FINANCIAL DOLLARIZATION:
EFFICIENT INTRANATIONAL RISK SHARING OR PRESCRIPTION FOR DISASTER?

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ABSTRACT

A large literature focuses on the implications of the dollar for international risk sharing. In contrast, we find evidence that most of the risk sharing associated with the dollar is intranational rather than international. It is sometimes suggested that the insurance benefits of the dollar are undone by an increased risk of financial fragility. We display empirical evidence that this concern is over-stated. We develop a simple model formalizing our findings about the insurance role of the dollar, which is consistent with the key cross-country facts on interest rate differentials, deposit dollarization and exchange rate depreciations in recessions.

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A data appendix is available at http://www.nber.org/data-appendix/w29034

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 emerging market economies (EMEs). 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 EMEs 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 more in a recession (see Dalgic (2018)). We infer from (a) and (b) 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 close in magnitude to dollar deposits.

To us, these three observations suggest a particular narrative about a 'typical' EME (the *domestic economy*). Households in the domestic economy who denominate their deposits in dollars purchase business cycle insurance from the households in the same economy 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 over the dollar rate, adjusted for the exchange rate. The payoff from the insurance is the spike in the dollar return that occurs when the local currency depreciates in a recession.

[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 many EME's these assets are in fact denominated in US dollars, in many cases they are in Euros or Yen, or another currency. 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.

However, the dollar would hardly be a good source of intranational insurance if dollarization simultaneously made a country more vulnerable to financial instability.[3] On the contrary, we find that, given the regulatory regime of the 2000s, the view that dollarization destabilizes (say, by increasing the likelihood of financial crisis or just forcing firms to walk away from good investment projects) receives little empirical support. We find that the most important variables for forecasting crises in EMEs are the VIX and the total dollar debt borrowed by domestic residents from foreigners. There is little systematic relationship between dollarization and financial instability. We reach this conclusion in part based on logit regressions on country panel datasets. In addition, we examine firm-level datasets for Peru and Armenia. Both these datasets cover periods when there were substantial exchange rate depreciations. These datasets allow us to compare firms that have currency mismatch on their balance sheets, but are otherwise the same. If balance sheet effects were important then a depreciation should lead the firm with a balance sheet mismatch to cut back on employment and investment. We do not see this happening in our Peruvian and Armenian datasets. Our firm-level findings complement those reported for other countries in Bleakley and Cowan (2008).

The last section of the paper describes a two-period, small open economy model formalizing our narrative. Motivated by our findings about the role of balance sheets, our model does not include financial frictions. 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 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 times when the agent's other sources of income are low.

The principle shock in our narrative is an export demand shock which causes the exchange rate to depreciate when domestic incomes are low in the second period.[4] Hedging

[3]For a description of how, in principle, deposit and credit dollarization could lead to financial crisis, see, for example, Bocola and Lorenzoni (2020).

[4]With one caveat, we suspect that our analysis would work for essentially any shock that causes the exchange rate to depreciate in a recession. We adopt the export demand shock primarily for expository

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.[5] Financial markets in effect allow these two types of agents to engage in an insurance arrangement. Households receive insurance by saving in dollar deposits.[6] *Ceteris paribus*, 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.

Our model also includes *foreign financiers*, who have mean-variance preferences over the foreign consumption good and trade domestic and foreign financial assets.[7] Financiers are reluctant to lend in the high return local currency assets because times are typically bad for them when the local EME is in recession and the local currency depreciates (see Hassan (2013)). This reluctance is consistent with a finding in Lustig and Verdelhan (2007). They show that in countries where the dollar exchange rate[8] depreciates more when US durable

purposes and also because Obstfeld (2022) argues that such shocks are important drivers of business cycles, especially for more open EMEs (see also Hassan (2013)). The literature offers several other factors that can cause shocks to create depreciations in a recession: being away from the center of trade networks (Richmond (2019)); invoicing in dollars (Gopinath et al. (2020); Akinci and Queralto (2018); Dalgic and Ozhan (2021)) and global value chains (Antràs and Chor (2013)). In addition, depreciations could occur in recessions because monetary policy is countercyclical. We suspect that whatever shocks cause depreciations in recession would motivate savers to hold dollar assets as a hedge. Our caveat stems from the fact that we also emphasize the role of deposit dollarization in creating a local interest rate premium. Below, we rely on a hedging motive on the part of foreign financiers that prevents them from wiping out that premium. Whatever shock causes the exchange rate to depreciate in a recession must be consistent with the existence of that hedging motive.

[5] 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.

[6] 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.

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

[8] That is, local currency per dollar.

consumption is low, the local interest rate premium is higher. Thus, the financiers in our model have a hedging motive that is similar to that of households in the EMEs. This view about financiers permeates the recent literature on the Global Financial Cycle.[9]

The novelty in our work is our finding that the dollar promotes risk sharing between people within countries more than between people across different countries (this complements the findings in Dalgic (2018)). The findings also resemble those for commodity markets reported in Chari and Christiano (2019). The latter show that commodity markets primarily allocate risks between users and producers of commodities (the analog of domestic households and firms in our model), and not between commodity market participants and outsiders (i.e., the financiers in our model).

The first section below defines the concept of deposit dollarization, and the international dataset that we have constructed on that variable. Section 3 presents results (a)-(c) summarized above. Section 4 examines data that would show a link between deposit dollarization financial crises, if such a link were pronounced. We find little evidence of such a link. 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 S 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

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

where S' denotes 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 S'.

[9]See, *inter alia*, Lustig and Verdelhan (2007), Lustig et al. (2011), Hassan (2013), Bruno and Shin (2015)), Maggiori (2017), Gourinchas et al. (2017), Farhi and Maggiori (2018), Gopinath and Stein (2018), Gourinchas et al. (2019, sec. 2.3), Bahaj and Reis (2020), Miranda-Agrippino and Rey (2020), Maggiori et al. (2020), Hofmann et al. (2022) and Obstfeld and Zhou (2022).

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

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

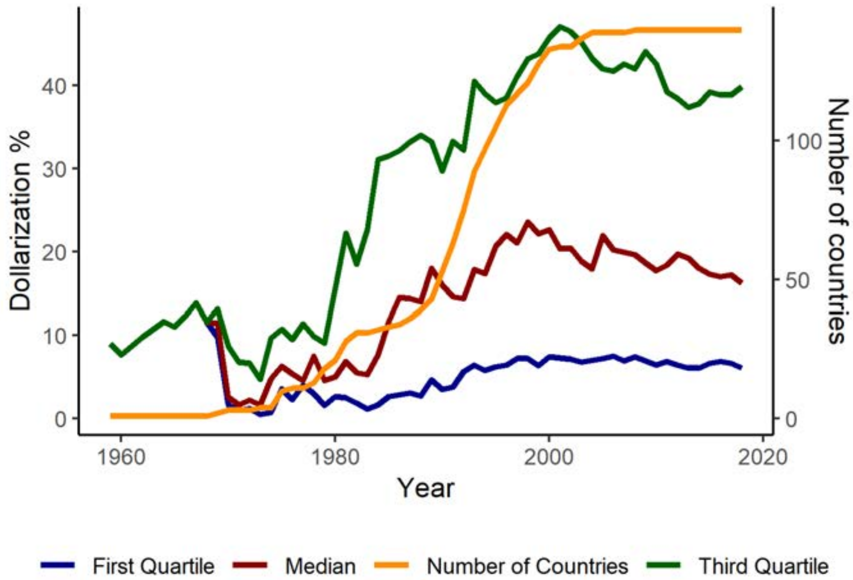
where both the numerator and denominator are expressed in local currency units. Our analysis is based on a dataset that we have constructed which extends Levy-Yeyati (2006). We extend his data to 2018 and expand coverage from 124 to 140 countries using publicly available data. We follow the literature (see Levy-Yeyati (2006)) in referring to 'foreign currency' as the dollar. In many cases, this is a good approximation. In other cases the foreign currency might be the Euro or the Yen, as well as other currencies.[10]

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.[11]

[10]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).

