Why Do Emerging Economies Borrow in Foreign Currency?

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1. Introduction

In thinking about the recent international financial, one is led to look for systematic differences between developed and less developed economies that would explain why the latter seem more prone to capital account and financial crises than the former. In an influential paper Eichengreen and Hausmann (1999) have put forward the idea that one key difference lies in the way countries borrow. Namely, for less developed countries

> ”the domestic currency cannot be used to borrow abroad or to borrow long term, even domestically”,

a situation which they describe as the “original sin” of international finance.

What is the cause of the original sin? Although the metaphore may suggest that it is due to a distant accident in history, any theory of the original sin must start by explaining why agents who live today borrow the way they do. That is, before the question is put in a historical/theological context, one must understand the proximate cause of original sin: why do borrowers, at a given point in time, tend to issue less domestic currency debt in less developed economies? This is the question I look at in this paper.

To put it succintly, the answer proposed in this paper is that the original sin is the result of domestic monetary policy. The argument will not sound very new. In fact, it is a very classical argument in the literature on sovereign debt (see, e.g., Calvo, 1996). One contribution of this paper is to show that the same cause can be invoked for private debt. So one does not need more than one cause to explain the private and public versions of the original sin.

This paper involves more than the generalization of a well-known argument to a slightly different context, however. The mechanism I emphasize in this paper is quite different from the one that has been emphasized in the sovereign debt literature. In that literature, foreign currency debt is useful because it disciplines governments that cannot credibly commit to a good monetary policy. This argument cannot be directly transposed to private debt—as noted by Calvo (2000). Private borrowers, being small, take the domestic monetary policy as given. They have very little incentives, at the individual level, to increase their default risk so as to shift government policies towards the social optimum.

The model developed in this paper looks at the impact of the domestic monetary environment on the risk of default in the private sector. Broadly speaking, I characterize a safe monetary environment as one that buffers firms against low realizations of their domestic currency income. I show that firms respond to a safe monetary environment by borrowing in domestic currency. A risky monetary environment, by contrast, is one that makes firms quite unsure about the future real value of their debts. Although economists are keen to point to the risk of foreign currency debt, a risky monetary environment makes domestic currency debt

dangerous too. Consider, for example, a situation where the monetary authorities defend the exchange rate by keeping the domestic interest rate high. Then borrowing in domestic currency can be quite risky for a domestic firm, the risk being that the real debt burden will be unbearable if the expected monetary expansion does not materialize ex post. Hence, a more risky domestic monetary environment might, somewhat paradoxically, lead to more foreign currency debt.[1]

The argument presented in this paper is also quite different from those developed in the literature on the currency mismatch in the corporate and banking sectors that bloomed following the Southeast Asian crisis. The recent theoretical literature has developed instead the following themes.

- Foreign currency debt arises because of the moral hazard created by bailout guarantees: McKinnon and Pill (1999), Burnside, Eichenbaum and Rebelo (1999), Schneider and Tornell (2001).

- Foreign currency debt arises because of a lack of domestic financial development: Caballero and Krishnamurthy (2001).

- Foreign currency debt arises because of commitment or signaling problems at the level of domestic entrepreneurs: Jeanne (2000), Aguiar (2000), Chamon (2001), Aghion et al (2001).

These arguments invoke failures in other areas than monetary policy.[2] I do not deny that these failures can play a role in principle--and may have played a significant role in Southeast Asia. However, the mere fact that we are talking about currencies should make monetary policy a prime suspect. It makes sense to explore how far we can go just with monetary policy before turning to other policy areas.

Before proceeding, I should dispel a possible misunderstanding about the kind of original sin this paper is about—a clarification that is all the more necessary that some other papers in this volume adopt a slightly different definition. As the quote given in the first paragraph suggests, to a first approximation, the original sin can be defined as an inability (or a reduced ability) of borrowers to issue domestic currency debt in less developed economies. The quote

[1] As it is stated, the argument may seem quite specific to corporate debt. However, there is an interpretation of the model that makes it applicable to sovereign debt. So one could argue that the mechanism presented in this paper is more general than the classical one, in the sense that it can be transposed to sovereign debt while the reverse is not true [to be developed].

[2] However, these other policy areas could be closely related to monetary policy. For example, a sound monetary framework may be viewed as a necessary component of financial development.

also hints at a distinction (emphasized more forcefully by Hausmann and Panizza in this volume) between a domestic and an international version of the original sin.[3] The present paper essentially ignores this distinction, since it looks at the currency composition of debt irrespective of where it is issued. As I shall argue later, I view the foreign version of the original sin as an interesting question, but one that probably involves a class of explanations that is very quite different from the one I look at in this paper.

The paper is structured as follows. I first present the assumptions of a simple partial equilibrium model of the currency composition of a firm's debt. Section 3 explains how monetary policy can insure firms against bad shocks. Section 4 then presents the main point of this paper: a domestic monetary regime that lacks credibility may induce firms to borrow in foreign currency. Section 5 discusses some policy implications, and section 6 concludes by discussing paths for further research.

2. The currency composition of corporate debt: a simple model

I adopt a deliberately partial equilibrium approach, by looking at the choice of the currency composition of debt by a small firm that takes domestic monetary policy as given. The analysis is based on a simple extension of the classical model of debt and default with costly state verification (Townsend, 1979; Gale and Hellwig, 1985) that incorporates a choice between domestic currency debt and foreign currency debt.

The model has two periods $t = 0,1$. I consider a small open economy in an environment of free capital mobility. The domestic and foreign currencies are called peso and dollar respectively, and the exchange rate at time *t* (the price of one dollar in terms of pesos) is denoted by S_t. The dollar interest rate is normalized to zero. Uncovered Interest Parity applies.

