EXCHANGE RATE REGIME AND FINANCING POLICIES OF THE CORPORATE SECTOR IN SMALL OPEN ECONOMIES

by

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To my wife, Ligia, and my son, Tomas

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CHAPTER I

Introduction

This dissertation studies the relationship between exchange rate regimes and financing decisions of corporations in small open economies with access to international capital markets.

The second chapter develops a model of the choice between local and foreign currency debt by capital-constrained firms facing exchange rate risk and hedging possibilities. The model shows that the currency composition of debt and the level of hedging are both endogenously determined as optimal firms' responses to a tradeoff between the lower cost of borrowing in foreign debt and the higher risk involved due to exchange rate uncertainty. Results of the model are broadly consistent with lending and hedging behavior of the corporate sector in small open economies recently hit by a currency crisis. In particular, the model is able to explain why, unlike predictions of previous work in the literature of currency crisis, the collapse of the fixed exchange rate regime in Brazil in early 1999 did not cause a major change in the currency composition of debt of the corporate sector.

The third chapter is co-authored with Uday Rajan and Amiyatosh Purnanandam. It studies the effect of hedging with foreign currency derivatives on Brazilian firms in the period 1997 through 2004, a period that includes the Brazilian currency cri-

sis of 1999. This chapter finds that, compared to non-user firms, derivative users have valuations that are 7-10% higher. Hedging with currency derivatives has three noticeable effects on firms: (i) it increases foreign debt capacity, so that there is a substitution from domestic debt to foreign debt, which is cheaper (ii) it removes the sensitivity of capital expenditures to Earnings Before Interest and Taxes (EBIT), and (iii) it results in higher net income, for a given level of leverage and EBIT. It is argued that access to foreign debt represents a primary friction over the sample period, which makes hedging valuable. The result on capital expenditures supports the Froot, Scharfstein, and Stein (1993) model.

The fourth chapter presents a case study to analyze hedging strategies implemented in practice by companies in Brazil. Two large companies, both operating in international markets and using financial hedging are chosen to illustrate how corporations deal with exchange rate risk. Consistent with corporate hedging theory, the case study finds that hedging contributes to smooth companies' earning and helps to mitigate the depletion of shareholder's equity. In turn, this contributes to reduce investor's risk perception about the firm and increases its foreign debt capacity. Findings are consistent with the model of optimal debt composition and hedging developed in the second chapter and with empirical evidence about the financial effects of hedging in Brazil of the third chapter.

CHAPTER II

Exchange rates, Optimal Debt Composition and Hedging in Small Open Economies

2.1 Introduction

Recent currency crises in East Asia and Latin America have been characterized by the presence of currency mismatches between assets and liabilities and inadequate hedging in the balance sheets of the corporate sector.[1] This mismatch between foreign currency liabilities and domestic currency denominated assets in firm balance sheets has been argued to be the root cause of the large output collapses following currency depreciations. [2] Under a fixed exchange rate regime, firms understand fixed exchange rates to be a guarantee and fail to insure their foreign exposure. [3] A direct implication of this line of reasoning is that once the exchange rate is allowed to float, firms will recognize their exposure, and foreign currency loans will be viewed as more costly so that firms reduce their foreign currency borrowing. Unlike this prediction, firm level evidence from Brazil over the period 1996 to 2001, suggests that the collapse of the fixed exchange rate regime in Brazil, in early 1999, did not

[1] A currency mismatch occurs when a large fraction of firms' debt is denominated in foreign currency while income and assets are denominated in domestic currency.

[2] To see more on the balance sheet explanation of currency crises see for example Krugman (1999), Aghion, Bacchetta and Banerjee (2001) and Schneider and Tornell (2000).

[3] This implication is also consistent with another strand in the literature that emphasizes a moral hazard problem introduced by implicit bailout guarantees provided by government, or free exchange rate risk management also provided by government when fixing the exchange rate. These guarantees bias the composition of debt toward foreign currency debt and eliminate incentives to hedge risk. See for example Burnside et al (2001).

cause a major change in the currency composition of debt of the corporate sector. This paper attempts to offer an explanation to this apparently surprising result.

To study this phenomenon the chapter develops a theoretical framework that examines the firm's choice of local and foreign currency debt in the presence of exchange rate risk and hedging possibilities. The model shows that the currency composition of debt and the optimal level of hedging are joint decisions and depend on common factors such as exchange rate risk and financial default, interest rates, the size of net worth and costs of foreign currency risk management. The key element driving the model results is the tradeoff that firms face between the lower cost of borrowing in foreign currency and the higher risk involved due to exchange rate uncertainty. When affordable, hedging reduces firms' exposure to currency risk and expands their debt capacity in foreign currency. Thus, even after a large currency depreciation, say after the collapse of a fixed exchange rate regime, hedged firms are able to maintain and even increase their access to foreign currency borrowing.

In the model, firms are forward-looking agents and make their borrowing decisions based on expectations of currency depreciation. Thus, even if they observe a fixed exchange rate, as long as they perceive that the regime is not credible or is no longer sustainable, they will anticipate a future depreciation and will start taking care of the devaluation risk by engaging in hedging activities. This seems to be the case of some firms in Brazil, which were hedged using currency derivatives even during the period of the fixed exchange rate. Furthermore, when financial markets provide enough tools to mitigate the effects of the devaluation risk (e.g. currency forward contracts), the collapse of the fixed exchange rate may cause only small changes in the currency composition of debt because with the opportunity to hedge companies may not reduce foreign currency debt after the devaluation.

The model predictions are broadly consistent with lending and hedging behavior of the corporate sector in small open economies that recently faced a currency crisis. The theory suggests that, when the economy moves from fixed to floating exchange rates, some firms change financing policies and the population of firms exposed to foreign exchange risk is altered. Firms with insufficient net worth and those unable to afford buying a hedge lose access to capital markets. Firms with high enough net worth and those able to hedge increase their foreign debt. Firms with intermediate net worth but unable to hedge borrow less in foreign currency, turn to domestic banks and are monitored in order to maintain their access to foreign capital markets. With a macroeconomic environment characterized by a moderate probability of currency depreciation and inexpensive hedging, these changes in the population of firms can offset each other so that the average currency composition of debt does not vary significantly across regimes.

The chapter builds on the model developed by Holmstrom and Tirole (1997) adapted to the context of a small open economy. The paper with the analytical framework most closely related to the one presented in this chapter is Martinez and Werner (2002). They also extend the Holmstrom and Tirole model to the small open economy case and find that before the Mexican crisis in 1994, the decision of borrowing in pesos or dollars depended on the exchange rate regime to the extent that an implicit guarantee was provided by the government by fixing the exchange rate. However, these authors treat the exchange rate as a deterministic variable so that no hedging strategies are discussed. Arguably, their model captures only part of the story; there is no discussion of how the interaction between domestic and dollar debt changes and how the population of firms is altered when the economy moves to a floating regime and firms are able to hedge. In their model, as in most

of the previous literature, it is implicit that large amounts of foreign currency debt represent a high degree of exposure to exchange rate risk.

As mentioned above, prior theoretical models suggest a negative impact of a large devaluation on companies' foreign currency borrowing and a reduction in currency mismatches. However, empirical findings on the relationship between exchange rate regimes and currency mismatches in the balance sheet of corporations are mixed and still subject to debate. Some studies find that the adoption of a floating exchange rate regime reduces currency mismatches by reducing the foreign currency borrowing and increasing the levels of hedging while others find that firms borrow even more after the currency crisis.[4] The model in this chapter helps explain these apparently contradicting results between theory and empirical evidence by providing an analytical framework in which currency mismatches are reduced after the currency crisis without having firms borrowing less in foreign debt. Hedging operations allow corporations, on aggregate, to maintain their access to international capital markets and have their currency composition of credit almost unchanged.

The reminder of the chapter is organized as follows. Section 2.2 presents the main empirical facts and the motivation for the analysis using firm-level data from Brazil. Section 2.3 describes the model of optimal debt allocation and hedging at the firm level. Section 2.4 offers the main results of the model under fixed and floating exchange rates. Section 2.5 concludes.

[4]Empirical support of currency mismatches and exchange rate exposure during fixed exchange rate regimes is found by Burnside et al (2001) in the Asian crisis, Dominguez and Tesar (2001) in 8 non-industrialized and emerging markets and Bonomo et al (2003) using financial data from Brazilian firms. On a different study also using Brazilian firms Rossi (2004) finds that the adoption of the floating regime reduced the foreign vulnerability of the corporate sector by having a negative impact on firms' foreign borrowing and a positive impact on hedging. However, Martinez and Werner (2002) find that firms in Mexico were able to increase their dollar debt borrowing after the crisis in 1995 and Arteta (2002) in a cross-country study finds no evidence that a floating exchange rate regime reduces bank currency mismatches. Similarly, Allayannis et al (2002) find that non-financial firms in Asian countries were able to maintain substantial levels of foreign currency debt even after the currency crisis. It is important to say however, that except for only few studies such as Rossi (2004) and Allayannis et al (2002), most studies in the empirical literature only used data on the currency composition of debt at the firm and bank level since data on hedging are often not available or hard to collect.

2.2 Empirical evidence on foreign currency exposure and hedging: Brazil 1996-2001

In this section firm-level data on Brazilian firms are examined before and after the currency crisis in 1999. Like other Latin American countries, Brazil suffered from unexpected reversals in capital flows after subsequent crises in Mexico (1994), East Asia (1997) and Russia (1998). The macroeconomic adjustment forced by substantial capital outflows at the end of 1998 brought large and persistent swings in the exchange rate that finally led to the collapse of the crawling peg and a sharp devaluation of the Brazilian real in January 1999.

Firm-level data correspond to financial information for almost 200 companies publicly traded in the São Paulo Stock Exchange Market (BOVESPA) over the period 1996 to 2001.[5] This information was taken directly from companies' annual financial reports. Data contain information on balance sheet variables such as the book value of assets, the currency composition of debt and shareholder's equity. Data on hedging transactions were hand-collected and consist of the year-end notional value of currency derivatives (forwards, futures, swaps and options) obtained from the footnotes to financial statements available at BOVESPA. Financial and state-owned firms are excluded because of their different motivation for using currency derivatives.

Table 2.1 illustrates the currency composition of debt and hedging activities of firms across exchange rate regimes. As seen from the table, there is not a major change in the currency composition of debt, measured by the ratio of dollar debt to total debt, when the Brazilian economy moved from the fixed to the floating exchange rate regime.[6] Over the sample, this ratio remains stable around 44%. On

[5]This period is chosen because it provides valuable information to a comparative analysis on firm's behavior regarding financing and risk management policies before and after the currency crisis in 1999, and also because disclosure of information on derivatives was mandatory only after 1995.

[6]The lack of major changes in the currency composition of debt remains even after correcting for the valuation effect of the currency depreciation in the ratio of foreign to total debt.

average, the dollar debt ratio slightly increased from 42% during the fixed exchange rate period to 45% during the floating period. Across different groups of firms the dollar debt ratio seems to exhibit a similar pattern, except for small firms that on average slightly decrease their dollar debt ratio. On the other hand, hedging operations, approximated by the fraction of the notional value of currency derivatives to dollar debt, increased from 1% in 1996 to 28% in 2001. Interestingly, data show that hedging operations increased during the floating exchange rate regime but were already observed during the fixed exchange rate period, especially for medium and large corporations. Large companies increased their hedging ratio on average from 6 to 26%. This latter observation indicates that even before the currency crisis, and most likely after crisis episodes in East Asia and Russia, some firms indebted in foreign currency were taking care of the devaluation risk by hedging their positions using currency derivatives. As will be seen later, this behavior is consistent with the model predictions highlighting the hedging side of financing policies in small open economies subject to currency risk. While highly suggestive, this table also seems to show some evidence of costly hedging since the increase in the hedging ratio mostly occurred in large and medium size companies while small firms appear to hedge a small fraction of their dollar debt even during the floating regime.

An interesting feature regarding the hedging behavior of the corporate sector in Brazil is that most financial hedging transactions correspond to currency swap contracts. Unlike evidence for U.S. large non-financial corporations, which report currency forwards and options as the most commonly used tool to manage exchange rate exposure, firms in Brazil seem to prefer currency swaps, effectively converting foreign debt into domestic debt through simultaneous transactions in the spot and the forward markets. Broad preference for currency swaps is also consistent with costly

hedging, since a swap reduces transaction costs by allowing companies to arrange in only one contract what may take several transactions (e.g. forward contracts) to replicate.[7]

Table 2.2 shows the number of firms holding financial debt in domestic and foreign currency and those using currency derivatives. These data also provide evidence of minor changes in the corporate sector's borrowing behavior. The number of firms borrowing in both currencies and the number of firms borrowing only in domestic currency both slightly increased during the floating regime. The number of firms increases during the sample period from 110 in 1996 to 185 in 2001. The number of firms that hedge using currency derivatives increases after the collapse of the exchange rate regime from 7 in 1997 to 62 in 2001. Interestingly, about 56% of the firms with dollar debt in the sample still remain unhedged during the floating regime.

Overall, the evidence presented in this section seems to support the view that there are no significant changes in the borrowing patterns of the Brazilian corporate sector during the period 1996 through 2001, that is, before and after the currency crisis. It should be mentioned that having a genuine measure of firm-level hedging is difficult, and the previous observations about hedging refer only to the use of currency derivatives. Firms may use different hedging strategies other than derivatives, such as holdings of dollar-denominated assets and revenues from exports, which are not emphasized in the current analysis and are left to the fourth chapter. The main point that can be emphasized however is that, contrary to prior suggestions, after the large depreciation that followed the collapse of the fixed exchange rate firms in Brazil were still able to borrow significantly in foreign currency, more companies

[7]Bonomo et al (2003) pointed out that Brazilian firms prefer currency swaps because they can obtain advantageous swap contracts from local banks. Banks, in turn, are able to offer these contracts because they are not exposed to exchange rate risk since they hold government bonds indexed to the dollar in their portfolios. According to these authors, in the end the hedge appears to be provided by government through bank intermediation.

hedged this debt by getting involved in currency derivative markets and there was still a large fraction of firms holding dollar debt which was not financially hedged through currency derivatives. As shown in the next section, predictions of the model of optimal debt allocation and hedging are consistent with these empirical facts.

2.3 A Model of Optimal Currency Composition of Debt and Hedging

Consider a small open economy described by a two-date model (t = 0, 1). The economy is populated by a continuum of risk-neutral firms, domestic banks and foreign banks. Firms are run by wealth-constrained entrepreneurs who need to raise funds to cover their investment outlays. Firms' investment projects can be financed by borrowing in either domestic currency from local banks or in foreign currency from foreign banks. Given the uncertainty about the exchange rate, firms can choose to hedge their foreign exchange risk by signing forward contracts offered by local banks. At t=0 firms sign debt contracts and make investment, borrowing and hedging decisions. At t=1, exchange rate and investment returns are realized and claims are settled. Agents are protected by limited liability so that no party can end up with negative payoffs.

2.3.1 Investment Projects

Each firm has access to a project requiring an investment of fixed size $I > 0$ at date 0, which yields at date 1 a verifiable return in domestic currency R in case of success and nothing in case of failure. Firms differ only in their initial capital A (which is publicly observable). The distribution of firms is described by the cumulative distribution function F(A). It will be assumed that $A < I$, so that firms need external funding to undertake their investments. There are three types of investment projects as described in Figure 2.1: a good project with a high probability of success P_G,

and a bad project and a worse project, each with the same probability of success P_B ($P_G > P_B$). The bad project gives a low private benefit b and the worse project gives a high benefit B to the entrepreneur, $B > b > 0$. Firms face a moral hazard problem in choosing a project. In the absence of proper incentives or outside monitoring, entrepreneurs can divert resources by deliberately reducing the probability of success of a project (from P_G to P_B) to enjoy the private benefit.

Figure 2.1: Three Types of Investment Projects

Project	Good	Bad	Worse
Probability of success	P_G	P_B	P_B
Private Benefit	0	b	B

Local banks can monitor firms to reduce the moral hazard problem and eliminate the worse project (B-project). Monitoring is costly so that local banks face a fixed cost $C > 0$. Foreign banks are uninformed investors (i.e. they are unable to monitor firms) and have access to alternative projects with a gross rate of return r^* in international markets. Furthermore, it is assumed that given the rate of return on investor capital in domestic currency denoted by r^f, only the good project has a positive expected net present value (NPV), even if the private benefit of the firm is included:

$$P_G\ R - r^f\ I > 0 > P_B\ R - r^f\ I + B \tag{2.1}$$

2.3.2 Financing Decisions and Exchange Rate Risk

In what follows, firms are represented by the index f; domestic banks are represented by the index m and foreign banks are represented by the index u. At date 0 a representative firm invests all its funds A [8] and signs debt contracts to borrow in

[8] It is also assumed that the internal rate of return of investment projets exceeds the market rate r_f which means that funds invested in the firm are worth the external rate of return plus an incentive effect.

domestic currency an amount I_m from local banks and in foreign currency an amount I_u from foreign investors so that:[9]

$$A + I_m + s_L \; I_u \geq I \tag{2.2}$$

where $s_L > 0$ is the exchange rate at date 0, quoted as s_L units of domestic currency per unit of foreign currency. Notice that investment return and exchange rate are both uncertain. This is a departure from the original credit model of Holmstrom and Tirole (1997). In addition to the moral hazard structure of their model, the current setup extends the firm's investment problem not only by considering the case of firms borrowing in foreign currency from international capital markets but also by adding a new dimension to the problem. In the setup here there is the possibility of default due to exchange rate risk and the hedging activities used by firms to mitigate that risk. Investment projects are now subject to two types of bad events: failure (economic default) or bankruptcy due to currency-led default (financial default). Exchange rate fluctuations, therefore, can turn solvent firms into bankrupt firms even when they undertake successful projects. It will be assumed that in the event of any type of default, firms' creditors are left with nothing.[10]

For simplicity, consider only two states of nature about the exchange rate: low (L) and high (H). At date 0 the exchange rate is s_L. If the economy operates under a fixed exchange rate regime then at date 1 $s_1 = s_L$. Under a floating exchange rate regime, at date 1 the exchange rate can either depreciate to $s_H > s_L$ with probability q, or remain unchanged with probability $1 - q$. To avoid losses due to exchange rate fluctuations, companies may decide to hedge their foreign exchange risk by buying

[9]There is no other source of funding (e.g. equity finance) in the model. As is the case of emerging economies in Asia and Latin America, a large part of the funds for investments are provided in the form of bank loans.

