Corporate Leverage and Currency Crises*

Arturo Bris
Yale School of Management

Yrjö Koskinen
Stockholm School of Economics

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Abstract

This paper provides an explanation of currency crises based on an argument that bailing out financially distressed exporting firms through a currency depreciation is ex-post optimal. Exporting firms have profitable investment opportunities, but they will not invest because high leverage causes debt overhang problems. The government can make investments feasible by not defending a fixed exchange rate and letting the currency depreciate. Currency depreciation always increases the profitability of new investments when revenues are in a foreign currency and costs are at least partially in domestic. Interestingly, foreign borrowing by exporting firms doesn't change the qualitative results: if firms' debt is denominated in foreign currency, a larger depreciation is needed to restore incentives to invest. An important feature in our model is that in general exporting firms choose to finance investments with debt instead of equity. Currency depreciation is socially optimal if risky projects have a higher expected return than safe projects and if firms are forced to rely on debt financing because of underdeveloped equity markets. Although currency depreciation is always ex-post optimal, it can be harmful ex-ante. Exporting firms know that the government will let the currency depreciate, if their risky investments have failed. This leads to excessive investment in risky projects even if more valuable safe projects are available.

Keywords: currency depreciation, debt overhang, emerging markets, efficient investment policy, excessive risk taking

JEL classification codes: F34, G15, G31, G32

1 Introduction

Currency crises have become a frequent phenomenon. During the past decade, there have been major crises in Europe (the ERM-crisis), in Latin America (the Tequila crisis) and most recently in Asia. According to Krugman (1997), '*major currency crises occur at an average rate of one every 19 months*'. Moreover, these crises are for the most part hard to explain by relying only on macroeconomic fundamentals.

In particular, the Asian currency crisis in 1997-98 was unexpected and its magnitude a shock. By conventional fiscal measures the governments of the afflicted countries were not in bad shape at all by the beginning of 1997. Only a couple of years earlier the very same countries were hold as good examples of prudent macroeconomic management by the World Bank. The budget deficits were not excessive even though the growth of these economies had slowed down somewhat during 1996. Current account deficits were large in some countries (Thailand and Malaysia), but in others (Korea and Indonesia) they were very modest. Krugman (1999) concludes that there was not a strong case to be made for currency depreciations because of macroeconomic reasons. Indeed, Radelet and Sachs (1998) blame financial panic caused by loss of confidence and changing expectations in the currency markets for the magnitude of the crisis, aggravated by bad advice from the IMF.

This paper provides a view of currency crises based on excessive indebtness and low profitability in the corporate sector, applicable to the Asian crisis, as well as to some extent to the earlier European and Latin American ones. The argument proposed in this paper is that restoring the incentives to invest for financially distressed exporting firms through a currency depreciation is ex-post optimal for an economy. In our model, the economy consists of profit maximizing exporting firms, whose products are sold in the world markets. These firms can choose either safe or risky business strategies that can be financed either with debt or equity. If the firms choose the risky strategies, they can attain with some probability very high profits. If the chosen strategies have failed, the exporting firms can partially recover their losses by investing in new profitable business opportunities. If the exporting firms have been financed by equity, the new investment opportunities are feasible and the investments will always take place. However, if the firms have been financed with debt they will not invest because of debt overhang problems: the new investment would only benefit the creditors.

The government would like the investments to take place, because the positive net present value investments would increase the amount of production in the economy measured in foreign currency. In our model, the domestic currency is initially pegged to the foreign one. The government can make investments feasible by not defending the peg and thus letting the currency float. The resulting equilibrium currency depreciation increases the profitability of new investments when revenues from the new investment are in a foreign currency and costs in domestic.

Currency depreciations are socially optimal if the risky investments have a higher expected value than the safe ones and if firms are forced to rely on debt financing. Without currency depreciations equity constrained firms might have to choose the less profitable safe strategy. Although currency depreciations in this context are always ex-post optimal, they can be harmful ex-ante. This can happen when the safe projects are the more valuable ones. Exporting firms know that the government will not defend the fixed exchange rate if their risky investments have failed, provided that investments have been financed with debt. In this model we show that exporting firms have an incentive to finance their risky projects with debt instead of equity, even if equity financing is

freely available. High leverage leads to a situation, where the exporting companies capture the upside of the investment, but do not suffer from the downside. This leads to excessive investment in risky projects at the expense of more valuable safe projects. Moreover, if exporting firms' old debt is denominated in foreign currency, a larger depreciation is needed to restore incentives to invest. So, somewhat counter intuitively foreign debt only exacerbates the problem. The government would like to commit not to let the currency depreciate, if the safe business strategies are more valuable for the economy as a whole. However, financial markets and exporting firms know that the government will rescue the exporting firms by letting the currency float if need be. Hence the government's wishes to maintain the fixed exchange rate are not credible.

Why did Asia experience a currency crisis? According to our model, the answer is that the countries afflicted were export oriented countries dominated by large firms with extremely high leverage and low profitability. The recent capital market liberalizations in these countries had resulted in increased borrowing in foreign currencies thus increasing leverage from already high levels. Moreover, depression in Japan, strong dollar and real depreciation of Chinese yuan had severely further reduced the profitability of the exporting companies. The only way out from this debt overhang problem was a currency depreciation.[1]

Our model is indebted to several papers, both in the fields of corporate finance and macroeconomics. The underinvestment problem due to debt overhang was first dealt with by Myers (1977). Jensen and Meckling (1976) show that high levels of debt can lead to overinvestment in risky projects. Berkovitch and Kim (1990) treat both leverage induced incentives to under- and overinvest. Especially important to our model is Dewatripont and Maskin (1995), who argue that credit decentralization as a commitment mechanism not to refinance investment projects, when refinancing is ex-post optimal, discourages managers from undertaking unprofitable risky ones in the first place. This paper is also related to Bolton and Scharfstein (1996), who show that liquidation due to inefficient renegotiation of debt can be beneficial in deterring default.

In the "first generation" of currency crises models of Krugman (1979) and Flood and Garber (1984) large budget deficits, that are financed through money creation, lead eventually to decline in currency reserves and to a speculative attack on the currency. In the "second generation" of currency crises models pioneered by Obstfeld (1994) the government has an incentive to devalue the currency because of mounting unemployment. The currency markets understand the government's incentives and the resulting attack on the currency increases the incentives of the government to devalue (through higher interest rates), eventually leading to a depreciation.

[1] Our model also helps to explain some aspects of previous currency crises. A good example is Finland during the European currency crisis in 1991-93. Finland had pursued export -led growth strategy not unlike the Asian countries. The exporting firms had high leverage and had invested heavily throughout the 1980's. Moreover, the capital markets had recently been liberalized, and as a result firms had increased their foreign borrowing. The chosen strategy of high leverage and excessive investments would have been risky at best of times, but Finland suffered two major external shocks: the German unification and the collapse of the Soviet Union. The German unification resulted in higher real interest rates and appreciating Deutsche mark to which the Finnish markka was pegged to through the ECU and the collapse of Soviet Union meant that Finland lost a major export market. The only way of making further investments feasible was to reduce costs, including the debt level, relative to the future cash flows. This was achieved by currency devaluation. The markka was devalued by 12% in November 1991 and then in the following year the government was forced to let the markka float resulting in even a bigger depreciation than the year before. For futher analysis of the Finnish crisis, see Honkapohja and Koskela (1999), especially for the role that financial liberalization played in the onset of the Finnish crisis.

Corsetti, Pesenti and Roubini (1998a, 1998b) argue in a somewhat complementary vein to us that creditors' capital was at least implicitly guaranteed in some Asian countries, if financial difficulties were to arise. This would naturally lead to overinvestment in risky projects at the expense of safer ones. The difference between us and Corsetti et al. is that in our model the exporting firms investments are guaranteed to succeed, not the financiers returns directly. Chang and Velasco (1998a, 1998b) model a currency crisis in a same way as Diamond and Dybvig (1983) model a bank run. With foreign borrowing and a fixed exchange rate, a run on banks becomes a run on the currency. The currency collapses when the central bank runs out of currency reserves. Krugman (1999) also puts financial distress or balance sheet problems at the center of currency crises. His order of causality is opposite to us: in his model, loss of confidence causes depreciation which then causes balance sheet problems, whereas in our model balance sheet problems cause a depreciation. Johnson et al. (2000) emphasize problems in corporate governance as an explanation to the Asian crisis and show that lack of outside investor protection is related to the amount of depreciation in emerging markets. In Caballero and Krishnamurthy (1999) outflow of capital can lead to domestic fire sales, because a country has a lack of international collateral, thus deepening a capital account crisis to a full financial crisis rendering these expectations self-fulfilling.

Both Gertler (1992) and Lamont (1995) have studied macroeconomic consequences of corporate debt overhang. In Gertler (1992), reduced current cash flow caused by adverse productivity shocks leads to a situation where new investments would benefit mainly debtholders. In Lamont (1995) debt overhang is caused by changes in expectations about future economic conditions.

The remaining of this paper is organized as follows: in Section 2 we present the basic framework, in Section 3 we extend the model in several directions. The empirical implications that arise from the model are analyzed in Section 4. Section 5 concludes the paper.

2 The Basic Model[2]

This a two period model with two markets: a foreign (world) market and a domestic (home) market. At $t = 0$, a representative firm[3] makes both the investment and the financing decisions. The firm produces in the home market, but sells its output in the world markets. The firm's output is the only source of export revenue available to the home market. All agents in our model are risk neutral and the world interest rate r^* is normalized to be zero. We assume that the firm is not big enough to affect the level of interest rates nor any other prices, so the firm acts as a price taker in all markets. We assume perfect capital mobility between the world and home markets. The domestic currency is assumed to be pegged to the foreign currency at $t = 0$.

The firm can invest in two projects. Both projects require the same initial investment I_1 denominated in the domestic currency, and the output from both projects is a tradable good that is sold in the foreign market. Prices in the foreign market are denominated in dollars. The exchange rate at $t = 0$ is normalized to be $e_o = 1$ units of domestic currency per one dollar.

[2] See figure 1 in the appendix for the timing of the events in the model.

[3] We can think of a firm representing a continuum of firms, which have the same opportunity set and face identical shocks.

Because of perfect capital mobility and risk neutrality, the uncovered interest rate parity holds:

$$\begin{aligned} r - r^* &= \frac{E(e) - e_0}{e_0} \\ \Longrightarrow r &= E(e) - 1, \end{aligned} \tag{1}$$

where r is the domestic interest rate. So the uncovered interest rate parity implies that the domestic interest rate is equal to the expected currency depreciation at $t = 1$.

