Financial Frictions, Foreign Currency Borrowing, and Systemic Risk*

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Abstract

We present a novel explanation for the prevalence of foreign-currency borrowing in emerging markets. First, under limited liability, foreign-currency denominated debt acts as a state-contingent claim: Borrowers maximizing profits in local currency are partly shielded from large devaluations through bankruptcy, when repaying foreign currency debt is expensive, but pay higher rates in non-devaluation states, when repayment is relatively cheaper. Second, foreign-currency borrowing can improve firms' incentives and reduce agency problems at the cost of higher systemic risk. The resulting trade-off between average performance and systemic stability, which becomes stronger when bankruptcies entail externalities, lends support to regulation limiting currency mismatches.

Keywords: liability dollarization, systemic risk, limited liability, banking crises

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1 Introduction

In this paper, we present a novel explanation for the prevalence of foreign-currency borrowing in emerging markets. First, we argue that foreign-currency-denominated liabilities act as a state contingent claim. Second, borrowing in foreign currency can improve firms' incentives and reduce the agency problem associated with limited liability and the unobservability of a firm's actions. In doing so, firms can reduce idiosyncratic risk. However, foreign currency borrowing also exposes the economy to the risk of correlated defaults through exchange rate devaluation. Critically, our explanation hinges on firm-level decisions and is independent of concerns related to the exploitation of government actions, or of coordinated actions across firms (see discussion below). Most importantly, our model provides a rationale why firms with no asset-side exposure to exchange rate movements may nevertheless find it optimal to create exposure through the liabilities side of their balance sheets.

Foreign currency borrowing, often referred to as "liability dollarization," has been a common feature in many emerging market economies. Figure 1 illustrates this pattern, showing that the total amount of foreign-currency denominated debt, expressed in US 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.[2] 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 (see Rosenberg and Tirpak, 2008).

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.[3] Indeed, there is a clear

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[1]Bruno and Shin (2017) 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]Consistent with this, Allayanis, Brown, and Klapper (2003) using a firm-level data set of East Asian firms show that interest rate differentials are a key determinant of foreign currency borrowing.

[3]While such unhedged debt positions can in principle be hedged in currency derivatives markets, financial hedges

Foreign Bank Lending and FX Denominated Bonds in Emerging Markets
(Billions of US dollars. Source: IMF, Global Financial Stability Report, 2015)
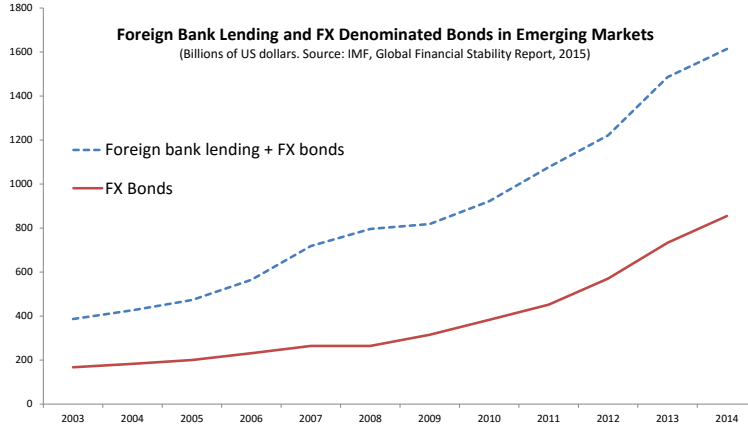
Figure 1: Foreign currency denominated debt in emerging markets, 2003-2014, expressed in US dollars. The solid red line represents the value of bonds outstanding from corporations in emerging market which were denominated in a foreign currency. The dashed blue line adds lending by foreign banks, the 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.

link between liability dollarization and the frequency of crises, in particular in the banking sector (see Schneider and Tornell, 2004). 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, 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 – see Rosenberg and Tirpak, 2008). 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

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often prove unreliable during systemic crises. Indeed, Allayanis, Brown, and Klapper (2003) find that East Asian firms that used financial hedges to hedge foreign currency debt were hit particularly hard during the 1997-98 East Asian financial crisis due to liquidity squeezes in the currency derivates markets. For additional evidence on hedging as a motive for foreign currency borrowing, see Keloharju and Niskanen (2001), Kedia and Mozumdar (2003), and Brown, Ongena and Yesin (2009).

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

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 is no 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, 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, so called, "peso problem" conditions – low probability of a large devaluation – as typical of exchange rate pegs and currency boards in emerging markets.[5] 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-currency 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 terms of domestic consumption, of repaying its foreign currency debt; and large enough 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. This occurs through a foreign currency lending rate that prices default risk fairly.

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: given the state-contingency resulting from the option to default, the firm's effective cost of borrowing is lower. 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

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[5]The term "peso problem" generally refers to the fact that when markets participants expect a discrete depreciation in the exchange rate, but with a small probability, standard tests for the efficiency of the forward exchange market may not be valid. In particular, if the depreciation (because rare) does not occur within the observed sample, market efficiency may be rejected (Krasker, 1980).

[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

to devaluation risk and hence possibly default, which is costly when bankruptcy costs are positive. 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 cost of financing depends on 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 activity and greater systemic risk. 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 profit maximization and 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' choices 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 beneficial.

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instance, Matutes and Vives (2000), Hellmann, Murdock, and Stiglitz (2000), Repullo (2004), Boyd and De Nicolo (2005), Allen, Carletti, and Marquez (2011), and Dell'Ariccia, Laeven, and Marquez (2014).

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, 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 reviews related studies. Section 3 presents some stylized facts that are consistent with the predictions of our model. Section 4 presents the main model. Section 5 examines the case with no moral hazard, while Section 6 studies the case with moral hazard. Section 7 discusses the trade-off between total expected output and aggregate risk. Section 8 extends the model to the case of counterparty risk. Section 9 concludes and briefly discusses the policy implications of the model.

2 Related literature

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 devaluing the currency, thereby reducing debt overhang problems for highly leveraged firms with profitable export opportunities.

Our analysis is also related to Schneider and Tornell (2004) and Ranciere et al. (2008). 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. A related literature has studied the effects of expected protection from sovereign defaults in the context of sovereign bond holdings of banks (e.g., Gennaioli, Martin, and Rossi, 2014).

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. 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.

The paper is also somewhat related to the literature on "original sin," which documents and studies the difficulty in emerging markets of using the local currency to borrow either long-term or in international markets (Eichengreen, Hausman, and Panizza, 2007). Unlike our paper, this literature typically focuses on sovereign transactions and on a moral hazard effect at the government level. Some of the theories behind the "original sin" posit that the lack of monetary credibility, together with high indebtedness, are important determinants of a country's inability to borrow in local currency as authorities may have an incentive to inflate the debt away (Hausman and Panizza, 2003). In contrast, we focus on situations in which private borrowers have access to funding in both foreign and local currency and explore the conditions under which one is preferred to the other. That said, our results in Section 6.4 that show how a poor governance environment may lead to the inability of an economy to use its own currency for debt transactions can be seen as extending the "original sin" concept to private borrowers.

Most of the existing work on the explanations for foreign currency borrowing, such as that discussed above, rely on firms trying to exploit some form of government policy that will then benefit them. These government distortions range from expectations of government bailouts (Bris and Koskinen, 2002; Schneider and Tornell, 2004) to devaluations (Velasco and Chang, 2004; Ranciere et al., 2008) to monetary policy (Jeanne, 2005). Our model shows that, even with risk neutrality for all parties, foreign-currency borrowing can be privately optimal in the absence of any government distortions when other financial imperfections such as limited liability are present. All that is required is a less-than-complete pass-through of exchange rate movements onto 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.

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, Mussa, 1986, Campa and Goldberg, 2005, Gopinath et al., 2010, as well as 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.

3   Stylized facts

In this section, we present stylized facts that are consistent with the predictions of our model. The model predicts that for a given expected devaluation, foreign currency borrowing is more attractive the larger the size of the expected movement in the exchange rate and the lower its probability. The challenge of assessing the empirical validity of this proposition is that generally data is available only on actual devaluations, or interest rate differentials, which per se do not allow us to decompose the expected devaluation into the expected exchange rate movement and its probability. We therefore turn to a unique and confidential survey dataset compiled by the Austrian National Bank called the OeNB Euro Survey, which asks potential borrowers in a number of Central and Eastern European countries both about their expectations to borrow in foreign currency and their expectations of developments in the exchange rate. This allows us to capture the component of interest rate differentials driven by the expectation of a devaluation and disentangle this from the unobserved expected size of the devaluation. Central and Eastern Europe is an ideal place to analyze the relationship between foreign currency borrowing and expected devaluations because it is a region where foreign currency borrowing is widespread and large currency movements have been quite common.

