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Financial Frictions, Foreign Currency Borrowing, and Systemic Risk*

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Abstract

Firms in emerging markets often borrow in foreign currency. Foreign currency borrowing can ameliorate financial frictions (by improving firms' incentives and reducing agency problems) but may increase systemic risk. In addition, through limited liability, foreign-currency denominated debt acts as a state-contingent claim: Borrowers maximizing profits in local currency are shielded from devaluations (when repaying FX debt is expensive) but pay higher rates in no-devaluation states (when repayment is relatively cheaper). The resulting trade-off between average performance and systemic stability, which becomes stronger when widespread bankruptcies increase the risk of failure, provides a rationale for regulatory measures that limit currency mismatches.

Keywords: liability dollarization, systemic risk, limited liability, banking crises
JEL Classification Numbers: E44, E58, G21

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Abstract

Firms in emerging markets often borrow in foreign currency. Foreign currency borrowing can ameliorate financial frictions (by improving firms' incentives and reducing agency problems) but may increase systemic risk. In addition, through limited liability, foreign-currency denominated debt acts as a state-contingent claim: Borrowers maximizing profits in local currency are shielded from devaluations (when repaying FX debt is expensive) but pay higher rates in no-devaluation states (when repayment is relatively cheaper). The resulting trade-off between average performance and systemic stability, which becomes stronger when widespread bankruptcies increase the risk of failure, provides a rationale for regulatory measures that limit currency mismatches.

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1 Introduction

In this paper we explore how foreign currency borrowing can ameliorate financial frictions in emerging economies while at the same time increasing systemic risk. Moreover, we focus on firm-level decisions to maximize expected profits that are independent of concerns related to the exploitation of government actions, or of coordinated actions across firms (see discussion below). Under conditions typical of fixed exchange rate regimes, foreign-currency-denominated liabilities improve firms' incentives and reduce the agency problem associated with limited liability and the unobservability of a firm's actions. In doing so, it reduces idiosyncratic risk for firms. However, foreign currency borrowing also exposes the system to the risk of correlated defaults through exchange rate devaluation.

Foreign currency borrowing (or liability dollarization) has been a common feature in several emerging market economies. Figure 1 illustrates this pattern, showing that the total amount of foreign currency denominated debt, expressed in U.S. Dollars, by corporations in emerging markets over the last decade has been large and increasing, readily surpassing the $1 Trillion mark.[1] Typically, this liability dollarization reduces the interest borrowers pay on their loans (these countries generally pay a currency premium) and has been associated with faster credit and economic growth. For instance, in the run-up to the recent global financial crises, among a sample of Eastern European countries, credit growth was the fastest in countries that had a larger share of credit denominated in foreign currency.

Liability dollarization, however, also increases systemic risk. Should the country experience a sharp currency depreciation, firms with unhedged foreign-currency denominated debt would find it difficult to honor their liabilities, resulting in widespread bankruptcies. Indeed, there is a clear link between liability dollarization and the frequency of crises, in particular in the banking sector.[2] Liability dollarization also appears to be associated with more rigid exchange rate regimes. For example, again in Eastern Europe, countries with currency boards or rigid pegs (such as Bulgaria,

[1]Bruno and Shin (2015) document that roughly one third of annual gross bond issuance by emerging market non-financial firms is foreign currency (i.e., US Dollar) denominated - see Figure 1. Apart from Asia, where the fraction of debt issuance that is foreign currency denominated is lower, issuance in foreign currency dominates in other emerging markets, such as Latin America (see IMF, 2015, figure 3.11). This becomes even more pronounced when focusing on external borrowing, where the fraction of such borrowing that is denominated in foreign currency is greater than 80%, as documented in Du and Schreger (2015).

[2]See Schneider and Tornell (2004).

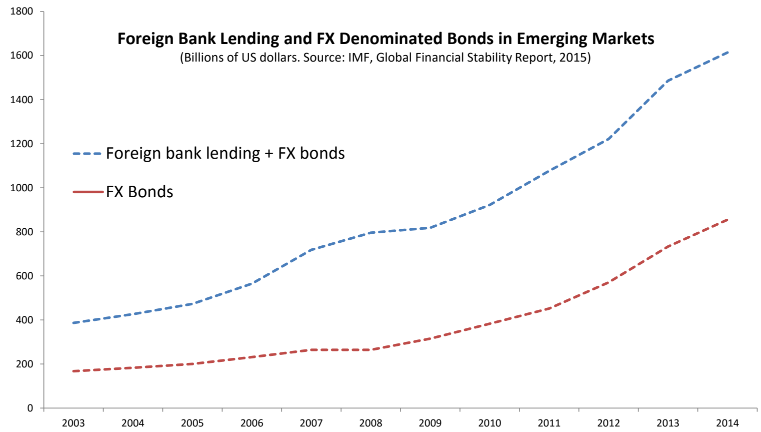


Figure 1: Foreign currency denominated debt in emerging markets, 2003-2014, expressed in U.S. Dollars. The solid red line represents the value of bonds outstanding from corporations in emerging market which were denominated in a foreign currency. The dashed blue line adds lending by foreign banks, the majority of which is foreign-currency denominated. The countries in the sample are Argentina, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Poland, Philippines, Romania, Russia, South Africa, Thailand, and Turkey.

Estonia, or Latvia) had a much larger share of credit to the private sector denominated in foreign currency than exchange rate floaters (such as the Czech Republic, Poland, and Slovakia).[3] There is also some evidence that the share of foreign currency lending in domestic credit gradually declined in countries that abandoned a fixed exchange rate regime.[4]

In our model, entrepreneurs borrow in order to invest in productive projects. A project's probability of success depends on the entrepreneur's costly effort. We introduce two basic financial frictions. First, entrepreneurs/firms are protected by limited liability. Second, an entrepreneur's effort is unobservable to lenders and cannot be contracted upon. These two frictions generate an inefficiency in the economy as they entail a backward bending credit supply curve (à la Stiglitz and Weiss, 1981). Higher interest rates reduce the entrepreneur's payoff in case of success and thus also reduce her effort. Then, when the cost of effort is sufficiently high, there does not exist an interest rate at which the lender can break even given the expected probability of repayment. Put differently, projects that could be funded under perfect information are rationed out of credit markets when the entrepreneur cannot commit to a particular level of effort.

We assume that the domestic currency is expected to depreciate relative to the foreign currency,

[3]See Rosenberg and Tirpak (2008).
[4]See Martinez and Werner (2002) for a study on Mexico in the aftermath of the Tequila crisis.

so that the risk free domestic interest rate is higher than the foreign rate, and that this spread is due to the expectation of a large devaluation to which markets attach a relatively low probability. We interpret these "peso problem" conditions as typical of exchange rate pegs and currency boards in emerging markets (where the foreign currency can be taken to be the US dollar or the euro). We also assume a less-than-complete exchange-rate pass-through, so that exchange rate movements have an impact on the solvency of firms with foreign-denominated liabilities. Under these conditions, firms derive two benefits from foreign currency borrowing. First, there is a pure state-contingent pricing effect driven by limited liability for the borrowing firm: devaluations increase the cost to the borrowing firm (which cares about its return in domestic currency) of repaying its foreign currency debt; and large devaluations lead to default when the firm is subject to limited liability. But default is efficient here since it allows the borrowing firm to reallocate repayment from states of the world in which it is expensive (i.e., devaluation states) to those in which it is relatively cheap (when the peg holds). This occurs through a foreign currency lending rate that prices default risk fairly.[5]

Second, we show that foreign currency borrowing reduces the moral hazard associated with limited liability. The reason is that borrowing in foreign currency acts as a bonding mechanism for the firm: since the risk free rate abroad is lower, the firm is able to obtain a lower interest rate loan. This creates a higher return for the firm whenever its project is successful, and provides the firm with a greater incentive to ensure that its return actually materializes, i.e., to put in more effort.[6] The trade-off, however, is that borrowing in foreign currency exposes the firm to devaluation risk, which can lead to default and hence bankruptcy costs. The probability of bankruptcy depends on the distribution of possible exchange rate movements: when the probability of an exchange rate movement is high, foreign currency lending worsens, rather than ameliorates, the agency problem. It is only when the devaluation risk is relatively low, but the potential movement in the exchange rate large, that borrowing in foreign currency increases firm value through the two channels discussed above. This is because the negative effect on incentives of the additional default risk is proportional to the probability of devaluation, while the positive effect stemming from reduced interest payments

[5]See Dell'Ariccia and Marquez (2015) for a general treatment of this issue.

[6]This is akin to what happens in standard banking models with risk shifting emanating from limited liability. In those models, higher deposit rates tend to increase risk taking by reducing bank profits (or franchise values). See for instance, Matutes and Vives (2000), Hellmann, Murdock, and Stiglitz (2000), Repullo (2004), Boyd and De Nicolo (2005), Allen, Carletti, and Marquez (2011), Dell'Ariccia, Laeven, and Marquez (2014).

depends in the expected exchange rate movement.

From a policy perspective, the paper supports the view that government intervention, in the form of (macro) prudential regulation and/or capital controls, to curb foreign currency borrowing and the systemic risks associated with it may be socially optimal. The paper points to a trade-off between superior productivity and greater systemic risk (defined as the risk of widespread failures, i.e., a crisis). This trade-off becomes important in the context of social costs of failure that may be non-linear and therefore large when risk is systemic. While the model assumes risk neutrality throughout, these concerns are likely important in practice.

