

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

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## A The Insurance Hypothesis

### A.1 Figure 2 After Removing Controls

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

Table A1: Determinants of Dollarization

|                                  | <i>Dependent variable:</i> |                       |                       |                       |                      |
|----------------------------------|----------------------------|-----------------------|-----------------------|-----------------------|----------------------|
|                                  | Dollarization              |                       |                       |                       |                      |
|                                  | (1)                        | (2)                   | (3)                   | (4)                   | (5)                  |
| Corr( $\Delta GDP, \Delta S/P$ ) | -34.161***<br>(6.843)      | -30.287***<br>(7.976) | -34.183***<br>(8.336) | -33.680***<br>(8.129) | -20.439**<br>(9.849) |
| Av Inflation                     |                            | 0.027***<br>(0.005)   | 0.025***<br>(0.005)   | 0.025***<br>(0.005)   | 0.022***<br>(0.005)  |
| Gini                             |                            |                       | 0.170<br>(0.195)      | 0.271<br>(0.196)      | 0.057<br>(0.270)     |
| Fuel Export                      |                            |                       | -0.057<br>(0.091)     | -0.069<br>(0.088)     | -0.073<br>(0.063)    |
| Reserves/GDP                     |                            |                       | 0.026<br>(0.016)      | 0.021<br>(0.016)      | -0.003<br>(0.014)    |
| Institutions                     |                            |                       |                       | -0.389**<br>(0.189)   | -0.239<br>(0.197)    |
| External Debt                    |                            |                       |                       |                       | 0.253***<br>(0.085)  |
| Constant                         | 21.429***<br>(1.882)       | 20.462***<br>(2.194)  | 10.937<br>(7.515)     | 9.519<br>(7.360)      | 12.942<br>(14.152)   |
| Observations                     | 121                        | 112                   | 94                    | 87                    | 58                   |
| R <sup>2</sup>                   | 0.168                      | 0.232                 | 0.325                 | 0.392                 | 0.362                |
| Adjusted R <sup>2</sup>          | 0.161                      | 0.218                 | 0.287                 | 0.347                 | 0.272                |
| Residual Std. Error              | 19.592 (df = 119)          | 19.197 (df = 109)     | 17.924 (df = 88)      | 17.144 (df = 80)      | 16.768 (df = 50)     |

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

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

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

Figure A1: Inflation vs Dollarization

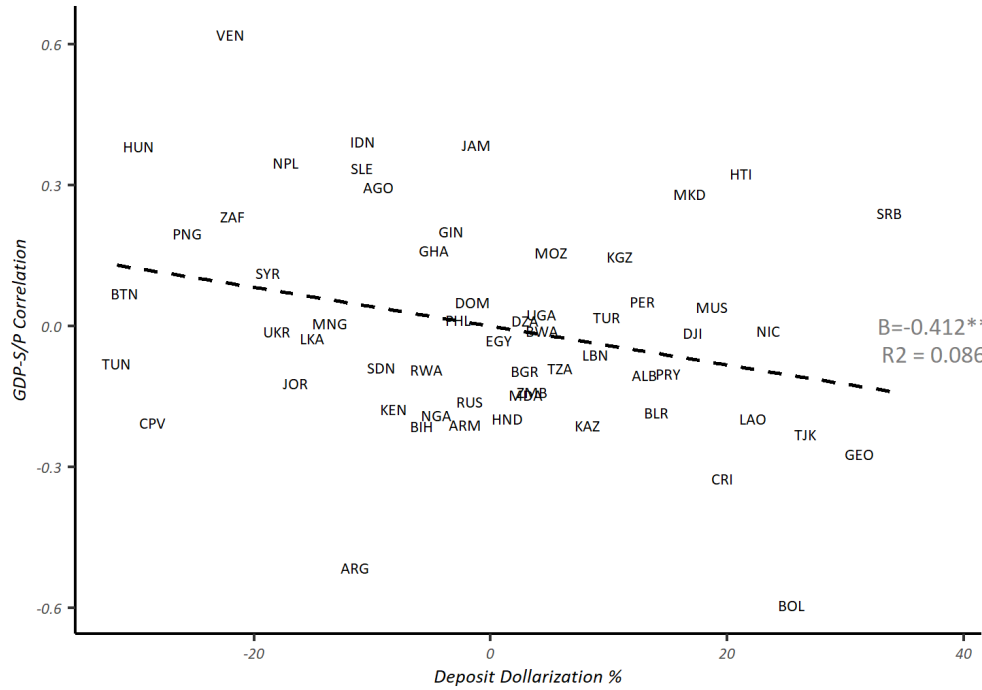


We find the insignificantly-different-from zero coefficient on dollar reserves in columns (3)-(5) in Table [A1](#) somewhat surprising. In effect, dollar reserves held by the government represent insurance for all the people in the country, households as well as the owners of firms. Governments holding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

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

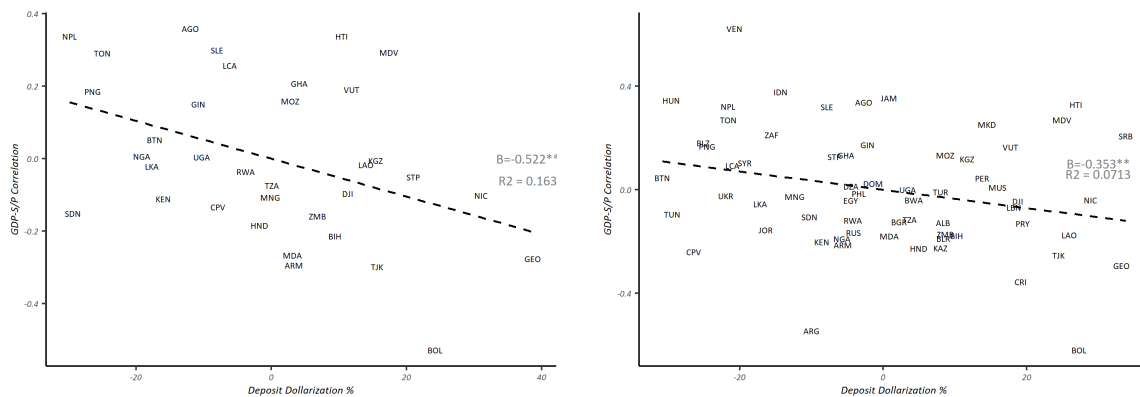
countries included in the latter two data sets is sharply reduced. Still, the results display a similar pattern: the correlation on the vertical axis has a statistically significant negative relationship with deposit dollarization.

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



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

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



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

## A.2 The Interest Rate Spread, $i - i^*$ , as a Tax

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

$$i^* \quad \underbrace{\text{dollar deposits in local currency units}}_{d^*} \quad + i \quad \underbrace{\text{local deposits}}_d . \quad (\text{A.1})$$

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

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

where  $\tau$  denotes the tax rate. Solving,

$$\tau = \frac{i - i^*}{i}\phi, \quad (\text{A.2})$$

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

We display the scatter plot of  $\tau$  against deposit dollarization in Figure A4.



Let  $a$  and  $a^*$  denote the domestic and foreign assets of banks, respectively, each measured in local currency units. Similarly, let  $b$  and  $b^*$  denote banks' domestic and foreign liabilities. In principle,  $a^*$  and  $b^*$  should not include the portion of assets or liabilities in which exchange rate risk has been removed with the use of hedging instruments.<sup>77</sup> Then, NOPFxCapital corresponds to  $m(s)$  for  $s = 1$  :

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

where the numerator,  $a^* - l^*$  represents the net unhedged banks' foreign asset position and the denominator is bank net worth.<sup>78</sup> The statistics, for  $s = 1$ , are reported in the first column of Table B2. To give  $m(1)$  an economic interpretation, we compute the magnitude of the depreciation,  $s$ , which would wipe out bank equity:

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

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

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

<sup>77</sup>The IMF data document, IMF (FSI, Chapter 6, part (vii), 2006), Paragraph 6.37, explains NOPFxCapital. Reporting countries have the option to produce one of two versions of NOPFxCapital: a narrow one, IMF (FSI, Table 6.2, line 49, 2006) and a broader one, IMF (FSI, Table 6.2, line 50, 2006). The two versions differ according to how much detail is provided about the reporting bank's derivative operations to hedge foreign exchange risk. Obviously, the broader one includes more such information. In many cases, notes on the data provided to the IMF on their financial stability indicators are provided on the IMF website, folder labeled 'table 3', indicator S230.

<sup>78</sup>Details about the composition of bank assets and liabilities (including derivatives) can be found in IMF (2006, Table 4.1, page 31)). The denominator of  $m(1)$  is positive for each of our observations.

Table B2: Currency Mismatch

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

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

For the 115 countries in the IMF dataset, the overwhelming majority, 93, have  $0 < m(1) < 1$ , and so they have zero foreign exchange (FX) risk according to the NOPFxCapital index.<sup>79</sup> That fact alone is an important indicator of the absence of currency mismatch in banks. The data on the remaining 22 countries are reported in Table B2. To understand the numbers in this table it is useful to look at particular cases. For example, in Nicaragua the IMF data indicate that NOPFxCapital is 1.0060 (rounded to 1). According to (B.1) with  $s = 1$ , Nicaraguan banks' net assets are nearly completely in dollars, i.e.,  $a - l$  is negative but essentially zero. If the assets were fully in dollars, bankruptcy would be impossible but given that  $a - l$  is slightly negative, it would take a whopping 99% appreciation in the exchange rate for bank equity to be wiped out.

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

<sup>79</sup>Two of the countries that we designate as having zero foreign exchange risk are Algeria and Comoros. In both cases the IMF reports zero foreign currency assets and liabilities in the years for which they report data. For the data source, see footnote 76.



sheets.<sup>80</sup> So, the large of NOPFxCapital in the case of Israel greatly overstates their banks' exposure to foreign exchange risk, which appears to actually be minimal. It is possible that the situation in Norway, Denmark and Switzerland is similar. The key point is that even if we take the statistics pertaining to the most risky 5 countries at face value, those countries have only a small amount of foreign exchange risk since their exchange rates would have to more than double for bank equity to be seriously at risk. The next group of 10 countries would require depreciations by factors of 10 or even over 100 for equity to be at risk. The final 6 countries have positive net foreign assets,  $a^* > l^*$ , with  $m(1) > 1$  so that  $a < l$ . So, their exchange rates would have to appreciate to create a risk to the banking system. For the most part these appreciations would have to be very large.

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<sup>80</sup>We are grateful to Nitzan Tzur-Ilan's help in this matter.

## C Firms are the Source of Household Insurance

Because our panel is unbalanced, the statistics in Table [C3](#) cover only the period 2010-2019.

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

Table C3: Decomposition of Dollar Borrowing and Lending

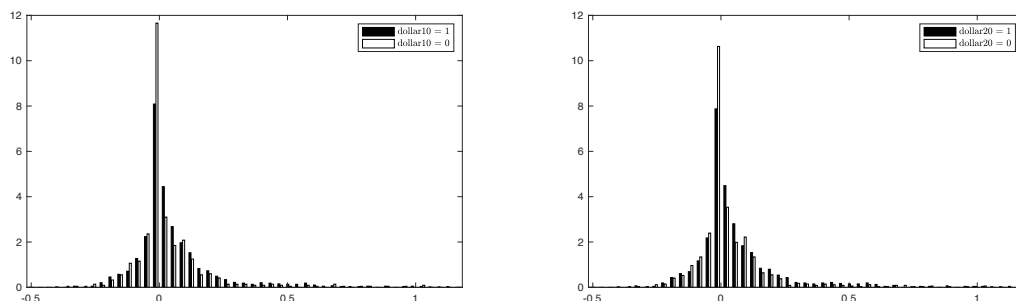
Notes: With one exception, local residents' dollar deposits in banks and dollar credit from banks to local residents was collected from individual central bank websites. The exception is Peru, where the end-of-year data were kindly provided by Paul Castillo of the Peruvian Central Bank, for the period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

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

We pooled all our annual data on deposit dollarization. Figure D5 displays the distribution of exchange rate depreciations, conditional on whether deposit dollarization was high or low in the previous year. Figure D5a uses a cutoff of 10% to identify high rates of deposit dollarization. Figure D5b uses a cutoff of 20%. We normalize the height of the bars, so that the product of their sum and the width of the bars is unity. Thus, the bars are an estimate of the underlying density function. In addition, to improve readability of the graphs, we dropped the smallest observation, as well as the largest 21 observations in the data.<sup>81</sup>

Figure D5: Exchange Rate Depreciations And Dollarization

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



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

Figure D5 examines the empirical density of exchange rate depreciations,  $\Delta e_{i,t} = \ln(e_{i,t}/e_{i,t-1})$ , where  $e_{i,t}$  denotes the domestic currency price of a unit of foreign currency in year  $t$  and country  $i$ . The median value of  $\Delta e_{i,t}$  in the entire sample is roughly zero and the mean is 0.074. The first panel, Figure D5a, reports the empirical density for all  $\Delta e_{i,t}$  corresponding to  $t, i$  with low levels of dollarization,  $\phi_{i,t-1} \leq .10$  (black bars) versus  $\Delta e_{i,t}$  in which  $\phi_{i,t-1} > .10$  (white bars).<sup>82</sup> The second panel is the same as the first, except that we compare  $i, t$  with

<sup>81</sup>The computations were done in MATLAB and the ‘edges’ on the horizontal axis are a grid with 50 equally-spaced points, where the first point is  $-0.5$  and the last is  $1.2$ . The observation  $1.2$  means that  $e_t/e_{t-1} = 1.2$ , where  $e_t$  denotes the year  $t$  exchange rate.

<sup>82</sup>See equation (1) for the definition of  $\phi_{i,t}$ . We use  $\phi_{i,t-1}$  rather than  $\phi_{i,t}$  to minimize potential distortions from an ‘automatic’ effect of exchange rate depreciation that raises deposit dollarization, holding the quantity of dollar deposits and domestic deposits fixed. This effect is at best marginal because it only matters for the (presumably) small number of countries which jump deposit dollarization bins when the exchange changes. In any case, we repeated the histogram for  $\Delta e_{i,t}$  and  $\phi_{i,t}$  and found little difference in the results. That is, we find that the empirical density does not reveal a systematic pattern of fewer depreciations in deposit

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

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dollarized economies.