[10]For example, in case of financial default the firm is declared bankrupt and its residual value is completely used to pay for bankruptcy costs.

currency forward contracts.

Let F be the one-period forward exchange rate charged to the firm and defined as units of domestic currency per unit of foreign currency. Given the possibility of economic and financial default on the firm side, it will be assumed that forward markets are efficient so that F is the expected exchange rate at date 0 and is given by:[11]

$$F = \begin{cases} (1-q)\ s_L + q\ s_H & \text{if financially solvent in both states L,H} \\ s_L & \text{if financially solvent in state L} \\ s_H & \text{if financially solvent in state H} \end{cases} \tag{2.3}$$

Note that $s_L \leq F \leq s_H$. Expression (2.3) states that the forward rate is adjusted according to the risk of financial default in a way such that over-hedging (e.g. infinite hedging in case of zero transaction costs) is ruled out as will be clear in the next paragraphs. Another important feature of the hedging contract is that payments in either direction are contingent on the project succeeding. In other words, when the project fails and state s_L occurs the firm has nothing so that it will not pay out on the hedging contract, but it will not receive any payment either if state s_H occurs and the project fails. This particular feature guarantees that a hedged firm will always be able to obtain a forward contract at the rate $F = (1-q)\ s_L + q\ s_H$, which occurs because the hedging contract is offered by domestic banks so that payments in both directions are netted out on average.[12]

Let h be the amount of forward contracts in foreign currency that the firm purchases and ϕ the transaction costs per unit of forward contract. For simplicity, let

[11] As shown later, the forward rate is related to interest rates according to a covered interest parity condition.

[12] For simplicity, it is assumed that firms buy forward contracts from domestic banks other than those from which they borrow so that transaction costs of hedging do not represent revenues to domestic lenders.

ϕ be also expressed in domestic currency per unit of foreign currency. At date 1, if the project succeeds, proceeds from hedging operations in domestic currency are:

$$\Pi^H = h\ (s_1 - F) - \phi\ |h| \tag{2.4}$$

Note that firms in the model are forward-looking agents. They make their debt and hedging decisions based on expectations of currency depreciation. Moreover, the probability of depreciation $q > 0$ could also be interpreted as the probability of devaluation during fixed exchange rates when the regime is not credible. Strictly speaking, $q > 0$ would be the conditional probability that the exchange rate is devalued at date 1 having been fixed at date 0.

A debt contract must specify the amount borrowed from each lender and the payments to each of them under all circumstances so that:

1. If the project fails, it pays zero to all parties.

2. At date 1, if the project succeeds and the firm does not default, project returns R plus proceeds from hedging operations (if any) are divided among parties, from which the firm receives $R_f(s_1) \geq 0$, local banks receive $R_m \geq 0$, foreign banks receive $s_1 R_u \geq 0$ and forward sellers receive $\phi|h| \geq 0$.

Note that debt payments to lenders are independent of the exchange rate at date 1, s_1, provided the firm is solvent. However, returns to the entrepreneur (the equity-holder) depend on s_1.

Financial default occurs at date 1 when the firm, even if undertaking a successful investment, is unable to meet its financial obligations and becomes bankrupt. Financial default is then given by the following condition:

$$R - R_f(s_1) - R_m(s_1) - s_1 R_u(s_1) + h(s_1 - F) - \phi|h| < 0 \tag{2.5}$$

As mentioned above, the forward rate in expression (2.3) rules out over-hedging. For example, consider the case of a firm wanting to buy a significantly high amount of forward contracts to increase its expected payment when s_H occurs but default when s_L occurs. Since the firm is solvent only in state H, expression (2.5) becomes positive in state H but negative in state L. By setting $F = s_H$ forward sellers eliminate incentives for firms to over-hedge because in such a case the firm will not be paid in the depreciation state.

The preceding analysis implies that the firm hedges its foreign exchange exposure in order to reduce the possibility of financial default. Furthermore, a firm that is hedged ex-ante cannot be insolvent or solvent in only one state. Since financial default may occur in either state L or H, let 1_L and 1_H be indicator variables such that:

$$1_H = \begin{cases} 1 & \text{if solvent in state H} \\ 0 & \text{if default in state H} \end{cases}$$

$$1_L = \begin{cases} 1 & \text{if solvent in state L} \\ 0 & \text{if default in state L} \end{cases} \tag{2.6}$$

Accordingly, expected cash flows to the entrepreneur with zero proceeds from hedging, when the firm invests in the good project are:

$$R_f(s_H) = \begin{cases} P_G\ [R - R_m - s_H\ R_u] & \text{if solvent in state H} \\ 0 & \text{if default in state H} \end{cases}$$

$$R_f(s_L) = \begin{cases} P_G\ [R - R_m - s_L\ R_u] & \text{if solvent in state L} \\ 0 & \text{if default in state L} \end{cases} \tag{2.7}$$

2.3.3 Firm's Expected Profits

At date 0, a firm with initial capital A and investment I chooses the currency composition of its debt (I_m and I_u), creditors' payments (R_m and R_u), its hedging amount (h) and its expected payments $R_f(s_L)$ and $R_f(s_H)$ to maximize expected total profits:

(2.8)

$$E[\Pi_{TOT}] = P_G[(1-q)1_L[R-R_m-s_LR_u]+q1_H[R-R_m-s_HR_u]-\phi|h|]+r^f(I-A-I_m-s_LI_u)$$

subject to resource constraints, incentive and participation constraints and non-negativity constraints (e.g. limited liability).

In setting up the problem in this way, it is assumed that the firm undertakes only good projects with probability of success P_G. This will be always the case because incentive constraints will be imposed. Recall that only good projects have $NPV > 0$ which means that if bad projects are undertaken no borrowing is obtained from creditors.

Depending on the exchange rate realization, when the firm is financially solvent, project returns R and proceeds from hedging operations are distributed among all the parties according to the following resource constraints:

$$R_f(s_L) + R_m + s_L\ R_u = R + h\ (s_L - F) - \phi|h| \tag{2.9}$$

$$R_f(s_H) + R_m + s_H\ R_u = R + h\ (s_H - F) - \phi|h| \tag{2.10}$$

When the firm defaults in either state H or L it pays nothing to parties and the residual value of the firm covers bankruptcy costs.

Let 1_m be an indicator variable such that $1_m = 1$ if the firm borrows from the local bank (with monitoring) and $1_m = 0$ if the firm borrows directly from foreign banks and not from local banks (without monitoring). Given the two states of nature of the exchange rate, the firm invests in a good project whenever it obtains an expected payment greater or equal than the expected payment of a bad project including private benefits, in other words, when:

$$P_G\ [(1-q)R_f(s_L)+qR_f(s_H)] \geq P_B[(1-q)R_f(s_L)+qR_f(s_H)]+1_m b+(1-1_m)B \tag{2.11}$$

This is the firm's incentive constraint and can be also written as:

$$(1-q)\ R_f(s_L) + q\ R_f(s_H) \geq 1_m\ \frac{b}{\Delta p} + (1-1_m)\ \frac{B}{\Delta p} \tag{2.12}$$

where $\Delta p = P_G - P_B > 0$.

2.3.4 Domestic Bank Lending

A local bank monitors the firm and finances the project whenever it receives an expected payment sufficient to cover the fixed monitoring cost C. The bank's incentive constraint is then given by:

$$[1_L\ (1-q) + 1_H\ q]\ R_m \geq 1_m\ \frac{C}{\Delta p} \tag{2.13}$$

On the other hand, the bank is willing to finance the project if it receives at least an expected payment net of monitoring costs equal to the opportunity cost of its funds. The participation constraint for the bank is then given by:

$$P_G\ [1_L\ (1-q) + 1_H\ q]\ R_m - 1_m\ C \geq r^f\ I_m \tag{2.14}$$

Let r denote the domestic lending rate that the local bank charges on I_m funds lent to the firm, defined as:

$$r = \frac{P_G\ [1_L\ (1-q) + 1_H\ q]\ R_m}{I_m} \tag{2.15}$$

The minimum domestic rate of return r acceptable for the bank to lend in domestic currency is determined by the condition

$$\frac{P_G\ C}{\Delta p} - C = r^f\ \frac{P_G\ C}{r\Delta p} \tag{2.16}$$

The previous expression is obtained by combining conditions (2.13) through (2.15), all holding with equality, and assuming that the bank lends to the project so that $1_m = 1$. This condition, in turn, implies that

$$r = r^f \frac{P_G}{P_B} \tag{2.17}$$

This expression for the domestic lending rate states that the cost of domestic funds incorporates a risk premium relative to the risk-free rate. At the minimum rate of return acceptable for a bank the risk premium is equal to the ratio of success probabilities of the good and bad projects.

Local banks can borrow and lend internationally and are able to replicate a forward contract. Perfect competition and non-arbitrage conditions ensure that banks are indifferent between lending in domestic currency at r^f, converting these funds into foreign currency at date 0 at the spot rate s_L and lending abroad in foreign currency earning r^*, and converting these funds back to domestic currency at the forward rate F. These transactions imply that:

$$r^f = r^* \frac{F}{s_L} \tag{2.18}$$

This is a covered interest rate parity condition and can be also expressed in terms of the domestic lending rate and the international rate as:[13]

$$r = r^* \frac{P_G}{P_B} \frac{F}{s_L} \tag{2.19}$$

In this expression $P_G > P_B$ and $F > s_L$ so that the bank lending rate r is always greater than the international interest rate r^*. Thus, foreign debt is always preferred to domestic debt. The result that foreign debt is cheaper than domestic debt is due to the moral hazard structure associated with investment projects. Intuitively, given that local banks face a fixed cost to monitor firms, then the lending rate in domestic loans incorporates not only the expected change in the exchange rate given by the ratio F/s_L but also a risk premium due to asymmetric information given by the ratio P_G/P_B. As a result, when they have to, firms will minimize borrowing from a local bank and obtain the rest of their funds from foreign lenders.

[13]Using covered interest rate parity and efficient markets hypothesis are certainly very strong and simplifying assumptions. The incorporation of parameter ϕ as transaction costs in setting up a hedging program is an attempt to add some friction and bring a more realistic feature of foreign exchange markets to the model. These transaction costs in practice are expressed as a bid-ask spread in forward and spot rate quotations.

The firm will be able to borrow in foreign currency if foreign banks are promised an expected payment greater than or equal to what they could obtain by investing their funds in international capital markets at the rate r^*. The foreign bank participation constraint in foreign currency is then:

$$P_G\ [1_L\ (1-q) + 1_H\ q]\ R_u \geq r^*\ I_u \tag{2.20}$$

2.3.5 Firm's Profit Maximization

The firm's problem is to find variables h, I_m, I_u, R_m, R_u, $R_f(s_L)$, $R_f(s_H)$ given exogenous parameters such as the firm's initial assets A, its fixed investment I, the foreign rate of return r^*, the probability of currency depreciation q and the cost of hedging ϕ, in order to:

Maximize $E[\Pi_{TOT}] =$

$$P_G(1-q)1_L[R - R_m - s_L R_u] + q1_H[R - R_m - s_H R_u] - \phi|h| + r^f(I - A - I_m - s_L I_u)$$

subject to

$$A + I_m + s_L\ I_u \geq I \tag{1}$$

If firm is solvent:

$$R_f(s_L) + R_m + s_L\ R_u = R + h\ (s_L - F) - \phi|h| \tag{2}$$

$$R_f(s_H) + R_m + s_H\ R_u = R + h\ (s_H - F) - \phi|h| \tag{3}$$

$$(1-q)\ R_f(s_L) + q\ R_f(s_L) \geq 1_m\ \tfrac{b}{\Delta p} + (1 - 1_m)\ \tfrac{B}{\Delta p} \tag{4}$$

$$[1_L\ (1-q) + 1_H\ q]\ R_m \geq 1_m\ \tfrac{C}{\Delta p} \tag{5}$$

$$P_G\ [1_L\ (1-q) + 1_H\ q]\ R_m - 1_m\ C \geq r^f\ I_m \tag{6}$$

$$P_G\ [1_L\ (1-q) + 1_H\ q]\ R_u \geq r^*\ I_u \tag{7}$$

$$R_f(s_H) \geq 0 \tag{8}$$

$$R_f(s_L) \geq 0 \tag{9}$$

Conditions (1) through (3) are resource constraints. Conditions (4) and (5) are the incentive constraints of the firm and the domestic bank. Conditions (6) and (7) are the participation constraints for domestic and foreign banks. Conditions (8) and (9) are non-negativity constraints for the firm's payments. Only one of these two non-negativity constraints will be binding when the firm defaults in one state of the exchange rate but is solvent in the other. Notice that there are 9 constraints to solve for 7 choice variables, which means that in equilibrium at least 7 constraints must be binding.

2.3.6 Equilibrium

The determination of the equilibrium as well as closed-form solutions for the currency composition of debt and optimal hedging are explained in detail in appendix A.1. As an illustration, consider that both borrowing and hedging decisions are endogenously determined as optimal firms' responses to a tradeoff between the lower cost of borrowing in foreign debt and the higher risk involved due to exchange rate uncertainty. As explained above, foreign currency debt is preferred to domestic debt so that the firm always tries to borrow directly from foreign banks. The smaller the size of its initial assets A, the more the firm demands from international banks. Since exchange rate uncertainty makes foreign debt risky, foreign banks demand a minimum net worth and hedging operations through currency forwards to ensure that the firm is solvent enough to repay its debt. If the firm's initial net worth is not sufficient to meet the foreign bank's requirement then the firm must be monitored and will borrow from domestic banks first, in order to be able to borrow from international markets. Local banks help firms undertake investments projects because domestic lending reduces the net worth requirement. Depending on the size of its net worth, the monitored firm may also need to hedge to demonstrate financial solvency.

Given that the internal rate of return is greater than the external rate on firm capital, entrepreneurs prefer to invest all their funds in the project. Therefore, constraint (1) in the firm's problem will be binding in most cases. The only exception occurs when a firm borrows only in domestic currency from local banks. Recall that local banks have to cover the fixed monitoring costs so that they lend all firms the same fixed amount in domestic currency. Therefore, when the firm has a net worth insufficient to borrow only in foreign currency but high enough to borrow the fixed amount in domestic currency, and the sources of funds exceed the size of investment, then constraint (1) is not binding and the firm has to invest its excess funds at the market rate r^f.

Another key feature of the model is that hedging decisions are perfectly observed by creditors. An immediate implication is that firms have incentives to hedge their exchange rate risk to reduce the probability of financial default. When affordable and useful, hedging increases profits by expanding the possibility of borrowing in foreign currency at a lower cost. The equilibrium level of hedging corresponds to any value within an optimal range defined by constraints (2), (3), (8) and (9) as shown in the appendix. Depending on exogenous parameters, in particular q and ϕ, the minimum level of hedging in this range can be positive or negative (negative hedging implies that the firm sells forward contracts). As shown in what follows, intermediate values of q and small enough ϕ make the minimum level of hedging positive so that a profit maximizing firm will always choose this minimum level. However, there will be situations when the firm optimally chooses not to hedge. To see this, let $\overline{q}$ be the probability of depreciation that makes the minimum level of hedging equal to zero and $\overline{\phi}$ be the transaction cost in forward markets above which, for any given

level of positive q, forward contracts are too costly to provide insurance.[14] When the probability of depreciation is too high, say $q > \overline{q}$, describing for example a situation of extreme exchange rate volatility, firms will find optimal to choose a zero level of hedging. On the other hand, when hedging is too costly, say $\phi > \overline{\phi}$, then even if available hedging is not affordable so that firms will also choose not to hedge.

A representative firm solves its profit maximization problem under two situations: when it hedges enough to avoid financial default and when it does not hedge at all.[15] Given that hedging is a necessary but not a sufficient condition for financial solvency, a firm with sufficiently high net worth can borrow only small amounts of foreign currency debt and be financially solvent without hedging. Therefore, when the firm does not hedge at all, there are two additional possibilities: the firm is solvent even without hedging or the firm defaults if it is not hedged. Each of these situations exists for a monitored company borrowing in both currencies and for a company borrowing only in foreign currency. These multiple cases imply that creditors demand different net worth levels depending on the composition of credit and the firm's hedging strategy.

Appendix A.2 illustrates the solution to all these net worth requirements. For the purpose of analysis, a brief description of them is in order: lower bar net worth levels denote minimum net worth requirements for firms being monitored and borrowing from domestic banks first while upper bar net worth levels denote the net worth requirements for firms borrowing directly from foreign banks. Accordingly, $\underline{A}_H$ is the minimum net worth for an optimally hedged firm that borrows in both domestic and foreign currency. Similarly, $\overline{A}_H$ is the minimum level of assets required for an

[14] It can be shown that $\overline{q} = 1 - (\frac{b}{\Delta p}\frac{s_H}{s_H - s_L})/(R - \frac{C}{\Delta p})$ and $\overline{\phi} = s_H - F = (1-q)(s_H - s_L)$ respectively.

[15] Partly hedging is ruled out because in case of currency depreciation, this level of hedging is not sufficient to avoid default so that the firm is forced to default as if hedging was zero in the first place. With sufficiently small but positive costs of hedging the firm will prefer zero hedging to partly hedging.

optimally hedged firm wanting to borrow only in foreign currency from international banks.

When the firm does not hedge and as a result is not solvent in state H then the minimum net worth requirements are $\underline{A}_{NH}$ and $\overline{A}_{NH}$ for firms being monitored by local banks and for firms borrowing directly from foreign banks respectively. If the firm is unhedged but solvent in state H then it faces a higher minimum net worth required by creditors: $\underline{A}_{SNH}$ if monitored by local banks and $\overline{A}_{SNH}$ if it demands borrowing directly from foreign banks. [16] An unhedged but solvent firm faces the highest net worth requirements. On the other hand, hedging, when affordable, allows the firm to face the lowest net worth requirement. In equilibrium, depending on the size of the firm's initial assets and its hedging strategy, there are different financing possibilities. To decide the optimal currency composition of its debt (e.g. how much to borrow from each source) and whether it should be hedged or not, the firm compares its initial assets A with these cutoff levels.

2.4 Hedging costs, Exchange rate risk and the Segmentation of firms in Equilibrium

2.4.1 Equilibrium with costless hedging ($\phi = 0$)

Costless hedging represents a long run equilibrium in which currency forward markets are competitive and well-developed so that transaction costs are negligible. The next two results illustrate the optimal financing policies when the economy operates under a fixed exchange rate regime and under floating exchange rates as two separate steady state equilibria.