Project S (safe) yields a sure return of X_s dollars at $t = 1$; project R (risky) yields $\overline{X}$ dollars with probability p and 0 with probability $1 - p$. However, if the risky project turns bad, the firm may make a continuation decision at $t = 1$, that involves investing I_2 in the domestic market at $t = 1$ and making a sure return of $\overline{X}$ dollars at $t = 2$, where we assume that $\overline{X} - I_2 > 0$, so the investment at $t = 1$ is a positive NPV investment[4]. If the investment does not take place the firm is liquidated and the proceeds from liquidation are L, where $L = 0$ without loss of generality. We assume that the following holds:

Assumption. $\overline{X} > X_s > I_1 > \overline{X} - I_2 > 0$.

The assumption $\overline{X} - I_2 - I_1 < 0$ guarantees that continuation is not profitable for the shareholders of the firm if debt has been used to finance the initial project. However, continuation is preferred to liquidation if the firm is all-equity financed. The NPV of the safe project is $X_s - I_1$and the NPV of the risky project is $p\overline{X} + (1 - p)(\overline{X} - I_2) - I_1$,when depreciation is not possible and hence the domestic interest rate $r = 0$. Now let us define $\overline{p}$ such that both S and R have the same NPV when exchange rates have been permanently fixed:

Definition. $\overline{p} = \frac{X_s - \overline{X} + I_2}{I_2}$.

It is easy to see that if $p \gtrless \overline{p}$, then

$$p\overline{X} + (1 - p)(\overline{X} - I_2) - I_1 \gtrless X_s - I_1 \tag{2}$$

Either project can be initially financed with debt or equity. If the project is financed with debt, the lender will require a face value for the loan that guarantees a discounted payoff equal to I_1, the cost of the project. Initially we assume that debt is denominated in the local currency, although we will relax the assumption later in the paper and show that currency depreciations become larger and more frequent in that situation. We also assume that direct renegotiation between the firm and its creditors is not possible. Essentially, we model currency depreciations as an alternative to renegotiation of the existing debt level in order to make the new investment feasible.

The government's objective is to maximize revenues for the economy, measured in the foreign currency and net of investment costs. At $t = 1$, after observing the outcome from the project, the government may let the peg go and allow the currency to float. If project S has been implemented, there is no incentive to let the currency float. Appreciation or depreciation of the currency would

[4]Denoting the return from the continuation investment by $\overline{X}$ at $t = 2$ is done because of notational simplicity. Nothing would change in the analysis if we assumed instead that the return at $t = 2$ would be such that $X_2 \geq \overline{X}$, where X_2 is the return from the continuation investment.

not increase the return X_s from exported output measured in foreign currency. There would be no net benefit for the economy from a change in the exchange rate in this case. Likewise if the risky project has been taken and the return is $\overline{X}$. If the risky project yields 0, the firm will invest in the new project, if the first project has been financed with equity, since $\overline{X} - I_2 > 0$. Since the new investment takes place in any case, there wouldn't be any net gain from a change in the exchange rate even in this case. However, to the extent that the project is financed with debt, the government prefers a depreciation if $\overline{X} - I_2 - F < 0$, where F is the face value of the debt used to finance I_1, and $e\overline{X} - I_2 - F \geq 0$. The reason is that without a depreciation there would be no export revenues at all. With currency depreciation there is a net increase in exports measured in dollars, because depreciation makes the new investment incentive compatible for the firm.

After the risky project has returned 0, the government lets the exchange rate float. The resulting equilibrium exchange rate is such that investors break even in financing the new investment, i.e. the exchange rate e becomes:

$$e = \frac{I_2 + F}{\overline{X}} > 1 \tag{3}$$

With this exchange rate both domestic and foreign investors are willing to finance the continuation investment.

The optimal exchange rate policy is contingent upon the project selection made by the firm. In the next section we analyze the case where depreciations are not possible, and determine which project the firm selects and how it is financed.

2.1 The case without depreciations

Let us define V_i^j as the value of the firm's equity when project i is taken and financed with $j = \{D, E\}$, where $i = \{S, R\}$ and D, E stand respectively for debt and equity.

If the firm has only access to equity markets, then clearly the efficient project is chosen, from (2). Suppose instead that the project is entirely financed with debt. Let F^i be the face value of the loan when project $i = \{S, R\}$ is taken. If S is taken, then it has to be that $F^S = I_1$. If the risky project is taken, then $F^R > I_1 > \overline{X} - I_2$ by assumption. Therefore shareholders will prefer to liquidate the firm (debt overhang) even when it is profitable for the firm to continue operations, and F^R satisfies:

$$I_1 = pF^R + (1-p)0$$

or $F^R = \frac{I_1}{p}$.

Were the project choice observable by the firm's debtholders, the resulting equity value when either project is taken would be $V_S^D = X_s - I_1 = V_S^E$, and $V_R^D = p\left[\overline{X} - \frac{I_1}{p}\right] + (1-p)0 = p\overline{X} - I_1$. Therefore $V_R^D < V_S^D$, and the safe project would always be taken, whenever $p \leq \overline{p}$. At the same time, the firm would be indifferent between debt and equity. For $p > \overline{p}$, the risky project is preferred, and it is financed with equity since $V_R^D < V_R^E = p\overline{X} + (1-p)(\overline{X} - I_2) - I_1$. Intuitively,

the highest NPV project is always taken, but the risky project has to be financed with equity to avoid the debt overhang problem.

Due to the unobservability of the project choice, firm's shareholders may deviate from the bondholders expectations and take, for instance, project R when a debt contract involving a face value $F^S = I_1$ is offered. Aware of the firm's incentives to deceive, creditors will accordingly adjust the face value of the debt contract. We prove next that, due to those incentives, equity is preferred to debt in some cases, and that the highest NPV project is always taken in the absence of depreciations.

Proposition 1 *When depreciations are not possible, the firm always chooses the highest NPV project. For $p \geq \overline{p}$, the risky project R is chosen and the project is financed with equity. For $p < \overline{p}$, the safe project S is chosen. If $p \leq \frac{X_s - I_1}{\overline{X} - I_1} < \overline{p}$, the firm is indifferent between debt and equity and if $\overline{p} > p > \frac{X_s - I_1}{\overline{X} - I_1}$, S is financed with equity.*

The previous results derives from the pervasive effect that the debt overhang problem has on the optimal project choice for shareholders. Continuation is optimal from the firm's perspective, but only from the shareholders' perspective if the firm is all-equity financed. For low values of p the profitability of the risky project is also low and the safe project is clearly preferred. For intermediate values of p the safe project is still preferred , but if financed with debt, shareholders have an incentive to promise a debt repayment I_1 and take the risky project instead. Bondholders are aware of that, but if they require a higher face value, the firm will inconsistently choose the safe project now. Therefore, the safe project can only be financed with equity when p is such that $\overline{p} > p > \frac{X_s - I_1}{\overline{X} - I_1}$. For high values of p , the risky project is chosen and it is financed with equity, since with debt financing the continuation investment can not be implemented.

Note finally that in the absence of currency crises the optimal decision, namely taking the highest-NPV project, is taken. In the following section we allow for the government to bail out the firm in case the risky project is taken and the firm defaults.

2.2 Allowing for depreciations

In this section we show that the firm may prefer the risky investment to the safe one, if the government decides to abandon the peg and let the exchange rate float at $t = 1$ when the risky project has failed. As long as the exchange rate e at $t = 1$ when the risky investment has failed is such that

$$e\overline{X} - I_2 - F_e^R \geq 0 \tag{4}$$

it may be optimal for the firm to invest on the second project, where F_e^i is the face value of the debt when depreciations are allowed and project i is taken, $i = \{S, R\}$. It is straightforward to show that $F_e^S = F^S = I_1$. Note that since $\overline{X} - I_2 > 0$, there is no need for depreciation when the risky project is financed with equity. Additionally, since the firm never defaults when the safe project is taken, the possibility of depreciations is restricted to the case of debt financing and risky project choice.

After the risky project has failed, the interest rate in the domestic market becomes $r = e - 1$ (from equation (1)). If the risky project has succeeded, there will be no currency rate changes, so

the domestic interest rate will be the same as the world interest rate $r^* = 0$. Since the risky project succeeds with probability p and fails with probability $1-p$, the discount rate $1+r$ to the risky project will be

$$p + (1-p)e. \tag{5}$$

Therefore, if we conjecture that (4) holds, the expected payoff to debtholders if R is taken and financed with debt will be $\frac{pF_e^R + (1-p)F_e^R}{p+(1-p)e} = \frac{F_e^R}{p+(1-p)e}$, which implies:

$$F_e^R = [p + (1-p)e]\, I_1 \tag{6}$$

Hence:

$$V_{R,e}^D = \frac{p\left[\overline{X} - (p+(1-p)e)\, I_1\right] + (1-p)\left[e\overline{X} - I_2 - (p+(1-p)e)I_1\right]}{p+(1-p)e} \tag{7}$$

if (4) holds, that is, if:

$$e \geq \frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1} = e^* \tag{8}$$

Hence, if $e > e^*$, equity value is $V_{R,e}^D$. Otherwise liquidation is optimal for the firms' shareholders, there are no depreciations, and $V_R^D = p\overline{X} < V_S^D = V_S^E$ for $p < \frac{X_s}{\overline{X}}$.

First we prove the lemma showing that the firm's profits are increasing in the amount of currency depreciation.

Lemma 1 *Firm's profits are increasing in e given that the risky project is chosen and continuation investment is feasible.*

There are two effects here: an increase in revenues $e\overline{X}$, but also increase in the discount rate $1+r = p+(1-p)e$, and the first effect dominates the second one. Note that the increase in the face value of debt and the increase in the discount rate cancel each other out.

Proposition 2 shows that, under some conditions, it is ex ante optimal for the firm to choose the risky project and finance it with debt, since it is ex-post optimal for the government to let the currency depreciate and increase the profitability of the risky project measured in domestic currency.

Proposition 2 *There exists $p^* < \overline{p}$ such that, for $p^* \leq p$, the firm chooses project R and finances it with debt. The currency is devalued with probability $1-p$ and after the depreciation the exchange rate becomes:*

$$e^* = \frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1} \tag{9}$$

When the success probability p of the risky project R is above a threshold, the firm prefers the risky project to the safe project S, even if S is preferred when depreciations are impossible, i.e. when p is such that $\overline{p} > p \geq p^*$. This ex-ante choice of inefficient investment is the cost of depreciations to the economy. The intuition is that the central bank implicitly insures the firm against bad realizations if R is chosen. The firm makes a profit if $\overline{X}$ occurs and breaks even if the low realization occurs. Note also that the creditors are compensated for the risk of depreciation. The losers in this situation are the suppliers of I_2, since the value of I_2 is now lower measured in dollars.

