financial market. In period 1 the representative foreigner financier borrows b^f in the foreign financial market, where b^f is denominated in foreign goods. The financier must pay back $b^f r^\$$ in period 2, where $r^\$$ is period 2 foreign goods per period 1 foreign good borrowed. The equilibrium has the following property:

$$e_1 r^* = r^\$, \tag{J.23}$$

for otherwise the financier would have an arbitrage opportunity. The financier uses the borrowed 'dollars' to make loans in the domestic credit market. Of these loans, $x^\$$ is the quantity of dollar loans and x^D is the quantity of peso loans. Both $x^\$$ and x^D are in units of foreign goods, so that the foreign financiers' financial constraint is:

$$x^\$ + x^D = b^f. \tag{J.24}$$

The foreign financier has other exogenous income, Y_2^f, in period 2, in foreign goods. This other income is imperfectly correlated with the period 2 foreign demand shifter, which we denote by Y_2^*. In particular,

$$Y_2^* = \xi + \nu, \tag{J.25}$$

where ξ and ν are independent random variables which are realized in period 2. We assume that the financier's period 2 other income has the following form:

$$Y_2^f = s\nu,$$

where s is a parameter that is known in period 1 before the financier solves its problem. Thus,

$$Cov\left(Y_2^f, Y_2^*\right) = s \times \sigma_\nu^2. \tag{J.26}$$

Both Y_2^f and Y_2^* are expressed in units of foreign goods.

The financier's consumption is the foreign consumption good value of its period 2 earnings:

$$x^\$ e_1 r^* + \frac{x^D e_1 r}{e_2} - b^f e_1 r^* + Y_2^f, \tag{J.27}$$

where we have substituted out $r^\$$ using the arbitrage condition. After substituting out for b^f from J.24, the financier's consumption of period 2 foreign goods is, after rearranging:

$$\left(\frac{r}{e_2} - r^*\right) x^D e_1 + Y_2^f. \tag{J.28}$$

The objective of the foreign financier is:

$$\max_{x^D} E\left(x^D e_1 \left(\frac{r}{e_2} - r^*\right) + Y_2^f\right) - \frac{\lambda^f}{2} var\left(x^D e_1 \left(\frac{r}{e_2} - r^*\right) + Y_2^f\right). \tag{J.29}$$

The solution to this problem is:

$$x^D = \frac{E\left(\frac{e_1}{e_2} r - r^\$\right)}{var\left(\frac{e_1}{e_2} r\right) \lambda^f} - \frac{Cov\left(\frac{e_1}{e_2} r, Y_2^f\right)}{var\left(\frac{e_1}{e_2} r\right)}. \tag{J.30}$$

Consider the hedging motive here. If the exchange rate depreciates when Y^f is low then the covariance term is positive and the foreign financier does not want to lend pesos in the domestic currency market. Note that if this covariance is sufficiently large then foreigners would still not lend pesos, even if there were a premium on r.

Note also that there is no solution for $x^\$$ and b^f in the foreign financier's problem. Dollars lent and dollars borrowed by the financier exactly cancel in their budget constraint. So, all choices of $x^\$$ and b^f that are consistent with (J.30), (J.24) are welfare-maximizing for the financier. Market clearing will provide the additional restriction needed to pin down the decision of the financier.

Foreign Financiers Participation in Futures Markets We assume that in period 1 foreign financiers have access to the same futures exchange that firms and households participate in. Similarly, we assume there is no period 1 market in dollar deposits. The foreign financiers buy H long contracts on period 2 dollars. In period 1 they commit to pay FH pesos in period 2 for H dollars. So, in period 2 they receive $H(e_2 - F)$ pesos from the exchange in case $e_2 > F$ and they pay in case $e_2 > F$. So, their period 2 profits, in dollar units, of buying H long contracts is:

$$\frac{H\left(e_2 - F\right)}{e_2}.$$

Because there is no local dollar lending market in period 1, we have that $x^{\$} = 0$, so that $x^{D,F} = b^{f,F}$. We use a different notation for peso loans and dollar borrowing by the financier when there are futures markets, because their participation in the local peso market will change when the dollar lending market is replaced by a dollar futures market.

The period 2 profits that financiers make by lending in the period 1 peso market are:

$$\frac{\overbrace{\overbrace{b^{f,F} e_1}^{\text{loans, in peso terms}} \times r}^{\text{dollar revenues}}}{e_2} - b^{f,F} r^{\$} = x^{D,F} e_1 \left(\frac{r}{e_2} - \frac{r^{\$}}{e_1} \right),$$

using the financial constraint, (J.24). Even though a local dollar lending market does not exist, we can still define r^* using arbitrage. In particular the sure dollar return on one peso is

$$r^* = \frac{r^{\$}}{e_1}.$$

So, in period 2 the foreign financiers have the following resources for consumption of the foreign good:

$$\frac{H\left(e_2 - F\right)}{e_2} + Y_2^f + x^{D,F} e_1 \left(\frac{r}{e_2} - r^* \right).$$

Then, using the arbitrage restriction on futures market, equation (J.8), we obtain that period 2 consumption for the foreign financier is:

$$\begin{aligned} \frac{H}{r^*}\left(r^* - \frac{r}{e_2}\right) + Y_2^f + x^{D,F} e_1 \left(\frac{r}{e_2} - r^*\right) &= \left(\frac{H}{r^*} - x^{D,F} e_1\right)\left(r^* - \frac{r}{e_2}\right) + Y_2^f \\ &= \tilde{x}\left(\frac{r}{e_2} - r^*\right) + Y_2^f, \end{aligned} \tag{J.31}$$

where

$$\tilde{x} \equiv \frac{H}{r^*} - x^{D,F} e_1. \tag{J.32}$$

Note that $\tilde{x}$ in effect is a choice variable of the financier because H and $x^{D,F}$ are, while the financier treats r^* and e_1 as beyond its control. In the futures market, the foreign financier has the same problem as in equation (J.29). Comparing equation (J.31) with equation (J.28) we see that the financier's budget equation is the same whether it participates in dollar and peso loan markets, or just peso loan markets and a futures market in which dollars and pesos are traded. The only difference is that in the former, the choice variables are x^D and

$x^{\$}$ (hence, b^f, by equation (J.24)) and in the latter the choice variables are $x^{D,F}$ and H (equation (J.24) then implies $b^{f,F} = x^{D,F}$).

Given the equivalence, the solution to the financier problem can be inferred from equation (J.30):

$$\tilde{x} = \frac{E\left(\frac{r}{e_2} - r^*\right)}{var\left(\frac{r}{e_2}\right)\lambda^f} - \frac{Cov\left(\frac{r}{e_2}, Y_2^f\right)}{var\left(\frac{r}{e_2}\right)}, \tag{J.33}$$

That is,

$$\tilde{x} = x^D e_1. \tag{J.34}$$

Any choice of H and $x^{D,F}$ consistent with (J.32) and (J.32) is welfare-maximizing for the financier.