[11]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).

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.

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.[12] The vertical axis depicts the correlation, over the available sample for a particular country, between its scaled real GDP

[12]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. See section E in the Online Technical Appendix for the list of countries used in the analysis. In many cases we examine data which are only available for a subset of the countries.

growth and its scaled growth in the domestic good value of foreign currency. The latter is S/P, where P is the domestic consumer price index. We scale the GDP and exchange rate variable for a given country by its standard deviation.[13] When the correlation is negative, this means that reductions in GDP are associated with an increase in the domestic goods value of the dollar. So, the more negative is this correlation the greater is the insurance value of dollar assets.[14] The horizontal axis corresponds to the country's average deposit dollarization rate defined in equation (1). A country's average deposit dollarization rate is computed using the same sample of data used to compute that countries correlation on the vertical axis. In almost all countries, the sample is 2000-2018.[15] By using time averaged data we minimize the role of valuation effects whereby high-frequency depreciations in the exchange rate automatically drive deposit dollarization in the same direction before market participants have a chance to adjust their portfolios. All of our econometric results are designed to minimize the role of such valuation effects.

In our analysis, we exclude 9 countries with substantial restrictions on deposit dollarization. The points in blue in Figure 2 correspond to 9 such countries.[16] The blue observations correspond to countries that, according to Nicolo et al. (2003), restrict residents from holding domestic 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. So, our basic result in Figure 2 is not sensitive to the countries that exclude.

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

[13]Because the variables are scaled in this way, the correlation is simply the regression of one variable on the other regardless of which variable is on the left or the right of the regression.

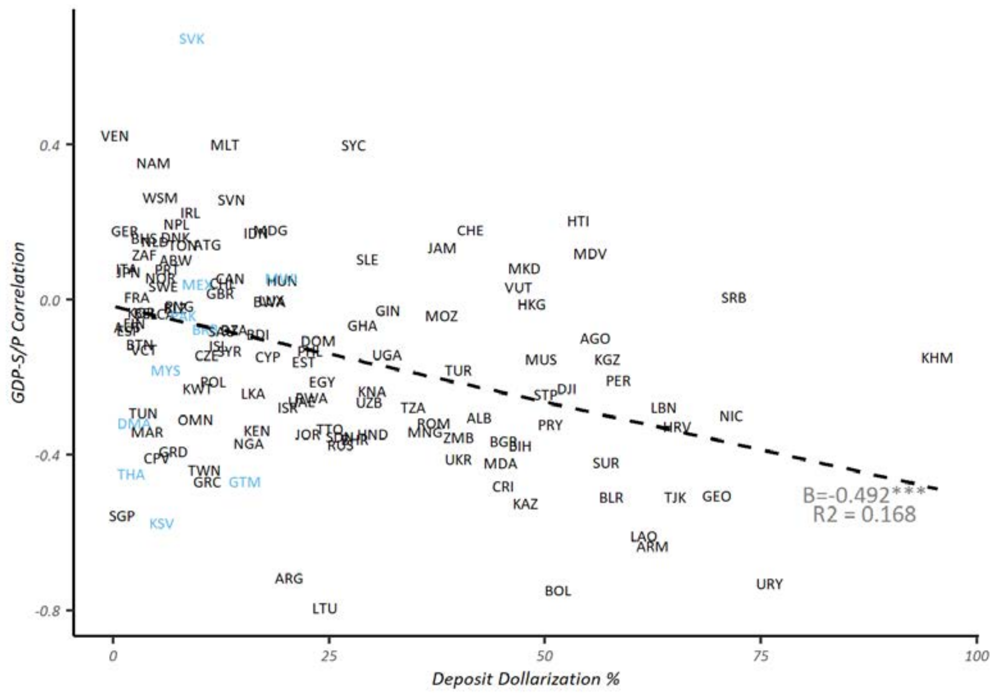
[14]Although we think that S/P is the variable of interest when considering the risk-sharing role of the dollar, we note that the relationship in Figure 2 is robust to: (i) the use of S instead of S/P and (ii) expanding the sample to the period 1995-2018.

[15]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.

[16]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 in our analysis 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.

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 quality of institutions measure; fuel as a share of exports; central bank reserves as a fraction of GDP; the measure of central bank independence constructed in Romelli (2022); 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 2. As an additional check on robustness, we also examine the Figure 2 relationship for 6 subsets of countries: those in the advanced economies, Africa, Asia, Latin America, Eastern Europe and the Middle East. We find the negative relationship reported in Figure 2 for Africa and Latin America and, to a lesser extent, Eastern Europe. We find little relationship in the Advanced Economies, Asia and the Middle East. The advanced economies roughly fit our pattern in that (apart from Greece and Malta) both their correlations and their deposit dollarization is close to zero. Asia and the Middle East do not appear to fit the pattern in Figure 2. But, we have little data on those regions and so it is hard to know what to make of this finding. For the details, see our Online Technical Appendix, Section A.3.

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



Notes: Data on the horizontal axis correspond to $100 \times \phi$, where ϕ is defined in equation (1); (ii) the 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, also, before computing the correlation we scale the growth rate of GDP and S/P by their sample standard deviations; (iii) deposit dollarization is defined in equation 1 and corresponds to the average over all available data for each country in the sample, 2000-2018; (iv) codes in the figure correspond to World Bank Country codes; (v) the statistic on the vertical and horizontal axis for a given country is based on the same sample period; (vi) the country codes indicated in blue indicate countries that restrict deposit dollarization according to Nicolo et al. (2003). See Online Technical 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 dataset, 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. There are two ways this reverse causality effect could occur. One is that dollarization increases vulnerability to financial crisis, a time when output is low and the exchange rate depreciates as capital flees the country. We present empirical evidence against this hypothesis in Section 4 below. Another argument for reverse causality has to do with the *balance sheet channel*. In particular, 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.[17] 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

[17] 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.

are forced to cut back on investment and employment. The empirical results summarized in Section 5 casts doubt on the importance of the balance sheet channel.