The previous result says that the probability of the firm being devalued is negatively related to the quality of the projects the firm may undertake. If we consider p as a measure of profitability, Proposition 2 implies that currency crises are more likely in a situation in which firm's return on investment is low. Harvey and Roper (1999) document that corporate performance indicators (ROE and ROIC) deteriorated throughout Asian markets immediately before the 1997 crisis. Our explanation for currency crises is also consistent with the results in Pomerleano (1998), who finds that, for example in Thailand average ROE declines rapidly from 13 percent in 1992 to 5 percent by 1996, and similar results are reported for other Asian countries. Corsetti et al. (1998a), for instance, report that 20 of the largest 30 conglomerates in Korea displayed in 1996 a ROIC below the cost of capital. Secondly, Pomerleano (1998) presents some evidence reflecting a dramatic increase in leverage in Asia in the period 1992-1996[5]. While these papers seem to suggest that excessive leverage taken on by corporations in these countries was one of the reasons for the dramatic depreciations they suffered, we have just shown how the financial excesses that precede a currency crisis are in fact optimal practices from the corporations' point of view, when the exchange rate is fixed but depreciations are possible.

The model presented here shows as well that, even if depreciations are ex-post optimal (as a means of bailing out exporting firms in financial distress), they are not always desirable ex-ante (since they lead to undertaking lower NPV projects and excessive risk). The solution is to have credible commitment mechanism not to let the currency depreciate. There is consensus by now that pegging the exchange rate is not such a mechanism. For instance,. Johnson (1999), states that: "*experience indicates that fixed parities lack credibility in financial market, particularly where capital controls have been abolished*". To the light of our model, the government cannot commit ex-ante not to devalue the currency because it is clearly optimal ex-post, once the risky project has been taken and failed. Only a common currency (where the exchange rate cannot be devalued by the national government) or adoption of somebody else's currency can serve as a commitment mechanism[6].

3 Extensions

In this section, we extend the basic framework in several directions. Firstly, we allow the firm to borrow in excess of its capital needs I_1. The firm faces a higher risk of default if is excessively levered, but the ex-post government's incentives to devalue the currency and bail the firm out may

[5] The average debt-to-equity ratio for Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, and Thailand increases from 48% as of 12/31/1992 to 77% as of 12/31/1996.

[6] So far currency boards (Hong Kong (1983), Argentina (1991), Estonia (1992), Lithuania (1994) and Bulgaria (1997)) have also been credible solutions against currency depreciations.

make the levered recapitalization desirable. Secondly, we restrict our attention to economies where equity markets are not developed, and equity financing is thus an expensive resource; the firm has access only to debt markets. This situation is interesting for two reasons: 1.) in the absence of currency depreciations, the firm may prefer project S even when it is inefficient, because the continuation investment is not feasible and 2.) equity cannot be used as a commitment device to take the safe project, so firms have an incentive to deceive investors leading even more excessive risk taking. Next we allow for the debt to be denominated in foreign currency and show that the firm may prefer foreign debt to both domestic debt and equity. After that we extend the analysis to the situation where the firm can gamble at $t = 2$ by taking a risky, but negative NPV project. This leads to excessive profits for the firm and even larger currency depreciations. Finally, we relax the assumption that the cost of I_2 does not adjust at all to the depreciation and show that our analysis still goes through, but with different parameter values.

3.1 Excess Borrowing

In the previous section, we allowed the firm to borrow just to finance its investment. Now we relax this assumption and let the firm borrow until it just breaks even in the good state after the risky project R has been chosen. This implies that the debt face value can be as high as $F_e^R = \overline{X}$. The company invests I_1 and distributes the remaining funds as an extraordinary dividend to shareholders.

In order for the investment to be feasible, the following condition has to hold:

$$e\overline{X} - I_2 - \overline{X} \geq 0 \tag{10}$$

This implies that the continuation decision is taken when the currency is depreciated. Rearranging the previous expression:

$$e \geq \frac{\overline{X} + I_2}{\overline{X}} = e^{**}$$

The exchange rate e^{**} is the amount of currency depreciation that makes investors willing to finance the continuation investment.

Proposition 3 *There exists* $p^{**} = \frac{\overline{X}I_1 - \overline{X}^2 + I_1 I_2}{I_1 I_2} < p^*$ *such that, for* $p^{**} \leq p$, *the firm chooses project R, borrows so that* $F = \overline{X}$ *and pays the amount of* $\frac{\overline{X}}{p+(1-p)e} - I_1$ *as dividend to shareholders at* $t = 0$. *The currency is depreciated with probability* $1 - p$ *and if the low state has occurred the exchange rate becomes*

$$e^{**} = \frac{\overline{X} + I_2}{\overline{X}}.$$

Excess borrowing, i.e. very high leverage, increases the parameter space where is optimal for the firm to choose the risky project instead of the safe one. The intuition is as follows: the firm breaks even after both the high and low realizations of the project R. The shareholders make their money from the dividend that is paid at $t = 0$ and this dividend is hence riskless. This dividend is greater than the profits from the safe project S. The only constraint that has to be satisfied is that the face value of debt can not be greater than the high realization of the risky project R ,

i.e. $F > \overline{X}$ is not allowed. Proposition 3 predicts increasing debt levels, and relatively high or constant payout ratios prior to the onset of a currency crisis. Note that excess borrowing plus high dividends is optimal for the firm's shareholders relative to a situation where the firm does not pay dividends and fully invests the proceeds from the debt issue.

3.2 Only debt available

So far we have assumed that investments can be financed either with debt or equity. Next we want to consider the case where only debt financing is available, or equity financing is more expensive. This corresponds to a case where equity markets are underdeveloped. A major reason for underdevelopment of equity markets is the lack of adequate minority shareholder protection (LaPorta et. al. 1998). This is the case in most emerging markets. If outside minority shareholders are subject to the opportunism of controlling shareholders, the required return needed to induce these outside investors to finance the investment would be higher than with stringent protection of their rights. Hence, equity financing would be more expensive than debt financing. In this case we make the assumption that both the risky and safe projects are financed with debt[7].

If the exchange rate is permanently fixed and hence depreciations are not possible at all, firms might have to forgo profitable, but risky investments and accept lower yielding safe investments instead. The reason is that because of the debt overhang problem, the continuation investment is not feasible any more. The risky project is chosen only the NPV of the first investment at $t = 0$ is higher for the risky project than for the safe project. The proposition is formalized as:

Proposition 4 *Assume that only debt is available for financing the investments and depreciations are not possible. Then, for $p \geq p^d > \overline{p}$, where $p^d = \frac{X_s}{\overline{X}}$, the firm chooses the project R. For $p < p^d$, the project S is chosen.*

The first-best investment choice would require that risky investments are taken whenever $p \geq \overline{p}$, but when debt financing is the only source of funds that is available, the risky investment is only chosen if $p \geq p^d > \overline{p}$. This result gives a rationale for efficiency enhancing depreciations. Currency depreciations may be good for an economy if the NPV of risky investments is high and if equity markets are underdeveloped. In this case, if we observe currency crises, they are just a negative realization of an optimal currency policy.

Now the firm can not commit to take the safe project with face value of debt I_1, even if it would be advantageous to it. The markets know this and charge a higher face value. This leads to a situation, where the conditions for choosing the risky project R are easier to fullfil.

Proposition 5 *Assume that only debt is available for financing the investments. Then, for* $\max[p^{**}, p^{***}] \leq p \leq \overline{p}$, *where* $p^{**} = \frac{\overline{X}I_1 - \overline{X}^2 + I_1 I_2}{I_1 I_2} < p^*$, $p^{***} = \frac{(X_s - I_1)(I_1 + I_2)}{\overline{X}\left(\overline{X} - X_s\right) + (X_s - I_1)(I_1 + I_2)} < p^*$, *the firm chooses project R and finances it with debt. The currency is devalued with probability* $1-p$ *and the exchange rate becomes after the depreciation:*

$$e^{***} = \frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1}$$

[7] Allowing equity financing, but making it more expansive would yield qualitatively similar results. We make the assumption of no equity financing jusr for expositional simplicity.

Note that the exchange rate after depreciation is exactly the same as in the case where the firm is allowed to use equity financing as well. The only difference is that now the conditions on p are less stringent: the creditors understand than when the firm is borrowing, it might have an incentive to fool the market and choose the risky project instead of the safe project. With debt, the firm can not commit to take the safe project, where as equity can serve as a commitment device for that purpose, since after equity financing the firm will always have an incentive to choose the project S.

Johnson et al. (1999) examine to what extent corporate governance variables caused the recent Asian crises. They conclude that the level of shareholder protection had an important effect on the extent of depreciations in the crisis. In particular, those countries with lower indexes of minority shareholder rights (La Porta et al. (1998)) experienced greater currency depreciation prior to 1996. We have just shown, in line with this piece of evidence, that in the absence of equity financing, some risky projects that would not otherwise be taken are preferred to riskless investments, therefore increasing the likelihood of depreciations and also inducing larger depreciations (the extent of the depreciation is larger for lower p).

3.3 Foreign Borrowing

From a general perspective, it can be argued as reasonable that an exporting firm will more likely be financed with foreign credit than with domestic credit. One of the most distinctive features of the recent Asia crises is the foreign debt burden borne by those countries. Pomerleano (1998), for example, shows that 89 percent of the Indonesian firms' leverage as of September 1997 was foreign currency denominated. Additionally, he finds that 60 percent of the total liabilities was short-term in Asian countries.

Therefore, in this subsection we consider the case where the investment I_1 is financed with foreign currency denominated debt. Thus, if the risky project turns bad and depreciation happens, the firm needs to pay F_R^D dollars to the foreign lender, or eF_R^D in the domestic currency. The face value of the debt must then satisfy:

$$\begin{aligned} I_1 &= \frac{pF_R^D + (1-p)eF_R^D}{p + (1-p)e} \\ &\Leftrightarrow \quad I_1 = F_R^D \end{aligned}$$

Additionally, the exchange rate in case of bad outcome must be such that:

$$\begin{aligned} & e\overline{X} - I_2 - eF_R^D \\ = \quad & e\overline{X} - I_2 - eI_1 \geq 0. \end{aligned}$$

This implies that after a depreciation, the exchange rate e has to satisfy

$$e \geq \frac{I_2}{\overline{X} - I_1} = e^f$$

We show next that when firms borrow abroad, the risky project becomes selected even when $p < p^*$, the threshold value in the basic case.