We construct a binary variable *Depreciation expected* denoting whether or not the individual expects the local currency to depreciate over the coming 5 years. We then use the within-country variation in this variable to capture variation in the probability of the expected devaluation. We include this variable alongside the interest rate differential between the country and the euro area. The differential is computed relative to the euro area interest rate since depreciation is expressed relative to the euro. Specifically, we compute the country's *Interest differential* as the difference between the country's 3-month money market rate and the 3-month euro area money market

rate, computed using Eurostat data. We expect that foreign currency borrowing is decreasing in the probability of a depreciation and increasing in the interest rate differential. After dropping countries with missing data on interest rate differentials, we are left with the following sample of eight Central and Eastern European countries: Bulgaria, Croatia, Czech Republic, Hungary, FYR Macedonia, Poland, Romania, and Serbia. Strictly speaking the survey does not ask about the size of a devaluation. Our approach is consistent with our results to the extent that the *Depreciation expected* variable can be interpreted as indicating the probability of a depreciation.

Regression analysis using the OeNB Euro survey data over the period 2008 to 2010 shows that individuals are less likely to borrow in foreign currency when they expect the local currency to depreciate (against the euro) and more likely to borrow in foreign currency when interest rate differentials are high. The results are presented in Table 1. The survey data covers the post-crisis period 2014 to 2015 and include four waves. Due to the lack in time-series variation in the *Interest differential,* the regression in column (1) does not include country fixed effects. The regression in column (2) drops the *Interest differential* variable and instead includes country fixed effects. Moreover, all regressions include survey wave fixed effects, and standard errors are adjusted for clustering at the individual respondent level, as a subset of respondents are interviewed multiple times over the sample period. The results are consistent with the prediction of the model: foreign currency borrowing is decreasing in the probability of a devaluation and increasing in the expected size of the devaluation of the currency. Similar evidence is in Zettelmeyer et al. (2009), who find that dollarization tends to be more prevalent in countries with higher interest rate differentials and in pegged exchange rate regimes (which presumably have a lower perceived probability of depreciation).

The model also predicts that foreign currency borrowing is decreasing in corporate bankruptcy costs. As a stylized fact consistent with this prediction of the model, we show that cross-sectionally countries with stronger creditor rights tend to have more foreign currency borrowing. The results are presented in Table 2. Since countries with more foreign currency borrowing might also be countries with deeper credit markets or more generally better macroeconomic policy frameworks, the regression also controls for the ratio of private credit to GDP, a variable that is commonly used in the literature to proxy for the development of credit markets. Data on creditor rights

Table 1: Foreign currency borrowing and currency depreciation expectations

Depreciation expected	-0.045*	-0.078***
	(0.023)	(0.023)
Interest rate differential	0.036***	
	(0.007)	
Country fixed effects	No	Yes
R-squared	0.035	0.152
Number of observations	1068	1068

Notes: Dependent variable is a dummy variable denoting whether the individual is expecting to borrow in foreign currency or not (missing if not expecting to borrow) over the coming 12 months. This variable is constructed using OeNB euro survey responses to question Q22 (Do you plan to take out a loan within the next 12 months and if so, in what currency?). Depreciation expected is a dummy variable indicating whether the individual expects the local currency to depreciate over the coming 5 years or not (i.e. stay the same or appreciate). This variable is constructed using OeNB euro survey responses to question Q4 (How do you think the exchange rate against the euro will develop over the next five years?). Interest rate differential is the difference between the country's 3-month money market rate and the 3-month euro area money market rate computed using Eurostat data. Countries included are Bulgaria, Croatia, Czech Republic, Hungary, FYR Macedonia, Poland, Romania, and Serbia. Sample period includes four semi-annual waves over the period 2014-2015. Regressions are estimated using OLS and include survey wave fixed effects and country fixed effects where indicated. Standard errors are adjusted for clustering at the individual respondent level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

and the ratio of private credit to nominal GDP are obtained from Djankov et al. (2007), while data on the fraction of foreign currency lending relative to nominal GDP are obtained from the International Monetary Fund (IMF)'s Vulnerability Exercise Database (not publicly available). The sample covers the period 1993-2010, which is the period for which data on foreign currency lending is available in the IMF's database. The creditor rights score ranges from 0 to 4, with higher scores indicating better protection. Regressions are estimated using OLS and include country and year fixed effects. The results are consistent with the prediction of the model: countries with stronger credit rights tend to have more foreign currency borrowing.

More generally, devaluation risk associated with foreign currency borrowing introduces systemic risk if many firms are exposed to it, and this will show up in the domestic banking sector in the form of increased risk of banking crises. This prediction is borne out by the data. Using data on foreign currency borrowing from the IMF's Vulnerability Exercise Database, 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

Table 2: Foreign currency borrowing and creditor rights

Creditor rights	19.86***	18.30***
	(1.15)	(0.025)
Private credit/GDP		-65.90***
		(4.40)
R-squared	0.90	0.89
Number of observations	484	438

Notes: Dependent variable is the percentage of foreign currency lending to nominal GDP in the country from the IMFs Vulnerability Exercise Database. Data on creditor rights and private credit/GDP are from Djankov et al. (2007). Creditor rights score ranges from 0-4, with higher scores indicating better protection. Sample period is period 1993-2010. Regressions are estimated using OLS and include country and year fixed effects (not reported).
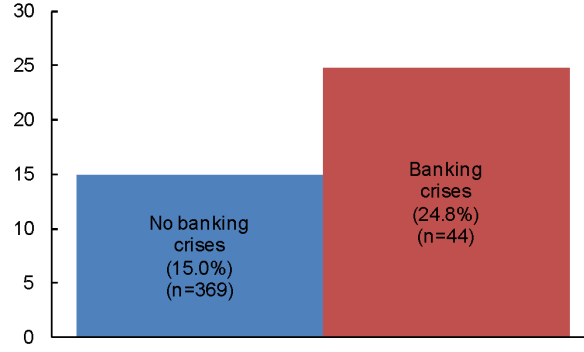$^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

borrowing averaged 24.8 percent of GDP in countries that experienced a banking crisis over the period 1970 to 2010 compared to only 15.0 percent of GDP in countries that did not experience a banking crisis over this period.

4 Model

Consider an economy populated by entrepreneurs/firms that invest 1 unit of their currency in risky assets that return y units of output 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. If the firm is unable to repay its debt obligations and must default, only a fraction d of the total output is recovered by lenders, and $1 - d$ is lost to bankruptcy costs, etc.

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: $r_f = r_f^* \frac{E[e_1]}{e}$, where r_f is the gross (credit) risk-free interest rate in domestic currency, r_f^* its equivalent in foreign currency, $E[e_1]$ the expected future exchange rate change, and e the current exchange rate, which is expressed as units of domestic currency per unit of foreign.[7] For simplicity,

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[7]There is some evidence that (un)covered interest partity does not hold in practice (see, for instance, Du et al.,

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

we assume that exchange rate movements are governed by a binomial distribution: the exchange rate stays constant with probability α, and depreciates by Δ with probability $1 - \alpha$.[8] Thus, we can rewrite the interest parity condition as

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

Domestic prices may partly reflect exchange rate movements, either because domestic inflation shocks lead to exchange rate movements, or because exchange rate movements get passed on to domestic prices, with prices in the home country partly indexed to the foreign currency. Specifically, we assume that the domestic price index $p\left(.\right)$ is given by

$$p(e_1) = \left\{ \begin{array}{l} 1 \text{ if } e_1 = e \\ \frac{e + w\Delta}{e} \text{ if } e_1 = e + \Delta \end{array} \right. ,$$

where $0 \leq w \leq 1$ represents the degree of pass through of exchange rate movements onto domestic prices. If $w = 0$, domestic prices do not respond at all to changes in the exchange rate e; if $w = 1$, domestic prices fully reflect all exchange rate movements and prices in the two currencies

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2016). However, our results carry through no matter the interest rate differentials as long as there is limited liability.