# E Dataset: Country-year availability and crises

Table E4: Country-year availability and years of crises

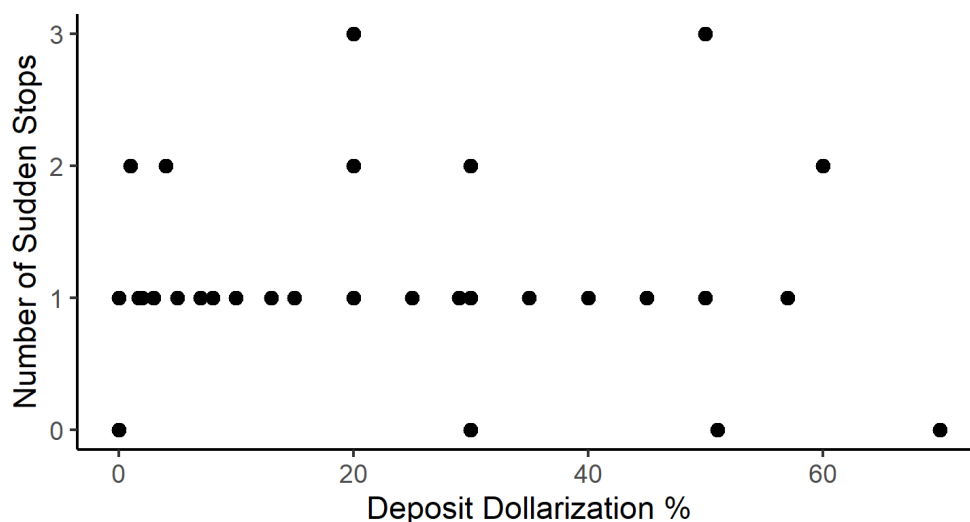
| Country                | Crisis1 | Crisis2 | Crisis3 | First Year | Last Year | Country                        | Crisis1 | Crisis2 | Crisis3 | First Year | Last Year |
|------------------------|---------|---------|---------|------------|-----------|--------------------------------|---------|---------|---------|------------|-----------|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

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

## F Bivariate Analysis: Sudden Stops

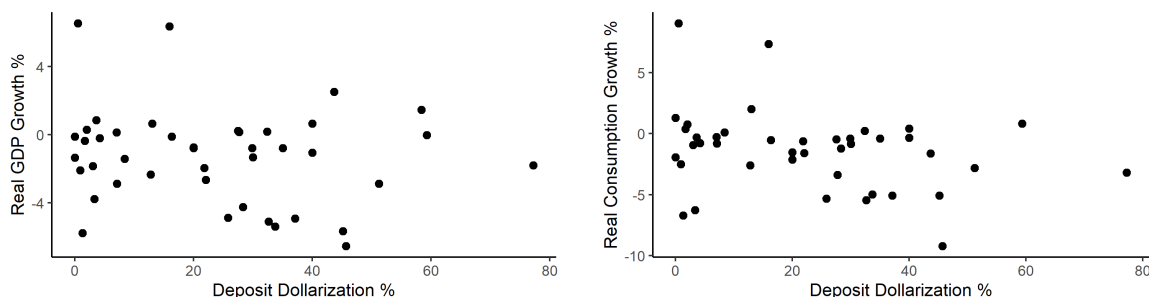
To investigate the robustness of the results in section 4, we use the Eichengreen and Gupta (2018) data on sudden stops. There are 34 countries that intersect with the 66 countries in the Eichengreen and Gupta (2018) dataset and the 124 countries in our dataset on deposit dollarization. There are 43 sudden stops in the data that we analyze. Figure F6 indicates that there is little relationship between the probability of a sudden stop and deposit dollarization. Figure F7 shows that there is little relationship between the cost of a sudden stop (measured in a decline of GDP growth or consumption growth) and deposit dollarization. Again, with this different measure of crisis we come a way with the same conclusion: there does not seem to be a systematic relationship between the probability of a crisis, or its cost if there is one, and deposit dollarization.

Figure F6: Eichengreen and Gupta (2018) Frequency of Sudden Stops versus Dollarization



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

Figure F7: Cost of [Eichengreen and Gupta \(2018\)](#) Severity of Sudden Stop and Deposit Dollarization



Note: See note to Figure [F6](#) for data on sudden stops. Real GDP and consumption growth is calculated by taking the difference between average growth rate during the sudden stop and the decade average around the sudden stop.

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

## G Bootstrap Analysis of Logistic Regression

Table [G5](#) provides more direct evidence on the relationship between crisis and dollarization, allowing for the possible role of exchange rates. First, the overall frequency of [Laeven and Valencia \(2018\)](#) crises, unconditional on the level of dollarization, is 1.8 percent in our sample of 2,281 observations. Second, if we consider just the subset of 1,690 observations in which  $\phi_{i,t} > 0.10$ , the probability of [Laeven and Valencia \(2018\)](#) crisis is 2.01 percent. Even for the 1,340 observations in which  $\phi_{i,t} > 0.20$  the probability of crisis is 1.87 percent.<sup>83</sup> These observations are consistent with our bivariate analysis in Section [\(4.1\)](#), though here it is based on data at a more temporally disaggregated level.

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

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

<sup>83</sup>With a little work, the 2 percent results can be recovered from Table [G5](#) from the entries in columns (3), (4) and (5). In each of the six panels, take the product of the probability (the number not in brackets or parentheses) and the number of observations (the number in parentheses) and sum across all six panels.

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

Each of the six panels corresponding to a depreciation range is composed of two rows. The first row of each panel in column (3) indicates the frequency of [Laeven and Valencia \(2018\)](#) crises, conditional on depreciation being in the interval defined in columns (1) and (2).<sup>84</sup> The first row of each panel in Columns (4)-(6) report the frequency of crisis conditional on that panel's depreciation interval, and conditional on the level of dollarization indicated in the column's header. The numbers in parentheses in columns (3), (5) and (6) indicate the quantity of observations in which the depreciation rate lies in the range specified in columns (1) and (2) and the deposit dollarization rate lies in the range indicated in the column heading.<sup>85</sup> Our depreciation intervals were designed in part to ensure roughly similar-sized samples in each interval.<sup>86</sup> The numbers in square brackets in columns (5) and (6) indicate the fraction of observations in the associated depreciation range that have deposit dollarization rates in excess of 10 percent and 20 percent, respectively.<sup>87</sup> Consistent with the evidence in Figure [1](#), the numbers in square brackets in columns (5) and (6) indicate that the fraction of our sample with deposit dollarization 10 (20) percent and higher is around 70 percent (60 percent). Moreover, the results indicate that these fractions rise with the exchange rate.

The numbers in the second row of each of the six panels in Table [G5](#) are p-values. In columns (3) and (4) the p-value is the probability that the frequency estimator exceeds its estimated value in the first row, under our null hypothesis: (a) the [Laeven and Valencia \(2018\)](#) crisis indicator is independent of both the depreciation rate and the level of deposit dollarization and (b) the joint density of deposit dollarization and the exchange rate is what we see in the data.<sup>88</sup> Note that the p-values are all well above the usual 1 and 5 percent cutoff values, 0.01 and 0.05. The table provides no evidence against the null hypothesis.

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

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<sup>84</sup>The frequency in column (3) unconditional, in that does not condition on any particular value of deposit dollarization.

<sup>85</sup>There is no number in parentheses in column (4), because the number of observations in that category is just the number in parentheses in column (3), minus the number in parentheses in column (5).

<sup>86</sup>The relatively large number of observations associated with the 0-3.7 interval reflects that we include the 365 zero observations in that interval.

<sup>87</sup>There is no square bracketed number in column (4), because that would just be unity minus the number in square brackets in column (5).

<sup>88</sup>For details of the bootstrap procedure we use to compute the p-values, see the notes to Table [G5](#).



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

In sum, the simple frequency analysis in Table [G5](#) provides no evidence that deposit dollarization makes a country vulnerable to a [Laeven and Valencia \(2018\)](#) crisis.

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

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

Note: Analysis is based on 2,281 annual observations on [Laeven and Valencia \(2018\)](#) crisis indicators, exchange rate changes and indices of deposit dollarization drawn from an unbalanced panel of emerging market economies. The table is composed of six panels. Each panel has two rows, and we begin by explaining the first row in a panel. The exchange rate depreciation bins in the first two columns were constructed as follows. A depreciation in year  $i$ ,  $x_i$ , is defined as  $x_i = 100 \ln(e_i/e_{i-1})$ . The smallest and largest  $x_i$ 's in our sample, -264.3 and 359.0, provide the lower and upper bounds of the first and sixth bins, respectively. The depreciations, -6.0 and 20.8 correspond to the 10th and 90th percentile values of the  $x_i$ 's in our sample, while 7.4 is the sample mean of the  $x_i$ 's. Finally,  $3.7=7.4/2$ . The 365  $x_i = 0$  are included the third bin, 0-3.7. In the first row of each panel, column (3) contains a number and a number in parentheses. Columns (4)-(6) contain, in addition, a number in square brackets. The number in column (3) is the frequency (in percent) that a Laeven-Valencia crisis occurs when  $x_i$  lies in the interval defined in the entries in columns (1) and (2). The numbers in columns (4) and (5) are the frequency of Laeven-Valencia crises that occur when the exchange rate lies in the interval defined by columns (1) and (2) and the economy is characterized by the level of dollarization indicated at the top of the relevant column. The numbers in parentheses in columns (4)-(5) are the number of observations in our sample in which  $x_i$  lies in the interval defined in columns (1) and (2), and the level of dollarization is as reported at the top of the column. The numbers in square brackets is the fraction of observations in which the exchange rate lies in the bin indicated in columns (1) and (2) which have the level of dollarization indicated in the top of the column. We now explain the entry in the second row in each panel. These are p-values under the null hypothesis that Laeven and Valencia crises are independent of  $x_i$  and the level of deposit dollarization. To understand our bootstrap procedure for computing the p-values, let  $X$  denote the 2281 by 4 matrix, where the first column contains the data on  $x_i$  and the other three columns contain 0,1 dummies: one that indicates a Laeven and Valencia crisis, and two which indicate whether deposit dollarization is above 10 percent, or 20 percent, respectively. To do the bootstrap we constructed 100,000 artificial datasets,  $X(1), \dots, X(100,000)$ . For the  $j$ th data set we randomly drew two sets of integers of length 2281, with replacement, from  $[1, \dots, 2281]$ . Then,  $X(j)$  was constructed by reordering the rows of the first column of  $X$  using the first set of random indices and reordering the rows in columns (2)-(4) with the second set of indices. In this way, we capture the null hypothesis that crises are independent of exchange rates and deposit dollarization. At the same time, our bootstrapped data preserve the empirical covariation between exchange rates and deposit dollarization. Using the artificial  $X(j)$ 's we compute 100,000 statistics corresponding to the statistics (the numbers without parentheses or brackets) based on  $X$  that appear in the first row, columns (3)-(5), in each panel. In column (3) of the second row of each panel we report the number of times that the simulated statistic exceeds its empirical analog in the first row. In the case of columns (4) and (5), the entry is a p-value for the increment in the probability of a crisis over its probability in the previous column. The p-value was computed across our 100,000 simulated datasets.

# H Appendix Logistic Regression Tables

## H.1 Different Measures of Uncertainty

Table H6: Different Measures of Uncertainty

|                           | (1)                  | (2)                  | (3)                 | (4)                  | (5)                  | (6)                  |
|---------------------------|----------------------|----------------------|---------------------|----------------------|----------------------|----------------------|
| Crisis                    |                      |                      |                     |                      |                      |                      |
| Dollar (20)               | -0.734<br>(-0.75)    | -0.641<br>(-0.70)    | -0.627<br>(-0.67)   | -0.615<br>(-0.70)    | -0.730<br>(-0.75)    | -0.590<br>(-0.66)    |
| $\Delta er$               | -0.283<br>(-0.08)    | -0.417<br>(-0.08)    | 0.512<br>(0.20)     | 0.136<br>(0.04)      | -0.622<br>(-0.16)    | -0.249<br>(-0.05)    |
| Dollar(20)* $\Delta er$   | -2.811<br>(-0.55)    | -3.892<br>(-0.72)    | -3.285<br>(-0.81)   | -3.588<br>(-0.80)    | -2.933<br>(-0.55)    | -3.949<br>(-0.72)    |
| High FL/FA                | 1.544<br>(1.27)      | 1.590<br>(1.36)      | 1.629<br>(1.36)     | 1.621<br>(1.37)      | 1.547<br>(1.29)      | 1.499<br>(1.34)      |
| High FL/FA * Low Reserves | -1.252<br>(-0.97)    | -1.354<br>(-1.07)    | -1.224<br>(-1.00)   | -1.307<br>(-1.07)    | -1.282<br>(-1.00)    | -1.259<br>(-1.03)    |
| Dollar(20) * Low Reserves | 1.538<br>(1.30)      | 1.402<br>(1.23)      | 1.550<br>(1.34)     | 1.425<br>(1.22)      | 1.573<br>(1.35)      | 1.513<br>(1.29)      |
| Reserves/GDP              | -1.033<br>(-0.45)    | -1.705<br>(-0.66)    | -0.288<br>(-0.15)   | -1.282<br>(-0.49)    | -1.019<br>(-0.44)    | -0.795<br>(-0.40)    |
| Real GDP Growth           | 0.0404<br>(0.53)     | 0.0706<br>(0.98)     | 0.0253<br>(0.35)    | 0.0560<br>(0.82)     | 0.0552<br>(0.74)     | 0.0618<br>(0.90)     |
| External Debt             | 0.332***<br>(5.84)   | 0.371***<br>(3.98)   | 0.280***<br>(5.75)  | 0.339***<br>(4.85)   | 0.351***<br>(5.43)   | 0.348***<br>(3.69)   |
| VIX                       | 0.126***<br>(2.77)   |                      |                     |                      |                      |                      |
| Global Factor             |                      | -0.408<br>(-0.89)    |                     |                      |                      |                      |
| Financial Stress          |                      |                      | 1.155**<br>(1.96)   |                      |                      |                      |
| Mon Pol Uncertainty       |                      |                      |                     | 0.00850<br>(0.61)    |                      |                      |
| Financial Uncertainty     |                      |                      |                     |                      | 4.368**<br>(2.52)    |                      |
| ExchangeRate Market Vol   |                      |                      |                     |                      |                      | 1.048*<br>(1.81)     |
| Constant                  | -8.281***<br>(-5.80) | -5.396***<br>(-9.14) | -122.7**<br>(-2.04) | -6.307***<br>(-4.05) | -9.731***<br>(-4.72) | -6.060***<br>(-8.58) |
| N                         | 1186                 | 1186                 | 1126                | 1186                 | 1186                 | 1186                 |
| Years                     | 1995-2017            | 1995-2017            | 1995-2017           | 1995-2017            | 1995-2017            | 1995-2017            |
| Countries                 | EMEs                 | EMEs                 | EMEs                | EMEs                 | EMEs                 | EMEs                 |
| Pseudo R2                 | 0.0537               | 0.0198               | 0.0576              | 0.0207               | 0.0457               | 0.0218               |