I focus on one entrepreneur in this economy. The entrepreneur is endowed with a project that requires the sacrifice of I^* dollars in period 0 and yields a stochastic return in period 1. The return of the project can be expressed in terms of dollars, R^*, or in terms of peso, R. Both are stochastic, viewed from period 0. Obviously, one has $SR^* = R$.

The domestic entrepreneur has no funds in period 0. He must enter financial contracts with (domestic or foreign) investors. Contracts are incomplete; in particular, it is not possible to write contracts in which the payment to investors is contingent on the project's return. I look at debt contracts with Costly State Verification (Townsend, 1979; Gale and Hellwig, 1985).[4]

[3] Domestic original sin relates to domestic debt while foreign original sin relates to foreign debt (i.e., debt issued under a foreign jurisdiction).

[4] The model of debt with costly state verification has been used in the macroeconomic literature on monetary policy, for example by Bernanke, Gertler and Gilchrist (1998). Other (continued)

Debt contracts are written in nominal terms, and can be denominated in dollar or peso. The entrepreneur promises to repay ρ pesos and ρ^* dollars. In the event he cannot repay his debt, the creditors pay a "verification cost" of C dollars and collect the project return R on a pro rata basis. The entrepreneur receives nothing in the event of default. There is perfect competition on the side of lenders, who reap no rent from lending to entrepreneurs.

For simplicity, I assume that the entrepreneur and investors maximize their dollar net incomes. The final utilities of the entrepreneur and its creditors are respectively given by

$$U = \max\left(0, \frac{R-\rho}{S} - \rho^*\right)$$

$$V = \min\left(\frac{R}{S}, \frac{\rho}{S} + \rho^*\right) - \delta C$$

where δ is a dummy variable that is equal to 1 if the entrepreneur defaults, and to zero otherwise.

The entrepreneur chooses his debt structure taking the stochastic distribution of R and S as given. At time 0 the entrepreneur maximizes his expected dollar income subject to the participation constraint of the lenders

$$(P)\begin{cases}\max_{\rho,\rho^*} E(U) \\ E(V) \geq I^*\end{cases}$$

Ex post (in period 1) the state of the economy $x \in X$ is revealed. Each state is characterized by an exchange rate $S(x)$ and a return $R(x)$. State x occurs with probability $\pi(x)$. I look how the equilibrium currency composition of debt conditional depends on the stochastic structure of the macroeconomic states.

$$X, \pi(\cdot), S(\cdot), R^*(\cdot) \Rightarrow (\rho, \rho^*)$$

Let me conclude the presentation of the assumptions with two remarks. First, the substance of the model would not be changed if one allowed the entrepreneur to hedge his exchange rate risk by entering into forward contracts. Let F denote the one –period forward exchange

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models of costly default could be considered, such as Diamond's (1984) model of debt with a non pecuniary punishment for default, or models where default involves the early termination or restructuration of projects (Bolton and Scharfstein, 1990; Dewatripont and Tirole, 1994). This would not change the essence of my results.

rate. Forward contracts are priced risk-neutrally in a frictionless market, so that $F = E(S)$. By promising to buy pesos at rate F, the entrepreneur achieves the same outcome as if he had issued more dollar-denominated debt and less peso-denominated debt. Currency hedging does not allow the entrepreneur to span new outcomes.

There is an insurance contract that the entrepreneur cannot subscribe in this model, and this is an insurance against the risk in the return of the project. If the entrepreneur could insure himself against this risk, there would be no default and the currency composition of debt would become irrelevant (a version of Modigliani-Miller). Given the absence of such an insurance, the entrepreneur attempts to insure himself indirectly, by choosing the currency composition of his debt.

3. Monetary policy as a source of insurance

The entrepreneur determines the currency composition of its debt so as to maximize the total expected payoff of the project, $E(U+V) = E(R^*) - E(\delta)C$, subject to the participation constraint of lenders. It directly follows that the entrepreneur's problem can be written:

$$(P') \qquad \begin{cases} \min_{\rho,\rho^*} E(\delta) \equiv \Pr(R^* < \rho^* + \rho / S) \\ E(V) \geq I^* \end{cases}$$

Proposition 1. *The entrepreneur chooses the currency composition of its debt so as to minimize the probability of default conditional on the lenders' participation constraint.*

Although the default cost is paid by the creditors ex post (in the event of a default), ex ante it is borne by the entrepreneur. Hence, the entrepreneur chooses the currency composition of its debt so as to minimize the probability of a default.

Note the contrast with moral hazard theories of foreign currency debt. In these theories, entrepreneurs borrow in foreign currency to undertake excessive risk—for example in the hope of a bailout (Burnside et al, 1999) or because of the limited liability constraint (Aghion et al, 2001). Here the entrepreneur attempts instead to *minimize* the risk of default.

Intuitively, the extent to which the entrepreneur can insure himself against his return risk depends on the macroeconomic environment, and in particular on the correlation between the exchange rate and the return of the project. The following result states a condition on the macroeconomic environment under which the entrepreneur can hedge himself perfectly against the risk of default by borrowing in domestic currency.

Proposition 2. *If* $\min R \geq I^* / E(1/S)$ *the entrepreneur reduces his default probability to zero by borrowing in domestic currency.*

The intuition and the proof are equally straightforward. Conditional on no default, the entrepreneur has to issue a quantity of domestic currency debt equal to $\rho = I^* / E(1/S)$. If the minimum realization of R is larger than $I^* / E(1/S)$, the entrepreneur can always repay. An entrepreneur who expects to receive a minimum quantity of pesos takes no risk by committing himself to repay a fixed quantity of pesos that is lower.

