DOLLARIZATION OF LIABILITIES: UNDERINSURANCE AND DOMESTIC FINANCIAL UNDERDEVELOPMENT

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ABSTRACT

While there is still much disagreement on the causes underlying recent emerging markets' crises, one factor that most observers have agreed upon is that contracting "dollar" (foreign currency) denominated external debt – as opposed to domestic currency debt – created balance sheet mismatches that led to bankruptcies and dislocations that amplified downturns. Much of the analysis of the "currency-balance sheet channel" hinges on the assumption that companies contract dollar denominated debt. Yet there has been little systematic inquiry into why companies must or choose to take on dollar debt. In this paper we cast the problem as one of microeconomic *underinsurance* with respect to country-wide *aggregate* shocks. Denominating external debt in domestic currency is equivalent to contracting the same amount of dollar-debt, complemented with insurance against shocks that depreciate the equilibrium exchange rate. The presence of country-level *international* financial constraints justify the purchase of such insurance even if all agents are risk neutral. However, if *domestic* financial constraints also exist, domestics will undervalue the social contribution of contracting insurance against country-wide shocks. Foreign lenders will reinforce the underinsurance problem by reducing their participation in domestic financial markets.

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1 Introduction

While there is still much disagreement on the causes underlying recent emerging market crises, one factor that most observers have agreed upon is that contracting "dollar" (foreign currency) denominated debt —as opposed to domestic currency debt— created balance sheet mismatches that led to bankruptcies and dislocations that amplified downturns. Much of the analysis of the "currency-balance sheet channel" hinges on the assumption that companies contract dollar denominated debt.[1] Yet there has been little systematic inquiry into why companies choose to take on this type of debt. Companies certainly recognize that contracting dollar debt brings with it the cost of a balance sheet mismatch. On the other hand, the attraction to dollar debt is that a company is able to fund itself - at least nominally – at lower interest rates. Is the low price of foreign debt worth the balance sheet risk for a company in an emerging market? Do prices allocate the risk efficiently? Should a policy maker be concerned that companies underprice the risk of dollar debt and therefore take on too much of it?

At an abstract level, the decision to take on dollar debt as opposed to domestically denominated debt is a decision to opt out of insurance against bad *aggregate* states of the world.[2] Imagine a Thai company that faces a currency denomination choice in taking on one period debt. Suppose that next period there are two (aggregate) states of the world: in the good state the baht/dollar exchange rate is one, in the bad state it takes more baht to purchase a dollar and the exchange rate is two. In either state of the world, the company will have assets that are worth A baht. Then, if the company chooses to take on D_d dollars of debt, its value next period is,[3]

$$\text{Good}: \quad A - D_d \quad \text{or} \quad \text{Bad}: \quad A - 2D_d.$$

While if the company took on D_b baht debt, its value is,

$$\text{Good}: \quad A - D_b \quad \text{or} \quad \text{Bad}: \quad A - D_b.$$

Normalizing by setting $D_d = D_b$, we can see that the only difference between these two cases is that in the former the company is required to make an additional payment of D_d in the bad state of the world. Thus, one can see the benefit due to issuing baht debt as that of purchasing insurance against the bad aggregate state. The firm buys a put option

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[1] For models of the balance sheet channel in emerging markets, see e.g., Caballero and Krishnamurthy (1999), Krugman (1999), Aghion, Bacchetta and Banerjee (1999), Chang and Velasco (1999).

[2] From general equilibrium asset pricing results, it may seem odd that we refer to insuring against aggregate shocks. With heterogeneity such insurance is desirable, will be traded, and can affect real outcomes.

[3] We have assumed there is no bankrupty here, or that $A > 2D_d$.

paying D_d in the bad state of the world. The cost of this strategy is the option-premium, which is reflected in a higher ex-ante interest rate vis-à-vis the dollar-interest rate.[4]

In our model all agents are risk neutral but domestics value and demand insurance because they face a risk of liquidation (or production interruptions) in bad states of the world as international financial constraints may become binding for the country.[5] If, as a result of the latter, agents expect the exchange rate to depreciate sharply during bad aggregate states of the world, they will provision international liquidity for these states – meaning they will "purchase" insurance that pays them dollars in the bad states of the world.

The question we ask is whether domestics purchase a socially efficient amount of insurance. Domestics will demand the right amount of insurance from the social point of view only if the *equilibrium* exchange rate —in our model, the relative price of foreign to domestic assets— reflects the social value of an extra unit of international liquidity (assets). We show that when domestic financial markets are well developed, in the sense that a domestic firm can pledge its entire marginal product from investment to domestic lenders, the exchange rate indeed reflects this marginal product and microeconomic insurance decisions support the second best. But when domestic financial markets are underdeveloped, domestic demand for international liquidity during crises is determined by the limited availability of domestic collateral rather than by marginal product. The empirical counterpart of this scenario is a wedge between the internal return on investment for a domestic firm and the external return that is promised to lenders. As a result, international liquidity is undervalued, and insurance to guard against a lack of international liquidity is eschewed by domestic firms.

While also driven by an insurance mispricing mechanism, our explanation for liability dollarization is quite distinct from ones that point out that fixed exchange rates offer free insurance and creates moral hazard that distorts investment choices (see e.g., Dooley (1997), and Burnside, Rebelo and Eichenbaum (1999)). In these models, fixing the exchange rate offers free insurance to firms that borrow in dollars and therefore encourages dollar borrowing. In our model, on the other hand, it is not government misbehavior but financial underdevelopment that creates the private underinsurance problem. This may explain why

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[4]Equivalently, the benefit due to issuing dollar debt is the premium on selling a foreign currency option paying D_d if the bad state of the world arises. A company that chooses to issue dollar debt receives this option premium in terms of a lower nominal interest cost, but faces the risk that in bad states of the world it must make a higher payment.

[5]The hedging motive, as in Froot, Scharfstein and Stein (1993), stems from the observation that financial constraints create hedging demand in a dynamic setting. However, in our case, the hedging demand stems from from an equilibrium-aggregate rather than a microeconomic constraint. The distinction is important, since we address a set of macroeconomic issues surrounding hedging.

the dollarization of liabilities problem extends across emerging markets, regardless of exchange rate systems.[6]

In addition to domestic demand problems, under-insurance may be driven by external supply problems. This has been emphasized in the policy literature. For example, Hausmann, et al (1999) refer to the "original sin" of emerging markets as the inability to borrow from foreign investors in domestic currency. A formalization of a supply effect is in Calvo and Guidotti (1990) in the context of public debt (see also Calvo (1996)). The argument is based on time-inconsistency of the government: ex-post governments will always devalue to reduce the value of local currency denominated debt. Seeing this, foreigners shy away from domestic currency debt.[7],[8] Our framework adds naturally to the list of supply problems. We extend our model and show that domestic financial underdevelopment can affect foreign lending supply and insurance in two ways. First, as financial development falls, foreign lenders find that it is less profitable to lend to firms with poor collateral, and hence their entry into domestic financial markets is cut back. Second, when interacted with a thin-market supply externality, we show that this withdrawal raises the risks that the fewer suppliers are exposed to and hence can feedback into higher lending and insurance premia.

The next section of this paper lays out the model, while section 3 describes the underinsurance problem. Section 4 explores in depth the connection between underinsurance and domestic financial underdevelopment. This section also serves as a transition to section 5, where we discuss external supply problems that may arise in this context. Section 6 contains final remarks. An appendix follows.

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[6]See, e.g., the evidence of dollarization of liabilities in fixed as well as flexible exchange rate systems in Hausmann et al. (1999).

[7]See also Allen and Gale (2000) for a similar argument. In their model, banks optimally invest in foreign bonds and issue domestic bonds. They argue that the risk of inflation may dissuade foreigners to purchase the domestic bonds. These explanations seem most compelling for high inflation countries (Latin America), rather than, for example, the Asian countries where chronic inflation was not a problem. Moreover, as Calvo (2000) points out, it is hard to extend this argument to private sector debt if one is interested in the connection between liability dollarization and financial difficulties. The problem is that the private sector has incentives to choose its liabilities to hedge its assets and avoid balance sheet mismatches, if they are indeed costly. Our explanation accounts for private sector debt choices, and is designed to address precisely this difficulty.

[8]Constraints on domestic currency external borrowing may have a domestic policy origin as well. Until recently in Chile, for example, external borrowing in domestic currency was taxed more heavily than dollar borrowing.

2 The Model

In this section we present the core model. It has three basic ingredients, all of them necessary to address the issues highlighted in the introduction: First, it roots the need for international insurance on the presence of external financial constraints and country-wide shocks. Second, it links the denomination of external debt to the insurance problem. And third, it highlights the role of imperfections in domestic financial markets on exchange rate determination and insurance demand.