Another piece of evidence against reverse causality can be seen in Figure 2. As noted above, several countries have regulations limiting the amount of deposit dollarization. Endogeneity aside, we expect - under the reverse causality hypothesis - in countries that adopt restrictive regulations the exchange rate depreciation in a recession should be reduced. But, Figure 2 indicates that the exchange rate drops even more in a recession for those countries. [18] Perhaps this puzzle can be resolved based on a failure of the exogeneity assumption.[19]

An alternative interpretation of the negative association in Figure 2 receives more support in our analysis. Under that interpretation, we call it *the insurance hypothesis*, 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. The literature stresses various factors (for example, risk appetite and the stance of monetary policy of major central banks) which drive up the exchange value of the dollar and are associated with downturns in emerging market economies (EME).[20]

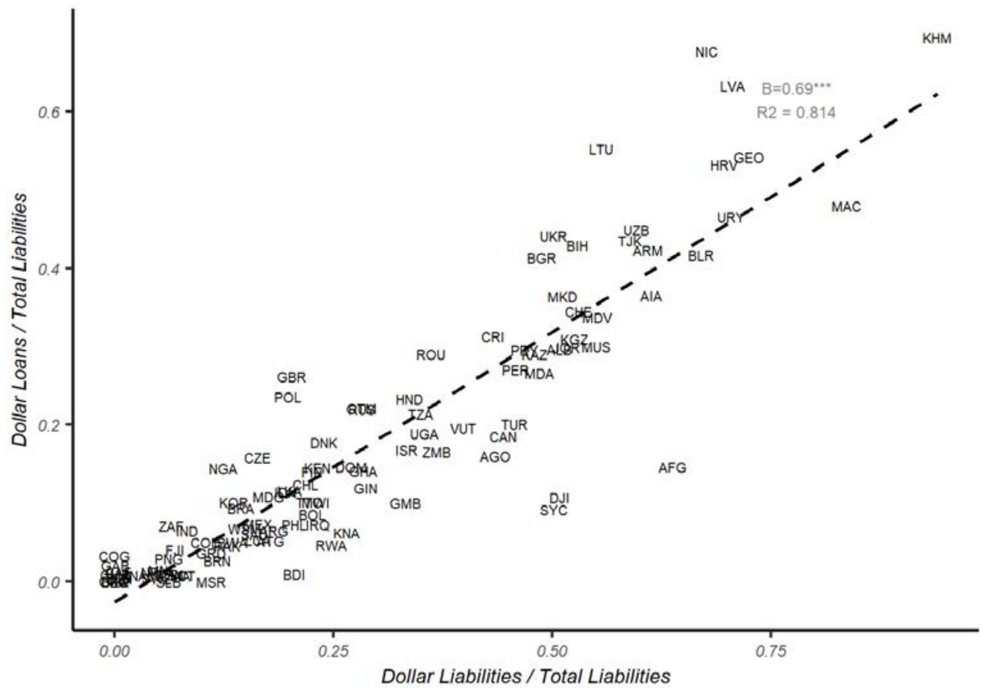
Under the insurance hypothesis the cross-country variation in dollar deposits is driven by demand, and so the price of dollar deposits is expected to covary positively with quantity. Specifically, for EMEs in which deposit dollarization is high, the supply of dollars in local lending markets is high 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 (opportunity cost) of holding dollar deposits, $i - i^*$, is high. The literature refers to $i - i^*$ as the local interest rate premium.

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

[19] 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.

[20] For surveys, see Gourinchas et al. (2019, sec. 2.3) and Obstfeld and Zhou (2022).

Figure 3: Dollar Loans Versus Dollars Liabilities

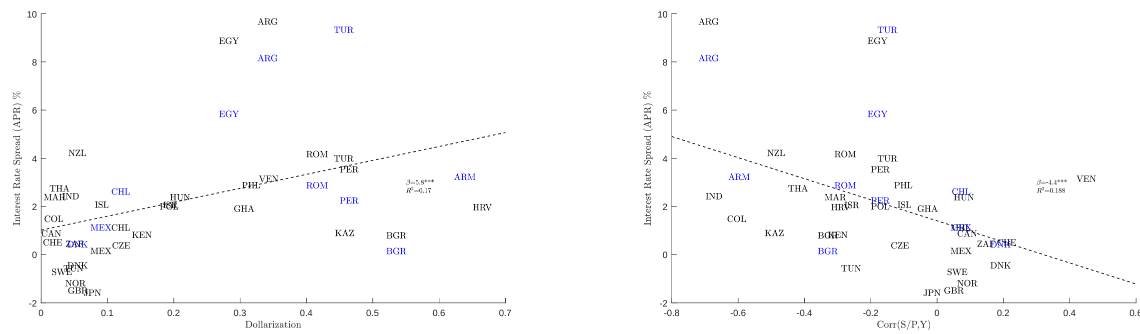


Notes: Data obtained from International Monetary Fund dataset, Financial Soundness Indicators. Each country is indicated by its World Bank code and the data represent, for each country, averages of the indicated ratio over the period, 2000-2018. The numerator variables on the y and x-axes are 'Foreign 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 local insurance premium, $i - i^*$, 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 dataset 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 (CIP), Dalgic (2018) combined the dollar interest rate with spot exchange rates and futures rates to compute $i - i^*$. 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.

Du et al. (2018) report deviations from CIP starting in the second half of our sample. To verify that our results are not an artifact of these deviations, we also look at direct measures of local interest rates. For 10 of our 33 countries we were able to obtain direct observations on local currency and dollar deposit rates from Central Bank websites. The premium, $i - i^*$, in these countries appears in the panels of Figure 4 in blue. In one country, Armenia, we do not have the 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.) Notably, the least squares (dashed) line drawn through the data is roughly unaffected by whether we use the blue or black data points.

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



Notes: (i) The horizontal axis variable in the left panel is ϕ defined in equation (1). (ii) The horizontal axis variable in the right panel corresponds to the vertical axis variable in Figure 2. (iii) 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. (iv) The dashed line in the figure is the least squares line based on the 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. (v) We verified that the results are robust to deleting Egypt, Turkey and Argentina, which may appear to be outliers. The results for the left and right panels are $\beta = 3^{***}$ and $R^2 = 0.15$ $\beta = -2.1^{**}$ and $R^2 = 0.14$, respectively. See subsection A.4 in the Online Technical Appendix for more information.

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.[21] We are cautiously optimistic that differences in reserve requirements across countries do not

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

substantially affect our analysis of interest rate spreads.[22]

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.[23] 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.

Other papers emphasize factors other than the countercyclicality of a country's real exchange rate in explaining the local interest rate premium. For example, Hassan (2013) emphasizes the importance of country size, Richmond (2019) emphasizes trade network centrality. Also, Della Corte et al. (2016) and Wiriadinata (2019) emphasize external debt. Dalgic and Ozhan (2021) show that the covariance between GDP movements and exchange rate changes remains a significant determinant of the local interest rate premium, even after controlling for size, centrality and external debt.