The condition stated in Proposition 2 says that the macroeconomic environment insures the entrepreneur against low realizations of R. Conditional on this macroeconomic environment, the entrepreneur insures himself against default by issuing domestic currency debt. To the extent that the entrepreneur's return is well correlated with economy-wide shocks, this could be interpreted as a counter-cyclical monetary policy that increases nominal demand in response to negative shocks. Note that the insurance is against a downside risk: it is against extreme realizations of the firm's income that could trigger a default.[5]

Proposition 2 describes a macroeconomic environment that induces the entrepreneur to borrow in domestic currency. The main theme in this paper is that the macroeconomic policies of less developed economies deviates from this ideal in important ways, and that as a result, entrepreneurs tend to borrow more in foreign currency. Of course, foreign currency debt exposes borrowers to risks. But conditional on the macroeconomic environment, foreign currency debt is less risky at the margin than domestic currency debt. This insight is very general and can be developed in different contexts.

4. Monetary Credibility and the Original Sin

This section presents the main point of this paper: lack of monetary credibility can induce domestic firms to borrow in foreign currency. Foreign currency debt, in turn, makes firms vulnerable to large depreciations.

I illustrate this general point with an example. For the sake of relevance and simplicity, I consider the case of a fixed currency peg. This case is important because most countries that had a crisis also had a fixed currency peg. However, the logic of the argument carries over to floating exchange rate regimes, as I shall argue at the end of this section. I also simplify the analysis by considering a three-state specification of the model.[6]

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[5] The insurance is against the type of tail-probability risk that Value-at-Risk models are supposed to measure.

[6] The model needs at least three states for perfect insurance to be impossible. The analysis can easily be extended to a larger number of states.

The reason that I specialize the model a bit is that it is difficult to derive properties of the solution to problem *(P')* without making further assumptions—and these assumptions are easier to justify in a specific economic context. For the intrigued reader I have included in the appendix some notes on the mathematics of the original sin—which turn out to have a beauty of their own. Reading the appendix may help the reader to understand the generality of the argument behind the particularity of the example. [Appendix to be completed.]

The structure of states is described in the following table.

State	Exchange Rate	Nominal Return	Probability
0: Fixed Peg	S_0	R_0	$1-\mu$
1: Small Devaluation	S_1	R_1	μp_1
2: Large Devaluation	S_2	R_2	μp_2

At time 0, the domestic authorities announce that they will maintain a fixed exchange rate peg S_0. They fulfill their promise with probability $1-\mu$. With probability μ they don't, and there is a devaluation. The devaluation can be small ($S = S_1 > S_0$) or large ($S = S_2 > S_1$). The conditional probabilities of a small and a large devaluation are respectively p_1 and $p_2 = 1 - p_1$. In the following I characterize the equilibrium as the credibility of the fixed peg decreases (i.e. μ increases).

I assume that a depreciation is associated with an increase in the peso value of the firm's revenue but a decrease its dollar value. This could be because of exchange rate overshooting, low pass-through if the firm is in the non-tradable sector, or because of the real disruption induced by the exchange rate crisis in the firm's operations. Currency mismatches in the non-tradable sector, in particular, are often argued to have been a serious aggravating factor in recent crises.

$$R_0 < R_1 < R_2 \quad , \quad \frac{R_0}{S_0} > \frac{R_1}{S_1} > \frac{R_2}{S_2}$$

Finally I make the following assumption:

$$\frac{R_2 - R_0}{S_2 - S_0} > \frac{R_1 - R_0}{S_1 - S_0}$$

The nominal income of the firm increases less than proportionately with the size of the nominal devaluation. This assumption simplifies the analysis by making *(P')* a concave problem (something explained in more details in the appendix). Although it is not purely

technical (because it has some economic content), this assumption is not essential, in the sense that one can build examples with similar properties where it is not satisfied.

The equilibrium currency composition of debt is characterized as follows.

> **Proposition 3.** *The minimum share of foreign currency debt in total debt is increasing with the devaluation probability μ. There are two thresholds in the devaluation probability, $\underline{\mu}$ and $\overline{\mu}$, such that*
>
> (i) *if the devaluation probability is smaller than $\underline{\mu}$, the entrepreneur issues no or little foreign currency debt and defaults with probability zero;*
>
> (ii) *if the devaluation probability is between $\underline{\mu}$ and $\overline{\mu}$, the level of foreign currency debt is high enough to trigger a default conditional on a large devaluation.*
>
> (iii) *if the devaluation probability is larger than $\overline{\mu}$, the entrepreneur cannot finance his project.*

(see the Proof in the appendix.)

First, let us start from the case where the fixed peg is perfectly credible ($\mu = 0$). Then the firm can borrow in domestic currency and never defaults (provided that the project is profitable, $R_0 / S_0 > I^*$). The foreign and domestic currencies are perfectly substitutable and as a result the minimum share of foreign currency debt in total debt is zero.

As the probability of a devaluation increases, so does the peso interest rate. There is a level of the peso interest rate above which the firm can no longer insure itself against the risk of default in all states. The firm is caught in a dilemma between issuing "too much" foreign currency debt—and defaulting conditional on a large devaluation—and issuing "too much" domestic currency debt—and defaulting conditional on the maintenance of the fixed peg. The firm chooses to default in the state that is less likely, which is the large devaluation state if the devaluation probability is small enough.

Hence in equilibrium the firm issues "too much" foreign currency debt when the credibility of the fixed peg falls below a threshold. The level of foreign currency debt is excessive in the sense that it bankrupts the firm conditional on a large devaluation.[7] While ex post this might

[7] It might seem counterintuitive that the firm ceases to insure against the risk of a large devaluation precisely when this risk increases. The problem is that the insurance possibilities shrink at the same time as the risks increase.

be viewed as a failure to hedge appropriately, the firm's behavior is in fact optimal ex ante, given the high cost of hedging. The high cost of hedging, in turn, results from the lack of credibility of the fixed peg.[8]

Figure 2 provides a numerical illustration of Proposition 3.[9] As the devaluation probability increases so does the spread on peso debt. This induces the firm to shift to dollar debt. When the peso spread exceeds some threshold, the firm stops caring about the risk of a large devaluation and borrows almost completely in foreign currency.[10] A spread appears in the interest rate at which the firm can borrow dollars because of the risk of default (conditional on a large devaluation). However, the spread remains higher on peso debt, the difference being due to the risk of depreciation. Finally, if the devaluation probability is too high the firm cannot borrow at all because the net value of its project becomes negative.