J.1.4 Final Consumption Good Production in Period 2

The final good is produced in period 2 by combining the domestically produced period 2 good, c_2^h, with an imported period 2 foreign good, c_2^f. We model this as being accomplished by a zero-profit, representative competitive good firm. The firm's CES production function is:

$$c_2 = \mathbb{A}\left[\omega_c^{\frac{1}{\delta}}\left(c_2^h\right)^{\frac{\delta-1}{\delta}} + (1-\omega_c)^{\frac{1}{\delta}}\left(c_2^f\right)^{\frac{\delta-1}{\delta}}\right]^{\frac{\delta}{\delta-1}}, \quad \mathbb{A} = \omega_c^{\omega_c}(1-\omega_c)^{1-\omega_c} \; 0 < \delta \leq 1. \tag{J.35}$$

The firm solves

$$\max_{c_2, c_2^h, c_2^f} c_2 - p_2^h c_2^h - e_2 c_2^f, \tag{J.36}$$

subject to the production function. Here, p_2^h denotes the value, in units of the final period 2 consumption good, of c_2^h. The first order conditions, expressed in Marshallian demand form, are:

$$c_2^h = c_2\omega_c\mathbb{A}^{\delta-1}\left(p_2^h\right)^{-\delta}, \; c_2^f = c_2(1-\omega_c)\mathbb{A}^{\delta-1}e_2^{-\delta}. \tag{J.37}$$

Note that when $\delta \to 0$ we obtain the Leontief result that the ratio of the home to foreign good in production is a constant, $\omega_c/(1-\omega_c)$, independent of relative prices. Also, in the Cobb-Douglas case, $\delta \to 1$, it is the ratio of expenditures on the two inputs that is constant, $\omega_c/(1-\omega_c)$.[112]

It is is well known that with linear homogeneity in production and perfect competition, equilibrium requires that the factor prices (expressed in units of the output good) satisfy a simple relation. We obtain this by substituting (J.37) into the production function and

[112]In the Cobb-Douglas case, the production function converges to $c_2 = \left(c_2^h\right)^{\omega_c}\left(c_2^f\right)^{1-\omega_c}$,by the presence of $\mathbb{A}$ in equation (J.35).

rearranging, to obtain:

$$p_2^h = \begin{cases} \left[\frac{A^{1-\delta}-(1-\omega_c)(e_2)^{1-\delta}}{\omega_c}\right]^{\frac{1}{1-\delta}} & 0<\delta<1 \\ (e_2)^{-\frac{1-\omega_c}{\omega_c}} & \delta=1 \end{cases}.$$

J.1.5 Market Clearing, Balance of Payments and GDP

This section describes the goods and financial market clearing conditions in periods 1 and 2.

Period 1 The market clearing condition in the period 1 goods market is given by

$$c_1^* + k_h = Y. \tag{J.38}$$

Here, Y is the period 1 endowment of domestic goods which households supply to the goods market. The credit they receive for these sales are deposited in the local banks.

Period 1 Gross Domestic Product (GDP) corresponds to Y. The demand for domestic period 1 goods is the sum of the demand by firms, k_h, and the demand by foreigners, c_1^*. We assume that foreigners' demand for domestic goods is given by:

$$c_1^* = \omega e_1^\eta Y^*,\ \eta > 0, \tag{J.39}$$

where η denotes the elasticity of demand for exports and Y^* denotes the foreign demand shifter, in units of foreign goods.

There are clearing conditions in each of the two local financial markets in period 1. The supply of peso loans is $d + x^D e_1$ and the demand for those loans is b. Clearing requires:

$$d + x^D e_1 = b. \tag{J.40}$$

Similarly, clearing in the period 1 market for dollar loans requires

$$d^* + x^\$ e_1 = b^*. \tag{J.41}$$

The balance of payments in period 1 requires that net exports, $c_1^* - e_1 k_f$, equals assets acquired by domestic residents, $d + d^*$, net of liabilities issued by domestic residents, $b + b^*$:

$$c_1^* - e_1 k_f = d + d^* - (b + b^*). \tag{J.42}$$

Period 2 The market clearing condition in the period 2 domestic goods market is given by

$$Y_2^h = c_2^h + c_2^*, \tag{J.43}$$

where c_2^* denotes exports. This is assumed to be determined by the following demand curve:

$$c_2^* = \left(\frac{e_2}{p_2^h}\right)^\eta Y_2^*, \tag{J.44}$$

after scaling the prices. Here, Y_2^* denotes foreign GDP in period 2, defined in (J.25). It is a function of e_2/p_2^h, the relative price of foreign versus domestic period 2 goods. The market clearing condition for period 2 final consumption goods is given by:

$$c_2 = c_2^{house} + c_2^{firm}.$$

Domestic GDP in period 2 measured by spending is the sum of consumption and exports net of imports:

$$GDP_2 = c_2 + p_2^h c_2^* - e_2 c_2^f. \tag{J.45}$$

Using the zero profit condition for final good producers, (J.36), as well as market clearing, (J.43), we find that the value-added representation of GDP is as follows:

$$GDP_2 = p_2^h Y_2^h. \tag{J.46}$$

Finally, the income representation of GDP is give by combining (J.46) with (J.16):

$$GDP_2 = w_2 + r_2^K K. \tag{J.47}$$

The balance of payments in period 2 requires that the receipts for net exports, $p_2^h c_2^* - e_2 c_2^f$, must equal net foreign asset accumulation. We express the period 2 balance of payments in units of period 2 final consumption. Because period 2 is the last period, net asset accumulation in period 2 results in a zero stock of net assets at the end of period 2. For example, if the net asset position at the end of period 1 were positive, then net asset accumulation in period 2 would be negative and the trade surplus would be negative as well.

On the asset side, recall that net asset accumulation by domestic residents in period 1 is $d + d^* - (b + b^*)$, in units of period 1 domestic goods. The period 2 net earnings on those assets, in period 2 final consumption units, is

$$dr + d^* r^* e_2 - (br + b^* r^* e_2).$$

So, the balance of payments requires:

$$p_2^h c_2^* - e_2 c_2^f = br + b^* r^* e_2 - (dr + d^* r^* e_2)\,. \tag{J.48}$$

That is, net exports must be positive in period 2 if interest obligations to foreigners exceed their obligations to domestic residents.