We explore this issue further by extending the model to consider the possibility that the failure of a counterparty negatively affects firms with successful projects and causes them to fail as well. This issue becomes more important the more firms fail at the same time, and we show that this adds an additional important wrinkle to the problem. In particular, the risk of devaluation acts as an externality if widespread failures may affect a firm's counterparties, thus having a detrimental effect on that firm's ability to repay even if it would be otherwise sound. If a sufficiently large fraction of firms borrows in foreign currency, others (who would have otherwise borrowed in local currency) may find it optimal to do the same as they are exposed to the risk of devaluation through its effects via the real economy. The possibility of counterparty failure thus affects firms' choice of whether to borrow in the domestic or the foreign currency as well as entrepreneurial effort - there is a complementarity in the choice of borrowing denomination - and may further exacerbate the likelihood and the severity of a systemic crisis. Under these conditions, measures aimed at limiting foreign currency borrowing may be welfare improving.

The paper relates to a broad literature on how financial imperfections contribute to shaping international capital flows. In Bris and Koskinen (2002), foreign currency borrowing arises because governments find it optimal ex post to bail out exporting firms by devaluating the currency, thereby reducing debt overhang problems for highly leveraged firms with profitable export opportunities. Our analysis is closest to Ranciere, Tornell, and Westermann (2008) and Schneider and Tornell (2004). As in those papers, foreign currency borrowing can help address an agency problem and increases output in tranquil times at the cost of greater risk of systemic crises. In those papers, however, credit rationing helps to resolve the asymmetric information problem between borrowers and lenders so that, in the absence of bailout guarantees, risk is correctly priced at the margin. Here, while risk is correctly priced in equilibrium, lenders cannot condition their pricing on an entrepreneur's effort. As a result, systemic risk associated with foreign currency borrowing can emerge even in the absence of bailout guarantees. From this point of view, our paper identifies an additional mechanism linking systemic risk and economic performance.

Several other papers focus on the interaction between liability dollarization and government behavior. In Jeanne (2009), a sovereign's inability to protect foreign creditors' rights results in a system dominated by short-term loans. This short maturity structure provides governments with incentives to enforce foreign contracts. However, it comes at the cost of risking liquidation (i.e., a "run") triggered by negative productivity shocks (a similar theme is in Tirole, 2003). In Velasco and Chang (2004), foreign currency borrowing emerges as a reaction to the expectation that the central bank will choose a fixed exchange-rate regime. Then, the financial instability that a devaluation would cause through balance-sheet effects induces the central bank to fight exchange rate flexibility, validating expectations. Under these conditions, committing to exchange-rate flexibility, if feasible, is welfare improving. A similar analysis is in Chamon and Hausmann (2005). In Jeanne (2005), foreign currency borrowing is an outcome of domestic monetary policy. If monetary policy mitigates default risk in the private sector, firms will tend to borrow in domestic currency. If, on the other hand, the monetary environment does not protect firms against low realizations of their domestic currency income, firms will borrow in foreign currency because borrowing in domestic currency can result in unbearably high real debt burdens if the expected domestic monetary policy does not materialize ex post. In Korinek (2011), foreign currency debt emerges from an optimal portfolio choice problem with a risk premium on local currency debt. The advantage of local currency debt is that it mitigates economic volatility. Local currency debt emerges at low levels of volatility of consumption and the exchange rate, as well as when risk premia on local currency debt are low.

Most of the existing work on the explanations for foreign currency borrowing, such as that discussed above, rely on firms trying to exploit some kind of government policy that will then benefit them. These government distortions range from expectations of government bailouts – as in Schneider and Tornell (2004) and Bris and Koskinen (2002) – to devaluations – as in Ranciere, Tornell, and Westermann (2008), Velasco and Chang (2004), and Chamon and Hausmann (2005) –

to monetary policy – as in Jeanne (2005). Our model shows that, even with risk neutrality for all parties, foreign-currency borrowing can be optimal in the absence of any government distortions when other financial imperfections such as limited liability and deviations from the law of one price are present. All that is required is a less-than-complete pass-through of exchange rate movements on local currency prices. This makes exchange rate movements and the currency composition of liabilities relevant for borrowers' solvency. And, critically, it allows for large currency depreciations to trigger limited liability protection. At the same time, the implied deviations from international prices provide a justification for the assumption that local borrowers maximize their profits in local currency. In contrast, with a complete pass-through (when local currency prices adjust in tandem with the exchange rate) the currency composition of liabilities is irrelevant and a depreciation cannot, per se, trigger a borrower's insolvency. Put differently, all borrowers would be naturally hedged if exchange rate movements were to pass through perfectly onto prices in the local currency.

There is ample evidence that exchange rate pass-throughs are less than complete in practice and that there can be long-lived deviations from the law of one price (see, for instance, Gopinath et al., 2010, and the survey by Rogoff, 1996). This, together, with the evidence of the large balance sheet effects associated with currency depreciations in countries with pervasive dollarization of liabilities (see, for instance, Calvo et al., 2004) suggest that the incomplete pass-through assumption underlying our model is realistic.

While we cast the analysis in the context of domestic- versus foreign-currency borrowing, we believe that several insights from our framework apply more broadly. In particular, the central finding that a reduction in idiosyncratic risk, and the related efficiency gains, may come at the cost of greater systemic risk applies to other contexts. For instance, consider the trade-off between fixed- and variable-rate debt contracts. Under normal conditions, short-term rates will be lower than long-term ones, allowing for better borrower incentives, much the way that foreign currency borrowing does in our model. However, such short term contracts will leave firms exposed to potentially sharp increases in their debt burden, in a similar fashion to how devaluation affects firms in our model. While interest rate changes will typically be small and gradual, unlike devaluation in our model, there are cases in which even marginal changes will imply payment difficulties for certain borrowers. For example, this kind of effect was observed for a large fraction of subprime borrowers when their contracts reset, suggesting that the basic ideas here may be applied to a broader context such as the maturity composition of debt rather than its currency denomination. A related argument has also been made in the context of the use of short term, or even demandable, debt by banks, where a risky financing choice can help alleviate a moral hazard problem that otherwise would lead to excessive risk taking or, equivalently, too little effort in monitoring (see Calomiris and Kahn, 1991, and Diamond and Rajan, 2001).

The paper proceeds as follows: Section 2 examines a series of stylized facts and the empirical literature on foreign currency borrowing and financial crises. Section 3 presents the main model. Section 4 examines the case with no moral hazard, while Section 5 studies the case with moral hazard. Section 6 extends the model to the case of counterparty risk. Section 7 discusses the trade-off between total expected output and aggregate risk. Section 8 concludes and briefly discusses the policy implications of the model.

2 Stylized facts and empirical evidence

In this section, we review the empirical literature on foreign currency borrowing and financial crises, and present some stylized facts that are consistent with the predictions of our model.

Much of the micro-level empirical literature on the determinants of foreign currency borrowing and the balance sheets effects that arise as a result of currency depreciations when firms borrow in foreign currency has focused, due to data limitations, on large and publicly traded firms. Allayanis, Brown, and Klapper (2003) investigate the capital structure of 327 large, publicly traded firms in East Asia around the time of the East Asian financial crisis and collect data on their local, unhedged foreign, and hedged foreign currency debt. They find that interest rate differentials are a key determinant of the use of foreign currency debt, and that the market value of firms that used financial hedges to synthetically convert foreign currency debt into local debt were hit particularly hard during the 1997-98 East Asian financial crisis. Bleakley and Cowan (2008) study the currency composition of the debt of 500 publicly traded firms in Latin America during the period 1990 to 1999, a period of substantial exchange rate volatility in this region of the world, and find that the sensitivity of firms' investments does not depend on the currency composition of their debt because firms tend to match the currency composition of their debt with the elasticity of their income to the exchange rate. For a sample of large US firms, Kedia and Mozumdar (2003) find that firms issue foreign currency debt mainly to hedge their exposure to foreign currencies. Similarly, Keloharju and Niskanen (2001) find for a sample of large Finnish firms that hedging features prominently in the decision to borrow in foreign currency, with firms for which exports represent a larger fraction of sales more likely to raise foreign currency debt. At the same time, they also find that firms tend to borrow in foreign currency when the foreign interest rate is relatively low, consistent with carry trade explanations.

Many of these results may be skewed by the focus on large and stock-exchange listed firms that are often in a better position to use financial hedges compared to small firms (either because of know-how or economies of scale). In fact, Gelos (2003), using data on 500 Mexican firms, shows that firm size is a key determinant of foreign currency borrowing in addition to imports and exports. Moreover, a large fraction of these firms has natural hedges against exchange rate risks because they operate in the tradable sector and have significant foreign currency revenues. Not surprisingly, much of this literature finds relatively small balance sheet effects associated with foreign currency borrowing during currency crises (for reviews, see Galindo, Panizza, and Schiantarelli, 2003, and Kamil, 2008).

Brown, Ongena and Yesin (2009) are the first to study the determinants of foreign currency borrowing for a representative sample of firms that includes small firms using survey data on firms in Eastern Europe. They find that firms that naturally generate a larger fraction of income in foreign currency, such as exporting firms, are more likely to borrow in foreign currency, while interest rate differentials and exchange rate volatility do not explain the use of foreign currency borrowing. Brown, Kirschenmann, and Ongena (2009) study a representative sample of Bulgarian firms and find that foreign currency borrowing is not only driven by demand factors but is partly supply-driven by banks that prefer to lend in foreign currency to minimize currency mismatches in their balance sheets, even when borrowers request loans in domestic currency. Obviously, this still exposes the banks to credit risks arising from balance sheet effects of their borrowers in case of currency depreciation.