Practitioners often entertain the view that foreign currency debt arises "simply" because the interest rate is so much higher on domestic currency debt. This argument is generally dismissed by economists as case of nominal illusion—the practitioner failing to see the difference between nominal and real interest rates. As this model shows, the practitioner's view makes perfect sense once it is interpreted as relating to the risk of a high ex post real interest rate, and there are bankruptcy costs. Bankruptcy costs are necessary to remove the Modigliani-Miller equivalence. The variability in the *ex post* real interest rate explains why domestic currency debt is dangerous—potentially more so than foreign currency debt.

To conclude this section, let me explain how the argument can be transposed to a floating exchange rate regime that lacks credibility. Let us assume that state 0, instead of being a fixed peg, is a floating exchange rate regime in which the monetary authorities minimize the firm's risk of default by pegging its peso income. That is, state 0 can be decomposed in n substates $0_1,\ldots.0_n$ with the same level of R but different levels of S. Then by continuity, the equilibrium is the same as before if the range of variation of S is not too large in the zero states.

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[8] In practice, the failure to hedge might also result from the lack of liquid markets for forex hedging instruments---an explanation often given for the failure to hedge against exchange rate risk in less developed economies. It is interesting to see that in this model, firms could fail to use these instruments even if they were available and priced efficiently, simply because hedging is too costly.

[9] Figure 1 was constructed using the following parameterization: $(S_0, S_1, S_2) = (1,1.2,5)$, $(R_0, R_1, R_2) = (1.1,1.3,2)$, $(p_1, p_2) = (0.7,0.3)$ and $C = 0.1$.

[10] The shift involves a discontinuous upward jump in foreign currency debt because of the discontinuous increase in the default probability.

More generally, if the floating exchange rate regime is not perfectly credible, then a premium arises in the peso interest rate, and this might shift the composition of debt towards the foreign currency for the same reason as with a fixed peg. Imperfectly credible floating exchange rates might not be very different, in this respect, from imperfectly credible fixed pegs.

5. Policy Implications

As documented by Hausmann and Panizza in this volume, a key difference between developed and less developed economies is that the latter have less long-term domestic currency debt. Graduating from original sin, then, means developing a monetary and financial system in which borrowers issue more long-term domestic currency debt in less developed economies.

I have presented a model in which the original sin can be attributed to a single cause: the lack of monetary credibility. The policy implication, then, is straightforward. It is to establish a credible monetary regime.

That emerging economies should enhance the credibility of their monetary regime is certainly not a new policy recommendation. However, this paper models a new benefit of credibility. Monetary credibility induces domestic firms to borrow in domestic currency ex ante, which increases the scope for monetary stabilization ex post. Conversely, the lack of credibility induces liability dollarization, which reduces the benefit of monetary autonomy. This reinforces the standard arguments in favor of monetary credibility.

There are very important questions related to transition policies. There is a large literature on the reforms conducive to better monetary credibility (central banks independence etc.) While these measures are certainly desirable in the class of models I have presented, monetary credibility is not established overnight in the real world, but as the outcome of a time-consuming process of building up reputation and institutions. One question, then, is what are the optimal transition policies with regard to the original sin? I come back to this question in the following section.

Some have advocated a *regulatory approach* to the problems posed by foreign currency debt, such as taxing, or forbidding international bank lending in foreign currency (see, e.g., Krueger, 2000; Goldstein,). It is easy to see that this approach does not work in my model: for example, taxing foreign currency debt unambiguously decreases the welfare of entrepreneurs. The reason is simple: the regulatory approach needs some kind of externality to work, and my model has none since it looks at one single firm. Of course, one can think of various negative externalities potentially associated with foreign currency debt, and some might exist in the real world.[11] However, if the core of the problem is the lack of monetary

[11] Three kinds of externality could arise. First, an externality could result from financial contagion. Second, monopolistic competition would generate a demand externality, which

(continued)

credibility, the regulatory approach is unlikely to be at the core of the solution. The solution is to establish a credible monetary framework.

6. Concluding Thoughts

Let me step back and take a broader perspective on the "original sin". There is a sense in which this paper has not answered the question in its title. I have presented a model explaining why firms do not borrow in domestic currency. This is not the same as explaining why they borrow in foreign currency. There are alternatives to domestic currency debt other than foreign currency debt: indexed debt, short-term debt (which could be viewed as a form of indexation in a simple three-period extension of the model). In a sense, the model was more about the absence of domestic currency debt than the presence of foreign currency debt. It was about the latter only because somewhat artificially, I assumed it to be the only alternative to domestic currency debt.

This is more than an idle theoretical point. Indeed, we observe a lot of variety in the domestic financial structures of emerging market economies (see Figure 2).

This raises a policy question of considerable practical relevance. A country's debt structure is influenced by domestic policies. What is the optimal debt structure, once reliance on long-term domestic currency debt is excluded by the original sin? Is it better to have short-term debt, indexed debt, foreign currency debt, or maybe as little debt (and as much equity) as possible? These have to be compared along several dimensions: financial stability, resilience to different types of shocks, monetary credibility etc. One can also ask which debt structures are more conducive to the development of a long-term domestic currency debt market (i.e., an escape from original sin itself).