J.1.6 Futures Market

We now consider the adjustments required for the case in which there is no local lending market for dollars, and there is instead a futures market. First, we consider market clearing in the period 1 futures market:

$$L + H = S,$$

or, after diving by r^*, and using equations (J.10), (J.32) and (J.22):

$$d^* - \tilde{x} + b^{f,F} e_1 = b^*,$$

so that clearing in the futures market requires

$$b^{f,F} e_1 = b^* + \tilde{x} - d^*.$$

It is interesting to observe that the total participation of foreign financiers in the domestic financial market, measured by b^f, is not affected whether local dollar lending markets are replaced by futures markets. To see this, use equation (J.34) and equation (J.24) to obtain:

$$b^{f,F} e_1 = \overbrace{b^* - d^*}^{x^\$ e_1} + x^D e_1 = b^f e_1. \tag{J.49}$$

Since we have an algorithm for computing the equilibrium in the version of the model with a loan market and having a futures market is equivalent, we can infer quantities in the futures market from the solution of the loan market version of the model. The formulas for b^*, d^* are unchanged, e.g., they correspond to equations (J.20) and (J.6), respectively. In addition, $\tilde{x}$ corresponds to $x^D e_1$ in the model with only loan markets. We conclude,

$$x^{D,F} e_1 = b^* + x^D e_1 - d^*, \tag{J.50}$$

where the values of the variables on the right of the equality correspond to their value in the baseline version of the model in which there are only loan markets. From equation (J.50) we consider several cases. First, if $b^* = d^*$ so that foreign financiers are not participating in the local dollar market, then the extent of their participation in a futures will not be affected since by equation (J.49) their overall participation is not affected by the markets. If $b^* > d^*$ then foreigners are supplying a positive amount of dollars in the local lending market, so that when that market is shut down they shift their financing into the peso lending market. We can see this simply by rewriting equation (J.50):

$$x^{D,F}e_1 - x^D e_1 = b^* - d^*$$

Obviously if they were borrowing in the dollar market then when that market is shut down, they reduce their lending in the peso market.

J.1.7 Futures Markets and Insurance Flows

In our model we have only one type of outsider, the foreign financier. We denote the quantity of long contracts for dollars by that agent by H. Suppose there are two types of foreigners. The number of dollars purchased long is denoted H^l and the number of dollars purchased short is H^s. Open interest, oi, is the sum of the long contracts or the sum of the shorts. Both sums are the same by market clearing in the futures market. Thus,

$$oi = L + H^l = S + H^s. \tag{J.51}$$

Also, we can define nff, net financial flows, as the net quantity of long contracts purchased by the foreign financier:

$$nff = H^l - H^s = S - L. \tag{J.52}$$

If $nff > 0$ then foreigners gain in the event of a jump in e_2, because on net, they are long on dollars. Presumably, the idea of exorbitant privilege/duty suggests that $nff < 0$ so that in fact foreigns provide insurance and lose when there is a depreciation in local currency, with a jump in e_2. The following identity is useful:

$$\overbrace{min\,[L, S]}^{\text{amount of insurance provided between domestic residence insiders}} + \overbrace{min\left[H^l, H^s\right]}^{\text{amount of insurance provide between foreigners}} + |nff| = oi \tag{J.53}$$

To verify this identify, consider the two possible scenarios, $L > S$ and $L < S$. Suppose (i) $L > S$. In this case $H^s > H^l$ according to equation (J.51). Then, $min\,[L, S] = S$, and equation (J.52) implies $min\left[H^l, H^s\right] = H^l$ and $|nff| = H^s - H^l$. Then,

$$min\,[L, S] + min\left[H^l, H^s\right] + |nff| = S + H^l + H^s - H^l = oi.$$

Now, suppose (ii) $S > L$. In that case, (J.51) implies $H^l > H^s$, so that $|nff| = H^l - H^s$, so that

$$min\,[L, S] + min\left[H^l, H^s\right] + |nff| = L + H^s + H^l - H^s = oi.$$

The case, $L = S$ is trivial so that equation This establishes equation (J.53). Rewriting, we have

$$\frac{min\,[L, S]}{oi} + \frac{min\left[H^l, H^s\right]}{oi} + \frac{|nff|}{oi} = 1,$$

which is displayed in section 3.3.1 in Chari and Christiano (2019).

J.1.8 Interest rate Spread

In this section, we consider the special case of our model $b^* = d^*$. Equating d^* from (J.6) with b^* from (J.20) and rearranging:

$$E\,(r - e_2 r^*) = -\frac{\lambda}{2} cov\left(r^* e_2, w_2 + r_2^K K\right) = -\frac{\lambda}{2} cov\,(r^* e_2, GDP_2)\,. \tag{J.54}$$

Here, the second equality uses (J.47). According to this expression, there is a positive premium on peso deposits if the exchange rate depreciates when GDP is low. This expression is consistent with the very simple intuition in the introduction, in which we disregarded the role of foreigners in domestic credit markets.

It is interest to see what equation (J.54) implies for the forward premium. Using the arbitrage restriction, equation (J.8), (J.54) can be written:

$$E\,(e_2 - F) = \frac{\lambda}{2} cov\,(e_2, GDP_2)\,, \tag{J.55}$$

after dividing both sides by r^*. From equation (J.55) we have F is bigger than Ee_2 when the exchange rate depreciates (i.e., e_2 jumps) in a recession. The reason for this is that when households obtain income insurance by buying dollars in the futures market, they bid up the price, F, of those dollars. They must do so, so that the people taking the other side of the deal earn a reward on average. So, we can think of the price of insurance being the money lost on average by the household, per dollar bought in the futures market, $E\,(e_2 - F)$. This money is transferred to the people who go short, firms and foreigners.

J.1.9 Equilibrium

The 24 unknowns in the model are:

$$K, r, r^*, e_1, e_2, p_2^h, p^K, r^K, b, b^*, k_h, k_f, w_2, d, d^*, c_2^{house}, c_2^{firm}, c_2, c_2^h, c_2^f, c_1^*, c_2^*, x^D, x^{\$},$$

with the understanding that variables with a subscript, 2, are vectors with length equal to the number of possible realizations of the exogenous shocks. We solve the model by reducing it to four equations in the four unknowns, K, r, e_1, e_2. The four equations are (J.21), (J.38), (J.40), and (J.48). We proceed by fixing values for K, r, e_1, e_2 and then using the other equations to determine the 20 other variables above.

J.2 Results

The section below describes the calibration of the model, which uses data from Peru. We then discuss the ability of our model to reproduce the key features of the Peruvian data.

J.2.1 Model Results

Exercise - Increase in Volatility Foreigners' Demand for Exports Figure J19 shows how the equilibrium changes as the standard deviation of the two foreign demand shocks, (ξ and ν in equation J.39) increases from 10 percent below their calibrated values to 10 percent above their calibrated value. A negative realization in that shock creates a recession in period 2 when demand by foreigners for the domestic good drops (see equation J.44). When that happens, the exchange rate, e_2, jumps (depreciates) and the wage rate, w_2,falls (see panel 2,1). This is why the hedging benefit of dollar deposits to the household of increasing dollar deposits increases with the rise in the volatility of the foreign demand shock (see the solid line with dots in panel 1,1). Households respond by increasing their dollar deposits, which appear as the solid like in panel 1,1 of Figure J19. Deposits have been scaled by a constant, Y_1, which is total deposits, $d + d^*$, according to equation J.1. Dollar deposits vary from 0.34 to 1.58 as the volatility of the demand shock varies from smallest to largest. Evidently, the demand for d^* is so high at the upper bound of the variance, that $d < 0$. That is, households borrow in local currency units in order to increase their dollar deposits above Y_1. Other things the same, the decrease in the supply of deposits denominated in local goods drives up the interest rate premium on domestic deposits (see panel 3,1). This moderates the household's incentive to increase its dollar deposits via a fall in the speculative motive. This motive, defined in equation (J.6), can be seen in the dot-dash line in panel 1,1, which shows that the speculative motive alone motivates households to set $d^* < 0$ because borrowing dollars from banks and lending the proceeds in the form of domestic currency on average makes money for the household when there is a premium on peso deposits. The speculative motive is quite strong and varies from -3.12 to -4.45 across the range of variation in Figure J19.