[8] 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. We show in Appendix A that the main results continue to hold for more general distributions of exchange rate movements as long as they include the possibility of large devaluations which may trigger limited liability. Likewise, there need not be an expected devaluation, so that $r_f > r_f^*$ is not necessary, as long as there is a positive probability of there being a large devaluation, even if there may also be the possibility of substantial appreciations in the currency.

move together. This means that if prices are the same at time zero, they will remain so after a devaluation. That is, purchasing power parity (PPP) applies. The value of output produced by the firm is then given by py, and the real profits of the firm are just the nominal profits (described in detail below) deflated by the price index p.

Finally, we assume that, when domestic prices are not responsive to exchange rate movements, the devaluation is sufficiently severe to trigger default when the firm borrows in foreign currency, in which case all of the project's revenue, net of bankruptcy costs, accrues to the lender. Specifically, we assume that, for $w = 0$, $\frac{1}{e}r_f^* > p(e)y\frac{1}{e+\Delta} = y\frac{1}{e+\Delta}$. The right hand side of the expression is simply the value of the firm's output, y, expressed in terms of foreign currency in the event of a devaluation, while the left hand side is the expected repayment that needs to be made. This is equivalent to assuming that $\Delta > \overline{\Delta} \equiv \frac{e(y-r_f^*)}{r_f^*}$, so that the size of the devaluation is sufficiently large relative to the value of the firm's output py, when domestic prices do not reflect exchange rate movements.

5   Equilibrium currency denomination with exogenous project risk

To highlight the role that limited liability plays in determining a firm's choice of currency in which to borrow, 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 and the option to default, 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. Likewise, we abstract from any hedging motives for borrowing in the foreign currency, which may stem from firm's operations if they have substantial revenue streams in foreign currency through international sales, for instance. In other words, we study why firms may create unhedged positions in the foreign currency through the liability sides of their balance sheets, even if in practice there may be additional reasons why firms choose to borrow in one currency over the other.

Given the price index $p(.)$ and degree of pass-through w, the firm's real profits when borrowing in the domestic currency when liability is unlimited, denoted by $\widetilde{\Pi}$, are given by

$$\widetilde{\Pi} = \alpha \frac{q_0 p(e) y - r_f}{p(e)} + (1 - \alpha) \frac{q_0 p(e + \Delta) y - r_f}{p(e + \Delta)}$$

$$= \alpha (q_0 y - r_f) + (1 - \alpha) \frac{q_0 \frac{e + w\Delta}{e} y - r_f}{\frac{e + w\Delta}{e}}$$

$$= q_0 y - r_f \left(\alpha + (1 - \alpha) \frac{e}{e + w\Delta} \right), \tag{2}$$

reflecting that when liability is unlimited, there is no default and hence no bankruptcy. The numerators of each term represent the firm's nominal profits which, when divided by the price index $p(x)$, give us real profits. Using the parity condition in (1) gives

$$\widetilde{\Pi} = q_0 y - r_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e} \right) \left(\alpha + (1 - \alpha) \frac{e}{e + w\Delta} \right). \tag{3}$$

When borrowing instead in foreign currency, since one unit of foreign currency converts today into e units of domestic currency, the firm only needs to borrow $\frac{1}{e}$ in foreign currency in order to have one unit of domestic currency to invest. Therefore, the firm only needs to repay $\frac{1}{e} r_f^*$, and its real profits $\widetilde{\Pi}^*$ when liability is unlimited are:

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

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

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

Now we introduce limited liability and derive the conditions under which a firm that borrows in foreign currency defaults as a result of a currency depreciation. The firm will be unable to meet its debt obligations in the event of a devaluation (when borrowing in the foreign currency) if

$$q_0 p(e + \Delta) y - \frac{(e + \Delta) r_f^*}{e} < 0, \tag{5}$$

or equivalently if

$$w < \overline{w} \equiv \frac{r_f^* (e + \Delta) - ye}{y \Delta q_0}.$$

Since we assume that $\Delta > \overline{\Delta}$, so that devaluations are large enough to trigger limited liability when $w = 0$, $\overline{w}$ will be strictly positive, implying that there are values of w such that for $w < \overline{w}$ the firm

will default in the event of a devaluation, whereas for $w \geq \overline{w}$ no default will occur.[9] Since we are interested in the effects of limited liability, we focus here on the case where $w < \overline{w}$. For that case, since a devaluation triggers default, expected profits under a foreign-currency contract are

$$\Pi^* = \alpha q_0 \left(p(e)y - r_L^* \right), \tag{6}$$

where $p(e) = 1$. To obtain the lending rate r_L^*, recall that, since one unit of foreign currency converts today into e units of domestic, the firm only needs to borrow $\frac{1}{e}$ in foreign currency in order to have one unit of domestic to invest. Therefore, the firm only needs to repay $\frac{1}{e} r_f^*$. The lending rate must therefore satisfy

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

where the second term on the LHS represents the residual value (in foreign currency) of the firm's product accruing to the lender in case of devaluation and default. After substituting for $p(e + \Delta)$, this gives

$$r_L^* = \frac{r_f^*}{\alpha q_0} - \frac{(1 - \alpha) \, dy}{\alpha} \frac{e + w\Delta}{e + \Delta}. \tag{7}$$

Substituting into Π^* above yields the firm's real profits when borrowing in foreign currency at interest rate r_f^* as

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

Since $p(e) = 1$ in the event of no devaluation, this reduces to

$$\Pi^* = q_0 y \left(\frac{\alpha (e + \Delta) + (1 - \alpha) d (e + w\Delta)}{e + \Delta} \right) - r_f^*. \tag{8}$$

5.1 No exchange rate pass-through $(w = 0)$

We first start with the case where $w = 0$, so that there is no pass-through of exchange rate movements onto domestic prices and the domestic firm's output y reflects its real consumption opportunities. We discuss in the next section the case where $w > 0$ and firms maximize their real

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[9]The threshold $\overline{w}$ can be shown to be strictly less than 1 since, for $w = 1$, (5) reduces to $\frac{e + \Delta}{e} \left(q_0 y - r_f^* \right) < 0$, which can never be satisfied since $q_0 y > r_f^*$ by assumption. It is also increasing in Δ, so that larger devaluations trigger limited liability for even greater degrees of exchange rate pass-through w.

profits. When $w = 0$, (1) guarantees that, when default is not possible, as would occur if liability were unlimited, the firm earns the same expected profits whether it borrows in domestic currency at interest rate r_f, or in foreign currency at r_f^*. To see this, note that for $w = 0$, the firm's profits when borrowing in domestic currency, (3), reduce to

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

Similarly, for $w = 0$, the firm's profits when borrowing in foreign currency, (4), simplify to

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

which is the same expression as above when borrowing in domestic currency. This exercise merely verifies that the usual parity condition, (1), is simply an indifference condition for the domestic firm in terms of which currency in which to borrow when it only cares about nominal returns.

As we next show, profits are no longer the same once we allow the firm to default in the event of a large devaluation.

Proposition 1 *Under limited liability, for $w = 0$, when there are no bankruptcy or liquidation costs (i.e., $d = 1$), and when (1) holds, firms prefer to borrow in foreign currency rather than domestic currency.*

Proof: When $d = 1$, so that there are no social losses associated with bankruptcy, and when $w = 0$, the firm's profits when borrowing in the foreign currency can be expressed as

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

Since the firm operates under limited liability, the lending rate in domestic currency will be $r_L = \frac{r_f}{q_0}$. Then, using (1), we can write the expected profits from borrowing in domestic currency as

$$\Pi = q_0 y - r_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e} \right), \tag{9}$$

which is the same as under unlimited liability. Comparing the profits under the two contracts, we

obtain:

$$\Pi^* - \Pi = yq_0 \left(\frac{e + \alpha\Delta}{e + \Delta}\right) - r_f^* - q_0 y + r_f^* \left(\alpha + (1 - \alpha)\frac{e + \Delta}{e}\right)$$

$$= -(1 - \alpha)\frac{\Delta}{(e + \Delta)e}\left(yq_0 e - r_f^*(e + \Delta)\right),$$

which is positive for $yq_0 e < r_f^*(e + \Delta)$, and is satisfied whenever $\Delta > \overline{\Delta}$. $\square$

The proposition establishes that whenever default is possible because of a sufficiently large devaluation, the default option tilts the borrower's choice in the direction of foreign-currency denominated contracts as long as there are no social losses associated with default (i.e., as long as $d = 1$). Starting from the interest rate parity condition, which makes a firm with unlimited liability indifferent between the two currencies, the introduction of limited liability makes the foreign-currency contract the preferred choice of the firm. This occurs because whenever the domestic currency depreciates, the firm is unable to fully repay its debt obligation, which is denominated in the foreign currency. Anticipating this, the lender demands higher repayment in the event of no devaluation, and in expectation is made whole. The domestic borrower, however, benefits from being able to shift some of the promised repayment from what it views as relatively expensive states of the world (when a devaluation occurs, the price of foreign currency expressed in domestic currency increases) to states of the world in which it views it as relatively cheaper to repay.