The nascent literature on the original sin has tended to focus on another question, related to the international segment of the debt market (i.e., debt issued under a foreign jurisdiction, most often in London, New York or Tokyo in practice). By contrast with domestic debt, this segment is characterized by a considerable degree of uniformity. To simplify, it is mid-term to long-term debt denominated in very few currencies, mainly the U.S. dollar (Hausmann, Panizza and Stein, 2000). This is what Hausmann and Panizza call the "foreign original sin" in their contribution to this volume.

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might interact in an interesting way with the choice over the currency composition debt ex ante (this would become relevant if I introduced nominal stickiness in the model: I would have to assume monopolistic competition between the price-setting agents.) Third, there could be a "common agency" problem (Tirole, 2001): if monetary policy is endogenous, individual firms will not internalize the impact of the currency composition of their debt on monetary policy. The first two externalities should generate "too much" foreign currency debt, while the last one should generate "too little" (as noted by Tirole, 2001).

It seems difficult to defend the thesis that "foreign original sin" is due primarily to faulty monetary policies in debtor countries. It is not the case that countries are able to issue domestic currency debt abroad simply because they have a credible monetary regime and deep domestic financial markets (there are examples of the contrary). Rather, the foreign original sin seems to be about the difficulty for small countries at the periphery of the international financial system to change the way finance is done at the center. It is about barriers to financial innovation.[12] In other terms, the reasons underlying foreign original sin are probably very different from the one I have discussed in this paper. I do not claim that monetary policy is the cure for all sins.

This said, one should be wary of an approach that would focus exclusively on the international segment of the debt market. The magnitude of the problems posed by the incompleteness of this particular market can be reduced by domestic monetary credibility in two ways. First, the problems posed by foreign currency debt are made less severe by a credible and predictable exchange rate regime. Second, the extent to which countries are effectively constrained by the foreign original sin depends on the alternative sources of finance. Improving monetary credibility should allow emerging market countries to issue more long-term domestic currency debt domestically, and thus reduce their reliance on foreign debt.

[12] Incidentally, the question here is not only why countries do not issue domestic currency debt, but why they don't issue other forms of debt, like commodity-indexed bonds (Caballero,) or GDP-indexed debt (Borensztein and Mauro, 2002). Borensztein and Mauro give an interesting discussion of possible barriers to financial innovation in the international debt market.

APPENDIX

Mathematical preliminaries

I first present a general approach to solving problem *(P)-(P')*. Then I apply it to prove Proposition 3.

First, the entrepreneur can compute the maximum expected income that can be pledged to creditors conditional on a default-free debt structure (i.e., such that the firm does not default in any state $x \in X$). If this maximum pledgeable income is larger than I^*, the entrepreneur can borrow safely. If not, the entrepreneur cannot finance his project with a default-free debt structure and must accept the risk of a default in some states.

The maximum expected repayment that the entrepreneurs can promise to investors conditional on a default-free debt structure is the solution to the following problem:

$$\begin{cases} \max \rho^* + \rho E(1/S) \\ \forall x \in X,\ \rho + \rho^* S(x) \leq R(x) \end{cases}$$

The constraints in this problem are represented graphically in figure A1. Each point corresponds to a state $x \in X$. A default-free debt structure (ρ, ρ^*) is such that the line $R = \rho + \rho^* S$ is below all the points.

It is easy to see that (i) if there are three states or more, and (ii) the points corresponding to the states are not all on the same line (i.e., the firm peso income is not a linear function of the exchange rate), then at least one point will have to be some distance above the line $R = \rho + \rho^* S$ in a default-free debt structure (for example point A or B in figure A1). In the corresponding state the firm repays strictly less than the total return of the project. This is why the maximum expected income that the firm can pledge to repay is strictly lower than $E(R/S)$ in a default-free debt structure.

In order to derive further results it is useful to distinguish two classes of problems *(P)*. But first, I must define a certain locus of points in the space (S, R). Let me remove from X all the states x such that there is another state $x' \neq x$ with the same exchange rate but a strictly lower return ($S(x) = S(x')$ but $R(x') < R(x)$). (That is I remove points like A in figure A1.) This leaves me with a subset of states $X' \subset X$. Then let me define the locus *(C)* as the curve joining all the points in X'. This curve is piece-wise linear if there is a finite number of states in X', but could be smooth if X' includes a continuum of states.

I say problem *(P)* is globally concave if curve *(C)* is globally concave, and globally convex if *(C)* is globally convex (see figures A2 and A3). In general, it could be that problem *(P)* is

neither globally convex nor globally concave because *(C)* is convex in some parts and concave in others. However, it is useful to focus on problems that are globally convex or concave because they have nice properties (the concave variety more so).

In particular, the maximum pledgeable income of the entrepreneur is quite easy to compute when problem *(P)* is concave. The corresponding debt structure is such that the no-default constraint $\rho + \rho^* S(x) \leq R(x)$ is binding for the two extreme states corresponding to the lowest and highest levels of the exchange rate in X' (points A and C in figure A2). If the no-default constraint is satisfied for these two states, then it is strictly satisfied for all other states by concavity of the curve (see e.g. point B in figure A2). Moreover, the amount by which the firm's repayment falls short of its income is minimized in all other states, implying that the firm's expected repayment cannot be increased (in an intermediate state like B in figure A2, the gap between income and repayment is measured by the vertical distance from C to the line).

If the firm's debt structure is not default-free, then the states in which the firm defaults also depend on the nature of problem *(P)*. If this problem is concave, the firm will default in extreme states, with very high or very low exchange rates. By contrast, if *(P)* is convex, the firm will default in intermediate states.

