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

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Abstract

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

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1 Introduction

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

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

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

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

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

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

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

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

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

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

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

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

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

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

as *households* and firm-households as *firms*.

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

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

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

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

[5]Our model only includes debt and loan markets in local currency and dollars. In the Online Technical Appendix, we show that this environment is isomorphic to an alternative environment in which dollar debt and loan contracts are not traded in EMEs. Instead, residents and foreign financiers participate in fully collateralized long and short forward contracts in dollars while deposit and debt contracts are denominated in local currency only. We do not emphasize the forward contract interpretation of our model because the evidence suggests that derivative contracts are not generally used in EMEs. Using data from Colombia, 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.

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

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

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

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

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

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

2 Some Concepts and Deposit Dollarization Data

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

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

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

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

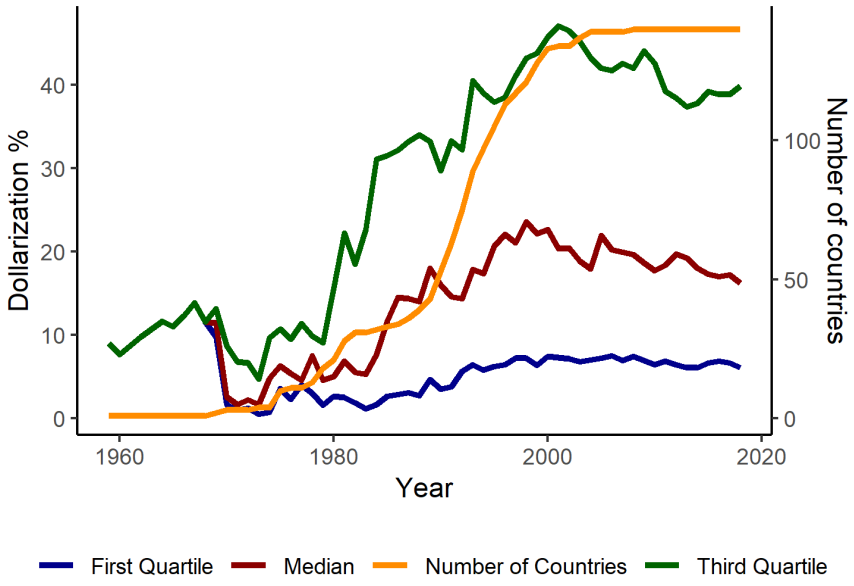
$$\phi_{i,t} = \frac{\text{value of dollar deposits held by domestic residents}}{\text{total deposits held by domestic residents}}, \tag{1}$$

where both the numerator and denominator are expressed in local currency units. Our analysis is based on a database that we have constructed which extends the database constructed in Levy-Yeyati (2006). We extend his data to 2018 and expand coverage from 124 to 140 countries.[9]

[9]In practice, 'deposits' are defined as demand deposits plus term deposits. In EMEs, deposits held by domestic residents are by far the major component of non-equity bank liabilities to domestic residents. For example, using data from the website of the Reserve Bank of Peru, we found that in December 2019, soles deposits of Peruvian residents were 159,467 million soles (of which, 18,370 million soles are government deposits). In the same month, resident dollar deposits were $31,549 million (government deposits were $613

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

Figure 1: Deposit Dollarization Data



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

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.

million). The exchange rate in that month was 3.37 soles per dollar. So, total deposits in that month were 265,787 million soles. Other bank liabilities to residents were 14,253 million soles and $1,037 million. So, total deposit liabilities held by residents were 94 percent of total liabilities to residents. Using these data, we have that ϕ in equation (1) is 0.40 in Peru for December 2019. We obtained banking data from the website of the Turkish Banking Regulation and Supervision Agency. That website provides information about bank deposit liabilities by currency and residency. This allows us to compute ϕ (this is 0.55 in December, 2020).

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

3.1 The Insurance Hypothesis

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

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

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

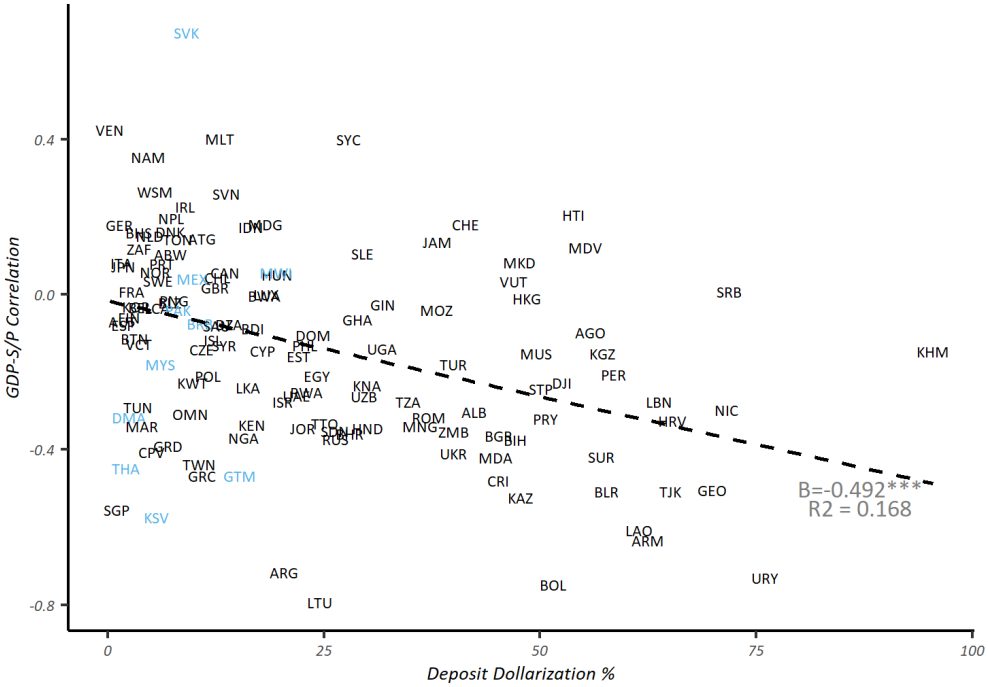
[12] Both GDP and S/P are logged and first differenced.

[13] 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.

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

controls.

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



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

One interpretation of the negative association in Figure 2 is that deposit dollarization drives the correlation on the vertical axis via a balance sheet channel. Countries whose banks have a large amount of dollar liabilities also make a large amount of dollar loans. This can be seen in Figure 3, which displays the average over the 2000s of these variables, scaled by total bank liabilities, in a cross-section of countries.[15] According to *the balance sheet channel*, other things the same, an exchange rate depreciation in a country with a high amount of dollar loans results in lower output as borrowers with unhedged dollar debt are forced to cut back on investment and employment. The expectation, under this hypothesis, is that if regulations to restrict deposit dollarization were exogenously imposed in some country, then exchange rate depreciations should be associated with smaller recessions in that country. Thus, the correlation on the vertical axis of Figure 2 would be expected to be *higher* for that country. But, Figure 2 indicates that that correlation is in fact *lower* than it is in other

[15] 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.

countries with low dollarization and no restrictions.[16] Perhaps this puzzle can be resolved based on a failure of the exogeneity assumption.[17] Still, Sections 4 and 5 below present more evidence against the balance sheet hypothesis. There, we show that deposit dollarization has no predictive power for financial crises or for the severity of a crisis when it happens. Also, firm-level data suggest that in the wake of a currency depreciation, the response of investment is not very different for firms with and without substantial currency mismatch on their balance sheets.

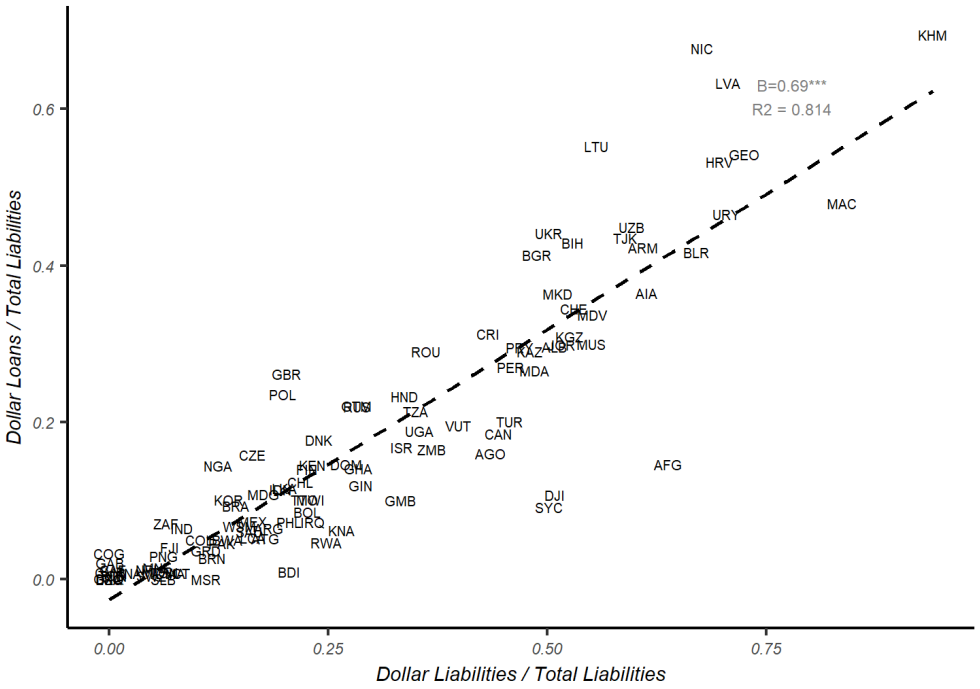
An alternative interpretation of the negative association in Figure 2 receives more support in our analysis. Under that interpretation, it is the correlation on the vertical axis of Figure that drives deposit dollarization. The idea is that in countries where the exchange rate depreciates most in recessions, households hold a larger fraction of their saving in dollars as a hedge against business cycle income risk. There are various reasons why a country's currency might depreciate in recessions. For example, fluctuations in GDP may be dominated by volatility in the demand for exports. Or, government policy might be inflationary in recessions. A related possibility is that financial disturbances originating in the US (the 2008 financial crisis, or simply a monetary policy tightening) can create a recession in the rest of the world and for safe-haven reasons lead to an appreciation of the dollar (see, for example, Gourinchas et al. (2010)). We refer to the hedging interpretation of Figure 2 as *the insurance hypothesis*.