3.2 Who Supplies Insurance to the Households?

When exchange rates depreciate during a recession, residents 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. Using evidence from a large IMF dataset on bank stability indicators, the first subsection below finds that banks have very little currency mismatch in the 2000s. So, banks do not appear to be the source of insurance payments to holders of deposits in the wake of a depreciation. Who then, is the source? The next two subsections below address this question using two data sets. In subsection 3.2.2 gather data on firm and household dollar loans from central bank websites for 16 EME's.[24] We show that in those countries, firm and household dollar borrowing is roughly equal to total dollar deposits. This suggests that, to a first approximation, firms and household borrowers are the source of the insurance payments that holders of dollar deposits receive when the currency depreciates. We find similar results with the different dataset assembled in Benetrix et al. (2020), which decomposes cross-country financial flows by currency. We report these results in subsection 3.2.3.

[22] 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 $i - i^*$.

[23] To gain a better understanding of the magnitude of $i - i^*$, Subsection A.5 in the Online Technical Appendix expresses $i - i^*$ as a tax on depositors.

[24] The data were obtained from central bank websites. 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 Technical Appendix. Column (1) of Table C3 shows that our 16 countries have somewhat higher deposit dollarization rates than the average in our sample. These countries do not strongly discourage dollar deposits according to the index in Nicolo et al. (2003).

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.[25] We conclude that, especially in emerging markets, there is not a serious currency mismatch in banks.[26] So, it appears that the owners of banks are not the ones providing insurance services to bank depositors.

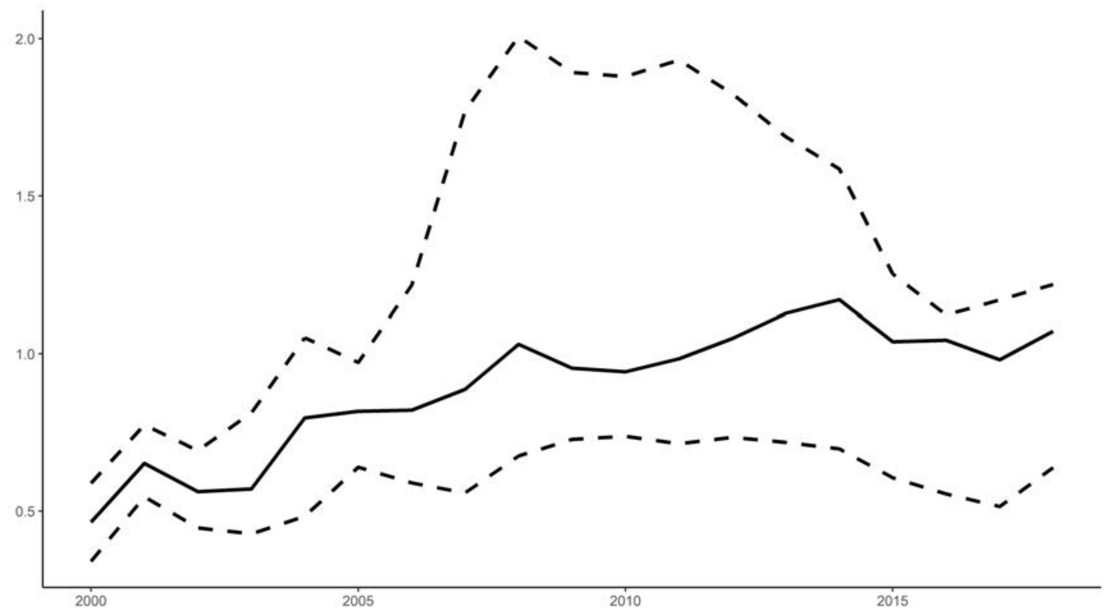
3.2.2 If it is not the banks, then who?

Here, we consider the 16 EMEs mentioned above. For each country and year, we compute the ratio to total bank deposits of household and firm dollar loans from all sources. The solid line in Figure 5 shows the median in each cross-section of these data. The upper and lower dashed lines indicate the upper and lower 25% quartiles. Note the bulge in the upper quartile. This reflects the widely-noted Eastern European household mortgage borrowing that occurred in the borrowing just mentioned. Notably, the median figure converges to unity in the middle of the sample. This is consistent with the hypothesis that holders of dollar deposits receive insurance from other domestic residents who borrow in dollars. Additional details about these data are provided in subsection C in the Online Technical Appendix.

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

[26] 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.

Figure 5: $\frac{\text{Household and firm dollar loans from all sources}}{\text{Total dollar bank deposits}}$



3.2.3 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 dollar deposits 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, $d_t^* + d_t^{*,f}$, created in the financial market of a particular country must be equal to the quantity of dollar liabilities, $b_t^* + b_t^{*,f}$, created in that financial market. That is,

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

where f indicates foreign resident. Here, 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 we include government dollar assets and liabilities. Equation (2) is the market clearing condition for trade in dollar financial assets between domestic and foreign residents.

After rearranging the terms on the left of equation (2), we obtain:

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

The first and second terms on the left of the equality represent the quantity of intra-group financial trade among resident and among non-residents, respectively. The third term denotes the quantity of financial trade between domestic and foreign residents. Thus, suppose that $d_t^* < b_t^*$. In this case, all the insurance received by holders of dollar deposits comes from local firms.[27] Suppose, instead, that $d_t^* > b_t^*$. In this case the insurance obtained by dollar depositors exceeds the amount, b_t^*, provided by firms, so that dollar depositors obtain $d_t^* - b_t^*$ insurance from foreigners. The object on the right of the equality in the above expression is a measure of the total amount of financial trade. Dividing, we have

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

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).[28]

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).[29]

[27] In principle, there are two scenarios by which insurance can pass between dollar depositors and dollar borrowers. The most straightforward scenario is that some residents deposit the dollars in a bank and firms then come to the bank to borrow those dollars. An alternative is that local banks use the dollar deposits to purchase foreign dollar 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, these two scenarios are the same. Results in the online appendix suggest that the first scenario is in fact the one that occurs in practice. In particular, for the median country in our sample of 16 EMEs, more than 90 percent of firm dollar borrowing is from local banks and relatively little is from international financial markets (see Figure (C8e)).

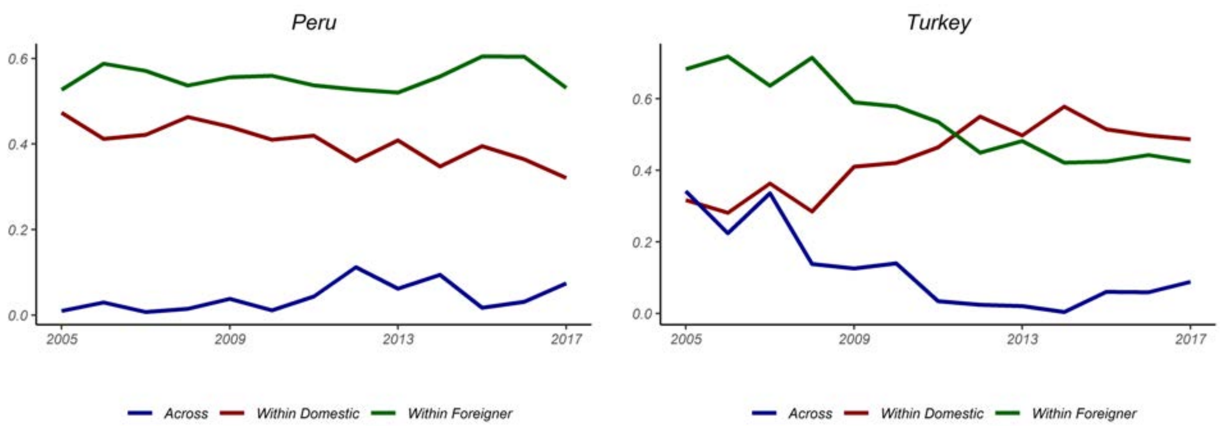
[28] We suspect that most of the dollar debt in $b_t^{g,*}$ is issued by the fiscal authorities. Similarly, we suspect that most of the dollar assets in $d_t^{g,*}$ are owned by the monetary authority. We do not know how much of the monetary authorities' dollar assets are the dollar liabilities issued 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.