Proposition 6 *There exists* $p^f = \frac{(X_s - I_1)I_2}{(X_s - I_1)I_2 - (X_s - \overline{X})(\overline{X} - I_2)} < p^*$ *such that, for* $p^f \leq p$*, the firm chooses project R and borrows in foreign currency. The currency is devalued with probability* $1 - p$ *and if the low state has occurred the exchange rate becomes*

$$e^f = \frac{I_2}{\overline{X} - I_1}. \tag{11}$$

When foreign credit is available, exporting firms prefer foreign borrowing to equity. This leads to larger depreciations, and $e^f > e^*$. So somewhat surprisingly, borrowing from abroad just exacerbates the problem. In Krugman (1999) foreign borrowing serves to magnify the effect of adverse shocks on real exchange rates. This is somewhat similar to our view, where foreign borrowing makes financial distress more costly, but through the currency depreciation such a cost is transferred to the rest of the economy. Therefore, firms gain from foreign leverage while they do not bear any of the costs. Whatever the transmission mechanism is, restrictions on foreign borrowing reduce the effect of the depreciation. In fact, as we formalize in the next Corollary, the firm will always prefer foreign debt to domestic.

Corollary 1 *When the risky project is taken, foreign debt financing is preferred to domestic debt.*

One interesting feature of the equilibrium is that the cost of debt in the presence of foreign borrowing is zero, the same as when the safe project is taken. In other words, the risky project becomes safe if it is financed abroad and depreciations are possible. This is a striking feature of our model because it implies that a currency crisis cannot be predicted on the basis of credit spreads. Radelet and Sachs (1999) argue that the Asian crisis was unexpected because lending terms did not tighten in advance of the onset of the crises. In fact, they note, rating agencies such as Standard & Poor's and Moody's dit not change the long term sovereign debt ratings for the countries in the region (exception made of the Philippines). To the extent that sovereign debt rates and corporate debt rates are positively correlated, this implies that borrowing costs for Asian firms remained stable before the crises started. We have just shown that the expectation of a depreciation leads to an increase in interest rates (as in the Mexican crisis, for example). In case exporting firms use domestic borrowing, the cost of debt increases (from equations (6) and (9) the cost of debt with domestic borrowing is $r_d = p + (1-p)\frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1} - 1 = (1-p)\frac{I_1 + I_2 - \overline{X}}{\overline{X} - (1-p)I_1} > 0$) when depreciations are possible. However, when the firm borrows abroad, the increase in domestic interest rates is offset by the increase in the face value of the foreign debt expressed in the domestic currency, since depreciations are now larger. This leaves the cost of debt unchanged for exporting firms in present value terms, and equal to the cost of debt that prevails when depreciations are not possible.

3.4 The threat of a risky and negative NPV continuation

In the previous analyses we have assumed that there is only one continuation investment and that investment has a positive NPV, i.e. that $\overline{X} - I_2 > 0$. Now we relax this assumption and show that the existence of risky, but less profitable continuation investment leads to larger currency depreciations that occur more often and also larger profits for the firm.

Assume that at $t = 1$, there is also a second possible continuation investment that yields $\overline{\overline{X}} > \overline{X}$ with probability s and 0 with probability $1 - s$, $s \in (0, 1)$. Further assume that the second investment is a negative NPV project, i.e. that $\overline{X} > I_2 > s\overline{\overline{X}}$. If this second investment

opportunity exists, the currency has to depreciate more than compared to the basic case of only one continuation investment. The reason is that previously only $e\overline{X} - I_2 - F_e^R \geq 0$ had to be satisfied in order for the positive NPV investment to take place. Now the condition for the highest NPV continuation investment to be optimal is more stringent: $e\overline{X} - I_2 - F_e^R \geq s\left(e\overline{\overline{X}} - I_2 - F_e^R\right) > 0$. If this condition is not fulfilled, investors are not willing to finance the continuation investment, since the firm would have an incentive to take the negative NPV project.

Proposition 7 *There exists p^{RC}, where $p^{RC} < p^* < \overline{p}$ such that, for $p^{RC} \leq p$, the firm chooses project R and finances it with debt. The currency is depreciated with probability $1-p$ and after the depreciation the exchange rate becomes*

$$e^{RC} = \frac{I_2 + pI_1}{\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}} > e^*$$

In this situation the firm makes excessive profits from the continuation investment. Previously, without the threat of wasting money, the condition for the second investment to be feasible was that the shareholders would break even. Now the shareholders have to be bribed into accepting the profitable safe project. This means that an even larger depreciation is needed to restore the correct incentives to invest.

3.5 Only partial real depreciation possible

3.5.1 The case of a partial real depreciation

We consider here the case when a partial real depreciation is possible. After the depreciation, domestic costs increase, but less than the amount of depreciation. After the depreciation, the continuation investment can be expressed as $\gamma e I_2 + (1-\gamma)I_2$. The interpretation of γ is either the proportion of the firm's costs denominated in foreign currency, or else the sensitivity of the firm's domestic costs to changes in the exchange rate. The case $\gamma = 0$ is the one we consider in the basic model; the case $\gamma = 1$ is considered later in this subsection.

Using the technology already developed, one can show that the condition for the risky project to be taken (and then for depreciations to happen) is:

$$X_s - I_1 \leq \frac{p\left[\overline{X} - (p + e(1-p))I_1\right] + (1-p)\left[e\overline{X} - \gamma e I_2 - (1-\gamma)I_2 - (p + e(1-p))I_1\right]}{p + e(1-p)} \qquad (12)$$

where $F = (p + e(1-p))I_1$.

We next prove the existence of a solution in which the risky project is selected.

Proposition 8 *In the case of a partial real depreciation:*

(i) The risky project is chosen, it is financed with debt, and depreciations happen with probability $(1-p)$ for $p^{PR} \leq p < \max(\overline{p}, 1-\gamma)$, where $p^{PR} = p^{PR}(\gamma)$ satisfies:

$$\frac{(1-\gamma)I_2 + p^{PR}I_1}{\overline{X} - \gamma I_2 - (1-p^{PR})I_1} = \frac{p^{PR}(\overline{X} - X_s) - (1-p^{PR})(1-\gamma)I_2}{(1-p^{PR})(X_s - \overline{X} + \gamma I_2)}$$

Moreover, p^{PR} *is increasing in* γ, $p^{PR}(0) = p^*$, $p^{PR}(1) = p^R = 1 - \frac{(\overline{R}-I_2)(\overline{R}-R_s)}{I_1 I_2}$, *and the optimal depreciation satisfies:*

$$e^{PR} = \frac{(1-\gamma)I_2 + pI_1}{\overline{X} - \gamma I_2 - (1-p)I_1}$$

(ii) The risky project is taken and it is financed with equity for $\max(\overline{p}, 1-\gamma) \leq p \leq 1$
(iii) Otherwise, the safe project is optimal and the firm is indifferent between debt and equity.

A partial real depreciation happens with probability $(1-p)$ and induces the firm to take the risky project (debt financed) in cases where $p^{PR} < p < \overline{p}$, that is, when the safe project has a greater NPV. The situation of an undesirable depreciation happens for low levels of γ. Similarly, when the risky project is optimal ($p > \overline{p}$) the firm chooses either debt (after a depreciation) or equity depending on whether p is lower or higher than $1-\gamma$. Figure 2 shows that there exists a region of inefficient depreciation: if γ is such that $p^{PR} < \overline{p}$, and $p^{PR} < p < \overline{p}$, the currency is devalued and the risky project is selected, but the safe project has a greater NPV. When $\overline{p} < p < 1$, the risky project is selected, being its NPV larger. The firm finances the risky project with debt in this case when $\overline{p} < p < 1-\gamma$, and uses equity otherwise.

[Insert Figure 2]

Finally, when inputs prices partially adjust to depreciations, depreciations need to be larger in order for firms to prefer continuation if the low state happens. Therefore, the domestic interest rate is also larger.

Corollary 2 *The equilibrium exchange rate* e^{PR} *that prevails after a depreciation is increasing in* γ.

The previous result, together with Lemma 1, implies that firm's profits are a decreasing function of the proportion that I_2 is denominated in the domestic currency, given that is optimal for the firm to choose the risky project and finance it with debt. This means that the firm prefers to import a proportion of its investment input. The intuition is exactly like with foreign borrowing: if a proportion of investment costs are denominated in dollars or otherwise adjust fully to a currency depreciation, a very large depreciation is needed to restore the incentive to take the continuation investment. From Lemma 1, we know that firm's profits are an increasing function of e, given that the risky investment is taken and it is financed with debt.

3.5.2 Domestic prices adjust fully to a depreciation

We consider here the case of a firm that will have to pay eI_2 to continue operations at $t = 2$ if the currency is devalued. So domestic costs fully adjust to the depreciation at once and depreciation of the real exchange rate is not possible at all. This is just an special case of the more general situation considered in the previous subsection. When this is the case, the value of the risky project when it is financed with debt becomes:

$$V_{R,e}^{D} = \frac{p\left[\overline{X} - (p + (1-p)e)\, I_1\right] + (1-p)\left[e(\overline{X} - I_2) - (p + (1-p)e)I_1\right]}{p + (1-p)e}$$

since the face value of the debt does not change with respect to the original case. The following result indicates that in this case depreciations do not happen.

Proposition 9 *If domestic costs fully adjust to the depreciation, then the risky project is taken, and it is financed with equity when $p \geq \overline{p}$. Otherwise the firm selects the safe project*

That is, and as shown in Figure 2, increasing γ (reducing partial real depreciation), *ceteris paribus* increases firm's profits to the extent that the firms chooses the risky project and finances it with debt. At some point profits start declining (whenever γ becomes $\gamma > \min[p^{PR}(\gamma), 1-p]$), and the firm prefers equity financing. The highest-NPV project is then selected. Proposition 9 describes the particular case of $\gamma = 1$.

3.6 Discussion and limitations

In most cases, countries try to defend their currencies when the pegged exchange rate is experiencing a speculative attack. In our model this does not make sense: currency depreciation is always ex-post optimal and a rational government would always let the peg go without any resistance. This limitation in our model is due to the two-period structure of the model. In a proper multi-period framework a government could care about its reputation. It would realize that acting ex-post optimally does not always lead to ex-ante desirable outcomes. Thus a government could try to foster a tough reputation by not letting its currency depreciate in order to give exporting companies incentives to invest efficiently in the first place. Our model points out to the difficulties of enhancing such tough reputations.

Moreover, governments usually defend their currencies by raising interest rates. According to our model, this only makes the situation worse for the highly leveraged companies. After increased interest rates, the debt overhang problem is even more severe for the exporting companies and the afflicted government would have an even greater incentive to let the currency depreciate. Thus high interest rates imposed by the government would be highly counterproductive. A more efficient way of defending a pegged exchange rate would be to impose restrictions on short-term capital flows.

Currency speculation would have a similar effect in our model than increased interest rates. Assume that there is a positive probability q, $q \in (0,1)$ of a speculative attack against the currency. A speculative attack could be self-fulfilling in the following way: assume that there is no debt overhang problem before the speculative attack, i.e. $\overline{R} - I_2 - F > 0$. With speculation, the new discount rate would be $qe + (1-q)$, if the attack is expected to be successful. With some parameter values we would indeed get a debt overhang problem, i.e. $\frac{\overline{R} - I_2}{qe + (1-q)} - F < 0$ and the speculative attack would succeed hence justifying the higher discount rate in the first place.