A simple intuition for the above result can be obtained by considering what would be an optimal contract for the firm. Such a contract would call for repaying as much as possible in low cost (i.e., no devaluation) states, up to the value of the firm's output $p(e)y$, and repaying as little as possible in high cost states, when the value of its output, $p(e + \Delta)y$, has gone down relative to the increase in the cost of foreign currency, Δ. More generally, the firm would like to make repayments that have a negative covariance with exchange rate movements so as to lower the expected cost of repayment and increase the payoff to the borrower. In other words, an optimal contract would have payments that are contingent on the exchange rate. Standard limited liability (i.e., risky debt) contracts, while not optimal, include a measure of state contingency: they yield a negative covariance between the firm's loan repayments and the exchange rate to the extent that the devaluation triggers default and allows the firm to repay less when the foreign currency has become more expensive. Therefore, standard financial contracts create an incentive to borrow in foreign currency, even if the default

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option is fairly priced.

While the result above makes use of the fact that $d = 1$, so that no losses are incurred in the event of default, it is useful to show explicitly that similar results hold in the context of deadweight bankruptcy losses. Specifically, the following result shows that, for a given interest rate differential, which is equivalent to having a constant expected real devaluation, debt denominated in the foreign currency is optimal when the probability of a devaluation is sufficiently small.

Corollary 1 *Assuming (1) holds, for $q_0 \in [0, 1]$, $w = 0$, and $d < 1$, and keeping the size of the expected real devaluation, $(1 - \alpha) \frac{\Delta}{e}$, 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 when protected by limited liability.*

Proof: Profits when borrowing in the domestic currency are

$$\Pi = q_0 y - r_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e} \right). \tag{10}$$

We can compare profits under the foreign contract, (8), to those under the domestic contract. For the case where $d = 0$: $\Pi^* > \Pi \Leftrightarrow$

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

As $\alpha \to 1$, the left hand side converges to $q_0 y - r_f^*$, whereas the right hand side converges to $q_0 y - r_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e} \right)$, which is strictly smaller. Therefore, as the probability of the devaluation decreases, keeping the expected devaluation, $(1 - \alpha) \frac{\Delta}{e}$, constant, the firm prefers to borrow in the foreign currency. Since Π^* is increasing in d, the degree of recovery for the lender when default occurs, it is straightforward to see that $\Pi^* (d) > \Pi$ for any $d > 0$ if it is true for $d = 0$. $\square$

The corollary shows that when bankruptcy costs are present, the parameter range under which the foreign-currency denominated contract is preferred shrinks. Essentially, the benefits from being able to reallocate payments across states of the world associated with the option to default are partly offset by the deadweight losses associated with default. As the probability of devaluation decreases and its impact increases, bankruptcy costs become less relevant. First, as α increases, default becomes less likely. Second, as the realized devaluation gets larger, the foreign-currency value of

the firm's revenue conditional on devaluation diminishes and, thus, so do the losses associated with bankruptcy costs. Formally,

$$\frac{\partial^2 \Pi^*}{\partial \alpha \partial d} = -q_0 y \frac{e}{(e + \Delta)} < 0.$$

This means that, for a given expected devaluation, the marginal benefit of recovering some output under bankruptcy is lower the higher is α; in other words, when a devaluation, and hence default, is less likely, the benefit of having a smaller fraction of cashflow destroyed is lower. This implies that for higher d, the threshold level of α above which borrowing in the foreign currency is optimal is lower: $\partial \underline{\alpha} / \partial d < 0$.

5.2 Real prices and exchange rates movements ($w > 0$)

So far we have obtained all results under the assumption that $w = 0$, so that $p(e + \Delta) = 1$ and exchange rate movements do not affect domestic prices. It is straightforward now to see that similar results hold if $w > 0$, so that $p(e + \Delta) = \frac{e + w\Delta}{e}$. To see this, we can compare profits when borrowing in foreign currency under limited liability, Π^*, to those under unlimited liability, $\widetilde{\Pi}^*$, after substituting for the price index $p(.)$:

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

When $d = 1$, so that there are no bankruptcy costs, we have

$$\begin{aligned}
\Pi^* - \widetilde{\Pi}^* &= q_0 y \left(\alpha + (1 - \alpha) \frac{e + w\Delta}{e + \Delta} \right) - r_f^* - \left(q_0 y - r_f^* \left(\alpha + (1 - \alpha) \frac{e + \Delta}{e + w\Delta} \right) \right) \\
&= \Delta (1 - \alpha)(1 - w) \frac{(\Delta + e) r_f^* - (e + w\Delta) y q_0}{(e + \Delta)(e + w\Delta)},
\end{aligned} \tag{11}$$

which is positive whenever $(\Delta + e) r_f^* > (e + w\Delta) y q_0$, which is exactly the condition for a devaluation to trigger default. Therefore, when bankruptcy is not costly, profits when borrowing in foreign currency are strictly higher under limited liability, even if the debt is fairly priced and compensates the lender appropriately for the default risk.

To understand why limited liability protection favors foreign currency borrowing over domestic-currency denominated debt also in this case, note that the comparison in (11) does not depend on the domestic interest rate and, consequently, on the relationship between the domestic rate r_f and the foreign rate r_f^*. The benefit of limited liability therefore accrues for any interest rate differential

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$r_f - r_f^*$, with the option to default always tilting the domestic firm's choice in the direction of borrowing in the foreign currency. More specifically, if the interest rate differential, $r_f - r_f^*$, is such that, for a given price index $p(.)$ and a degree of pass through $w \geq 0$, the domestic firm is indifferent between borrowing in domestic versus foreign currency when liability is unlimited, it will strictly prefer to borrow in foreign currency when it can avail itself of limited liability protection.[10][11]

Finally, for $d < 1$, so that bankruptcy is costly, it is clear that a version of Corollary 1 continues to hold: for a given interest rate differential $r_f - r_f^*$, decreases in the probability of a devaluation that are coupled with commensurate increases in the size of any devaluation so as to keep the size of the expected devaluation constant will favor foreign currency borrowing. Hence, the results from Section 5.1 extend to the case where domestic prices respond to exchange rate fluctuations.

6 Moral hazard and currency choice

In this section, we allow firms to determine the probability of success of their projects, q, at a cost $\frac{c}{2}q^2$. Since, as we show above, the firm's ability to default as a result of limited liability when the devaluation is sufficiently severe at the margin always makes borrowing in the foreign currency more attractive irrespective of the degree of exchange rate pass through onto domestic prices, in what follows we focus on the case where $w = 0$, so that nominal prices do not adjust as a result of devaluation in the domestic currency. Doing so considerably simplifies the expressions without much, if any, loss in the generality of the results.

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[10]We can solve explicitly for the interest rate differential, $r_f - r_f^*$, that makes the firm indifferent when it is not protected by limited liability. Equating $\widetilde{\Pi}$ to $\widetilde{\Pi}^*$, and solving for the domestic risk-free interest rate r_f yields:

$$r_f = r_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e + \alpha w \Delta} \right). \tag{12}$$

Defining $F(w) \equiv 1 + (1 - \alpha) \frac{\Delta}{e + \alpha w \Delta}$, we can express the indifference condition as $r_f = F(w) r_f^*$, so that $F > 1$ can be interpreted as the multiple over the foreign risk free rate that makes a domestic borrower indifferent between borrowing in its own currency at r_f or in the foreign currency at r_f^*. $F(w)$ is decreasing in w, and, for $w = 0$, we have that $r_f = F(0) r_f^* = \left(1 + (1 - \alpha) \frac{\Delta}{e} \right) r_f^*$, which is simply the standard uncovered interest parity condition (UIP) given by (1).