[29]

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. We only use data for the intersection of our sample of 16 countries and the Benetrix et al. (2020) sample because the latter do not report firm dollar borrowing.

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 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

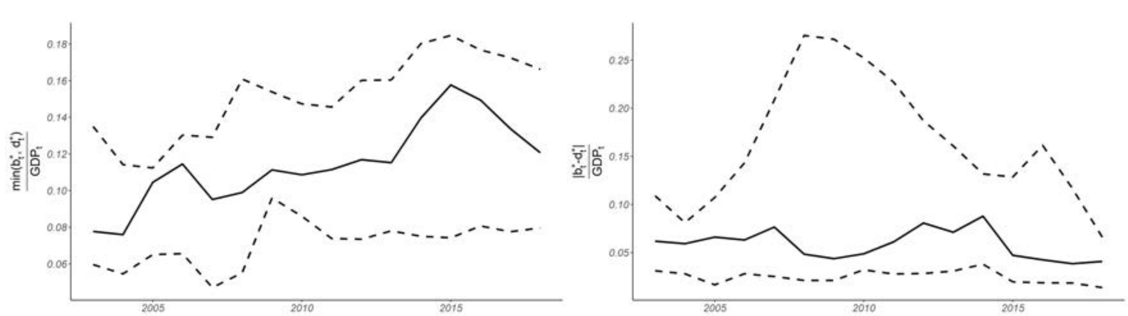


Note: These data correspond to the three terms on the left of the equality in equation (3). They represent the share of dollar financial flows between residents of the indicated country ('Within Domestic'), between foreigners ('Within Foreigner') and between residents and foreigners ('Across'). As explained 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.

In effect, our conclusion that intranational insurance flows are bigger than international flows simply rests on the observation that gross international capital flows (i.e., the min operator) are larger than net flows (i.e., the absolute value operator).

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: Section 3.2.2 provides 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.

If we are only concerned with the within-country resident and the across-country categories, then 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. As before, the solid line indicates the median across countries for each year. The dashed lines indicate the 75^{th} and 25^{th} percentiles. The key result is that the across-country insurance flows are small compared to the within-country flows. The median cross-country flows are only on average equal to 55 percent of the 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.[30] Dollarization does not appear to be an important explanatory variable. We reach these conclusions based on standard sampling theory applied to logit regressions. As a check on the robustness of inference the Online Technical Appendix turns to standard diagnostic devices used in the machine learning literature. These methods confirm our finding about the importance of the VIX and high external debt and the unimportance of dollarization in forecasting crisis (see subsection H.11).

[30]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.

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).

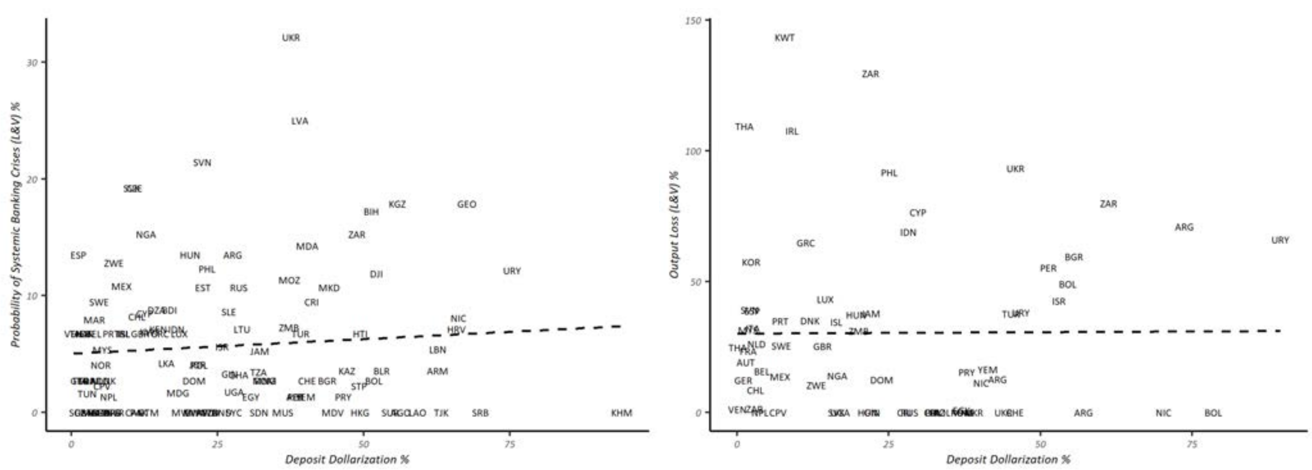
The data on systemic banking crises from Laeven and Valencia (2020) cover the period, 1980-2017, and include 151 systemic banking crises. According to the criteria in Laeven and Valencia (2020), a country experiences a banking crises if it meets two conditions:[31]

- 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 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) dataset 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

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

Figure 8b displays the relationship between Laeven and Valencia (2020)'s measure of the cost of a crisis and deposit dollarization.[32] 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 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.[33] 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.

[32] 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.

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

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 trigger a financial crisis by creating a dollar shortage in banks. 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 domestic banks. One way is for the central bank to accumulate liquid dollar reserves that it can use to provide limited lender-of-last-resort services. A shortcoming of this approach is that it would generate moral hazard problems in case it encourages banks to make overly risky dollar loans (*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.[34] 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.[35] 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

[34] 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 dataset constructed in Federico et al. (2014) (see this) 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) dataset shows that regulators can impose higher reserve requirements on dollar demand deposits than on dollar deposits of longer duration.

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

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 confirms 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 $p\left(x_{i,t};\beta\right)$ denote the probability that year t is the first year of a Laeven and Valencia (2020) systemic banking crisis for country i.[36] 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.[37] Let

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

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

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

so that the log odds of a crisis is the linear function, $x_{i,t}^T\beta$, where T denotes transposition.[38] Note that by construction, $0 \leq p_{i,t}\left(x_{i,t};\beta\right) \leq 1$. By the orthogonality property of $\varepsilon_{i,t}$

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

[36] 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.

[37] 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 Technical Appendix shows that the results we report below are robust to including additional lags.

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

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.[39] To ensure robustness of our conclusions to our sampling theory we also use a bootstrap approach in subsection H.11 in the Online Technical Appendix.

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 $t-1$ subscripts are deleted).[40] 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 Technical 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).[41] 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.[42] Also, FA denotes the dollar

[39]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 $\varepsilon_{i,t}$.