Proof of Proposition 3

The model given in section 4 is a concave problem with three states. It can be represented like in figure A4. The default-free debt structure (ρ, ρ^*) that maximizes the firm's pledgeable income is such that the line $R = \rho + \rho^* S$ goes through points A and C. The firm's pledgeable income is

$$V_{safe}^{e} = E\left(\frac{R}{S}\right) - \mu p_1 \eta$$

where η is the gap between the dollar income of the firm and its dollar repayment in state 2 (point B). If one writes S_1 as a weighted average of S_0 and S_2 with weights $1-\lambda$ and λ respectively, this gap is equal to

$$\eta = \frac{R_1 - (1-\lambda)R_0 - \lambda R_2}{S_1}$$

Because the problem is concave, the entrepreneur chooses between defaulting in state 0 (no devaluation) and defaulting in state 2 (large devaluation), if he has to. As long as the probability of a devaluation μ is lower than ½, the entrepreneur chooses to default in the large devaluation state. Conditional on this, the debt structure (ρ, ρ^*) that maximizes the firm's pledgeable income is achieved when the line $R = \rho + \rho^* S$ goes through points A and

B. The expected repayment is then given by the project's expected return net of the cost of default in state 3:

$$V^e_{risky} = E\left(\frac{R}{S}\right) - \mu p_2 C$$

It is easy to see that the firm's maximum pledgeable income is larger under a risky debt structure if

$$p_2 C < p_1 \eta$$

a condition that I assumed to be satisfied. Then, the proof of Proposition 3 easily follows. The thresholds $\underline{\mu}$ and $\overline{\mu}$ are the values of μ for which V^e_{safe} and V^e_{risky} are equal to I^* respectively.

Let us denote by $\gamma \equiv$ the decrease in the project's dollar return resulting from a devaluation, and by $\beta \equiv R_0 / S_0 - I^*$ the net benefit of the project conditional on no devaluation. Then ir follows from $E(R/S) = I^* + \beta - \mu\gamma$ that probability thresholds $\underline{\mu}$ and $\overline{\mu}$ are given by

$$\underline{\mu} = \frac{\beta}{\gamma + p_1 \eta}, \quad \overline{\mu} = \frac{\beta}{\gamma + p_2 C}.$$

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Figure 1. Devaluation Risk and Foreign Currency Debt

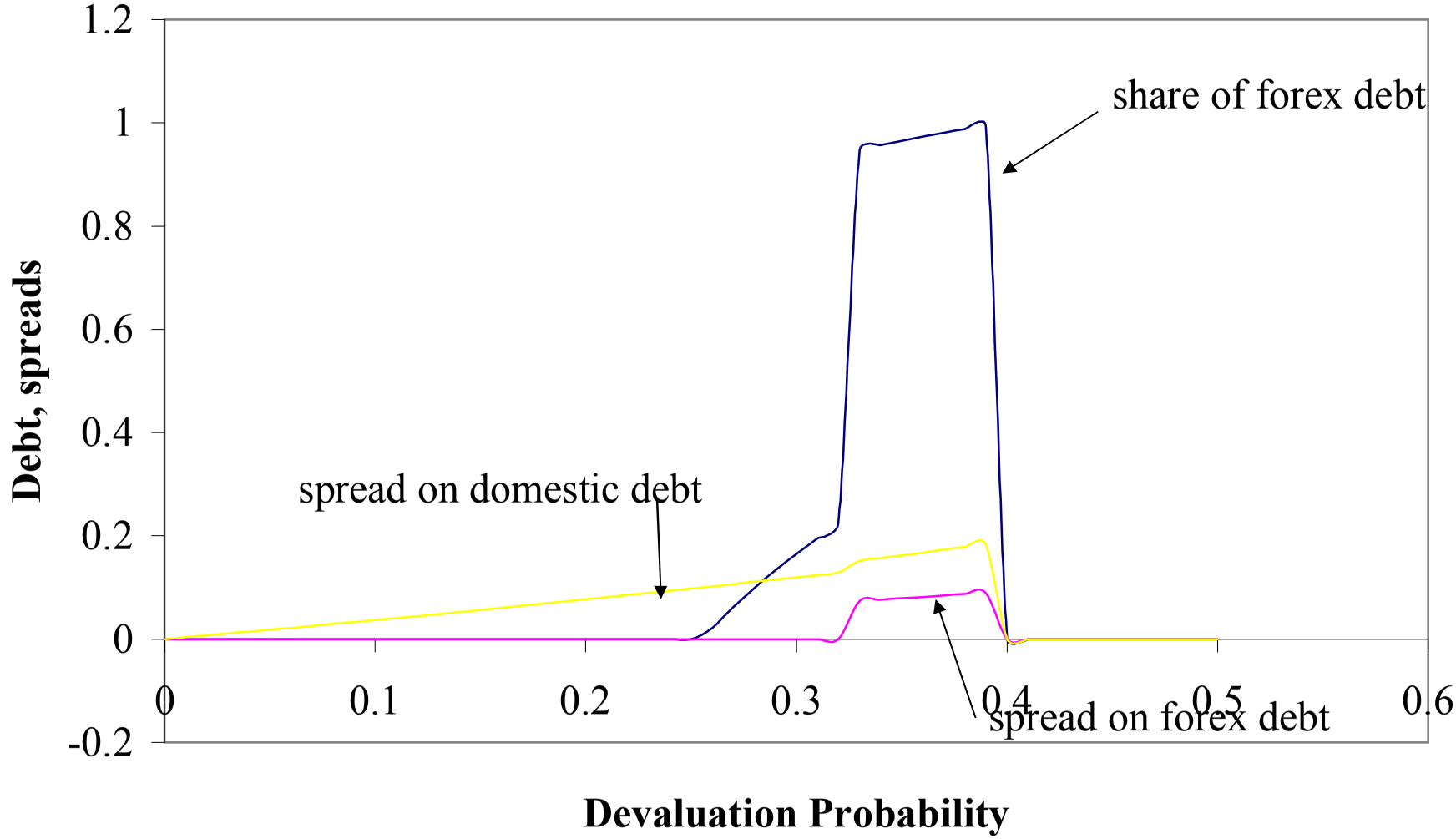

Figure 2. Dollar Debt (% of liabilities)

Share of dollar debt in total liabilities for a sample of publicly traded firms.