Although the speculative motive makes households averse to dollar deposits when there is a premium on the peso interest rate, the hedging motive is stronger. If households were infinitely risk averse (i.e., $\lambda = \infty$) then the hedging motive would be the only motive operating on households. Across the range of variation in Figure J19 households would want to hold 3.30-5.33 in (scaled) deposits. That is, despite the premium on peso deposits, they want to borrow those deposits, $d < 0$, in order to make d^* very large. Operating through the speculative motive of the household, the relative increase in the domestic rate of interest partially offsets the household's greater hedging motive stronger hedging motive when foreign demand shocks are more volatile. The hedging motive alone makes the demand for dollar deposits rise from 0.34 to 1.58 over the range of volatilities displayed in Figure J19. The 1,1 panel in J19 The premium on the domestic rate of interest Note how the speculative motive (see the dot-dashed line) dictates that households borrow in dollars, $d^* < 0$, and lend in local currency. Total deposits is 1.58, so then the standard rises by 10 percent, deposits are almost entirely in dollars.

For firms, the hedging motive leads to the opposite response in the market for loans. Hedging considerations dictate reducing dollar borrowing when the exchange rate depreciates more in a recession, which is a time when they have low income (see the solid line with dots in panel 1,2). Other things the same, firms' desire to shift borrowing from dollars to local currency adds to the upward pressure on the premium on local currency (see 3,1). With dollar borrowing less attractive and rates on domestic borrowing going up, firms reduce borrowing overall (see panel 3,3). With less borrowing, firms' financial constraint, equation (J.14), implies less investment. With reduced investment, the demand for foreign inputs decreases, leading to a jump (depreciation) in the period 1 exchange rate, e_1. This raises firms' shadow cost of capital, p^K (see equation (J.13)), amplifying the fall in capital investment, K (see panel 2,2).

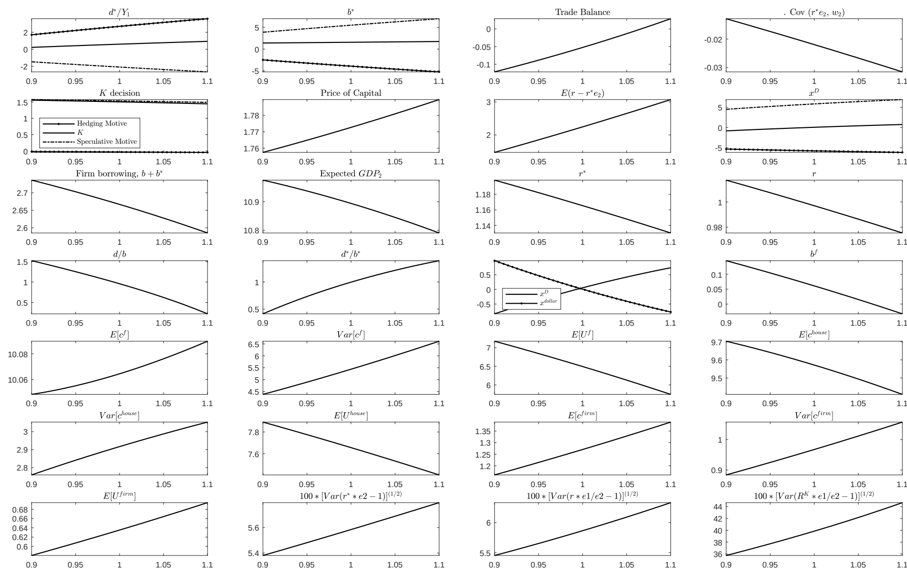
Evidently, net acquisition of assets by domestic residents, $d + d^* - (b + b^*)$, rises with the volatility in the foreign demand shock.[113] The balance of payments, equation (J.42), requires that the trade surplus increase. This is accomplished in part by the stimulus to exports, c_1^*, occasioned by the depreciation in the period 1 exchange rate (see equation (J.39)).

It is interesting to see what the model has to say about the role of foreign financiers, especially given the premium on the domestic rate of interest rises (see panel 3,1). Foreign financiers' speculative motive (the dot-dash line) suggests that they should borrow dollars, convert them into domestic currency and lend the proceeds, x^D, in the domestic financial market. Given the premium on the domestic interest rate this would, in expected value, earn them a profit. They don't exploit this opportunity because with the higher volatility of export demand in period 2, lending in domestic currency units is a bad hedge for foreign financiers. Their other sources of income tend to drop when the demand for exports drop (see

[113]Recall, from equation (J.1), that $d + d^* = Y$, which is pre-determined. So, the conclusion in the text about net asset accumulation reflects the fall in $b + b^*$ observed in panel 3,3 of Figure J19.

equation (J.26)). With the bigger depreciation in the domestic currency when this happens, this strategy hits financiers with losses in their own currency units just when their other sources of income are low.

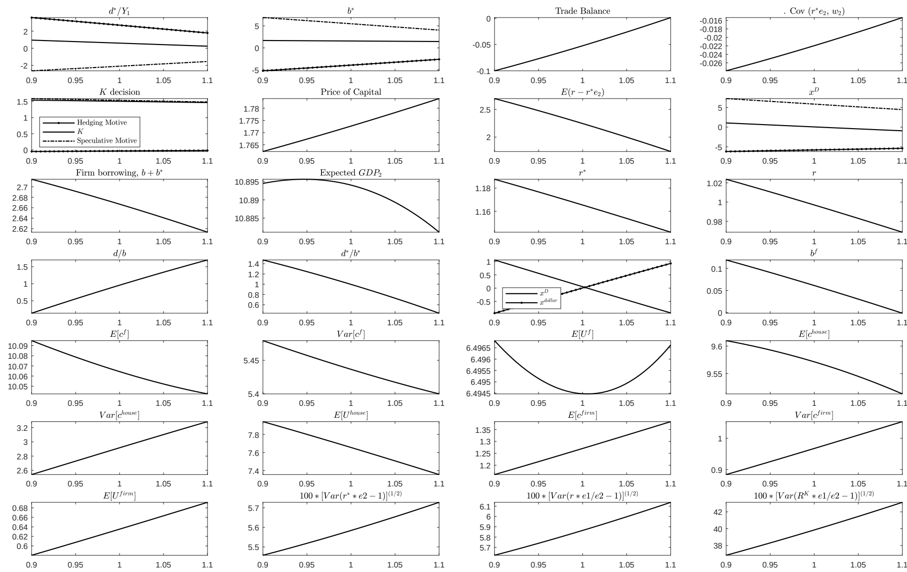
Figure J19: Increase in volatility of trade shock, ξ and ν



Note: horizontal axis displays $x \in [0.9, 1.1]$ and vertical axis is value of indicated variable(s) when the values of σ_ξ and σ_ν in Table (**??**) are replaced by $x\sigma_\xi$ and $x\sigma_\nu$. Here, ν and ξ are the shocks to period 2 foreign demand for domestic period 2 tradable goods (see equation (J.25)). The legend in the panels with three graphs correspond to the legend in the 2,2 panel.