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

[41]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".

[42]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

claims on foreigners by the same institutions, which we presume are relatively liquid. Our time series on FL/FA are displayed in Figure 9.

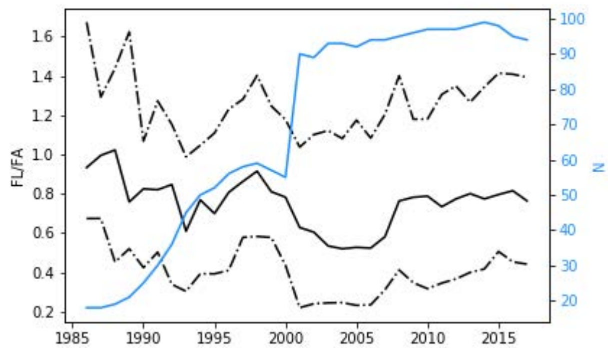


Figure 9: FL/FA

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

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.

year t in our sample.[43] 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 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.[44] The tenth variable is 'External Debt', which corresponds to interest payments by all residents on foreign debt, divided by GDP.[45] 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 $t-2$. [46] 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.[47] 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 $x_{i,t}$

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

[44] Source: IMF International Financial Statistics

[45] 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.

[46] 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 $\Delta rer_{i,t-1}$.

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

for each i. [48]

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 of the variables in $x_{i,t}$. The variables included in each column are reported in 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 it is referred to as the 'j^{th} variable', $j = 1, ..., 12$. Columns labeled (1)-(4) use data for all the countries in our sample ('All') while columns (5)-(8) only include EMEs.[49] We also report an R^2 diagnostic for our logit regressions at the bottom of each column.[50] The variable, N, denotes the number of country-year observations, i, t, 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 Technical 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 H in the Online Technical Appendix. For example, subsection H.7 reports the robustness of our results to incorporating the exchange rate regime classifications constructed in Ilzetzki et al. (2019).

Financial Dollarization and Crises

We begin by studying the role in financial crises of deposit dollarization. Consider first the significance of the deposit dollarization dummy in row 1 of Table 1.

[48]We also included the interaction of the VIX and Dollar dummies as well as the interaction of the High FL/FA and Dollar dummies. We report results that include these variables in subsection H.5 in the Online Technical Appendix. Because their coefficients are not significant and other results do not change, we leave these variables out of the main results, which are reported in Table 1 below.

[49]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.

[50]Specifically, we report the pseudo-R^2 provided by STATA, $1 - var\left(\hat{\varepsilon}_{i,t}\right)/var\left(y_{i,t}\right)$. 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, $var\left(z_{i,t}\right) = \sum_{i,t}\left(z_{i,t} - \bar{z}\right)^2/N$, 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), $\beta(1)$	-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)
$\Delta e, \beta(2)$	-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, $\beta(3)$	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, $\beta(4)$			1.690***	1.245		1.503**	1.296	0.899
			(2.83)	(1.41)		(2.54)	(1.46)	(0.97)
High FL/FA *Δe, $\beta(5)$			-4.526*	-5.221*		-2.470	-2.693	-4.807*
			(-1.72)	(-1.80)		(-1.42)	(-1.40)	(-1.74)
Low Reserve, $\beta(6)$				-0.872			-1.240	-2.224**
				(-0.88)			(-1.17)	(-2.14)
Dollar(20) * Low Reserves, $\beta(7)$				0.338			1.022	2.448*
				(0.42)			(0.75)	(1.75)
High FL/FA * Low Reserves, $\beta(8)$				1.128			0.580	0.503
				(0.98)			(0.41)	(0.32)
External Debt, $\beta(9)$								0.381***
								(7.37)
Real GDP Growth, $\beta(10)$	-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, , $\beta(11)$	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, $\beta(12)$		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)
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
p_value($\beta(1) = \beta(3) = 0$)	0.0258	0.156	0.856	0.763	0.660	0.796	0.594	0.249
p_value($\beta(4) = \beta(5) = 0$)			0.00000196	0.000209		0.000170	0.000532	1.91e-48

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 Technical Appendix section E; the countries in 'EME' include the countries in 'All', excluding the ones listed in footnote 49. Our unbalanced panel covers annual data over the period, 1995-2017. In subsection H.2 in the Online Technical 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 Technical Appendix.

Note that, with one exception, the coefficient on this variable is not significant. In the exceptional case (see column (8)) it is marginally significant but has the 'wrong' sign from the perspective of the idea that financial dollarization is dangerous. The results in row 1 indicate that, other things the same and for small Δe, high deposit dollarization does not appear to be associated with an increase in the likelihood of a financial crisis. This is consistent with the bivariate analysis in section 4.1.

Column (1) of Table 1 comes closes in spirit to the results reported in Levy-Yeyati (2006). The parameter, $\beta(2)$, is a measure of the strength of expenditure switching effects while $\beta(3)$ is a measure of balance sheet effects. Note that, consistent with the expenditure switching interpretation, $\beta(2)$ is negative and (marginally) significant. Also, consistent with the balance sheet interpretation, $\beta(3)$ is positive and statistically significant. So, the impact of a depreciation on the probability of crisis is statistically significantly higher in an economy with high deposit dollarization than it is in an economy with $Dollar\,(20) = 1$. The large and statistically significant value of $\beta(3)$ is one of the reasons that Levy-Yeyati (2006) concludes that financial dollarization is dangerous.

However, the results in Table 1 show that the statistical significance of the coefficient on $\Delta e \times Dollar\,(20)$ is not robust. First, we see from column (2) that the estimate of $\beta(3)$ is not significant if we also include the lagged real exchange rate, rer, in the logit regression. Second, our principle interest is in EME's and when we focus only on these countries (see column (5)), then the coefficient on $\Delta e \times Dollar\,(20)$ is also not significant. Third, when we add the other potentially relevant variables listed in subsection 4.2.2 the significance of the coefficient on $\Delta e \times Dollar\,(20)$ also disappears.[51] We conclude that the relationship between depreciations and financial crisis is not systematically related to whether an economy has a high level of deposit dollarization.[52]

We now include our second measure of financial dollarization, FL/FA, in the analysis of banking crises (see rows 4 and 5 in Table 1). Consider row 4 first. This shows that the coefficient on High FL/FA is significant when we include all countries, but only if we exclude central bank reserves (compare columns (3) and (4)). Similarly, if we focus exclusively on EMEs, then the significance of the coefficient on High FL/FA drops somewhat (compare columns (3) and (6)). If we then add central bank reserves, the coefficient on High FL/FA is not significant (see column (7)).[53] Now, consider row 5, which reports estimates of $\beta(5)$. The point estimates of the interaction of High FL/FA and $\mathit{\Delta} e$ are all the 'wrong' sign from the perspective that financial dollarization destabilizes the financial system.

[51] In the Online Technical Appendix Section H.9 we display additional evidence on the lack of robustness in Levy-Yeyati (2006)'s findings that the coefficient on $\Delta e \times Dollar\,(20)$ 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 $\Delta e \times Dollar\,(20)$ 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 (see equation (4)).