Source: Bleakley and Cowan, based on Bloomberg/Economatica.

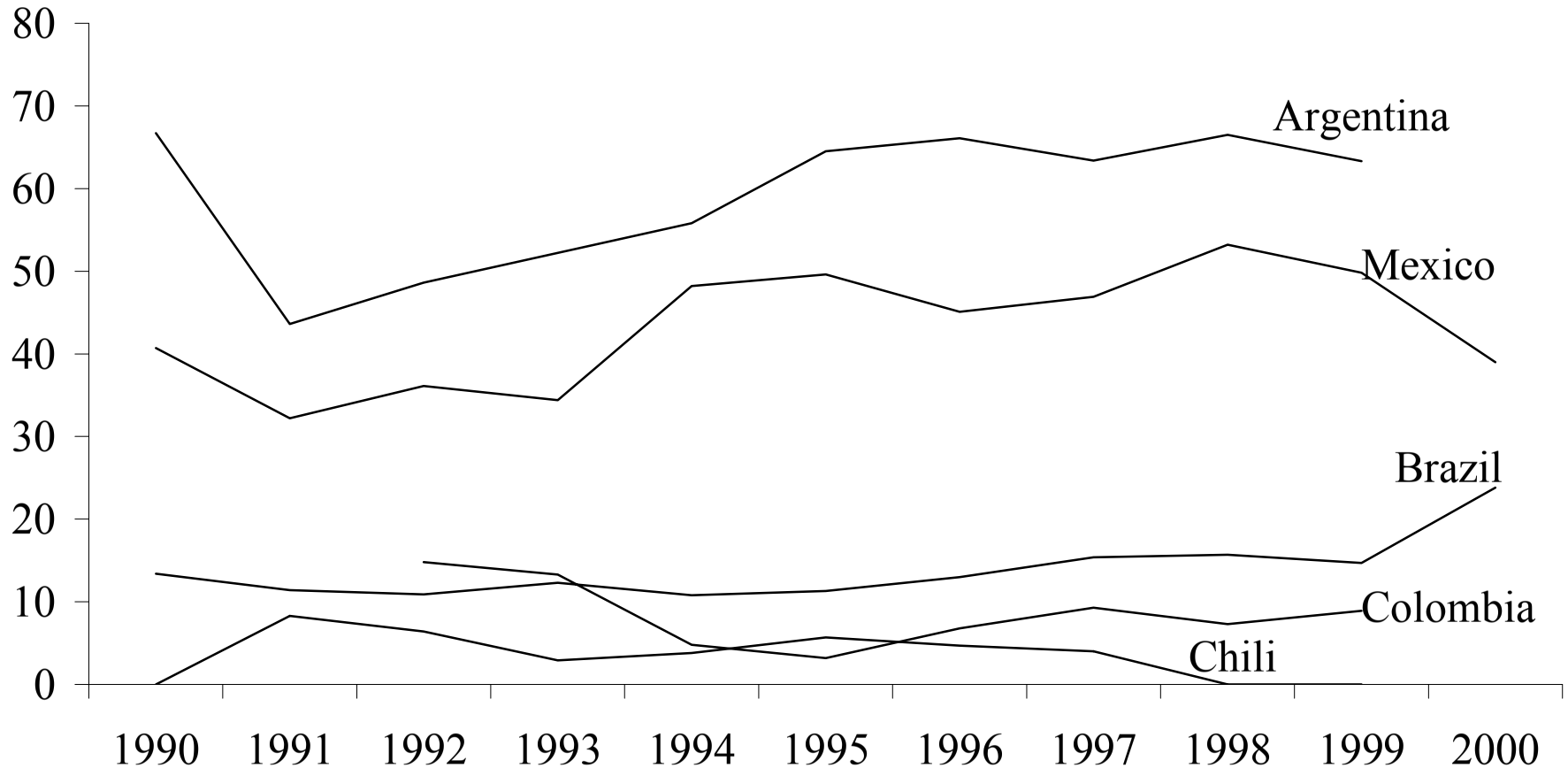

Figure A1

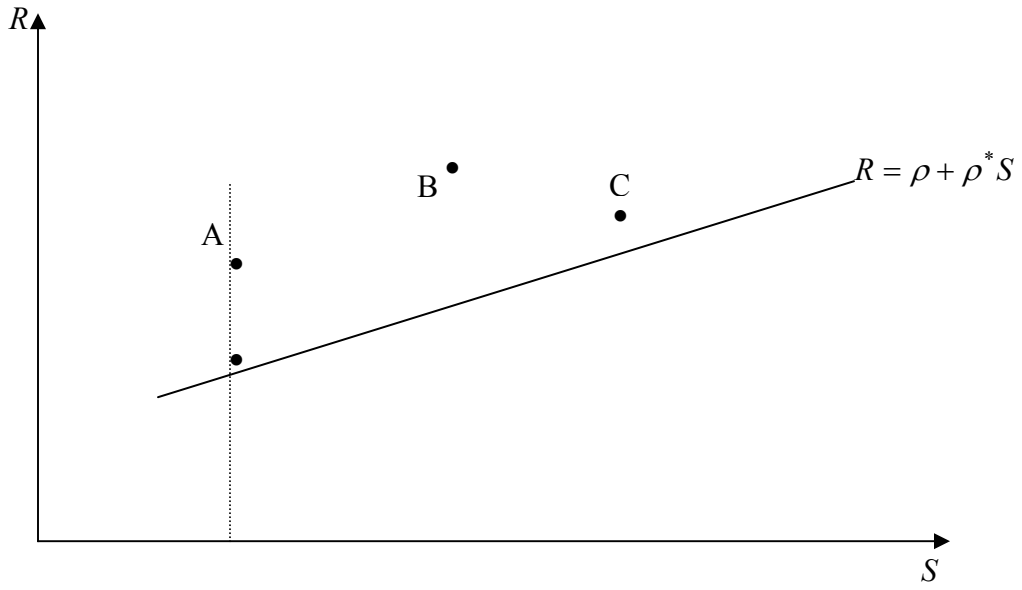