*t* statistics in parentheses

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

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

## H.2 Adding Second lag

Table H7: Probability of Banking Crises

|                                    | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  |
|------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                    | Crisis               | Crisis               | Crisis               | Crisis               | Crisis               |
| Crisis                             |                      |                      |                      |                      |                      |
| Dollar (20)                        | -0.587<br>(-0.67)    | -0.534<br>(-0.30)    | -0.423<br>(-0.39)    | -1.147<br>(-0.71)    | -0.828<br>(-0.46)    |
| $\Delta er$                        | -0.910*<br>(-1.85)   | -3.284<br>(-0.84)    | 0.470<br>(0.69)      | 0.470<br>(0.21)      | -0.0846<br>(-0.02)   |
| Dollar(20)* $\Delta er$            | 3.085**<br>(2.54)    | 4.300<br>(1.04)      | 1.612<br>(1.00)      | 1.255<br>(0.46)      | 1.444<br>(0.41)      |
| High FL/FA                         |                      | 2.001*<br>(1.80)     |                      | 1.296**<br>(2.19)    | 1.373<br>(1.30)      |
| Dollar(t-2) (20)                   | 0.180<br>(0.28)      | 1.055<br>(0.70)      | 0.776<br>(0.72)      | 1.453<br>(0.88)      | 1.507<br>(0.80)      |
| Dollar(20)(t-1)*(t-2)* $\Delta er$ | -1.921*<br>(-1.72)   | -2.052<br>(-0.90)    | -1.917<br>(-1.52)    | -2.897<br>(-1.26)    | -3.979<br>(-1.36)    |
| VIX                                | 0.169**<br>(2.56)    | 0.166***<br>(2.92)   | 0.0787*<br>(1.92)    | 0.130***<br>(2.87)   | 0.125***<br>(2.60)   |
| High FL/FA * Dollar (20)           |                      | -0.858<br>(-0.84)    |                      |                      | -0.818<br>(-0.82)    |
| Reserves/GDP                       |                      | -3.371**<br>(-2.04)  |                      | -2.281<br>(-1.08)    | -1.674<br>(-0.86)    |
| Real GDP Growth                    |                      | 0.0193<br>(0.24)     |                      | 0.0131<br>(0.16)     | 0.0515<br>(0.61)     |
| External Debt                      |                      |                      |                      |                      | 0.320***<br>(3.76)   |
| Constant                           | -7.614***<br>(-5.22) | -8.857***<br>(-4.40) | -6.137***<br>(-5.51) | -7.908***<br>(-5.76) | -8.561***<br>(-4.79) |
| N                                  | 2255                 | 1521                 | 1891                 | 1427                 | 1185                 |
| Years                              | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            |
| Countries                          | All                  | All                  | EMEs                 | EMEs                 | EMEs                 |
| Pseudo R2                          | 0.119                | 0.173                | 0.0378               | 0.118                | 0.130                |

*t* statistics in parentheses

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

### H.3 Adding Interaction Terms

Table H8: Probability of Banking Crises

|                         | (1)<br>Crisis        | (2)<br>Crisis        | (3)<br>Crisis        | (4)<br>Crisis        |
|-------------------------|----------------------|----------------------|----------------------|----------------------|
| Crisis                  |                      |                      |                      |                      |
| Dollar (20)             | 0.177<br>(0.32)      | 0.0895<br>(0.14)     | 1.620<br>(0.74)      | 1.698<br>(0.79)      |
| $\Delta er$             | -0.0278<br>(-0.01)   | -0.0563<br>(-0.02)   | -0.0947<br>(-0.04)   | -0.103<br>(-0.05)    |
| Dollar(20)* $\Delta er$ | -0.983<br>(-0.27)    | -0.948<br>(-0.26)    | -1.090<br>(-0.35)    | -1.011<br>(-0.32)    |
| High FL/FA              | 1.330*<br>(1.95)     | -0.242<br>(-0.15)    | 1.295**<br>(2.11)    | -0.234<br>(-0.15)    |
| VIX                     | 0.133***<br>(2.84)   | 0.0956**<br>(1.97)   | 0.172**<br>(2.56)    | 0.135*<br>(1.89)     |
| FL/FA * Dollar (20)     | -0.0440<br>(-0.45)   |                      |                      | -0.0404<br>(-0.41)   |
| Reserves/GDP            | -2.191<br>(-1.09)    | -2.277<br>(-1.13)    | -2.235<br>(-1.11)    | -2.260<br>(-1.10)    |
| Real GDP Growth         | 0.0137<br>(0.16)     | 0.0103<br>(0.12)     | 0.0128<br>(0.16)     | 0.0126<br>(0.15)     |
| VIX * High FL/FA        |                      | 0.0608<br>(1.00)     |                      | 0.0631<br>(1.06)     |
| VIX * Dollar (20)       |                      |                      | -0.0596<br>(-0.83)   | -0.0610<br>(-0.83)   |
| Constant                | -7.840***<br>(-5.53) | -6.850***<br>(-5.59) | -8.796***<br>(-4.26) | -7.909***<br>(-3.85) |
| N                       | 1429                 | 1429                 | 1429                 | 1429                 |
| Years                   | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            |
| Countries               | EMEs                 | EMEs                 | EMEs                 | EMEs                 |
| Pseudo R2               | 0.110                | 0.113                | 0.112                | 0.116                |

*t* statistics in parentheses

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

### H.4 10% Cutoff

Table H9: Probability of Banking Crises

|                         | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|-------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Dollar (10)             | -0.164<br>(-0.37)    | 0.452<br>(0.75)      | 0.452<br>(0.75)      | 0.540<br>(0.94)      | 0.899<br>(0.87)      | 1.469<br>(1.36)      |
| $\Delta er$             | -0.775*<br>(-1.82)   | -4.902<br>(-1.15)    | -4.902<br>(-1.15)    | 0.533<br>(1.01)      | 0.461<br>(0.46)      | -2.007<br>(-1.18)    |
| Dollar(10)* $\Delta er$ | 1.198*<br>(1.73)     | 3.264<br>(0.77)      | 3.264<br>(0.77)      | 0.108<br>(0.11)      | -1.414<br>(-0.97)    | -0.191<br>(-0.10)    |
| High FL/FA              |                      | 1.521**<br>(2.28)    | 1.521**<br>(2.28)    |                      | 1.257**<br>(2.07)    | 0.764<br>(1.26)      |
| VIX                     | 0.165**<br>(2.48)    | 0.164***<br>(2.95)   | 0.164***<br>(2.95)   | 0.0750*<br>(1.77)    | 0.131***<br>(3.00)   | 0.126***<br>(2.82)   |
| Reserves/GDP            |                      | -3.617**<br>(-2.22)  | -3.617**<br>(-2.22)  |                      | -2.352<br>(-1.17)    | -1.815<br>(-0.95)    |
| Real GDP Growth         |                      | 0.00563<br>(0.08)    | 0.00563<br>(0.08)    |                      | 0.00762<br>(0.10)    | 0.0316<br>(0.45)     |
| External Debt           |                      |                      |                      |                      |                      | 0.289***<br>(4.41)   |
| Constant                | -7.583***<br>(-5.28) | -8.680***<br>(-5.58) | -8.680***<br>(-5.58) | -6.283***<br>(-4.62) | -8.375***<br>(-5.11) | -9.108***<br>(-5.60) |
| N                       | 2262                 | 1524                 | 1524                 | 1919                 | 1445                 | 1186                 |
| Years                   | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017            |
| Countries               | All                  | All                  | All                  | EMEs                 | EMEs                 | EMEs                 |
| Pseudo R2               | 0.0405               | 0.0626               | 0.0626               | 0.00506              | 0.0259               | 0.0411               |

*t* statistics in parentheses

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

## H.5 Level of Dollarization

Table H10: Level of Dollarization

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

*t* statistics in parentheses

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

## H.6 Exchange Rate Regimes

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

Table H11: Exchange Rate Regimes

|                           | (1)                  | (2)                  | (3)                  | (4)                   |
|---------------------------|----------------------|----------------------|----------------------|-----------------------|
| Crisis                    |                      |                      |                      |                       |
| Dollar (20)               | 0.114<br>(0.27)      | -0.213<br>(-0.27)    | -0.673<br>(-0.78)    |                       |
| $\Delta er$               | 0.0774<br>(0.11)     | 0.251<br>(0.09)      | -1.343<br>(-0.33)    |                       |
| Dollar(20)* $\Delta er$   | 0.342<br>(0.41)      | -1.368<br>(-0.36)    | -1.785<br>(-0.33)    |                       |
| High FL/FA                |                      | 1.775**<br>(2.30)    | 1.506*<br>(1.75)     |                       |
| VIX                       | 0.0678**<br>(2.05)   | 0.121***<br>(3.13)   | 0.115***<br>(2.74)   |                       |
| Peg                       | -6.052***<br>(-6.72) | -8.192***<br>(-6.40) | -8.648***<br>(-6.33) | -4.421***<br>(-10.28) |
| Crawling peg              | -5.772***<br>(-7.07) | -7.513***<br>(-6.64) | -8.222***<br>(-6.51) | -4.144***<br>(-15.03) |
| Managed float             | -5.598***<br>(-6.83) | -8.035***<br>(-7.67) | -8.590***<br>(-8.40) | -3.819***<br>(-10.77) |
| Freely float              | 0<br>(.)             | 0<br>(.)             | 0<br>(.)             | 0<br>(.)              |
| Parallel mkts.            | -5.171***<br>(-4.55) | -6.297***<br>(-4.16) | -6.645***<br>(-4.43) | -2.996***<br>(-7.39)  |
| Freely Falling            | -2.461***<br>(-2.64) | -1.531<br>(-1.00)    | -1.938<br>(-1.27)    | -0.693<br>(-1.13)     |
| High FL/FA * Low Reserves |                      | -0.465<br>(-0.58)    | -0.734<br>(-0.80)    |                       |
| Dollar(20) * Low Reserves |                      | -0.411<br>(-0.38)    | 0.371<br>(0.31)      |                       |
| Reserves/GDP              |                      | -2.870<br>(-0.88)    | -1.460<br>(-0.57)    |                       |
| Real GDP Growth           |                      | 0.0920<br>(1.56)     | 0.128***<br>(3.11)   |                       |
| External Debt             |                      |                      | 0.384***<br>(2.78)   |                       |
| N                         | 1807                 | 1365                 | 1120                 | 1888                  |
| Years                     | 1995-2017            | 1995-2017            | 1995-2017            | 1995-2017             |
| Countries                 | EMEs                 | EMEs                 | EMEs                 | EMEs                  |
| Pseudo R2                 |                      |                      |                      |                       |

*t* statistics in parentheses

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

## H.7 Different Cutoffs

In Table [H12](#), we plot dollarization and exchange rate interaction coefficients for different dollarization cutoffs. As the cutoff increases, dollarization coefficient becomes more negative whereas the interaction term becomes more positive, while they are still not statistically significant at 5% level. In Figure [H10](#) we plot AUC-ROC curves for 40% cutoff. Dollarization itself has poor prediction and it does not contribute much to the performance on top of VIX

and External Debt.

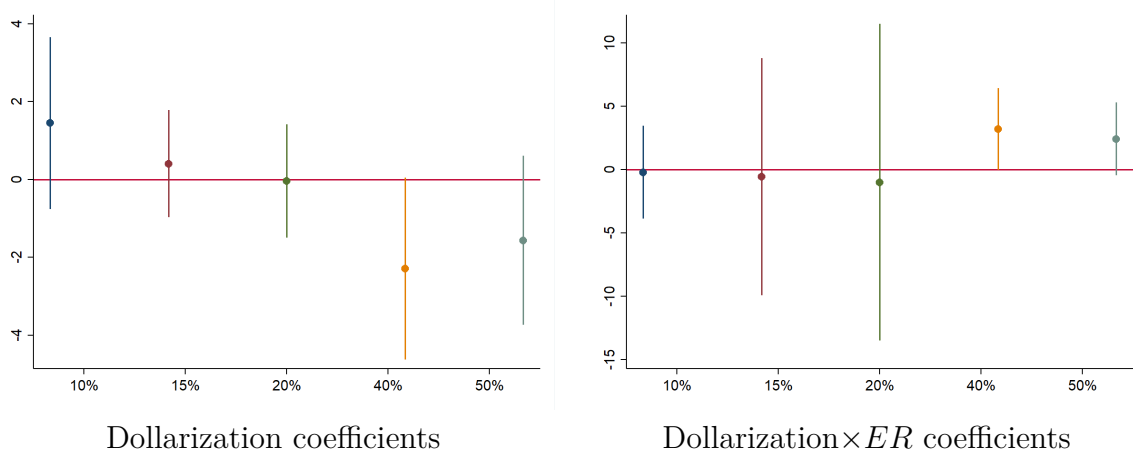


Table H12: Coefficients of logistic regression for different dollarization cutoffs, lines represent 95% confidence interval

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

## H.8 Levy-Yeyati (2006) Evidence

[Levy-Yeyati \(2006\)](#) is an influential paper often cited by authors that consider deposit dollarization as a source of financial fragility. Using his own dataset, we replicate his results and show that they are highly fragile. Column 1 of [H13](#) replicates table 5, column 6 in [Levy-Yeyati \(2006\)](#). Column 2, employs country-year cluster as discussed in [Petersen \(2009\)](#). Columns 3 and 4 use 15% and 20% dollarization cutoffs respectively. Finally, column 5 uses post 1990 data. Note that the dollarization loses significance at 5% when the correct standard errors are used. In all other columns, dollarization variables are not statistically significant.