[52] In subsection H.4 of the Online Technical Appendix we also include the interaction of the product of the previous *two* years' values of the Dollar dummy and the exchange rate, $\mathit{\Delta} e$. We find that this extra variable is not statistically significant and does not change the results.

[53] We also considered a version of the analysis in column (6) that includes *External Debt* and the estimate of $\beta(4)$ is not significant in this case either.

Thus, it appears that financial dollarization, whether measured by deposit dollarization or FL, is not significantly related to increased vulnerability to a systemic financial crisis.

Financial Dollarization, Crises and Reserves

We now discuss the role of central bank reserves in financial stability (see rows (6)-(8)). First, the point estimates for $\beta(6)$ in Table 1 indicate that low reserves are associated with a reduced level of vulnerability to financial crisis. This is consistent with the moral hazard effect of central bank reserves discussed in subsection 4.2.1. Second, $\beta(6) + \beta(7)$ is small and positive, indicating that an economy with low reserves that has a high level of deposit dollarization does not have a significantly different probability of crisis than an economy with high reserves (i.e., Low Reserve = 0).[54] Third, the point estimate of $\beta(6) + \beta(8)$ is negative. This is consistent with the idea that an economy with Low Reserves does not have an elevated probability of a banking crisis.

Other Variables and Crises

Now consider External Debt, 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 Schularick and Taylor (2012), Gourinchas and Obstfeld (2012)[55] and Sufi and Taylor (2022)'s finding that strong credit growth is associated with an elevated chance of financial of financial crisis.[56]

Also, 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)).[57] We also investigated whether the comovement of

[54]In subsection H.6 of the Online Technical Appendix we display the version of Table 1 with Dollar (20) replaced by Dollar (10). There we show that $\beta(6) = -13.81$, with a $t-$statistic of -11.13. Also, $\beta(7) = 13.22$ with a $t-$statistic of 9.32. So, the results for $\beta(6)$ and $\beta(7)$ are individually quite different from the results reported in Table 1. However, for our purposes, what matters is the sum, $\beta(6) + \beta(7)$ and this is now slightly negative and not significantly different from zero, consistent with Table 1. Other features of Table 1 are robust to the different cutoff in Dollar.

[55]Gourinchas and Obstfeld (2012) also report that real exchange rate depreciations are significantly and positively related to financial crisis. The results in row (12) of Table 1 show that the point estimates are consistent with their results, but they are not statistically significant. Gourinchas and Obstfeld (2012)'s dataset begins in 1970, but our dataset does not include data before 1995. When we redo the results in Table 1 with the subset of variables for which we have data going back to 1970, we obtain the Gourinchas and Obstfeld (2012) finding that the real exchange rate is strongly statistically significant (see Online Technical Appendix, subsection H.1). We infer that the significance of the real exchange rate data is driven primarily by the pre-1995 data.

[56]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.

[57]In Subsection H.3 in the Online Technical 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"

the VIX and financial crisis is bigger in countries with High FL/FA or in countries with $Dollar\,(20) = 1$. To do this we included the interaction of these indices with the VIX in our logit specification. In both cases the coefficient on the interaction terms is not statistically significant (see Online Technical Appendix, subsection H.5).

Turning to the connection of our work with Gourinchas and Obstfeld (2012), they find that Δrer and credit growth are very important explanatory variables for crises. The results in Table 1 are consistent with their conclusion about credit growth, but our control variables apparently drive out the real exchange as a statistically significant explanatory variable (see subsection H.1 in the Online Technical Appendix for further discussion).

In sum, we find that financial crises are forecastable to some extent, using variables like the VIX and external debt. However, we find no evidence for a strong relationship between financial dollarization and financial crises.[58] Our inference is based on the standard asymptotic sampling theory associated with GMM. In subsection H.5 of the Online Technical Appendix we use a completely different sampling theory based on the bootstrap and obtain similar conclusions.

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 financial 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). The cost of a crisis includes lost output in each year that the crisis continues.[59] The number of observations, N, at the bottom of the table is small relative to the value of N in Table 1, reflecting the small number of crises in our data. The country-specific right hand variables in Table 2 include only observations for the year before the first year of a crisis. As in the logit regression, 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)).

(see Baker et al. (2019)). The Online Technical Appendix also considers the "global financial factor" (see Miranda-Agrippino and Rey (2020)) which turns out not to be significant.

[58] In subsection H.10 of the Online Technical Appendix we display these results in graphical form. We do this by graphing the crisis probability function in column 8 of Table 1 for various setting of the right hand variables.

[59] Scarring effects which continue after the crisis is over are not included in the cost measure. See footnote 32 for more discussion of the output cost measure of a crisis.

The critical result in the table is that the coefficient on deposit dollarization has the 'wrong' sign (row (1)), but in any case is never significantly different from zero. 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 crisis. As in Table 1, reserves are not significant. The point estimates on real GDP growth are negative, suggesting that the cost of crisis is greater if it hits an economy that is already weakening for other reasons. However, the coefficients on GDP growth are for the most part not significant, particularly when all data for EMEs are included (see column (8)).

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. At the same time, for the EME countries that are the main focus of the analysis, when all variables are included FL/FA is not statistically significant.

For our purposes there are two takeaways from Tables 1 and 2. The first is that financial dollarization does not increase a country's vulnerability to financial crisis. The second is that if a crisis occurs, the degree of financial dollarization does not affect the severity of the crisis. Our results for FL/FA and external debt do indicate that policy pay attention to dollar borrowing by domestic residents from foreigners.

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.[60] 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 non-financial firm investment, not exchange rate fluctuations per se.

Table 2: Output Loss in Banking Crises

	(1)	(2)	(3)	(4)	(5)	(6)
Dollar (20), $\beta(1)$	-16.07	-29.02	-3.468	-22.72	-26.55	33.97
	(-1.25)	(-1.72)	(-0.15)	(-1.01)	(-1.26)	(0.37)
$\Delta e, \beta(2)$	-51.62	17.74	105.7	-131.7	64.43	301.0
	(-0.77)	(0.31)	(0.91)	(-1.23)	(0.63)	(0.43)
Dollar(20)*Δe, $\beta(3)$	42.69	78.41	-22.81	119.8	18.67	-442.3
	(0.66)	(0.88)	(-0.19)	(1.14)	(0.12)	(-1.18)
VIX	-1.300	-3.062**	-2.782	-1.748	-2.876	-2.947
	(-0.94)	(-2.22)	(-1.73)	(-0.96)	(-1.69)	(-0.61)
High FL/FA, $\beta(4)$		29.42**	54.81*		31.86**	88.97
		(2.48)	(1.85)		(3.04)	(0.75)
Reserves/GDP		54.31	68.49		65.73	74.98
		(0.40)	(0.42)		(0.45)	(0.33)
Real GDP Growth		-1.749	-2.160		-2.255*	-2.022
		(-1.50)	(-1.38)		(-2.30)	(-0.39)
High FL/FA * Dollar (20)			-33.11			-79.26
			(-0.87)			(-0.68)
External Debt						0.158
						(0.02)
Constant	72.99*	105.7**	78.48	91.36	97.93**	51.98
	(1.77)	(3.03)	(1.58)	(1.71)	(2.55)	(0.26)
N	41	19	19	25	16	14
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	All	All	All	EMEs	EMEs	EMEs
Adj R2	0.00162	0.414	0.400	-0.0247	0.350	0.125

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 49.