[16] As explained in appendix A.2, a second and more stringent criterion for unhedged and solvent firms is also considered. This is the case of firms that are solvent and expect to receive the maximum expected payment given by constraint (4) even in the depreciation state. The minimum net worth requirment for these firms is even higher: $\underline{A}_S$ if they are monitored and $\overline{A}_S$ if they want to borrow only from international markets.

Lemma 1. In an economy with credible fixed exchange rates, that is when q=0, an optimal strategy for a firm is not to hedge its dollar debt.

Proof: See Appendix B.1

This basic result explains why a fixed exchange rate biases the currency composition of debt for some firms towards foreign currency debt and eliminates incentives to operate in forward markets. By fixing the exchange rate, the government provides a form of public hedging or free risk management to the corporate sector by creating a perception of no foreign exchange risk.[17] Consequently, some firms that otherwise would not be able to borrow at all, or some others that should be monitored to have access to international capital markets, are now able to obtain foreign currency debt without constraints. This situation creates incentives for entrepreneurs to borrow extensively in foreign currency without hedging and to maintain currency mismatches in their balance sheets. As predicted by the balance sheet approach of currency crises, in the event of unexpected and large currency depreciation the corporate sector in this economy could face widespread bankruptcy.

Lemma 2. In an economy with floating exchange rates when $0 < q < \overline{q}$ in equilibrium the optimal strategy for a firm with net worth A such that $\underline{A}_H < A < \underline{A}_{SNH}$ or $\overline{A}_H < A < \overline{A}_{SNH}$ is to hedge its dollar debt through currency forwards enough to avoid bankruptcy.

Proof: See Appendix B.2

According to this result, during a floating regime or a non-credible fixed exchange rate regime, as long as a positive probability of currency depreciation makes forward

[17] With costless hedging and $q = 0$ the cutoff thresholds of the net worth requirements are at their lowest value and the firm is indifferent about how much it hedges since $F = s_L$.

contracts a useful instrument to deal with exchange rate risk, the firm immediately hedges to reduce the possibility of financial default and obtain more funding from foreign banks. Even in the presence of currency risk the firm is able to borrow in foreign currency at a lower cost because hedging reduces the required net worth. Without transaction costs in forward markets hedging is always preferred to not hedging and any firm that is not solvent in state H has incentives to hedge enough to avoid financial default. This is the case when the firm uses a mixture of domestic and foreign debt or when it borrows only in foreign currency. Note also that hedging is beneficial only for firms that are not solvent in state H; firms with net worth above the minimum requirement for solvency in state H do not need to hedge.

The previous equilibrium result when hedging is costless determine a particular ordering of net worth requirements and define an equilibrium segmentation of firms into different categories depending on their demand for bank loans and their hedging strategy, as shown in Figure 2.2. Well-capitalized firms with net worth $A > \overline{A}_H$ finance their investment directly in foreign currency from international banks. Poorly capitalized firms with $A < \underline{A}_H$ cannot invest at all since they have no access to any type of finance. In between, somewhat capitalized firms with $\underline{A}_H < A < \overline{A}_H$ can invest only to the extent that they are monitored and demand domestic bank loans. Firms in the monitoring region $[\underline{A}_H, \overline{A}_H]$ finance their investment with a mixture of domestic and foreign debt. As already mentioned, whether firms hedge their foreign debt or not also depends on the size of their initial asset. Well-capitalized firms need not hedge if $A > \overline{A}_{SNH}$ but must hedge if A $\in [\overline{A}_H, \overline{A}_{SNH}]$. Similarly, somewhat capitalized firms need not hedge if A $\in [\underline{A}_{SNH}, \overline{A}_H]$ but must hedge if A $\in [\underline{A}_H, \underline{A}_{SNH}]$.

A typical firm within the monitoring region uses a mixture of domestic and foreign

currency debt to finance its investment. However, as mentioned above, there are firms with net worth $A < \overline{A}_H$ but $A + I_m > I$ that only demand bank loans in domestic currency and invest their excess funds outside the firm at the market rate. The minimum net worth requirement for these firms is A_B and is lower than $\overline{A}_H$.

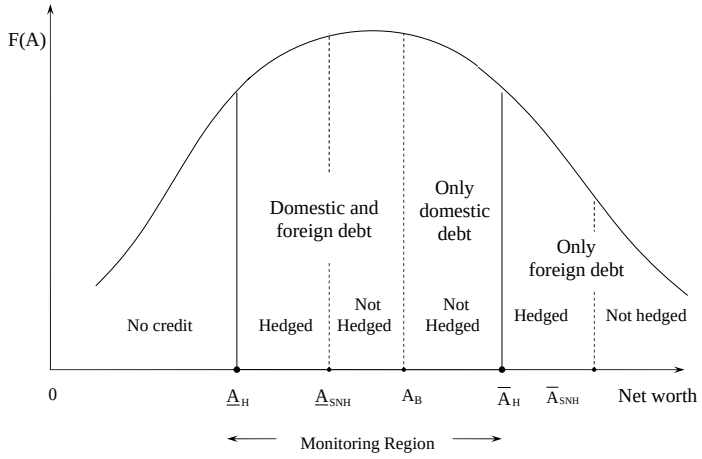

Figure 2.2: Equilibrium Segmentation of firms

The distribution of net worth requirements in the equilibrium segmentation implied by Lemma 2 and depicted in Figure 2.2 is:

$$\underline{A}_H < \underline{A}_{SNH} < A_B < \overline{A}_H < \overline{A}_{SNH}$$

Interestingly now, within the monitoring region there are firms borrowing in domestic and foreign currency, some of which must be hedged, and also firms borrowing only in domestic currency that need not hedge. Note that in the equilibrium segmentation displayed in Figure 2.2 firms may borrow only in domestic currency after having the possibility to borrow in both currencies and not the opposite. This ap-

parently surprising feature of the model is explained by the fact that domestic loans are more expensive and supplied in a fixed amount due to fixed monitoring costs. Therefore, firms in the monitoring region use the fixed amount in domestic currency only after exhausting the possibility of borrowing in foreign currency depending on the size of its net worth. Furthermore, firms within the monitoring region are different from firms borrowing only in foreign currency because for the first group, bank monitoring makes the moral hazard problem less severe.

Lemma 1 and Lemma 2 are consistent with prior predictions in the literature, in particular with the government guarantees approach that highlights the incentives for firms to borrow extensively in foreign currency debt without hedging when the exchange rate is fixed. If the fixed exchange regime is credible so that $q = 0$ and the expected exchange rate at date 1 is $s_L = 1$, there is no possibility of financial default and the equilibrium segmentation is similar to that in the original Holmstrom and Tirole model, with firms borrowing in foreign currency and not hedging. Another interesting implication derived from Lemma 2 is that not all firms must hedge during a floating regime because some of them have enough net worth to be financially solvent even in the depreciation state.

2.4.2 Equilibrium with costly hedging ($\phi \geq 0$)

In the previous analysis when $\phi = 0$ net worth requirements $\underline{A}_{NH}$ and $\overline{A}_{NH}$ are irrelevant because all firms are optimally hedged. This is not the case when hedging is costly. The next result shows that currency mismatches also arise during floating regimes because hedging activities even if available can be unaffordable for all firms when transaction costs in currency forward markets are sufficiently high.

Proposition 1. *With costly hedging and a positive probability of depreciation the optimal strategy for a firm in the monitoring region, regarding debt composition and hedging, depends on* q *and* ϕ *such that:*

1. *When* $q \geq \overline{q}$ *the firm borrows the least it can in domestic currency from local banks and borrows the rest in foreign currency from foreign banks and does not hedge its foreign debt.*

2. *When* $0 < q < \overline{q}$ *and* $0 < \phi < (1-q)(s_H - s_L)$ *the firm finds it optimal to borrow the least it can in domestic currency from local banks and the rest in foreign currency from foreign banks and:*

   - *If* ϕ *is small enough then the firm with* $\underline{A}_H < A < \underline{A}_{SNH}$ *will always hedge its foreign debt.*
   - *If* ϕ *is sufficiently high then only some firms with* $\underline{A}_{NH} < A < \underline{A}_{SNH}$ *hedge its foreign debt.*

3. *When* $\phi \geq (1-q)(s_H - s_L)$ *the firm finds it optimal to borrow the least it can in domestic currency from local banks and the rest in foreign currency from foreign banks and does not hedge its foreign debt.*

Proof: See Appendix B.3

Figure 2.3 illustrates all different hedging possibilities implied by Proposition 1. Notice that the minimum net worth requirement to obtain credit in both domestic and foreign currency varies depending on parameters q and ϕ. In the first case, extremely high probability of depreciation makes optimal hedging zero so that no firm participates in currency forward markets. A similar situation occurs in the third case when some firms have incentives to hedge but forward contracts are too expensive or nonexistent. Although these two situations look similar in that firms do

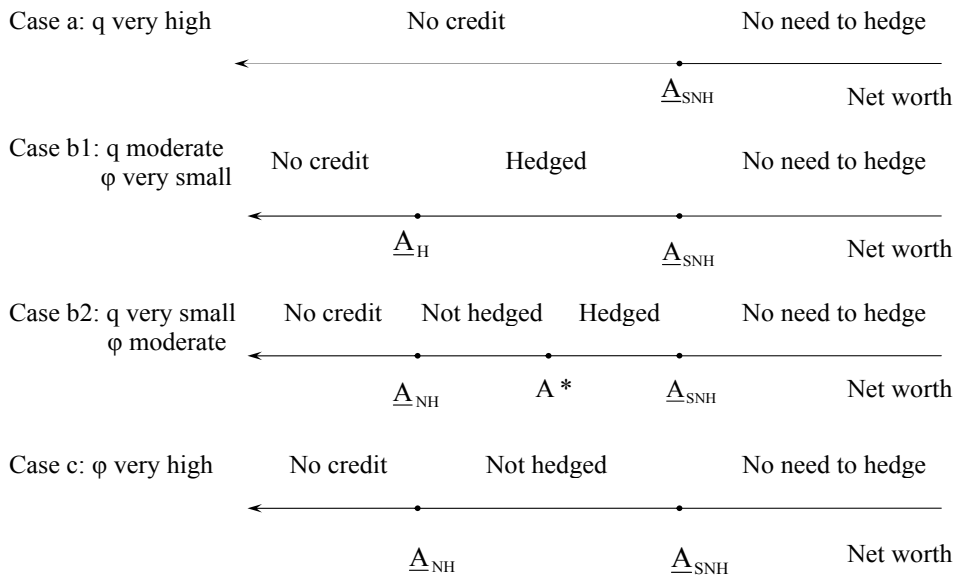

Figure 2.3: Different Hedging strategies within the monitoring region.
This graph shows different cutoff levels of net worth defining different hedging strategies for firms that use a mixture of foreign and domestic debt. In the graph $\underline{A}_H$ is the minimum net worth requirement for a firm that must hedge to be solvent, $\underline{A}_{SNH}$ is the minimum net worth requirement for a firm to be solvent even without hedging, and A^* is a specific net worth requirement for firms that must hedge when hedging is moderately costly.

not hedge, they are different and have different interpretations. Intuitively, higher values of both q and ϕ increase the net worth requirement making it more difficult to borrow in both domestic and foreign currency. In the first situation (Case a), q is too high and the firm is forced to borrow only small amounts in foreign currency so that it can be solvent in state H without hedging. In the third case (Case c), however, a firm that is not solvent in state H is still able to borrow larger amounts of foreign debt even when it cannot afford to hedge. This latter firm has a currency mismatch in its balance sheet and would default if state H happens.

The second case in proposition 1 corresponds to intermediate values of q and ϕ which allow firms to hedge. When the cost of hedging is small enough any firm needing to hedge to be solvent will always hedge (case b1) and the cutoff level $\underline{A}_{NH}$ is irrelevant. However, as the cost of hedging increases some firms have incentives to borrow in both currencies but find it optimal not to hedge their foreign debt. Now $\underline{A}_{NH}$ becomes the relevant cutoff level defining the lower limit in the equilibrium segmentation. The proof of proposition 1 describes the cutoff level A^* below which firms do not hedge because hedging is too costly. These firms would default in the event of currency depreciation (case b2). This particular situation describes the case of economies of scale in hedging operations. Firms with small net worth tend to be highly leveraged and demand more foreign currency debt than larger firms and cannot cover this exposure because the level of hedging required is not affordable. In contrast, firms with higher net worth demand less foreign currency debt and require a lower level of hedging to manage their exposure even when forward contracts are somewhat expensive.

The preceding analysis shows that the equilibrium segmentation is determined by endogenous net worth requirements which, in turn, depend on exogenous parameters, in particular, those describing the macroeconomic environment such as interest rates, exchange rates, probability of currency depreciation and costs of hedging. All these parameters are the same for every firm. Hence, the investment project has a unique segmentation in equilibrium. Depending on its initial assets, a firm determines both its debt composition and its hedging strategy by locating itself within the segmentation. The next result illustrates how different parameters associated with different exchange rate regimes and different stages of development in forward markets affect the allocation of domestic and foreign debt and the hedging behavior.

Proposition 2. *When the economy moves from fixed to floating exchange rates and in the floating regime* $0 < q < \overline{q}$ *and* $\phi < (1-q)(s_H - s_L)$*, all else equal:*

1. *Fewer firms obtain funding for their investment.*
2. *Fewer firms finance their investment borrowing directly form foreign banks.*
3. *Some firms borrowing only in foreign currency from international banks during the fixed exchange rate turn to local banks and demand domestic loans during the floating regime.*

Proof: See Appendix B.4

To illustrate these results, consider that in equilibrium, domestic currency borrowing I_m is a fixed amount and each firm in the economy demands the same minimum amount from local banks. The aggregate demand for domestic bank loans D_m is then:

$$D_m(r^*, q) = [F(\overline{A}_H(r^*, q)) - F(\underline{A}_H(r^*, q))]I_m(r^*, q)$$

where the individual demand I_m is written as a decreasing function of both r^* and q. On the other hand, the aggregate demand for foreign currency loans is given by:

$$D_u(r^*, q) = \int_{\underline{A}_H(r^*,q)}^{\overline{A}_H(r^*,q)} [I - I_m(r^*, q) - A]dF(A) + \int_{\overline{A}_H(r^*,q)}^{\infty} [I - A]dF(A)$$

Since r and q are exogenous parameters and assuming perfect competition in the domestic banking system, the supply of domestic funds is perfectly elastic at the domestic lending rate r and the supply of foreign loans is perfectly elastic at the

international interest rate r^*, which means that D_m and D_u determine respectively the aggregate amounts of domestic and foreign lending in equilibrium.

An increase in q brought by the collapse of the fixed exchange rate regime has an ambiguous effect on D_m because both cutoff levels $\underline{A}_H(r^*, q)$ and $\overline{A}_H(r^*, q)$ increase and there are two opposing effects. A first group of firms with insufficient net worth and those unable to hedge cannot borrow at all and are dropped so that D_m decreases. Some other firms turn to domestic banks and increase D_m because they have insufficient net worth or are unable to hedge and cannot borrow only in foreign currency.

The impact of q on D_u is ambiguous as well. Firms that were previously borrowing in foreign debt and turned to domestic debt reduce their demand for foreign currency debt so that D_u drops. However, firms with intermediate net worth and those able to hedge remain in the monitoring region and increase their demand for foreign debt because I_m decreases for them and, as a result, D_u increases. In sum, a number of firms borrow less in both currencies and some others borrow more in foreign currency. The extent to which these changes in the population of firms affect the aggregate currency composition of debt depends on the distribution function F(A). Possible changes in the population of firms after the collapse of the fixed exchange rate regime are illustrated in the next figure.

Figure 2.4 shows that the switch in the exchange rate regime shifts the monitoring region to the right, making it more difficult for firms to borrow in foreign currency. Note that all net worth requirements except $\overline{A}_{SNH}$ shift to the right when the probability of currency depreciation increases. The minimum net worth requirement for firms that are solvent even without hedging and borrow directly from international banks does not shift because it does not depend on the probability of depreciation,

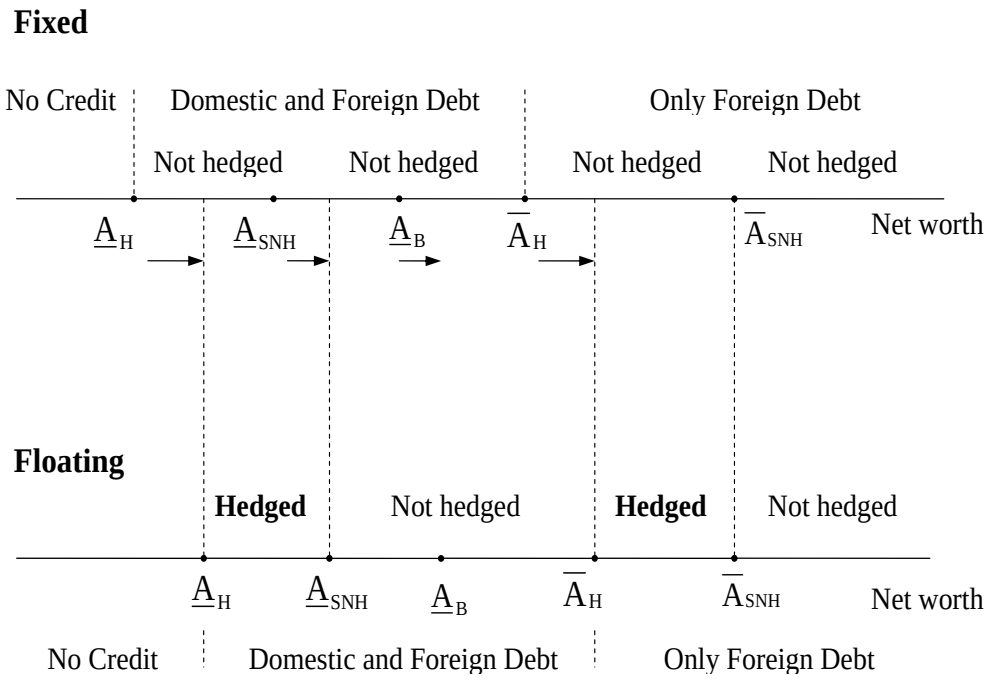

Figure 2.4: Changes in the equilibrium segmentation of firms
This graph shows how the net worth requirements defining the equilibrium segmentation of firm change when the economy moves from fixed to floating exchange rates. In the graph, $\underline{A}_H$ is the minimum net worth requirement for a firm that must hedge to be solvent and borrow in domestic and foreign debt, $\underline{A}_{SNH}$ is the minimum net worth requirement for a firm to be solvent even without hedging and borrow in foreign and currency debt, $\underline{A}_B$ is the minimum net worth required to borrow only in domestic currency. $\overline{A}_H$ is the minimum net worth requirement for a firm that must hedge to be solvent and borrow directly from foreign banks, $\overline{A}_{SNH}$ is the minimum net worth requirement for a firm to be solvent even without hedging and borrow directly from foreign banks.

which means that firms with such large net worth are not concerned about exchange rate risk when they borrow in foreign currency.