Table H13: Levy-Yeyati (2006) Replication

|                         | (1)                      | (2)                    | (3)                      | (4)                      | (5)                     |
|-------------------------|--------------------------|------------------------|--------------------------|--------------------------|-------------------------|
| Crisis                  |                          |                        |                          |                          |                         |
| Dollar(10)              | 0.411<br>(0.92)          | 0.411<br>(0.63)        |                          |                          | 0.794<br>(0.99)         |
| Dollar(10)* $\Delta er$ | 3.196**<br>(2.39)        | 3.196*<br>(1.69)       |                          |                          | 2.274<br>(0.90)         |
| Dollar(15)              |                          |                        | 0.234<br>(0.47)          |                          |                         |
| Dollar(15)* $\Delta er$ |                          |                        | 1.208<br>(1.22)          |                          |                         |
| Dollar(20)              |                          |                        |                          | 0.0388<br>(0.08)         |                         |
| Dollar(20)* $\Delta er$ |                          |                        |                          | 1.436<br>(1.46)          |                         |
| $\Delta er$             | -2.321<br>(-1.50)        | -2.321<br>(-1.02)      | -0.567<br>(-0.44)        | -0.730<br>(-0.51)        | -1.084<br>(-0.46)       |
| FL/FA                   | 0.00698<br>(1.42)        | 0.00698<br>(1.47)      | 0.00444<br>(1.64)        | 0.00479<br>(1.34)        | 0.00332<br>(1.62)       |
| FL/FA * $\Delta er$     | 0.146<br>(1.53)          | 0.146<br>(1.57)        | 0.0963*<br>(1.77)        | 0.104<br>(1.48)          | 0.0709<br>(1.44)        |
| $\Delta p$              | -1.092<br>(-0.93)        | -1.092<br>(-0.81)      | -0.628<br>(-0.50)        | -0.648<br>(-0.52)        | -1.490<br>(-1.18)       |
| $\Delta tt$             | 0.0112<br>(0.86)         | 0.0112<br>(0.73)       | 0.0106<br>(0.66)         | 0.0112<br>(0.69)         | 0.00556<br>(0.27)       |
| realint                 | -0.00000817**<br>(-2.40) | -0.00000817<br>(-1.62) | -0.00000782**<br>(-2.37) | -0.00000774**<br>(-2.30) | -0.00000672*<br>(-1.71) |
| M2/reserves             | -0.00600<br>(-0.36)      | -0.00600<br>(-0.38)    | -0.00595<br>(-0.38)      | -0.00623<br>(-0.41)      | -0.0171<br>(-0.93)      |
| gdppc_i                 | 0.00000564**<br>(2.25)   | 0.00000564*<br>(1.85)  | 0.00000504<br>(1.62)     | 0.00000510<br>(1.61)     | 0.00000539<br>(1.42)    |
| $\Delta$ gdp            | -0.00105<br>(-0.03)      | -0.00105<br>(-0.03)    | -0.00000944<br>(-0.00)   | -0.0000249<br>(-0.00)    | 0.0338<br>(0.68)        |
| private credit/gdp      | 0.795<br>(0.59)          | 0.795<br>(0.45)        | 0.896<br>(0.53)          | 0.959<br>(0.60)          | 1.000<br>(0.43)         |
| cash/assets             | -0.922<br>(-0.69)        | -0.922<br>(-0.80)      | -0.962<br>(-0.74)        | -0.979<br>(-0.75)        | -0.276<br>(-0.23)       |
| capital flows/gdp       | -0.575<br>(-0.37)        | -0.575<br>(-0.44)      | -0.501<br>(-0.36)        | -0.570<br>(-0.41)        | -1.233<br>(-0.59)       |
| composite_avg           | -0.671*<br>(-1.93)       | -0.671<br>(-1.59)      | -0.692*<br>(-1.78)       | -0.723**<br>(-1.99)      | -0.711<br>(-1.40)       |
| sudden stop             | -0.243<br>(-0.27)        | -0.243<br>(-0.26)      | -0.217<br>(-0.22)        | -0.206<br>(-0.21)        | -0.208<br>(-0.23)       |
| currency crisis         | 1.109*<br>(1.80)         | 1.109*<br>(1.81)       | 0.924<br>(1.40)          | 0.936<br>(1.40)          | 0.825<br>(1.57)         |
| Constant                | -2.912***<br>(-5.87)     | -2.912***<br>(-6.76)   | -2.847***<br>(-5.78)     | -2.749***<br>(-5.85)     | -3.264***<br>(-6.00)    |
| N                       | 483                      | 483                    | 483                      | 483                      | 343                     |
| Years                   | 1976-2003                | 1976-2003              | 1976-2003                | 1976-2003                | 1990-2003               |
| StDev Cluster           | Country                  | Country-year           | Country-year             | Country-year             | Country-year            |
| Cutoff                  | 10%                      | 10%                    | 15%                      | 20%                      | 10%                     |

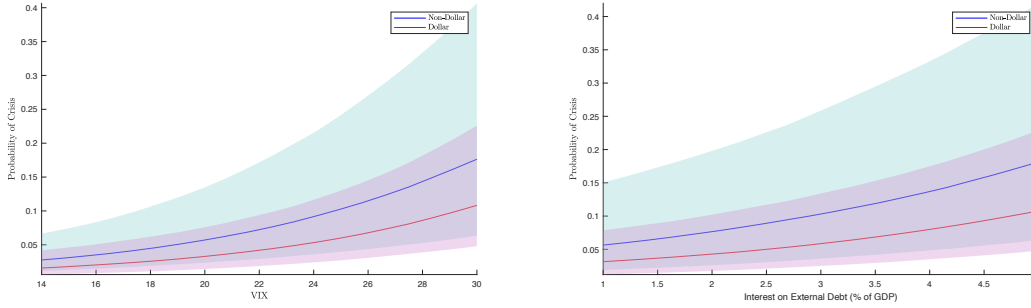
t statistics in parentheses

\* p&lt;0.1, \*\* p&lt;0.05, \*\*\* p&lt;0.01

## H.9 Implied Probabilities from the Logistic Regression

Figure H8 plots the implied probability of a banking crises using the results under the column 6 of table 1 along with one standard deviation confidence intervals. In a relatively calm period (VIX=14), a country with high external debt has a probability of a systemic banking crises around 2% while the probability rises to around 10% when there is high global uncertainty (VIX=30). Similarly, a country with low external debt has a probability of a systemic banking crises around 5% when VIX is very high; this probability rises to 10% when the interest on external debt rises to 5% of GDP.

Figure H8: Implied Probability of Systemic Banking Crisis



(a) Variations in VIX, for Country with Relatively High External Debt Burden (b) Variations in External Debt Burden, Holding VIX fixed at High Value

Note: Vertical axis shows the response of the systemic crisis probability to variations in the variable in figure title. In each panel probabilities are reported for the case in which the deposit dollarization dummy is unity (“Dollar”) and zero (“Non-Dollar”). In first panel, external debt interest costs are fixed at 5 percent of GDP. In the second panel the VIX is held fixed at 30. In both panels the other variables are fixed at roughly their average values:  $\Delta er = 0$ ,  $FL/FA = 1$ ,  $\Delta GDP = 0$ ,  $Reserve/GDP = 0.1$ . Computations for the graphs are based on regression results in column 6 of table [4](#).

## H.10 Diagnostics for the Logit Regression

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

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

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

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

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

Here, we see the problem with  $\bar{p} = 0$ . That would give us a 100 percent false positive rate. We compute  $TPR(\bar{p})$  and  $FPR(\bar{p})$  for a grid of values of  $\bar{p}$  over the unit interval. Our results are presented in Figure [H9](#), where each point on the solid line is  $g(\bar{p})$ , where

$$g(\bar{p}) \equiv (TPR(\bar{p}), FPR(\bar{p})), \bar{p} \in [0, 1]. \quad (\text{H.1})$$

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

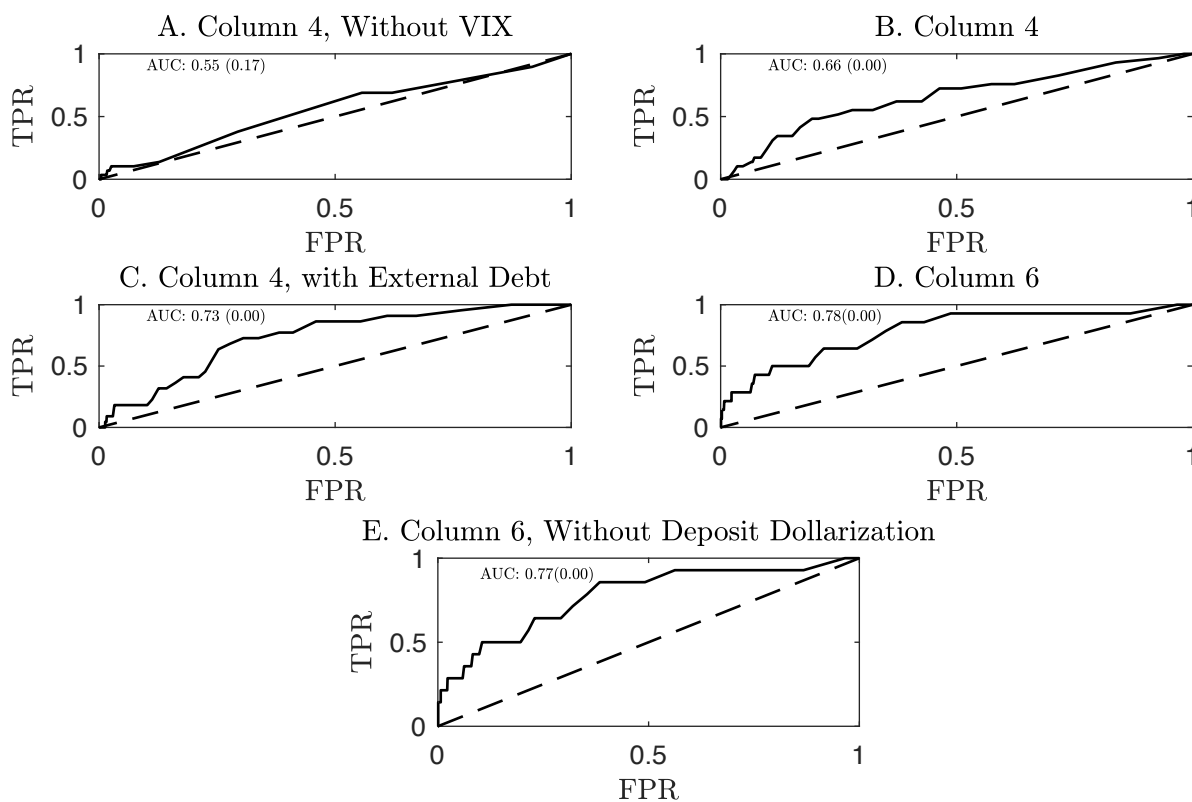
Panel A of Figure [H9](#) graphs  $g(\bar{p})$  for the specification of  $p$  underlying the results in column 4 of Table [1](#), except that the VIX is not included in the logit regression when it is estimated. This is a forecasting model that only uses exchange rate depreciations, deposit dollarization and the interaction between the two variables to forecast systemic banking crises. Note that  $g(\bar{p})$  is very close to the 45 degree line. The integral of  $g$  over  $\bar{p} \in (0, 1)$  is referred to as the Area Under the ROC curve (AUC). is reported to be 0.55, slightly higher than what it would be if  $g$  were exactly the 45 degree line. In fact,  $g$  is not statistically significantly different from the 45 degree line. We determined this based on a particular bootstrap exercise. First, we computed the integral underneath the solid line, AUC=0.55. We then computed an artificial AUC by replacing the crisis probabilities,  $p(x_{i,t}; \hat{\beta})$ , for each  $i, t$  with an independent draw from a uniform distribution. We repeated the latter exercise 5,000 times. The number in parentheses in Panel A of Figure [H9](#) displays the fraction of times that artificial AUC's exceed the empirical AUC=0.55. The result  $p$ -value is 0.17 and is indicated in Panel A. That is, the simple logit crisis forecasting model underlying Panel A is not significantly better than a random forecasting model. This is consistent with our conclusion that deposit dollarization is not helpful for forecasting crises.

Panel B of Figure [H9](#) graphs the ROC,  $g(\bar{p})$ , when the underlying forecasting model is exactly the one in column 4 of Table [1](#), so that it includes the VIX. Note that now the  $p$ -value now is zero. So, comparing Panels A and B we see that the VIX does help significantly in crises. Still, according to [Hosmer et al. \(2013\)](#), page 177) and AUC of 0.66 is really only a little better than a random forecasting model. Panel C works with a version of the logit model in column 4 which is estimated with External Debt also included. Adding this variable improves the forecasting model as shown by the fact that the AUC jumps to 0.73.

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

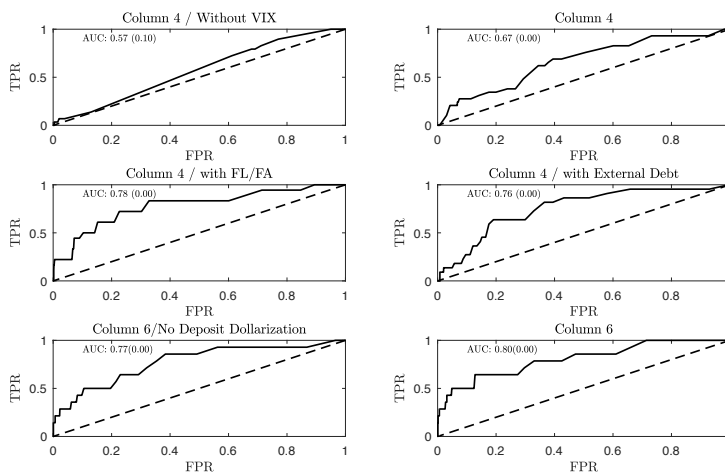
In sum, we find that our logit model is in a sense an ‘acceptable’ model for forecasting crises. The analysis here suggests that the important variables for forecasting crises are the VIX and external debt. Deposit dollarization is not related to crises.