2.1 Preferences and Technology

Consider a three period world indexed by $t = 0, 1, 2$. There are two sets of agents: domestic entrepreneurs/firms and foreign investors. All agents are risk neutral and competitive. Assume that there is a unit measure of each type of agent. Domestics borrow from foreign investors, contract debt repayments, and invest in production at date 0. Then at date 1, there are idiosyncratic and an aggregate shock that determine the injection of funds required to continue production. The aggregate shock only takes on two values: we shall distinguish between the high (aggregate) state and the low state depending on the size of the shock. Finally at date 2, debts are fully repaid and all agents consume.

Production. All production requires imported or dollar goods and produces domestic or baht goods. At date 0 a firm borrows b_0 dollars from a foreigner, exchanges this for imported raw materials and creates capital of k at a cost of $c(k)$. Thus,

$$c(k) \leq b_0$$

The function $c(k)$ is assumed to be convex and increasing in order to generate an interior solution. Once created, the capital is "baht" – it generates local currency revenue, and its value as collateral will vary with the exchange rate. We formalize this below.[9]

At date 2, if all things go well, capital generates Rk units of baht goods. However, at date 1 production may be interrupted by an idiosyncratic liquidity shock, and the firm is required to import an additional one unit of foreign goods per unit of capital in order to realize output of Rk baht. If a firm chooses not to, then its output falls to $r < R \equiv r + \Delta$ on the capital that is not saved. Thus, suppose that a firm chooses to save a fraction $\theta \leq 1$ of its capital units, then date 2 output for this firm is,

$$(1 - \theta)rk + \theta Rk,$$

and this firm must import θk units of goods to compensate for the shock.

We assume that when the aggregate state is good, no firm is affected by a liquidity shock. When the aggregate state is bad, on the other hand, half of the firms need to reinvest. The

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[9]Our model is entirely real, hence any allusion to the exchange rate refers to the real exchange rate.

shock is country-wide in the sense that a positive measure of firms are affected by it in the bad state, while it is idiosyncratic in that an individual firm has a probability of $\frac{1}{2}$ of being affected by it in the bad state.[10] The probability of the bad state is π, while that of the good state is $1 - \pi$.[11]

At date 2, the domestic entrepreneurs/firms pay off all debts incurred at date 0 and date 1 from production proceeds and consume the excess. Their preferences are,

$$U^d = c^B + c^D \qquad\qquad c^B, c^D \geq 0$$

where c^B is consumption of baht goods, and c^D is consumption of dollar goods.

Foreigners may be called on at date 0 and date 1 to supply dollars to domestics to finance production. Their preferences are over consumption of dollars (foreign goods) at all three dates,

$$U^f = c_0^D + c_1^D + c_2^D.$$

These preferences pin down the dollar risk free interest rate at one.

2.2 International and Domestic Financial Markets

Foreigners do not consume any of the output from domestic capital. This is the sense in which capital generates only local currency revenues. Goods produced using domestic capital are non-traded, so that the value of capital falls as the exchange rate between these baht goods and dollars depreciates. Note also that because of this, foreigners cannot be repaid in baht goods. We shall assume that domestics have an exogenously specified endowment of foreign currency revenues arriving at date 2 given by w. Thus, while foreigners may be willing to accept baht goods as repayment on debts, they will immediately swap these in exchange for the foreign currency endowment. The exchange rate for this transaction is denoted as e (baht per dollar). However, for expositional purposes it is easier to proceed by assuming that foreigner lend only against the foreign currency revenue stream of w, so that any swapping of baht for dollars is only in the background.

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[10]The fact that heterogeneity rises during bad states is not important. We need heterogeneity in the bad state for domestic financial markets to matter, but adding heterogeneity in the good aggregate state would not add any substantive insight and would complicate the expressions.

[11]We also need to make an assumption that date 0 investment in capital is sufficiently profitable. Thus, R and r are high enough that,

$$(1 - \pi)R + \pi \frac{R + r}{2} > c'(w),$$

where w is the firm's date 2 endowment of foreign currency (see below).

This expression just says that despite the possibility of the production shock at date 1, investment is profitable. Finally to guarantee an interior solution (i.e. $k < c^{-1}(w)$) we assume that,

$$(1 - \pi)R + \pi \frac{R + r}{2} < (R - r)c'(w).$$

Assumption 1 *(Foreign Lending)*
All foreign lending takes the form of debt contracts that are fully secured by the foreign currency collateral of w. Lending is default free, so that the maximum repayment on debt is w.

By debt we mean contracts that are not contingent on purely idiosyncratic performance. As one might imagine, flexibility in specifying debt repayments contingent on the type of firm could provide greater insurance. Of course, in practice, these shocks are idiosyncratic and may be hard to observe so that contingent contracts are not enforceable.

Assumption 2 *(Non-observability of Production Shock) The identity of firms receiving the date 1 production shock in the low state is private information of the firm, and is not observable by any lender.*

Debt repayments are, however, assumed to be made contingent on the (observable) aggregate state, ω. To be more precise:

Definition 1 *Let $\omega \in \{l, h\}$ be the state of the world at date 1. A date 0 dollar debt contract between a domestic firm and a foreign investor will specify date 2 repayments, f^ω, and date 0 funding of b_0 dollars. Since foreign investors are risk neutral, competitive, and the dollar interest rate is one,*

$$b_0 = \pi f^l + (1 - \pi) f^h$$

Additionally, since all debt is fully secured,

$$f^\omega \leq w$$

As we argued in the introduction, the question of dollar liabilities vis-a-vis baht liabilities is simply a question of how high f^l is relative to f^h. We shall shortly prove that, in equilibrium, $e^l > e^h$. Since the effective baht repayment for the firm contracting dollar liabilities is $e^\omega f^\omega$, equal dollar repayments in high and low states would have the firm making larger baht repayments in the low state. On the other hand, if liabilities were baht denominated, then f^l would be lower for the same f^h.

Unlike foreigners, domestics do value baht revenues, so they are willing to lend to each other against domestic capital. However, the domestic financial market is underdeveloped, so that not all of the output from capital is pledgeable to a domestic lender. Only rk of the date 2 goods serves as domestic collateral. Instead, if the financial market was fully developed, then $(1-\theta)rk + \theta Rk$ would be domestic collateral. For $\theta > 0$, the latter expression is clearly larger. In section 4, we shall work through this case to clarify the model.

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Assumption 3 *(Domestic Lending)*

Domestic firms may lend to each other at either date 0 or date 1. All domestic lending is fully secured by baht revenues. However, the domestic credit market is underdeveloped, so that only rk of the date 2 baht revenues can be used to secure financing from another domestic.

The limited domestic lending part of this assumption is the central ingredient for our underinsurance result, for it is responsible for the emergence of a gap between social and private valuation of external insurance. This will be clear after we describe its role in determining the equilibrium exchange rate during external crises.

2.3 Decisions and Equilibrium

Let us suppose that a firm borrows b_0 funds at date 0, and creates capital of k. At date 1, there are two possible states of the world. In the high state, there are no shocks, and all firms continue to produce Rk. Net of the repayment of f^h, this implies that entrepreneurs in the high state consume,

$$V^h = Rk + w - f^h.$$

In the low state, firms are divided into two groups: those that receive the shock are distressed, while those that do not are intact. Consider the problem for a distressed firm in raising funds to alleviate its production shock. A choice of θk will result in output at date 2 of $(1 - \theta)rk + \theta Rk$ goods. In order to save a fraction θ of distressed capital, the firm must raise finance and reinvest θk imported goods. It can do this in two ways. First, the firm can go to foreigners to raise additional funds. That is the firm can always raise directly,

$$b_1 \leq w - f^l.$$

The latter quantity will always be positive in equilibrium.[12] The rest must come from intact firms, which also have access to foreign investors since their capacity to borrow abroad at date 1 is also $w - f^l$.

A distressed firm can use its baht collateral of rk to borrow dollars from intact firms. Since the exchange rate is e^l, the firm can borrow a maximum amount of $b_1^D \leq \frac{rk}{e^l}$ dollars from intact firms. Through this "credit chain" —which represents the domestic financial markets in our framework— the distressed firm is able to aggregate the resources of the economy and pledge this to foreigners to raise funds for date 1 reinvestment. We can then write the problem of a distressed firm as,

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[12]Since firms are ex-ante homogeneous $w > f^l$, otherwise there would be no international liquidity left in the aggregate in the low state. But since reinvestment must be sufficiently profitable for external crisis to be interesting, we rule out such corner.

$$(P1) \quad V_s^l \equiv \max_{\theta, b_1, b_1^D} \quad w + (1-\theta)rk + \theta Rk - f^l - b_1 - b_1^D$$

$$\text{s.t.} \quad (i) \qquad b_1 \leq w - f^l$$

$$(ii) \qquad \frac{b_1^D}{e^l} + b_1 \leq w - f^l + \frac{rk}{e^l}$$

$$(iii) \qquad \theta k = b_1 + \frac{rk}{e^l}$$

$$(iv) \qquad 0 \leq \theta \leq 1.$$

Constraints (i) and (ii) are balance sheet constraints (net marketable assets greater than liabilities), while constraint (iii) reflects that new investment must be fully paid with the resources received by the firm at date 1 in taking on debts of b_1 and b_1^D. Constraint (iv) is purely technological.