Figure 2.4 also illustrates that changes in hedging behavior can be significant if the increase in the probability of depreciation is relatively small. However, depending on

how large q and ϕ are, these changes could be small. For example, as q increases and approximates to $\overline{q}$ the group of firms that hedge using currency forwards becomes smaller and can be very small if ϕ is also sufficiently high as to prevent some firms from hedging.

2.4.3 The Brazilian Experience

As a final illustration, consider how the results of the model match up with the currency crisis in Brazil in early 1999. The model results suggest that the lack of major changes in the borrowing behavior of the corporate sector in Brazil could reflect a moderate increase in the probability of currency depreciation and the existence of somewhat costless hedging. After the floating regime is adopted, some firms borrow less in both domestic and foreign currency and some others borrow more in foreign currency. Moreover, a group of firms borrowing in foreign currency do not hedge either because they cannot afford to buy forward contracts or because their net worth is sufficiently high and they are solvent even in the event of currency depreciation. These changes in the population of firms can offset each other so that the currency composition of debt does not vary significantly across regimes.

Needless to say, there are various other aspects of the macroeconomic environment as well as firm-specific characteristics conditioning the currency composition of lending and the hedging behavior of firms in reality. Moreover, in contrast to what the model assumes, a currency crisis most likely affects the firms' net worth so that the distribution of firms may not be constant across regimes. Furthermore, other parameters such as the probability of success and the investment payoff R are certainly different across firms and are also affected by the collapse of the exchange rate regime. How companies deal with higher foreign exchange risk definitely depends on changes in these variables, treated as invariant parameters in the model. For

example, depending on specific characteristics such as export status, type of ownership or the existence of other sources of funding; firms can adopt hedging strategies other than the use of currency forwards. Nevertheless, the model developed in the paper suggests changes in the behavior of a representative firm and impacts on the population of firms that are broadly consistent with the empirical facts observed in recent currency crises in small open economies, and in particular, in Brazil over the period 1996 to 2001.

2.5 Conclusion

This paper introduces hedging decisions in a model of optimal debt allocation at the firm level to understand the sources of currency mismatch in the balance sheet of the corporate sector of countries that recently faced a currency crises. The model explains why some firms with access to foreign currency debt hedge their currency exposure and others do not, as an optimal response to appropriate incentives given by the macroeconomic environment. Under fixed exchange rates firms borrow extensively in foreign currency and do not hedge because they have no incentives to do so given that government provides a type of free risk management. Under a floating regime, when the probability of currency depreciation is moderate and hedging is affordable firms use currency forwards to hedge their exchange rate risk exposure and reduce the probability of financial default. Hedging complements net worth required by creditors allowing hedged firms to expand their capacity to access foreign capital markets.

Despite the obvious limitations of a partial equilibrium analysis and some simplifying assumptions, the model is able to provide an analytical framework to determine endogenously the currency composition of credit and the optimal level of hedging at

the firm level. Consistent with the empirical evidence in Brazil during 1996 to 2001, the model predicts that with a moderate probability of currency depreciation and somewhat costless hedging, the changes in the population of firms after the economy adopts a floating regime can offset each other so that the currency composition of debt does not vary significantly across regimes.

While the currency composition of debt remained stable in Brazil after the collapse of the exchange rate regime, costless hedging operations seem to provide an effective vehicle to reduce foreign exposure without affecting significantly the aggregate level of borrowing. A direct policy implication of the model is then the necessary emphasis that policymakers should give to the development of currency derivatives markets to help the corporate sector smooth the transition to a free-floating exchange rate regime.

Table 2.1: Brazil: Currency Composition of Debt and Hedging Operations (in means)

	1996	1997	1998	1999	2000	2001	Average Fixed ER	Floating ER
Foreign Debt/Total Debt	38.1	43.2	43.6	44.6	44.8	45.1	41.6	44.8
Small	27.3	32.2	23.6	27.3	29.5	23.9	27.7	26.9
Medium	35.2	40.7	43.0	46.0	44.6	46.2	39.6	45.6
Large	53.7	58.5	63.3	58.2	59.5	63.3	58.5	60.3
Currency Derivatives/Foreign Debt	0.5	4.9	7.0	6.1	11.6	27.5	4.1	15.1
Small	0.0	0.0	3.4	0.0	0.0	2.3	1.1	0.8
Medium	0.0	5.5	7.1	7.4	8.6	22.4	4.2	12.8
Large	1.5	6.3	8.7	7.1	22.7	48.5	5.5	26.1

Note: Total debt is the sum of foreign and domestic debt and both are measured in local currency.
Currency derivatives correspond to the notional value of forwards, futures, swaps and options.
Source: Financial annual reports and footnotes to financial statements of companies publicly traded at the São Paulo Stock Exchange Market (BOVESPA).

Table 2.2: Brazil: Exchange Rate Exposure over time

	Fixed ER				Floating ER	
	1996	1997	1998	1999	2000	2001
Total Number of firms	110	149	177	179	183	185
Number of firms with no financial debt	5	4	4	5	6	4
Number of firms with only domestic debt	20	29	34	36	36	40
Number of firms with dollar and domestic debt	84	114	136	135	136	137
Firms hedged using dollar derivatives	1	6	23	23	39	62
Firms not hedged	83	108	113	112	97	75
Number of firms with only dollar debt	1	2	3	3	5	4
Firms hedged using dollar derivatives	0	1	0	0	1	0
Firms not hedged	1	1	3	3	4	4

Source: Financial annual reports and footnotes to financial statements of companies publicly traded at the São Paulo Stock Exchange Market(BOVESPA).

CHAPTER III

The Financial Effects of Real Hedging

3.1 Introduction

This chapter considers the use of currency derivatives by Brazilian firms in a period surrounding the 1999 currency crisis, and examines the effect of hedging on firm policy and value.[1] Until January 1999, Brazil had a managed exchange rate policy (a "crawling peg") for its currency, the real. Following a severe currency crisis, the policy was abandoned in favor of a fully floating exchange rate in January 1999. The economy suffered through a large recession as a result of the crisis. Many firms in Brazil had liabilities denominated in foreign currencies (primarily US dollars), and were now exposed to large levels of currency risk. Usage of currency derivatives increased steadily from 1997 to 2004, our period of study, with over 40% in the sample using currency derivatives by the end of the period.

Our setting has a number of natural advantages. First, following the radical change in exchange rate policy and the upheaval in the economy, Brazilian firms were in a state of disequilibrium. It would require some time for firms to determine what their optimal policies should be in the new environment. If all firms are behaving optimally, in equilibrium hedging should not add value.[2] Put another way,

[1] This chapter is co-authored with Uday Rajan and Amiyatosh Purnanandam.

[2] For example, in the model of Adam, Dasgupta, and Titman (2007), in equilibrium some firms hedge and others do not, but each firm is indifferent between hedging and not. Thus, no firm can gain from changing its hedging strategy.

if hedging does appear to be of value, non-hedging firms must either be behaving sub-optimally, or perhaps have some hidden cost to hedging that is unobserved by the econometrician. Thus, we are more likely to find that hedging has an effect in a disequilibrium situation.

Second, the nature of the risk faced by firms is clear. In our sample, we restrict attention to firms that had some liabilities denominated in foreign currency over the period of study. In the fixed exchange rate period, such positions were hedged via government policy, so to speak. Once the exchange rate was floated, firms would have to hedge on their own to protect against a further fall in the Brazilian real. Thus, both the source of risk and the direction of the hedge are immediate to deduce, with a clear prediction that hedging currency risk should lead to greater foreign currency debt. For many studies with US firms, it can be unclear whether firms are hedging or speculating, or indeed what the nature of their exposure is. For example, a firm using currency derivatives in the US may be concerned about a rise in the dollar (if it is an exporter) or a fall in the dollar (if it imports any components or materials).

Finally, the crisis itself was exogenous to the actions of any particular firm, though of course it came about as a result of a weakness in the overall economy. Since the decision to hedge is endogenous, our setting does not completely represent a natural experiment. Nevertheless, it is a setting in which the value of currency hedging exogenously changed from close to zero (in the fixed exchange rate period) to a large positive number (in the floating exchange rate period). If hedging has any value, its value should be demonstrable when such a large shock occurs.

Why do firms hedge? Stulz (1996) suggests that the primary reason to hedge is to reduce the likelihood of costly "left-tail" events such as financial distress or an inability to carry out an investment policy. Leland (1998) formally demonstrates

this motive in a dynamic capital structure model: the reduction in the probability of financial distress leads to increased debt capacity and thus to a higher firm value via increased interest tax shields. Empirically, Graham and Rogers (2002) examine a sample of US firms in the period 1994–95, and suggest that firms indeed hedge to increase debt capacity, and the resultant tax benefits add about 1.1% to firm value.

While we also find that hedging increases debt capacity and is associated with higher value, there is a subtle difference that comes from our context. Following the currency crisis, it is reasonable to argue that the Brazilian economy as a whole was capital-constrained, as were firms in particular. In such an environment, foreign currency debt, when available and hedgeable, can be a cheaper source of capital than domestic debt.

We consider a sample of firms that have foreign currency liabilities, and so are exposed to foreign exchange risk. We identify firms in our sample that use currency derivatives, and tag these as "hedgers." While hedged firms in our sample have higher levels of foreign currency debt as compared to non-hedgers, they have lower levels of domestic debt, so that there is a substitution away from domestic to foreign currency debt. Of course, hedging and leverage are simultaneously determined as part of optimal financial policy, as shown in the model of the second chapter and also as Graham and Rogers (2002) point out. Since hedging increases only foreign debt capacity, overall leverage proves to be a good instrument in estimating the decision to hedge. Controlling for this endogeneity, we find that the ratio of foreign to total debt is approximately 16% higher for hedged firms.

We further find that hedged firms are able to invest more than non-hedged firms. Hedgers have a capital expenditure to total assets ratios about 20% higher than non-hedgers. Thus, in our setting, hedging adds value by enabling firms to maintain

capital expenditures at a time of overall economic stress. The basic friction faced by firms is a shortage of capital, which results in underinvestment by non-hedged firms. The benefit of currency hedging is thus twofold: it provides greater access to capital, and it provides greater access to a cheaper source of capital, foreign currency debt. Thus, we provide evidence to support the theoretical predictions of Froot, Scharfstein, and Stein (1993), who point out that hedging can increase value by mitigating the underinvestment problem.

Using a sample of US firms over the period 1990–95, Allayannis and Weston (2001) estimate that on average there is a premium of 4.87% of value for firms that use foreign currency derivatives. However, it is unclear what frictions faced by US firms would lead to such a large premium. Muddying the waters further, Guay and Kothari (2003) demonstrate the extent of derivative usage by US firms is small. In their sample, a simultaneous three standard deviation change in exchange rates, interest rates, and commodity prices will change the equity value of the median firm by only 1.3%.

Since using derivatives is an endogenous decision, it is possible that non-users have devised other methods of hedging. Indeed, Tufano (1996) points out that gold firms employ many different methods of operational and financial hedging. Since we cannot determine operational hedging techniques given our data, we use the terms "derivative user" and "hedger" synonymously. Petersen and Thiagarajan (2000) demonstrate the case of two gold firms with similar eventual risk exposures, though one uses derivatives and the other a mix of methods. This again brings us back to the idea that, in equilibrium, hedging should not add significant value.

A possible resolution for this paradox is that the hedging premium estimated by Allayannis and Weston (2001) is not directly related to a friction that has been over-

come, but is rather associated with the overall financial skill and savvy of the firm's managers. That is, derivative usage is a proxy for overall financial sophistication, and sophisticated firms have higher value.

In our sample, we find that while derivative users and non-users have similar gross margins, derivative users have significantly higher net incomes (both margins and net incomes are divided by total assets to control for scale), controlling for factors such as size and leverage. The economic magnitude here is striking, with net income being approximately 80% higher for hedger firms. At least indirectly, we are thus able to demonstrate that derivative usage is an important component of financial policy for hedged firms.[3]

Our results on the financial performance of hedged versus unhedged firms contrast somewhat with those of Allayannis, Brown, and Klapper (2002), who find that, following the East Asian currency crisis, hedged foreign currency debt is associated with worse financial performance of East Asian firms, whereas unhedeged debt is not. In their work, the worse performance of firms with hedged debt is attributed in part to illiquidity of derivative markets following the currency crisis. The difference in our results is perhaps attributable to the longer period of our study. The bulk of derivative usage occurs in the later years in our sample.

Overall, we find that hedger firms have a value that is 5–6% higher than that of non-hedgers. The magnitudes of the differences in net income, capital expenditures, and profitability support a value difference of this size. As is standard in the literature, we use Tobin's q, or the ratio of market value of the firm to its book value, as our measure of value. The increase in value obtains even after controlling for unobservable firm characteristics via firm fixed effects. In a fixed effects regression,

[3]We do not have data on the positions and terms of derivatives held by firms, so cannot directly conduct an analysis similar to Guay and Kothari (2003).

identification of the coefficient on the hedger variable comes via firms that switch from not using derivatives to using derivatives in a given year. Thus, we are able to exploit the panel nature of our data.

Thus, in our context, derivatives add value by helping a firm overcome an identifiable and large friction. An important contribution of our paper is to demonstrate a specific channel via which hedging can add value: it increases a firm's capacity to take on foreign currency debt. In addition to implications for cash flows, this has a direct effect on a firm's cost of capital, to the extent that hedged foreign debt is a cheaper form of capital than domestic debt at a time of extreme transition in the economy.

In related work, Rossi (2007) examines the decision of Brazilian firms to hedge, and their choice of instruments, over the period 1996 to 2004, using a data set that is substantially similar to ours. Our results on the driving factors behind the hedging decision are similar: this decision depends on the size of the firm and the extent of foreign currency debt. While our focus is on the effect of hedging on firm value and financial performance, in the last section of the paper, we account for the endogeneity in the decision to hedge.

The rest of the chapter is organized as follows. We provide some background information on the Brazilian economy and the currency crisis in Section 3.2. Section 3.3 briefly describes our data and sources, while Section 3.4 contains the main results. We conclude with Section 3.5.

3.2 Brazil: Macroeconomic Environment

In late 1998 and early 1999, Brazil suffered from a financial crisis that led to its currency, the real, being fully floated on January 15, 1999. The real (denoted as

R$) was introduced in July 1994, as part of a stabilization package known as the Real Plan. The package included elements of privatisation and dollarisation, and was primarily intended to control inflation (which had averaged 1,403% per year from 1990 to 1993) and foster economic growth. The plan successfully reduced inflation to 20% by 1995. Averbug (2002) describes the motivation and implementation of the Real Plan.

As part of the plan, important regulatory changes were also introduced in the financial markets to reduce the controls on capital flows and improve the access of corporations to foreign currency debt from international capital markets. With the introduction of the real, a crawling peg exchange rate regime was adopted, with preannounced narrow bands within which the exchange rate was maintained. In this paper, we refer to the period before January 1999 as the "fixed exchange rate regime."

The years leading up to 1999 saw financial crises affect Mexico (1994), East Asia (1997), and Russia (1998). The Brazilian economy was especially severely affected by the Russian crisis of August, 1998, and suffered substantial capital outflows. External aid from the IMF and the G-7 provided a breather, but capital outflows increased again in January, 1999, leading to the fixed exchange rate regime being abandoned in favor of a floating regime. There were continued shocks to the economy in the floating exchange rate period, with the Argentina crisis of 2001–02 having a ripple effect throughout Latin America, and a presidential election in 2002 contributing some political uncertainty.

3.2.1 Exchange rate and GDP

Figure 3.1 displays the exchange rate (in real/$) and nominal GDP of Brazil over the period 1996 through 2005. As seen from the figure, the exchange rate surged

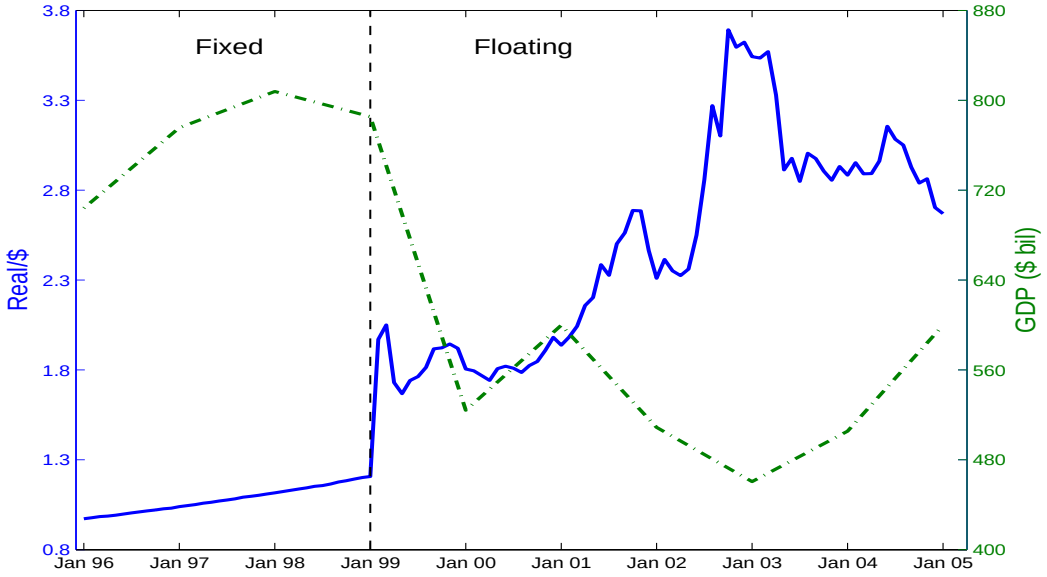

Figure 3.1: Brazil exchange rate and GDP, 1996 to 2005

immediately after the real was floated in January, 1999, with the value of the real falling by about 65% within two weeks. The real/$ rate increased sharply again in 2001 and 2002. Further, compared to the orderly change in the value of the real in the fixed exchange rate regime, in the floating era the real was significantly more volatile. The figure also displays Brazil's GDP from 1996 to 2005. GDP fell substantially in 2000 and 2002 as the economy experienced a severe contraction in response to the financial crisis.