A further limitation in our paper is that we only model the behavior of exporting firms. We could introduce a fully domestic non-tradable sector, whose firms would produce intermediate goods for the exporting sector. In our context that would mean explicitly modelling the firms that produce the investment inputs I_1 and I_2. Those firms would have their own capital structures.

Our results would not change if these firms were financed by equity or domestic credit: a currency depreciation would not create problems for the non-tradable sector. However, if these firms used debt denominated in foreign currency, a currency depreciation could create a debt overhang problem for these firms. Our model can be understood as benchmark case: even if we ignore all the costs that a currency depreciation imposes to the non-tradable sector, depreciations can still be very problematic, since they could lead to excessive investments in risky projects.

4 Empirical Implications

Our model establishes a causal relationship between exporting firms' capital structure and exchange rate policy. We have shown that, if depreciations are possible, firms will engage in debt-financed, risky projects that, in case of financial distress, make a depreciation ex-post optimal for the government. Knowing that, the government would like to commit not to devalue. The model predictions can be summarized as follows:

1. Exporting firms will display increasing leverage prior to currency crises in countries with fixed exchange rates. Leverage increases in our model increase the probability of a depreciation. Note that the causality implied by our model does not imply that leverage increases are always early warnings of currency crises, since the extent of the crisis depends on the riskiness of the projects that are debt-financed. Pomerleano (1999), and Corsetti et al. (1998a) document leverage increases preceding the Asian crises of 1997.

2. Common currencies and currency boards induce leverage reductions. Cross–sectionally, these reductions are larger for export-oriented firms. The previous result implies as well that the riskiness of exporting firm's cash flows, and therefore the firm's beta, decrease after the introduction of either the common currency or the currency board.

3. Focusing on economies with fixed exchange rate regimes, our model implies that we should observe higher leverage in export industries compared to domestic industries (once other factors such as size and profitability have been controlled for), in small export-oriented countries. Across countries, we provide an explanation why leverage tends to be higher in small export-oriented countries compared to large countries (controlling for industry). For example, we should observe that Finnish paper and pulp industry displays higher debt levels when compared to Canadian or US firms in the same industry. Pomerleano (1999) supports that prediction with a sample of countries that have suffered a currency crisis.

4. Decreases in firm profitability are an early warning of currency problems. Similarly, the model implies that small, export-oriented countries that suffer depreciations display declining profitability prior to the depreciation. This implication is in line with the evidence in Pomerleano (1998) and Harvey and Roper (1999). Additionally the model predicts that dividends increase or stay the same even if profitability decreases for the exporting firms prior to a currency crisis.

5. Underdeveloped equity markets and hence a forced reliance on debt financing increases the probability and magnitude of depreciations. This implication is consistent with the evidence provided by Johnson et. al. (2000).

6. If borrowing is in foreign currency, credit spreads for exporting companies in the country that is likely to face a currency crisis, should not increase.

7. The model finally provides some policy implications, namely that abolishing capital controls (by decreasing the costs of borrowing from abroad) may increase the magnitude and likelihood of depreciations. The reason is that, as shown in In Section 3.3, foreign borrowing by large exporting firms induces larger depreciations under fixed exchange rates[8]. Corsetti et al. (1998b) discuss the effects of restrictions on short-term inflows on the magnitude of a crisis, and refer to the experiences of Chile, Colombia and Slovenia in support of our view. However, Krugman (1999) argues that restrictions on foreign-currency debt may not be sufficient if other forms of capital flight are still possible. On the empirical side, Kaminsky and Reinhart (1996) report that banking crises help in predicting balance-of-payment crises, and that banking crises are preceded by lending booms fueled by capital inflows and financial liberalization.

5 Conclusions

The countries that have recently experienced currency depreciations have been export-oriented ones with large exporting firms. This paper has provided a framework to analyze the reasons for depreciations for such countries. The argument is based on depreciations being ex-post optimal for the economies in question. After experiencing negative shocks exporting firms have profitable investment opportunities, but they will not invest because of very high debt levels. The government can solve these debt overhang problems and make investments feasible, since depreciation of the currency increases the profitability of new investments when revenues are in a foreign currency and costs of the new investment are in domestic. Although currency depreciation is ex-post optimal, it can have adverse ex-ante consequences. Exporting firms know that the government will let the currency depreciate, if their risky investments have failed, provided that investments have been financed with debt. This leads to excessive investment in risky projects and high leverage at the expense of more valuable safe projects and equity financing. Knowing this, the government would like to commit not to let the currency depreciate, whenever the costs of depreciation to the society are greater than the private gains of depreciation to the exporting firms. Foreign borrowing by exporting firms only exacerbates the problem. If firms' existing debt is denominated in a foreign currency, a larger depreciation is needed to restore incentives to invest. Moreover, when foreign credit is available, firms prefer that to domestic credit.

Letting the currency depreciate is also ex-ante optimal if the risky projects have a higher NPV than the safe projects and if the equity markets are underdeveloped. With underdeveloped equity markets firms are forced to rely on debt financing. This leads to involuntary debt overhang problems that can be avoided by letting the currency depreciate. Excessive reliance on debt financing could imply that either exporting firms are gambling at the expense of others or that they are severely equity rationed. Thus, for emerging markets, a permanently fixed exchange rate coupled with underdeveloped equity markets would be a dangerous combination. It is then of utmost importance for emerging markets to try to improve the functioning of equity markets trough changes in corporate governance and minority shareholder protection.

[8]This implication does not hold if domestic financial markets are not competitive. With non-competitive domestic financial markets, foreign borrowing could imply a decrease in real interest rate, and thus the safe project would become relatively more advantageous for the exporting firms.

It has been argued (see Giavazzi and Pagano (1988)), that a system like the European Monetary System increases the credibility of governments' policies toward achieving price stability. However, the increased costs of depreciations have not been enough to deter governments from letting their currencies depreciate: the incentives to devalue can be very strong indeed. In our framework, it is not surprising that fixed exchange rate regimes have proved to be so untenable, especially coupled with free capital mobility. If governments of small exporting countries really want to commit not to devalue, then the credible solutions are either adopting a common currency like the Euro or a complete dollarization of the economy. It has been argued that adopting a common currency can be dangerous because of asymmetric shocks. According to our model, it is because of such shocks that a small country should adopt a common currency. Like in all moral hazard problems, providing insurance (through depreciations in our model) increases the need for insurance. The firms' investment strategies are not exogenous. When depreciations are impossible, there will be less need for depreciations.

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6 Appendix

Proof of Proposition 1

Suppose the case with debt financing. If debtholders expect the company to take the safe project, they will offer a debt contract that promises I_1 at $t = 1$. Therefore, the value of the equity with the safe project will be:

$$V_S^D = X_s - I_1 = V_S^E$$

that is, the firm is indifferent between debt and equity. However, the firm may have an incentive to cheat and take the risky project when:

$$V_S^D < V_R^D = p\left[\overline{X} - I_1\right]$$

This happens whenever $p > \widehat{p} = \frac{X_s - I_1}{\overline{X} - I_1}$. Note that, since $\overline{X} - I_1 - I_2 < 0$, $\widehat{p} < \overline{p}$. Therefore, for $p < \widehat{p}$, the firm takes the safe project and it is indifferent between debt and equity. For $p > \widehat{p}$, debtholders will be aware of the firm's incentives to cheat and will require a face value $\frac{I_1}{p}$, in which case the safe project is preferred, since :

$$p\left[\overline{X} - \frac{I_1}{p}\right] < X_s - I_1$$

by assumption.

Finally, we have to prove that, when the firm is offered the contract $\frac{I_1}{p}$, it is not willing to cheat and take the safe project. Cheating will never be an equilibrium if the following holds:

$$p\left[\overline{X} - \frac{I_1}{p}\right] > X_s - \frac{I_1}{p}$$

as long as $X_s - \frac{I_1}{p} > 0$, or $p > \frac{I_1}{X_s}$

or if

$$p^2\overline{X} - p(X_s + I_1) + I_1 > 0$$

Therefore, the firm will cheat (take the safe project when it is offered $\frac{I_1}{p}$), for $p_l < p < p_h$, where p_l and p_h are the two roots of the previous square function. It is straightforward to show that $\frac{I_1}{X_s} < p_l$. Hence for $p \in [\widehat{p}, \min(p_h, \overline{p})]$, the debt market breaks down: if offered $\frac{I_1}{p}$ (face value corresponding to the risky project) the firm takes the safe project; if offered I_1 (face value corresponding to the safe project) the firm takes the risky project. Hence the project can only be financed with equity. Proof of Lemma 1

The value of the firm's equity when the risky project is taken, it is financed with debt, and depreciations may happen is:

$$V_{R,e}^D = \frac{p\left[\overline{X} - (p + (1-p)e)\, I_1\right] + (1-p)\left[e\overline{X} - I_2 - (p + (1-p)e)I_1\right]}{p + (1-p)e}$$

Differentiating with respect to e, we obtain:

$$\frac{\partial}{\partial e}V_{R,e}^{D} = \frac{-(1-p)pI_1 + (1-p)\left(\overline{X} - (1-p)I_1\right)}{p+(1-p)e} - \frac{(1-p)\left[p\left(\overline{X} - (p+(1-p)e)\,I_1\right) + (1-p)\left(e\overline{X} - I_2 - (p+(1-p)e)\,I_1\right)\right]}{\left[p+(1-p)e\right]^2}$$

which equals:

$$\frac{\partial}{\partial e}V_{R,e}^{D} = \frac{(1-p)^2 I_2}{\left[p+(1-p)e\right]^2} > 0$$

Proof of Proposition 2

Project R is optimal if $V_{R,e}^{D} > V_{S}^{E}$, that is, if:

$$\frac{p\left[\overline{X} - (p+(1-p)e)\,I_1\right] + (1-p)\left[e\overline{X} - I_2 - (p+(1-p)e)I_1\right]}{p+(1-p)e} > X_s - I_1$$

which is equivalent to:

$$p\overline{X} + (1-p)\left[e\overline{X} - I_2\right] > (p+(1-p)e)X_s \tag{13}$$

Let us define e' from the previous expression as:

$$p\overline{X} + (1-p)\left[e'\overline{X} - I_2\right] = (p+(1-p)e')X_s$$

Since $\overline{X} > X_s$, (13) holds for $e > e'$. Solving for e' we obtain:

$$e' = \frac{p(X_s - \overline{X}) + (1-p)I_2}{(1-p)(\overline{X} - X_s)} \tag{14}$$