An intact firm at date 1 has only one decision: how much finance will it extend to the distressed firm. Suppose that the firm accepts claims at date 1 of x_1 (face value of date 2 baht) in return for making a date 1 contribution of $x_{1,d}/e^l$ dollars, then,

$$(P2) \quad V_i^l \equiv \max_{x_1} \quad w + Rk + x_1 - \frac{x_1}{e^l}$$

$$\text{s.t.} \qquad \frac{x_1}{e^l} \leq w - f^l$$

The constraint reflects the fact that an intact firm can, at maximum, lend $w - f^l$ dollars to the distressed firm.

Date 0 problem. At date 0, a firm looking forward to date 1 can expect to find itself as either distressed or intact, and in either the low or the high state. Thus the decision at date 0 is,

$$(P3) \quad \max_{k, b_0, f^\omega} \quad (1-\pi)V^h + \pi(V_s^l + V_i^l)/2$$

$$\text{s.t.} \quad f^h, f^l \leq w$$

$$b_0 = \pi f^l + (1-\pi)f^h$$

$$c(k) = b_0.$$

Equilibrium. An *equilibrium* of this economy consists of date 0 and date 1 decisions, (k, b_0, f^ω) and $(\theta, b_1^\omega, b_1^D, x_1^D)$, respectively, and prices e^ω. Decisions are solutions to the firms' problems (P1), (P2), and (P3) given prices. At these prices, the exchange market clears.

The only equilibrium price is the exchange rate. Given the preferences of domestics, the following must hold true.

Lemma 1 *Let c^B and c^D denote the equilibrium consumption of any intact entrepreneur in the domestic economy at date 2. Then,*

- *If $c^B, c^D > 0$, then $e = 1$.*

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- *If $c^B > 0$, but $c^D = 0$, then $e \geq 1$.*

The case of $c^B = 0$ and $c^D \geq 0$, can never occur in our model since production always generates at least some baht, and the domestics must consume this baht.

The exchange rate is 1 as long as the solution is interior, with domestics consuming both baht as well as dollar goods. However, if the economy runs out of dollar goods, the exchange rate will depreciate further to reflect this scarcity. Since this is precisely the case we shall be interested in, we shall construct an equilibrium where this happens at date 1 in the low state.[13] The equilibrium exchange rate, e^l is determined in the domestic financial market, where intact firms lend dollars to distressed firms against baht:[14]

$$\frac{1}{2}b_1^D = \frac{1}{2}x_1^D. \tag{1}$$

Let us now study equilibrium in l-state in more detail. Consider a distressed firm that faces the choice of restructuring an additional unit of capital at date 1. Let,

$$\Delta = R - r$$

be the baht return to saving one unit of capital. First, remember that a firm values one baht and one dollar equally for consumption at date 2 (i.e. $U = c^D + c^B$). As a result, if $\Delta \geq 1$, then the distressed firm would choose to borrow as much as it can against its foreign currency revenues at the dollar interest rate of one, and reinvest these funds to return Δ baht goods at date 1.

$$b_1 = w - f^l. \tag{2}$$

If the amount raised from international investors, $w - f^l$, is less than the funds needed for restructuring, k, the firm will have to access the foreign exchange market to make up the shortfall. It can sell up to rk date 2 baht to another domestic at the exchange rate of e^l. It will choose to do this as long as $\Delta \geq e^l$, or the baht return on restructuring exceeds the exchange rate. The maximum amount of funds raised is,

$$b_1^D \leq \frac{rk}{e^l}. \tag{3}$$

As long as the sum of $\frac{rk}{e^l}$ and the right hand side of (2) is more than the borrowing need of k, the firm is unconstrained in its reinvestment at date 1 and all production units will be

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[13]See Caballero and Krishnamurthy (1999) for a variant of this model where the shortage of dollars occurs at date 1 but not at date 2 (liquidity crisis). This "fire sale" dimension of the problem is not important for the qualitative aspects of the issues we are addressing in this paper.

[14]More precisely, what we refer to as the exchange rate at date 1, is a date 2 forward exchange rate. The international interest rate is one and interest parity must hold. Thus, $e_1(1 + i_1) = e_2$, where i_1 is the domestic interest rate. The model has a free parameter in that we do not, nor need to, pin down the domestic interest rate. Choosing $i_1 = 0$, allows us to call this the date 1 exchange rate as well.

saved. In this case, the firm will borrow less than $\frac{rk}{e^l}$ (and perhaps less than the international debt capacity).

Intact firms can tender at most their excess international debt capacity of $w - f^l$ in return for purchasing domestic debt. They will choose to do this as long as the exchange rate exceeds one, or $e^l > 1$.

Assume for a moment that $\Delta \geq e^l \geq 1$ so that distressed firms borrow as much as they can, and intact firms lend as much as they can. Then, in total the economy can import $w - f^l$ goods, which is directed to the distressed firms. A necessary condition for all production units to be saved is that,

$$\frac{k}{2} \leq w - f^l. \tag{4}$$

If this constraint is violated, then some capital units are not restructured at date 1,

$$\theta \frac{k}{2} = w - f^l \qquad \theta < 1.$$

We shall refer to this constraint as the *international liquidity constraint*. When neither (3) nor (4) binds, all production units are saved. Since in equilibrium $c^D > 0$, it must be that the exchange rate is one.

The other extreme case is when both (3) and (4) bind. Equilibrium in the exchange market requires that,

$$\frac{rk}{e^l} = w - f^l.$$

Since (3) binds, distressed firms sell all of their baht revenues to intact firms. As (4) binds, intact firms purchase this by borrowing as many dollars as they can and paying this to distressed firms. Solving for e^l, yields

$$e^l = \frac{rk}{w - f^l} > 1. \tag{5}$$

In this case, the exchange rate is depreciated since there is a scarcity of dollar assets relative to baht assets.

Now, depending on parameters, there are four regions that may occur at date 1 in state l – distinguished by the four combinations of binding constraints, (4) and (3). We focus on the cases where the international financial constraint (4) binds, and study cases in which the domestic constraint (3) may or may not bind. If (4) binds, the exchange rate in the l state is depreciated.

Lemma 2 *(Exchange Rates) If (4) binds, then c^D of an intact firm at date 2 is zero. From Lemma 1, we can conclude that $e^l \geq 1$. If (4) does not bind, c^D of an intact firm is greater than zero, and $e^l = 1$. In the high state, since there are no liquidity shocks, $e^h = 1$.*

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With just this constraint, firms will anticipate that taking on dollar debt implies higher baht payments in the l state. Since this is precisely the state where they will need resources to finance the production shock, they will shy away from contracting to make high payments in this state. We will show that in this case, firms appropriately value the insurance offered by contracting domestic currency debt. This changes when (3) binds, and domestic firms are credit constrained. We shall show in this case that there is an externality whereby firms undervalue insurance against the low state.

2.4 Currency Denomination as an Aggregate Contingency

Let us pause at this juncture and contrast dollar debt and baht debt within our framework. An uncontingent dollar debt contract will specify repayments of $f^h = f^l \equiv f_{dollar}$. Therefore since the dollar interest is one,

$$b_{0,dollar} = \pi f_{dollar} + (1 - \pi) f_{dollar} = f_{dollar}.$$

Next consider an uncontingent baht debt contract with repayments given as $f^h = f^l \equiv f_{baht}$. The dollar equivalent repayments are f_{baht} in the high state, and $\frac{f_{baht}}{e^l}$ in the low state, where $e^l > 1$. Thus, the amount of dollar equivalent that the firm is able to borrow at date 0 is,

$$b_{0,baht} = \pi \frac{f_{baht}}{e^l} + (1 - \pi) f_{baht} = f_{baht} - \pi(e^l - 1)\frac{f_{baht}}{e^l}.$$

Let us normalize by choosing, $f_{dollar} = f_{baht} = f$. Then it is easy to see that,

$$b_{0,baht} = b_{0,dollar} - \pi(e^l - 1)\frac{f}{e^l},$$

or that, for a fixed face value of debt, the firm is able to borrow less dollars by issuing baht debt than dollar debt.

The reason behind this is that the firm takes exchange rate risk in its debt issue. Vis-a-vis baht debt, when the firm borrows in dollars it simultaneously sells a put option struck at one on f baht. Equivalently the firm is able to obtain a lower interest rate on its debt when it takes on dollar debt than baht debt, but in return takes on the risk that the exchange rate may depreciate at date 1.

With these preliminaries behind, we can turn to our main substantive results.