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

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

[17] 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.

Figure 3: Dollar Loans Versus Dollars Liabilities



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

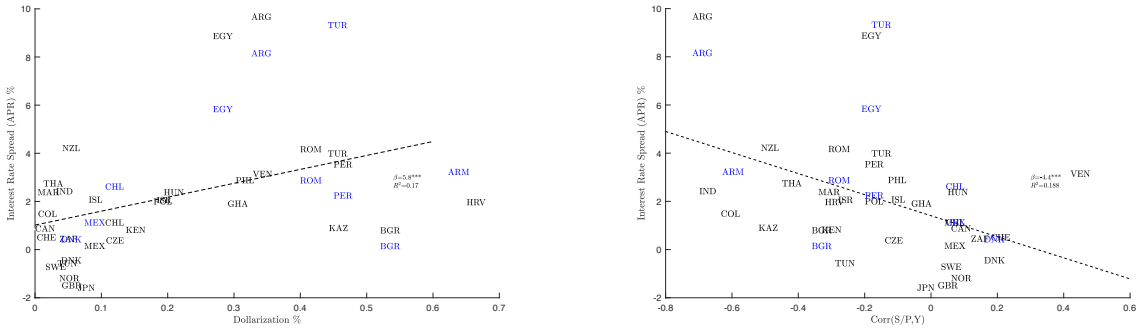
We investigate the implication of the insurance hypothesis that the price of dollar deposits, $i - i^*$, is high in countries where deposit dollarization is high. We use the data on $i-i^*$ constructed by the indirect method in Dalgic (2018) for the 33 countries in our database for which there are futures markets in currencies. The $i - i^*$ data were constructed using the return on a US government security as a measure of the nominal risk-free dollar return. Using the assumption of covered interest parity, Dalgic (2018) combined the dollar interest rate with spot exchange rates and futures rates to compute $i - i^*$.[18] The average for each country of $i - i^*$ over the 2000s are displayed for each of our 33 countries in Figure 4. The first panel contains the scatter plot of $i - i^*$ against deposit dollarization. The second panel displays the scatter of $i - i^*$ against the correlation between S/P and GDP. The latter is the same correlation appearing on the vertical axis in Figure 2.

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

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

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

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



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

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

A potential distortion for both measures of $i - i^*$ is the impact on interest rate spreads of differential reserve requirements on domestic versus dollar bank deposits. Federico et al. (2014) provide a dataset on reserve requirements by local versus foreign currency deposits in banks. In their sample of 52 countries the average difference in reserve requirements for most countries is small. Exceptions are Peru (26), Honduras (23), Serbia (18) and Uruguay (13), where numbers in parentheses are the difference in the percent reserve requirements.[19] We are cautiously optimistic that differences in reserve requirements across countries do not substantially affect our analysis of interest rate spreads.[20]

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

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

We now turn to the two panels Figure 4 to evaluate the price implications of the insurance hypothesis. The first panel is consistent with that hypothesis' implication that $i - i^*$ is typically higher in countries with deposit dollarization.[21] The second panel is consistent with with the idea that the demand for dollarized deposits is driven by the correlation between the domestic goods value of a dollar, S/P, and GDP.

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

3.2 Who Supplies Insurance to the Households?

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

[21] To gain a better understanding of the magnitude of $i - i^*$, Subsection A.2 in the Online Appendix expresses $i - i^*$ as a tax on depositors.

3.2.1 It is not the Banks

The evidence suggests that there is little currency mismatch in banks, indicating that they are not the ones providing the insurance to households. This is consistent with the view that bank regulators, particularly in the 2000's, have worked to ensure that banks do not have significant currency mismatch on their balance sheets. A relevant statistic is compiled by the International Monetary Fund (IMF). We perform stress tests on the banking system in each of the 115 countries covered by the IMF dataset, by asking what exchange rate depreciation (or, in some cases, appreciation) would be required to wipe out bank equity. We find that, for the overwhelming majority, 93, there is no possible depreciation that would have this effect. For the other countries, the depreciation would have to be truly extreme.[22] We conclude that, especially in emerging markets, there is not a serious currency mismatch in banks.[23] So, it appears that the owners of banks are not the ones providing insurance services to bank depositors.

3.2.2 If it is not the banks, then who?

The results reported in Figure 5 summarize information about borrowing and lending for 16 EMEs which do not discourage dollar deposits according to the index in Nicolo et al. (2003).[24] In all panels of Figure 5, except Panel (5f), the solid line is the median in the cross-section of countries for the indicated year and the specified statistic. The upper and lower dashed lines indicate the boundaries of the upper and lower 25% quartiles. Panel (5f) indicates the number of countries for which we have observations, for each year. The dashed line indicates the number of countries for which the firm and household components of deposits are available, for each year. This line is only relevant for the results in Panel (5a). The solid line indicates the number of countries in the cross-section for each year. The solid line is relevant for all panels apart from Panel (5a). Panel (5f) indicates that we have data for a relatively small fraction of our countries before 2010. Also, the number of countries whose data allow us to differentiate between household and firm deposits is always less than 16.[25]

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

[23] 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.

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

[25] With one exception, the deposit and bank credit were obtained from central bank websites. The exceptional case is Peru, where the household versus deposit data where kindly provided to us by Paul Castillo. We obtained data on the stock of debt issued by nonfinancial firms in international debt markets from the

Panel (5a) shows that in the median country, most of the deposits (around 60 percent) are held by households.[26] The lower quartile is close to 50 percent, so that in a small number of countries firms hold more deposits than households (Peru is such a country). Panel 5b reports total firm borrowing (local banks and international debt markets) as a share of total dollar deposits, where the share increased from 25% to 100% for the median country between 2000-2018.[27] From this figure we see that this scaled measure of firm dollar borrowing has been rising steadily over time. It is interesting to note from Panel (5e) that, for the median country, more than 90 percent of firm dollar borrowing is from local banks and relatively little is from international financial markets. This is not the case for all the countries in our sample. The decline in the lower quartile reflects the fact that (see, for example, Shin (2018)) firms in some countries have substantially increased their borrowing in international markets since the 2010s.[28]

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

BIS website, https://stats.bis.org/ . For the reasons given in Shin (2013) and Coppola et al. (2021), we use the data based on nationality.

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

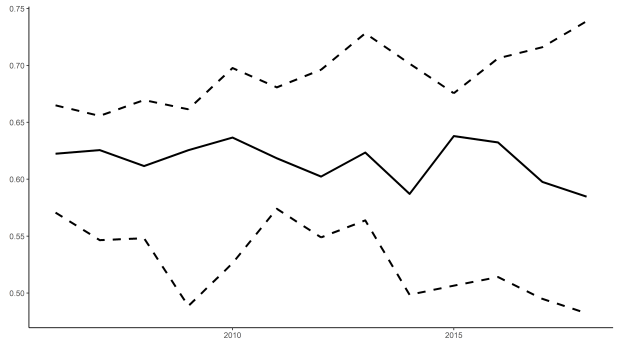
[27] We do not include foreign direct investment and other portfolio equity investment firm dollar borrowing, b^*. These do appear on the liability side of non-financial firm balance sheets, but their rate of return is not stipulated in dollar terms. These liabilities are not of direct interest to us because our focus is on the insurance implications of international financial instruments whose rate of return is fixed in dollars.

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

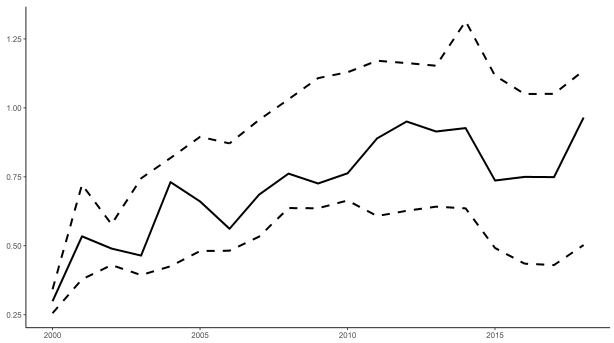
That is, in the median country, non-financial firms are the source of the insurance enjoyed by households when they hold dollar deposits.