[11]The effect identified here, through the option to default in the event of a sufficiently large currency depreciation, is related to but distinct from "Siegel's Paradox" (Siegel, 1972), who was among the first to observe that parity conditions for the two sides of a currency transaction are different because of Jensen's inequality: i.e., the fact that $E\left[\frac{1}{e}\right] \neq \frac{1}{E[e]}$, where e is the exchange rate, expressed as units of domestic currency per unit of foreign. See Edlin (2002) for further discussion. Our result similarly exploits Jensen's inequality through the non-linearity introduced by the default option, but holds irrespective of the interest rate differential between domestic and foreign risk free bonds.

6.1 Domestic currency borrowing

Much as above, when a firm borrows in local currency and there is no pass through of exchange rate movements onto domestic prices (so that $w = 0$), it's expected profits can be written as

$$\Pi = q(y - r_L) - \frac{c}{2}q^2, \tag{13}$$

which is the same as (9) after subtracting the cost of effort, $\frac{c}{2}q^2$. Maximizing (13) 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 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 the profit-maximizing effort $\widehat{q}$ to obtain $\widehat{q} = \frac{y - \frac{r_f}{\widehat{q}}}{c}$, and then solve for $\widehat{q}$ as

$$\widehat{q} = \min\left\{\frac{y + \sqrt{y^2 - 4cr_f}}{2c}, 1\right\}, \tag{14}$$

where (14) reflects the fact that the positive root that solves for the equilibrium value of effort is Pareto optimal (this can be easily shown).[12] 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 the equilibrium effort to obtain $\widehat{r}_L = y - \widehat{q}c$, which, after substituting for $\widehat{q}$ yields

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

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[12] 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.

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

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

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

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

Finally, we can use the uncovered 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, $(1 - \alpha)\frac{\Delta}{e}$:

$$\widehat{\Pi} = \frac{1}{2c}\left(\frac{y + \sqrt{y^2 - 4cr_f^*\left(1 + (1 - \alpha)\frac{\Delta}{e}\right)}}{2}\right)^2. \tag{15}$$

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.

6.2 Foreign currency borrowing

Similarly to above, when $w = 0$, we can write a firm's expected profit when it borrows in foreign currency as

$$\Pi^* = \alpha q(y - r_L^*) - \frac{c}{2}q^2, \tag{16}$$

which is essentially the same as (6) after imposing $w = 0$ and subtracting the cost of effort. We maximize (16) with respect to effort to obtain

$$\widehat{q}^* = \min\left\{\left(\frac{y - r_L^*}{c}\right)\alpha, 1\right\}. \tag{17}$$

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

Since firms only repay when the currency does not depreciate, for a lender to be willing to lend in foreign currency the interest rate needs to compensate him for both the borrower idiosyncratic risk, $1 - q$, and the devaluation risk, $1 - \alpha$. As above, we continue to assume that $\Delta > \overline{\Delta}$, meaning that devaluations are always larger enough to trigger default, and that, when such default occurs,

only a fraction d of the total output is recovered. We then 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

$$\alpha q^{*C} \frac{1}{e} r_L^* + (1-\alpha) q^{*C} dy \frac{1}{e+\Delta} = \frac{1}{e} r_f^*, \tag{18}$$

where (18) makes use of the fact that, as described above, since one unit of foreign currency converts today into e units of domestic currency, the firm only needs to borrow $\frac{1}{e}$ in foreign currency in order to have one unit of domestic currency to invest. From this we can solve for the equilibrium foreign denominated loan rate, $\widehat{r}_L^*$, as

$$\widehat{r}_L^* = \frac{r_f^*}{\alpha q^{*C}} - \frac{(1-\alpha)\,dy}{\alpha} \frac{e}{e+\Delta}.$$

We can substitute $\widehat{r}_L^*$ into (17) and solve for $\widehat{q}^*$ to obtain

$$\widehat{q}^* = \alpha y \frac{\left(1 + \frac{(1-\alpha)d}{\alpha} \frac{e}{e+\Delta}\right)}{c} - \frac{r_f^*}{cq^{*C}}.$$

Define $A = \left(1 + \frac{(1-\alpha)d}{\alpha} \frac{e}{e+\Delta}\right)$ – the case where $d=0$ corresponds to $A=1$. Again recognizing that in equilibrium $\widehat{q}^* = q^{*C}$, the solution is

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

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

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

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

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

$$= \frac{1}{2c}\alpha^2 (y - \widehat{r}_L^*)^2,$$

where we note the dependence of the firm's equilibrium profits $\widehat{\Pi}^*$ on the recovery rate in case of default, d. Substituting for $\widehat{r}_L^*$ and simplifying, $\widehat{\Pi}^*$ becomes

$$\widehat{\Pi}^*(d) = \frac{1}{2c}\left(\frac{\alpha y A + \sqrt{A^2 y^2 \alpha^2 - 4cr_f^*}}{2}\right)^2, \tag{19}$$

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

6.3 Equilibrium debt currency denomination

We can now study under what conditions firms prefer to borrow in foreign rather than domestic currency when firms are subject to moral hazard and project success is endogenous. We state the following, which extends the results from Section 5 to the case where project success is endogenous.

Proposition 2 *For any $d \geq 0$, and keeping the size of the expected devaluation, $(1 - \alpha)\frac{\Delta}{e}$, 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 rather than domestic currency.*

Proof: A firm will prefer to borrow in foreign currency if $\widehat{\Pi}^* > \widehat{\Pi}$. Using (15) and (19), we can write this inequality as

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

Letting $d = 0$, this expression reduces to

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

$\Leftrightarrow$

$$y\alpha + \sqrt{y^2\alpha^2 - 4cr_f^*} > y + \sqrt{y^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta}{e}\right)}. \tag{20}$$

If (20) is satisfied, then borrowing in foreign currency will be optimal for the firm. From here, one sees that as α and $\frac{\Delta}{e}$ increase so as to keep $(1 - \alpha)\frac{\Delta}{e}$ 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.

Finally, note that $\widehat{\Pi}^*(d)$ is increasing in d since A is clearly increasing in d. Therefore, if $\widehat{\Pi}^*(0) > \widehat{\Pi}$, $\widehat{\Pi}^*(d)$ will also be greater than $\widehat{\Pi}$ for $d > 0$. $\square$

Proposition 2 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: the

option to default 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 cheaper. 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, Δ, large, the net effect from borrowing in foreign currency on firms' effort is positive. We show this formally in the following corollary:

Corollary 2 *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, and it's effort $\widehat{q} < 1$ (i.e., there is an interior solution), the firm's equilibrium profits can be expressed as

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

By contrast, when it borrows in foreign currency, the firm's equilibrium profits are

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

From this, it is trivially true that $\widehat{\Pi}^* > \widehat{\Pi} \Leftrightarrow \widehat{q}^* > \widehat{q}.$ □

The corollary establishes that foreign currency borrowing has an incentive effect for the firm, which goes hand in hand with the benefit the firm obtains from borrowing in foreign currency. 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.

6.4 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 – recall 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 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.[13] Likewise, we use $\bar{c}^*$ to denote the maximum effort cost such that borrowers can obtain foreign currency denominated debt for the case where $d = 0$, so that there is no recovery in case of default.[14] Formally, for borrowers with higher effort costs, (14) and/or (17) do not admit a real solution.

Proposition 3 *Keeping the expected devaluation, $(1 - \alpha)\frac{\Delta}{e}$, constant, when the risk of devaluation is sufficiently low (i.e., α is large) but the size of the possible devaluation is large ($\frac{\Delta}{e}$ 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:

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

The equivalent threshold value for foreign currency borrowing is

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

Comparing the two cutoffs, it is immediate that

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

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[13]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.

[14]It is straightforward to see that if the firm can obtain a foreign currency loan when $d = 0$, it will also be feasible to obtain a loan if $d > 0$ and the lender is able to recover something when a devaluation forces the firm to default. The results from Proposition 3 therefore extend to the case where $d > 0$.

or, rearranging,

$$\bar{c}^* > \bar{c} \Leftrightarrow (1 - \alpha)\frac{\Delta}{e} > \frac{(1 - \alpha^2)}{\alpha^2}. \tag{21}$$

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

Proposition 3 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 (high c) may have access to foreign currency credit but not to domestic denominated credit. The reason is that, for firms in countries where 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 effective cost of borrowing. 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.