Additionally, for R to be an optimal choice, we need (4) to be satisfied, which requires $e > e^*$. Let us then define p^* as the value of p such that $e^*(p^*) = e'(p^*)$. Hence:

$$\frac{p^*(X_s - \overline{X}) + (1-p^*)I_2}{(1-p^*)(\overline{X} - X_s)} = \frac{I_2 + I_1 p^*}{\overline{X} - (1-p^*)I_1} \tag{15}$$

Note that $e'(p)$ is continuous in p for $0 \leq p \leq 1$, $\frac{\partial e'}{\partial p} < 0$, $e'(0) > 0$ and $\lim_{p \to 1} e' = -\infty$. Additionally, $e^*(p)$ is continuous in p for $0 \leq p \leq 1$, $\frac{\partial e^*}{\partial p} < 0$, $e^*(0) < e'(0)$ and $e^*(1) > 0$. Hence, $p^* \in [0,1]$ and $e^*(p) - e'(p) > 0$ for $p > p^*$. Therefore, for $p^* < \overline{p}$, it has to be $e^*(\overline{p}) - e'(\overline{p}) > 0$.

$$\begin{aligned} & e^*(\overline{p}) - e'(\overline{p}) \\ = & \frac{I_2 + I_1 \frac{X_s - \overline{X} + I_2}{I_2}}{\overline{X} - (1 - \frac{X_s - \overline{X} + I_2}{I_2}) I_1} - \frac{\frac{X_s - \overline{X} + I_2}{I_2}(X_s - \overline{X}) + (1 - \frac{X_s - \overline{X} + I_2}{I_2}) I_2}{(1 - \frac{X_s - \overline{X} + I_2}{I_2})(\overline{X} - X_s)} \\ = & \frac{I_2 + I_1 \frac{X_s - \overline{X} + I_2}{I_2}}{\overline{X} - (1 - \frac{X_s - \overline{X} + I_2}{I_2}) I_1} - 1 \end{aligned}$$

using the definition of $\overline{p}$. This is positive since:

$$I_2 + I_1 \frac{X_s - \overline{X} + I_2}{I_2} > \overline{X} - (1 - \frac{X_s - \overline{X} + I_2}{I_2}) I_1.$$

To see that, note that the last expression is equivalent to:

$$\begin{aligned} & \frac{I_2 (I_1 - \overline{X} + I_2)}{I_2} > 0 \\ \Leftrightarrow & (I_2 - \overline{X} + I_1) > 0 \end{aligned}$$

by assumption. To ensure continuity, the optimal $e = e^*$.

Next, we need to prove that $F_e^R < \overline{X}$. In equilibrium, for $p^* < p \leq 1$, $F_e^R = [p + (1-p)e^*] I_1$, and substituting the value of e^* from (8), the condition that must be satisfied becomes:

$$\overline{X} > \left[p + (1-p) \frac{I_2 + I_1 p}{\overline{X} - (1-p) I_1} \right] I_1$$

or $p > \frac{\overline{X} I_1 - \overline{X}^2 + I_1 I_2}{I_1 I_2} = p^{**}$. Hence, to prove that, in equilibrium, $F_R^D < \overline{X}$, it suffices to prove that $p^{**} < p^*$. A sufficient condition for that is $e^*(p^{**}) - e'(p^{**}) < 0$, where e^* and e' come respectively from (8) and (13). Substituting p^{**} into (13), yields:

$$e'(p^{**}) = \frac{I_2}{\overline{X} - X_s} - \frac{\overline{X} + I_2 - \frac{\overline{X}^2}{I_1}}{\frac{\overline{X}^2}{I_1} - \overline{X}}$$

Also:

$$\begin{aligned} e^*(p^{**}) &= \frac{I_2 + \frac{\overline{X} I_1 + I_1 I_2 - \overline{X}^2}{I_2}}{\overline{X} - \frac{\frac{\overline{X}^2}{I_1} - \overline{X}}{I_2}} \\ &= \frac{I_2^2 + \overline{X} I_1 + I_1 I_2 - \overline{X}^2}{\overline{X}(I_2 - \overline{X} + I_1)} \\ &= \frac{\overline{X} + I_2}{\overline{X}} \end{aligned}$$

Hence:

$$\begin{aligned} & e^*(p^{**}) - e'(p^{**}) \\ = \quad & \frac{\overline{X}+I_2}{\overline{X}} - \frac{I_2}{\overline{X}-X_s} + \frac{\overline{X}+I_2-\frac{\overline{X}^2}{I_1}}{\frac{\overline{X}^2}{I_1}-\overline{X}} \end{aligned}$$

Rearranging terms yields:

$$\begin{aligned} & e^*(p^{**}) - e'(p^{**}) \\ = \quad & -\frac{I_2(X_s+I_1)}{(\overline{X}-I_1)(\overline{X}-X_s)} < 0 \end{aligned}$$

Finally, we need to prove that $V^D_{R,e} > V^E_R$. This derives directly from Lemma 1.

Proof of Proposition 3

In the proof for Proposition 2 it was shown that the face value of debt $F^R_e \leq \overline{X}$, if $p \geq \frac{\overline{X}I_1-\overline{X}^2+I_1I_2}{I_1I_2} = p^{**}$. Project R is optimal if $V^D_{R,e}(\overline{X}) > V^E_S$, where $V^D_{R,e}(\overline{X})$ denotes the value of the firm's equity when the risky project is chosen, and it is financed with debt $\overline{X}$. Hence:

$$\frac{p\left[\overline{X}-\overline{X}\right]+(1-p)\left[e\overline{X}-I_2-\overline{X}\right]}{p+(1-p)e} + \left[\frac{\overline{X}}{p+(1-p)e} - I_1\right] > X_s - I_1 \tag{16}$$

which is equivalent to:

$$p\overline{X} + (1-p)\left[e\overline{X}-I_2\right] > (p+(1-p)e)X_s \tag{17}$$

Let us define e' from the previous expression as:

$$p\overline{X} + (1-p)\left[e'\overline{X}-I_2\right] = (p+(1-p)e')X_s \tag{18}$$

Since $\overline{X} > X_s$, (18) holds for $e > e'$. Solving for e' we obtain:

$$e' = \frac{p(X_s-\overline{X})+(1-p)I_2}{(1-p)(\overline{X}-X_s)} \tag{19}$$

In order for the R to be the optimal choice, we need that $e \geq e^* > e'$. Hence

$$\frac{\overline{X}+I_2}{\overline{X}} > \frac{p(X_s-\overline{X})+(1-p)I_2}{(1-p)(\overline{X}-X_s)}.$$

This simplifies to be

$$\overline{X}^2 - X_s - X_sI_2 > p\left(\overline{X}^2 - X_s - X_sI_2\right),$$

which holds for any $p < 1$.

Additionally, $p^{**} < p^*$ from the proof of Proposition 2.

Secondly, we need to prove that $V^D_{R,e} > V^E_R$ in this case. From (16):

$$\begin{aligned} V^D_{R,e} - V^E_R &= \frac{p\left[\overline{X} - \overline{X}\right] + (1-p)\left[e^{**}\overline{X} - I_2 - \overline{X}\right]}{p + (1-p)e^{**}} + \left[\frac{\overline{X}}{p + (1-p)e^{**}} - I_1\right] \\ & \quad -p\overline{X} + (1-p)(\overline{X} - I_2) \\ &= -(1-p)^2 \frac{I_2(1-e^{**})}{p + (1-p)e^{**}} > 0 \end{aligned}$$

since $e^{**} > 1$.

Finally, for excess borrowing to be optimal, we need to show that $V^D_{R,e^{**}}(\overline{X}) > V^D_{R,e^*}$. Note that:

$$\begin{aligned} V^D_{R,e^{**}}(\overline{X}) &= \overline{X} - I_1 - \frac{(1-p)I_2}{p + (1-p)e^{**}} \\ V^D_{R,e^*} &= \overline{X} - I_1 - \frac{(1-p)I_2}{p + (1-p)e^*} \end{aligned}$$

Therefore it suffices to show that $e^{**} > e^*$. That is:

$$\begin{aligned} \frac{\overline{X} + I_2}{\overline{X}} &> \frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1} \\ \iff \overline{X}^2 - I_1\overline{X} - (1-p)I_1 I_2 &> 0 \end{aligned}$$

since, using $I_2 < \overline{X}$,

$$\begin{aligned} \overline{X}^2 - I_1\overline{X} - (1-p)I_1 I_2 &> \overline{X}^2 - I_1\overline{X} - (1-p)\overline{X}I_1 \\ &= \overline{X}(\overline{X} + pI_1) > 0 \end{aligned}$$

Proof of Proposition 4

$V^D_S = X_s - I_1 < V^D_R = p\overline{X} - I_1 \Rightarrow p > \frac{X_s}{\overline{X}}$

Proof of Proposition 5

Assume for now that the following conjecture holds: face value of debt is I_1 and the firm promises to invest in the safe project S. It is optimal for the firm to cheat if $V^D_{R,e} > V^D_S$, that is,

$$\frac{p\left[\overline{X} - I_1\right] + (1-p)\left[e\overline{X} - I_2 - I_1\right]}{p + (1-p)e} > X_s - I_1$$

which is equivalent to:

$$(1-p)e\left[\overline{X} + I_1 - X_s\right] > p\left(X_s - \overline{X}\right) + (1-p)\left(I_1 + I_2\right) \tag{20}$$

Let us define e'' from the previous expression as:

$$(1-p)e''\left[\overline{X}+I_1-X_s\right] > p\left(X_s-\overline{X}\right)+(1-p)\left(I_1+I_2\right) \tag{21}$$

Since $\overline{X}+I_1-X_s>0$, (21) holds for $e>e''$. Solving for e'' we obtain:

$$e''=\frac{p(X_s-\overline{X})+(1-p)\left(I_1+I_2\right)}{(1-p)(\overline{X}+I_1-X_s)} \tag{22}$$

With the face value of debt $F=I_1$, the depreciation has to satisfy

$$e\overline{X}-I_1-I_2\geq 0,$$

hence the exchange rate after depreciation is

$$e^*=\frac{I_1+I_2}{\overline{X}}$$

In order for R to be chosen, we need that $e\geq e^*>e''$.Hence

$$\frac{I_1+I_2}{\overline{X}} > \frac{p(X_s-\overline{X})+(1-p)\left(I_1+I_2\right)}{(1-p)(\overline{X}+I_1-X_s)} \tag{23}$$

This is equivalent to

$$p>\frac{\left(X_s-I_1\right)\left(I_1+I_2\right)}{\overline{X}\left(\overline{X}-X_s\right)+\left(X_s-I_1\right)\left(I_1+I_2\right)}=p^{***}$$

From (23), p^{***} satisfies

$$e^*(0)=\frac{I_1+I_2}{\overline{X}}=\frac{p^{***}(X_s-\overline{X})+(1-p^{***})\left(I_1+I_2\right)}{(1-p^{***})(\overline{X}+I_1-X_s)}=\widetilde{e}(p^{***}) \tag{24}$$

Additionally, and from the previous expression together with (13), clearly $\widetilde{e}(p)<e'(p)\ \forall p\in[0,1]$. Let $\widetilde{p}$ be such that $e'(\widetilde{p})=e^*(0)$. Therefore $e'(\widetilde{p})=e^*(0)>e^*(p)=e'(p^*)$ because $e^*(p)$ is decreasing in p from Proposition 2. Hence $\widetilde{p}<p^*$ and from (24) and the definition of $\widetilde{p}$, $p^{***}<\widetilde{p}<p^{**}$.