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

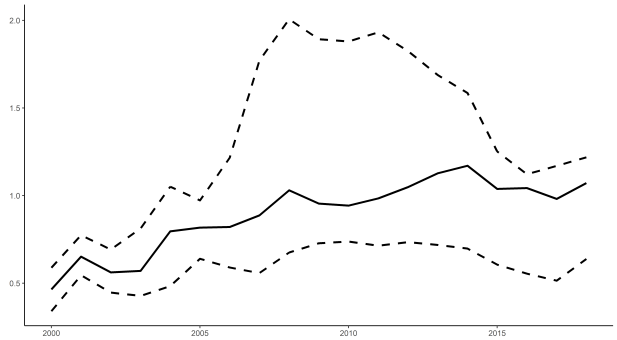
(a) $\phi_t = \frac{\text{Household dollar bank deposits}}{\text{Total dollar bank deposits}}$



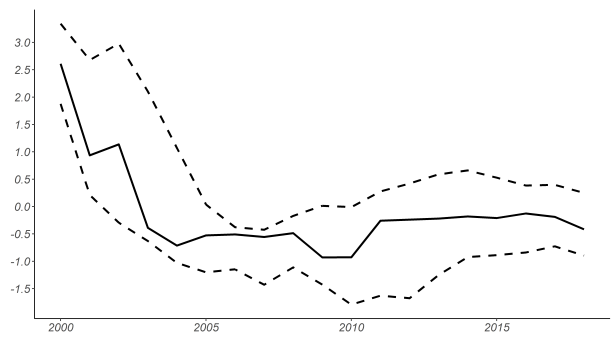
(b) $\frac{\text{Firm dollar debt from all sources}}{\text{Total dollar bank deposits}}$



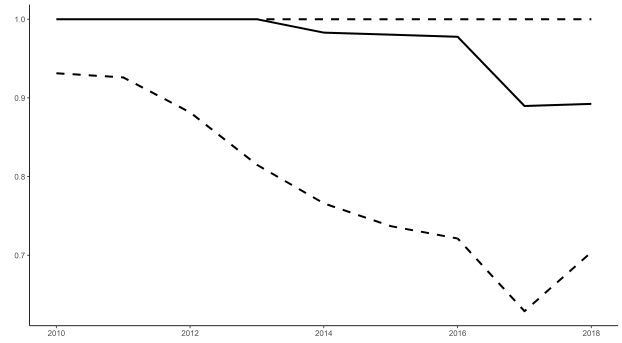
(c) $\frac{\text{Household and firm dollar loans from all sources}}{\text{Total dollar bank deposits}}$



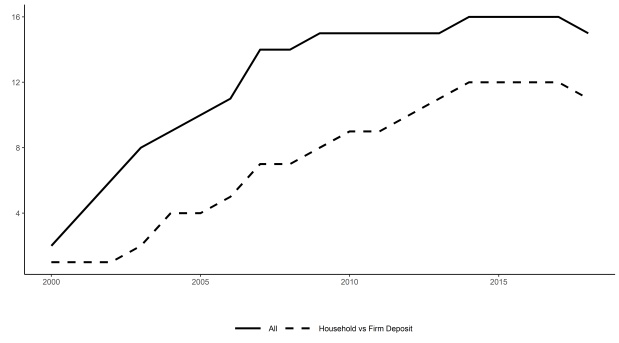
(d) $\frac{\text{Government (including central bank) dollar liabilities net of dollar assets}}{\text{Total dollar bank deposits}}$



(e) $\frac{\text{firm dollars from banks}}{\text{firm dollars from all sources}}$



(f) Number of Observations



Note: Sub-figures (a)-(e): Black line is median, across all 16 countries listed in Footnote 24, of the indicated statistic, for the indicated year. Upper dashed line is upper 25^{th} percentile and lower dashed line is lower 25^{th} percentile. Data were obtained from Central Bank websites. Sub-figure (5f): The dashed line indicates the number of countries for we have data on the composition of deposits in terms of households and firms. The solid line indicates the number of countries for which we have all the other data. In Sub-Figure (a), ϕ_t is the average across all countries, i, of $\phi_{i,t}$ for each t, where $\phi_{i,t}$ is defined in equation (1).

Finally, consider Panel (5d), which indicates that EME governments began to accumulate a substantial amount of dollar assets beginning in the early 2000s.[29] For the median country, the amount of the dollar accumulation by the government is about 1/2 of total dollar deposits. We interpret this accumulation as insurance obtained from foreigners on behalf of all residents, including households and the people that own the firms. How to allocate these insurance benefits across the two types of households is beyond the scope of this paper. Instead, we focus on the insurance obtained by households when they choose the currency composition of their deposits. This represents a lower bound on the insurance that they receive because it abstracts from any insurance received via the fiscal authorities.

3.3 Decomposing International Versus Intra-national Insurance Flows

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

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

Here, d and b denotes assets and liabilities, respectively, denominated in local currency. Also, a * indicates that the financial instrument has a dollar denominated return so that in units of the domestic currency the return depends on the future realized exchange rate. In addition, variables without the superscript denote domestic non-financial residents and variables with superscript, f, denotes foreign residents. We exclude the dollars borrowed and lent by domestic financial institutions because the results in section (3.2.1) suggest that these cancel. Below, we explain how government enters the picture. Equation (2) is the market clearing condition for trade in dollar financial assets between domestic and foreign residents.

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

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

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

The first and second terms represent the quantity of financial trade between residents and non-residents, respectively. The third term denotes the quantity of financial trade between domestic and foreign residents. Suppose, for example that $d_t^* < b_t^*$. In this case, the quantity of insurance obtained by households is fully provided by private firms.[30] In this case, $b_t^* - d_t^* > 0$ is the component of insurance provided by domestic residents to foreigners. The object on the right of the equality is a measure of the total amount of financial trade. Dividing, we have

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

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).[31]

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).[32] 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

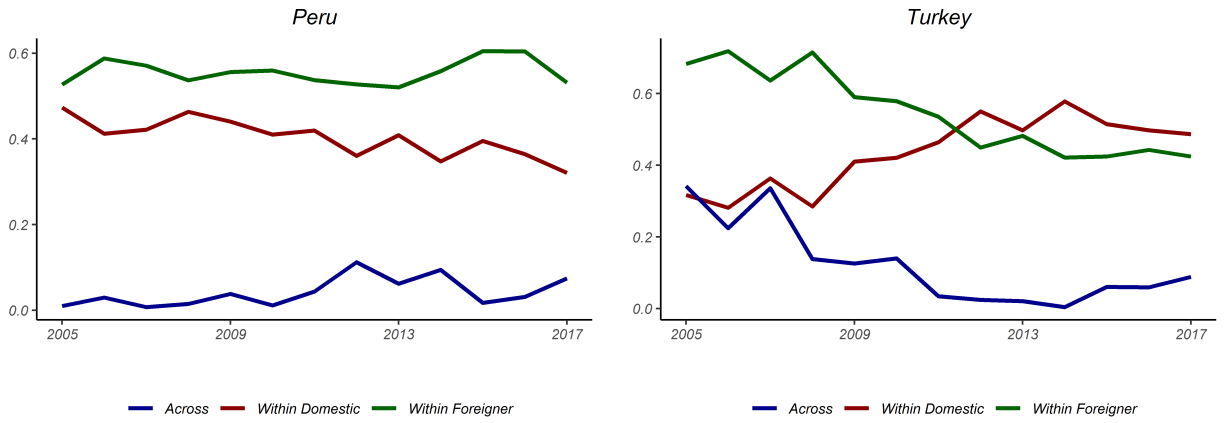
[30] There are two channels by which this can occur. The most straightforward is that the households deposit the dollars in a bank and the firms then come to the bank to borrow those dollars. An alternative is that local banks use the dollar deposits to purchase foreign assets and then domestic firms borrow the dollars by issuing dollar bonds in international markets. From the point of view of who receives the insurance payments and who makes them, the two scenarios are the same.

[31] 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.

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

flows, especially after 2010 in the case of Turkey.

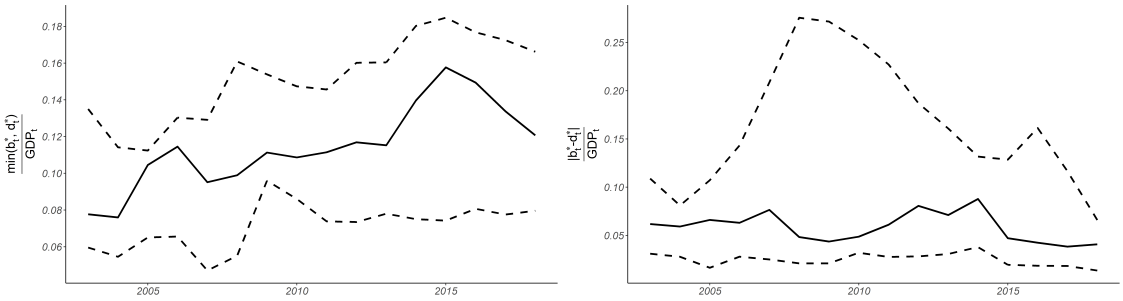
Figure 6: Decomposition of Insurance Flows



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

Figure 7: Intra-national vs International Positions

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



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

Our primary interest is in the within-country resident category versus the across-country category. For this, we do not require the Benetrix et al. (2020) data. We display information about the time series data on a measure of intra-national insurance, $\min(b_t^*, d_t^*)/GDP_t$ versus inter-national insurance, $|b_t^* - d_t^*|/GDP_t$ for our 16 countries in Figure 7. The solid line indicates the median across countries for each year. The dashed lines indicate the 75^{th} and 25^{th} percentiles.[33] The key result is that the across-country insurance flows are small

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

compared to the within-country flows. The median cross-country flows are on average 55 percent of within-country flows.

4 Banking Crises and Dollarization

The results of the previous section sketched a relatively benign picture of deposit dollarization: it is a insurance arrangement, mainly between different people inside individual countries. However, there is a persistent view that deposit dollarization is dangerous, by increasing the vulnerability of banks to a systemic crisis. We showed that banks hold little currency mismatch on their balance sheets, so deposit dollarization does not appear to pose a direct risk to banks. Nevertheless, there are at least two ways in which deposit dollarization can raise the risk of a systemic banking crisis. The first way is if the recipients of dollar loans from banks themselves have substantial currency mismatch. This is not necessarily a problem if firms have natural hedges and if firms which borrow dollars have sufficiently low leverage that they can absorb balance-sheet shocks. There is a second way that deposit dollarization could risk a banking crisis even if banks appear to have no currency mismatch on their balance sheets. If there is substantial maturity mismatch, then a crisis could within a matter of days convert a situation in which there is little currency mismatch into one in which there is substantial mismatch. This could happen by if creditors suddenly become unwilling to roll over short term dollar liabilities and force banks into fire-selling their illiquid dollar liabilities. So, even though banks appear to have no currency mismatch, it is still an interesting empirical question whether there is evidence of an association between dollarization and the incidence of financial instability.