Proposition 3 together with Corollary 2 tells us that, rather than increasing the problem associated with limited liability, borrowing in foreign currency may attenuate risk shifting problems and actually increase the overall 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.

Finally, 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, we can state the following result

Corollary 3 *Suppose that at $c = \hat{c}$, $\widehat{\Pi}^* = \widehat{\Pi}$. Then, for $c < \hat{c}$, $\widehat{\Pi}^* < \widehat{\Pi}$, while for $c > \hat{c}$, $\widehat{\Pi}^* > \widehat{\Pi}$.*

Proof: Recall that, for $d = 0$, $\widehat{\Pi}^* > \widehat{\Pi} \Leftrightarrow$

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

Note now that, while increases in c have a negative impact on both sides of the expression, the RHS will decrease more quickly than the LHS, for all α, e, r_f^*, y, and Δ. Therefore, if $\widehat{\Pi}^* = \widehat{\Pi}$ for some $c = \widehat{c}$, we will have that $\widehat{\Pi}^* > \widehat{\Pi}$ for $c > \widehat{c}$, and the opposite for $c < \widehat{c}$. $\square$

This results above highlight that when the cost of effort is firm-specific, firms for whom controlling moral hazard is more important will choose to denominate their debt in foreign currency whenever possible (i.e., when $c < \overline{c}^*$). We discuss the aggregate implications of this further below.[15]

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' choices of debt denomination translate into aggregate risk. When lenders operate under perfect competition and break even in expectation, 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 4 *For any $d \geq 0$, 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 2, 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 equivalent to

$$\alpha \left(Ay\alpha + \sqrt{A^2 y^2 \alpha^2 - 4cr_f^*} \right) > y + \sqrt{y^2 - 4cr_f^* \left(1 + (1 - \alpha) \frac{\Delta}{e} \right)}. \tag{22}$$

Keeping the expected depreciation constant as $\alpha \to 1$, the RHS of (22) remains constant, while, for $d = 0$ so that $A = 1$, 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 when $d = 0$. Since

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[15]Our results 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).

the LHS is monotonically increasing in A, and A is increasing in d, a similar $\underline{\alpha}(d)$ must exist for $d > 0$. $\square$

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. Further, from (22) it is immediate that $\underline{\underline{\alpha}}$ is decreasing in d and c. It follows that these kind of policies will be more likely to be justified in countries with poorer governance and property rights or higher monitoring and bankruptcy costs.

These results have a natural interpretation from the point of view of a trade-off between average performance and systemic risk. A risk averse government would view very negatively realizations involving a large mass of borrowers in default (systemic crises) and might 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 (20) 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, $1 - \widehat{q}$ (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 (i.e., 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.

The rationale for government intervention to limit foreign currency mismatches gains an additional dimension if foreign currency borrowing entails potential externalities, such as when widespread defaults raise counterparty risk. We discuss this case in the next section.

8   Complementarities

So far we have examined each borrower's risk of failure in isolation. Entrepreneurs are exposed to their own idiosyncratic risk and, if they borrow in foreign currency, to devaluation risk. However, a firm's failure and, hence, whether or not it borrows 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 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 (e.g., 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 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.[16] 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

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[16]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. Acharya and Yorulmazer (2007) and Farhi and Tirole (2012) obtain a similar result, but in their cases 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.

$\theta < \overline{\theta}$, 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

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

As in many other models with strategic complementarities, this game may admit multiple equilibria. A firm's effort is weakly increasing in it's beliefs about other firms' effort. Thus, in principle there could be two symmetric equilibria: one with high effort and no risk of externalities arising from counterparty risk, and one with low effort and counterparty risk. Since our interest is in the role of foreign currency borrowing, here we focus on a parameter range for which, in the absence of foreign currency contracts, only the high effort equilibrium exists. We, then, consider the case where

$$1 - \overline{\theta} < \widehat{q}_i = \frac{(y - r_L)\left(1 - \overline{G}\right)}{c}, \tag{23}$$

so that 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. Put differently, firms behave as in the case without counterparty risk.

We now introduce foreign currency borrowing. Define $\widehat{c}$ as the effort cost parameter such that, for given α, firms would be indifferent between borrowing in foreign or domestic currency if they were not concerned about how the possibility of counterparty failure might affect them (as in Corollary 3). As above, assume that $1 - \overline{\theta} < \widehat{q}_i = \frac{(y - r_L)\left(1 - \overline{G}\right)}{c}$, 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

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and domestic currency. The former remains identical to what we studied before, since counterparty risk becomes relevant only conditional on devaluation, and conditional on devaluation firms that borrowed in foreign currency fail anyway. As we show below, however, the firm's expected profit when borrowing in domestic currency is not identical to that in the 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 that borrows in foreign currency is relatively low. However, when enough firms borrow in foreign currency, domestic-currency borrowers become exposed to the risk that their counterparties may fail through the correlated default of foreign-currency borrowers in the event of a depreciation. In this case, the expected profit for borrowing in domestic currency becomes

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

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 is

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

which yields

$$\widehat{q} = \min \left\{ \frac{\left(1 - (1 - \alpha) \overline{G} \right) (y - r_L)}{c}, 1 \right\}. \tag{24}$$

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

$$\widehat{r}_L = \frac{r_f}{q^C \left(1 - (1 - \alpha) \overline{G} \right)}. \tag{25}$$

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 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 (25) into the expression for $\widehat{q}$ and solving, we obtain

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

Noting that, from (24), $\widehat{r}_L = y - \frac{c\widehat{q}}{\xi}$, we can substitute for $\widehat{q}$ and obtain

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

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

We can now replace $\widehat{r}_L$ and $\widehat{q}$ in the expression for the firm's expected equilibrium profit and obtain

$$\widehat{\Pi}_C = \frac{1}{2c}\left(\frac{y\xi + \sqrt{y^2\xi^2 - 4cr_f}}{2}\right)^2, \tag{26}$$

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 state the following results:

Lemma 1 *1) For a given $\overline{G} \in (0,1)$, there exists a $\widehat{\widehat{c}} < \widehat{c}$ such that, for any $c > \widehat{\widehat{c}}$, we have $\widehat{\Pi}_C < \widehat{\Pi}^*$; 2) $\forall c < \widehat{c}$ (that is, for c such that $\widehat{\Pi} > \widehat{\Pi}^*$), there exists a $\overline{G} \in (0,1)$ such that $\widehat{\Pi}_C > \widehat{\Pi}^*$; 3) there exists a $\overline{G} \in (0,1)$ such that $\widehat{\widehat{c}} = 0$.*

Proof: After imposing (1), we can rewrite (26) as

$$\widehat{\Pi}_C = \frac{1}{2c}\left(\frac{y\xi + \sqrt{y^2\xi^2 - 4cr_f^*\left(1 + (1-\alpha)\frac{\Delta}{e}\right)}}{2}\right)^2. \tag{27}$$

Profits from a foreign currency contract (with $d = 0$) are

$$\widehat{\Pi}^* = \frac{1}{2c}\left(\frac{\alpha y + \sqrt{y^2\alpha^2 - 4cr_f^*}}{2}\right)^2. \tag{28}$$

For part (1), note that since $\xi = 1 - (1-\alpha)\overline{G} < 1$ whenever $\overline{G} > 0$, we have $\widehat{\Pi}_C < \widehat{\Pi}$. Then, for a given $\overline{G} \in (0,1)$, there must exist a $\widehat{\widehat{c}} < \widehat{c}$ such that for any $c > \widehat{\widehat{c}}$ we have $\widehat{\Pi}_C < \widehat{\Pi}^*$.