3 Underinsurance: Excessive dollar Liabilities

3.1 Competitive Equilibrium versus Planner's Choice

Definition 2 *If f^h and f^l are debt repayment choices (in units of dollars) in a competitive decentralized equilibrium, and F^h and F^l are debt repayment choices of a central planner,*

then we shall say that the economy has **excessive dollar liabilities** *if,*

$$\frac{f_h}{f_l} < \frac{F_h}{F_l}.$$

The logic behind this definition stems from the previous section. When normalized so that all repayments are in dollar terms, the only difference between dollar and baht contracted debt repayment is in the size of the repayment in the l state versus the h state. Taking on dollar debt means, per unit of debt, higher repayments in the l state.[15]

Let us now write down the date 0 decentralized problem in an environment where both (3) and (4) bind. First, let us rewrite (P3), substituting in the value function from (P1) and (P2). A date 0 choice of (k, f^h, f^l) result in date 2 resources (net of any contracted debt) in the high state of,

$$Rk + w - f^h.$$

On the other hand in the low state, if the firm is distressed, it has date 2 resources of,

$$(w - f^l)\Delta + \frac{rk}{e^l}\Delta$$

This is because $(w - f^l)$ is directly pledged to foreigners, and the proceeds invested at the project return of Δ. The rk of domestic collateral is sold at the exchange rate of e^l, and the proceeds invested at Δ. If the firm is intact, date 2 resources are,

$$(w - f^l)e^l + Rk.$$

Thus the date 0 program is,

$$(P4) \quad \max_{k, f^h, f^l} \quad (1 - \pi)(Rk + w - f^h) + \pi\tfrac{1}{2}\left((R + r\tfrac{\Delta}{e^l})k + (\Delta + e^l)(w - f^l)\right)$$
$$s.t. \quad f^h, f^l \le w$$
$$c(k) = \pi f^l + (1 - \pi)f^h$$

Consider next the choices of a central planner who maximizes an equally weighted sum of the utilities of the domestic agents, subject to the domestic and international borrowing constraints. Suppose the central planner makes a date 0 choice of (K, B_0, F^h, F^l), where capital letters denote the central planner's aggregate quantities. Then, at date 1, in the high state, all firms will end up with resources of,

$$V^h = RK + W - F^h.$$

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[15]We allow firms to take on contingent dollar debt contracts and have them choose the pattern of payments (f^h, f^l). To map this directly into the language of uncontingent baht and dollar debt contracts, note that there are two states of the world and that these two (uncontingent) liabilities are linearly independent. Thus spanning results apply. The pattern of repayments of (f^h, f^l) can be implemented by taking on some baht debt and some dollar debt. We say there is excessive dollar debt when a central planner would choose a lower fraction of dollar debt than private agents.

In the l state, a distressed firm receives,

$$(W - F^l)\Delta + \frac{rK}{e^l}\Delta.$$

But since we are interested in an expression that is free of prices, simply substitute the market clearing condition,

$$e^l = \frac{rK}{W - F^l}$$

into the above. Then,

$$V_s^l = 2(W - F^l)\Delta$$

Similarly, an intact firm receives,

$$(W - F^l)e^l + RK.$$

And substituting in the market clearing condition,

$$V_i^l = (r + R)K$$

Therefore the constrained efficient debt choices in this economy are,[16]

$$(P5) \quad \max_{K,F^h,F^l} \quad (1 - \pi)(RK + W - F^h) + \pi\frac{1}{2}\left((R + r)K + 2\Delta(W - F^l)\right)$$
$$\text{s.t.} \quad F^h, F^l \leq W$$
$$c(K) = \pi F^l + (1 - \pi)F^h$$

The objective in (P5) represents the constrained efficient solution as opposed to the first best solution. Our central planner is still subject to the international debt constraint – i.e. the economy raises $\pi F^l + (1 - \pi)F^h$ which is limited by W.

Lemma 3 *In both (P4) and (P5), $F^h = f^h = W$.*

Proof: see appendix.

The result is fairly obvious. In the h state, since there is no chance of a liquidity shock, there is no reason to leave an slack in the debt repayment. Optimality requires firms to borrow as much as possible against W in this state and use the proceeds to increase K at date 0.

Lemma 4 *If $\Delta > e^l$, then $F^l < f^l$, or debt repayments are set too high in the l state in the decentralized equilibrium.*

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[16]This expression can be arrived at directly by noting that if (4) binds, then all the date 1 dollars of the economy must go toward saving capital units. Since there are $W - F^l$ dollars that the economy has in aggregate, and each generates a return of Δ, we have the latter half of this expression. Given a shock that reduces output to rK for one-half the firms, we have the former part of the expression.

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Proof: see appendix.

The easiest way to understand this result is to contrast the terms in the objectives corresponding to the l state in both (P4) and (P5). Suppose that f^l and F^l were equal. Now, imagine an experiment of increasing f^l and F^l by \$1. In both cases this will allow for more borrowing at date 0, and will raise an additional π dollars. This in turn can be used to increase capital investment by $\frac{\pi}{c'(k)}$. Therefore the benefit to borrowing a dollar and investing it is to increase capital by the same amount in both centralized and decentralized cases. Now consider the cost. In both cases, there is one dollar less of funds for saving distressed capital units in the l state at date 1 – i.e. $(w - f^l)$ falls by one dollar. The firms in (P4) take this cost to be,

$$\frac{1}{2}(\Delta + e^l)$$

while the central planner recognizes that this cost truly is,

$$\frac{1}{2}2\Delta = \Delta.$$

The central planner's cost of taking on the extra dollar of debt exceeds the firm's perceived cost by,

$$\frac{\Delta - e^l}{2}.$$

As long as $\Delta > e^l$ it must be that firms set $f^l > F^l$.

Definition 3 *Define the* **index of domestic underdevelopment** *as the difference between the marginal profit of saving a distressed production unit and the exchange rate of* e^l.

$$s_d = \Delta - e^l,$$

Then note the following:

Lemma 5 *(Domestic Underdevelopment) Suppose that (4) binds in the l state so that $e^l > e^h = 1$. If (3) also binds, then it must be that $s_d > 0$. Alternatively, if (3) does not bind, then it must be that $s_d = 0$.*

The reason we refer to s_d as the index of domestic underdevelopment is that it is only greater than zero when the credit constraint between domestic firms binds (i.e (3)). An environment in which there are no domestic credit constraint is analogous to one in which $s_d = 0$.

Proof: Consider the FOC for the exchange transaction by a distressed firm. If $\Delta > e^l$, the firm finds it profitable to borrow as much as possible against its baht revenues of rk. Assuming maximum borrowing, $e^l = \frac{rk}{w - f^l}$. Now there are two cases. If $\Delta > \frac{rk}{w - f^l}$, this is

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an equilibrium and both (3) binds and since $\Delta - e^l > 0$ we have that $s^d > 0$. The other case is when, at maximum borrowing, $\Delta \le \frac{rk}{w-f^l}$. Here, a firm will not find it profitable to borrow as much as possible against rk since the return from saving a distressed unit of capital is less than or equal to the exchange rate. As a result, $b_1^D < \frac{rk}{e^l}$, and (3) does not bind. Additionally, since $\Delta - e^l = 0$, we have that $s^d = 0$.

Proposition 1 *(Excessive dollar liabilities.) Firms in an economy in which $s_d > 0$, hence (3) and (4) are binding, contract excessive dollar liabilities.*

3.2 The Externality

When a domestic firm makes its financing and production choices, it looks not only at the revenue generated by capital investment but also at the liquidity services that this capital provides at date 1. That is, the creation of a liquid asset is an important aspect of real investment decisions when a sudden need for fresh resources may arise before projects are completed. From the aggregate point of view of the central planner, only internationally liquid assets have such value, since date 1 production needs may be satisfied only with dollars.

Comparing (P4) and (P5) at $f^l = F^l$ reveals that, relative to the central planner, individual agents add a term to their objective function which is directly related to the microeconomic liquidity service of domestic and international assets:

$$\pi \frac{1}{2} \left(\left(\Delta - e^l \right) \frac{rk}{e^l} - \left(\Delta - e^l \right) (w - f^l) \right). \tag{6}$$

When the economy is in the l state, a firm may be distressed or intact with equal probability. If distressed, at the margin it uses its domestic asset (i.e. rk) as collateral. If not, it sells its international liquidity to distressed firms. In order for the microeconomic problem to coincide with that of the central planner, there must be no rent in the former activity, while the latter must yield the full marginal product of reinvestment. It is apparent that when $s^d > 0$ neither condition holds; the collateral value of domestic assets is overvalued while the return on supplying valuable international liquidity is depressed.

Both problems have the same root. When domestic financial markets are underdeveloped, distressed firms can only pledge a fraction of their marginal product of date 1 investment of Δ. The constrained nature of their demand for international liquidity is good news for a distressed firm in need for such liquidity and in possession of pledgeable domestic assets, because it faces less competition for international liquidity, and is thereby able to retain a fraction of the surplus from fresh investment. It is bad news for an intact firm attempting to profit from its international liquidity, because this firm receives less than the

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social surplus due to investment. Both margins are distorted exactly by the domestic credit spread of s_d.[17]

4   A Closer Look at the Connection between Financial Underdevelopment and Underinsurance

We have argued that excessive dollarization of liabilities stems from domestic financial market underdevelopment. When there are credit constraints affecting borrowing/lending between domestic agents, agents will systematically undervalue the insurance that taking on domestic currency liabilities affords. This section develops this argument further in two steps. First, we relax the credit constraints of a few domestic agents in order to separate the effect of distorted asset prices from the direct effect of credit constraints on agents' choices. Second, we show that when domestic financial constraints vanish for all domestics the second best is attained, despite the fact that the aggregate shocks have a real and negative effect on the economy. We conclude that it is domestic financial constraints, rather than negative shocks, which are behind our underinsurance results.