We ask two questions. First, does deposit dollarization raise the probability of a systemic banking crisis? The data appears to show that there is no relation between deposit dollarization and crisis. Second, we ask what are the losses, in terms of foregone output, of a crisis once it happens? We find that there is no relation between the severity of a crisis and deposit dollarization. We begin by examining the relevant unconditional moments in the data. We then bring in conditioning variables and use various econometric methods, which differ according to the amount of structure that is imposed. Our conclusion is that the empirical evidence provides no evidence that there is a link between financial dollarization and vulnerability to systemic banking crisis.

Interestingly, we do find variables that help to forecast crises. Consistent with the results in Forbes and Warnock (2012), we find that the VIX helps. We also find that the level of external dollar debt helps to forecast crisis. This finding is also consistent with results in the literature. For example Mendoza and Terrones (2008) shows that in EMEs, rapid credit expansion is likely to be financed by capital inflows, i.e., external debt. Gourinchas and

Obstfeld (2012) find that rapid credit expansion predicts banking crises in emerging markets. Finally, Caballero (2016) finds that large capital inflows into EMEs predict banking crises.

In sum, while our results are consistent with existing findings that too much borrowing raises the risk of crisis, the currency denomination of debt does not, per se, increase that probability. Of course, our results are drawn from a sample in which most countries are governed by sensible prudential rules. For example, regulators take care that there are not large currency mismatches in banks.

That large external debt is associated with crisis is not surprising. We expect that countries, like people, that borrow a lot have a higher chance of getting into trouble. While a lot of borrowing entails risks, the denomination of deposits and credit in a country governed by sensible prudential rules does not appear to be risky.

4.1 Bivariate Analysis

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

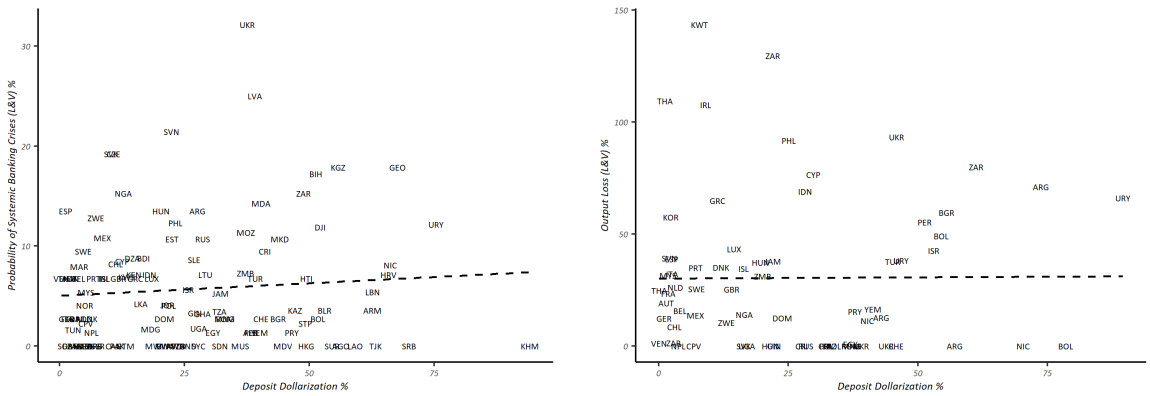
The data on systemic banking crises from Laeven and Valencia (2018) cover the period, 1980-2017, and include 151 systemic banking crises. According to the criteria in Laeven and Valencia (2018), a country experiences a banking crises if it meets two conditions:

- significant banking policy intervention measures were 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.

See Laeven and Valencia (2018) for additional details on how they operationalized the above conditions.

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 (2018) dataset with our deposit dollarization data includes 81 banking crises. Figure 8 plots the fraction of years a country is in a banking crisis against the average deposit dollarization in that country over the same years.

Figure 8: Probability of Laeven and Valencia (2018) Banking Crises, Output Loss and Deposit Dollarization



We also investigate the relationship between the magnitude of the loss in output and deposit dollarization. We take Laeven and Valencia (2018)'s measure of the output loss, in terms of GDP, associated with the crisis.[34] Figure 8 indicates that the cost of a sudden stop is not significantly related to the level of deposit dollarization.The key take-away from Figure 8 is: (i) there does not appear to be a strong relationship between deposit dollarization and the frequency of banking crises; and (ii) if a crisis occurs, the resulting loss in output does not appear to be related to a country's level of deposit dollarization.

4.2 Multivariate Analysis

Although suggestive, examining the simple covariance between deposit dollarization and financial crises could hide important causal links between the two variables. To see this, it is useful to distinguish between two channels by which an exchange rate depreciation can affect the probability of a crisis. One is the *expenditure switching channel,* whereby an exchange depreciation leads to an expansion in output by encouraging domestic and foreign residents to buy more domestic goods. The expansion improves balance sheets generally and thus reduces the probability of a banking crisis. The second channel, the balance sheet channel, was discussed in Section 3.1. This channel may be important if substantial dollar deposits lead to currency mismatch. In this case, there are direct and indirect channels whereby a depreciation could hurt bank balance sheets. There is a variety of ways in which lack of correlation between deposit dollarization and banking crisis could in principle hide causality from deposit dollarization to crisis. For example, suppose that the balance sheet channel

[34] Laeven and Valencia (2018) measure the output loss as follows. To compute the output loss in a particular crisis year, say year t, they compute the HP filter of the log, real GDP data from $t-20$ (or, first available observation) to $t-1$. They extrapolate the HP trend into years t to $t+3$. The loss is measured as the sum of the deviations between log GDP and its HP extrapolated trend in periods t to $t+3$.

is important, so that when deposit dollarization is high a substantial depreciation would destabilize the banking system. If government policy in countries where deposit dollarization is high responded to high dollarization by vigorously using monetary and other policies to prevent substantial depreciation, then we might well see no relationship between deposit dollarization and the probability of a banking crisis. We examined this possibility by pooling all our data on deposit dollarization and exchange rate depreciation. We then compare the distribution of exchange rate depreciations, depending on whether deposit dollarization was high or low in the previous year. We found that for countries with high deposit dollarization rates, the density of depreciations is skewed slightly to the right. That is, if anything, countries with high deposit dollarization are a little more likely to see a high depreciation in the next year (for details, see Section D in the Online Appendix). We infer two things from this analysis. First, the lack of association between dollarization and financial crisis suggested by Figure 8 does not appear to be an artifact of monetary policy. Second, there is a simple interpretation of the results which is consistent with the insurance hypothesis. Namely, households increase the share of their deposits held in dollars when they anticipate an exchange depreciation.

A related concern about our inference from Figure 8 stems from the obvious noisiness of the bivariate relationship between dollarization and crises. Although the slope of the least squares line is not significantly different from zero, it is also not significantly different from a big positive or negative number. We bring other data into the analysis to see if the additional information helps us to more precisely identify any relationship between deposit dollarization and crisis. The variables that we bring into the analysis are motivated by the balance sheet channel. Our first exercise examines three variables: deposit dollarization, frequency of crises and exchange rates. We ask whether the likelihood of crisis is different across high- and low-dollarized economies for a given exchange rate depreciation. We find that the level of dollarization does not affect the likelihood of crisis after a depreciation. To ensure robustness to specification error, this analysis is relatively unstructured and inference is based on the bootstrap (see Online Appendix Section G). We then incorporate many more variables, but at the same time we increase the degree of econometric structure by using logit regression.

Our basic finding is robust across all econometric exercises. They all confirm the impression conveyed by Figure 8 that there is little relationship between deposit dollarization and the frequency or cost of financial crisis.

4.2.1 Evidence Based on Logit Regressions

The previous discussion is based on relatively unstructured econometric methods to draw inference about the relationship between deposit dollarization and crises. In this section,

we do the analysis with logit regression. Although this approach places more structure on the analysis (hence, raises the possibility of specification error), it also allows us to consider a larger number of conditioning variables. Our findings for deposit dollarization in this subsection mirrors what we found in the previous two subsections. Because we consider more variables in this section, we are able to evaluate aspects of financial dollarization more generally and our results match the literature in pointing to risks from aspects of financial dollarization other than dollarized deposits. Still, the conclusion of this section is that deposit dollarization does not contribute to the likelihood of a systemic banking crisis.