Figure J20 displays the impact on equilibrium of increasing the standard deviation of the technology shock, A, in equation (J.15). When this shock increases in importance, then the depreciation that occurs in a recession is reduced (see panel 1,2). With the hedging value of dollar deposits reduced, households shift from dollar deposits into local currency deposits (see panel 1,1). With the supply of local currency deposits in local lending markets increased, the premium on the domestic interest rate is reduced (see panel 2,2).

Figure J20: Increase in volatility of productivity shock



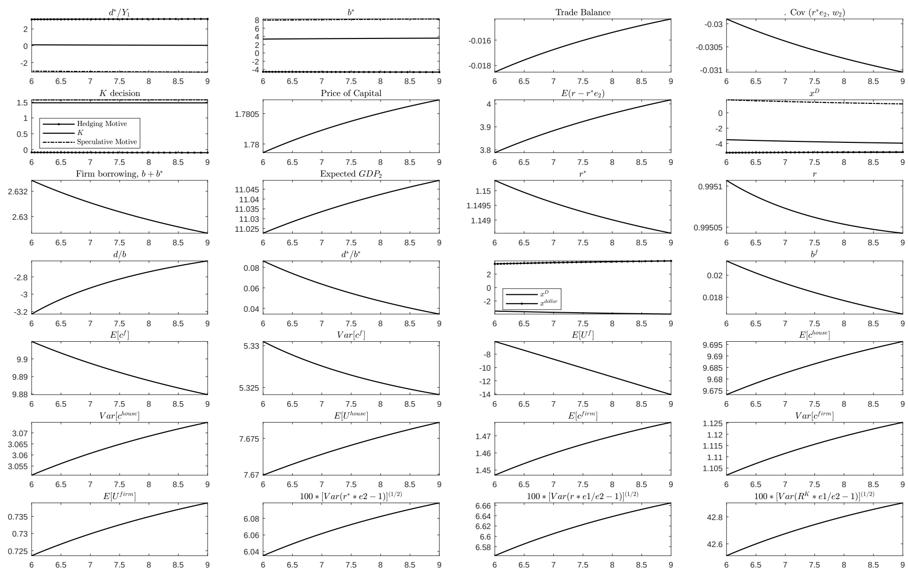
Note: horizontal displays $x \in [0.9, 1.3]$ and vertical axis is value of indicated variable when the value ofσ_A in Table (**??**) is replaced by $x\sigma_A$. Here, A is the technology shock experienced by domestic firms in period 2 (see equation (J.15)).

Exercise - Risk Aversion of Foreign Financiers Figure (J21) shows what happens when we increase the risk aversion of the foreign financiers (see λ^F in equation (J.29)). When foreign financiers become more risk averse they are more reluctant to lend in local currency. With the fall in demand for local currency by foreign financiers, the exchange rate, e_1, depreciates (see the definition of p^K in (J.13) and panel 2,2 of Figure (J21)). The fact that foreign financiers lend less in the local currency market, we see that the interest premium on local currency rises (see panel 2,3). (Foreigners substitute so much into dollar lending that they actually finance this in part by borrowing in local currency to lend in dollars (see how x^D becomes negative in panels 2,4 and 4,3).) Households respond by substituting a little towards peso deposits (panel 1,1). But, overall there is a reduction in local deposits, so that the domestic interest rate premium rises (see panel 2,3). Firms are pushed into borrowing in dollars, but they don't like this so overall borrowing by firms, $b + b^*$, decreases (see panel 3,1). Net foreign asset accumulation goes up because $d + d^*$ is constant. By the balance of payments, this means the trade surplus must rise. The rise in e_1 increases period 1 exports (that e_1 rises can be seen in the fact that p^K rises, according to equation (J.13)). The reduced demand for imports by firms because they cut back on production, also helps increase the trade surplus (see 'sudden stop' in panel 1,3).

Note from the 3,3 panel that r^* falls. This has to be, because $r^\$ = e_1 r^*$, and $r^\$$ is being held constant. But, if r^* goes down then so does r, even though the premium on r goes up.

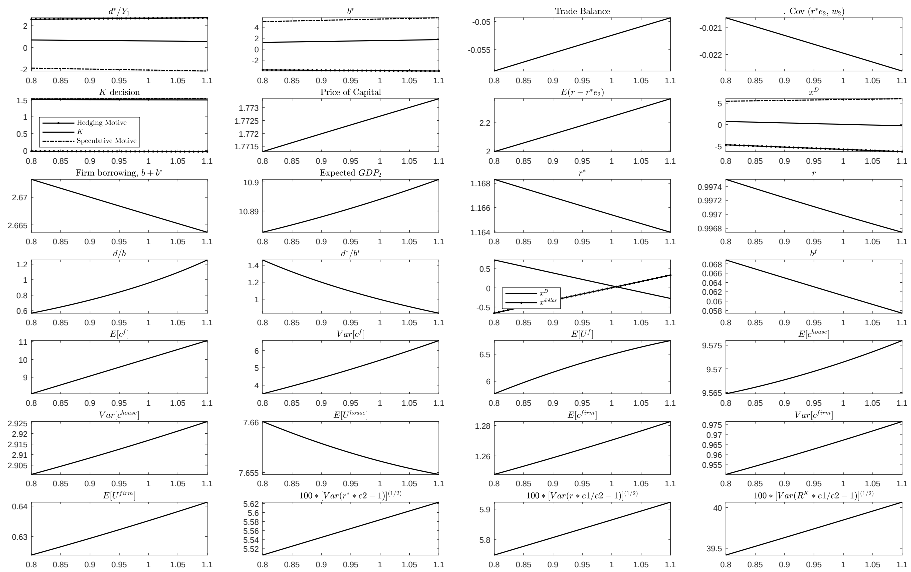
Not surprisingly, because there is less borrowing by firms in the first period, the expected period 2 GDP declines (see panel 3,2).

Figure J21: Increase in foreign financier risk aversion



Exercise - Income comovement of Foreign Financiers Figure J22 shows what happens when we increase the degree of comovement between the trade shock and the income of foreign financiers by increasing the value of s in (J.26). This change makes domestic currency loans a bad hedge, and the effects resemble those in Figure J21.