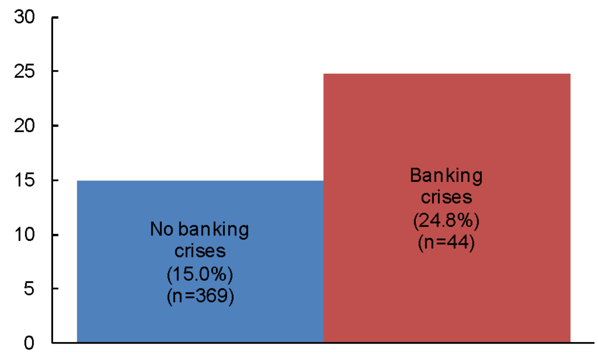
Ranciere, Tornell, and Vamvakadis (2010) also study a representative sample of firms in Eastern Europe and focus on foreign currency borrowing by firms with no foreign currency income. They find that currency mismatches reduce interest rates and enhance growth of small firms in non-tradable sectors, thereby contributing to growth in tranquil times, while at the same time increasing the probability of crises. They argue that the expectation of government bailouts in the event of a currency crisis is one of the mechanisms that fosters the use of foreign currency borrowing by firms that face borrowing constraints.

The empirical link between foreign currency borrowing and boom-bust cycles has led countries to implement regulatory policies to slow foreign currency borrowing during credit booms, although these policies have typically met with only limited success, mainly because these policies are generally easy to circumvent through, for instance, direct borrowing from abroad (Rosenberg and Tirpak, 2008). At the macro-level, a large empirical literature links banking and currency crises to credit booms accompanied by an overvalued currency, although most of this literature does not distinguish between local and foreign currency borrowing (see, for example, Kaminsky and Reinhart, 1999). In an exception, Ize and Levy-Yeyati (2003) show that the use of foreign-currency debt can be linked to macroeconomic uncertainty, including the relative volatility of domestic inflation and the real exchange rate.

Using data on foreign currency borrowing from the IMF's Vulnerability Exercise Database (not publicly available), Figure 2 shows a clear link between the degree of foreign currency borrowing in the country and the occurrence of banking crises, as defined in Laeven and Valencia (2008), in a sample of 114 countries. Foreign currency borrowing from banks in countries that experienced banking crises over the period 1970 to 2010 stood at 24.8 percent on average compared to only 15.0 percent in countries that did not experience a banking crisis over this period. These empirical findings are consistent with the prediction from our model that foreign currency borrowing exposes borrowers to exchange rate risk and exposes lenders to default risk from devaluation-driven balance sheet effects.

On the deposit-taking side of banks, De Nicolo, Honohan, and Ize (2003) show that dollarization is associated with deeper financial development, especially in high inflation environments. This is consistent with the model in Caballero and Krishnamurthy (2003) who argue that limited financial development reduces the incentives for foreign lenders to enter emerging markets.

Using data from Levy-Yeyati (2006) on the degree of dollarization of deposits in the country,



Notes: The red (blue) bar denotes the average percentage of foreign currency lending to nominal GDP across country-year observations for those years over the period 1970-2010 during which the country did (not) experience a systemic banking crisis, as defined in Laeven and Valencia (2010). Data on banking crises from Laeven and Valencia (2010), "Resolution of Banking Crises: The Good, the Bad, and the Ugly," IMF working paper 10/146, and data on percentage of foreign currency lending to nominal GDP from the IMF's Vulnerability Exercise Database. Number of country-year observations (n) between brackets. Sample of 114 countries.

Figure 2: Foreign currency lending to GDP and occurrence of banking crises, 1970-2010

Figure 3 shows a clear link between dollarization and the occurrence of banking crises, in line with the findings on the link between foreign currency lending and banking crises shown in Figure 2. The ratio of foreign currency deposits in total deposits is about 29 percent on average for countries that experienced a banking crisis over the period 1970 to 2004 compared to only 18 percent for countries that did not experience a banking crisis over this period.

A related literature studies the link between exchange rate regimes and banking crisis. Burnside, Eichenbaum, and Rebelo (2001) argue that banks in countries with a fixed exchange rate regime do not completely hedge the exchange risk that arises from the currency mismatch between their assets and liabilities in anticipation of government bailouts, and that such open foreign exchange positions makes banks prone to banking crises associated with currency crises. Empirical studies generally find that fixed exchange rate regimes, and especially those with hard pegs, are more prone to banking crises than flexible exchange rate regimes or those with adjustable pegs, and that banking crises in fixed exchange rate regimes are more costly in terms of severity of crisis and output losses (Eichengreen, 2002, Demac and Martinez Peria, 2003, and Husain et al., 2005).

Figure 4 shows that foreign currency borrowing is more pervasive in countries with fixed exchange rate regimes, which together with Figure 2 suggests that the currency composition of borrowing may be a key driver linking fixed exchange rate regimes to crises. In the context of our model this association can be interpreted as fixed exchange rates being associated with higher expected

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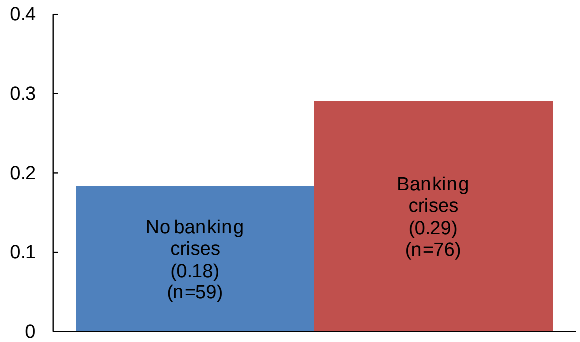

Notes: Bars denote the average degree of dollarization over the period 1970-2004 across countries depending on whether or not they experienced a systemic banking crisis during the period 1970-2004, as defined in Laeven and Valencia (2008). Degree of dollarization is the ratio of foreign currency deposits in total deposits. Data on the occurrence of banking crises are from Laeven and Valencia (2008), “Systemic Banking Crises: A New Database”, IMF Working Paper 08/224, and data on the degree of dollarization are from Levy-Yeyati (2006), “Financial Dollarization: Evaluating the Consequences,” Economic Policy, January, pp. 61-118. Number of country observations (n) between brackets.

Figure 3: Degree of dollarization and occurrence of banking crises, 1970-2004

devaluations despite higher probabilities (α) of the exchange rate remaining constant.

3 Model

Consider an economy populated by entrepreneurs/firms that invest $1 in risky assets that return y when successful and 0 otherwise. A firm's effort determines the probability of success, q, at a cost $\frac{c}{2}q^2$. The cost c reflects country level institutional considerations that make it difficult for firms to establish good governance structures, such as because of the poor enforcement of investor rights. Firms have no initial funds and need to borrow in order to invest. The loan contract specifies the *gross* interest rate (i.e., one plus the net interest rate) r_L to be repaid by the borrower.

This is an open economy and firms can borrow in a competitive credit market, in either the domestic or a foreign currency. The two currencies are linked by a standard interest parity condition: $r_f = r_f^* \frac{\overline{e}}{e}$, where r_f is the gross (credit) risk-free interest rate in domestic currency, r_f^* its equivalent in foreign currency, $\overline{e}$ the expected future exchange rate change, and e the current exchange rate. For simplicity, we assume that exchange rate movements are governed by a binomial distribution: the exchange rate stays constant with probability α, and depreciates by Δe with probability $1-\alpha$.[7]

[7] We use the simplest exchange rate process possible to illustrate the main effects in the model, which stem from limited liability and agency problems within the firm. The main results can all be shown to hold for more general distributions of exchange rate movements as long as they include the possibility of large devaluations which occur relatively infrequently.

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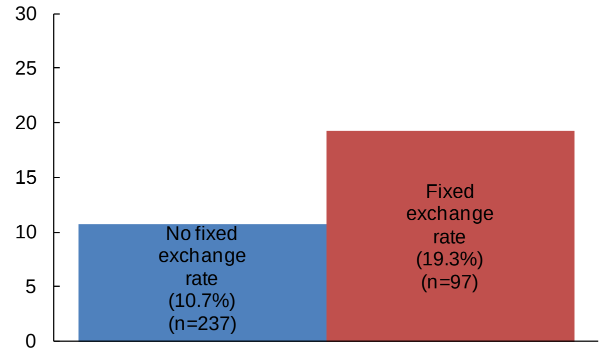

Notes: The red (blue) bar denotes the average percentage of foreign currency lending to nominal GDP across country-year observations over the period 1970-2010 during which the country did (not) have a fixed exchange rate regime. Data on classification of exchange rate regimes from Reinhart, Carmen and Kenneth Rogoff, 2004, “The Modern History of Exchange Rate Arrangements: A Reinterpretation,” Quarterly Journal of Economics 119(1): 1-48, and data on percentage of foreign currency lending to nominal GDP from the IMF’s Vulnerability Exercise Database. We define fixed exchange rate regimes as exchange rate regimes with preannounced or de facto pegs (classification codes 2, 3 or 4 in Reinhart and Rogoff). Data on exchange rate regimes are averaged over the period 1970-2007. Number of country-year observations (n) between brackets.

Figure 4: Exchange Rate Regimes and Foreign Currency Lending, 1970-2010

Thus, we can rewrite the interest parity condition as

$$r_f = r_f^* \left(1 + (1-\alpha)\frac{\Delta e}{e}\right). \tag{1}$$

Without loss of generality, we normalize the current exchange rate e to 1, so that Δe measures not just the absolute change in the exchange rate, but also the relative change.