Logit Methodology and Data Used in the Analysis Our logit results are reported in Table 1. Let $p_{i,t}$ denote the probability that year t is the first year of a Laeven and Valencia (2018) systemic banking crisis for country i. We adopt the assumption in standard logit analysis, that the log odds, $p_{i,t}/\left(1-p_{i,t}\right)$ of a crisis is a linear function of a set of year $t-1$ variables on country i, $x_{i,t}$. It has been pointed out (see, e.g., Bussiere and Fratzscher (2006) and Gourinchas and Obstfeld (2012)) that the period $t-1$ state of the economy may not contain enough information to determine the probability of a crisis in period t. For example, if some variables are high in the previous period (say foreign debt), but this is not part of a longer-run pattern, this may not signal an imminent crisis. But, if the high value of the variable in the previous period is part of a longer-term buildup, then perhaps it does signal a crisis. To accommodate this kind of possibility, subsection H.2 in the Online Appendix includes results which incorporate more lags. The results reported below are robust to this modification.[35]

Our observed data are $y_{i,t} \in \{0,1\}$ where 1 indicates a Laeven and Valencia (2018) systemic banking crisis in period t, country i. We model the binomial variable, $y_{i,t}$, as follows:

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

where $p_{i,t}\left(x_{i,t};\beta\right) = E\left[y_{i,t}|x_{i,t};\beta\right]$ and we adopt the following functional form:

$$p\left(x_{i,t};\beta\right) = \frac{1}{1+e^{-x_{i,t}^T\beta}}. \tag{4}$$

Here, the column vector, $x_{i,t}$, includes period $t-1$ variables, the superscript, T, denotes

[35] See Bussiere and Fratzscher (2006), who propose an alternative approach based on a multinomial distribution. They and Gourinchas and Obstfeld (2012) apply the approach in a setting much like ours. The difference between our approach and theirs is we ask 'given period t data, what the probability that a crisis starts in period $t+1$?', while they ask 'given period t data what is the probability of crisis that a crisis starts in some period, $t+1, ..., t+k$, where k may be bigger than 1?' The model that we estimate can also answer the Bussiere and Fratzscher (2006) type of question, conditional on a forecast of the state of the economy in $t+1, ..., t+k-1$.

transposition and β is a column vector of parameters to be estimated. The j^{th} element of β denotes the semi-elasticity of the odds of a crisis with a change in the j^{th} element of $x_{i,t}$.[36] Note that by construction, $0 \leq p_{i,t}\left(x_{i,t};\beta\right) \leq 1$. By the orthogonality property of conditional expectations we have that $\varepsilon_{i,t}$ is orthogonal to each element in the vector, $x_{i,t}$, when β is set at its true value, β_0. That is, [37]

$$E\left[y_{i,t} - p\left(x_{i,t};\beta_0\right)\right] x_{i,t} = 0. \tag{5}$$

Our setting is a special case of the Generalized Method of Moments environment considered by Hansen (1982). We estimate β_0 by choosing the value of β, $\hat{\beta}$, having the property that the sample analog of equation (5) is satisfied. The number of equations in (5) is equal to the number of elements in β, so that the estimator is exactly identified. For the purpose of inference, we allow for heteroscedasticity in $\varepsilon_{i,t}$, as well as correlations over i for given t and over t for given i. [38]

We include the following variables in $x_{i,t}$, in addition to a constant. First, there is $\Delta e_{i,t-1}$, the log difference of the previous year's exchange rate, relative to its value in the prior year. Also, $Dollar\left(20\right)_{i,t-1}$ is a dummy variable which is unity if deposit dollarization exceeds 20 percent (i.e., $\phi_{i,t-1} > 0.20$) in the preceding year.[39] This dollar dummy is an indicator of 'high deposit dollarization'. In Online Appendix Subsection H.4 we show that the results are robust to adopting a 10 percent cutoff rather than the 20 percent cutoff adopted here. We also include the cross-product of the exchange rate change and the dollar dummy. The sum of the coefficients on $\Delta e_{i,t-1}$ and the cross-product term captures the balance effect: a depreciation in an economy with high deposit dollarization creates balance sheet effects that destabilize the bank system.

The specification of our logit regression also allows us to consider another channel by with deposit dollarization could destabilize the banking system. Suppose currency mismatch is in the hands of firms which have the capacity to absorb exchange rate fluctuations, so that the standard balance sheet channel is not operative. If there is substantial maturity mismatch between dollar liabilities and dollar assets then, as noted in the introduction to this section, banks which have no currency mismatch could suddenly have a great deal of mismatch if creditors refuse to roll over their short term dollar deposits and banks are forced to sell illiquid dollar assets. If this roll over problem occurred with domestic currency assets and

[36] It is straightforward to verify that, given equation (4), the log-odds of a banking crisis is $\ln\left(p_{i,t}/\left(1-p_{i,t}\right)\right) = x_{i,t}^T\beta$.

[37] Here, we use the assumption that $p\left(x_{i,t};\beta_0\right) = E\left[y_{i,t}|x_{i,t}\right]$. In addition, we use the orthogonality property of expectation, $E\left\{\left(y - E\left[y|x\right]\right)x\right\} = 0$.

[38] 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).

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

liabilities, the central bank could always solve the problem by providing liquidity. But, a central bank with only a modest amount of foreign reserves could not play a lender of last resort role in case creditors refuse to roll over dollar deposits. To capture this channel, we also construct a dummy variable, 'Low Reserves'. This variable is unity for country i and year t if country i's central bank has a lower dollar reserves to GDP ratio than the median value of that ratio in the cross-section of countries in year t. We also include the interaction of Low Reserves for i and $t-1$ with $Dollar\,(20)_{i,t-1}$. The coefficient on this interaction term is a measure of this alternative balance sheet channel which operates through maturity mismatch and can be expected to matter most when the central bank is low on reserves.

In addition, we consider the variable, FL/FA.[40] Here, FL denotes dollar liabilities by non-central bank financial institutions to foreigners. Also, FA denotes dollar claims on foreigners by the same institutions. Our time series on FL/FA is displayed in Figure 9.

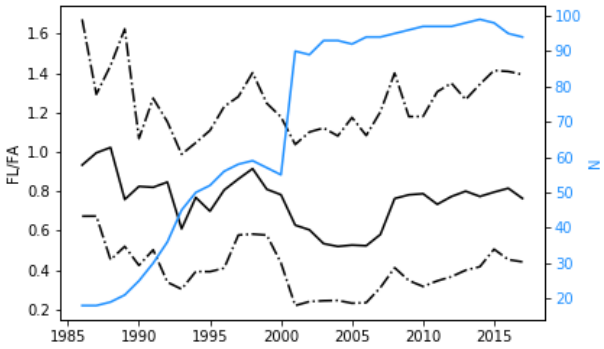


Figure 9: FL/FA

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).

The number of countries for which we have data 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. One reason that high FL/FA might be a source of fragility for the banking system is based on the rollover logic described above,

[40] 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".

which is particularly relevant when assets and liabilities are in dollars.

Our analysis in Subsection 3.2.1 suggests that when $FL - FA > 0$, then the banks hold $FL - FA$ in the form of dollar claims on domestic residents. High FL/FA would indicate vulnerability to crisis if the bank assets corresponding to $FL - FA$ are relatively illiquid and of longer maturity than the liabilities in FL. [41] Of course, if a country's central bank held a lot of dollar assets then in principle it could play a lender of last resort role to prevent a rollover crisis in the banking system when $FL/FA > 1$. This is why we also include the interaction of the Low Reserves dummy with the High FL/FA dummy.

We include the current value of the VIX, the index of financial market volatility produced by the Chicago Board Options Exchange.[42] This is motivated by the findings in Forbes and Warnock (2012) and Miranda-Agrippino and Rey (2020), which suggest that the VIX is an indicator of global risk appetite. We also include the ratio of central bank foreign reserves to GDP.[43] A priori, one expects this to reduce the probability of a crisis. For example, knowing that a central bank with large amounts of foreign reserves could step in and provide banks with liquidity in the event of a run, foreigners might be less tempted to refuse to roll over FL. Real GDP growth is included[44], as well as the cross-product of the FL/FA and deposit dollarization indices. We include '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 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 crisis by damaging balance sheets in the event of a depreciation.

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 in cases that countries have crises that last for more than one year. Table 1 reports $t-$statistics for the null hypothesis that the true parameter is zero in parentheses beneath point estimates.

[41] We have not done a systematic analysis of the relative maturity of liabilities in FL versus the assets, $FL - FA$. We were able to obtain data on one country, Peru. Pre-2000's data on Peru are consistent with the idea that the short term (less than two years) component of FL is high. 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 dollar borrowing by banks that is short term was above 90% from 1992 until late 1999 (there was a dip to around 80% from mid-1996 to mid-1997). The fraction of short term borrowing then fell steadily and has been fluctuating in a 13% to 30% range in recent years. This suggests that, at least in the case of Peru, the chances of a rollover crisis with FL are small. We are grateful to Paul Castillo for providing us with these numbers.

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

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

The first three columns of Table 1 include all data covering the period 1995-2017. We indicate N, the number of country, year observations in the data set. The last three columns of the table do not include advanced countries and emerging economies in the Eurozone.[46] We also report an R^2 diagnostic for our logit regressions at the bottom of each column.[47]

Results of Logit Regressions Consider the first column of Table 1, which has the flavor of the findings in Levy-Yeyati (2006). The results in that column suggest that an exchange rate depreciation is less likely to lead to a systemic crisis if deposit dollarization is low (i.e., $Dollar\,(20)_{i,t-1} = 0$). Levy-Yeyati (2006) interprets the significance of the coefficient on the cross product, $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$, as reflecting that high financial dollarization causes the balance sheet channel associated with an exchange rate change to dominate the expenditure switching channel. However, that the significance the cross-product coefficient is not robust to the introduction of other relevant variables. For example, in column (2) we include the FL/FA dummy and the significance of the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ goes away. Levy-Yeyati (2006) also includes the FL/FA dummy in his analysis, so column (2) shows that that analysis is not robust the introduction of post-2003 data. Similarly, comparing columns (1) (which uses all our data) and (4) (only EME's), we see that the significance of the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ also ceases to be significant if we only look at EME's. In the Online Appendix Section H.8 we display additional evidence on the lack of robustness in Levy-Yeyati (2006)'s findings that the coefficient on $\Delta e_{i,t-1} \times Dollar\,(20)_{i,t-1}$ is statistically significant.[48] So, deposit dollarization does not play a significant role in the probability of a systemic banking crisis.