For (2), note that, for $\overline{G} = 0$, trivially we have $\widehat{\Pi}_C = \widehat{\Pi}$. It follows by continuity that $\forall c < \widehat{c}$, (that is for c such that $\widehat{\Pi} > \widehat{\Pi}^*$), there exists some $\overline{G}' \in (0,1)$ such that for $\overline{G} < \overline{G}'$ we have $\widehat{\Pi}_C > \widehat{\Pi}^*$. For $\overline{G} = 1$ we have $\widehat{\Pi}_C < \widehat{\Pi}^*$ irrespective of c. By continuity, this means that there exists a some $\overline{G}'' \in (0,1)$ such that for $\overline{G} > \overline{G}''$ we have only the equilibrium where counterparty risk influences the firm's. Finally, direct comparison of $\widehat{\Pi}_C$ and $\widehat{\Pi}^*$ establishes part (3). $\square$

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.

Consider, for instance, the case where a mass φ of firms has low effort costs c_1, and a mass $1 - \varphi$ has high effort costs c_2, with $c_2 > \widehat{c} > c_1$.[17] Then, from Corollary 3, in the absence of other concerns, a mass φ of entrepreneurs would borrow in domestic currency and the rest in foreign currency. However, now counterparty risk may induce even low effort cost firms to borrow in foreign currency. First, for $1 - \varphi > \overline{\theta}$, a devaluation will trigger counterparty risk. Thus, for $c_1 > \widehat{\widehat{c}}$, all firms will borrow in foreign currency. Second, for $1 - \varphi < \overline{\theta}$, two symmetric equilibria arise. In the first, high-cost firms will borrow in foreign currency and low-cost firms in domestic currency, and no firm's decision is influenced by counterparty risk. In the second, low-cost firms, expecting other low cost firms to borrow in foreign currency, all switch to foreign currency borrowing, with the associated counterparty risk fulfilling their expectations. Finally, for $c_1 < \widehat{\widehat{c}}$, low cost firms choose domestic currency borrowing even when exposed to counterparty risk. For this region, it follows that the only equilibrium is the one prevailing in our baseline model without counterparty risk: low-cost firms borrow in domestic currency, and high-cost firms in foreign currency, irrespective of φ. (The different cases are summarized in Figure 3 below. Note that, while $\widehat{\widehat{c}}$ is clearly downward sloping as a function of $\bar{G}$, it need not be linear. We draw it as a straight line for simplicity.)

The implication of this result is that there are conditions under which measures aimed at preventing or limiting foreign currency borrowing can be beneficial. 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

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[17]This extension is consistent with the interpretation we suggested above of c as measuring the degree of firm-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.
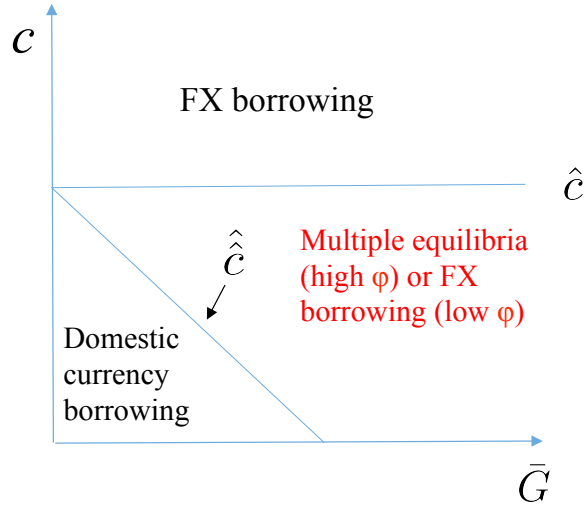
Figure 3: The figure characterizes the possible equilibria as a function of the effort cost parameter c and the counterparty risk variable $\bar{G}$. For $c > \hat{c}$, all firms borrow in foreign currency because of the counterparty risk. For $c < \hat{\hat{c}}$, all firms borrow only in domestic currency and counterparty risk does not affect each firm's choice of currency denomination for debt. For $c \in \left(\hat{\hat{c}}, \hat{c} \right)$, there are multiple equilibria when the fraction of high cost firms is large (high φ), or a unique equilibrium with only foreign currency borrowing when this fraction is small (low φ).

foreign currency, and who may not be much affected by counterparty risk.

9 Discussion and Conclusions

This paper presents a model where foreign currency borrowing may ameliorate agency problems between firms and lenders relative to borrowing in domestic currency. In particular, the analysis here provides a rationale why firms with no existing exposure through, for instance, the sale of their products in international markets, may nevertheless find it optimal to borrow in foreign currency, thus creating an unhedged exposure. The benefit 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 beneficial in certain circumstances. Such government intervention could come in the form of capital controls or prudential regulation, or some combination of the two.[18]

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, such as commercial banks and insurance companies, 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 and concentration- such as tightening open position limits, in relation to bank capital, and stepping up of foreign currency-related liquidity requirements - may be effective. By increasing the cost of borrowing in foreign currency, these measures would reduce the interest rate differential and broaden the range of parameters for which domestic currency borrowing is preferred. In addition, at least in principle, rules could be designed to curb individual exposures to currency-related risk (for instance, limits on the foreign-currency exposure banks can have with individual borrowers) and thus reduce the probability of a limited-liability triggering shock.

In contrast, when borrowers (corporates or households) take on foreign currency debt directly from foreign lenders (banks or capital markets), borrowing cannot easily 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 for the case of prudential limits, capital controls, if effective, would also reduce the interest rate differential and thus increase the attractiveness of domestic currency borrowing. However, in this case, it would be much harder to impose measures that direct intermediaries to limit the exposure of individual borrowers.

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[18]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.

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 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.

A   A more general model

In this section, we show that the main results of the paper do not depend on there being only two possible states of the world– devaluation or no devaluation – or even that there is an *expected* devaluation, so that $r > r^*$. To see this, consider the following generalization of the model. As before, there are two time periods, $t = 0$ and 1. At $t = 0$, the exchange rate is e_0, stated as the price of foreign currency in terms of domestic currency, and will be e_1 at $t = 1$. Without loss of generality we write the future exchange rate as $e_1 = e_0 + \widetilde{d}$, where $\widetilde{d}$ is a random variable in some bounded domain: $\widetilde{d}(\omega) \in [\underline{d}, \overline{d}]$ for all states $\omega \in \Omega$. Devaluations are then simply states where $d(\omega) > 0$. The state space $\Omega = \{\omega_1, .., \omega_N\}$ is finite, with each state equally likely, so that the probability for each state is $\frac{1}{N}$.[19] The domestic risk free interest rate r and the foreign risk free rate r^* are linked by a standard uncovered interest parity condition: $r = r^* \frac{E[e_1]}{e_0}$. We normalize the current exchange rate to 1: $e_0 = 1$.

A domestic firm has an investment opportunity that costs 1 unit in domestic currency and returns a random amount $\widetilde{Y}$, where $E\left[\widetilde{Y}\right] > r$. The firm needs to borrow the 1 unit if it wants to invest. The firm is risk neutral, and wants to maximize expected profits.

Lenders have access to funds and are also risk neutral, behaving competitively in the lending market. We assume that lenders care about repayment in the currency in which they lend. For simplicity in this section, we assume that there is no correlation between exchange rate movements and domestic prices; i.e., the degree of exchange rate pass-through is zero.

Analysis

We start with the case where the firm has to meet its obligations in all states of the world, which corresponds to the case of unlimited liability. If the firm borrows in foreign currency, its expected return, in terms of domestic currency, is

$$\Pi = E\left[\widetilde{Y} - r^* e_1\right], \tag{29}$$

where the expression takes into account that the firm repays r^* in foreign currency, so it must convert that into the domestic currency equivalent in assessing its return. We can further write Π

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[19]Assuming each state is equally likely simplifies some of the expressions, but is not important for the analysis.

as

$$E\left[\widetilde{Y}\right] - r^* E\left[e_1\right] = E\left[\widetilde{Y}\right] - r^*\left(e_0 + E\left[\widetilde{d}\right]\right)$$
$$= E\left[\widetilde{Y}\right] - r^*\left(1 + E\left[\widetilde{d}\right]\right)$$

where the second line obtains because of the normalization that $e_0 = 1$.

Without loss of generality, we order the states so that $\widetilde{d}\left(\omega_i\right) \leq \widetilde{d}\left(\omega_j\right)$ for $i < j$, meaning that we are going from states of low to high exchange rates, and hence low to high price for the foreign currency. We first establish a very general result on repayment to the lender: Consider any repayment scheme $L\left(\omega\right)$ in foreign currency such that $E\left[L\left(\omega\right)\right] = r^*$.