During the fixed exchange rate period of the Real Plan, Brazilian firms had borrowed heavily in dollars, though the supply of foreign capital was periodically affected by crises in other parts of the world. Of course, during this period, firms had no incentive to hedge their exchange rate exposure, since the real-to-dollar rate was stable and predictable. After January 1999, firms that had relied on foreign debt were now exposed to exchange rate risk, increasing their financial vulnerability.[4] In addition, from the viewpoint of a foreign lender, loans to Brazilian companies were

[4]Examining a 1991 devaluation in Brazil, Bonomo, Martin, and Pinto (2003) find a significant drop in corporate investment.

now riskier.

3.2.2 Interest rates

Figure 3.2 displays the evolution of the "Selic," the Brazilian Central Bank's overnight lending rate, from the period 1996 through 2004. Apart from a couple of spikes corresponding to the East Asian (1997) and Russian (1998) currency crises, the Selic rate in this period hovered around 20-25%.

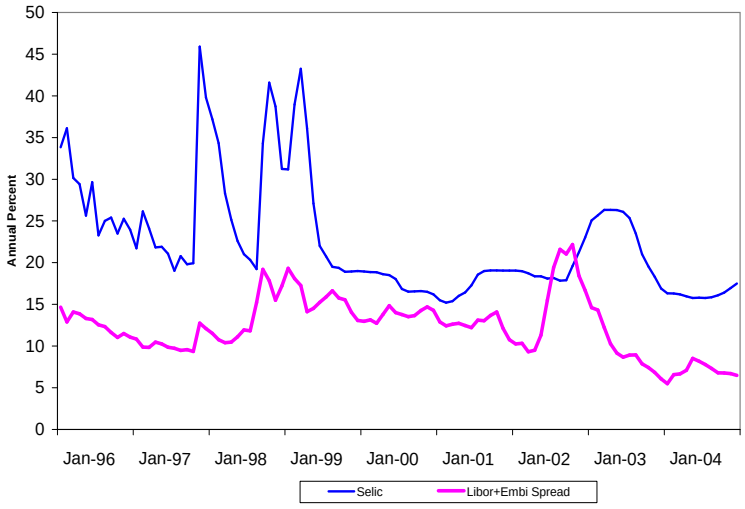

Figure 3.2: Domestic interest rate (Selic) and foreign borrowing rate

Also displayed in the figure is a proxy for the cost of foreign loans to a Brazilian firm. This proxy is determined by the LIBOR rate plus the JP Morgan Emerging Markets Bond Index (EMBI) spread. The EMBI spread is a global emerging markets spread that accounts for currency and country risk. Since it is a global spread, it is a crude proxy for the cost of foreign capital to a Brazilian firm. Nevertheless, during the period of study, the Selic was consistently higher than the proxy cost of foreign

loans, suggesting that foreign currency debt was cheaper than domestic debt.

An important reason why domestic credit in Brazil may have been more expensive than foreign credit is imperfect competition in the domestic banking sector. Suppliers of foreign capital competed in global markets, and had to offer competitive rates. However, the domestic banking sector had low levels of financial intermediation, and inefficiencies in the legal system resulted in high costs of debt recovery in case of firm defaults. Belaisch (2003) finds evidence of oligopolistic behavior in the Brazilian banking sector. Further, during this period, the government had exhibited a tendency to meet its financial needs by issuing high-yielded securities, possibly crowding out investment in domestic firms. Arida, et al., (2005) suggest that high credit spreads for Brazilian firms were mainly caused by this crowding out effect.

3.2.3 Stock market capitalization

Figure 3.3 displays the total market capitalization of the Brazilian stock market. The market capitalization reflected a cyclical behavior that followed closely the evolution of global markets and the instability associated with financial and currency crises in emerging market economies. Compared to the fixed exchange rate regime, market capitalization increased during the floating regime, particularly the year 2000. On average, market capitalization increased from US$217 billion (25% of GDP) before the currency crisis in 1996 to US$ 341 billion (44% of GDP) by 2004. Overall capitalization fell in the year preceding the currency crisis (1998) and in 2001-02, with a short period of political uncertainty during the presidential elections in 2002. The increase in the later years was facilitated both by the recovery of the economy as a whole and by an improved and modern legal framework.

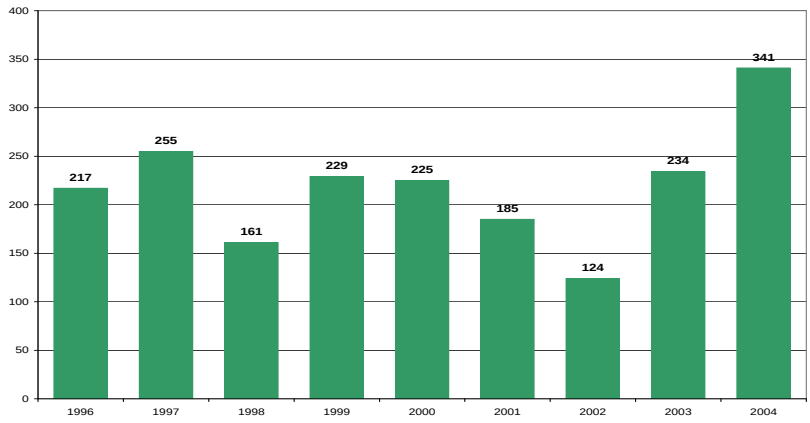

Figure 3.3: Stock market capitalization (billions of reals)

3.3 Data

Data are collected from two sources. First, we obtain financial statement and market value information for all Brazilian firms listed in the *Economatica* database as of August, 2006. This comprises a list of more than 350 firms. We exclude financial firms, which may use currency derivatives to hedge operational rather than financial risk. We also exclude state-owned and foreign-owned firms, both of which may have deep pockets.

For each of the firms contained in the database in 2006, we obtain annual financial statements and equity market values for the period 1997 through 2004 from *Economatica*. Thus, our data consist of large firms only, and potentially suffer from a survivorship bias: we have no data on firms that may have gone bankrupt or been acquired. If non-hedgers are more likely to fail, the bias works against our finding any value to hedging.

While *Economatica* provides equity market values on many firms, there are several

missing values. As a second way of determining equity values, we also determine for each firm, and each class of share it has issued, the average daily closing price for the last five trading days of each year. The two main classes of shares issued are "ON" (corresponding to common stock) and "PN" (corresponding to preferred stock), with some firms having sub-classes of each. We then determine the value of each class for each firm by multiplying the average price times the number of shares outstanding, and add across the classes to determine the overall market value of equity for the firm. For many firms, there are no data on market prices. As a cross-check, we find a high correlation between the market values from the two methods, when both are available.

Our second source of data is BOVESPA, the Brazilian stock exchange, in São Paulo. The BOVESPA web site provides the footnotes to the annual financial statements over our period of study. The sets of firms listed in *Economatica* and BOVESPA are different so that our overall data set is the intersection of these two sources of information. We obtain the following items of information for each firm and each year from the footnotes to the balance sheet: whether a firm uses foreign exchange derivatives, whether it is an exporter, whether it has dollar assets, and the amount of foreign debt outstanding.

Following regulation CVM No. 235, introduced on March 23, 1995, in the footnotes to the balance sheet a publicly traded company is required to disclose whether it uses derivative contracts, and also the nature and face value of the contracts.[5] Thus, for many firms, we can identify whether they use currency derivatives. Many non-users explicitly mention that they do not use derivatives, whereas many firms also do not mention derivatives at all. The latter are treated as missing values. Since

[5]The CVM is the Brazilian analog of the SEC in the US.

we only know the kinds of derivative contracts used (e.g., exchange rate or currency derivatives, and swaps, options, or forward contracts) and their notional value, but not the terms of the contracts themselves, we create a dummy variable *dderiv* set to 1 if firms use foreign exchange derivatives, and zero otherwise.

Similarly, we create a dummy variable *export* set to 1 if a firm is an exporter, and zero otherwise. On exports, some firms disclose data on exports as part of the annual report to the senior administration. In other cases, firms mention they are exporters but do not disclose information about foreign sales. The *export* dummy is set to 1 in each case.

We also create a dummy variable *dol* set to 1 if a firm holds assets denominated in or indexed to US dollars. Such assets include cash and deposits in foreign currency and government bonds (treasury notes and central bank bonds indexed to the dollar). Finally, in many cases, firms report the currency composition of their debt, from which we determine the foreign to total debt ratio for each firm.

Our basic measure of value is the ratio of a firm's market value to its book value, where market value is determined as the sum of book value of debt and market value of equity, and book value is the sum of book value of debt and book value of equity. We remove observations with missing values for market value of equity, book equity, cash holdings, and derivative usage. Finally, we restrict the sample to firm-year pairs in which a firm had some exposure to foreign currency risk, in terms of foreign currency debt. We expect currency derivatives to not have any value for firms which are not exposed to currency risk.

Our final data set is an unbalanced panel containing 167 firms and 1,023 observations (firm-year pairs). We winsorize all variables in both tails at the 1% level to control for outliers.

Figure 3.4 shows the number of firms in each year of our sample. The number of derivative users grows for the first four years and levels out between 53 and 58 over the last four years. The total number of firms grows for the first three years, and is between 133 and 141 over the last five years.

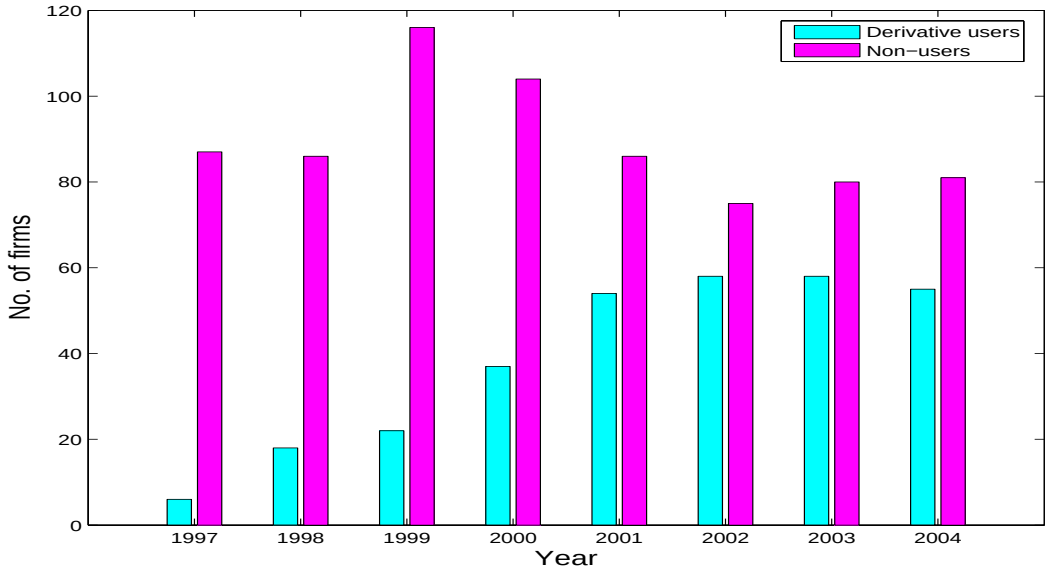

Figure 3.4: Number of firms in sample

3.4 Results

Our principal argument is that hedging with derivatives increases the foreign debt capacity of a firm, which in turn increases firm value by lowering the cost of capital. Our tests investigate both the effect of derivative usage on firm value and its effect on the foreign debt taken on by a firm. Our measure of value is in the spirit of Tobin's Q and is computed as the ratio of (book value of debt plus market value of equity) to (book value of debt plus book value of equity).

We start with a description of the key statistics of our sample firms and a univariate comparison of derivative users and non-users. For the rest of the paper, we use the term "hedgers" to mean "derivative users" and "non-hedgers" to mean

"non-users."

Table 3.1 presents some descriptive statistics. Panels A and B provide the mean, median and standard deviation of some key firm characteristics of hedgers and non-hedgers respectively, and Panel C provides the corresponding statistics for all firms. Apart from the usual caveats that apply to univariate tests, in our exercise we also need to keep in mind the effect of pooling observations across different years.

The univariate analysis shows some obvious differences in firm characteristics across the two groups. Hedgers are much larger firms, both in terms of their revenue and market capitalization. The median hedger firm's revenue (R$ 1,214 million) is more than five times that of the median non-hedger firm (R$ 228 million). The median hedger firm's book leverage (33.69%) is about 10% higher than that of the median non-hedger firm (22.39%). Noticeably, while the domestic leverage (i.e., the ratio of local currency debt to book value of assets) is similar at about 10% for the median firm across the two groups, hedgers have a substantially higher foreign currency leverage (defined as the ratio of foreign currency debt to book value of assets). The median hedger firm has a foreign currency leverage of 20.96% as against 4.93% for the median non-hedger firm. The differences in firm size, book leverage and foreign leverage across the two groups are all significant at 1% level. Further, we find that hedgers keep significantly higher cash-balances as compared to non-hedgers.

We also investigate the operating profitability and capital expenditures of the two groups. While the earnings before interest and taxes (scaled by total assets), called *margin* in the table, is similar (about 20%) across the two groups, we find that hedgers have net income to assets ratio approximately double that of non-hedgers, and a capital expenditures to assets ratio almost 50% higher than non-hedgers. Finally, we find that the median asset market-to-book ratio for hedgers is

1.01 as against 0.71 for the median non-hedger firm. This difference is significant at 1% level.

Overall, our univariate results show that hedgers are large firms with high leverage, especially high foreign currency debt. They seem to have similar operating profitability as non-hedgers, but are able to invest more via capital expenditures. In addition, their market value is significantly higher compared to their non-hedger counterparts. Given the differences in their characteristics, it is hard to attribute this large value difference to the usage of derivatives alone. In the rest of this Section, we try to tease out the effect of derivatives on firm value more precisely, with a battery of tests.

3.4.1 Valuation Effects

To isolate the effects of derivatives on firm value, we need to control for other known drivers of value. Consider a simple dividend or earnings growth model of firm valuation. Any variables that potentially affect either the firm's future cash-flows or its cost of capital are relevant for value. In particular, we include the following controls: (i) the firm's operating profit margin, which is a measure of its current earnings (ii) the log of sales revenue, which we use as a proxy for firm size throughout the paper (iii) the cash balance of the firm, which relates both to firm risk and perhaps to future growth opportunities (iv) the growth in sales revenue, which proxies for the expected growth rate of the firm and (v) industry and year fixed effects. We now describe the role of each of these.

The operating profit margin of a firm is its earnings before interest and taxes scaled by total assets, and measures its profitability prior to financial income or expenses. This corresponds to the numerator in an earnings growth model of firm value. Since derivatives directly affect financial income, we use operational earnings

as our profitability control.

Next, we control for firm size. Large firms are likely to have lower risk, and thus a lower cost of capital. Especially during an economic downturn, large firms are expected to better withstand adverse shocks. This could happen, for example, due to their ability to access external capital markets relatively easily or due to their more competitive positions in product markets, as compared to small firms. We include the log of the firm's sales revenue as a control for market size. We find similar results for an alternative definition of firm size based on the log of total assets of the firm.

Similarly, we also control for the firm's cash balance. If we view cash as an extreme form of hedging, a higher cash balance should also imply lower risk, and should be especially valuable during these years. In addition, a high cash balance may also proxy for better investment opportunity in the future, which can have an effect of firm value via the growth rate.

In the spirit of the dividend growth model, we need a proxy for the expected growth rate in the firm's earnings. In the absence of direct growth forecasts, we use the firm's sales growth as a proxy for its growth potential. This variable is computed by measuring the year-by-year percentage growth in a firm's sales revenue.

Finally, we control for industry and year fixed-effects. Based on their primary industry classification, we group firms into 16 industry groups and include these dummies in the model. It is very likely that industry affiliation captures a large component of a firm's growth opportunities as well as its risk, and therefore its cost of capital. Year dummies are included to control for significant changes in macroeconomic conditions from year-to-year. Most notably, we control for the effect of inflation in our analysis through these dummies.

Table 3.2 provides the basic regression results for the effect of currency derivative

usage on value. In Models 1 and 2, we provide results from pooled OLS regression estimation with firm-level clustered standard errors. Models 3 and 4 provide median regression results, which are more robust to the effects of outliers. Consistently across these models, we find that firm value is higher for large firms and firms with better operating profitability. High sales growth firms and firms with high cash balances also have higher value, but these results are statistically weak in the pooled regression.

We find a positive and significant coefficient on *dderiv*, the dummy variable representing the hedger firms. While the coefficient estimates from the OLS model are large (in the range of 16-17%), the median regressions show that derivative users have about 5-7% higher value than their non-user counterparts.

Since these effects are economically large, we next turn to identifying their source. An immediate possibility is an omitted variable problem. That is, do we find these effects because we have not been able to control for some firm-specific factor that creates higher value and that is also positively correlated with derivative usage? For example, better managerial ability, which is unobservable, could be one potential candidate for an alternative interpretation of our results.

To deal with this concern, we exploit the panel nature of our data and estimate a firm fixed effects model. In such a model, any firm-specific omitted factor that is constant from year-to-year, including unobservable managerial skill, is automatically controlled for. Table 3.3 provides the regression estimates from various specifications of the fixed-effect model. Since we have firm fixed effects, we drop industry dummies from these models. To account for correlated errors across firms in the same industry, we cluster standard errors at the industry-level.

In the base case specification that does not include year dummies, we find a

positive and significant coefficient of 8.28% on *dderiv* dummy. Derivative users seem to gain value when they begin using derivatives. This is a powerful result since it implicitly controls for various unobserved characteristics of the firm and is thus a result closer to *causation* from hedging to firm-value. Compared to the OLS model of Table 3.2, we find that the point estimate of *dderiv* has dropped by almost half in this specification, consistent with the idea that the firm-specific unobservable factors contribute significantly to the OLS point estimates.

In Model 2, we include year dummies and find that our results become weaker. We need to interpret this with caution since year dummies are also correlated with derivative usage in the Brazilian economy during this period. As the country was adjusting to the new economic forces of a floating exchange-rate regime, firms gradually started using derivative contracts over time, providing a secular time-trend in the number of derivative users, as shown in Figure 3.4. This creates a correlation between year dummies and derivative usage, which in turn leads to lower statistical significance on *dderiv* variable.