From Proposition 2, $p^{**}<p^*$. Hence, the firm will deviate and take the risky project for $\max[p^{**},p^{***}]\leq p\leq\overline{p}$, and the face value cannot be I_1.

We finally need to check that the firm takes the risky project whenever the face value of the debt equals $I_1[p+(1-p)e]$. This is equivalent to:

$$\begin{aligned}\frac{p\left[\overline{X}-\left(p+(1-p)e\right)I_1\right]+(1-p)\left[e\overline{X}-I_2-\left(p+(1-p)e\right)I_1\right]}{p+(1-p)e}\\ >X_s-\left(p+(1-p)e\right)I_1\end{aligned}$$

or, equivalently:

$$\frac{p\overline{X} + \left[(1-p)e\overline{X} - I_2\right] - (p + (1-p)e)\, I_1}{p + (1-p)e} > X_s - (p + (1-p)e)\, I_1$$

Note that the left hand side of the previous expression is decreasing in p, and the right hand side is increasing in p. Therefore, it suffices to show the result for $p = p^*$. For $p = p^*$, and from the definition of (13) and (8),

$$\begin{aligned} \frac{p^*\overline{X} + \left[(1-p^*)e\overline{X} - I_2\right] - (p^* + (1-p^*)e)\, I_1}{p^* + (1-p^*)e} &= X_s - I_1 \\ &> X_s - (p^* + (1-p^*)e)\, I_1 \end{aligned}$$

Therefore, $F_R^D = I_1[p + (1-p)e^*]$ and the optimal depreciation is

$$e^* = \frac{I_2 + I_1 p}{\overline{X} - (1-p)I_1}$$

Proof of Proposition 6

Project R is optimal if $V_{R,e}^{D,f} > V_S^E$, that is, if:

$$\frac{p\left[\overline{X} - I_1\right] + (1-p)\left[e\overline{X} - I_2 - eI_1\right]}{p + (1-p)e} > X_s - I_1$$

which is equivalent to:

$$p\overline{X} + (1-p)\left[e\overline{X} - I_2\right] > (p + (1-p)e)X_s \tag{25}$$

Let us define e' from the previous expression as:

$$p\overline{X} + (1-p)\left[e'\overline{X} - I_2\right] = (p + (1-p)e')X_s$$

Since $\overline{X} > X_s$, (25) holds for $e > e'$. Solving for e' we obtain:

$$e' = \frac{p(X_s - \overline{X}) + (1-p)I_2}{(1-p)(\overline{X} - X_s)} \tag{26}$$

In order for the R to be the optimal choice, we need that $e \geq e^f > e'$. Hence

$$\frac{I_2}{\overline{X} - I_1} > \frac{p(X_s - \overline{X}) + (1-p)I_2}{(1-p)(\overline{X} - X_s)},$$

which holds for any p such that

$$p > \frac{(X_s - I_1)\, I_2}{(X_s - I_1)\, I_2 - \left(X_s - \overline{X}\right)\left(\overline{X} - I_2\right)} = p^f. \tag{27}$$

Now we have to show that $p^f < p^*$. First note that $\frac{I_2+I_1 p}{\overline{X}-(1-p)I_1}$ is decreasing in p. Hence, from (15):

$$\begin{aligned}\frac{p^*(X_s-\overline{X})+(1-p^*)I_2}{(1-p^*)(\overline{X}-X_s)} &= \frac{I_2+I_1 p^*}{\overline{X}-(1-p^*)I_1} \\ &< \frac{I_2}{\overline{X}-I_1} = \frac{p^f(X_s-\overline{X})+(1-p^f)I_2}{(1-p^f)(\overline{X}-X_s)}\end{aligned}$$

and, since $\frac{p(X_s-\overline{X})+(1-p)I_2}{(1-p)(\overline{X}-X_s)}$is decreasing in p, it follows that $p^f < p^* < \overline{p}$.

Finally we have to show that the firm prefers foreign borrowing to domestic. Foreign borrowing is optimal if

$$\frac{p\left[\overline{X}-I_1\right]+(1-p)\left[e^f\overline{X}-I_2-e^f I_1\right]}{p+(1-p)e^f} >$$
$$\frac{p\left[\overline{X}-(p+(1-p)e)\,I_1\right]+(1-p)\left[e\overline{X}-I_2-(p+(1-p)e)I_1\right]}{p+(1-p)e},$$

which is equivalent to

$$\frac{p\overline{X}+(1-p)\left[e^f\overline{X}-I_2\right]}{p+(1-p)e^f} > \frac{p\overline{X}+(1-p)\left[e\overline{X}-I_2\right]}{p+(1-p)e}.$$

This simplifies to be

$$p\,(1-p)\left(e^f-e\right)\overline{X} > p\,(1-p)\left(e^f-e\right)\left(\overline{X}-I_2\right),$$

or $\overline{X} > \overline{X}-I_2$

Proof of Corollary 1

From Proposition 6, $V_{R,e^f}^{D,f} = \frac{p\left[\overline{X}-I_1\right]+(1-p)\left[e^f\overline{X}-I_2-e^f I_1\right]}{p+(1-p)e^f}$,where e^fcomes from (11). Clearly, $V_{R,e}^{D,f}$ is increasing in e^f, since:

$$\frac{\partial V_{R,e^f}^{D,f}}{\partial e^f} = \frac{(1-p)e^f\left[\overline{X}-I_1\right]}{p+(1-p)e^f} - \frac{(1-p)I_2}{p+(1-p)e^f} > 0$$

Using $e^f > e^*$ from (8):

$$\begin{aligned}V_{R,e^f}^{D,f} &> V_{R,e}^{D,f} \\ &= \frac{p\left[\overline{X}-I_1\right]+(1-p)\left[e\overline{X}-I_2-eI_1\right]}{p+(1-p)e} \\ &= \frac{p\left[\overline{X}-(p+(1-p)e)\,I_1\right]+(1-p)\left[e\overline{X}-I_2-(p+(1-p)e)I_1\right]}{p+(1-p)e} \\ &= V_{R,e}^{D}\end{aligned}$$

Proof of Proposition 7

The optimal depreciation is in this case:

$$e^{RC} = \frac{I_2 + pI_1}{\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}}$$

And $e^{***} = e^*$ if $s = 0$.
Differentiating with respect to p:

$$\begin{aligned}\frac{\partial e^{RC}}{\partial p} &= \frac{I_1\left[\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}\right] - I_1\left(I_2 + pI_1\right)}{\left[\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}\right]^2} \\ &= \frac{I_1}{\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}}(1 - e^{RC}) < 0\end{aligned}$$

because $e^{RC} > 1$.
Differentiating now with respect to s, yields:

$$\frac{\partial e^{RC}}{\partial s} = \frac{\frac{\overline{\overline{X}} - \overline{X}}{(1-s)^2}\left(I_2 + pI_1\right)}{\left[\overline{X} - (1-p)I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}\right]^2} > 0$$

which implies $e^{***} > e^*$.
Finally, let us define p^{RC} as the probability of the risky project succeeding such that:

$$\frac{I_2 + p^{RC}I_1}{\overline{X} - (1-p^{RC})I_1 - \frac{s(\overline{\overline{X}} - \overline{X})}{1-s}} - \frac{p^{RC}(X_s - \overline{X}) + (1-p^{RC})I_2}{(1-p^R)(\overline{X} - X_s)} = 0 \tag{28}$$

or $e^{RC}(p^{RC}) - e'(p^{RC}) = 0$,where e' comes from (14).

Therefore, the risky project is taken, it is financed with debt, and the currency is devalued, for $p > p^{RC}$. The first term in (28). Hence, $e^{RC} - e'$ is increasing in p (using Proposition 2), and increasing in s. Therefore, $p^{RC} < p^*$. Finally, since $e^{RC} > e^*$, $e\overline{X} - I_1 - F_e^R > 0$.

Proof of Proposition 8

Suppose $X_s - \overline{X} + \gamma I_2 \leq 0$. This implies that $\gamma \leq \frac{\overline{X} - X_s}{I_2}$, and the risky project is preferred if:

$$e \geq \frac{p(\overline{X} - X_s) - (1-p)(1-\gamma)I_2}{(1-p)(X_s - \overline{X} + \gamma I_2)} = e''$$

Note that, in this case:

$$\begin{aligned} & p(\overline{X} - X_s) - (1-p)(1-\gamma)I_2 \\ \leq \; & p(\overline{X} - X_s) - (1-p)(I_2 - \overline{X} + X_s) \\ < \; & -(1-p)(\overline{X} - I_2) - (1-p)(I_2 - \overline{X}) = 0 \end{aligned}$$

using the fact that $\gamma \leq \frac{\overline{X} - X_s}{I_2}$and the stated parameter assumption.Therefore $e'' > 0$

Additionally, the optimal depreciation must satisfy:

$$e\overline{X} - \gamma e I_2 - (1-\gamma)I_2 - (p + (1-p)e)I_1 \geq 0$$

which is equivalent to:

$$e \geq \frac{(1-\gamma)I_2 + pI_1}{\overline{X} - \gamma I_2 - (1-p)I_1} = e^{PR}$$

Then, for R to be preferred with depreciation, it has to be true that $e^{PR} \geq e''$, which implies:

$$\frac{(1-\gamma)I_2 + pI_1}{\overline{X} - \gamma I_2 - (1-p)I_1} \geq \frac{p(\overline{X} - X_s) - (1-p)(1-\gamma)I_2}{(1-p)(X_s - \overline{X} + \gamma I_2)}$$

Let p^{PR} be such that $e^{PR}(p^{PR}) - e'(p^{PR}) = 0$. Solving for γas a function of p^{PR}, yields:

$$\gamma = \frac{I_1 I_2 (1-p^{PR})^2 - I_2 X_s (1-p) + \overline{X} p(\overline{X} - X_s)}{I_2 \left[X_s - (1-p)I_1 - p\overline{X}\right]}$$

And from this expression, $\frac{\partial p^{PR}}{\partial \gamma} \geq 0, \forall \gamma \in [0,1]$.