Figure J22: Increase in comovement between foreign financier income and trade shock

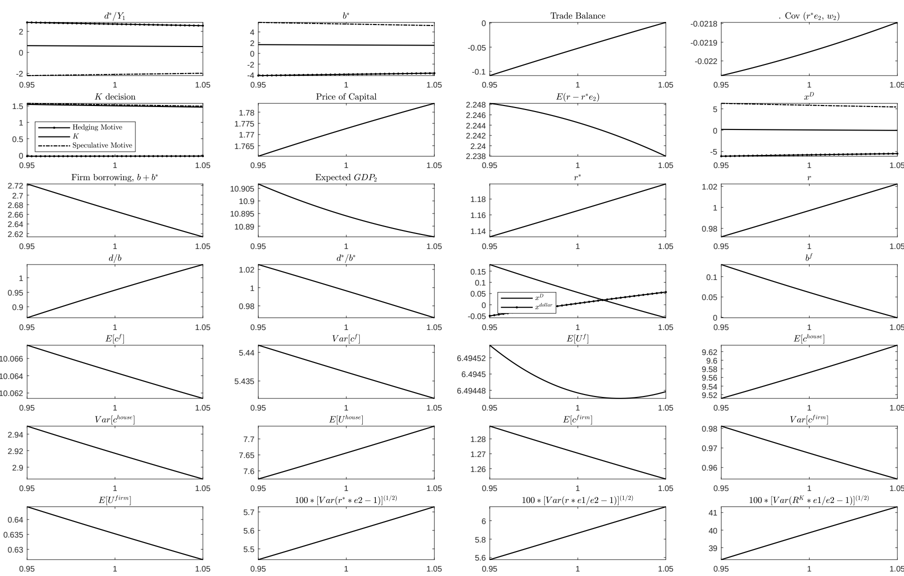


Exercise - Increase in $r^{\$}$ Figure J23 displays the impact of increasing $r^{\$}$. Obviously, that makes dollar assets more attractive. This means that the foreign financier prefers to lend in the dollar market (see panel 4,3). The reduction in the demand for local currency by the foreign financier leads to a depreciation in the exchange rate (see p^K in panel 2,2 and recall equation (J.13)). The reduced supply of funds to the domestic peso market implies that there is an increase in the local currency premium (see panel 2,3). This forces local firms to substitute away from local currency borrowing and into dollar borrowing, which they don't naturally like to do for hedging reasons. So, total firm borrowing, $b + b^*$, goes down (see panel 3,1). So, there is a fall in foreign capital inflows. By the balance of payments (see (J.42)), this implies that the trade balance must increase (see panel 1,3). Holding quantities fixed in J.42, a depreciation makes the trade balance go down (the 'J' curve effect). But, the increase in exports occasioned by the depreciation (see equation J.39), as well as the decline in imports, k_f, ensures that the trade balance actually goes up so that the balance of payments is satisfied. The 4,4 panel indicates that the total amount of dollars borrowed by the foreign financiers, to lend into the local market (either as dollars or pesos) goes down. The fact that capital flows to the domestic economy go down is consistent with evidence in Figure 7 of Miranda-Agrippino and Rey (2020).

Interestingly, the rise in $r^{\$}$ leads in the next period to a fall in domestic GDP. This looks marginally like it contradicts the results in the 1,1 panel of Figure 7 of Miranda-Agrippino and Rey (2020). They do show that there is an initial drop in foreign GDP after a rise in

$r^{\$}$, but that drop is not statistically significant. Eventually, foreign GDP rises after a rise in $r^{\$}$, but that is just barely significantly different from zero. Finally, note that the variance of e_2 goes up (see 7,2 panel of Figure J23). In addition, the variance of the rate of return (in dollars) on investments abroad goes up too. In panel 7,3 of Figure J23 we see that the variance on the return, $re_1/e_2 - 1$, of local currency investments expressed in dollars, goes up. The variance, in dollars, on the rate of return to capital, $R^k e_1/e_2 - 1$, also goes up. The overall rise in variability of returns, seems consistent with results reported in the results in Figure 6 (middle panel) of Miranda-Agrippino and Rey (2020). There, they show that a rise in $r^{\$}$ leads to a fall in the Global Factor, which looks like (the inverse of) the VIX (see panel (a) in their Figure 2). We have not yet investigated how to compute their Global Factor in our model (the only asset price we have is p^K), or their measure of Global Risk Aversion.

Figure J23: Increase in $r^{\$}$



J.3 Summary, Model

In sum, these calculations show that the model can be used to articulate a narrative which summarize our empirical findings. In the calibrated model, configuration of shocks are such that the exchange rate depreciates in a recession. In this case, households have an incentive to denominate their deposits in dollars. In addition, the resulting scarcity of local currency in local currency markets will create the premium on the domestic interest rate observed in many emerging market countries. In our model, foreigners do not trade away that premium by lending in local currency because their position resembles that of domestic households.

Lending for foreigners, as for domestic households, is a bad hedge when the exchange rate depreciates in a recession. In this case, dollar deposits represent an insurance mechanism, by with firms provide income insurance to households. Firms are compensated for borrowing in dollars by being charged a low rate on average. Households pay for the insurance by the opportunity cost of not earning the higher average rate on deposits denominated in domestic currency units.

K Appendix Material on Domestic Household

This appendix explores alternative interpretations of the household's mean-variance utility function. This reinterpretation would also apply to the other mean-variance agents in the model.

K.1 Low Probability of Disaster Restriction

We explored an alternative to the household problem in which it maximizes expected utility subject to a lower bound on the risk of disaster, defined as $c_2^{house} \leq c_l$, where c_l is a 'disaster' level of consumption. In the end, we did not succeed, but there may yet be some approximate sense in which this is similar to our statement of the household problem. The problem is

$$\max_{d^*} Ec_2^{house}$$

subject to

$$\text{prob}\{(e_2 r^* - r)\, d^* + w_2 + Yr < c_l\} \leq p.$$

Put differently, we want to choose d^* to maximize expected utility subject to $CDF\,(c_l; d^*) \leq p$. Setting this up as a Lagrangian problem, we have that d^* solves

$$\max_{d^*} E\left[(e_2 r^* - r)\, d^* + w_2 + Yr\right] + \lambda \left[p - CDF\,(c_l; d^*)\right].$$

Under the assumption of normality (which underlies the utility specification in equation (J.4)) we have

$$CDF\,(c_l; d^*) = \frac{1}{2}\left[1 + erf\left(\frac{c_l - E\left[(e_2 r^* - r)\, d^* + w_2 + Yr\right]}{\sqrt{2Var\left((e_2 r^* - r)\, d^* + w_2 + Yr\right)}}\right)\right],$$

where, for any y,

$$erf\,(y) = \frac{2}{\sqrt{\pi}} \int_0^y e^{-t^2}.$$

By Leibniz's rule we have

$$erf'(y) = \frac{2}{\sqrt{\pi}} e^{-y^2}.$$

The simplicity of this expression will be useful. The first order condition of the household's problem is:

$$\begin{aligned}
E(e_2 r^* - r) &= \lambda CDF_{d^*}(c_l; d^*) \\
&= \lambda \frac{1}{2} \frac{2}{\sqrt{\pi}} e^{-\left(\frac{c_l - E[(e_2 r^* - r)d^* + w_2 + Yr]}{\sqrt{2Var((e_2 r^* - r)d^* + w_2 + Yr)}}\right)^2} \times \frac{d}{dd^*}\left(\frac{c_l - E[(e_2 r^* - r)d^* + w_2 + Yr]}{\sqrt{2Var((e_2 r^* - r)d^* + w_2 + Yr)}}\right)
\end{aligned}$$