4.1   Constrained and Unconstrained Firms

Suppose that a fraction λ of the domestic firms face no domestic credit constraints. Thus, for these firms the date 1 debt constraint is,

$$b_1^D \leq \frac{(1 - \theta)r + \theta R}{e^l} k. \tag{7}$$

For $\theta > 0$, it is clear that,

$$\frac{(1 - \theta)r + \theta R}{e^l} k > \frac{rk}{e^l}$$

or that these firms are less credit constrained than those of (3).

Lemma 6 *(7) will never bind for unconstrained firms.*

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[17]For the distortion in the relative valuation of the liquidity service of both assets to arise, it must be the case that $r > 0$. Otherwise, the initial capital investment in k does not yield any domestic collateral that gives liquidity service, and all liquidity provision can only be done via changes in financing decisions. Thus, to be precise, the presence of domestic financial constraints is not a sufficient condition for the externality to arise. On the other hand, the case where $r = 0$ is non-generic in the sense that we usually think that capital investment creates a liquid asset as a byproduct. Nevertheless, if $r = 0$ but there is a domestic financial constraint arising from the limited pledgeability of date 1 reinvestment, there would be no externality. While such a friction would affect the leverage coefficient of any down payment available at date 1, and distort the relative valuations of international and domestic liquidity at date 1, this distortion would have no consequence as there is no action by a domestic that would affect the amount of domestic liquidity at date 1 and therefore be altered by the distortion.

Proof: Suppose that these firms chose to save θ units of capital by issuing debt that garners θk dollars. Then the maximum amount of dollars they can raise is,

$$\frac{(1-\theta)r + \theta R}{e^l}k > \theta\frac{R}{e^l}k$$

Since,

$$R = r + \Delta > \Delta \geq e^l$$

we can conclude that,

$$\frac{(1-\theta)r + \theta R}{e^l}k > \theta k.$$

Thus given any θ these firms will always be able to obtain funds required to restructure all of their capital units.

Next consider the date 0 program for these firms. As before in the h state, $V^h = Rk + w - f^h$. In the l state, if the firm is intact it receives,

$$V_i^l = Rk + (w - f^l)e^l$$

while if distressed,

$$V_s^l = rk + (\Delta - e^l)k + (w - f^l)e^l = Rk - e^l k + (w - f^l)e^l$$

This is because the firm is always able to save all of its capital units by borrowing k dollars at the exchange rate of e^l, and generating Δ baht at date 2. Combining, yields the date 0 program of an unconstrained firm:

$$(P6) \quad \max_{k,f^h,f^l} \quad (1-\pi)(Rk + w - f^h) + \pi\left((R - \tfrac{e^l}{2})k + e^l(w - f^l)\right)$$
$$s.t. \quad f^h, f^l \leq w$$
$$c(k) = \pi f^l + (1-\pi)f^h$$

Lemma 7 *Let $\hat{f}^\omega$ represent optimal choices in (P6). Then, for $\Delta > e^l > r$,*

$$\frac{\hat{f}^h}{\hat{f}^l} < \frac{f^h}{f^l}.$$

Proof: see appendix.

Thus unconstrained firms are more willing to take on dollar debt than constrained firms. The reason for this is that, on the margin, firms that find balance sheet mismatches more costly are the ones that prefer to take on baht debt. However, unconstrained firms are precisely the ones that can afford balance sheet mismatches. As a result, they undervalue

the insurance aspect of baht debt even more strongly, as they still face the distorted asset prices brought about by the constrained nature of liquidity demand.[18,19]

Let us now look at the limit, when $\lambda = 1$, so that no domestic firm is (domestically) credit constrained. In this case, domestic firms follow socially optimal debt choices.

Lemma 8 *If* $\lambda = 1$ *and (4) binds, then* $e^l = \Delta$ *and* $e^h = 1$.

Proof: Consider investment demand at date 1 by a distressed firm. Suppose in contradiction that $\Delta > e^l$. Then the distressed firm will choose to borrow as much as it can and save production units. Now from Lemma 6 we note that (7) can never bind, or that the domestic firm is never credit constrained. This implies that distressed firms will issue debt and save all of their capital units ($\theta = 1$). Thus,

$$b_1^D = \frac{k}{2}$$

However, since (4) binds,

$$\theta \frac{k}{2} = w - f^l$$

for $\theta < 1$. Which implies that,

$$b_1^D > w - f^l.$$

This violates market clearing. There is excess demand for dollars at date 1. As a result it must be that $\Delta = e^l$.

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[18]The restriction that $r < e^l$ is fairly weak in the sense that it is sufficient but not necessary, and there is a wide range of parameters for which the result holds.

[19]When there is heterogeneity among domestics, the fact that the unconstrained firms take on excessive dollar liabilities can be partially solved via private contracts. Imagine the following insurance contract at date 0: constrained firms receive dollars from unconstrained firms in the l state, and in return constrained firms pay unconstrained firms in the h state and in baht (out of the rk of baht collateral, which was unmortgaged in any case). This contract would be possible if the type of firm (constrained versus unconstrained) is observed at date 0. This seems a reasonable assumption (i.e. credit worthy versus less credit worthy firms). The value of a dollar in the l state to a constrained firm is,

$$\frac{\Delta + e^l}{2} > 1$$

while the cost of mortgaging one unit of the baht collateral in the h state is only one. Thus, constrained firms are willing to pay a high price for this insurance contract. Unconstrained firms find that reducing $\hat{f}^l$ in order to take the other side of the insurance contract costs only e^l, while they stand to reap as high as a premium of $\frac{\Delta + e^l}{2}$ by selling this insurance. The price implicit in the insurance contract increases the unconstrained firms' valuation of dollars in the l state to $\frac{\Delta + e^l}{2}$ from e^l. This brings debt choices of unconstrained and constrained firms in line with each other. However, since $\Delta > e^l$, it still leaves room between the social value of dollars in the l state and the private value of dollars and the economy is still left excessively liability dollarized.

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Now if $e^l = \Delta$, then $s_d = 0$. The program for a firm at date 0 is (P6) modified to let $e^l = \Delta$.

$$\max_{k,f^h,f^l} \quad (1 - \pi)(Rk + w - f^h) + \pi \left(\frac{R+r}{2}k + \Delta(w - f^l) \right)$$
$$\text{s.t.} \quad f^h, f^l \leq w$$
$$c(k) = \pi f^l + (1 - \pi)f^h$$

This program is identical to that of (P5). Hence, if $\lambda = 1$, the economy makes efficient choices in the denomination of its liabilities.

4.2 Discussion

The economy with $\lambda = 1$ has aggregate shocks and exchange rate fluctuations, yet there is no underinsurance. The only difference between the case with $\lambda = 0$ and $\lambda = 1$ is that $s_d > 0$ in the l state when $\lambda = 0$. It is important to recognize that the underinsurance result only arises in states of the world where $s_d > 0$. Hence we have argued that in this case domestics undervalue insurance against the l state. At an abstract level, with a different specification of shocks it is theoretically possible to construct a model in which $s_d > 0$ in the h state, and $s_d = 0$ in the l state. In this case we would have the odd result that domestics don't sufficiently value insurance against the h state. The model we have presented perfectly aligns the incidence of a high domestic spread with the l state of the world. To us, this seems the empirically plausible model of reality – domestic spreads tend to be higher in crisis periods – thus the natural prediction of the model is that there is underinsurance against these states. Nevertheless, it is worth pointing out that underinsurance is caused directly by high domestic spreads, and only indirectly by bad shocks.

The general principle behind our result is that credit constraints leads to constrained demand for funds – those in need of funds are not credible in transferring surplus created by these funds to the providers of these funds. Suppliers of funds, in a dynamic context, find that the business of lending to firms with bad collateral is not a particularly profitable business and transfer their resources elsewhere. In the next section, we argue that this logic also helps explains why the entry of "specialist" foreign lending into domestic markets (i.e. credit line facilities, foreign banks) is retarded. This also suggests a supply channel for why foreign lenders are reluctant to lend in domestic currency.

5 Limited Foreign Credit Lines: Further Costs of Domestic Financial Underdevelopment

Foreigners, thus far, are passive lenders. They make no profits and simply lend at the international interest rate of one. Needless to say, such characterization of foreigners (and

many domestic savers) is hardly realistic. This section extends the model to study the effects of financial underdevelopment on foreign lending decisions. For this, we introduce an active margin whereby foreign lenders may pay a fixed cost and choose to specialize in lending to the domestic market. We characterize both the quantity of foreign lending and the form that it takes. The quantity results stem directly from section 4. If domestic financial markets are underdeveloped there will be limited entry of foreigners into the domestic market, as lenders find that the business of lending to firms with poor collateral is not a profitable one. Conditional on entry, we show that the optimal contracts that these foreign lenders extend look very much like contingent credit lines. Finally, we introduce complementarities in foreign lending decisions and demonstrate how financial underdevelopment may also increase the interest rates and insurance premia charged by foreign lenders.