4 Optimal currency denomination with exogenous project risk

We first consider the case where the firm must choose the denomination of its debt - domestic or foreign currency - but its project’s success probability is exogenous and independent of effort. Studying this issue allows us to isolate the effect of currency denomination stemming purely from limited liability without confounding it with effects related to the moral hazard problem that may arise from the firm’s effort decisions. Specifically, we assume that a project’s probability of success is fixed by an exogenous parameter q_0, and is not subject to the firm’s control. This is equivalent to assuming that effort q leads to project success $q_0 + q$, but that the cost $c = \infty$, so that no firm would ever put in any additional effort to increase project success above q_0.

When borrowing in domestic currency, a firm’s expected profits can be written as

$$\Pi = q_0(y - r_L), \tag{2}$$

which reflects the fact that the firm is protected by limited liability and that the project will only pay off with probability q_0. When the project does pay off, the cash flow from the project is y, and the firm repays the lender the promised amount r_L. Since there is no effort for this benchmark case, the firm's expected profits are then just $q_0(y - r_L)$. The interest rate on the loan has to reflect the risk associated with the project, q_0. With no moral hazard, and competitive credit markets, we have

$$q_0 r_L = r_f \Rightarrow r_L = \frac{r_f}{q_0}.$$

We can substitute this into the expression for expected profits to get

$$\Pi = q_0 \left(y - \frac{r_f}{q_0} \right) = q_0 y - r_f.$$

It is useful to use the interest parity condition to express this in terms of the foreign risk free rate, in which case we get

$$\Pi = q_0 y - r_f^* \left(1 + (1 - \alpha) \frac{\Delta e}{e} \right).$$

We can write the firm's expected profits when borrowing in foreign currency in similar fashion:

$$\Pi^f = \alpha q_0 (y - r_L^*), \tag{3}$$

which reflects the fact that the project only pays off with probability q_0, but also the firm's return net of loan repayment is only positive if the domestic currency does not depreciate. The loan interest rate must again reflect the lender's expectations of actually being repaid.

Assume that there are no liquidation costs and that in case of depreciation all of the project's revenue accrues to the lender. In that case, the lending rate on the foreign denominated loan must satisfy

$$\alpha q_0 r_L^* + (1 - \alpha) q_0 y \frac{e}{e + \Delta e} = r_f^*,$$

which gives

$$r_L^* = \frac{r_f^*}{\alpha q_0} - \frac{(1 - \alpha) y}{\alpha} \frac{e}{e + \Delta e}.$$

Plugging r_L^* back into the profit function gives

$$\Pi^* = \alpha q_0 \left(y - \frac{r_f^*}{\alpha q_0} + \frac{(1 - \alpha) y}{\alpha} \frac{e}{e + \Delta e} \right) = q_0 y \left(\frac{\alpha \Delta e + e}{e + \Delta e} \right) - r_f^*. \tag{4}$$

We can now establish the following.

Proposition 1 *When there are no bankruptcy or liquidation costs, and when uncovered interest parity (UIP) holds (as in (1)), firms prefer to borrow in foreign currency rather than domestic currency.*

Proof: Using the expressions above, profits for the borrowing firm are higher when borrowing in foreign currency than when borrowing in domestic currency if

$$\Pi^{*}=q_0 y\left(\frac{\alpha\Delta e+e}{e+\Delta e}\right)-r_f^{*}>q_0 y-r_f^{*}\left(1+(1-\alpha)\frac{\Delta e}{e}\right)=\Pi.$$

Rearranging yields

$$q_0 y\left(\frac{\alpha\Delta e+e}{e+\Delta e}\right)-\frac{r_f^{*}(e+\Delta e)}{e+\Delta e}>q_0 y-r_f^{*}\left(\frac{e+(1-\alpha)\Delta e}{e}\right),$$

which is equivalent to

$$r_f^{*}>\frac{eq_0 y}{(e+\Delta e)}. \tag{5}$$

The right hand side is the expected value of the output ($q_0 y$) expressed in foreign currency ($eq_0 y$) in the event of a devaluation, so that we divide by $e+\Delta e$. This by assumption is less than the foreign risk free rate, r_f^{*}. Therefore, (5) is always satisfied and borrowing in foreign currency is always preferred when UIP holds and there is no liquidation or bankruptcy costs. □

To understand the source of the gain associated with borrowing in foreign currency, it is useful to compare the result from Proposition 1 to what would obtain if the borrowing firm were subject to unlimited liability and could commit to fully repay the lender in all states of the world. For ease of exposition, normalize the initial exchange rate so that $e=1$.

When liability is unlimited, the firm's payoff when borrowing in foreign currency is

$$\widetilde{\Pi}^{*}=q_0\left[\left(y-r_f^{*}\right)-(1-\alpha)(1+\Delta e)r_f^{*}\right]-(1-q_0)\left[\alpha r_f^{*}+(1-\alpha)(1+\Delta e)r_f^{*}\right].$$

For simplicity, let $q_0=1$, in which case the expression becomes

$$\widetilde{\Pi}^{*}=y-r_f^{*}(1+(1-\alpha)\Delta e)$$

Note that this is identical to the expected profit from borrowing in local currency. Indeed, absent limited liability or other frictions, the interest parity condition is constructed by imposing equality in the firm's payoffs regardless of in which currency it borrows. Notice, however, that

$$\Pi^* - \widetilde{\Pi}^* = y\left(\frac{\alpha\Delta e + 1}{1+\Delta e}\right) - r_f^* - y + r_f^*\left(1 + (1-\alpha)\Delta e\right)$$
$$= (1-\alpha)\Delta e\left(r_f^* - \frac{y}{1+\Delta e}\right),$$

which is positive since we assumed that, in the devaluation state, the firm's revenue is not sufficient to cover the foreign risk-free rate: $r_f^* > \frac{y}{1+\Delta e}$. Indeed, this is the same condition as in the proof of the proposition given that with unlimited liability the firm is indifferent between borrowing in either the domestic or the foreign currency.

Thus, $\widetilde{\Pi}^* < \Pi^*$, the profits that obtain under limited liability when $q_0 = 1$. The reason is that when liability is unlimited and the firm is required to repay the same amount, r_f^*, in all states of the world (i.e., whether devaluation occurred or not), the firm bears the entire cost associated with the devaluation, which is $(1-\alpha)\Delta e$. From the perspective of the borrowing firm, however, this is suboptimal since when the currency depreciates, which occurs with probability $1-\alpha$, it bears a cost $1+\Delta e$ per unit it has to repay, rather than the cost e (normalized to 1) when no depreciation has occurred. In other words, depreciation of the domestic currency makes foreign currency denominated debt repayment more expensive for a firm that cares about its return or profits measured in domestic currency.

Limited liability, by contrast, allows the firm to default when the devaluation is large, and shift payments it would otherwise have to make into states of the world where no devaluation has taken place and as a consequence the firms views it as cheaper to repay. The lender, who is risk neutral, is indifferent as long as in expectation he receives the foreign interest rate r_f^*. Indeed, the larger is the probability that no devaluation takes place (i.e., the larger is α), the easier it is for the borrowing firm to increases its repayment in no-devaluation states, and still obtain the return y from its investment. Thus, for α large enough, the savings obtained from being able to repay in low cost (in terms of the cost of buying foreign currency) rather than in high cost states allows the firm to borrow more cheaply in foreign currency. This gain only presents itself as a result of limited liability, which is triggered when a sufficiently large devaluation takes place.[8] It is important to note as well that, unlike much of the extant literature, here the preference for borrowing in foreign

[8] Dell'Ariccia and Marquez (2015) provides a general treatment of this issue showing that a contract with state-contingent payments negatively correlated with the exchange rate level is preferred to a non state-contingent contract.

currency arises purely because of limited liability, and does not depend on attempts to exploit possible government actions, or coordinated actions across firms. To our knowledge, ours is the only rational firm-level explanation for "liability dollarization" of firms.

The extreme result in Proposition 1 is predicated on the fact that there are no frictions associated with a firm's default. In particular, there are no liquidation or bankruptcy costs that arise when the firm fails to repay. More realistically, one may well expect a trade-off between the losses that may arise under bankruptcy and the gains from being able to shift payments across states. To introduce a real cost associated with possible bankruptcy, assume going forward that under devaluation, the lender receives nothing back from the borrower. This would be consistent, for instance, with a very large devaluation that leaves little on the firm's balance sheet, and which subsequently gets lost as part of bankruptcy proceedings. While extreme and also perhaps somewhat unrealistic, as we show later this assumption in fact biases against borrowing in foreign currency. Under this assumption, we can establish the following variant of Proposition 1.