Fixed-effect regression estimates depend closely on the year in which a firm switches from not using derivatives to using them. To the extent that markets can partly anticipate a firm's overall financial policy such as raising foreign debt and using derivative contracts to hedge the associated currency risk, it is possible that a firm's market value reflects these choices before the actual reporting of derivative usage by the firm. Exploring the linkages between derivative usage and firm value in this framework, we experiment with an alternative fixed effects model. In this model, we assume that the market anticipates derivative usage, and therefore the valuation effect is observed a year before the actual reporting of derivative usage by the firm. Note that due to annual reporting requirements, we only observe derivative

usage at the end of the year, whereas the hedging itself may have taken place at any time during the year. In this alternative specification, which we term "lagged reporting," we assign the derivative usage to the beginning of the year firm characteristics rather than the end of the year characteristics. The results are shown in Models 3 and 4 of Table 3.3. For both models, with and without year dummies, we find that derivative usage is associated with a 9-10% value increase, and is statistically significant. Taken all the four models together, we conclude that the firm value increases consequent to the adoption of a derivative-based currency risk management program by a firm. Our other results from the fixed-effect regression show that firm value increases significantly with operating profitability and somewhat with the amount of cash held.

3.4.2 Sources of Value Creation

Why should hedging add value? The previous section documents a strong association between currency derivative usage and firm value. Motivated by previous studies, we now explore two channels via which this value creation may be taking place: (a) the effect of derivatives on a firm's net profitability, after controlling for its operating profitability; and (b) the effect of derivatives on a firm's capital expenditures.

Effect on net profits

Hedging can lead to higher debt capacity, which in turn can add value to the firm due to increased tax shields. Leland (1998) formalizes the theoretical argument, and Graham and Rogers (2002) demonstrate this effect for US firms. In our context, we argue that hedging currency risk leads to a higher foreign currency debt capacity. If the domestic debt market is capital-constrained in a period of economic crisis, access

to the foreign debt market may allow a firm to continue to raise external capital. In addition, if foreign currency debt is cheaper due to frictions in the domestic capital market, a higher fraction of foreign currency debt in the firm's debt mix may lead to a lower cost of capital and thus a higher value. These arguments suggest that hedged foreign debt has a lower interest cost than domestic debt, and derivative usage thus has a positive impact on a firm's value through its direct effect on net profitability. The univariate resuts in Table 3.1 suggest that hedgers have a net income to total assets ratio about twice as high as non-hedgers. We now formally estimate the effect of derivative usage on a firm's net profitability, after controlling for the operating profit margin.

We regress a firm's net income to total asset ratio on *dderiv* and a host of control variables. Most importantly, we control for the EBITDA to total assets ratio to control for the effect of operating decisions on firm profit. In addition, we control for depreciation and amortization (scaled by total assets), which will reduce net income. We include firm size in the model to account for the effect of economies of scale on net income. Larger firms may have a lower (per dollar) cost of raising external funds, which in turn may lead to better profitability. Next, we control for leverage: firms with more debt have higher interest expenses, which will mechanically drive down net profitability. We explore the link between derivative usage and leverage in greater detail in subsequent analysis. Since our dependent variable is a flow measure, we take the average of beginning and end of year leverage for this regression, to control for the effects of debt that may have been raised during the year. Finally, many Brazilian firms have income from investments in subsidiaries, which we control for by including the investment income to total asset ratio in the model. We include industry and year fixed effects in all models.

Table 3.4 provides the regression results. Models 1 and 2 are estimated using OLS with pooled observations, and the associated t-statistics are reported after clustering standard errors at the firm level. Models 3 and 4 use the median regression method. As expected, we find that firms with higher operating profits, lower depreciation and amortization expenses, lower debt, higher investment income, and larger size all have higher net income. Controlling for these effects, the estimated coefficient on *dderiv* is 1.6% in Model 1 (OLS) and 1.6% in Model 3 (Median regression), both with a statistical significance at a level of 5% or better. That is, for every dollar of operating profit, derivative users are able to generate a higher net income than non-users, after controlling for the influence of several other variables that affect net income.

Where is this effect coming from? Mechanically, it clearly relates to the financial management side of the firm's business. In our univariate tests we find similar levels of operating profit margins for the two groups of firms, as shown in Table 3.1. Taken together, these results imply that hedging makes a difference at the level of financial income and expenses of the firm. This is consistent with the notion that foreign debt, when hedged, is cheaper than domestic debt. Thus, for a given level of leverage and operating profit, derivative users, which have a higher proportion of foreign debt in their capital mix, will have a higher net income than non-users.

Next, we interact *dderiv* with firm's leverage and include the interaction term in Models 2 and 4 of Table 3.4. We find a positive and significant coefficient on the interaction term. The negative effect of leverage on net profitability remains negative as in the earlier models. The interaction result tells us that, compared to non-hedgers, the marginal effect of leverage on a hedger's net profit is positive and significant. This suggests that hedgers have a lower cost of debt, perhaps because they can borrow a greater amount in foreign currency. We formally analyze this

possibility in depth in later sections.

Effect on capital expenditure plan

We next consider the effect of derivatives on capital expenditures. Froot, Scharfstein, and Stein (1993) suggest that hedging minimizes the frictions associated with raising external financing and thereby allows a firm to maintain a smooth investment policy. In particular, the sensitivity of investment to a firm's internal profit should be lower for hedgers as compared to non-hedgers. This is especially true in our sample, since the entire economy is passing through a major transition. During such a period, scarcity of internal funds and poor health of the domestic banking sector have the potential to severely hamper a firm's investment plan.

We estimate the effect of currency derivative usage on a firm's capital expenditure (scaled by beginning-of-the-year total assets). In these regressions, we control for the firm's operating profit (EBIT), size (the log of sales revenue), and leverage (to capture the effect of capital structure on investment policy). We include year and industry dummies to capture the effects of the macroeconomic environment and industry-specific growth opportunities. The results are presented in Table 3.5. In Models 1 and 2, we present a pooled OLS specification, whereas Models 3 and 4 provides median regression estimates.

The coefficients on *dderiv* in Models 1 and 3 suggest that hedgers invest about 1.3–1.2% (as a proportion of total assets) more than non-hedgers. The univariate results in Table 3.1 show that the average level of capital expenditure in our sample is about 6.3%. Therefore, compared to the average firm in the sample, the mean hedger firm invests about 20% more than its non-hedger counterpart. The other coefficients in these models indicate that firms invest more when they have higher internal profits and higher size, though the latter results are statistically insignificant

in the OLS specifications.

In Models 2 and 4, we drop the profitability margin from the regression, and instead include two interaction variables in the model: (a) margin interacted with *dderiv* and (b) margin interacted with $1-dderiv$. The first interaction term captures the sensitivity of capital expenditures to internal profits for derivative users, whereas the second term does that for non-users.[6] This allows us to estimate the sensitivity of investments to internal profits across the two groups and provides a cleaner test of the theory of Froot, et al. (1993). With this model specification, the coefficient on *dderiv* is larger and more strongly significant. More importantly, we find a positive and significant coefficient of 6.26% on the interaction of $margin$ with the non-hedger dummy, and statistically zero coefficient on the interaction with the hedger dummy. That is, the investment-cash-flow sensitivity of derivative users is zero, whereas it is positive for the non-users. Consistent with Froot, Scharfstein, and Stein (1993), we find that derivative users' capital expenditure policy is insulated from the availability of internal funds, whereas the same is not true for non-users.

A large literature has investigated the sensitivity of investments to cash flows. Alternative interpretations have been offered to the empirical finding of a positive coefficient on internal cash flows in an investment regression, including (i) firms face financial constraints, and therefore depend on internal funds to undertake capital expenditures, and (ii) when cash-flows are high, firms have better investment opportunities, which in turn produces a positive correlation between investments and cash flow. In our regressions, we control for industry-specific effects, so it is hard to argue that high cash flow proxies for a better investment opportunity set for non-hedgers. Rather, it appears that using of derivatives eases access to external capital, and thus

[6]We obtain similar results when we interact derivative usage or lack thereof with EBITDA rather than EBIT.

makes a firm's investment less sensitive to shocks to internal funds.

Summarizing the results from capital expenditure and net profitability regressions, we find that (a) derivative users are able to generate higher profits for every dollar of operating profits they have, (b) derivative users seem to have low-cost debt in their portfolio and (c) their investment plans are less sensitive to their own funds, perhaps due to easier access to external funds. What could possibly explain these findings? We conjecture that using currency derivatives allows firms to borrow more in foreign currency, which is a cheaper source of capital. Access to the local currency debt market may be limited for all firms in the period of the economic crisis, so that access to foreign currency debt mitigates the effects of credit rationing. We provide empirical evidence to this hypothesis in the remainder of the paper.

3.4.3 Derivatives and foreign debt capacity

We estimate the effect of derivatives on the ratio of foreign currency debt to total debt for a firm. Before presenting the formal analysis, we note that firms are likely to use dollar derivatives and foreign currency debt in conjunction, and therefore these two decisions are determined jointly. In an extreme case, it can be argued that the regression results from an estimation of foreign currency debt to total debt ratio on dollar derivatives can be entirely driven by reverse causation. Later in the paper, in Section 3.4.5, we carefully account for this possibility in our paper. We therefore defer a serious discussion of endogeneity to the later section.

We model the ratio of foreign debt to total debt for each firm in each year as a function of currency derivative usage and several control variables. The controls include firm size as large firms are expected to have better access to various sources of funds including foreign currency debt. Our other control variables are motivated by two broad economic arguments. First, we firm may have natural hedges that

reduce the dollar risk arising from its debt portfolio. An export-oriented firm, for example, may have a natural advantage in borrowing in foreign currency debt. We include a dummy variable *export* that equals one if a firm reports export income in its footnotes, zero otherwise. Several Brazilian firms also hold financial assets linked to the US dollar. These include foreign currency accounts as well as domestic bonds indexed to the US dollar. We include a dummy variable *dol* that equals one for firms with dollar assets, zero otherwise. Our second set of controls are motivated by the studies on the determinants of leverage in general (see Titman and Wessels (1988) and Graham, Lemmon and Schallheim (1998) for example), and are included these controls in the regression to ensure that our results are not simply driven by incentives to raise more debt. These control variables capture the effects of growth options, profitability, asset tangibility and non-debt tax shields enjoyed by the firm. As a proxy for growth options, we include sales growth, measured as the year-by-year percentage growth in sales revenue. Asset tangibility is captured by the ratio of Property, Plant and Equipment to total assets. We include depreciation and amortization scaled by total assets as a control for non-debt tax shields.

Table 3.6 provides the regression estimates. In Models 1-3, we provide OLS estimates with standard errors clustered at the firm level. Industry and year fixed effects are included as well. We find a positive and significant coefficient on *dderiv* suggesting that derivative users have higher foreign debt in their liability. The point estimates suggest that derivative users have about a 17–18% higher foreign currency debt ratio than their non-user counterparts. In Model 4, we estimate a firm fixed effects model and obtain a coefficient of 6.77% on *dderiv*, which is significant at the 1% level.

Recall that we have required, as a sample selection criterion, that all firms in our

sample have some foreign currency debt. This ensures that all our firms face some degree of exchange rate risk with respect to R$-US$ exchange rate. However, it is plausible that our results suffer from a simultaneous equations bias: firms with large foreign debt are more likely to hedge. We next use an instrumental variable model to address this issue and to estimate the effect of derivatives on foreign currency debt net of the reverse causation effect. We model the foreign currency debt ratio and currency derivative usage both as endogenous variables. The first-stage regression (the *dderiv* equation) requires a reasonable model of the derivative usage decision. As a precursor to our instrumental variable regression, therefore, we next estimate a hazard rate model of the determinants of derivative usage.

3.4.4 Hazard rate model of derivative usage

Theoretical models suggest that firms use derivatives to minimize frictions such as bankruptcy costs, financial distress, costly external financing and managerial incentives (see, for example, Stulz (1984), Smith and Stulz (1985), Froot, Scharfstein, and Stein (1993)). Much of our empirical understanding about why firms use derivatives is driven by studies based on US firms (such as Geczy et al. (1997) and Purnanandam (2007)). Bartram et al. (2007) provide evidence from international data by investigating derivative usage across number of countries.

Many empirical studies in this area are based on cross-sectional data or data points with a limited time-series. Since we have a panel data, as a by-product of our research we estimate a richer model to capture the dynamic behavior of why firms hedge. There are likely to be high fixed costs to establishing a hedging program, which include hiring sophisticated managers and learning about various hedging options and how the contracts work. Once these costs are incurred, it is likely that a firm will continue to hedge in the future.

We therefore model a firm's decision to hedge in a Cox-proportional hazard rate framework. This framework, often used in the bankruptcy prediction literature (see Shumway (1997)), estimates the probability of hedging by a firm conditional on the fact that it has not hedged as yet. The coefficient estimates tell us the effect of various firm characteristics on a firm's decision to begin hedging in the next year, given that it has not hedged in the past.

The Cox-proportional hazard model assumes that the hazard rate for firm j at time t (i.e., firm j's probability of using derivatives at time t conditional on it being a non-user so far) is the following:

$$h(t|x_j) = h_0(t)exp(x_{j,t-1}\beta_j)$$

In this equation, $x_{j,t-1}$ refers to the firm characteristics at the end of year $t-1$ that are likely to be associated with a firm's decision to hedge using derivatives in year t. h_0, called the baseline hazard function, represents the hazard ratio for a hypothetical firm that assumes a value of zero uniformly for all x_j. Using this functional framework, the model is estimated using a maximum likelihood estimate (see Cox (1972) for estimation details) to obtain the β coefficients.

For this estimation all the level variables (such as firm size and leverage) are measured as of the beginning of the year. Thus, the interpretation of our results is in a predictive sense. Motivated by earlier theoretical work and empirical studies based on US data, we include firm size as a proxy for economies of scale and access to derivatives market in the Cox-model. We include leverage to control for hedging motivations emerging from financial distress concerns. We also include the squared value of leverage in our model, to control for the fact that the decision to hedge may be concave in leverage: firms with very high leverage may have no incentive to hedge even when faced with higher expected bankruptcy costs (see Purnanandam

(2007)). Since holding cash is an alternative way to hedge, we control for a firm's cash balance. Annual sales growth captures the effects of growth opportunities in the spirit of Froot, et al. (1993). Finally, we include *dol*, the dollar asset dummy, and *export*, the export dummy, to account for sources of natural hedges.

Table 3.7 presents the estimation results. We find that larger firms and high growth firms are more likely to use derivatives, as reported by Geczy, et al. (1997) in their sample of large US firms. Further, firms with high cash balances are more likely to use derivatives, suggesting that these two hedging methods are complementary. Finally, we find a strong non-monotonic relation between leverage and derivative usage. At low leverage levels, the likelihood of using derivatives is increasing in leverage, but the pattern reverses for highly-levered firms. This finding is consistent with the theoretical and empirical findings of Purnanandam (2007), who reports a similar non-monotonic relation between leverage and hedging for US firms.

Therefore, the key drivers of a firm's hedging decision in Brazil seem to be in line with what other authors have found among US firms. Our results provides an econometric improvement over earlier studies as they exploit the panel nature of our data, and can be taken as an out-of-sample evidence for some of the earlier work on derivative usage.

3.4.5 Instrumental variable regression

We now turn to the issue of establishing a causal relation from derivative usage to foreign debt ratio in a simultaneous equation framework. For the first-stage regression, we need reasonable instruments for derivative usage. Our hazard rate regressions demonstrate that variables such as leverage and leverage-squared are strong predictors of derivative usage in our sample. In unreported analysis, we find that leverage terms (especially the square) do not have strong explanatory power in ex-

plaining a firm's foreign currency debt to total debt ratio, after we control for the effect of derivatives and other variables that enter various models in Table 3.6. Thus, we exploit the non-monotonicity between leverage and hedging and use leverage and leverage-squared as instruments for derivative usage in the first stage regression. We also include the cash balance (as a ratio of total assets) as an instrument.

Since derivative usage is a binary variable, at the first stage, we estimate a Probit model for the choice of derivative usage. This ensures that the fitted values will lie between zero and one. As suggested by Maddala (1983, pages 244-245), we then take the linear projection of first stage estimates and substitute it into a second stage OLS regression with foreign debt to total debt ratio as the dependent variable. The second stage standard errors are corrected for the two-stage estimation bias. Table 3.8 presents the second-stage results for IV model. Our first stage estimates (not reported) are similar to the estimates from the Cox-model. In addition, we check for the validity and strength of our instruments. The partial R-squared measures the improvement obtained in the model's fit in the first-stage regression by including the instruments. As reported in the table, we are able to explain over 7% of variation in the first stage regression by the addition of our instruments. The χ^2 statistic confirms that the excluded instruments are jointly significant.

Models 1 and 2 of Table 3.8 show that, controlling for endogeneity, we obtain a point estimate between 6–7% on the effect of derivative usage on the foreign currency debt ratio. As in the OLS model, the coefficient is significant at the 1% level. The magnitude of the coefficients is in line with that reported in Table 3.6 in the firm fixed effects specification (Model 4). While these coefficients are less than half as large as the corresponding OLS coefficients (which are about 16–17%), overall we find that using derivatives does lead to a higher foreign debt capacity for a firm.

3.4.6 Economic significance

Our OLS estimates from Table 3.2 show that derivative users have about a 17% higher value than non-users, which is very large. The median regressions in the same table, which are less sensitive to outliers, estimate this effect at 5-6%. The fixed effect regressions in Table 3.3 control for firm-specific unobservables, and suggest that the valuation effect of derivative usage is in the range of 6-10%. Are these economic magnitudes plausible? Using our conservative estimates, can derivative instruments add 5–6% value to a firm?

We argue that derivatives may add value both via their effect on cash flows, and, indirectly, via their effect on foreign debt capacity and thus the cost of capital for a firm. The currency shocks faced by the Brazilian economy in the period following the switch to the floating exchange rate regime in early 1999 are substantial. With segmented capital markets, foreign capital, if available to a firm, is cheaper and thus of value. In our sample, derivative usage appears to have an impact on the profitability of a firm as well as its access to foreign debt.

When we investigate the effect of derivatives on financing and operating policies of the firm, we find that derivative users have a ratio of net income to total assets that is higher by about 1.6% compared to non-users, after controlling for operating profits, investment income and level of debt. The average non-user has a net income to total asset ratio of about 2% in our sample. Thus, the derivative users are able to generate about an 80% higher income than non-users, which is an economically large number. We find that at least a part of this can be explained by higher foreign debt in their debt mix. We find that derivative users have about a 7% higher ratio of foreign to total debt compared to non-users. The average ratio for non-users in the sample is about 42%, implying an increase in the ratio of over 16%. Finally, we

also find that derivative users invest about 1.2% more than the non-user firms, an increase of more than 20% compared to the average non-user.