5.1 Foreign Specialists

Let us return to the model of section 4.1, with $0 < \lambda < 1$. Suppose that there is a unit measure of foreign lenders, each with a date 0 endowment in dollars of w^f. Each lender can choose to pay a fixed cost of F (dollars) at date 0 in order to "specialize" in domestic lending. If they pay the fixed cost, they can value baht goods as do domestic agents:

$$U = c^D + c^B$$

while if they do not:

$$U = c^D.$$

Paying the fixed cost allows specialists to count the rk of baht output as collateral for any lending. With this modification, we capture the idea that specializing in the domestic market enables the investor to receive higher returns on lending to domestics.[20]

A specialist has w^f dollars that he will invest in loans backed by domestic baht collateral. But he can improve its return (see below) if he first enters into a contingent agreement with foreign non-specialists. In particular, he will want to have the maximum possible international liquidity when it is most valuable (the l state). He does so by converting his date 0 w^f dollars into $\frac{w^f}{\pi}$ dollars at date 1 in the l state —and 0 dollars in the h state— by transacting with other foreign non-specialist lenders. That is, the specialist invests in a contingent claim that pays $\frac{1}{\pi}$ dollars in the l state. Since foreign non-specialists are risk neutral, they would willingly supply such a claim.

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[20]Concretely, one might imagine these baht goods are acceptable payment if there are many more periods after date 2, and the foreign specialist can reinvest these baht goods in production of the export sector and in this way retrieve his payments over time. In this case, we should interpret F as the cost of acquiring the knowledge of business practices that enables this specialist to remain in the domestic market.

The $\frac{w^f}{\pi}$ dollars can then be invested against baht collateral at date 1 at the exchange rate of $e^l > 1$, earning the specialist,

$$\frac{w^f}{\pi}e^l$$

baht at date 2 in the l state. Thus entry gives expected utility of,

$$U^e = w^f e^l - F,$$

while non entry gives utility of

$$U^{ne} = w^f.$$

Let us denote by $0 < \alpha < 1$ the fraction of foreigners that choose to enter the domestic market. The free entry constraint determines that α is such that:

$$w^f(e^l - 1) = F.$$

Note that if s_d is high, then $e^l - 1$ will be low (for given participation) and foreign entry will be limited. This is the effect of financial development on specialist entry. Before characterizing the equilibrium with entry, let us define the lending contract.

5.2 Contingent Lending Contract

Definition 4 *(Specialist Lending Contract)*
A contract between a foreign specialist and a domestic firm will specify, $(d_\$^0, d_\$^h, d_\$^l)$, as payments from specialist to domestic firm. The resource constraint for the lender will require that,

$$d_\$^0 + (1 - \pi)d_\$^h + \pi d_\$^l = w^f. \tag{8}$$

That is, the expected present value of these payments must equal w^f (recall that the specialist has already signed a contingent contract with foreign non-specialist). The contract will also specify baht repayments of (t^h, t^l) from firm to specialist lender, satisfying,

$$t^h, t^l \leq Rk$$

if the firm is unconstrained, and

$$t^h, t^l \leq rk$$

if the firm is constrained.

The last two constraints are simply that promised repayments of (t^h, t^l) must be fully collateralized. Since the specialist can always earn $e^l - 1$ on his dollars, the contract must satisfy,

$$(1 - \pi)t^h + \pi t^l = e^l(d_\$^0 + (1 - \pi)d_\$^h + \pi d_\$^l) \tag{9}$$

Consider next the problem for a constrained firm. In addition to making a borrowing decision from foreign non-specialists, it can also choose to borrow from foreign specialists. Thus,

$$(P7) \quad \max_{k,f^h,f^l,d_\$^0,d_\$^h,d_\$^l,t^h,t^l} \quad (1-\pi)(Rk + w + d_\$^h - f^h - t^h) +$$

$$\pi \tfrac{1}{2}\left((R - t^l + (r - t^l)\tfrac{\Delta}{e^l})k + (\Delta + e^l)(w + d_\$^l - f^l)\right)$$

$$s.t. \quad f^h, f^l \leq w$$

$$t^h, t^l \leq rk$$

$$(1-\pi)t^h + \pi t^l = e^l(d_\$^0 + (1-\pi)d_\$^h + \pi d_\$^l)$$

$$c(k) = \pi f^l + (1-\pi)f^h + d_\$^0$$

The following lemma characterizes the solution to this problem.

Lemma 9 *(Contingent Credit Lines) The optimal specialist lending contract will have the specialist lending dollars at date 0 and at date 1 in the l state. In return, the specialist will receive baht repayments in the h state, and potentially some baht repayment in the l state. This can be interpreted as a credit line from which the firm draws down $d_\$^0$ at date 0, and $d_\$^1$ in the l state, and pays a fee of t^h in the high state, and if the line is drawn down in the l state, a fee of t^l.*

We relegate the proof of this lemma to the appendix, but the essence of it can be immediately seen from the structure of the constrained firm's problem:

- For the same reason that $f^h = w$, the firm will choose to set $d_\$^h = 0$. That is, since having excess dollars in the h state is not valued, the firm would prefer to have none.

- Likewise since dollars are valued in the low state to cope with the production shock, $d_\$^l > 0$. Moreover, since production at date 0 is a profitable enterprise, $d_\$^0 > 0$.

- Firms don't value having any slack in the h state. As a result they will fully borrow against their domestic collateral of rk and set $t^h = rk$.

- Borrowing against one unit of domestic collateral in the l state generates dollars at date 0 of $\frac{\pi}{e^l}$. However, waiting till date 1 to borrow against unit of domestic collateral in the l state generates dollars at date 1 in the l state of $\frac{1}{e^l}$. In the objective function, the latter is weighted by π, and hence we can conclude that the firm is indifferent on any choice of $t^l \geq 0$.

5.3   Equilibrium, Entry, and Financial Development

Let us turn next to equilibrium and ask how many specialists enter the domestic market at date 0.

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At date 1 in the l state, market clearing has distressed constrained firms selling $rk - t^l$ of domestic collateral and distressed unconstrained firms selling $Rk - t^l$. As we noted, firms are indifferent on the choice of t^l. In fact there are two cases. If $\alpha w^f e^l < (1-\lambda)rk + \lambda Rk$, then $t^l = 0$, otherwise $t^l > 0$.[21] For simplicity, let us take the case where $t^l = 0$ (there is a wide range of parameters where this assumption is valid). Since intact firms have $w - f^l + d^l_\$$ dollars:

$$e^l = \frac{(1-\lambda)rk + \lambda Rk}{w - f^l + d^l_\$}.$$

Now suppose that α specialists choose to enter the market, then rewriting (8) with $d^h_\$ = 0$, we have,

$$d^l_\$ = \alpha \frac{w^f - d^0_\$}{\pi}.$$

Substituting this into the above expression yields:

$$e^l = ((1-\lambda)r + \lambda R)\frac{k}{w - f^l + \alpha\frac{w^f - d^0_\$}{\pi}}.$$

All things being equal, e^l is decreasing in α. In fact, k, f^l and $d^0_\$$ will also change when e^l changes since these quantities are determined in equilibrium. However, it is easy to show that $\frac{\partial e^l}{\partial \alpha} < 0$.[22] As more foreign specialists choose to enter the market, the supply of dollars in the l state rises and hence the exchange rate appreciates.

The next comparative static worth noting is that $\frac{\partial e^l}{\partial \lambda} > 0$. That is, as the domestic market has more unconstrained firms so that it is more developed, there is more domestic collateral and the return on lending dollars to these firms rises and hence e^l rises. Figure 1 below represents this as an equilibrium for the entry decision. The solid line represents the demand for foreign specialist funds as a function of the exchange rate. The curve d' represents demand in an economy which is more financial developed (i.e. λ is higher). Since foreigners require that,

$$e^l + 1 = \frac{F}{w^f}$$

[21]The logic behind this constraint is that firms always prefer to pay foreign specialists with collateral in the h state. At maximum, this is $(1-\lambda)rk + \lambda Rk$. Foreigners require a return of e^l on the aggregate dollars of αw^f that enter the domestic market. The constraint follows.