Proposition 2 *For $q_0 \in [0,1]$, and keeping the size of the expected devaluation, $(1-\alpha)\frac{\Delta e}{e}$, constant, there exists a value $\underline{\alpha} < 1$ such that if the probability of no devaluation, α, is greater than $\underline{\alpha}$, firms prefer to borrow in foreign currency rather than domestic currency.*

Proof: Under the assumption that there is no recovery when a devaluation takes place and the firm defaults, the promised repayment on the foreign loan, r_L^*, must satisfy

$$\alpha q_0 r_L^* = r_f^* \Rightarrow r_L^* = \frac{r_f^*}{\alpha q_0}.$$

Plugging this back into (3) yields

$$\Pi^* = \alpha q_0 \left(y - \frac{r_f^*}{\alpha q_0} \right) = \alpha q_0 y - r_f^*. \tag{6}$$

From 6 above, $\Pi^* > \Pi \Leftrightarrow$

$$\alpha q_0 y - r_f^* > q_0 y - r_f^* \left(1 + (1-\alpha)\frac{\Delta e}{e} \right).$$

As $\alpha \to 1$, the left hand side converges to $q_0 y - r_f^*$, which is larger than the right hand side, which is independent of α given that the expected devaluation, $(1-\alpha)\frac{\Delta e}{e}$, is held constant. Therefore, for α large enough $\Pi^* > \Pi$. $\square$

Proposition 2 shows that when the risk of devaluation is sufficiently low, but the actual devaluation if it occurs is large, borrowing in foreign currency may be optimal relative to having debt denominated in domestic currency even when the devaluation causes a loss for all parties. In other words, "peso problem" conditions push firms toward borrowing in foreign rather than domestic currency. This preference for a currency mismatch between assets and liabilities, which occurs for the same reason as in Proposition 1, arises despite the fact that a parity condition holds between the domestic and the foreign risk free rate, that the firm is risk neutral and there is no agency problem, and that there is no government action (e.g., a bailout) being exploited.

5 Moral hazard and currency choice

In this section, we allow firms to determine the probability of success of their projects, q, at a cost $\frac{c}{2}q^2$. As described below, because of leverage and the non-observability of effort, this introduces a moral hazard problem.

5.1 Domestic currency borrowing

Much as above, when a firm borrows in local currency, it's expected profits can be written as

$$\Pi = q(y - r_L) - \frac{c}{2}q^2,$$

which is the same as (2) except that we subtract the cost of effort, $\frac{c}{2}q^2$. Maximizing this with respect to the level of effort gives

$$\widehat{q} = \frac{y - r_L}{c}.$$

The interest rate charged on the loan has to reflect the level of risk associated with the project. Suppose that investors or lenders conjecture a level of effort q^C. Since lenders are competitive, this then means that

$$q^C \widehat{r}_L = r_f \Rightarrow \widehat{r}_L = \frac{r_f}{q^C}.$$

In equilibrium, lenders' beliefs about the amount of effort that will be supplied must be correct, which means that $q^C = \widehat{q}$. We can substitute this into the expression for optimal effort $\widehat{q}$ to obtain $\widehat{q} = \frac{y - \frac{r_f}{\widehat{q}}}{c}$, and then solve for $\widehat{q}$ as

$$\widehat{q} = \min\left\{\frac{y + \sqrt{y^2 - 4cr_f}}{2c}, 1\right\}, \tag{7}$$

where (7) reflects the fact that the positive root that solves for the equilibrium value of effort is Pareto optimal (this can be easily shown).[9] The constraint that $\widehat{q} \leq 1$ reflects the fact that $\widehat{q}$ is the probability of project success and hence cannot exceed 1. Throughout, we focus on the case where there is an interior solution for the firm's effort, so that $\widehat{q} < 1$. It is straightforward to see that parameter values exist that guarantee $\widehat{q} < 1$ in equilibrium. We also assume that financing is viable, which amounts to assuming that $\widehat{q}$ is a real variable. A sufficient condition to guarantee this is that $y^2 - 4cr_f > 0$. We come back to this issue later when we explore the conditions under which investment, which entails financing, is feasible.

We can now invert the expression for optimal effort to obtain $\widehat{r}_L = y - \widehat{q}c$, which, after substituting for $\widehat{q}$ yields

$$\widehat{r}_L = y - c\frac{y + \sqrt{y^2 - 4cr_f}}{2c} = \frac{y}{2} - \frac{\sqrt{y^2 - 4cr_f}}{2}.$$

Using the optimal value $\widehat{q}$, we can write the equilibrium expected profits as

$$\begin{aligned}\Pi &= \widehat{q}(y - r_L) - \frac{1}{2c}(y - r_L)^2 = \frac{1}{c}(y - r_L)^2 - \frac{1}{2c}(y - r_L)^2 \\ &= \frac{1}{2c}(y - r_L)^2.\end{aligned}$$

Substitute now for the optimal $\widehat{r}_L$ to obtain

$$\widehat{\Pi} = \frac{1}{2c}\left(\frac{y + \sqrt{y^2 - 4cr_f}}{2}\right)^2.$$

Finally, again as above, we can use the interest rate parity condition, (1), to write the equilibrium profits $\widehat{\Pi}$ as a function of the foreign risk free rate, r_f^*, and the expected exchange rate movement, $(1-\alpha)\frac{\Delta e}{e}$:

$$\widehat{\Pi} = \frac{1}{2c}\left(\frac{y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}}{2}\right)^2. \tag{8}$$

Note that leverage and the fact that risk cannot be priced at the margin generates a moral hazard problem: In the absence of limited liability, the firms' effort choice would be $q^* = \frac{y}{c} \geq \widehat{q}$. Then, since equilibrium effort is below its socially optimal level (and lenders are competitive), borrowers would benefit from a mechanism that allowed them to reduce the moral hazard problem.

[9] While in principle the negative root may also be part of a Nash equilibrium, we assume going forward that the Pareto dominant solution - the positive root - will be chosen.

5.2 Foreign currency borrowing

We assume, as above, that the possible depreciation Δe is large enough that, in the event of a depreciation, the firm would go bust and default on its loan. Similar to above, we can write a firm's expected profit when it borrows in foreign currency as

$$\Pi^* = \alpha q(y - r_L^*) - \frac{c}{2}q^2,$$

which is essentially the same as (3) except that it subtracts the cost of effort. We maximize these profits Π^* with respect to effort to obtain

$$\widehat{q}^* = \min\left\{\left(\frac{y - r_L^*}{c}\right)\alpha, 1\right\}. \tag{9}$$

As above, we will focus on the case where an interior solution exists, so that $\widehat{q}^* < 1$.

Now, since firms only repay when the currency remains stable, for banks/investors to be willing to lend in foreign currency the interest rate needs to compensate them for both the borrower idiosyncratic risk, $1-q$, and the devaluation risk, $1-\alpha$. As above, we assume that under devaluation, the lender receives nothing back from the borrower. This would be consistent, for instance, with a very large devaluation that leaves little on the firm's balance sheet, and which subsequently gets lost as part of bankruptcy proceedings, and biases against borrowing in foreign currency. Under this assumption, we have that, given a conjectured level of effort q^{*C} and competitive credit markets, the promised repayment on the foreign loan, r_L^*, must satisfy

$$q^{*C}\alpha r_L^* = r_f^*.$$

From this we can solve for the equilibrium foreign denominated loan rate, $\widehat{r}_L^*$, as

$$\widehat{r}_L^* = \frac{r_f^*}{q^{*C}\alpha}.$$

As above, we can substitute $\widehat{r}_L^*$ into the expression for the optimal effort $\widehat{q}^*$ given in (9) and solve for $\widehat{q}^*$ to obtain

$$\widehat{q}^* = \frac{1}{2c}\left(y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}\right).$$

Noting that $\widehat{r}_L^* = y - \frac{c\widehat{q}^*}{\alpha}$, we can substitute for $\widehat{q}^*$ and obtain

$$\widehat{r}_L^* = y - \frac{c\frac{1}{2c}\left(y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}\right)}{\alpha} = \frac{y}{2} - \frac{\sqrt{y^2\alpha^2 - 4cr_f^*}}{2\alpha},$$

which gives us the equilibrium loan rate when the firm borrows in foreign currency.

Given the equilibrium loan rate $\widehat{r}_L^*$ and effort level $\widehat{q}^*$, we can replace these in the expression for the firm's expected profits as

$$\widehat{\Pi}^* = \widehat{q}^*(y - \widehat{r}_L^*)\alpha - \frac{c}{2}\left(\widehat{q}^*\right)^2 = \left(\frac{y - \widehat{r}_L^*}{c}\right)\alpha(y - \widehat{r}_L^*)\alpha - \frac{1}{2c}\alpha^2\left(y - \widehat{r}_L^*\right)^2.$$

Simplifying, $\widehat{\Pi}^*$ becomes

$$\widehat{\Pi}^* = \frac{1}{2c}\left(\frac{y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}}{2}\right)^2, \tag{10}$$

which again expresses the firm's equilibrium profits as a function of the foreign risk free rate.

5.3 Equilibrium debt currency denomination

We can now study under what conditions firms prefer to borrow in foreign rather than domestic currency when project success is endogenous. We state the following result, which replicates the result in Proposition 2 for the case where project success is endogenous.