Lemma 2 *If $Y\left(\omega_j\right) > L\left(\omega_j\right) e_1\left(\omega_j\right)$, and $L\left(\omega_k\right) > 0$ for some $j < k$, then there exists $\delta > 0$ such that paying instead $L\left(\omega_j\right) + \delta$ and $L\left(\omega_k\right) - \delta$ weakly increases the borrower's payoff, and strictly increases it if $d\left(\omega_j\right) < d\left(\omega_k\right)$.*

Proof: The borrower's expected payoff is

$$E\left[\widetilde{Y}\right] - E\left[e_1 L\right] = E\left[\widetilde{Y}\right] - e_0 E\left[L\right] - E\left[Ld\right],$$

where $E\left[L\right] = r^*$. We can write this out explicitly as

$$E\left[\widetilde{Y}\right] - e_0 E\left[L\right] - \frac{1}{N}\sum_{i=1}^{N} L\left(\omega_i\right) d\left(\omega_i\right).$$

Consider now just the last term, which we can write as

$$\frac{1}{N}\sum_{i=1}^{N} L\left(\omega_i\right) d\left(\omega_i\right) = \frac{1}{N}\left(\sum_{\substack{i=1 \\ i\neq j,k}}^{N} L\left(\omega_i\right) d\left(\omega_i\right) + L\left(\omega_j\right) d\left(\omega_j\right) + L\left(\omega_k\right) d\left(\omega_k\right)\right)$$

$$\geq \frac{1}{N}\left(\sum_{\substack{i=1 \\ i\neq j,k}}^{N} L\left(\omega_i\right) d\left(\omega_i\right) + \left(L\left(\omega_j\right) + \delta\right) d\left(\omega_j\right) + \left(L\left(\omega_k\right) - \delta\right) d\left(\omega_k\right)\right)$$

since $d\left(\omega_j\right) \leq d\left(\omega_k\right)$. The inequality is strict if $d\left(\omega_j\right) < d\left(\omega_k\right)$. Since $r^* = E\left[L\right] = \frac{1}{N}\sum_{i=1}^{N} L\left(\omega_i\right) = \frac{1}{N}\left(\sum_{\substack{i=1 \\ i\neq j,k}}^{N} L\left(\omega_i\right) + \left(L\left(\omega_j\right) + \delta\right) + \left(L\left(\omega_k\right) - \delta\right)\right)$, and $Y\left(\omega_j\right) > L\left(\omega_j\right) e_1\left(\omega_j\right)$, this establishes the result for $0 < \delta \leq \min\left\{Y\left(\omega_j\right) - L\left(\omega_j\right), L\left(\omega_k\right)\right\}$. $\square$

The lemma shows that any contract with payments in "high cost" states for the borrower, which are states with high exchange rates, can be improved by shifting at least part of the repayment to

"low cost" states. This increases the return to the borrower while keeping the lender indifferent. We restrict the result to settings where $Y(\omega) > L(\omega)e_1(\omega)$, thus ruling out "money pumps" that create an potentially infinitely large arbitrage opportunity. The intuition for the result is similar to that in the body of paper, in that the firm finds it optimal to enter into contracts whose repayments are negatively correlated with movements in the exchange rate, i.e., where $cov\,(L, e_1) < 0$.

We can now apply Lemma 2 to establish the main result in the paper related to the structure of foreign currency denominated debt. Specifically, we can now show that if $E\left[\widetilde{Y}\right] > r$, any repayment scheme where $L\,(\omega) = r^*$ for all ω (i.e., where the loan is risk free for the lender) can be Pareto dominated by a repayment scheme that pays less in devaluation states and more in no devaluation states. We state this result formally below.

Proposition 5 *Suppose that $L\,(\omega) = r^*$ for all ω, and that $e_1\,(\omega_j) < e_1\,(\omega_k)$ for some j, k. Then, there exists some repayment scheme $L' \neq L$ with $E\,[L'\,(\omega)] = r^*$ such that the borrower's payoff is higher under L' than under L.*

Proof: Since $L\,(\omega) > 0$ for all ω, and some states have a greater (relative) depreciation, we can apply the lemma to states j, k. $\square$

So far, we have not made use of the uncovered interest parity condition (UIP), $r = r^* \frac{E[e_1]}{e_0}$. It is now obvious that even if UIP holds and all parties are risk neutral, Proposition 5 establishes that a risk free loan (i.e., one where $L\,(\omega) = r^*$ for all ω) can be improved upon by reducing payments in high exchange rate (i.e., high devaluation) states and increasing them proportionally in low exchange rate states. Thus, whether interest rate parity holds or not does not affect the result from Proposition 5.

The benefits of limited liability

While the results above establish that exchange rate movements create opportunities to increase aggregate surplus by shifting payment across states, in practice this requires the creation of state contingent securities with payments tied to individual states of the world, i.e., a full set of Arrow-Debreu securities. In the absence of a full set of such traded securities, here we explore an alternative contingency arrangement that can help firms achieve some portion of the possible games. Specifically, we study how the introduction of limited liability - the option to default - can create value

for the borrower, without having any negative effect on the lender to the extent that default is anticipated and priced ex ante.

To isolate the effect of limited liability, we assume that there is no uncertainty about output, so that it is fixed and the same in each state: $Y(\omega) = \bar{Y}$ for all $\omega \in \Omega$. We define limited liability as a firm's ability to refuse to repay any amount $L(\omega) e_1(\omega)$ greater than $\bar{Y}$. In other words, any feasible repayment scheme L must, in equilibrium, satisfy $L(\omega) e_1(\omega) \leq \bar{Y}$. We can now state the following result:

Proposition 6 *Let $\bar{Y} > r^*$. Any contract with a fixed repayment $L(\omega) = r^*$ for all ω, and where $L(\omega) e_1(\omega) > \bar{Y}$ for some (possibly many) states ω, can be replaced with a new contract $L'(\omega)$ that: (1) is feasible in the sense of satisfying limited liability; (2) has the same expected repayment for the lender, $E[L'] = E[L]$; and (3) makes the borrower (weakly) better off.*

Proof: Since $E[L] = r^*$ and $Y > r^*$, the repayment the borrower needs to make, $L(\omega) e_1(\omega)$, will be greater than $\bar{Y}$, when the devaluation is sufficiently large in that state: $d(\omega) > \frac{\bar{Y}}{L(\omega)} - e_0$. The contract can be replaced by an alternative contract L' that reduces the payment to $L'(\omega) = \frac{\bar{Y}}{e_1(\omega)}$ and distributes the remainder, $L(\omega) - L'(\omega)$, across feasible states, where $L(\omega) e_1(\omega) < \bar{Y}$. The new contract L' will satisfy limited liability by construction, and has the same expected repayment for the lender as L. Finally, since it reduces the repayment in states with larger devaluations, it increases the return to the borrower. $\square$

Proposition 6 establishes that limited liability can be used as a tool to reallocate payments across states, from high to low cost states. In other words, limited liability creates a form of state contingency through borrower's default option, which creates value on aggregate that can then be used to compensate the lender so as to keep him indifferent, while strictly increasing the payoff to the borrower.

The final step is to note that, if the firm were to borrow in the domestic currency at interest rate r, its expected profit would be equal to

$$\Pi = E\left[\widetilde{Y} - r\right]. \tag{30}$$

Applying the UIP condition, that $r = r^* \frac{E[e_1]}{e_0}$, we can write this as

$$\Pi = E\left[\widetilde{Y} - r^* \frac{E\left[e_1\right]}{e_0}\right]. \tag{31}$$

Equation (31) is the same as (29), the firm's profits when borrowing in foreign currency at interest r^*, with a promise to always repay. The finding that a limited liability contract increases the firm's payoff when borrowing in foreign currency therefore also establishes that it does better with this contract than with the domestic currency contract when UIP holds.

Finally, the results here are predicated on the absence of any bankruptcy costs, so that defaulting is costless for the firm and invoking limited liability is always beneficial. If we allow for a positive cost $K > 0$ whenever the firm defaults, the benefit of defaulting in state ω, which is proportional to $e_1(\omega) - E\left[e_1|\text{no default}\right]$, would have to be weighed against this cost. It is then obvious that borrowing in the foreign currency and defaulting will only be optimal when the devaluation is sufficiently large, so that the benefit of defaulting outweighs the cost of doing so.

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