Differentiating the last term,

$$\frac{d}{dd^*} \frac{c_l - \mu(d^*)}{(2\sigma^2(d^*))^{1/2}}$$

where

$$\begin{aligned}
\mu(d^*) &\equiv E[(e_2 r^* - r) d^* + w_2 + Yr] \\
\sigma^2(d^*) &\equiv Var((e_2 r^* - r) d^* + w_2 + Yr),
\end{aligned}$$

so that

$$\mu'(d^*) = E(e_2 r^* - r).$$

Also,

$$\frac{d}{dd^*} \frac{c_l - \mu(d^*)}{(2\sigma^2(d^*))^{1/2}} = -\frac{\mu'(d^*)}{(2\sigma^2(d^*))^{1/2}} - \frac{1}{2} \frac{c_l - \mu(d^*)}{\sqrt{2}(\sigma^2(d^*))^{3/2}} \frac{d}{dd^*}\sigma^2(d^*)$$

Then,

$$\begin{aligned}
\frac{d}{dd^*}\sigma^2(d^*) &= \frac{d}{dd^*} E[(e_2 - Ee_2) d^* r^* + w_2 - Ew_2]^2 \\
&= 2E[(e_2 - Ee_2) d^* r^* + w_2 - Ew_2][(e_2 - Ee_2) r^*] \\
&= 2var(e_2) d^* (r^*)^2 + 2r^* cov(w_2, e_2). \qquad \text{(K.1)}
\end{aligned}$$

Substituting,

$$\begin{aligned}
\frac{d}{dd^*} \frac{c_l - \mu(d^*)}{(2\sigma^2(d^*))^{1/2}} &= -\frac{E(e_2 r^* - r)}{(2\sigma^2(d^*))^{1/2}} \\
&\quad - \frac{1}{2} \frac{c_l - \mu(d^*)}{\sqrt{2}(\sigma^2(d^*))^{3/2}} \left[2var(e_2) d^* (r^*)^2 + 2r^* cov(w_2, e_2)\right].
\end{aligned}$$

This expression does not look like our mean-variance problem.

For what it's worth, we verified that our formula for the derivative of the CDF, using the error function 'works' in the case that we differentiate the CDF with respect to c_l. Then, we should get the Normal density function.

$$CDF\left(c_l; d^*\right) = \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{c_l} e^{-\frac{1}{2}\left(\frac{c-\mu(c;d^*)}{\sigma_c(d^*)}\right)^2} dc$$

We know that if we differentiate this w.r.t. c_l then the derivative of CDF is the Normal pdf evaluated at c_l.

Consider the CDF of a Normal variable with mean μ and variance, σ^2. For given x, the CDF with the error formula is:

$$CDF\left(x\right) = \frac{1}{2}\left[1 + erf\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\right]$$

Differentiating with respect to x,

$$CDF'\left(x\right) = \frac{1}{2} erf'\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\frac{1}{\sigma\sqrt{2}}$$

But,

$$erf'\left(y\right) = \frac{2}{\sqrt{\pi}} e^{-y^2}$$

so, as expected:

$$CDF'\left(x\right) = \frac{1}{2}\frac{2}{\sqrt{\pi}} e^{-\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)^2}\frac{1}{\sigma\sqrt{2}} = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)^2},$$

K.2 Risk Neutrality With Variance Constraint

Now, suppose the household maximizes expected utility subject to an upper bound constraint on the variance of consumption:

$$\max_{d^*} Ec_2^{house}$$

subject to

$$var\left(c_2^{house}\right) \leq \alpha V^h.$$

In Lagrangian form,

$$Ec_2^{house} + \nu\left[\alpha V^h - var\left(c_2^{house}\right)\right],$$

where $\nu > 0$ is the multiplier. To see this, suppose $\nu = 0$. Then the solution when there is a premium on r, is to set $d^* = -\infty$ which makes the variance $+\infty$. To avoid violating the constraint, ν must be positive.

It is useful to simplify the variance term:

$$\begin{aligned}
var\left[\left(e_2 r^* - r\right) d^* + w_2 + Yr\right] &= E\left[\left(e_2 r^* - r\right) d^* + w_2 + Yr - E\left(\left(e_2 r^* - r\right) d^* + w_2 + Yr\right)\right]^2 \\
&= E\left[e_2 r^* d^* + w_2 - E\left(e_2 r^* d^* + w_2\right)\right]^2 \\
&= E\left[\left(e_2 - Ee_2\right) r^* d^* + w_2 - Ew_2\right]^2 \\
&= var\left(r^* e_2\right)\left(d^*\right)^2 + var\left(w_2\right) + 2d^* cov\left(r^* e_2, w_2\right) \qquad \text{(K.2)}
\end{aligned}$$

Writing the problem explicitly and in Lagrangian form, we have

$$E\left[\left(e_2 r^* - r\right) d^* + w_2 + Yr\right] + \nu\left[\alpha V^h - E\left(\left(e_2 - Ee_2\right) d^* r^* + w_2 - Ew_2\right)^2\right]$$

The first order condition is:

$$\begin{aligned}
E\left(e_2 r^* - r\right) &= \nu 2E\left[\left(\left(e_2 - Ee_2\right) d^* \left(r^*\right)^2 + w_2 - Ew_2\right)\left(e_2 - Ee_2\right) r^*\right] \\
&= \nu 2 var\left(e_2\right) d^* \left(r^*\right)^2 + \nu 2 r^* cov\left(w_2, e_2\right)
\end{aligned}$$

So,

$$d^* = \frac{E\left(e_2 r^* - r\right)}{\nu 2 var\left(e_2 r^*\right)} - \frac{cov\left(w_2, r^* e_2\right)}{var\left(r^* e_2\right)}. \qquad \text{(K.3)}$$

It is useful to make the functional dependence of ν on V^h explicit. By risk neutrality and assuming

$$E\left(e_2 r^* - r\right) \neq 0,$$

then the complementarity condition implies:

$$var\left(c_2^{house}\right) = \alpha V^h. \qquad \text{(K.4)}$$

Equations (K.3) and (K.4) represent two equations in our two unknowns, d^* and ν. Substituting from equation (K.2):

$$var\left(r^* e_2\right)\left(d^*\right)^2 + var\left(w_2\right) + 2d^* cov\left(r^* e_2, w_2\right) = \alpha V^h. \qquad \text{(K.5)}$$

(K.3) and (K.5) can be solved as one nonlinear equation in ν. In particular, fix ν and compute d^*. Then, evaluate (K.5). Adjust ν until (K.5) is satisfied. Problem is that the solution is not analytic, and not apparently very similar to the problem in section (J.1.1).