Figure H9: The Information Content For Financial Crises in Deposit Dollarization, the VIX and External Debt



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

Figure H10: The Information Content For Financial Crises in Deposit Dollarization (40% cutoff), the VIX and External Debt



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

## I Balance Sheet Effects

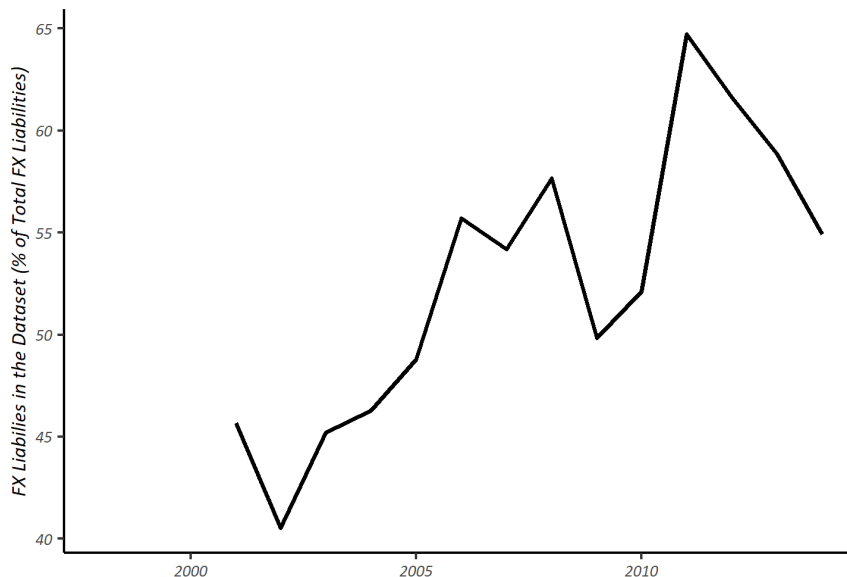
### I.1 Analysis of Firm-Level Data in Peru and Armenia

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

#### I.1.1 The Ramírez-Rondán (2019) Dataset

We use the Ramírez-Rondán (2019) data to investigate investment effects of an exchange rate depreciation. After 2006, these data account for well over 50% of all dollar borrowing by non-financial firms in Peru (see Figure I11).

Figure I11: Total Dollar Borrowing in Panel Data Set, Divided by Total Dollar Borrowing by All Non-financial Firms



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

Table [I14](#) displays our ordinary least squares regression results. The evidence suggests that sales growth and GDP growth are the main drivers of investment and currency mismatch on firm balance sheets is relatively unimportant. Figure [I11](#) shows that total borrowing in the [Ramírez-Rondán \(2019\)](#) dataset encompasses the majority of borrowing by non-financial firms in Peru, at least beginning in 2006.

The left hand variable in our regression is the  $i^{th}$  firm's investment in year  $t$ . We measure investment by the change in the log of the  $i^{th}$  firm's fixed assets<sup>[89](#)</sup> In addition to a constant term, there are two types of right-hand variables: those that pertain to the  $i^{th}$  firm as well that those that pertain to the economy as a whole. Firm-level variables include sales/total assets, leverage, and log assets. The last column in Table [I14](#) also uses the firm-level dummy variable, *Large*. That variable is unity for firm  $i$  in year  $t$  if the  $i^{th}$  firm's assets are in the top quartile of firm assets in year  $t$ . We also include the dummy variable, *Mismatch*. This variable takes on a value of unity for firm  $i$  in year  $t$  if the firm's net dollar assets, scaled by its total assets, are less than the median value of that ratio across all firms in year  $t$ .<sup>[90](#)</sup> We also include a dummy variable, *Exporter*, which is unity for firms whose exports are on

<sup>89</sup>The [Ramírez-Rondán \(2019\)](#) dataset also includes a variable, expenditures on fixed assets, which could be used to measure investment. When we used this variable as the left-side variable in our regressions we obtained results very similar to what is reported in Table [I14](#). These results can be provided on request by the authors.

<sup>90</sup>The median cutoff is negative in each year. Our data on firms' net dollar asset position does not include derivatives.

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

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

Consider column 1 in Table [114](#), which includes both firm and year fixed effects. The coefficient on  $Mismatch \times \Delta ER$  indicates that when there is a nominal depreciation, firms with high currency mismatch tend to cut back on investment in the subsequent year but the coefficient is not significantly different from zero. Column 2 adds aggregate variables instead of year fixed effects. Here, two things are worth noting. First, the coefficient on  $\Delta ER$  indicates that when there is a nominal depreciation, firms tend to cut back on investment in the subsequent year. The second row of column 2 indicates that the subset of firms with currency mismatch cut back on investment a little more, in the wake of a depreciation. Critically, the coefficients in both cases are not significantly different from zero. Second, note that sales and GDP growth are the only significant explanatory variables for investment. Column 3 includes additional controls and do not significantly change the picture that emerges in column 2. Interestingly, the coefficient on *Large* is positive and modestly significant, while the coefficient on  $\log(Assets)$  is negative, though not significant. This suggests that investment is not strongly related to firm size over most of the range of sizes, but is increasing for very large firms. Column 3 also includes a binary variable for Exporters. We find that the exporters invest relatively less after a depreciation but its estimate is not statistically different from zero. Overall, the point estimates in all columns suggest the balance sheet channel is negligible.

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

Columns 3, 4 and 5 include additional controls and do not significantly change the picture that emerges in column 2. Interestingly, column 5 shows that the coefficient on *Large* is positive and modestly significant, while the coefficient on  $\log(Assets)$  is negative, though

not significant. This suggests that investment is not strongly related to firm size over most of the range of sizes, but is increasing for very large firms.

Table I14: Balance Sheet Effects in Peru

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

Standard errors in parentheses

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

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

For our purposes the critical finding in Table [I14](#) is that balance sheet effects on non-



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

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

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

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

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

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

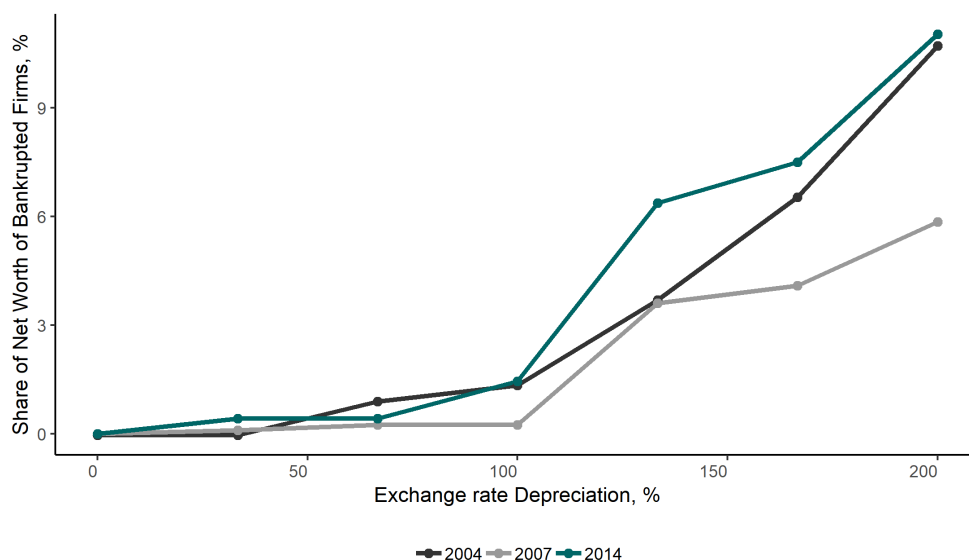
$$\chi_i(\Delta S) = \begin{cases} 1 & NetAssets_i + \Delta S \times NetFX_i < 0 \\ 0 & \text{Otherwise} \end{cases}$$

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

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

Figure [I12](#) plots the fraction of defaulting firm net worth,  $Default$ , against counterfactual exchange rate depreciations for three years. Note that even with a 200% exchange rate depreciation, less than 10% of the total firm equity goes bankrupt.

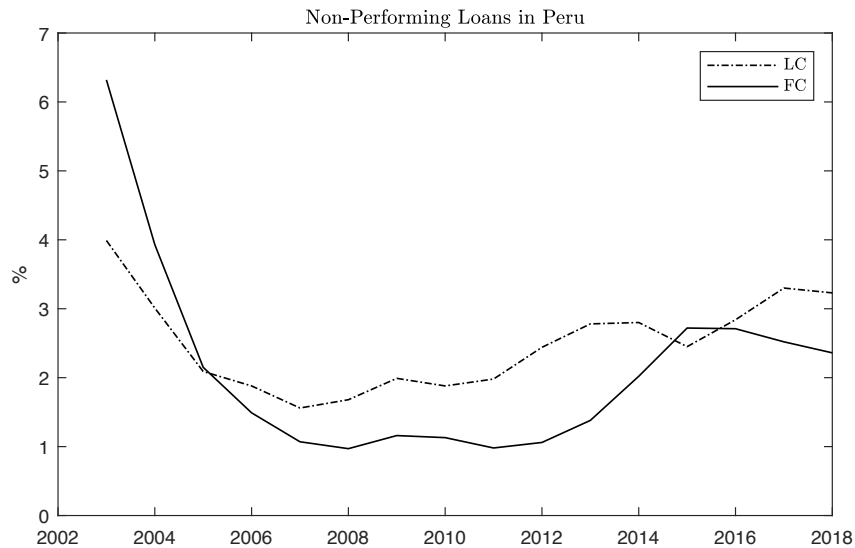
Figure I12: Fraction of Defaulting Firm Net Worth



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

It is possible that the data analysis above is distorted by a kind of survival bias. One piece of evidence which suggests this is not the case can be found in data on non-performing loans for Peru and Turkey (see Figure I13). The figures distinguish between foreign currency and domestic currency loans to non-financial business and households. In Peru, the thing to note is that these rates are roughly the same. One period that is of particular interest to us is 2013-2015, when the large depreciation occurred. Note that the non-performance rate on foreign currency loans did rise then. However, it simply rose up to the rate on domestic currency loans. We view this evidence as complementary to the other evidence displayed in this section which suggests that the balance sheet effects on non-financial firms of exchange rate depreciation are not large.

Figure I13: Non-performing Loans



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

### I.1.2 The Humala (2019) Dataset

Following a period of relative calm, Peru experienced a sharp, three-year depreciation starting in 2013. The PEN depreciated around 30%. We use the quarterly balance sheet data from 28 largest firms in Peru studied in Humala (2019) to see what sort of foreign exchange losses they experienced and how their investment responded.<sup>91</sup>

Figure I14a plots cumulative foreign exchange losses during the period covered by the two vertical lines in Figure I15d against currency mismatch in 2012Q4.<sup>92</sup> Each observation has a number attached, so that it is possible to compare observations across figures. The losses and mismatch in Figure I14a are expressed as a ratio of their 2014Q2 equity.<sup>93</sup> The data set does not include information about whether a firm has ‘natural hedges’ in the form of revenues from exports. Figure I15d shows a positive relationship between currency mismatch and foreign exchange losses. Interestingly, there are two firms, 7 and 20, that are outliers in terms of the magnitude of their foreign exchange losses. There is one firm, 10, that is an outlier in terms of initial currency mismatch.

Figure I14b displays total investment for each firm during the period of the depreciation,

<sup>91</sup>The raw data source is the Superintendency of the Securities Markets in Peru.

<sup>92</sup>Our cumulative data go one year beyond the period over which the depreciation occurred, in order to capture its full effects.

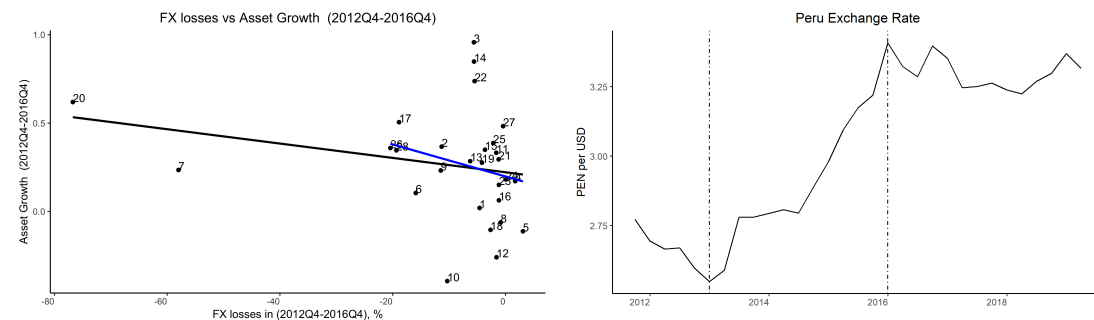
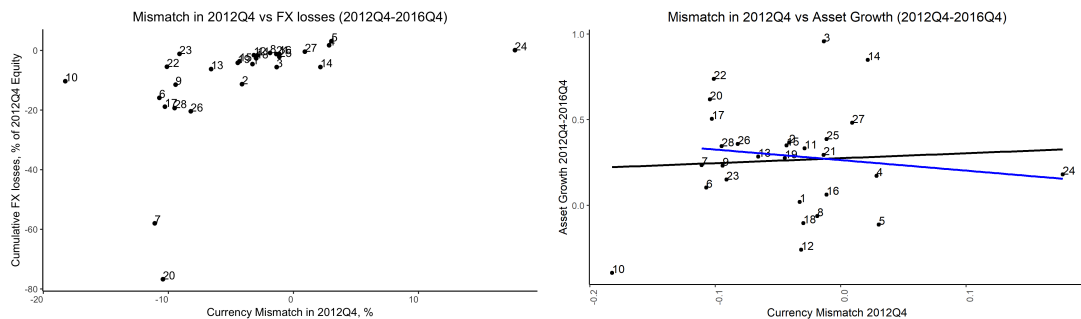
<sup>93</sup>Currency mismatch is defined as the (Dollar Assets - Dollar Liabilities + Net Derivative Position)/Total Assets. Equity is total assets minus total liabilities. All these data, plus the foreign exchange losses analyzed below, are reported by the firms to the Peruvian government agency, the Superintendency of the Securities Markets, which in turn is the data source for the dataset constructed in Humala (2019).

against currency mismatch on the eve of the depreciation. A firm's total investment is the log of the ratio of total assets in 2016Q4 to total assets in 2012Q4. The key finding is that investment is not significantly related to mismatch at the start of the depreciation. Firm 10, which had the most mismatch in the initial period, also had the lowest level of investment. That single observation suggests a link between the two variables. However, taking into account all 28 observations there does not appear to be a link. Figure I14b displays two regression lines, one that uses the firm 10 observation and the other that does not. Both of those lines are roughly the same and essentially flat.

The channel by which currency mismatch might affect investment should operate through foreign exchange losses. So, Figure I15c plots investment against foreign exchange losses. The two outliers in Figure I14a, firms 7 and 20, are apparent in this figure. Note that their levels of investment are at the mean or above the mean of the other firms. The figure displays two least squares regression lines, one with and one without the outliers. In both cases, the point estimates indicate, if anything that investment is higher the bigger are the foreign exchange currency losses.