Overall, therefore, we find derivative usage to be associated with an 80% higher net profit after controlling for operating profits, a 16% higher foreign to total debt ratio and a 20% higher capital expenditure as compared to the average non-user firm. These are all economically large numbers. While the net profit and capital expenditures directly capture the effects on current and future cash flow, the foreign to total debt ratio affects the cost of capital for firms as well. Given the magnitudes of these numbers, the 5–6% value difference that we conservatively report for derivative users is certainly plausible. In our context, when the economy passes through extreme adverse shocks, derivative usage becomes particularly important, and add considerable value to a firm by allowing it to have smooth financing and operating policies.

3.5 Conclusion

The Brazilian currency crisis of 1999 represents a natural setting in which to study the effects of corporate financial policy on firm performance and value. The switch to a floating exchange rate in January 1999 was followed by periods of high volatility and rapid depreciation of the real. We study a sample of 167 Brazilian firms that all have some foreign currency debt, and examine the effect of hedging with derivatives on a firm's financial performance and its value.

We find that foreign currency hedging is positively correlated with the value of a firm, as measured by the ratio of market value to book value. In our sample, all firms have some debt denominated in foreign currency, so are exposed to exchange rate risk. In a pooled regression, derivative usage is associated with approximately

a 7 to 10% increase in firm value.

We identify some specific channels via which hedging is valuable. First, it increases the ability of a firm to take on foreign currency debt. It is likely that, in the aftermath of the economic crisis, domestic capital is scarce and hedged foreign debt is cheaper. Second, hedging allows a firm to continue making capital expenditures regardless of its current profitability (as measured by EBIT).

Of course, the decision to hedge is endogenous. A hazard rate model suggests that the decision to begin using derivatives depends on, among other variables, total leverage (i.e., the ratio of total debt to assets) and the square of leverage. Indeed, we find that these are good instruments for derivative usage. Using these instruments, we find that derivative usage leads to an approximately 7% increase in the ratio of foreign debt to total debt.

Firm characteristics Across Derivative Users and Non-Users
This table provides the descriptive statistics for the sample firms. Panels A and B provide the descriptive statistics for the non-users and users of derivatives, respectively. Panel C provides the corresponding number for all firms pooled across the two groups. All the summary statistics are pooled across sample years starting in year 1998 and ending in 2004. *Revenue* is the sales of a firm represented in millions of R$. $MarketCap$ denotes the market capitalization of the firm's equity in millions of R$ computed by multiplying the number of shares by year end share price. *Leverage* is the ratio of book value of debt to book value of assets. *Domestic* and $Foreign$ leverage represent the ratio of local currency borrowings and foreign currency borrowings to the book value of total assets, respectively. $Market/Book$ ratio of assets is computed as the ratio of (book value of debt + market value of equity) to (book value of debt + book value of equity). $Market/Book$ of equity represent the ratio of market value of equity (i.e., market capitalization) to its book value. $Margin$ denotes the ratio of earnings before interest and taxes to the book value of total assets. $Net\ Income/TA$ denotes the ratio of net income to book value of total assets. $Quick$ measures the ratio of current assets to current liabilities. $Cash/TA$ measures the cash-holdings as a fraction of book value of total assets. $Capex$ represents the ratio of capital expenditure to the one-year lagged value of total assets. The number of observations for $Capex$ variable is lower than other variables as it requires total assets from the previous year in denominator. Columns labeled as N, $Median$ and $Mean$ represent the number of observations, median and mean, respectively. *Std.Dev.* represents the standard deviation.

Table 3.1: Firm characteristics Across Derivative Users and Non-Users

Variable	N	Median	Mean	Std.Dev.
Panel A: Non-Users				
Revenue	715	228.2370	523.6458	856.4104
Market Cap	715	66.7580	322.2439	871.4893
Leverage	715	0.2239	0.2378	0.1781
Domestic Leverage	715	0.1085	0.1415	0.1407
Foreign Leverage	715	0.0493	0.0964	0.1194
Market/Book (Asset)	715	0.7131	0.8303	0.5687
Market/Book (Equity)	715	0.5075	1.0299	2.0840
Margin	715	0.1987	0.2216	0.1537
Net Income/TA	715	0.0200	0.0187	0.0954
Quick	715	1.3496	1.7553	1.5261
Cash/TA	715	0.0327	0.0711	0.0926
Capex	625	0.0401	0.0555	0.0625
Panel B: Users				
Revenue	308	1214.3945	2553.1309	3530.5675
Market Cap	308	617.4578	2108.4502	3811.1485
Leverage	308	0.3369	0.3447	0.1296
Domestic Leverage	308	0.1028	0.1213	0.0852
Foreign Leverage	308	0.2096	0.2233	0.1243
Market/Book (Asset)	308	1.0122	1.1957	0.6746
Market/Book (Equity)	308	1.0296	1.5685	2.0124
Margin	308	0.2165	0.2437	0.1364
Net Income/TA	308	0.0410	0.0391	0.0710
Quick	308	1.2510	1.3686	0.6451
Cash	308	0.0613	0.1074	0.1124
Capex	284	0.0602	0.0784	0.0678
Panel C: All Firms				
Revenue	1023	411.2240	1134.6736	2263.6956
Market Cap	1023	134.7062	860.0264	2359.1912
Leverage	1023	0.2744	0.2700	0.1721
Domestic Leverage	1023	0.1055	0.1354	0.1269
Foreign Leverage	1023	0.1052	0.1346	0.1341
Market/Book (Asset)	1023	0.8025	0.9403	0.6251
Market/Book (Equity)	1023	0.6220	1.1921	2.0765
Margin	1023	0.2043	0.2283	0.1490
Net Income/TA	1023	0.0268	0.0248	0.0892
Quick	1023	1.3269	1.6389	1.3355
Cash	1023	0.0391	0.0820	0.1003
Capex	909	0.0459	0.0626	0.0650

Table 3.2: Firm Value and Derivative Usage

This table presents the regression estimates from a regression of market-to-book value on derivative usage and other control variables. The dependent variable in the regression is the market-to-book value of the firm's asset defined as the ratio of the (book value of total debt plus market value of equity) to the (book value of debt plus book value of equity). The explanatory variables are defined as follows: *dderiv* is a binary variable that equals one for the users of dollar derivatives (i.e., derivatives used to hedge against USD exposure). *logsize* is the natural logarithm of the firm's total revenue for the year. *margin* measures the operating profit of the firm and is measured as the ratio os Earnings before interest and Taxes to the book value of total assets. *salesgrowth* represents the percentage growth in year-by-year revenue of the firm. $cash/TA$ is measured as the ratio of firm's cash holdings to the book value of total assets. All the regressions include industry dummies based on 2-digit industry classification and year fixed effects. Models 1 and 2 are estimated using OLS regression with pooled data, whereas Models 3 and 4 are estimated using the Median (quantile) regression. Robust t-statistics adjusted for firm level clustering, for OLS models, are given in brackets under column t-stat. Adjusted R^2 (for the OLS model) and the number of observations are given in the last two rows.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
logsize	0.0855	(2.85)	0.0830	(2.82)	0.0867	(15.66)	0.0887	(12.38)
margin	0.6675	(2.10)	0.6669	(2.09)	0.2085	(3.42)	0.1857	(2.37)
dderiv	0.1744	(2.39)	0.1623	(2.23)	0.0690	(3.36)	0.0549	(2.06)
salesgrowth	0.0865	(1.27)	0.0820	(1.21)	0.0742	(2.95)	0.0850	(2.67)
$cash/TA$			0.3892	(1.35)			0.3155	(3.03)
intercept	-0.5787	(-1.44)	-0.5809	(-1.44)	-0.5504	(-7.28)	-0.6025	(-6.19)
R^2	0.245		0.248					
N	1023		1023		1023		1023	
Year dummies	yes		yes		yes		yes	
Industry dummies	yes		yes		yes		yes	

Table 3.3: Firm Value and Derivative Usage: Fixed Effect Model

This table presents the fixed-effect regression estimates from a regression of firm's market-to-book ratio on derivative usage and control variables. The dependent variable in the regression is the market-to-book value of the firm's asset defined as the ratio of the (book value of total debt plus market value of equity) to the (book value of debt plus book value of equity). The explanatory variables are defined as follows: *dderiv* is a binary variable that equals one for the users of dollar derivatives (i.e., derivatives used to hedge against USD exposure). *logsize* is the natural logarithm of the firm's total revenue for the year. *margin* measures the operating profit of the firm and is computed as the ratio of Earnings before interest and Taxes to the book value of total assets. *salesgrowth* represents the percentage growth in year-by-year revenue of the firm. *Cash* is measured as the ratio of firm's cash holdings to the book value of total assets. Robust t-statistics adjusted for industry level clustering, for Models 1-4, are given in brackets under column t-Statistic. We provide the estimation details in the last four rows. *Lagged reporting* is set to *no* for the base models. This flag is set to *yes* for models in which we assign derivative usage dummy to a value of one starting a year before the actual reporting by the firm.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
logsize	0.1130	(1.81)	0.0073	(0.20)	0.1149	(1.81)	0.0072	(0.20)
margin	1.7060	(4.41)	1.4494	(4.57)	1.7066	(4.41)	1.4458	(4.60)
dderiv	0.0828	(2.13)	0.0616	(1.57)	0.0980	(2.66)	0.0863	(2.34)
salesgrowth	0.0008	(0.02)	0.0144	(0.32)	0.0002	(0.00)	0.0159	(0.35)
cash/TA	0.2749	(1.94)	0.2490	(2.51)	0.2861	(2.05)	0.2525	(2.56)
intercept	-0.9381	(-1.15)	0.3862	(0.81)	-0.9733	(-1.18)	0.3796	(0.78)
R^2	0.162		0.292		0.162		0.293	
N	1023		1023		1023		1023	
Year dummies	no		yes		no		yes	
Firm fixed-effect	yes		yes		yes		yes	
Industry Cluster	yes		yes		yes		yes	
Lagged reporting	no		no		yes		yes	

Table 3.4: Derivatives and Profitability

This table presents regression estimates from a regression of firm's net profitability on derivative usage and control variables. The dependent variable in the regression is the ratio of net income to total assets of the firm. The explanatory variables are defined as follows: *dderiv* is a binary variable that equals one for the users of dollar derivatives (i.e., derivatives used to hedge against USD exposure). *logsize* is the natural logarithm of the firm's total revenue for the prior year. $ebitda/TA$ is computed as Earnings before interest, Taxes and Depreciation for the same fiscal year scaled by total assets. *levavg* represents the average of the beginning and end of year book leverage. dep/TA measures the Depreciation and Amortization scaled by the beginning of the year book value of total assets. $invinc/TA$ measures the firm's income from investment in other firm's equity scaled by total assets. $levavg * dderiv$ is the interaction of average leverage and derivative dummy variables described earlier. Models 1 and 2 are estimated using OLS method, whereas Models 3 and 4 use Median regression technique. Robust t-statistics adjusted for firm level clustering for OLS regressions are given in brackets under column t-Statistic. We provide other estimation details in the last two rows.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$logsize$	0.0057	(1.81)	0.0055	(1.77)	0.0072	(5.41)	0.0075	(5.50)
$ebitda/TA$	0.1837	(4.92)	0.1851	(4.95)	0.1635	(10.46)	0.1629	(10.29)
$levavg$	-0.1201	(-4.47)	-0.1335	(-4.50)	-0.1079	(-9.18)	-0.1115	(-8.56)
$invinc/TA$	1.4825	(6.07)	1.4784	(6.07)	1.1907	(8.31)	1.2463	(8.68)
dep/TA	-0.8168	(-3.42)	-0.8203	(-3.33)	-0.5716	(-6.53)	-0.5674	(-6.35)
$levavg * dderiv$			0.0784	(1.84)			0.0534	(1.81)
$dderiv$	0.0159	(1.97)	-0.0095	(-0.56)	0.0161	(3.35)	-0.0048	(-0.45)
$intercept$	-0.0488	(-1.18)	-0.0447	(-1.08)	-0.0536	(-3.00)	-0.0563	(-3.09)
R^2	0.331		0.333					
N	953		953		953		953	
Year dummies	yes		yes		yes		yes	
Industry dummies	yes		yes		yes		yes	

Table 3.5: Derivatives and Capital Expenditure

This table presents regression estimates from a regression of firm's capital expenditure on derivative usage and control variables. The dependent variable in the regression is the ratio of capital expenditure to beginning of the year total assets of the firm. The explanatory variables are defined as follows: *dderiv* is a binary variable that equals one for the users of dollar derivatives (i.e., derivatives used to hedge against USD exposure). *logsize* is the natural logarithm of the firm's total revenue for the prior year. *margin* is computed as the ratio of Earnings before Interest and Taxes for the same fiscal year scaled by the year end total assets. *levavg* represents the average of the beginning and end of year book leverage. $margin * dderiv$ is the interaction of *margin* and derivative dummy variables described earlier, which means that it takes the value of *margin* for the users of derivative zero otherwise. $margin * (1 - dderiv)$ takes the value of *margin* for non-hedgers and zero otherwise. Models 1 and 2 are estimated using OLS method, whereas Models 3 and 4 use Median regression technique. Robust t-statistics adjusted for firm level clustering for OLS regressions are given in brackets under column t-Statistic. We provide other estimation details in the last two rows.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
logsize	0.0025	(1.37)	0.0021	(1.14)	0.0031	(3.19)	0.0029	(3.66)
levavg	-0.0154	(-0.95)	-0.0127	(-0.79)	-0.0173	(-2.09)	-0.0187	(-2.73)
dderiv	0.0132	(1.80)	0.0309	(2.45)	0.0115	(3.35)	0.0229	(4.44)
$margin * dderiv$			-0.0093	(-0.27)			0.0056	(0.36)
$margin * (1 - dderiv)$			0.0626	(2.94)			0.0543	(5.43)
margin	0.0430	(2.33)			0.0505	(4.74)		
dderiv	0.0132	(1.80)	0.0309	(2.45)	0.0115	(3.35)	0.0229	(4.44)
intercept	0.0372	(1.46)	0.0359	(1.45)	0.0176	(1.36)	0.0176	(1.66)
R^2	0.179		0.182					
N	889		889		889		889	
Year dummies	yes		yes		yes		yes	
Industry dummies	yes		yes		yes		yes	

Table 3.6: Derivatives and Foreign Currency Debt

This table presents regression estimates from a regression of firm's foreign currency debt on derivative usage and control variables. The dependent variable in the regression is the ratio of foreign currency debt to the total debt of the firm. The explanatory variables are defined as follows: *dderiv* is a binary variable that equals one for the users of dollar derivatives (i.e., derivatives used to hedge against USD exposure). *logsize* is the natural logarithm of the firm's total revenue for the prior year. *margin* is computed as the ratio of Earnings before Interest and Taxes for the same fiscal year scaled by the year end total assets. *salesgrowth* represents the percentage growth in year-by-year revenue of the firm. dep/TA measures the Depreciation and Amortization scaled by the beginning of the year book value of total assets. *export* is a dummy variable that equals one for the exporters, zero otherwise. *dol* is a dummy variable that equals one for firms that hold dollar assets, zero otherwise. ppe/TA is the ratio of firm's permanent assets (plant,property and equipment) to the total assets. Models 1-3 are estimated using OLS method, whereas Model 4 is based on firm fixed-effects. Robust t-statistics adjusted for firm-level clustering for Models 1–3 and industrly-level clustering for Model 4 are given in brackets under the columns labelled t-stat.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$logsize$	0.0719	(6.81)	0.0659	(5.92)	0.0578	(4.45)	0.0350	(1.66)
$margin$	-0.2136	(-1.57)	-0.2190	(-1.65)	-0.2054	(-1.40)	-0.1640	(-1.06)
$dderiv$	0.1805	(5.89)	0.1816	(5.96)	0.1688	(5.66)	0.0677	(2.59)
$export$			0.0779	(2.00)	0.0656	(1.66)	-0.0331	(-0.63)
dol					0.1083	(2.45)		
$sale_growth$					-0.0606	(-1.94)		
ppe_TA					-0.1439	(-1.34)		
dep_TA_1					0.2876	(0.38)		
$dderiv$	0.1805	(5.89)	0.1816	(5.96)	0.1688	(5.66)	0.0677	(2.59)
$intercept$	-0.3369	(-2.30)	-0.3222	(-2.23)	-0.1601	(-0.92)	0.0578	(0.22)
R^2	0.361		0.369		0.393		0.057	
N	992		992		947		992	
Year dummies	yes		yes		yes		yes	
Industry dummies	yes		yes		yes		no	
Firm fixed-effects	no		no	no			yes	

Table 3.7: Cox-Proportional Hazard Model

This table presents Cox-Proportional Hazard Model regression estimates from a regression of firm's decision to use derivatives for the first time on various firm-level characteristics. The dependent variable in the regression is a binary variable that equals one in the year when firms start using derivatives, and zero otherwise. After the first year in which derivative-usage is reported by a firm, it is not used for estimation in the subsequent years. In particular we estimate the following model: $h(t|x_j) = h_0(t)exp(x_j\beta_x)$; where h stands for the hazard rate of derivative usage, meaning it is the probability of using derivatives next year conditional on not having used derivatives in the past. h_0 is the baseline hazard rate and h_t reports hazard rate conditional on set of covariates given by x_j at time t. In this table, we report the *beta* coefficients of this regression. The explanatory variables ($x_i s$) are defined as follows: *logsize* is the natural logarithm of the firm's total revenue for the prior year. *leverage* is computed as the ratio of total debt to total assets measured as of the beginning of the year. *levsquare* is the squared value of *leverage* described above. $cash/TA$ measures the cash holdings of the firm scaled by the total assets for the prior year end. *export* is a dummy variable that equals one for the exporters, zero otherwise. *dol* is a dummy variable that equals one for firms that hold dollar assets, zero otherwise. Both these variables are also measured as of the prior year. *salesgrowth* is the percentage increase in firm's sales during the year. In model 2 and 4, we also control for year dummies.