Note that the VIX plays a significant role in all our results. When it comes to EME's (our principal interest) the only two variables that matter significantly for a banking crisis are the VIX and the country's external debt (see column (6)).[49] We only include external debt in our analysis of EME's because our data source does not include non-EME data.

Turning to $High\,FL/FA$ note that columns (2) and (5) imply that that variable is

[46] The advanced economies that are deleted 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.

[47] Specifically, we report the pseudo-R^2 provided by STATA, $1 - var\,(\varepsilon_{i,t})\,/var\,(y_{i,t})$, evaluated at the estimated values of the logit parameter estimates.

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

[49] In Subsection H.1 in the Online Appendix we explore alternative measures of uncertainty, but find that the VIX has the biggest $t-$statistic. Two alternative measures of uncertainty that are almost as useful as the VIX are "financial stress" (see Puttmann (2018)) and "exchange rate market volatility" (see Baker et al. (2019)). The Online Appendix also considers the "global financial factor" (see Miranda-Agrippino and Rey (2020)) which turns out not to be significant.

statistically significant. As explained above, there are good economic reasons why $FL/FA > 1$ might be a source of vulnerability to crisis. High FL/FA could trigger a classic rollover crisis in the banking system when the central bank cannot act as a lender of last resort in dollars. This suggests that the interaction of the Low Reserves dummy with FL/FA should have a positive and significant coefficient. In fact, column (3), (5), (6) show that the coefficient is negative and not significant. So, the positive coefficient on FL/FA appears to be a puzzle, at least for the classic liquidity crises.[50] An alternative interpretation of the results is suggested by the findings in column (6). When we include External Debt in the equation, then FL/FA ceases to be significant. Taken together, the evidence suggests that the statistical significance of FL/FA only reflects its role as an indicator of external debt, and not that FL/FA per se is necessarily important.

In sum, we find that financial crises are forecastable to some extent, with variables like the VIX and external debt.[51] However, our forecasting exercise provides no support to the idea that there is an association between deposit dollarization and financial crises.

4.2.2 Dollarization and the Severity of Banking Crises

Previous subsections show that there is little evidence that deposit dollarization affects the likelihood of a crisis. Here, we ask a different question: "conditional on a crisis occurring, is the economic cost greater for an economy with high deposit dollarization?". We answer this question using the ordinary least squares results reported in Table 2. In each regression the left-hand variable is the quantity of GDP lost that can be attributed to the crisis, as measured in Laeven and Valencia (2018).[52] The cost of a crisis includes lost output in subsequent years for crises that last more than one year.[53] The number of observations, N, at the bottom of the table is relatively small, reflecting the small number of crises in our

[50] The result is a puzzle for sunspot crises ('classic liquidity crises') in which banks are solvent but nevertheless susceptible to liquidity problems, as in Gertler and Kiyotaki (2015). The liquidity problem could make solvent banks insolvent in case short-term creditors to domestic banks refuse to roll over their dollar loans and banks are forced to sell long-term assets at fire-sale prices. A central bank with sufficient dollar reserves could prevent such a crisis by lending banks dollars using the banks' long-term illiquid dollar assets as collateral. Understanding this in advance, a model like that in Gertler and Kiyotaki (2015) predicts that dollar creditors would have no reason to refuse to roll over in the first place. It is from this perspective that the statistical insignificance of the coefficient on the interaction term between the Low Reserves dummy and FL/FA is puzzling. However, suppose news arrives suggesting that banks dollar assets are of lower quality than initially believed. In this case, the assets are not good collateral and perhaps even a government with ample reserves might not be in a position to help. By this logic the significant coefficient on FL/FA and non-significant coefficient on the interaction term on reserves may not be a puzzle after all.

[51] Subsection (H.10) in the Online Appendix uses standard metrics to show that the model in column (6) of Table 1 represents an 'acceptable' forecasting model for crises. Consistent with the results in the table, those metrics show that the crucial variables for forecasting crises are the VIX and external debt, while deposit dollarization is not related to crises.

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

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

data. The country-specific right hand variables in Table 2 include only observations on the year before the first year of a crisis. We do this to mitigate endogeneity problems. The only variable that is not country-specific is the VIX, and we include its contemporaneous value on the right side of the regression. The right hand variables in Table 2 are similar to the right hand variables in Table 1 for the sake of symmetry. As in the logit regressions, we permit heteroscedasticity in the error terms, as well as autocorrelation and cross-country correlations (see Petersen (2009)).

Table 1: Probability of Systemic Banking Crisis

	(1)	(2)	(3)	(4)	(5)	(6)
Crisis						
Dollar (20)	-0.435	-0.281	-0.149	0.234	-0.107	-0.603
	(-0.75)	(-0.41)	(-0.22)	(0.52)	(-0.15)	(-0.76)
Δer	-0.923*	-3.367	-3.464	0.279	-0.0461	-0.662
	(-1.84)	(-0.97)	(-0.98)	(0.50)	(-0.02)	(-0.19)
Dollar(20)*Δer	1.652**	2.509	2.819	0.392	-0.931	-2.024
	(2.29)	(0.53)	(0.59)	(0.55)	(-0.29)	(-0.39)
High FL/FA		1.599**	1.636*		1.732*	1.544
		(2.34)	(1.74)		(1.83)	(1.45)
VIX	0.166**	0.160***	0.159***	0.0751*	0.126***	0.120***
	(2.47)	(2.96)	(2.90)	(1.78)	(2.89)	(2.86)
Reserves/GDP		-3.738**	-4.587		-4.349	-2.464
		(-2.19)	(-1.43)		(-1.23)	(-0.94)
Real GDP Growth		0.0391	0.0409		0.0334	0.0637
		(0.48)	(0.49)		(0.39)	(0.84)
High FL/FA * Low Reserves			-0.0813		-0.708	-1.067
			(-0.13)		(-0.69)	(-0.93)
Dollar(20) * Low Reserves			-0.319		0.0639	0.861
			(-0.40)		(0.06)	(0.89)
External Debt						0.340***
						(4.93)
Constant	-7.535***	-8.262***	-8.134***	-5.994***	-7.348***	-7.901***
	(-5.06)	(-5.24)	(-5.43)	(-5.31)	(-6.03)	(-6.65)
N	2262	1543	1543	1919	1464	1204
Years	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Countries	All	All	All	EMEs	EMEs	EMEs
Pseudo R2	0.0487	0.0758	0.0783	0.00382	0.0294	0.0505

t statistics in parentheses

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

Notes: 'left hand variable' is Laeven and Valencia (2018) banking crisis indicator; for list of countries see footnote 46.

The critical result in the table is that the coefficient on deposit dollarization has the 'wrong' sign, but in any case is never significantly different from zero. Note that the adjusted R^2 is negative in column 4 and 6, consistent with the finding that none of the variables in the associated regression is significant, as well as the fact that N is small. Notably, the VIX

is never significant for EMEs, despite the fact that it plays an important role in determining the probability of a crisis (see Table 1). Still, it is interesting that the coefficient on the VIX is always negative, and in one case, when we include advanced economies, it is significant. This is (modest) evidence that when the VIX is high then the output loss from a crisis is small. One interpretation of this is based on the fact that the VIX is the only variable that is common across countries. This may suggest that when the trigger of a crisis is external to a country, then the resulting output loss is less severe than when the cause is internal.

Column 5 adds FL/FA, central bank reserves and real GDP growth in the year before a crisis. As in Table 1, reserves are not significant. Real GDP growth is significant, suggesting that the cost of crisis is greater if it hits an economy that is already weakening for other reasons. Table 1 indicates that slow GDP growth per se does not raise the probability of a crisis. However, since the cost of a crisis is greater if it hits a slow-growing economy, risk aversion may dictate that policymakers prepare for crisis when GDP growth is low.

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

For our purposes the main takeaway from Tables 1 and 2 is that deposit dollarization does not increase a country's vulnerability to financial crisis and if one occurs, it does not affect its severity. Our results for FL/FA and external debt do indicate that policy pay attention to dollar borrowing by domestic residents from foreigners.

5 Impact of Financial Dollarization on Transmission of Shocks

Even if deposit dollarization does not increase the probability of crisis or raise the cost of crisis once it occurs, it may still have harmful effects in other ways. In particular, given the relative absence of currency mismatch in banks, deposit dollarization forces currency mismatch onto non-financial firms. For example, when the exchange rate depreciates the banking system may remain stable, but firms with heavy dollar liabilities may be forced to inefficiently pass up on good investment and employment opportunities. This is a *balance sheet channel* associated with a depreciation that is similar to the analogous channel for banks discussed in Section 4.2. In line with other evidence in the literature, our empirical

results support the idea that, with sensible prudential policy in place, the balance sheet channel is relatively weak. Sales and GDP appear to be the main drivers of nonfinancial firm investment, not exchange rate fluctuations per se. An exchange rate depreciation could also impact investment activity by an *investment price channel* which raises the local currency price of critical imported investment goods. This expenditure switching-type channel has nothing directly to do with the financial dollarization issues considered in this paper.

Table 2: Output Loss in Banking Crises

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

t statistics in parentheses

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

Notes: left hand variable is GDP growth; for list of countries see footnote 46

[54] In any case, the evidence for an investment price channel is also weak.[55] The point estimates are not significant and they are even have the wrong sign.[56]

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

[55]Alfaro et al. (2018) note heterogenous impact of RER depreciations on the performance of exporting firms. In particular, exporting firms which are more dependent on imported intermediate inputs, do not benefit from RER depreciations. So, our evidence against the investment price channel may reflect lack of power. However, we stress that there is no direct relationship between the investment price channel and financial dollarization and if there is an indirect effect, that appears to be ambiguous (see footnote 54).