Figure I14: Currency Mismatch, Foreign Exchange Losses and Credit Growth 2012Q2-2016Q4

(a) Currency Mismatch, Foreign Exchange Losses (b) Credit Dollarization vs Asset Growth 2012Q2-2016Q4



(c) FX Losses and Credit Growth 2012Q2-2016Q4 (d) Nominal Exchange Rate in Peru

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

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

### I.1.3 Armenia Dataset

Armenia experienced a substantial 17% depreciation between early November 2014 and the end of February 2015 (see figure [I15](#)). We study how non-financial firm investment in 2015, 2016 and 2017 is associated with the level of a firm’s dollar debt before the depreciation. Our data are annual and end-of-year. We obtain end-of-2013 firm-level data on dollar debt from the Credit Registry of the Central Bank of Armenia.<sup>94</sup> Our credit dollarization variable is a firm’s dollar debt divided by its total credit. We also analyze a firm’s dollar debt scaled by total assets (financial and fixed), both at end of 2013 (our pre-depreciation observation). Our credit dollarization measure as well as scaled dollar credit are both in percent by multiplying by 100. Asset data were obtained from Armenia’s State Revenue Committee and matched with the corresponding credit registry data.<sup>95</sup> Our measure of investment is 100 times  $\Delta Capital_t$  the log level of the firm’s fixed assets (e.g., structures and equipment) at the end of year  $t$  minus that level at the end of year  $t - 1$ , for  $t = 2015, 2016, 2017$ .

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

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

<sup>94</sup>This dataset contains the universe of all loans in Armenia.

<sup>95</sup>This dataset contains asset and investment information the firms which file corporate tax reports. This tends to be larger firms in Armenia. Smaller companies in Armenia file tax reports which are not required to include asset and investment information.

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

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

The parameter,  $N$ , in the bottom row of Table [I15](#) indicates the number of firms in the dataset. Note that the value of  $N$  declines as we go from 2015 to 2016 and 2017. We investigated whether the decline in  $N$  might have been caused by firms experiencing severe balance sheet effects because of the depreciation. If that were true, then our results for 2016 and 2017 in Table [I15](#) would be distorted by selection effects. In fact, we found that the pre-depreciation level of credit dollarization for firms that do not appear in the 2016 and 2017 tax data does not differ substantially from the average credit dollarization of all the firms in our dataset.<sup>96</sup>

We redid the regressions in the first three columns of Table [I15](#), including a dummy variable that indicates whether a firm is an exporter or not. We interacted the dummy variable with the credit variable and found that the resulting coefficient is not significantly different from zero, although we lose a substantial number of observations when want to know if a firm is an exporter or not.<sup>97</sup> This finding is similar to the one reported above for Peru as well as the one found in [Bleakley and Cowan \(2008\)](#). A firm with substantial dollar debt appear to have the same investment response to a depreciation shock whether the firm

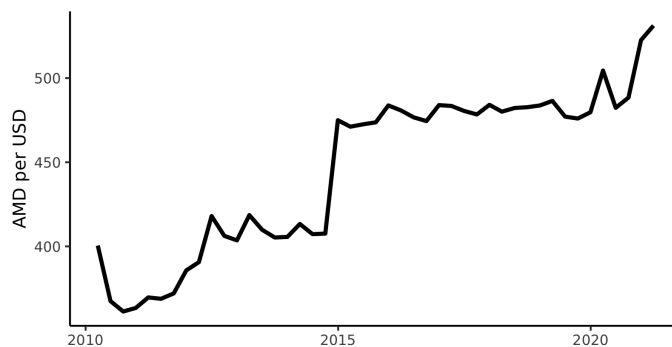
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<sup>96</sup>We compared the average of our end-of 2013 credit dollarization measures for firms that appear in the 2016 and 2017 data with the average for firms that disappear from either or both of those two years and these averages are not significantly different.

<sup>97</sup>The number of firms for which the export status is reported is about 1/6 of the number of firms in our dataset.

is an exporter or not.

Figure I15: Nominal Exchange Rate in Armenia



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

Table I15: Balance Sheet Effects in Armenia

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

Notes: ; *t* statistics in parentheses

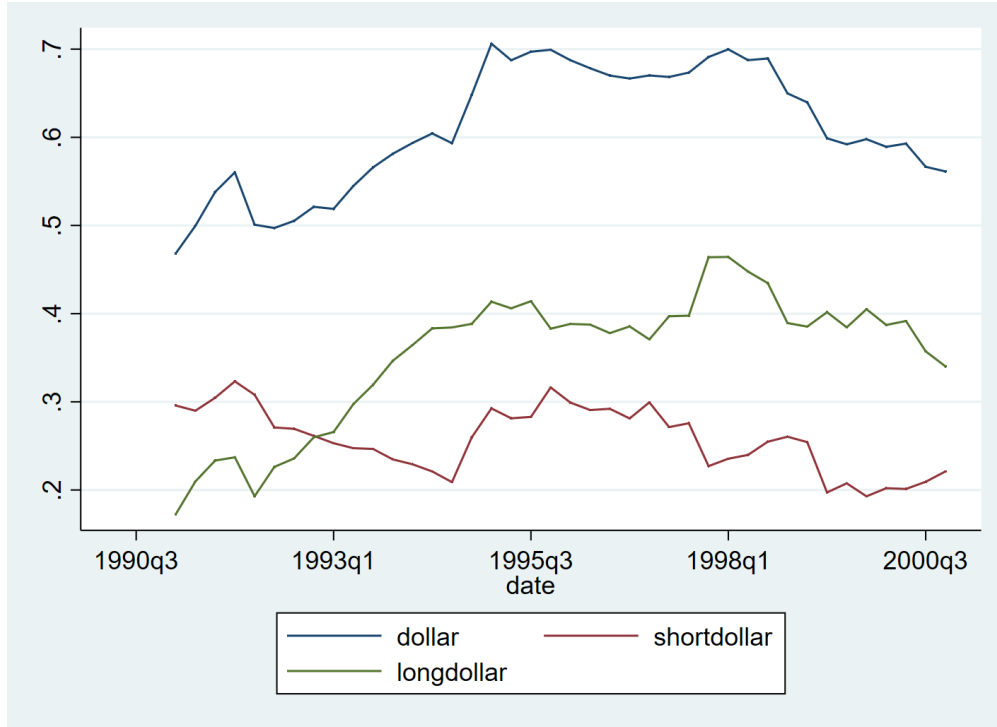
\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

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

## I.2 Dollar Borrowing in Mexico

Figure I16 shows total dollar credit as well as short term and long term credit to non-financial firms in Mexico. The data are scaled by total firm credit. So, the total dollar credit data are the sum of the short-term and long-term data. Note that most dollar credit is long-term.

Figure I16: Dollar Credit to Non-Financial Firms, by Currency, in Mexico



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

## J Model Analysis

The first section below describes our model. The second section shows that the model provides a reasonable framework for organizing our empirical results. That section also relates our model to other analyses. Section [J.2.1](#) relates the results of our model to the empirical findings in [Miranda-Agrippino and Rey \(2020\)](#). We show that an exogenous increase in the dollar rate of interest leads to an appreciation of the dollar, a reduction of capital flows in 'the rest of the world', which we assume is composed of small open economies like our model. Although we imagine those economies are somewhat different from each other, they are not sufficiently different to represent a diversifiable risk to our foreign financiers. In addition, we show that the variance of the rate of return on assets (all rates of return are converted into dollar units) increase when the dollar rate increases, suggesting that a measure of the VIX rises in our model after an increase in the dollar interest rate. These results are consistent with the results reported in [Miranda-Agrippino and Rey \(2020\)](#). Our results also can be compared with [Ilzetzki and Jin \(2020\)](#). They report, using 1990-2009 data, that a rise in the dollar interest rate leads to a depreciation in the exchange rate and a rise in foreign output. [Ilzetzki and Jin \(2020\)](#) conjecture that a simultaneous change in risk aversion can account



for these results. We explore the impact of changing the risk aversion parameter for foreign financiers in section [J.2.1](#). We show (see Figure [J.2.1](#)) that with a decline in risk aversion, foreign (US) financiers make more loans in foreign currency in order to take advantage of the interest premium in the domestic economy. As they acquire foreign currency to lend in the local currency market, the exchange value of the dollar depreciates. In addition, the local interest rate premium falls and local firms borrow more. This borrowing finances investment and higher GDP in the next period. These effects are consistent with the conjectures in [Ilzetzki and Jin \(2020\)](#) about the effects of risk averse

## J.1 The Model

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

### J.1.1 Worker-Households

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

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

The household’s period 2 budget constraint is:

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

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

consumption good. It is useful to substitute out for  $d$  in (J.2) using (J.1):

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

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

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

$$\max_{d^*} E c_2^{house} - \frac{\lambda}{2} \text{var} (c_2^{house}), \quad (\text{J.4})$$

subject to (J.3) and  $0 < l_2 \leq 1, c_2^{house} \geq 0$ . With a little algebra it is easy to establish that<sup>98</sup>

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

where

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

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

$$(1 - \rho^2) \text{var} (w_2) \geq 0,$$

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<sup>98</sup>Taking into account that  $Yr$  and  $d^*$  are not random, we have,  $\text{var} (c_2^w) = \text{var} [d^* e_2 r^* + w_2]$ . Denoting  $s \equiv e_2 r^*, Q = w_2$ ,

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

where

$$a = \text{var} (s), b = 2\text{Cov} (s, Q), c = \text{var} (Q).$$

Equation (J.5) follows by simple rearrangement.

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

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

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

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

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

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

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

$$r = Fr^*. \quad (\text{J.8})$$

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

rearranging, we obtain:

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

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

$$\frac{L}{r^*} = d^* \quad (\text{J.10})$$

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

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

### J.1.2 Firm-Households and Period 2 Domestic Output

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

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

$$K = k_h^\omega k_f^{1-\omega}. \quad (\text{J.11})$$

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

$$\min_{k_h, k_f} e_1 k_f + k_h + p^K [K - k_h^\omega k_f^{1-\omega}], \quad (\text{J.12})$$

where  $p^K$  denotes the Lagrange multiplier on the constraint. Also,  $e_1$  denotes the period 1 real exchange rate: it is the amount of the domestic period 1 good required to purchase 1

unit of the period 1 foreign good. The solution to the firm's cost minimization problem is:

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

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

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

$$p^K K = b + b^*, \quad (\text{J.14})$$

where the firm treats  $p^K$  as an exogenous (shadow) price (see equation (J.13)).<sup>99</sup>

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

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

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

$$p_2^h Y_2^h - w_2 l_2 = r_2^K K, \quad (\text{J.16})$$

where

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

---

<sup>99</sup>A simple envelope argument establishes  $p^K$  is the marginal cost to the firm of  $K$ . An interior solution to the minimization problem sets the first order optimality conditions for  $k_h$  and  $k_f$  to zero and satisfies the complementary slackness conditions:  $p^K [K - k_h^\omega k_f^{1-\omega}] = 0$  and  $p^K \geq 0, K - k_h^\omega k_f^{1-\omega} \leq 0$ . Because the prices of  $k_f$  and  $k_h$  are positive, we know that the constraint is binding, so that  $K - k_h^\omega k_f^{1-\omega} = 0$  is part of the solution. At the optimum, the inputs are functions,  $k_f(K), k_h(K)$  of  $K$ . Thus the minimized cost,  $C(K)$ , is  $C(K) = e_1 k_f(K) + k_h(K) + p^K [K - (k_h(K))^\omega (k_f(K))^{1-\omega}]$ . Differentiating with respect to  $K$ , we obtain

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

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

so that

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

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

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

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

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

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

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

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

$$R_2^K = \frac{r_2^K}{p^K}. \quad (\text{J.18})$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$r_2^K K = e_2 S$$

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

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

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

$$b^* = \frac{S}{r^*}. \quad (\text{J.22})$$

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

### J.1.3 Foreign Financiers

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

$$e_1 r^* = r^\$, \quad (\text{J.23})$$

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

$$x^\$ + x^D = b^f. \quad (\text{J.24})$$

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

$$Y_2^* = \xi + \nu, \quad (\text{J.25})$$

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

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



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

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

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

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

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

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

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

The objective of the foreign financier is:

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

The solution to this problem is:

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

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

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

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

units, of buying  $H$  long contracts is:

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

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

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

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

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

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

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

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

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

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

where

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

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

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

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

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

That is,

$$\tilde{x} = x^D e_1. \quad (\text{J.34})$$

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

#### J.1.4 Final Consumption Good Production in Period 2

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

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

The firm solves

$$\max_{c_2, c_2^h, c_2^f} c_2 - p_2^h c_2^h - e_2 c_2^f, \quad (\text{J.36})$$

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

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

Note that when  $\delta \rightarrow 0$  we obtain the Leontief result that the ratio of the home to foreign good in production is a constant,  $\omega_c / (1 - \omega_c)$ , independent of relative prices. Also, in the Cobb-Douglas case,  $\delta \rightarrow 1$ , it is the ratio of expenditures on the two inputs that is constant,  $\omega_c / (1 - \omega_c)$ .<sup>100</sup>

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 by substituting (J.37) into the production function and

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<sup>100</sup>In the Cobb-Douglas case, the production function converges to  $c_2 = (c_2^h)^{\omega_c} (c_2^f)^{1-\omega_c}$ , by the presence of  $\mathbb{A}$  in equation (J.35).

rearranging, to obtain:

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

### J.1.5 Market Clearing, Balance of Payments and GDP

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

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

$$c_1^* + k_h = Y. \quad (\text{J.38})$$

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

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

$$c_1^* = \omega e_1^\eta Y^*, \quad \eta > 0, \quad (\text{J.39})$$

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

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

$$d + x^D e_1 = b. \quad (\text{J.40})$$

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

$$d^* + x^S e_1 = b^*. \quad (\text{J.41})$$

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

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

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

$$Y_2^h = c_2^h + c_2^*, \quad (\text{J.43})$$

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

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

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

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

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

$$GDP_2 = c_2 + p_2^h c_2^* - e_2 c_2^f. \quad (\text{J.45})$$

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

$$GDP_2 = p_2^h Y_2^h. \quad (\text{J.46})$$

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

$$GDP_2 = w_2 + r_2^K K. \quad (\text{J.47})$$

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

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

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

So, the balance of payments requires:

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

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

### J.1.6 Futures Market

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

$$L + H = S,$$

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

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

so that clearing in the futures market requires

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

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

$$b^{f,F} e_1 = \overbrace{b^* - d^*}^{x^s e_1} + x^D e_1 = b^f e_1. \quad (\text{J.49})$$

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

$$x^{D,F} e_1 = b^* + x^D e_1 - d^*, \quad (\text{J.50})$$

where the values of the variables on the right of the equality correspond to their value in the baseline version of the model in which there are only loan markets. From equation (J.50) we consider several cases. First, if  $b^* = d^*$  so that foreign financiers are not participating in the

local dollar market, then the extent of their participation in a futures will not be affected since by equation (J.49) their overall participation is not affected by the markets. If  $b^* > d^*$  then foreigners are supplying a positive amount of dollars in the local lending market, so that when that market is shut down they shift their financing into the peso lending market. We can see this simply by rewriting equation (J.50):

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

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

### J.1.7 Futures Markets and Insurance Flows

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

$$oi = L + H^l = S + H^s. \quad (\text{J.51})$$

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

$$nff = H^l - H^s = S - L. \quad (\text{J.52})$$

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

$$\begin{array}{l} \text{amount of insurance provided between domestic residence insiders} \\ \overbrace{\min [L, S]} \quad + \quad \overbrace{\min [H^l, H^s]} \quad + |nff| \\ \hspace{18em} = oi \end{array} \quad (\text{J.53})$$

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

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

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

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

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

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

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

### J.1.8 Interest rate Spread

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

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

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

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

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

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

### J.1.9 Equilibrium

The 24 unknowns in the model are:

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



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

## J.2 Results

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

### J.2.1 Model Results

**Exercise - Increase in Volatility Foreigners' Demand for Exports** Figure J17 shows how the equilibrium changes as the standard deviation of the two foreign demand shocks, ( $\xi$  and  $\nu$  in equation J.39) increases from 10 percent below their calibrated values to 10 percent above their calibrated value. A negative realization in that shock creates a recession in period 2 when demand by foreigners for the domestic good drops (see equation J.44). When that happens, the exchange rate,  $e_2$ , jumps (depreciates) and the wage rate,  $w_2$ , falls (see panel 2,1). This is why the hedging benefit of dollar deposits to the household of increasing dollar deposits increases with the rise in the volatility of the foreign demand shock (see the solid line with dots in panel 1,1). Households respond by increasing their dollar deposits, which appear as the solid line in panel 1,1 of Figure J17. Deposits have been scaled by a constant,  $Y_1$ , which is total deposits,  $d + d^*$ , according to equation J.1. Dollar deposits vary from 0.34 to 1.58 as the volatility of the demand shock varies from smallest to largest. Evidently, the demand for  $d^*$  is so high at the upper bound of the variance, that  $d < 0$ . That is, households borrow in local currency units in order to increase their dollar deposits above  $Y_1$ . Other things the same, the decrease in the supply of deposits denominated in local goods drives up the interest rate premium on domestic deposits (see panel 3,1). This moderates the household's incentive to increase its dollar deposits via a fall in the speculative motive. This motive, defined in equation (J.6), can be seen in the dot-dash line in panel 1,1, which shows that the speculative motive alone motivates households to set  $d^* < 0$  because borrowing dollars from banks and lending the proceeds in the form of domestic currency on average makes money for the household when there is a premium on peso deposits. The speculative motive is quite strong and varies from  $-3.12$  to  $-4.45$  across the range of variation in Figure J17.

Although the speculative motive makes households averse to dollar deposits when there is a premium on the peso interest rate, the hedging motive is stronger. If households were

infinitely risk averse (i.e.,  $\lambda = \infty$ ) then the hedging motive would be the only motive operating on households. Across the range of variation in Figure J17 households would want to hold 3.30-5.33 in (scaled) deposits. That is, despite the premium on peso deposits, they want to borrow those deposits,  $d < 0$ , in order to make  $d^*$  very large. Operating through the speculative motive of the household, the relative increase in the domestic rate of interest partially offsets the household's greater hedging motive stronger hedging motive when foreign demand shocks are more volatile. The hedging motive alone makes the demand for dollar deposits rise from 0.34 to 1.58 over the range of volatilities displayed in Figure J17. The 1,1 panel in J17 The premium on the domestic rate of interest Note how the speculative motive (see the dot-dashed line) dictates that households borrow in dollars,  $d^* < 0$ , and lend in local currency. Total deposits is 1.58, so then the standard rises by 10 percent, deposits are almost entirely in dollars.

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

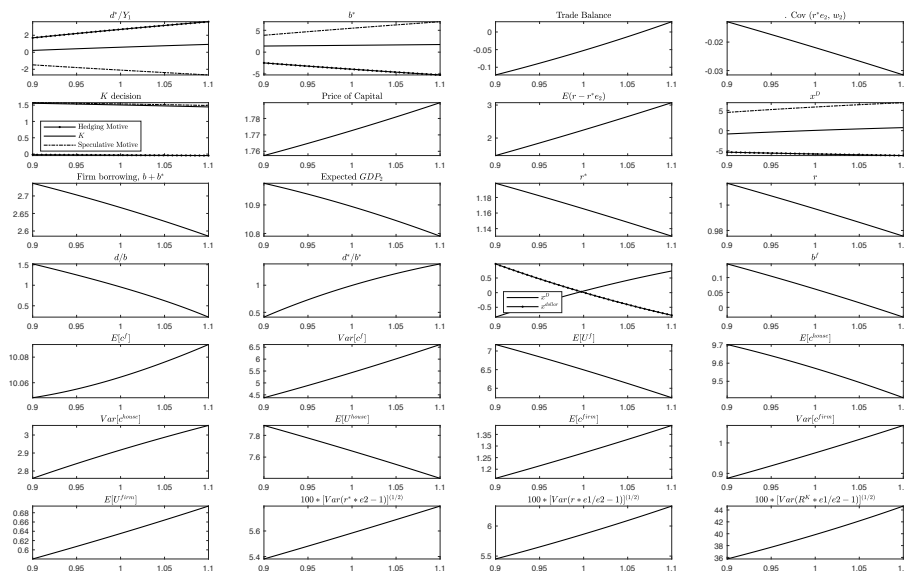
Evidently, net acquisition of assets by domestic residents,  $d + d^* - (b + b^*)$ , rises with the volatility in the foreign demand shock.<sup>101</sup> The balance of payments, equation (J.42), requires that the trade surplus increase. This is accomplished in part by the stimulus to exports,  $c_1^*$ , occasioned by the depreciation in the period 1 exchange rate (see equation (J.39)).

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

<sup>101</sup>Recall, from equation (J.1), that  $d + d^* = Y$ , which is pre-determined. So, the conclusion in the text about net asset accumulation reflects the fall in  $b + b^*$  observed in panel 3,3 of Figure J17.

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

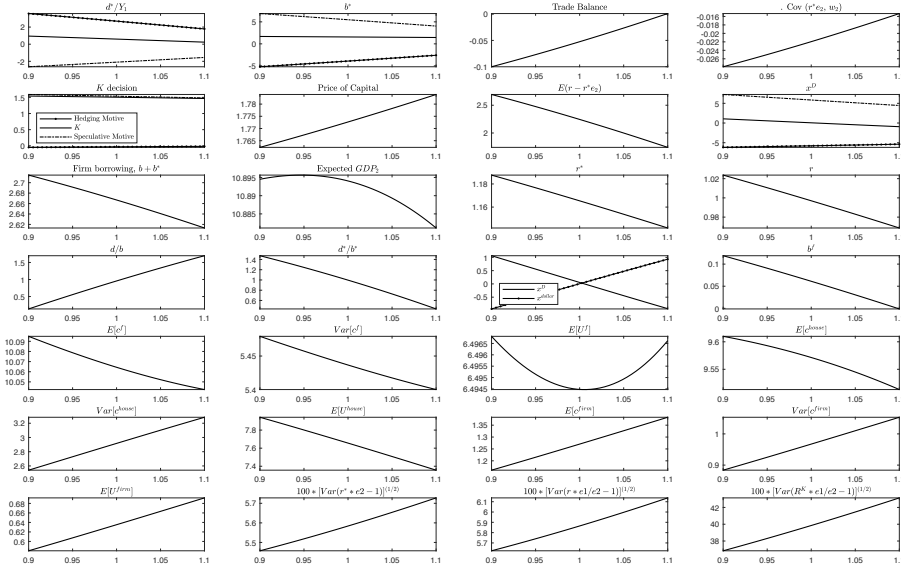
Figure J17: Increase in volatility of trade shock,  $\xi$  and  $\nu$



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

Figure J18 displays the impact on equilibrium of increasing the standard deviation of the technology shock,  $A$ , in equation (J.15). When this shock increases in importance, then the depreciation that occurs in a recession is reduced (see panel 1,2). With the hedging value of dollar deposits reduced, households shift from dollar deposits into local currency deposits (see panel 1,1). With the supply of local currency deposits in local lending markets increased, the premium on the domestic interest rate is reduced (see panel 2,2).

Figure J18: Increase in volatility of productivity shock



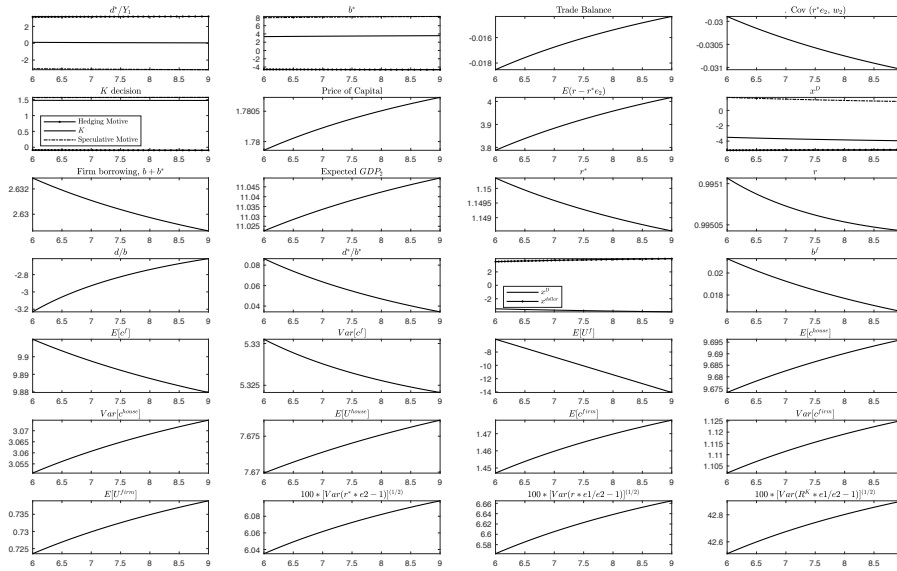
Note: horizontal displays  $x \in [0.9, 1.3]$  and vertical axis is value of indicated variable when the value of  $\sigma_A$  in Table (??) is replaced by  $x\sigma_A$ . Here,  $A$  is the technology shock experienced by domestic firms in period 2 (see equation (J.15)).

**Exercise - Risk Aversion of Foreign Financiers** Figure (J19) shows what happens when we increase the risk aversion of the foreign financiers (see  $\lambda^F$  in equation (J.29)). When foreign financiers become more risk averse they are more reluctant to lend in local currency. With the fall in demand for local currency by foreign financiers, the exchange rate,  $e_1$ , depreciates (see the definition of  $p^K$  in (J.13) and panel 2,2 of Figure (J19)). The fact that foreign financiers lend less in the local currency market, we see that the interest premium on local currency rises (see panel 2,3). (Foreigners substitute so much into dollar lending that they actually finance this in part by borrowing in local currency to lend in dollars (see how  $x^D$  becomes negative in panels 2,4 and 4,3).) Households respond by substituting a little towards peso deposits (panel 1,1). But, overall there is a reduction in local deposits, so that the domestic interest rate premium rises (see panel 2,3). Firms are pushed into borrowing in dollars, but they don't like this so overall borrowing by firms,  $b + b^*$ , decreases (see panel 3,1). Net foreign asset accumulation goes up because  $d + d^*$  is constant. By the balance of payments, this means the trade surplus must rise. The rise in  $e_1$  increases period 1 exports (that  $e_1$  rises can be seen in the fact that  $p^K$  rises, according to equation (J.13)). The reduced demand for imports by firms because they cut back on production, also helps increase the trade surplus (see 'sudden stop' in panel 1,3).

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

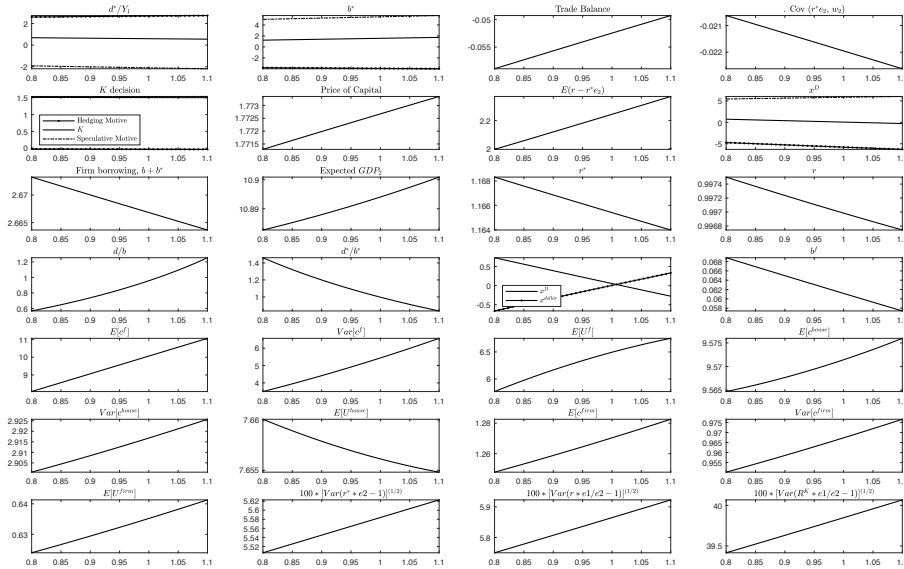
Not surprisingly, because there is less borrowing by firms in the first period, the expected period 2 *GDP* declines (see panel 3,2).

Figure J19: Increase in foreign financier risk aversion



**Exercise - Income comovement of Foreign Financiers** Figure J20 shows what happens when we increase the degree of comovement between the trade shock and the income of foreign financiers by increasing the value of  $s$  in (J.26). This change makes domestic currency loans a bad hedge, and the effects resemble those in Figure J19.