Our analysis is based on two firm-level datasets for Peru and one dataset for Armenia.[61] 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

[60]For example, Baron et al. (2020) show that there are several credit crunch episodes not linked with an overall banking crises.

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

by Peruvian non-financial 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 I18d). 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.

Non-performance rates (NPR) on local and dollar currency loans in Peru convey a message similar to the findings discussed above. Beginning in the mid 2000s, the NPR on dollar loans is, with one exception, less than the NPR on local currency loans. The exception occurs during the severe currency depreciation episode discussed above. But even then, the NPR on dollar and local currency loans are briefly simply equal.

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 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.

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

Regarding the similar findings, Kim et al. (2015) examine firm sales in the wake of the depreciation of the Korean Won in the Asian Financial Crisis. In their full dataset they report (p. 216), "..firms with no foreign debt experienced larger declines in sales growth during the crisis than firms with foreign debt". These results are consistent with ours in that, overall, balance sheet effects appear not to hurt the economic function of firms.[62] Kim et al. (2015) do show that small firms are hurt by a depreciation, but these firms are not a substantial portion of the economy.[63] In his study of Mexico, 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.[64] Moreover, Aguiar (2005) finds that the response of investment to an exchange rate depreciation is small for firms that issue longer-maturity debt. Finally, Bleakley and Cowan (2008) study 450 firms in Argentina, Brazil, Colombia, Chile, and Mexico and they find that balance sheet effects are relatively modest. They conclude, "...firms holding more dollar debt do not invest less than their peso-indebted counterparts following a depreciation."

On the whole, our results and those in the existing literature suggest that the role of balance sheet effects in exchange rate changes is not large in EMEs, at least in the prudential regime in place after 2000. There do appear to be some exceptions. But, these may simply suggest further improvements in prudential regulation: discourage small firms from borrowing in dollars, encourage firms to not take out too much short term debt and keep a watchful eye on high-leverage firms that borrow dollars. Also, a lesson from Eastern Europe may be that banks should be discouraged from issuing foreign currency loans to borrowers with little exchange rate experience (see Verner and Gyongyosi (2020)).

[62] Taken literally, the results suggest that having foreign debt stimulated sales.

[63] Hardy (2018) reports similar results for Mexico, 2008-2013 when a large depreciation occurred.

[64] See Figure I19 in Subsection I.2 in the Online Technical Appendix.

6 Model

Here, we display the simplest model that can formalize the ideas suggested to us by our data analysis. The model has two periods. The first period opens at a point in time after that period's worker-household consumption has occurred and its saving decision is a state variable. The only decision for the worker-household in the first period 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 first-period capital investment by a firm-household which has no resources of its own. The model continues into a second period, when production and consumption occurs. Although the model is highly stylized we assign values to the parameters using data on Peru. Peru is a useful example for us because it has no capital controls (IMF (2018, p. 2508)), the level of deposit dollarization is substantial and there is a large premium on the domestic currency.

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 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.[65]

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:[66]

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

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, $E\left(r - e_2 r^*\right) > 0$. 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 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.

[65]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 Technical Appendix. The observation is perhaps already obvious from the second equality in equation (8). Note that $\left(e_2 r^* - r\right) d^* = \left(e_2 r^* - F\right) L$ 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 $\left(e_2 - F\right) L$ pesos from the futures exchange in period 2 if $\left(e_2 - F\right) > 0$. Otherwise, $\left(e_2 - F\right) L$ 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.

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

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.[67]

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.[68]

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

[67] 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 Technical Appendix.

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

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).[69] 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:

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

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

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

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

[69] In terms of the futures market in footnote (65), with $b^* > 0$ the firm in effect goes long on $b^* r^*$ futures contracts in dollars.

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:

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

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:

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

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 has 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 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[70].

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

[70] 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.

is:

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

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:

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

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 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:

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

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.[71]

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.[72] 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).

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).[73] 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:

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

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

[71] 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.

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

[73] 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.

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., $100 \times (b-d)/b \cong 1$).[74] Why don't foreigners wipe out the local currency premium by lending local currency in large quantities? The answer in our model is that foreigners have the same hedging motive to avoid local currency assets 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. 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.[75] 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

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

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

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 (2015)). This literature typically abstracts from this hedging motive (see Lustig and Verdelhan (2007) for the importance of the hedging motive).

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

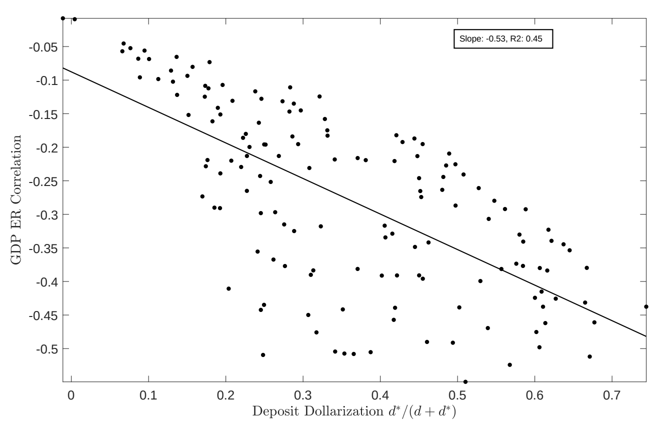
Figure 10 replicates figure 2 using model simulations. The model is simulated using different values for standard deviations of trade, foreign income, productivity shocks. Note that the model can get the basic correlation right and it is flexible enough to allow for dispersion.

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 have substantial restrictions on holding dollar accounts.[76] 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. The interest rate spread declines as households are forced to save in pesos but the exchange rate becomes more volatile, which reduces investment. Foreigners gain slightly 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. In countries where the exchange rate depreciates in a recession, a recession triggers a transfer of local currency from domestic dollar borrowers to domestic dollar lenders. It is also possible that dollarization itself creates risks by affecting the transmission of shocks or increasing the likelihood of financial crisis. But, the data from the 2000s do not appear to support the latter view.

With these considerations in mind, we construct a simple two-period model capturing what we find to be the key features of the data. This exercise is a check on the coherence of the impressions drawn from empirical analysis. For example, the notion that there is a premium on risk free domestic interest rates because domestic residents prefer dollars for insurance purposes leads to the question: 'why don't foreigners step in and make money on the carry trade?' Our model addresses this question in a way that is consistent with the current consensus in the literature.[77] We take the position that the risk in emerging market economies is not diversifiable by foreign financiers and that hedging considerations limit their appetite for domestic currency assets. Their hedging motive stems from our model assumption that financiers' other sources of income tend to drop too, when the domestic economy experiences a recession.

There is one potential negative implication associated with dollarization, which is that it might negatively affect the potency of monetary policy. We are exploring this possibility in

[76] See IMF (2018) for the current state of capital controls in Mexico (page 2082) and India (page 1488).
[77] See footnote 9.

our current research.

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