Proposition 3 *Keeping the size of the expected devaluation, $(1-\alpha)\frac{\Delta e}{e}$, constant, when q is endogenous there exists a value $\underline{\alpha} < 1$ such that if the probability of no devaluation, α, is greater than $\underline{\alpha}$, firms prefer to borrow in foreign currency rather than domestic currency.*

Proof: A firm will prefer to borrow in foreign currency if $\widehat{\Pi}^* > \widehat{\Pi}$. Using (8) and (10), we can write this inequality as

$$\frac{1}{2c}\left(\frac{y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}}{2}\right)^2 > \frac{1}{2c}\left(\frac{y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}}{2}\right)^2.$$

$\Leftrightarrow$

$$y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*} > y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}. \tag{11}$$

If (11) is satisfied, then borrowing in foreign currency will be optimal for the firm. From here, one sees that as α and $\frac{\Delta e}{e}$ increase so as to keep $(1-\alpha)\frac{\Delta e}{e}$ constant, hence keeping the domestic risk-free rate constant, $\widehat{\Pi}^f$ increases while $\widehat{\Pi}$ remains constant. As $\alpha \to 1$, the left hand side converges to $y + \sqrt{y^2 - 4cr_f^*}$, which is strictly greater than $y + \sqrt{y^2 - 4cr_f}$ since $r_f^* < r_f$ whenever there is a positive risk of a devaluation. $\square$

Much like in Proposition 2, Proposition 3 establishes that an increase in the size of a large devaluation that occurs with only a small probability - a "peso-problem" - favors foreign currency borrowing. The result stems from two effects associated with limited liability. The first is that discussed in the previous section: limited liability allows the firm to shift foreign-denominated debt payments from the devaluation state in which they are expensive to the non-devaluation state in which they are cheap. The second effect operates through a reduction in moral hazard. Borrowing in foreign currency has two effects on a firm's effort. By lowering the interest rate the firm has to pay when successful, it leads to greater effort (lower risk taking). At the same time, however, by exposing the firm to devaluation risk, it has the opposite effect. The reduction in interest rate is proportional to the expected depreciation of the local currency and inversely proportional to the probability of depreciation; which also determines the increase in default risk. It follows that when the probability of depreciation is low (large α), but the exchange rate movement conditional on depreciation, Δe, large, the net effect from borrowing in foreign currency on firms' effort is positive. We show this formally in the following corollary:

Corollary 1 *Whenever it is optimal to borrow in foreign currency, so that $\widehat{\Pi}^* > \widehat{\Pi}$, the firm also exerts more effort and reduces risk more when borrowing in foreign currency than when borrowing in domestic currency: $\widehat{q}^* > \widehat{q}$.*

Proof: When the firm borrows in domestic currency, optimal effort is given by

$$\widehat{q} = \frac{y + \sqrt{y^2 - 4cr_f}}{2c} = \frac{y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}}{2c}.$$

By contrast, when it borrows in foreign currency, optimal effort is

$$\widehat{q}^* = \frac{y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}}{2c}.$$

From this, $\widehat{q}^* > \widehat{q} \Leftrightarrow$

$$y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*} > y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}, \tag{12}$$

which is the exact same condition that guarantees $\widehat{\Pi}^* > \widehat{\Pi}$. $\square$

The corollary establishes an equivalence between a firm's effort and its optimal choice of financing arrangement. Specifically, it establishes that the preferred denomination of debt, in the sense of maximizing the firm's profit, is also the one that leads to greater effort. Note that, as before, the result holds precisely because the domestic borrower values his profit - and hence consumption - in terms of his domestic currency, whereas the lender values repayment expressed in terms of the foreign currency. In other words, it depends on the assumption of an incomplete exchange-rate pass-through, an issue that has been shown to be relevant empirically (see Gopinath et al., 2010). It can readily be shown that if pass-throughs were always complete, the currency composition of liabilities would be irrelevant in this model.

One simple interpretation of this condition is as a fixed exchange rate regime where a change in the foreign risk free rate, r_f^*, is immediately reflected onto an equal change in the domestic rate r_f because of the free flow of capital and the fact that with a (relatively credible) fixed exchange rate regime expectations of a devaluation will not be affected by the change in the foreign interest rate.

By contrast, if α is low but the expected depreciation is also small (to maintain consistency with the interest rate parity condition), then the risk of bankruptcy costs and lower effort associated with foreign currency borrowing imply that profits are higher when borrowing in domestic currency. As above, this can be interpreted as a flexible exchange rate regime, where adjustments in the exchange rate are more frequent (i.e., lower α) but also typically smaller. We note, however, that (11) is written entirely in terms of the foreign rate r_f^*, meaning that throughout we are assuming that parity is maintained by adjustments in the domestic risk free rate r_f. In other words, the exercise conducted here cannot readily be interpreted as representing a flexible (i.e., fully floating) exchange rate regime. We discuss this case in more detail later.

As a final point, we show that the assumption that under devaluation the lender receives no repayment actually biases the firm against foreign borrowing. Suppose that instead under devaluation there is some residual amount less than what is promised to the lender, r_L^*, and which the lender can recover in case of default. The expression for the firm's profit will remain unchanged since under devaluation, which occurs with probability $1-\alpha$, there will still be nothing left for the firm. However, since the lender recovers something, the equilibrium loan rate r_L^* should be lower, ceteris paribus. Given that the optimal effort decision for the firm is given by $\widehat{q}^* = \left(\frac{y-r_L^*}{c}\right)\alpha$, this implies that $\widehat{q}^*$ will be higher, so that the firm's project is more likely to pay off. This has an additional feedback effect onto r_L^* since the loan rate will also be lower when the probability of full repayment, $\hat{q}^*$, increases. Both of these effects together imply that the firm's equilibrium expected profit $\hat{\Pi}^*$ will be higher when the lender obtains some recovery in case of devaluation. Therefore, the assumption we used above, that no such recovery exists, in fact biases our results against the optimality of foreign denominated borrowing.

5.4 Credit rationing

So far we have assumed that the parameters are such that credit markets clear. Yet, our model admits credit rationing (a la Stiglitz and Weiss, 1981). This occurs when the cost of effort c is large enough that moral hazard prevents lenders from breaking even. To see this, consider that the condition for a firm to obtain credit in domestic currency is that $y^2 - 4cr_f \geq 0$. In contrast, if the firm were able to commit to a certain level of effort, it could obtain credit under the less stringent condition $y^2 - 2cr_f \geq 0$. This raises the question of whether foreign currency denominated loans relax the borrowing constraint for firms/countries that might have been otherwise rationed out, given that, under certain conditions, it raises their equilibrium effort.

We show that this is indeed the case in the following result. Define $\bar{c}$ as the maximum effort cost such that firms can obtain credit domestically.[10] Likewise, we use $\bar{c}^*$ to denote the maximum effort cost such that borrowers can obtain foreign currency denominated debt. Formally, for borrowers/economies with higher effort costs (7) and/or (9) do not admit a real solution.

Proposition 4 *Keeping the expected devaluation, $(1-\alpha)\frac{\Delta e}{e}$, constant, when the risk of devaluation is sufficiently low (i.e., α is large) but the size of the possible devaluation is large ($\frac{\Delta e}{e}$ is large), we have $\bar{c}^* > \bar{c}$.*

Proof: The marginal borrower in domestic currency is one for whom $y^2 - 4cr^* = 0$, which after some rearranging delivers the following threshold value of c:

$$\bar{c} = \frac{y^2}{4r_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}.$$

The equivalent threshold value for foreign currency borrowing is

$$\bar{c}^* = \frac{\alpha^2 y^2}{4r_f^*}.$$

[10] More precisely, given that the cost of effort q is $\frac{c}{2}q^2$, $\bar{c}$ is the threshold value of the parameter for the cost function above which (i.e., for $c > \bar{c}$) firms are unable to obtain credit.

Comparing the two cutoffs, it is immediate that

$$\overline{c}^* > \overline{c} \Leftrightarrow \frac{\alpha^2}{r_f^*} > \frac{1}{r_f^* \left(1 + (1-\alpha)\frac{\Delta e}{e}\right)},$$

or, rearranging,

$$\overline{c}^* > \overline{c} \Leftrightarrow (1-\alpha)\frac{\Delta e}{e} > \frac{\left(1-\alpha^2\right)}{\alpha^2}. \tag{13}$$

(13) can be always satisfied by increasing α and $\frac{\Delta e}{e}$ so that $(1-\alpha)\frac{\Delta e}{e}$ remains constant. □

Proposition 4 highlights again the effect of "peso-problem" conditions, this time on firms' access to credit. The proposition establishes that, under conditions where severe devaluations are possible but rare, firms in countries with weaker institutions may have access to foreign currency credit but not to domestic denominated credit. The reason is that, for firms in countries where the cost of effort c is relatively high, the only way to get financing is to use foreign denominated debt as a bonding mechanism, and take advantage of the lower cost of borrowing, r_f^*, in the event of no devaluation. However, such a mechanism is only possible when the risk of devaluation is not too large, even if the trade-off is a larger devaluation when and if it occurs.

While we interpret c as a country-level variable reflecting the development of institutions that protect investors, we note that we can also interpret c as a cross-sectional, firm-level variable measuring agency problems within the firm. In this case, Proposition 4 would stipulate that, for firms that have access to borrowing in either domestic or foreign currency, those who benefit the most from the bonding provided by foreign currency borrowing will choose to denominate their debt in foreign currency. Our result can thus be viewed as complementing findings in the literature on firms' listing choices, where a similar argument (with substantial evidence in favor) has been made: firms that choose to cross-list their equity in foreign exchanges are those who are likely to benefit the most from the positive signal provided by generally more stringent listing requirements abroad (see, e.g., Doidge et al., 2009, or Miller, 1999, among others).

Coupled with Proposition 5, these result tells us that, rather than increasing the problem associated with limited liability, borrowing in foreign currency attenuates the risk shifting problem and increases the likelihood that the lender is repaid. In other words, countries with weak institutions can actually increase investment through foreign currency borrowing. We note, however, that in our model the lender - whether domestic or foreign - plays no role other than to provide financing.

We thus abstract from other solutions to limited pledgeability or poor enforcement that may be available, such as those emphasized in the literature on relationship banking (e.g., Rajan, 1992, Hauswald and Marquez, 2006) or monitored financing (e.g., Holmstrom and Tirole, 1997). To the extent that c reflects country level difficulties in committing to exert effort, it is likely that such alternatives would likewise not be present.