Figure J20: Increase in comovement between foreign financier income and trade shock

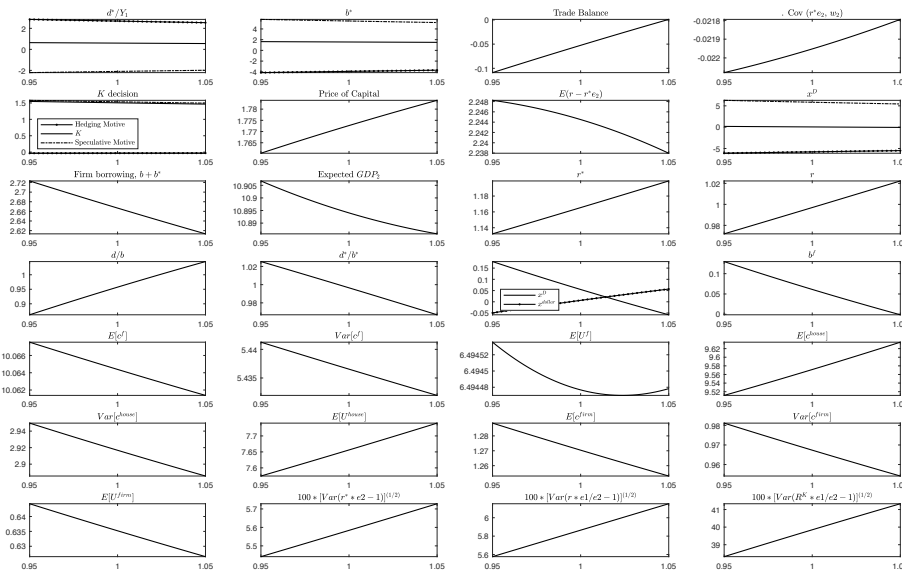


**Exercise - Increase in  $r^{\$}$**  Figure J21 displays the impact of increasing  $r^{\$}$ . Obviously, that makes dollar assets more attractive. This means that the foreign financier prefers to lend in the dollar market (see panel 4,3). The reduction in the demand for local currency by the foreign financier leads to a depreciation in the exchange rate (see  $p^K$  in panel 2,2 and recall equation (J.13)). The reduced supply of funds to the domestic peso market implies that there is an increase in the local currency premium (see panel 2,3). This forces local firms to substitute away from local currency borrowing and into dollar borrowing, which they don't naturally like to do for hedging reasons. So, total firm borrowing,  $b + b^*$ , goes down (see panel 3,1). So, there is a fall in foreign capital inflows. By the balance of payments (see (J.42)), this implies that the trade balance must increase (see panel 1,3). Holding quantities fixed in J.42, a depreciation makes the trade balance go down (the 'J' curve effect). But, the increase in exports occasioned by the depreciation (see equation J.39), as well as the decline in imports,  $k_f$ , ensures that the trade balance actually goes up so that the balance of payments is satisfied. The 4,4 panel indicates that the total amount of dollars borrowed by the foreign financiers, to lend into the local market (either as dollars or pesos) goes down. The fact that capital flows to the domestic economy go down is consistent with evidence in Figure 7 of [Miranda-Agrippino and Rey \(2020\)](#).

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

$r^{\$}$ , but that drop is not statistically significant. Eventually, foreign GDP rises after a rise in  $r^{\$}$ , but that is just barely significantly different from zero. Finally, note that the variance of  $e_2$  goes up (see 7,2 panel of Figure J21). In addition, the variance of the rate of return (in dollars) on investments abroad goes up too. In panel 7,3 of Figure J21 we see that the variance on the return,  $re_1/e_2 - 1$ , of local currency investments expressed in dollars, goes up. The variance, in dollars, on the rate of return to capital,  $R^k e_1/e_2 - 1$ , also goes up. The overall rise in variability of returns, seems consistent with results reported in the results in Figure 6 (middle panel) of [Miranda-Agrippino and Rey \(2020\)](#). There, they show that a rise in  $r^{\$}$  leads to a fall in the Global Factor, which looks like (the inverse of) the VIX (see panel (a) in their Figure 2). We have not yet investigated how to compute their Global Factor in our model (the only asset price we have is  $p^K$ ), or their measure of Global Risk Aversion.

Figure J21: Increase in  $r^{\$}$



### J.3 Summary, Model

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

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

## K Appendix Material on Domestic Household

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

### K.1 Low Probability of Disaster Restriction

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

$$\max_{d^*} E c_2^{house}$$

subject to

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

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

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

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

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

where, for any  $y$ ,

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



By Leibniz's rule we have

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

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

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

Differentiating the last term,

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

where

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

so that

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

Also,

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

Then,

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

Substituting,

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

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

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

we should get the Normal density function.

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

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

Consider the CDF of a Normal variable with mean  $\mu$  and variance,  $\sigma^2$ . For given  $x$ , the CDF with the error formula is:

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

Differentiating with respect to  $x$ ,

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

But,

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

so, as expected:

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

## K.2 Risk Neutrality With Variance Constraint

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

$$\max_{d^*} E c_2^{house}$$

subject to

$$var(c_2^{house}) \leq \alpha V^h.$$

In Lagrangian form,

$$E c_2^{house} + \nu [\alpha V^h - var(c_2^{house})],$$

where  $\nu > 0$  is the multiplier. To see this, suppose  $\nu = 0$ . Then the solution when there is a premium on  $r$ , is to set  $d^* = -\infty$  which makes the variance  $+\infty$ . To avoid violating the constraint,  $\nu$  must be positive.

It is useful to simplify the variance term:

$$\begin{aligned}
\text{var} [(e_2 r^* - r) d^* + w_2 + Yr] &= E [(e_2 r^* - r) d^* + w_2 + Yr - E ((e_2 r^* - r) d^* + w_2 + Yr)]^2 \\
&= E [e_2 r^* d^* + w_2 - E (e_2 r^* d^* + w_2)]^2 \\
&= E [(e_2 - E e_2) r^* d^* + w_2 - E w_2]^2 \\
&= \text{var} (r^* e_2) (d^*)^2 + \text{var} (w_2) + 2d^* \text{cov} (r^* e_2, w_2) \tag{K.2}
\end{aligned}$$

Writing the problem explicitly and in Lagrangian form, we have

$$E [(e_2 r^* - r) d^* + w_2 + Yr] + \nu [\alpha V^h - E ((e_2 - E e_2) d^* r^* + w_2 - E w_2)^2]$$

The first order condition is:

$$\begin{aligned}
E (e_2 r^* - r) &= \nu 2E \left[ \left( (e_2 - E e_2) d^* (r^*)^2 + w_2 - E w_2 \right) (e_2 - E e_2) r^* \right] \\
&= \nu 2 \text{var} (e_2) d^* (r^*)^2 + \nu 2 r^* \text{cov} (w_2, e_2)
\end{aligned}$$

So,

$$d^* = \frac{E (e_2 r^* - r)}{\nu 2 \text{var} (e_2 r^*)} - \frac{\text{cov} (w_2, r^* e_2)}{\text{var} (r^* e_2)}. \tag{K.3}$$

It is useful to make the functional dependence of  $\nu$  on  $V^h$  explicit. By risk neutrality and assuming

$$E (e_2 r^* - r) \neq 0,$$

then the complementarity condition implies:

$$\text{var} (c_2^{\text{house}}) = \alpha V^h. \tag{K.4}$$

Equations (K.3) and (K.4) represent two equations in our two unknowns,  $d^*$  and  $\nu$ . Substituting from equation (K.2):

$$\text{var} (r^* e_2) (d^*)^2 + \text{var} (w_2) + 2d^* \text{cov} (r^* e_2, w_2) = \alpha V^h. \tag{K.5}$$

(K.3) and (K.5) can be solved as one nonlinear equation in  $\nu$ . In particular, fix  $\nu$  and compute  $d^*$ . Then, evaluate (K.5). Adjust  $\nu$  until (K.5) is satisfied. Problem is that the solution is not analytic, and not apparently very similar to the problem in section (J.1.1).

In any case, this is not what the VaR people, like Danielsson et al. (2010), are talking about since they assume  $w_2$  is non-random so that  $\text{var} (w_2) = \text{cov} (r^* e_2, w_2) = 0$ . In that

case,

$$\text{var}(r^* e_2) (d^*)^2 = \alpha V^h$$

so using equation (K.3) we get nonsense:

$$d^* = 1.$$

This is probably why Danielsson et al. (2010) make the constraint on the standard deviation,  $(\text{var}(c_2^{\text{house}}))^{1/2}$ , instead of on  $\text{var}(c_2^{\text{house}})$ . We look at the latter case in the following subsection.

### K.3 Risk Neutrality With Value at Risk Constraint

Now consider the following problem:

$$\max_{d^*} E c_2^{\text{house}}, c_2^{\text{house}} = (e_2 r^* - r) d^* + w_2 + Y r$$

subject to

$$\alpha [\text{var}(c_2^{\text{house}})]^{1/2} \leq V^h.$$

Again, under the assumption that  $E(e_2 r^* - r) \neq 0$ , we have that  $E c_2^{\text{house}}$  can be driven to positive infinity by driving  $d^*$  to  $\pm\infty$ . So, in this case the restriction will be binding. Writing the problem in Lagrangian form, we obtain

$$\max_{d^*} E c_2^{\text{house}} + \xi \left( V^h - \alpha [\text{var}(c_2^{\text{house}})]^{1/2} \right),$$

where  $\xi \neq 0$ . The first order conditions are:

$$E(e_2 r^* - r) = \xi \frac{\alpha}{2} \frac{d \text{var}(c_2^{\text{house}})}{[\text{var}(c_2^{\text{house}})]^{1/2} d d^*}, \quad (\text{K.6})$$

where, using equation (K.2)

$$\frac{d \text{var}(c_2^{\text{house}})}{d d^*} = 2 \text{var}(r^* e_2) d^* + 2 \text{cov}(r^* e_2, w_2).$$

We can write equation (K.6) as follows:

$$E(e_2 r^* - r) = \alpha \xi \frac{\text{var}(r^* e_2) d^* + \text{cov}(r^* e_2, w_2)}{[\text{var}(c_2^{\text{house}})]^{1/2}} = \alpha \xi \frac{\text{var}(r^* e_2)}{[\text{var}(c_2^{\text{house}})]^{1/2}} d^* + \alpha \xi \frac{\text{cov}(r^* e_2, w_2)}{[\text{var}(c_2^{\text{house}})]^{1/2}},$$

or, using the fact that the constraint binds,

$$\begin{aligned} d^* &= \frac{1}{\alpha\xi} \left[ E(e_2 r^* - r) - \alpha\xi \frac{\text{cov}(r^* e_2, w_2)}{[\text{var}(c_2^{\text{house}})]^{1/2}} \right] \frac{[\text{var}(c_2^{\text{house}})]^{1/2}}{\text{var}(r^* e_2)} \\ &= \frac{V^h}{\alpha^2 \xi} \frac{E(e_2 r^* - r)}{\text{var}(r^* e_2)} - \frac{\text{cov}(r^* e_2, w_2)}{\text{var}(r^* e_2)}, \end{aligned} \quad (\text{K.7})$$

which looks just like equation (J.6), with  $\lambda = \alpha^2 \xi / V^h$ . So, the solution is given by equation (K.7) and the binding constraint:

$$\alpha \left[ \text{var}(r^* e_2) (d^*)^2 + \text{var}(w_2) + 2d^* \text{cov}(r^* e_2, w_2) \right]^{1/2} = V^h. \quad (\text{K.8})$$

At this point, the problem is analytically complicated. It can be solved by choosing a particular value of  $\xi$  and then computing  $d^*$  using equation (K.7). Then, adjust  $\xi$  until (K.8) is satisfied.

In Danielsson et al. (2010) it is assumed that  $\text{var}(w_2) = \text{cov}(r^* e_2, w_2) = 0$ , so that (K.7) and (K.8) reduce to

$$d^* = \frac{V^h}{\alpha^2 \xi} \frac{E(e_2 r^* - r)}{\text{var}(r^* e_2)}, \quad V^h = \alpha \left[ (d^*)^2 \text{var}(r^* e_2) \right]^{1/2}. \quad (\text{K.9})$$

Note that the second equation cannot be used to compute  $d^*$ , only its absolute value. We first get an expression for  $\xi$ . Using the second equation in (K.9) to substitute out for  $V^h$  in the first equation,

$$d^* = \frac{\alpha [\text{var}(r^* e_2)]^{1/2} d^* E(e_2 r^* - r)}{\alpha^2 \xi \text{var}(r^* e_2)},$$

so that, after cancelling  $d^*$  on both sides and rearranging:

$$\xi = \frac{E(e_2 r^* - r)}{\alpha [\text{var}(r^* e_2)]^{1/2}}. \quad (\text{K.10})$$

Just like in Danielsson et al. (2010, eq. 14), according to the first equality in (K.10), the multiplier,  $\xi$ , is proportional to an object that looks like the Sharpe ratio. Using equation (K.10) to substitute out for  $\xi$  in the expression for  $d^*$  in the first expression in (K.9):

$$d^* = \left( \frac{V^h}{\alpha^2 \xi} \right) \frac{E(e_2 r^* - r)}{\text{var}(r^* e_2)} = \frac{V^h}{\alpha^2} \frac{\alpha [\text{var}(r^* e_2)]^{1/2} E(e_2 r^* - r)}{E(e_2 r^* - r) \text{var}(r^* e_2)} = \frac{V^h}{\alpha [\text{var}(r^* e_2)]^{1/2}} = d^*,$$

where the last equality uses the second equality in equation (K.10).

It seems misleading to think of the first equation in (K.9) as determining  $d^*$  as a function

of the ‘shifter’,  $\xi$ . The latter variable moves with the mean return and the variance of  $r^*e_2$ . It seems like the only expression which delivers  $d^*$  as a function of exogenous variables alone is the binding constraint, adjusted so that you can sign  $d^*$  :

$$d^* = \text{sign} [E(e_2r^* - r)] \frac{V^h}{\alpha [\text{var}(r^*e_2)]^{1/2}}$$

This looks very different from equation (J.6). Apart from the sign of  $E(e_2r^* - r)$ , it seems to leave no role for the magnitude of  $E(e_2r^* - r)$ , which plays an important role in the mean-variance approach.