Figure A2. The concave case

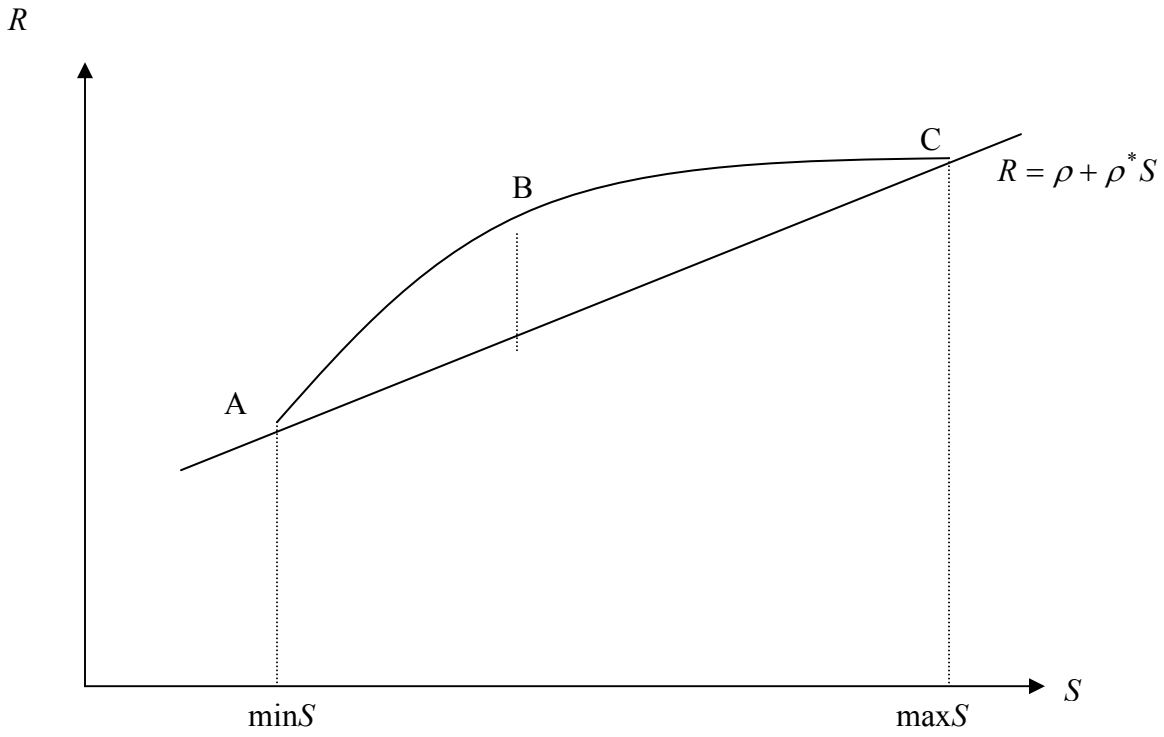

Figure A3. The convex case

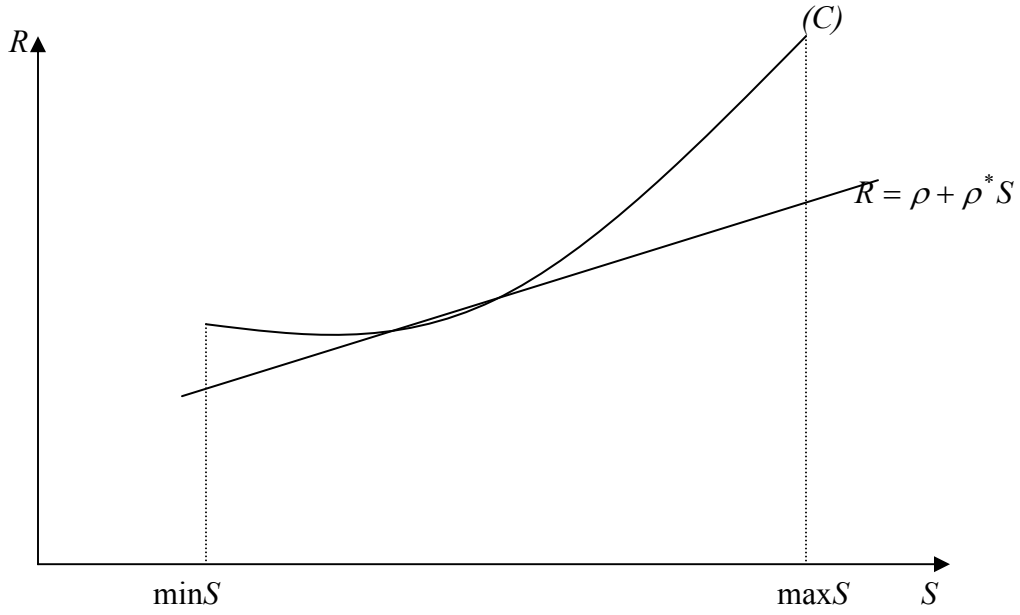

Figure A4. Proposition 3