[22]The algebra is as follows. Differentiating and rewriting,

$$\frac{k}{w - f^l + \alpha\frac{w^f - d^0_\$}{\pi}} \quad \frac{w^f - d^0_\$}{\pi} = -\frac{\partial e^l}{\partial \alpha} \times$$

$$\left(\frac{1}{(1-\lambda)r + \lambda R} - \frac{\partial k}{\partial e^l}\frac{1}{w - f^l + \alpha\frac{w^f - d^0_\$}{\pi}} - \frac{k}{(w - f^l + \alpha\frac{w^f - d^0_\$}{\pi})^2}\left(\frac{\partial f^l}{\partial e^l} + \frac{\alpha}{\pi}\frac{\partial d^0_\$}{\partial e^l}\right) \right)$$

Since, $\frac{\partial k}{\partial e^l}, \frac{\partial f^l}{\partial e^l}, \frac{\partial d^0_\$}{\partial e^l} < 0$, we have the sign.

in order to enter, in the region where $\alpha < 1$, α is such that the equilibrium exchange rate is exactly $e^l = \frac{F}{w^f} - 1$.
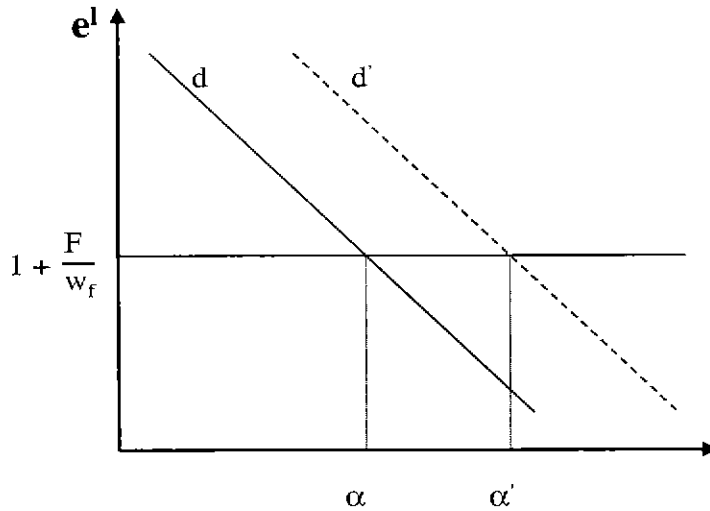

Figure 1: Entry by Foreign Specialists

Lemma 10 *In the region where $\alpha < 1$ and $t^l = 0$, α is increasing in λ. Financial development increases foreign specialist entry into the domestic lending market.*

5.4   Supply Multiplier and Financial Development

Let us pause for a moment and take stock. Our explanation for excessive dollar liabilities is that domestic firms look at the interest rate charged when borrowing in baht, compare this to the interest rate charged in dollars, fully recognize that there is exchange rate risk if they opt for dollar borrowing, and yet conclude that it is preferable to borrow (more than the central planner does) in dollars. The explanation rests purely on domestic demand for insurance against bad aggregate outcomes. But it would appear that in reality there is also another side of the story. Lenders —i.e. mostly foreigners— may evaluate lending in baht vis-a-vis lending in dollars, and conclude that they require an extremely high premium for the former option. Below we show that it is possible to connect such supply response to the very same deficiencies that led to depressed demand.

Of course, one tricky question that needs to be addressed is: too high a premium relative to what? In our model with passive foreigners, this question could not be addressed. Foreigners were risk neutral and competitive and provided insurance elastically at actuarially fair prices. Introducing foreign specialist lenders gives a point of comparison whereby this question can be addressed.

We have already seen that foreign specialists provide an insurance role by entering into the domestic market and accepting baht collateral against their loans. Indeed, the contingent credit lines that they extend are fashioned to provide insurance against the l state (especially when $t^l = 0$). Limited insurance supply would mean that foreign specialists require too high a return on their provision of contingent credit lines. For example, if a foreign specialist were to lend dollars at date 0 and receive back dollars at date 1, he would charge at the international interest rate of one on this loan. However, if the same specialist received baht collateral against his loan, then (9) tells he would require a return of e^l on his loan. In the case of contingent credit lines with $t^l = 0$, the foreign specialist requires that,

$$(1 - \pi)t^h = e^l(d_\$^0 + \pi d_\$^1).$$

Thus, we shall interpret $e^l - 1$ as the premium for lending against baht collateral for a foreign specialist.

Moving beyond emerging market debt, there seems to be some theory and evidence for limited insurance supply in other asset markets leading to high liquidity premia. For example, it is often pointed out that the catastrophe insurance market is severely capital constrained leading to very high insurance premiums and insurance cycles (see Froot and O'Connell (1997)). Some of the explanations for the meltdown in the US credit market during the fall of '98 argue that hedge funds which are normally liquidity suppliers to markets, such as LTCM, grew constrained and became liquidity users as they exited from markets.[23]

Given our focus on domestic underdevelopment, we shall restrict attention to studying a channel whereby domestic under velopment causes too high a lending premium. When the domestic market is underdeveloped, foreign specialist entry is also limited, as foreigners find lending in the domestic market unprofitable. Now one plausible avenue through which this may affect supply is a thin market externality. That is, suppose foreign lenders prefer to lend in a market in which there are already other foreign lenders. A microeconomic model for this phenomena is provided in Allen and Gale (1994). We defer to their results, and take a reduced form approach to this issue by positing complementarity in foreign entry decisions.[24] Suppose that F depends on the amount of entry, so that,

$$F(\alpha) = \begin{cases} \bar{F} & \text{if } \alpha \leq \hat{\alpha} \\ \underline{F} & \text{if } \alpha > \hat{\alpha}. \end{cases}$$

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[23]See Xiong (1999) for an analysis of wealth constrained hedge funds, or Allen and Gale (1994) for a model with similar results, but in a market segmentation, stock market model. See Holmstrom and Tirole (1998) and Krishnamurthy (2000) for limited insurance supply in a macroeconomic context.

[24]Investors in the Allen and Gale (1994) model must pay a fixed cost to enter the market, and face the risk that they may have to liquidate and exit the market. In this instance they prefer that there are other investors in the market as this increases liquidation values and reduces ex-ante variance of asset prices. There is thus a complementarity between the entry decisions of investors.

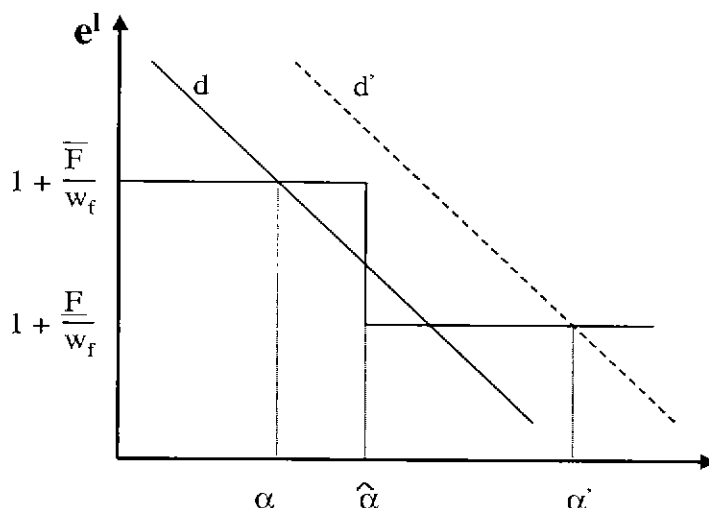Figure 2 illustrates the effect of complementarity.

Figure 2: Complementary Entry Decisions

At the low level of financial development corresponding to d, there is the possibility that foreign specialists anticipate little entry by others and stay out of the market. However, if the market is sufficiently developed (d'), this possibility disappears, as all specialists expect plenty of entry and therefore enter themselves. Contrasting the equilibrium liquidity premia, we see that as λ rises and equilibrium shifts to d', the premium charged by foreign specialists also falls.

6 Final Remarks

We began the paper highlighting an apparent dilemma: Excessive dollarization of private liabilities has played a central role in most recent emerging market crises. But given that this is a private decision, why don't firms anticipate the dangers and avoid dollar debt?

Our answer began with a motive to hoard international liquidity: firms experience occasional needs of external resources and the country has only limited access to international financial markets – moreover, liquidation or limited reinvestment in unfinished projects is very costly. Purchasing international insurance against shocks that increase the aggregate ratio of needs to availability of external resources is an efficient mechanism to hoard this liquidity, and issuing debt denominated in domestic rather than in foreign currency implements this insurance.

The reason for underinsurance lies in another financial market imperfection: the limited domestic collateral of distressed firms. When these constraints are widespread, there is

restricted competition for available international liquidity, since demand is constrained by insufficient domestic collateral rather than by marginal product. In equilibrium, this leads to a private overvaluation of domestic collateral —since there is little competition with other domestic collateral— and undervaluation of international liquidity —since it faces a constrained demand. As a result, firms demand and produce the wrong kind of liquidity and collateral. A particular dimension of this syndrome is the insufficient demand for external insurance, and a particular dimension of underinsurance is the excessive dollar-indebtedness.

Once domestic financial underdevelopment shrinks the size of the effective international liquidity market, it takes only a step to have also the supply of such liquidity by foreign specialists shrink. Thus supply and demand factors reinforce each other.