In any case, this is not what the VaR people, like Danielsson et al. (2010), are talking about since they assume w_2 is non-random so that $var\left(w_2\right) = cov\left(r^* e_2, w_2\right) = 0$. In that case,

$$var\left(r^{*}e_{2}\right)\left(d^{*}\right)^{2}=\alpha V^{h}$$

so using equation (K.3) we get nonsense:

$$d^{*}=1.$$

This is probably why Danielsson et al. (2010) make the constraint on the standard deviation, $\left(var\left(c_{2}^{house}\right)\right)^{1/2}$, instead of on $var\left(c_{2}^{house}\right)$. We look at the latter case in the following subsection.

K.3 Risk Neutrality With Value at Risk Constraint

Now consider the following problem:

$$\max_{d^{*}} Ec_{2}^{house},\ c_{2}^{house}=\left(e_{2}r^{*}-r\right)d^{*}+w_{2}+Yr$$

subject to

$$\alpha\left[var\left(c_{2}^{house}\right)\right]^{1/2}\leq V^{h}.$$

Again, under the assumption that $E\left(e_{2}r^{*}-r\right)\neq 0$, we have that Ec_{2}^{house} can be driven to positive infinity by driving d^{*} to $\pm\infty$. So, in this case the restriction will be binding. Writing the problem in Lagrangian form, we obtain

$$\max_{d^{*}} Ec_{2}^{house}+\xi\left(V^{h}-\alpha\left[var\left(c_{2}^{house}\right)\right]^{1/2}\right),$$

where $\xi\neq 0$. The first order conditions are:

$$E\left(e_{2}r^{*}-r\right)=\xi\frac{\alpha}{2\left[var\left(c_{2}^{house}\right)\right]^{1/2}}\frac{dvar\left(c_{2}^{house}\right)}{dd^{*}}, \tag{K.6}$$

where, using equation (K.2)

$$\frac{dvar\left(c_{2}^{house}\right)}{dd^{*}}=2var\left(r^{*}e_{2}\right)d^{*}+2cov\left(r^{*}e_{2},w_{2}\right).$$

We can write equation (K.6) as follows:

$$E\left(e_{2}r^{*}-r\right)=\alpha\xi\frac{var\left(r^{*}e_{2}\right)d^{*}+cov\left(r^{*}e_{2},w_{2}\right)}{\left[var\left(c_{2}^{house}\right)\right]^{1/2}}=\alpha\xi\frac{var\left(r^{*}e_{2}\right)}{\left[var\left(c_{2}^{house}\right)\right]^{1/2}}d^{*}+\alpha\xi\frac{cov\left(r^{*}e_{2},w_{2}\right)}{\left[var\left(c_{2}^{house}\right)\right]^{1/2}},$$

or, using the fact that the constraint binds,

$$d^* = \frac{1}{\alpha\xi}\left[E\left(e_2 r^* - r\right) - \alpha\xi\frac{cov\left(r^* e_2, w_2\right)}{\left[var\left(c_2^{house}\right)\right]^{1/2}}\right]\frac{\left[var\left(c_2^{house}\right)\right]^{1/2}}{var\left(r^* e_2\right)}$$

$$= \frac{V^h}{\alpha^2\xi}\frac{E\left(e_2 r^* - r\right)}{var\left(r^* e_2\right)} - \frac{cov\left(r^* e_2, w_2\right)}{var\left(r^* e_2\right)}, \tag{K.7}$$

which looks just like equation (J.6), with $\lambda = \alpha^2\xi/V^h$. So, the solution is given by equation (K.7) and the binding constraint:

$$\alpha\left[var\left(r^* e_2\right)\left(d^*\right)^2 + var\left(w_2\right) + 2d^* cov\left(r^* e_2, w_2\right)\right]^{1/2} = V^h. \tag{K.8}$$

At this point, the problem is analytically complicated. It can be solved by choosing a particular value of ξ and then computing d^* using equation (K.7). Then, adjust ξ until (K.8) is satisfied.

In Danielsson et al. (2010) it is assumed that $var\left(w_2\right) = cov\left(r^* e_2, w_2\right) = 0$,so that (K.7) and (K.8) reduce to

$$d^* = \frac{V^h}{\alpha^2\xi}\frac{E\left(e_2 r^* - r\right)}{var\left(r^* e_2\right)},\ V^h = \alpha\left[\left(d^*\right)^2 var\left(r^* e_2\right)\right]^{1/2}. \tag{K.9}$$

Note that the second equation cannot be used to compute d^*, only its absolute value. We first get an expression for ξ. Using the second equation in (K.9) to substitute out for V^h in the first equation,

$$d^* = \frac{\alpha\left[var\left(r^* e_2\right)\right]^{1/2} d^*}{\alpha^2\xi}\frac{E\left(e_2 r^* - r\right)}{var\left(r^* e_2\right)},$$

so that, after cancelling d^* on both sides and rearranging:

$$\xi = \frac{E\left(e_2 r^* - r\right)}{\alpha\left[var\left(r^* e_2\right)\right]^{1/2}}. \tag{K.10}$$

Just like in Danielsson et al. (2010, eq. 14), according to the first equality in (K.10), the multiplier, ξ, is proportional to an object that looks like the Sharpe ratio. Using equation (K.10) to substitute out for ξ in the expression for d^* in the first expression in (K.9):

$$d^* = \left(\frac{V^h}{\alpha^2\xi}\right)\frac{E\left(e_2 r^* - r\right)}{var\left(r^* e_2\right)} = \frac{V^h}{\alpha^2}\frac{\alpha\left[var\left(r^* e_2\right)\right]^{1/2}}{E\left(e_2 r^* - r\right)}\frac{E\left(e_2 r^* - r\right)}{var\left(r^* e_2\right)} = \frac{V^h}{\alpha\left[var\left(r^* e_2\right)\right]^{1/2}} = d^*,$$

where the last equality uses the second equality in equation (K.10).

It seems misleading to think of the first equation in (K.9) as determining d^* as a function of the 'shifter', ξ. The latter variable moves with the mean return and the variance of $r^* e_2$. It seems like the only expression which delivers d^* as a function of exogenous variables alone is the binding constraint, adjusted so that you can sign d^* :

$$d^* = sign\left[E\left(e_2 r^* - r\right)\right] \frac{V^h}{\alpha \left[var\left(r^* e_2\right)\right]^{1/2}}$$

This looks very different from equation (J.6). Apart from the sign of $E\left(e_2 r^* - r\right)$, it seems to leave no role for the magnitude of $E\left(e_2 r^* - r\right)$, which plays an important role in the mean-variance approach.