Therefore, for project R to be optimal, it has to be $p \geq p^{PR}$, from Proposition 2. It is easy to prove that, $e^{PR}(p,\gamma) - e'(p,\gamma)$ is decreasing in γ. Besides, it is increasing in p. Hence $\frac{\partial p^{PR}}{\partial \gamma} \geq 0$ which implies $p^{PR} \geq p^*$.

Suppose instead that $X_s - \overline{X} + \gamma I_2 > 0$.This implies that $\gamma > \frac{\overline{X} - X_s}{I_2}$, and the risky project is preferred if:

$$e < \frac{p(\overline{X} - X_s) - (1-p)(1-\gamma)I_2}{(1-p)(X_s - \overline{X} + \gamma I_2)} = e''$$

Additionally, the optimal depreciation must satisfy:

$$e\overline{X} - \gamma e I_2 - (1-\gamma)I_2 - (p + (1-p)e)I_1 \geq 0$$

which is equivalent to:

$$e \geq \frac{(1-\gamma)I_2 + pI_1}{\overline{X} - \gamma I_2 - (1-p)I_1} = e^{PR} \tag{29}$$

Then, for R to be preferred with depreciation, it has to be true that $e^{PR} < e''$, which implies:

$$\frac{(1-\gamma)I_2 + pI_1}{\overline{X} - \gamma I_2 - (1-p)I_1} < \frac{p(\overline{X} - X_s) - (1-p)(1-\gamma)I_2}{(1-p)(X_s - \overline{X} + \gamma I_2)}$$

Let p^{PR} be such that $e^{PR}(p^{PR}) - e'(p^{PR}) = 0$. For project R to be optimal, it has to be $p \geq p^{PR}$, from Proposition 2. Using $X_s - \overline{X} + \gamma I_2 < 0$,results $e^{PR}(p) - e'(p)$ decreasing in p, and $\frac{\partial p^{PR}}{\partial \gamma} > 0$.Therefore, the risky project is taken for $p > p^{PR}$.

Finally, we need to check whether $V^D_{R,e} > V^E_R$ in this case. From (12):

$$\begin{aligned} V^D_{R,e} - V^E_R &= \frac{p\left[\overline{X} - (p + e^{PR}(1-p))I_1\right] + (1-p)\left[e^{PR}\overline{X} - \gamma e^{PR} I_2 - (1-\gamma)I_2 - (p + e^{PR}(1-p))I_1\right]}{p + e^{PR}(1-p)} \\ &\quad -p\overline{X} - (1-p)(\overline{X} - I_2) + I_1 \\ &= \frac{(1-\gamma-p)(e^{PR}-1)(1-p)}{p + e^{PR}(1-p)} I_2 \end{aligned}$$

Since the denominator is always positive, and $e^{PR} > 1$, the numerator is positive (negative) when $1 - p - \gamma > (<) 0$, that is, when $\gamma < 1 - p$. To conclude the proof, it is easy to verify that $p^{PR}(\gamma = 1 - \overline{p}) < \overline{p}$.

Proof of Corollary 2

Deriving $V^D_{R,e}$,

$$\frac{\partial V^D_{R,e}}{\partial \gamma}\Big|_{e=e^{PR}} = -(1-p)\frac{[\gamma - (1-p)]\, I_2}{[p + (1-p)e^{PR}]^2}\frac{\partial e^{PR}}{\partial \gamma}$$

which is positive for $\gamma < 1 - p$, since $\frac{\partial e^{PR}}{\partial \gamma} = I_2 \frac{I_1 + I_2}{\left[\overline{X} - \gamma I_2 - (1-p)I_1\right]^2} > 0$. From Proposition 8, the risky project is financed with debt whenever $\gamma < 1 - p$.

7 Proof of Proposition 9

Follows directly from Proposition 8.

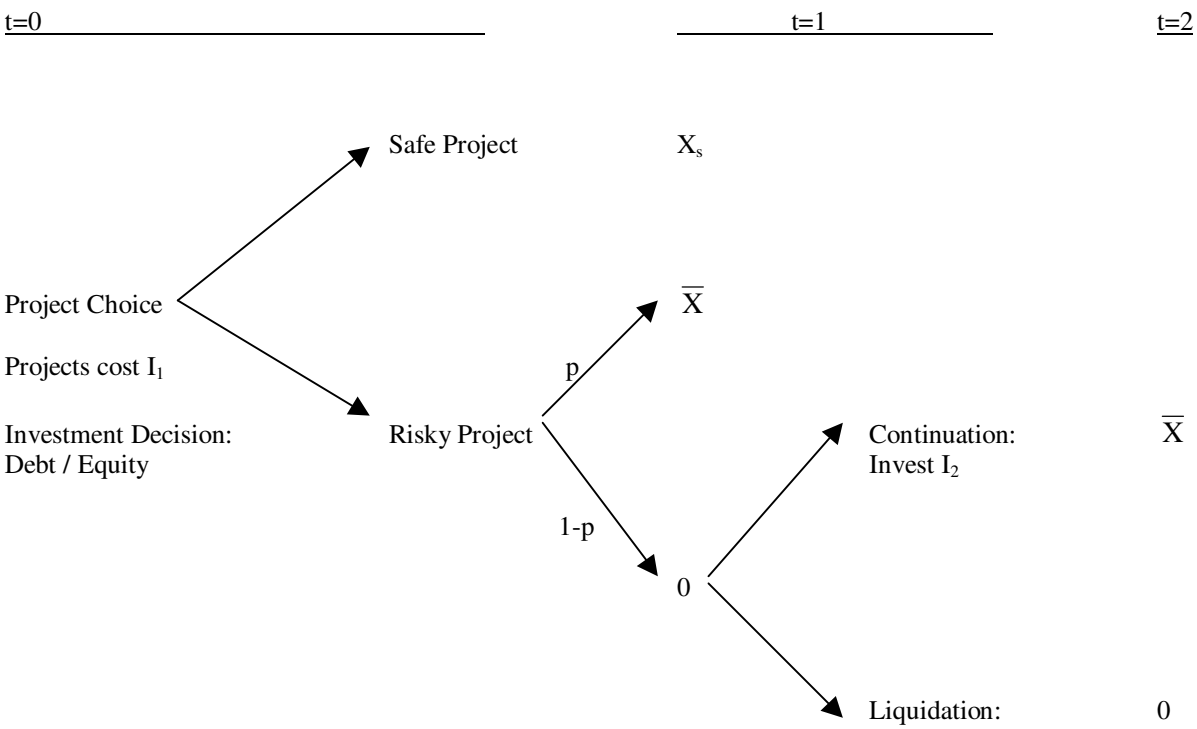

Figure 1. **Timing of the game**.
The firm can invest in two projects. Both projects require the same initial investment I_1 in the domestic market, and the output is an exportable good that is sold in the foreign market. Prices in the foreign market are denominated in dollars. The exchange rate at e_o=1 units of domestic currency per dollar. Project S (safe) yields a sure return of X_s dollars at t=1; project R (risky) yields $\overline{X}$ dollars with probability p and 0 with probability 1-p. However, if the risky project turns bad, the firm may make a continuation decision at t=1, that involves investing I_2 in the domestic market at t=1 and making a sure return of $\overline{X}$ dollars at t=2. Otherwise the firm is liquidated at the proceeds from liquidation are L, where L=0.

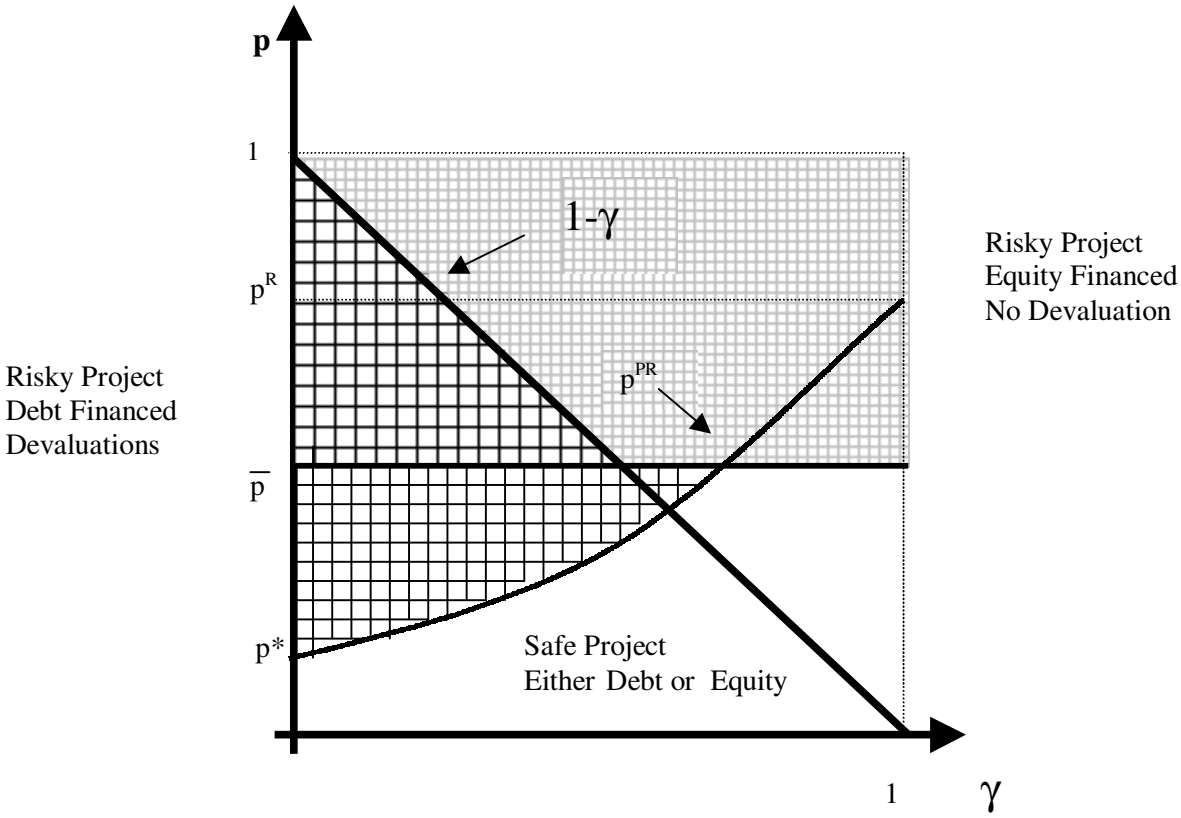

Figure 2. The case of a Partial Real Devaluation.
The graph shows the threshold value p^{PR} such that the currency is devalued for $p^{PR}<p<\max(\bar{p},1-\gamma)$ the risky project is taken, and it is financed with debt. When When $\max(\bar{p},1-\gamma)\leq p\leq 1$, the risky project is optimal, and it is financed with equity. When γ is such that $0\leq p<\min(p^{PR},\bar{p})$, the safe project is preferred.