In Caballero and Krishnamurthy (2000) we show that this environment motivates intervention to manage the international liquidity of a country. However, we also show that attempting to do so within the constraints of illiquid domestic financial markets can be dangerous and policy intervention may backfire. Many of the issues and limitations we discussed there would apply here as well: in particular, to the question of whether a central planner should contract contingent external credit lines for the private sector.

Another issue that arises is whether permanently fixing the nominal exchange rate solves the problem by eliminating the need for insurance. At some level the answer to this question is obviously no. Our discussion referred to the real rather than the nominal exchange rate, and the international liquidity constraint is a real resource constraint rather than a domestically mandated one. On the other hand, our current framework is not well suited for addressing such question since our real exchange rate represents a convolution of observed exchange rates and domestic asset prices (interest rates). Different models about goods markets and the extent and nature of segmentation of the different domestic assets markets yield different mappings from our framework to nominal exchange rates. Addressing this issue is the next step in our agenda.

A Appendix

A.1 Proof of Lemma 3

Take the Lagrangian for (P5),

$$\mathcal{L}^* = (1-\pi)(RK + W - F^h) \;\; + \;\; \pi\frac{1}{2}\left((R+r)K + 2\Delta(W - F^l)\right) - $$
$$\lambda(c(K) - \pi F^l + (1-\pi)F^h) - \mu_h(F^h - W) - \mu_l(F^l - W)$$

First,

$$\frac{\partial \mathcal{L}^*}{\partial K} = (1-\pi)R + \pi\frac{R+r}{2} - \lambda c'(K) = 0$$

Likewise, if $\mu_h = 0$, it would be that,

$$\frac{\partial \mathcal{L}^*}{\partial F^h} = -(1-\pi) + \lambda(1-\pi) = \frac{1-\pi}{c'(K)}\left((1-\pi)R + \pi\frac{R+r}{2} - c'(K)\right) > 0$$

Where we substituted in λ from above and noted that the project is sufficiently profitable at date 0 to arrive at the inequality. Since $\frac{\partial \mathcal{L}^*}{\partial F^h} > 0$, it must be that $F^h = W$. The same logic applies to the case of (P4).

A.2 Proof of Lemma 4

Consider the FOC for F^l in (P5),

$$\frac{\partial \mathcal{L}^*}{\partial F^l} = -\pi + \pi\lambda = \frac{\pi}{c'(K)}\left((1-\pi)R + \pi\frac{R+r}{2} - \Delta c'(K)\right)$$

Given our technical assumptions, this will ensure $W > F^l > 0$. Now consider the FOC for f^l in (P4). This is,

$$\frac{\partial \mathcal{L}}{\partial f^l} = \frac{\pi}{c'(k)}\left((1-\pi)R + \pi\frac{R+r}{2} - \Delta c'(k) + (\Delta - e^l)(\pi\frac{r}{2} + c'(k))\right)$$

Suppose that $F^l = f^l$ then it must be that $K = k$ so that,

$$\frac{\partial \mathcal{L}}{\partial f^l} = \frac{\partial \mathcal{L}^*}{\partial F^l} + \frac{\pi}{c'(k)}(\Delta - e^l)(\pi\frac{r}{2} + c'(k)) > \frac{\partial \mathcal{L}^*}{\partial F^l},$$

as long as $\Delta > e^l$. This violates the FOC, so it must be that $f^l > F^l$ if $s_d = \Delta - e^l > 0$.

A.3 Proof of Lemma 7

For the same logic as in lemma 3, we will have that $\hat{f}^h = f^h = w$. Take the FOC for $\hat{f}^l$ from (P6):

$$\frac{\partial \hat{\mathcal{L}}}{\partial \hat{f}^l} = \frac{\pi}{c'(\hat{k})}\left((1-\pi)R + \pi(R - \frac{e^l}{2}) - e^l c'(\hat{k})\right).$$

Likewise, from (P4),

$$\frac{\partial \mathcal{L}}{\partial f^l} = \frac{\pi}{c'(k)} \left((1-\pi)R + \pi \frac{R + \frac{\Delta}{e^l} r}{2} - \frac{\Delta + e^l}{2} c'(k) \right).$$

Suppose that $f^l = \hat{f}^l$, then it must also be that $k = \hat{k}$, and,

$$\frac{\partial \hat{\mathcal{L}}}{\partial \hat{f}^l} = \frac{\partial \mathcal{L}}{\partial f^l} + \frac{\pi}{c'(k)} \left(\frac{\pi}{2}(R - e^l - \frac{\Delta}{e^l} r) + \frac{\Delta - e^l}{2} c'(k) \right).$$

Which can be rewritten as,

$$\frac{\partial \hat{\mathcal{L}}}{\partial \hat{f}^l} = \frac{\partial \mathcal{L}}{\partial f^l} + \frac{\pi}{c'(k)} \left(\frac{\pi}{2e^l}(r - e^l)(e^l - \Delta) + \frac{\Delta - e^l}{2} c'(k) \right).$$

For $\Delta > e^l > r$, both terms in the parentheses are positive. In this case, it must be that $\hat{f}^l > f^l$. We could also rewrite this as,

$$\frac{\partial \hat{\mathcal{L}}}{\partial \hat{f}^l} = \frac{\partial \mathcal{L}}{\partial f^l} + \frac{\pi}{c'(k)} \frac{\Delta - e^l}{2} \left(c'(k) - \frac{\pi}{e^l}(r - e^l) \right).$$

This produces the weaker restriction that $\Delta > e^l$ or $s_d > 0$, as well as,

$$c'(k) - \frac{\pi}{e^l}(r - e^l) > 0,$$

which, for example, is easily satisfied for small π, or if the probability of the negative shock is small.

A.4 Proof of Lemma 9

We shall do this proof in steps. First, consider the Lagrangian for (P7),

$$
\begin{aligned}
\mathcal{L} &= (1-\pi)(Rk + w + d_\$^h - f^h - t^h) + \pi \frac{1}{2} \left((R + r\frac{\Delta}{e^l})k - t^l(1 + \frac{\Delta}{e^l}) + (\Delta + e^l)(w + d_\$^l - f^l) \right) \\
&\quad - \mu^h(f^h - w) - \mu^l(f^l - w) \\
&\quad - \psi^h(t^h - rk) - \psi^l(t^l - rk) \\
&\quad - \phi((1-\pi)t^h - \pi t^l - e^l(d_\$^0 + (1-\pi)d_\$^h + \pi d_\$^l)) \\
&\quad - \lambda(c(k) - \pi f^l - (1-\pi)f^h - d_\$^0)
\end{aligned}
$$

Then,

$$\frac{\partial \mathcal{L}}{\partial k} = (1-\pi)R + \pi \frac{R + r\frac{\Delta}{e^l}}{2} - \lambda c'(k) = 0$$

Hence,

$$\lambda = \frac{1}{c'(k)} \left((1-\pi)R + \pi \frac{R + r\frac{\Delta}{e^l}}{2} \right)$$

Let us start with f^h. If $f^h < w$, then $\mu^h = 0$. Suppose so,

$$\frac{\partial \mathcal{L}}{\partial f^h} = -(1-\pi) + \lambda(1-\pi) = \frac{1-\pi}{c'(k)}\left((1-\pi)R + \pi\frac{R + r\frac{\Delta}{e^l}}{2} - c'(k)\right) > 0$$

where the last inequality follows from the assumption that date 0 investment is sufficiently profitable. Hence, $f^h = w$.

Consider t^h next. If $t^h < rk$ then $\psi^h = 0$. First note that, from the FOC with respect to $d_\$^0$,

$$\phi = -\frac{\lambda}{e^l}.$$

Then,

$$\frac{\partial \mathcal{L}}{\partial t^h} = -(1-\pi) - \phi(1-\pi) = \frac{1-\pi}{e^l c'(k)}\left((1-\pi)R + \pi\frac{R + r\frac{\Delta}{e^l}}{2} - e^l c'(k)\right) > 0.$$

Hence we can conclude that $\psi^h > 0$ and $t^h = rk$.

Take $d_\$^h$ next. Assuming the constraint does not bind,

$$\frac{\partial \mathcal{L}}{\partial d_\$^h} = (1-\pi) + \phi e^l(1-\pi) = (1-\pi) - \lambda(1-\pi) < 0.$$

Therefore it must be $d_\$^h = 0$.

Finally consider t^l. First note that from the FOC for $d_\$^l$,

$$\frac{\partial \mathcal{L}}{\partial d_\$^l} = \frac{\pi}{2}(\Delta + e^l) - \pi\phi e^l = \frac{\pi}{2}(\Delta + e^l) - \pi\lambda = 0.$$

Therefore,

$$\lambda = \frac{\Delta + e^l}{2}.$$

Now,

$$\frac{\partial \mathcal{L}}{\partial t^l} = -\frac{\pi}{2}(\Delta + e^l) - \phi\pi = -\frac{\pi}{2}(\Delta + e^l) + \frac{\lambda}{e^l}\pi = 0.$$

Hence the firm is indifferent over its choice of t^l.

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