[56]See the discussion of the results for the exchange rate depreciation, ΔER, in Table I14 in Subsection

Our analysis is based on two firm-level datasets for Peru and one dataset for Armenia.[57] The first Peruvian dataset has annual observations for 118 firms over the period, 1999-2014. In any one year, this unbalanced panel includes data for 80-100 firms and was constructed for the research reported in Ramírez-Rondán (2019). This dataset is attractive because it has a relatively large number of observations, it includes information about whether or not a firm is an exporter, and it includes the assets and liabilities of the firms by currency of denomination. Moreover, the firms in the dataset account for most of the dollar borrowing by Peruvian nonfinancial firms. This dataset indicates that a firm's investment response to an exchange rate depreciation is not significantly related to the degree of currency mismatch on its balance sheet. Moreover, among the firms with significant currency mismatch, the response of investment to an exchange rate depreciation is not significantly related to whether or not it is an exporter. Finally, we exploit our observations on assets and liabilities by currency denomination to do stress tests on the firm balance sheets. We infer that the reason depreciations have little impact on firms is that the ones with currency mismatch on their balance sheets have low leverage and can handle the consequences of exchange rate fluctuations.

Our second Peruvian dataset was constructed for the research reported in Humala (2019) and contains a balanced panel for 28 large, publicly traded firms. This dataset has the advantage that it includes the period of the large 30 percent currency depreciation that occurred in Peru over the three years, 2013-2015 (see Figure I15d). While the data do not indicate the extent to which firms are naturally hedged by exports, they do include information about firms' holdings of foreign exchange derivatives. We show that there is no significant relationship between a firm's currency mismatch on its balance sheet on the eve of the depreciation, 2012Q4, and its investment over the subsequent years, 2012Q4 to 2016Q4.

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

The exception in our analysis of the Armenian data lies with the firms in the top quartile

I.1.1 of the Oline Appendix.

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

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. For example, a number of firms in the sample have leverage so high that they are technically in default. There are even some firms whose dollar debt alone exceeds the value of their total assets. Perhaps the leverage of these firms is mis-measured in the sense that assets are measured at historical rather than market value. Or, perhaps these firms have a lot of intangible capital that is not fully reflected in their total asset data.

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

Regarding the existing literature, Kim et al. (2015) show that small firms in Korea with dollar debt decreased investment following the Asian crises but the effect is negligible (or even positive) for large firms with dollar debt. 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.[58] Moreover, he finds that the response of investment to an exchange rate depreciation is small for firms that issue longer-maturity debt. In Pratap et al. (2003)'s analysis of Mexican data they report strong balance sheet effects following the 1994 crisis but not in the 1998 crisis. They interpret the difference as reflecting better management of exchange rate risk. Their results are consistent with the view that sound prudential policy is important, but that financial dollarization *per se* is not a problem. Finally, Bleakley and Cowan (2008) study 450 firms in 5 Latin American countries and they find that balance sheet effects are relatively modest.[59] That is, they conclude "...firms holding more dollar debt do not invest less than their peso-indebted counterparts following a depreciation."[60]

In sum, our results and those in the existing literature suggest that the role of balance sheet effects in exchange rate changes is relatively modest in EMEs. Of course, most of

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

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

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

this evidence is drawn from a period in which regulatory authorities have been attentive to prudential policy. Much of that policy should no doubt be kept in place and in some cases perhaps even strengthened. For example, the evidence from Mexico might warrant making sure firms do not take out too much short term dollar debt and the Armenian data may suggest (subject to the measurement issues raised above) keeping a watchful eye on high-leverage firms that borrow dollars.

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

The principle in the previous paragraph suggests that banks should not be permitted to have large currency mismatch on their balance sheets.[61] Banks typically have a much higher level of leverage than nonfinancial firms, and so they cannot handle substantial currency depreciation. This is especially so because central banks in EMEs have at best only a limited capacity to act as lenders of last resort when there is a dollar liquidity problem. Because a large part of bank liabilities serve as the medium of exchange for transactions in goods and services, if banks fail because of an exchange rate depreciation, the consequences are felt by a wide range of people who took no part in the bank's currency portfolio decisions. Fortunately, these views are widely understood and, as we show in Subsection 3.2.1, regulators in the 2000s appear to have successfully acted to prevent currency mismatch in their national banking systems.[62]

What is important for our analysis is that, overall, most firms with dollar mismatch do

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

[62] Another example of dollarization where prudential regulation is warranted is the large increase in foreign-currency denominated mortgages taken by households in Eastern Europe. Presumably, a number of factors contributed to this phenomenon. Among these is a moral hazard problem when a large group of people undertake a correlated risk (e.g., acquire foreign currency-denominated liabilities). In this case, members of the group may, knowing that many others are undertaking the same risk, believe that the government (e.g., other tax payers) will come to the rescue in case things go awry and there is a substantial appreciation in the currency in which the debt is taken. Fortunately, regulators are now well aware of this risk and are taken suitable measures.

not appear to cut back on investment after a depreciation. We conclude that, with sensible prudential policy in place, the dollar mismatch pushed onto non-financial firms by households that choose to hold dollar deposits does not appear to impose substantial economic disruption on EME economies.

6 Model

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

6.1 Worker-Households

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

$$d + d^* = Y. \tag{6}$$

The household's period 2 budget constraint is:

$$c_2^{house} = dr + d^*r^*e_2 + w_2l_2 = (e_2r^* - r)\, d^* + w_2 + Yr, \tag{7}$$

after substituting out for d using equation 6. 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 (7), 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.[63]

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

$$\max_{d^*} Ec_2^{house} - \frac{\lambda}{2} var\left(c_2^{house}\right), \tag{8}$$

subject to the second restriction in (7). The solution to a problem with these mean-variance preferences is standard:[64]

$$d^* = -\frac{E\left(r - e_2 r^*\right)}{\lambda var\left(r^* e_2\right)} - \frac{cov\left(r^* e_2, w_2\right)}{var\left(r^* e_2\right)}. \tag{9}$$

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 (9), 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.

[63] The model with peso and dollar deposits is isomorphic to a model with no dollar deposits and a futures market in dollars. For the details, see the Online Appendix. The observation is perhaps already obvious from the second equality in equation (7). 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.

[64] For details, see the Online 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:

$$K = k_h^{\omega} k_f^{1-\omega}. \tag{10}$$

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

$$e_1 k_f = (1-\omega)\, p^K K,\ k_h = \omega p^K K, \tag{11}$$

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:

$$p^K = \left(\frac{e_1}{1-\omega}\right)^{1-\omega} \left(\frac{1}{\omega}\right)^{\omega}, \tag{12}$$

which is exogenous to the firm. We refer to p^K as the shadow price of capital.[65]

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

$$p^K K = b + b^*. \tag{13}$$

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.[66]

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

$$Y_2^h = (AK)^{\alpha} l_2^{1-\alpha}, \tag{14}$$

where l_2 denotes the quantity of labor hired in period 2 and A denotes a technology shock

[65] The marginal cost expression in equation (12) is the standard one for the Cobb-Douglas production function in equation (10). For further discussion see subsection J.1.2 in the Online Appendix.

[66] 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. A difference is that the foreign financiers' preferences are in terms of the dollar good (see Equation (27) below), while the firm-household preferences are in terms of the domestic good (see equation (8)).

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

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

$$r_2^K = \alpha p_2^h Y_2^h / K. \tag{15}$$

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,

$$c_2^{firm} = r_2^K K - (br + b^* r^* e_2) = \left(R_2^K - r\right) p^K K - b^* (e_2 r^* - r), \tag{16}$$

where the second equality follows by substituting out for b using equation (13).[67] Also, the rate of return on capital, R_2^k, is the marginal earnings on capital, divided by its shadow price:

$$R_2^K = \frac{r_2^K}{p^K}. \tag{17}$$

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

$$\max_{b^*,K} E(c_2^{firm}) - \frac{\lambda}{2} var(c_2^{firm}), \tag{18}$$

subject to (16) and $c_2^{firm} \geq 0$ in each period 2 state of nature. Optimization of b^* implies:

$$b^* = \frac{E(r - e_2 r^*)}{var(e_2 r^*)\lambda} + \frac{cov\left(e_2 r^*, r_2^K\right)}{var(e_2 r^*)}. \tag{19}$$

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 (15), r_2^K, is proportional to $p_2^h Y_2^h$. Below,

[67] In terms of the futures market in footnote (63), with $b^* > 0$ the firm in effect goes long on $b^* r^*$ futures contracts in dollars.

(see equation (40)) we show that $p_2^h Y_2^h$ corresponds to period 2 GDP. Thus, the hedging motive of the firm is the same as it is for the household, so that makes the firm averse to borrowing in dollars. However, the firm can be induced to borrow in dollars anyway by the speculative motive if there is a sufficiently high premium on the domestic interest rate (i.e., $E\left(r - e_2 r^*\right) > 0$).