6 Complementarities

So far we have examined each borrower's risk of failure in isolation. All entrepreneurs are exposed exclusively to their own idiosyncratic risk. In addition, those that borrow in foreign currency are exposed to devaluation risk, but their failure and, hence, the fact that they borrow in foreign currency, does not have any impact on other firms. This is obviously a simplification as we can envisage several circumstances under which widespread bankruptcies (possibly associated with a currency depreciation) would have negative effects on other firms' abilities to meet their own obligations. Consider, for instance, how the failure of a counterparty may affect a firm's cash flow and hence its ability to repay its own creditors. This is particularly problematic if the counterparty is an important customer who might be receiving items on credit (e.g., trade credit), such as in an upstream/downstream relationship, so that the counterparty's failure implies not just the loss of future business, but also losses in current revenue for the supplier. Another example can be drawn from the financial services industry, where lenders (i.e., banks) are reliant for repayment on the success of the projects in which their borrowers invest: if borrowers' projects fail, the bank cannot be repaid and will itself face financial difficulties.

In this section, we modify our simple model to examine these issues. We assume that in the case of widespread bankruptcies, all entrepreneurs are at risk of failure even if their own projects would otherwise have turned out successful. Specifically, we assume that when a firm fails, there is a positive probability that its counterparties will also fail. This means that, from the perspective of a given firm i, the higher the fraction of *other* firms that fail, the more likely it is that firm i will fail itself. This is because as the fraction of failing firms increases, there is a greater likelihood that some of those failing firms may be a counterparty to firm i. This provides firms with an incentive to correlate their default states. Put differently, for a given probability of default, it pays off to concentrate it in states of the world in which other firms are likely to fail as well.[11] Borrowing in foreign currency can be a strategy aimed at that objective.

We formalize this as follow: for any firm, there is a probability $G(\theta)$ that it will be unable to meet its own obligations when a fraction $0 \leq \theta \leq 1$ of other firms fail, irrespective of the success or failure of its own venture, with G increasing in θ. For simplicity, we will assume that $G(\theta) = 0$ for $\theta < \overline{\theta}$, and $G(\theta) = \overline{G}$ for $\theta \geq \overline{\theta}$.

We start with the extreme case where there is no foreign currency borrowing. First, note that with a continuum of firms, in a symmetric equilibrium where each firm chooses the same effort q, exactly a portion $\theta = 1 - q$ of firms will fail. Then, if $q < 1 - \overline{\theta}$ (so that $\theta > \overline{\theta}$) each firm will face a risk of counterparty default, meaning that with probability $G(\theta) = \overline{G}$ the firm fails irrespective of the realization of its project. We can now write the expected profits for firm i as

$$\Pi = \begin{cases} q_i(y - r_L) - \frac{c}{2}q_i^2, \text{ for } q_{-i} > 1 - \overline{\theta} \\ q_i\left(1 - \overline{G}\right)(y - r_L) - \frac{c}{2}q_i^2, \text{ for } q_{-i} < 1 - \overline{\theta} \end{cases}$$

where q_{-i} are the entrepreneur's beliefs about the level of effort to be exerted by other firms. Depending on its beliefs, firm i will choose

$$\widehat{q}_i = \begin{cases} \frac{y - r_L}{c}, \text{ for } q_{-i} > 1 - \overline{\theta} \\ \frac{(y - r_L)\left(1 - \overline{G}\right)}{c}, \text{ for } q_{-i} < 1 - \overline{\theta} \end{cases}$$

Now consider the case where $1 - \overline{\theta} < \widehat{q}_i = \frac{(y - r_L)\left(1 - \overline{G}\right)}{c}$. With only domestic-currency borrowing, there is never a symmetric equilibrium where firms suffer as a result of counterparty failure because the belief that $q_{-i} < 1 - \overline{\theta}$ cannot be correct. We focus here on this case since it means that in the absence of other aspects, such as the ability to borrow in another currency, counterparty failure is not a large concern because firms don't anticipate a high likelihood that they will be affected.

We now introduce foreign currency lending. Assume that a mass φ of firms has low effort costs c_1, and a mass $1 - \varphi$ has high effort costs c_2, with $c_2 > \widehat{c} > c_1$, where $\widehat{c}$ is the threshold value of the cost below which firms borrow in domestic currency and above which they borrow in foreign currency if they were not concerned about how the possibility of counterparty failure might affect them, as in Section 5.3.[12] This means that, in the absence of other concerns, a mass

[11] Farhi and Tirole (2012) obtain a similar result, but in their case the incentive to correlate failure stems from the expectation of public bailouts. We abstract from such mechanisms and focus only on the pecuniary externalities associated with a large numbef of failures.

[12] This extension is consistent with the interpretation we suggested above of c as measuring the degree of firm-

φ of entrepreneurs would borrow in domestic currency and the rest in foreign currency. As above, assume that $1-\overline{\theta} < \widehat{q}_i = \frac{(y-r_L)(1-\overline{G})}{c_2}$, which implies that in the absence of devaluation counterparty failure does not lead to the failure of a firm with a successful project. Under these assumptions, consider again the expressions for expected profits for borrowing in foreign and domestic currency. The former remains identical to what we studied before, since counterparty risk is only relevant conditional on devaluation, and conditional on devaluation firms that borrowed in foreign currency fail anyway.[13] As we show below, however, the firm's expected profit when borrowing in domestic currency is not identical to that in case without counterparty risk.

By construction, there will be no equilibrium where firms adjust their borrowing behavior as a result of the counterparty risk, when the fraction of firms with relatively low effort cost, is very high. However, when φ is relatively low, domestic currency borrowers become exposed to the risk that their counterparties may fail through the correlated default of foreign currency borrowers. In this case, the expected profit for borrowing in domestic currency becomes

$$\Pi_C = q\left(\overline{G}\alpha + 1 - \overline{G}\right)(y - r_L) - \frac{c_1}{2}q^2,$$

where the subscript C refers to the profits under the possibility that counterparty failure sinks the firm in question. The first order condition for effort q when borrowing in domestic currency is

$$\left(1 - (1-\alpha)\,\overline{G}\right)(y - r_L) - c_1 q = 0,$$

which yields

$$\widehat{q} = \min\left\{\frac{\left(1 - (1-\alpha)\,\overline{G}\right)(y - r_L)}{c_1}, 1\right\}. \tag{14}$$

Lenders will price these loans according to their probability of repayment, so that, for a conjectured effort level q^C, the loan rate must satisfy

$$\widehat{r}_L = \frac{r_f}{q^C\left(1 - (1-\alpha)\,\overline{G}\right)}. \tag{15}$$

We can immediately see that the risk of counterparty failure affects the foreign/domestic currency choice through three channels: 1) it directly affects the expected profits from borrowing in domestic

specific agency problems. For that case, we argued that for firms that have access to both domestic and international lending markets, it is those firms with larger agency problems and thus a larger need to bond themselves that borrow in the foreign currency. We exploit this structure further here.

[13] This is a byproduct of the simplifying assumption that $G(\theta) = 0$,for $\theta < \overline{\theta}$.

currency; 2) it reduces the optimal level of effort when borrowing in domestic currency; and 3) it increases the interest rate for loans in domestic currency beyond the amount caused by the reduction in effort q (the probability of repayment drops from q to $\alpha q + (1-\alpha)\left(1-\overline{G}\right)q$).

For ease of exposition define $\xi = 1 - (1-\alpha)\overline{G}$. Then, by substituting (15) into the expression for $\widehat{q}$ and solving, we obtain

$$\widehat{q} = \min\left\{\frac{1}{2c_1}\left(y\xi + \sqrt{y^2\xi^2 - 4c_1 r_f}\right), 1\right\}.$$

Noting that, from (14), $\widehat{r}_L = y - \frac{c_1\widehat{q}}{\xi}$, we can substitute for $\widehat{q}$ and obtain

$$\widehat{r}_L = \frac{y}{2} - \frac{\sqrt{y^2\xi^2 - 4c_1 r_f}}{2\xi},$$

which gives us the equilibrium loan rate when the firm borrows in domestic currency.

As in the previous section, we can replace $\widehat{r}_L$ and $\widehat{q}$ in the expression for the firm's expected equilibrium profit and obtain

$$\widehat{\Pi}_C = \frac{1}{2c_1}\left(\frac{y\xi + \sqrt{y^2\xi^2 - 4c_1 r_f}}{2}\right)^2, \tag{16}$$

from which it is immediate that, since $\overline{G} > 0$ implies $\xi < 1$, we must have $\widehat{\Pi}_C < \widehat{\Pi}$. That is, the risk of counterparty failure associated with devaluation reduces the expected profits from borrowing in domestic currency. We can now derive a result related to firms' choices of borrowing in domestic versus foreign currency.