Finally, optimization of K leads to the following solution:

$$p_1^K K = \frac{E\left(R_2^K - r\right)}{var\left(R_2^K\right)\lambda} + \frac{cov\left(e_2 r^*, R_2^K\right)}{var\left(R_2^K\right)} b^*. \tag{20}$$

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,

$$e_1 r^* = r^\$, \tag{21}$$

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:[68]

$$x^\$ + x^D = b^f. \tag{22}$$

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,

$$Y_2^* = \xi + \nu, \tag{23}$$

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

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

assume that the financier's period 2 other income has the following form:

$$Y_2^f = s\nu, \tag{24}$$

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

$$cov\left(Y_2^f, Y_2^*\right) = s \times \sigma_\nu^2. \tag{25}$$

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

$$x^\$ e_1 r^* + \frac{x^D e_1 r}{e_2} - b^f e_1 r^* + Y_2^f, \tag{26}$$

where we have substituted out $r^\$$ using the arbitrage condition, equation (21). After substituting out for b^f from 22, the financier's consumption of period 2 foreign goods is, after rearranging:

$$\left(r - r^* e_2\right) x^D \frac{e_1}{e_2} + Y_2^f. \tag{27}$$

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:

$$x^D = \frac{E\frac{e_1}{e_2}\left(r - e_2 r^*\right)}{var\left(\frac{e_1}{e_2} r\right)\lambda^f} - \frac{cov\left(\frac{e_1}{e_2} r, Y_2^f\right)}{var\left(\frac{e_1}{e_2} r\right)}, \tag{28}$$

after using the no-arbitrage condition, equation (21). We have stressed that an empirically plausible model of an EME will have the property that there is a premium on the local currency. Equation (28) implies that, other things the same, this motivates foreign financiers to lend in terms of domestic currency. Of course, if they actually did this to a sufficient extent, then in equilibrium there could be no premium on the domestic interest rate. However, the foreign financiers also have a hedging motive. Suppose that in states of the world when the exchange rate depreciates (i.e., e_2 is high) their other sources of income, Y_2^f, are low. In that case, their hedging motive makes foreign financiers averse to lending in domestic currency, even in the presence of a local premium.[69]

[69] 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.

6.4 Final Consumption Good Production in Period 2

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

$$c_2 = \mathbb{A}\left[\omega_c^{\frac{1}{\delta}}\left(c_2^h\right)^{\frac{\delta-1}{\delta}} + (1-\omega_c)^{\frac{1}{\delta}}\left(c_2^f\right)^{\frac{\delta-1}{\delta}}\right]^{\frac{\delta}{\delta-1}}, \quad \mathbb{A} = \omega_c^{\omega_c}\left(1-\omega_c\right)^{1-\omega_c} \; 0 < \delta \leq 1. \tag{29}$$

The firm solves

$$\max_{c_2, c_2^h, c_2^f} c_2 - p_2^h c_2^h - e_2 c_2^f, \tag{30}$$

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

$$c_2^h = c_2 \omega_c \mathbb{A}^{\delta-1}\left(p_2^h\right)^{-\delta}, \; c_2^f = c_2\left(1-\omega_c\right)\mathbb{A}^{\delta-1} e_2^{-\delta}. \tag{31}$$

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 (31) 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

$$c_1^* + k_h = Y. \tag{32}$$

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:

$$c_1^* = \omega e_1^{\eta} Y_1^*, \; \eta > 0, \tag{33}$$

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:

$$d + x^D e_1 = b. \tag{34}$$

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

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

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, $b + b^*$:

$$c_1^* - e_1 k_f = d + d^* - (b + b^*). \tag{36}$$

6.5.2 Period 2

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

$$Y_2^h = c_2^h + c_2^*, \tag{37}$$

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:

$$c_2^* = \left(\frac{e_2}{p_2^h}\right)^\eta Y_2^*. \tag{38}$$

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:

$$GDP_2 = c_2 + p_2^h c_2^* - e_2 c_2^f. \tag{39}$$

Using the zero profit condition for final good producers (the maximized value of the objective

in (30) is zero) as well as market clearing, (37), we find that GDP_2 in equation (39) can be expressed in value-added terms as follows:

$$GDP_2 = p_2^h Y_2^h. \tag{40}$$

So, by equation (15) and its analog for w_2 :

$$r_2^K = \alpha GDP_2/K,\ w_2 = (1-\alpha)\, GDP_2, \tag{41}$$

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:

$$p_2^h c_2^* - e_2 c_2^f = br + b^* r^* e_2 - (dr + d^* r^* e_2)\,. \tag{42}$$

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 (9) with b^* from (19) and rearranging, we obtain:

$$E\left(r - e_2 r^*\right) = -\frac{\lambda}{2} cov\left(r^* e_2, w_2 + r_2^K K\right) = -\frac{\lambda}{2} cov\left(r^* e_2, GDP_2\right). \tag{43}$$

Here, the second equality uses equation (40). 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 (29) and (10)). 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.[70]

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.[71] 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 roughly coincides with 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).[72] 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 (9)) with equation (39) and other equilibrium conditions. In particular the Cobb-Douglas assumption about production in equation (14) 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:

$$d^* = -\frac{E(r - e_2 r^*)}{\lambda var(r^* e_2)} - (1-\alpha)\frac{cov(r^* e_2, GDP_2)}{var(r^* e_2)}. \tag{44}$$

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 (44), explaining why $d^* > 0$ even though households lose money

[70] 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.

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

[72] 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 (19), with equation (39) 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., $100 \times (b-d)/b \cong 1$).[73] Why don't foreigners' exploit this apparent profit opportunity by lending local currency in large quantities and thereby erase the interest rate premium? The answer in our model is that foreigners have the same hedging motive to avoid local currency assets 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.[74] 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.

[73] Recall, from equation (34), that $x^D e_1/b = (b-d)/b$.

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

We conclude that, conditional on our model, the hedging motive of foreign financiers plays a crucial role in quantifying basic features of the data. In many ways, our model resembles the models used in the literature, (e.g., Gabaix and Maggiori (2015) and Bruno and Shin (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, 14	0.38
λ	Risk aversion, domestic residents, 8, 18	1.55
λ^f	Foreign Financier Risk aversion, 28	1.55
η	Elasticity of demand for exports, 33, 38	3.28
Y^*	Period 1 trade demand, 33	1.35
s	Covariance parameter, financier income, 25	3.82
Y	Period 1 GDP, 6	3.17
μ_ν	Mean, ν shock to foreign demand, 23	2.97
μ_A	Mean productivity, 14	7.85
μ_ξ	Mean, ξ shock to foreign demand, 23	7.16
σ_A	Std dev, log productivity, 14	$0.22\mu_A$
σ_ξ	Std dev, log ξ shock to foreign demand, 23	$0.68\mu_\xi$
σ_ν	Std dev log u shock to foreign demand, 23	$0.22\mu_\nu$

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

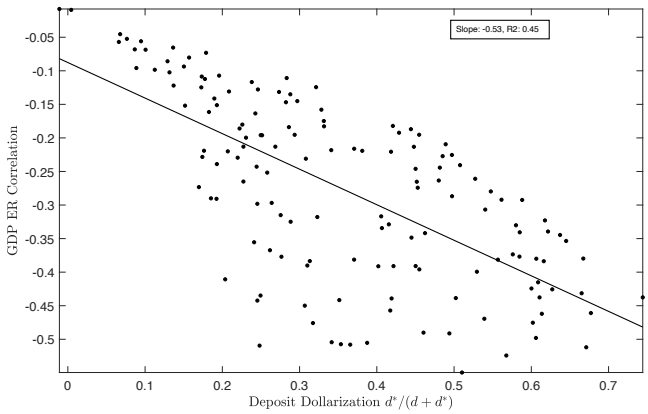
Figure 10 replicates figure 2 using model simulations. The model is simulated using different values for standard deviations of trade, foreign income, productivity shocks. Note that the model can get the basic correlation right and it is flexible enough to allow for dispersion.

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%
$E(e_2 r^*)$	Expected Dollar Rate	0.975		0.975	0.975
$100\times E(r-e_2 r^*)$	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
$\frac{c_1^*-e_1 k_f}{Y}$	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 $100\times(r-e_2 r^*)=2.20$, requiring $\lambda^f=45$. (2) d^* denotes the foreign currency deposits of residents, measured in soles and d denotes the domestic currency deposits of residents, and the ratio is an average over 2000-2016 (source: CBP). (3) b (b^*) denotes soles (dollar) borrowing by non-financial firms from Peruvian banks (source: CBP) plus international securities issued by nonfinancial corporations in soles (dollars) (source: BIS); ratios are averages over the period, 2000-2016. (4) Average of scaled trade surplus, over 2000-2017, scaling in model by Y and in the data by GDP (source: World Bank, World Development Indicators). (5) The implicit tax is based on the domestic interest rate inferred by covered interest parity and US/soles forward rates. (6) Here, r and r^*e_2 are measured as the real return, in units of Peruvian CPI goods, associated with soles deposits (r) and dollar deposits (r^*e_2) in Peruvian banks over 2004-2014 (source: CBP). (7) Correlation based on S/P (S denotes soles per dollar, P denotes Peruvian CPI) and Peruvian real GDP, where both variables were log, first differenced, covering the period 2000-2018. (8) 'standard deviation' corresponds to standard deviation of error term in AR(1) representation fit to annual data on log Real Broad Effective Exchange Rate for Peru, 2001-2020.

Figure 10: GDP ER Correlation vs Dollarization in the Model



Prohibiting Deposit Dollarization

Several emerging market economies (Mexico, Brazil, India etc) do not allow residents to hold dollar accounts. In this section, we evaluate the consequences of such a policy using our model. Table 5 shows that the utility of both workers and firms go down. Workers

lose their means of insurance whereas firms end up borrowing at high local interest rates. Interest rate spread declines as households are forced to save in pesos but the exchange rate becomes more volatile, which reduces investment. Foreigners slightly gain from the policy as they sell peso assets short to gain insurance against consumption fluctuations coming from their exogenous income.

Table 5: Consequences of Prohibiting Deposit Dollarization

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

7 Concluding remarks

We provide evidence that financial dollarization in emerging markets is mostly a within-country risk sharing arrangement. Exchange rates often depreciate in recessions, setting off a transfer of local currency from domestic borrowers to domestic lenders.

In principle, another hypothesis could be at work. The desire for local lenders to denominate their deposits in dollars may reflect their fear of a financial crisis which then becomes self fulfilling because of the resulting currency mismatch. We find no evidence that deposit dollarization has any association with financial crisis and so this alternative hypothesis seems implausible.

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

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