Lemma 1 *The threshold value of effort cost c below which borrowing in domestic currency is optimal, denoted by $\widehat{c}$, is lower when $\overline{G} > 0$, so that counterparty risk is relevant, than when $\theta = 0$ and a counterparty's failure has not significant impact on a firm's ability to meet its own obligations.*

Proof: The threshold value $\widehat{c}$ comes from comparing a firm's profit when it borrows domestically, $\widehat{\Pi}$, to what it obtains when borrowing in foreign currency, $\widehat{\Pi}^*$: $\widehat{c}$ is the value of c that satisfies $\widehat{\Pi} = \widehat{\Pi}^*$. As established in (16), however, $\widehat{\Pi}_C < \widehat{\Pi}$, while profits when borrowing in foreign currency are invariant to the possibility of contagion. Therefore, if at $c = \widehat{c}$ we have $\widehat{\Pi} = \widehat{\Pi}^*$, we must also then have $\widehat{\Pi}_C < \widehat{\Pi}^*$, so that foreign currency borrowing is strictly preferred. This implies that the threshold value must be lower in order for firms to be indifferent. $\square$

The lemma describes a relatively straightforward implication of the analysis above, which is that the threshold value of the effort cost below which borrowing in domestic currency is optimal decreases once counterparty risk is present. This implies a complementarity in firms' choices of currency in which to borrow because it means that once a sufficient number of firms borrow in foreign currency, it may be optimal for the remaining firms to do so as well even if, absent counterparty risk, they would have preferred to borrow in domestic currency. One stark example of the possible effect associated with this shift in firms' preferences for domestic versus foreign currency borrowing can be obtained by considering the case when $c_1 = \widehat{c}$, where $\widehat{c}$ is as described above. For this case, low cost firms when counterparty risk is not an issue are exactly indifferent between foreign and domestic currency borrowing. However, for any counterparty risk $\overline{G} > 0$, these firms will strictly prefer to borrow in foreign currency. By continuity, there will exist a $\overline{G}$ such that for firms with $c \in [\underline{c}, \widehat{c})$ we will have $\widehat{\Pi} > \widehat{\Pi}^* > \widehat{\Pi}_C$: once counterparty risk is possible, firms that would otherwise have borrowed in domestic currency will instead choose to borrow in foreign currency. In the context of our setting where there are only two types of firms, the risk of counterparty failure causes all firms to borrow in foreign currency and as a result increases the degree of systemic risk to which all firms are exposed, increasing the likelihood that all firms fail at once in the event of a devaluation.

The implication of this result is that there are conditions under which measures aimed at preventing or limiting foreign currency borrowing can be welfare enhancing. Note, however, that these measures may not lead to Pareto improvements. Restrictions on foreign currency borrowing can contain the risks associated with counterparty failure and, thus, improve the incentives and profits of entrepreneurs that would otherwise switch to borrowing in foreign currency. But they do so at the cost of worse incentives and lower profits for those that would otherwise prefer to borrow in foreign currency, and who may not be much affected by counterparty risk.

7 Aggregate risk

In previous sections, we identified under what conditions firms find it individually optimal to borrow in foreign versus domestic currency. In this section we explore how firms' optimal choices of debt denomination translate into aggregate risk. In the baseline model without counterparty risk, lenders operate under perfect competition and always break even in expectation, and total surplus is simply borrowers' profits. However, since foreign-currency borrowing entails the additional risk of default by devaluation, the question arises of whether it may lead to an increase in risk despite the increase in expected profits. We answer this question formally in the following proposition:

Proposition 5 *There exists an* $\underline{\underline{\alpha}} > \underline{\alpha}$ *such that the probability that a firm is solvent is higher under foreign-currency than under domestic-currency borrowing:* $\alpha\widehat{q}^* > \widehat{q}$ *if and only if* $\alpha > \underline{\underline{\alpha}}$.

Proof: From Corollary 1, it follows that for $\alpha = \underline{\alpha}$, $\widehat{q}^* = \widehat{q}$, from which it is immediate that at $\alpha = \underline{\alpha}$, $\alpha\widehat{q}^* < \widehat{q}$. Now, we can write the condition $\alpha\widehat{q}^* > \widehat{q}$ as

$$\alpha\left(y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*}\right) > y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta e}{e}\right)}. \tag{17}$$

Keeping the expected depreciation constant as $\alpha \to 1$, the RHS of (17) remains constant, while the LHS converges to $\left(y + \sqrt{y^2 - 4cr_f^*}\right) > \widehat{q}$. Thus, there must exist a $\underline{\underline{\alpha}} > \underline{\alpha}$ such that at $\alpha = \underline{\underline{\alpha}}$ we have $\alpha\widehat{q}^* = \widehat{q}$, with $\alpha\widehat{q}^* > \widehat{q}$ for greater values of α. □

The Proposition shows the laissez-faire solution does not necessarily minimize risk, even if it maximizes total surplus. Indeed, for $\alpha \in \left(\underline{\alpha}, \underline{\underline{\alpha}}\right)$ foreign currency borrowing is individually optimal, but leads to higher risk of insolvency than domestic currency debt. It follows that a social planner or government concerned not only with aggregate expected output, but also with the probability of default might prefer a currency denomination different from the laissez-faire solution. This opens the door for government policies aimed at limiting foreign currency borrowing by agents that are not naturally hedged.

The rationale for government intervention and limits on foreign currency mismatches has an additional dimension when widespread defaults raise the possibility of counterparty risk. As shown in the previous section, in cases where the threat of counterparty risk induces a large fraction of borrowers to switch to foreign currency borrowing, limiting firms' abilities to borrow in foreign currency can increase average performance (reduce defaults) while at the same time reducing systemic risk taking. The reason is that, through limiting currency mismatches, regulation can eliminate inefficiencies stemming from the externality associated with counterparty risk. Doing so may be particularly important when counterparty risk is high, since then the devaluation risk can trigger a larger systemic problem either directly through contagion, or through firm's increased desire to borrow in foreign rather than domestic currency.

These results have a natural interpretation from the point of view of a trade-off between average performance and systemic risk. With either counterparty risk or a government averse to default, realizations involving a large mass of borrowers in default (systemic crises) would be viewed very negatively, leading a concerned government to be willing to trade average performance for a reduced probability of systemic crisis.

As an example, consider an economy where borrowers' effort cost coefficient c is drawn from a uniform distribution. Also, assume that condition (11) holds, so that if allowed, all firms will borrow in foreign currency. It is easy to see that, under these conditions, a trade-off emerges. In the absence of foreign currency borrowing, the model delivers a predictable proportion of borrowers that default, $1-\widehat{q}$ (indeed, with a continuum of borrowers and no aggregate risk, the realized number of failures will be identical to the expected one). By contrast, when all entrepreneurs borrow in foreign currency, there will be a mass $1-\widehat{q}^{*} < 1-\widehat{q}$ of failures when the currency does not depreciate. But everybody will default (call this a systemic crisis) when it does depreciate. It follows that a government allowing foreign currency borrowing can obtain a reduction in "tranquil-times" failures of $\widehat{q}^{*}-\widehat{q}$ at the cost of a probability $1-\alpha$ of systemic crisis.

8 Discussion and Conclusions

This paper presents a model where foreign currency borrowing, through limited liability which allows the firm to enjoy a lower interest rate, may ameliorate agency problems between firms and lenders relative to borrowing in domestic currency. The reduction in idiosyncratic risk, however, comes at the cost of exposure to the risk of default should the currency devalue sharply. A trade-off emerges between average performance in tranquil times and systemic risk: foreign currency borrowing reduces the average number of failures in the economy, but will lead to widespread bankruptcies when the currency devalues. In addition, if widespread defaults can lead otherwise successful borrowers to default (by triggering a deep recession, for instance), then a sufficiently large fraction of firms borrowing in foreign currency may induce others to switch to foreign currency borrowing as well. In this case, foreign currency borrowing may actually be welfare reducing beyond its effect through systemic risk.

Our results support the view that government intervention to curb foreign currency borrowing and the contagion risks associated with it may be socially optimal in certain circumstances. Such government intervention could come in the form of capital controls or prudential regulation, or some combination of the two.[14]

The analysis of specific measures for intervention is beyond the reach of our stylized model. In practice, however, the optimal response depends on the type of risk and firms that are being targeted. If foreign-currency borrowing occurs in the context of regulated institutions, prudential regulation may be effective in containing systemic risk. This, for instance, would be the case when corporates fund themselves primarily through local banks or when the problem is primarily with banks and other intermediaries funding themselves in hard currency on international markets and lending domestically in local currency, bank regulatory measures aimed at limiting foreign currency mismatches - such as tightening open position limits, in relation to bank capital, and stepping up of foreign currency-related liquidity requirements - may be effective. In contrast, when borrowers (corporates or households) take on foreign currency debt directly from foreign lenders (banks or capital markets), borrowing cannot be contained through prudential regulation. Then, the rationale for broader-reaching capital controls aimed at curbing cross-border flows would have to be evaluated.

As argued in the introduction, we have focused our analysis on the question of domestic- versus foreign-currency borrowing. However, several insights from our framework apply more broadly. In particular, the central finding that a reduction in idiosyncratic risk, and the related efficiency gains, may come at the cost of greater systemic risk applies to other contexts. For instance, consider the trade-off between fixed- and variable-rate debt contracts. Under normal conditions, short-term rates will be lower than long-term ones, allowing for better borrower incentives, much the way that foreign currency borrowing does in our model. However, such short term contracts will leave firms exposed to potentially sharp increases in their debt burden, in a similar fashion to how devaluation affects firms in our model. While interest rate changes will typically be small and gradual, unlike

[14] See Ostry et al. (2011) for an overview of the considerations and tradeoffs involved in determining the optimal mix of macroeconomic policies, capital controls, and prudential regulation to manage foreign currency lending and capital inflows more generally.

devaluation in our model, there are cases in which even marginal changes will imply payment difficulties for certain borrowers. For example, this kind of effect was observed for a large fraction of subprime borrowers when their contracts reset, suggesting that the basic ideas here may be applied to a broader context.

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