	Model 1		Model 2		Model 3		Model 4	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
logsize	0.5932	(7.13)	0.6121	(7.79)	0.5382	(5.79)	0.5368	(6.31)
leverage	8.3866	(2.95)	10.4364	(3.11)	8.5328	(2.95)	10.2344	(3.00)
levsquare	-12.4736	(-2.88)	-15.7130	(-3.04)	-12.8876	(-2.89)	-15.9289	(-3.02)
$cash/TA$	2.3976	(2.69)	2.6091	(2.32)	2.5124	(2.71)	2.3940	(2.26)
salesgrowth	0.9553	(3.14)	0.5490	(1.65)	0.8918	(2.85)	0.4460	(1.38)
dol					0.4503	(1.53)	0.6784	(2.05)
export					-0.1144	(-0.50)	0.0190	(0.06)
N	719		719		719		719	
Year dummies	no		yes		no		yes	
Industry dummies	no		yes		no		yes	

Table 3.8: Derivatives and Foreign Currency Debt: IV Regression

This table presents regression estimates from Instrumental Variable regressions of firm's foreign currency debt on derivative usage and control variables. The dependent variable in the regression is the ratio of foreign currency debt to the total debt of the firm. The endogenous variable is the derivative usage of firm, *dderiv*. We estimate the model using IV regression technique. In the first stage *dderiv* is instrumented with firm's *leverage*, its squared term, $lev - squared$ and firm's cash holdings, $cash/TA$. The explanatory variables are defined as follows: *logsize* is the natural logarithm of the firm's total revenue for the prior year. *margin* is computed as the ratio of Earnings before Interest and Taxes for the same fiscal year scaled by the year end total assets. dep/TA measures the Depreciation and Amortization scaled by the beginning of the year book value of total assets. *export* is a dummy variable that equals one for the exporters, zero otherwise. *dol* is a dummy variable that equals one for firms that hold dollar assets, zero otherwise. *salesgrowth* represents the percentage growth in year-by-year revenue of the firm. ppe/TA is the ratio of firm's permanent assets (plant,property and equipment) to the total assets. Robust t-statistics adjusted for firm level clustering are given in brackets under column t-Statistic. We provide the statistics from the first-stage estimation in the last three rows. Partial R^2 measures the improvement in adjusted (pseudo) R-squared obtained by including the instruments in the first stage Probit model of derivative usage. Chi-squared statistics test for the joint significance of all excluded instruments.

	Model 1		Model 2	
	Estimate	t-stat	Estimate	t-stat
logsize	.0339	(2.68)	0.0420	(2.84)
margin	-0.0710	(-1.20)	-0.0905	(-1.15)
dderiv	0.0715	(4.37)	0.0618	(3.27)
export	0.1130	(6.05)	0.1044	(5.14)
dol	0.1081	(5.32)	0.1202	(4.92)
salesgrowth			-0.0561	(-1.69)
ppe/TA			-0.0359	(-0.60)
dep/TA			0.2902	(0.66)
intercept	0.1345	(0.72)	0.0419	(0.19)
R^2	0.3251		0.3325	
N	992		947	
Year dummies	yes		yes	
Industry dummies	no		no	
Partial R^2	0.0729		0.0851	
Chi-squared Stat	74.70		64.92	

CHAPTER IV

Corporate Hedging Strategies in Brazil: Are they effective?

4.1 Introduction

After the currency crisis in January 1999, an increasing number of companies in Brazil have become active in purchasing financial derivatives to manage their foreign exchange exposure. This chapter extends the analytical framework developed in the second chapter to investigate how companies use different hedging strategies to mitigate the effects of exchange rate fluctuations on their financial operations.

By conducting a close examination of the explanatory notes to consolidated financial statements and annual reports, the chapter presents a case study of two Brazilian companies over the period 1997 through 2004. The purpose of the case study is twofold. First, it provides an overview of different hedging strategies to illustrate how risk management operations are executed in practice. Second, by comparing theoretical arguments and companies' real strategies, the paper attempts to answer whether these risk management policies have been effective in mitigating exchange rate risk. Among other advantages, this case study method provides a better understanding of risk management activities, some institutional details involved in the hedging process in Brazil and the identification of specific motivations involved at the firm level.

Companies are exposed to a variety of operational, financial and market risks inherent to their own businesses and also to the behavior of the aggregate economy. For example, a firm doing international business benefits from a depreciating currency when it sales to foreign markets. However, the firm faces higher operating costs if it imports intermediate goods from abroad. On the other hand, a company's financial performance may be affected when the supply of foreign capital decreases as a result of the country's political instability or when domestic borrowing is reduced during times of economic downturn or as a consequence of financial crises.

During the period of study, Brazil experienced severe macroeconomic shocks and firms were exposed to different sources of risks. The focus in this study, however, is exchange rate risk and how companies deal with it. As descriptive examples, two companies are studied: Companhia Siderurgica Nacional and Votorantim Celulose e Papel. Although they belong to different industries, both companies have sufficiently large foreign currency operations that expose them to foreign exchange risk. Among several candidates, these two companies were chosen because they have the most complete set of information (significant quantity and quality of information) sufficient for detailed description and further evaluation of the companies' risk management policies.

The main findings of the case study are consistent with theory. The behavior of the two companies studied is consistent with the model of optimal debt composition and hedging and with empirical evidence about the financial effects of hedging in Brazil of the previous chapters. Firms use financial derivatives, mainly cross-currency swaps, and holdings of foreign currency denominated assets to protect against further currency devaluation. By reducing the impact of exchange rate fluctuations on net income, hedging helps smooth earnings, increase the firm's capacity to borrow in

foreign currency at lower cost and secure funding to the firm's planned investment.

The remainder of the chapter is organized as follows. Section 4.2 extends the model of the first chapter to incorporate alternative hedging activities. Sections 4.3 and 4.4 present the case study in Companhia Siderurgica Nacional and Votorantim Celulose e Papel respectively. Section 4.5 concludes.

4.2 Optimal debt composition and different methods of hedging

The model of optimal debt composition and hedging of the second chapter shows that currency mismatches in the balance sheet of companies may be reduced after a currency crisis, without having firms borrowing less in foreign debt. When affordable, currency forwards are used to deal with exchange rate risk and reduce the probability of financial default brought by currency fluctuations. Hedging complements net worth and collateral requirements allowing firms to expand their capacity to access foreign capital markets. In the model, there is a range for optimal hedging given by the following expression:

$$\frac{s_H R_u + R_m - R}{s_H - F - \phi} \leq h \leq \frac{R - R_m - s_L R_u}{F - s_L + \phi} \tag{4.1}$$

The lower limit value in this expression is determined by the firm's exposure when the exchange rate is s_H (e.g. the devaluation state) and the upper limit when the exchange rate is s_L (e.g. non-devaluation state). The exchange rate is quoted as units of domestic currency per unit of foreign currency (e.g. Brazilian real per US dollar), h is the amount of forward contracts in foreign currency, ϕ is the cost of hedging, R_m is the payment to local banks for domestic currency loans and R_u the payment to international banks for foreign currency debt. R is the investment project return, and $R(s_H)$ and $R(s_L)$ what the firm is left with after debt payments.

With positive but small cost of hedging ϕ the firm chooses:

$$h = \frac{s_H R_u + R_m - R}{s_H - F - \phi} \tag{4.2}$$

If R is taken as the firm's operating profits, equal to net domestic sales (domestic sales minus domestic operating costs) plus net exports (foreign sales minus imports of intermediate goods), [1] then it is clear that when companies expect the local currency to depreciate, larger revenues from net exports are a natural hedge and substitute for a long position in forward contracts. [2]

Another hedging method, investment in foreign currency assets, can be introduced in the model as an alternative investment opportunity paying the risk free rate r^f. If markets are efficient and interest parity condition holds, the firm must be indifferent between investing such funds in domestic currency at r^f and investing them in foreign currency at the international rate r^*.

Why would a firm want to invest part of its funds outside the investment project when the expected return from the project is greater than the risk free rate? This could occur either because another distortion is in place (e.g. the firm may be risk averse and has a motivation to hold a buffer stock that pays for increased exchange rate risk) which is a real possibility not explicitly considered in the model, or because costly hedging can induce the firm to borrow less in foreign currency, which is equivalent in the model, to have part of the borrowed funds invested at the same rate paid for its debt. Thus, in the context of the model, when forward contracts are too costly, investing in foreign currency assets is an alternative hedging strategy

[1] This is similar to the formulation Martinez and Werner (2001) used to study the impact of net exports on the ratio of foreign currency debt to total debt for Mexican firms between 1992 and 2000. It assumes that export prices are fixed in the foreign currency.

[2] Currency appreciation is not explicitly model in this analytical framework. However, more realistically, in such situation net exports represent an additional source of exposure. Therefore, hedging would require either a reduction in net exports or a short position in forward contracts.

because it reduces the amount of debt exposed to exchange rate risk.

The model of the second chapter is then consistent with actual currency risk management operations at the firm level such as the use of revenues from net exports, as a natural hedge, and investment in foreign currency assets, both working as alternative methods to the use of currency forwards. In what follows and to distinguish among these financial strategies, derivative hedging will refer to the use of currency forwards (or any other derivative such as swaps, options or futures) and non-derivative hedging will refer to holdings of foreign currency assets or revenues from net exports.

Aside from the model implications, a vast literature in corporate finance provides theoretical arguments for why firms hedge. For example, firms may have incentives to hedge because hedging operations provide a tool to reduce the risk of financial distress (Stulz and Smith, 1985 and Leland, 1998). Firms may also hedge to smooth earnings exposed to exchange rate fluctuations and by that improve its business opportunities (Froot, Scharfstein and Stein, 1993). As seen in chapter three, empirical evidence based on a sample of 167 non-financial firms in Brazil seems to indicate that, consistent with financial theory, financial hedging has positive and significant effects on firms' investment and profitability. By smoothing firms' earnings, hedging increases their debt capacity in foreign currency.

4.2.1 Types of Financial Exposure

A firm's currency exposure can be classified as follows:

1. Translation or accounting exposure, which results from the need to translate foreign currency financial statements of affiliates in other countries into single reporting currency in consolidated financial statements. For example, U.S. branches operating in Brazil need to translate financial statements originally

prepared in Brazilian real into U.S. dollar. Any adjustment resulting from differences between assets and liabilities is usually recognized in an equity account on the balance sheet.

2. Transaction exposure, which arises from transactions denominated in foreign currency such as borrowing and lending when repayment is to be made in currencies other than the local currency. This is the most common type of exposure that firms try to mitigate mechanically by hedging.

3. Operating or economic exposure, which results from competition in the market when the company experiences changes in the present value of its cash flows caused by unexpected exchange rate movements. For example, companies have part of their revenues denominated in foreign currency when they sell goods abroad and also part of their costs are affected by currency fluctuations because the firm may import intermediate goods.

The case studies in this chapter focus on transaction exposure, among other things, because it is easier to identify and measure and also because it is the main type of exposure derivative hedging is aimed at eliminating. As will be seen, Brazilian companies hedge their transaction exposure posed by their transactions denominated in foreign currency (imports, exports, debt and acquisition of foreign assets) using both financial derivatives (futures, forwards, options and swaps) and also holdings of assets denominated in foreign currency. In some cases, firms refer to export revenues as an alternative means providing a natural hedge to economic exposure.

4.2.2 Hedging as a means of transactional exposure management

Hedging is a financial transaction by which the firm takes a position, either acquiring an asset or a contract (e.g. forward contract, swap contract, etc) that will

rise or fall in value with an expected movement in the exchange rate to offset the drop or rise in value of an existing position.

The most common derivative transaction used by Brazilian companies is a swap contract. It consists of the exchange of two currencies at a given exchange rate with an agreement to reverse the trade at the same exchange rate or any prespecified rate at some date in the future. In this contract, one party pays the other annual interest payments. Given that in an emerging market like Brazil companies have access to borrow in foreign currency from offshore markets, at floating rates such as the LIBOR rate, instead of the plain vanilla currency swap described above, most companies use a cross-currency interest rate swap contract, with an arrangement similar to an interest rate swap.

Under a cross currency interest rate swap, the company exchanges with a bank its foreign debt, say U.S. dollars contracted at floating rates, for local debt contracted at rates in Brazilian real (e.g. CD rate) at a given exchange rate (e.g. forward rate). Figure 4.1 illustrates how the cross currency swap is implemented.

In the figure, a Brazilian firm has U.S. dollar debt for US$ 100 at 1 year maturity. Due to expected depreciation of the real, the firm wants to swap this debt for real-denominated debt since most of its earnings are determined in real.

Suppose today the firm enters into a 1 year cross currency swap contract with a commercial bank, exchanging US$ debt into real debt at a forward rate F (real/US$). On each interest payment day, the firm pays the bank interest at the domestic rate equal to the Brazilian CD rate. The company receives from the bank US$ interest equivalent to the LIBOR rate plus margin. These payments are used to continue paying interest on its US$ debt. Whether or not the notional amount is exchanged at the beginning of the contract is optional. At maturity, the notional amount in

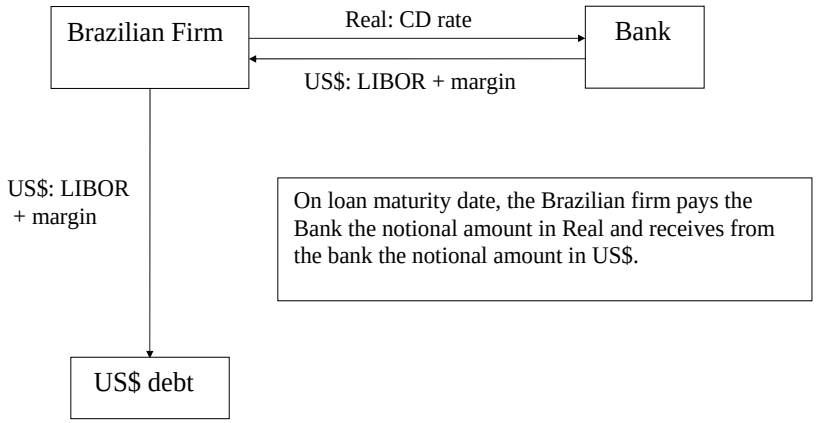

Figure 4.1: Cross Currency Interest Rate Swap

US$ is exchanged, the firm pays F*100 in real and receives from the bank US$ 100.

At the date of the financial report (e.g. end of the fiscal year) gains or losses on the swap contract will depend on whether the exchange rate is greater or less than F. If $S > F$ then the swap contract gives a net gain of $(S - F) * 100$ real. If $F > S$ then the swap contract gives a loss of $(F - S) * 100$ real. This gain or loss offsets the open position the firm has in US$.

Although the theoretical model of debt composition and hedging uses forward contracts as the only derivative hedging tool, both currency swaps and cross-currency swaps are consistent with this assumption. Swap contracts can be thought as a series of forward contracts or as two simultaneous transactions, one in the spot market (exchange of notional values at the beginning) and the other in the forward market (exchange of notional values at maturity using a contracted rate). When there is

no exchange of initial notional values then the swap contract is more similar to the forward contract, except for the fact that interest payments are also exchanged.

More important, from the model perspective, is the operating difference between derivative hedging and investment in foreign currency assets. When firms are exposed to exchange rate risk, both methods provide financial income to offset exchange rate losses in case of currency depreciation. However, when the firm takes a position in the swap contract, there is no need for holding on the principal amount exchanged. Moreover, these funds can be used to finance productive investment, which has a higher expected return than investment in foreign currency assets.

Finally, it is worth mentioning that the model of debt composition and hedging determines an optimal amount of derivative hedging as a function of the expected cost of capital and the size of the firm's net worth. This optimal hedging is not necessarily equal to the total amount of foreign currency debt. Moreover, derivative hedging can be zero even when the firm borrows extensively in foreign currency if the firm has large enough net worth.

4.3 Case Study in Companhia Siderurgica Nacional

Companhia Siderurgica Nacional is the second largest steel-producer in Brazil and one of the largest steel makers in Latin America. Companhia Siderurgica Nacional (CSN) operates in the steel and iron sector, manufacturing a wide range of value-added steel products, such as hot-dip galvanized sheets and tin mill products. CSN runs its own source of iron ore, limestone and dolomite mines, in the State of Minas Gerais, Brazil, where the company is located. Using imported coal, CSN produces approximately 75 to 80% of its coke requirements in its own coke batteries. The company was privatized in 1993. During most of the 1990s, CSN experienced a large expansion process, part of which included strategic investments in railroads and power supply companies. As a result, at present CSN is a fully integrated company.

4.3.1 Market Share, customers, competitors and Exports

During 2004, Brazil was the eighth largest crude steel producer in the world with a production output of 32.9 million tons, equivalent to 3% of total world steel production. Brazil accounted for approximately half of total steel production in Latin America, approximately twice the size of Mexico's and approximately one-third the size of the U.S. steel production. As shown in Table 4.1, in the domestic market CSN is the second most important steel maker with a total production of 5.5 million of tons, about 17% of the total steel production in Brazil.

As a highly competitive Brazilian producer in world markets, CSN enjoys several comparative advantages such as the low-cost of labor in Brazil, the high-grade iron ore reserves, and the good quality of Brazil's infrastructure (railways and ports). CSN sells its products in local and international markets as a main raw material for manufacturing industries, including the automotive, home appliance, packaging, con-

struction and steel processing industries. CSN has an important regional presence, selling steel products over 61 countries. In 2004, the three main export destinations were North America (44%), Europe (32%) and Asia (11%).

4.3.2 Exchange rate and Interest rate exposure

CSN is exposed to exchange rate risk as a result of its business operations in world markets. The company sells steel abroad, imports intermediate goods from foreign markets, and holds assets and liabilities in foreign currency. Between 1997 and 2004, the company held on average 87% of its total debt in foreign currency. Also, 20 to 25% of raw materials were imported. Raw material represented about 45% of production costs so that currency fluctuations affected approximately 10% of its production costs. Thus, currency depreciation increased financial costs of foreign denominated debt and operating costs due to imports of intermediate goods.

In an emerging market economy like Brazil companies are exposed not only to currency risk but also to interest rate risk. The company's foreign debt comes mainly from offshore markets at a floating interest rate equal to the LIBOR rate plus a risk premium that varies between 2 to 5 percentage points. Real-denominated debt is indexed to floating rates such as the long term interest rate (TJLP) and short term investments receive the CD rate.

From an accounting perspective, the impact of exchange rate fluctuations is recorded as part of net financial income, under the item named 'Monetary and exchange rate gain (loss), net' on the income statement. As seen from Table 4.2, exchange rate losses depleted the firm's net income and were significantly large after the currency crisis in 1999, particularly in 2002 when the Brazilian real depreciated 52%. Exchange rate losses impact the balance sheet by reducing retained earnings on shareholder's equity.

4.3.3 Exchange rate risk management policy

The company's Treasury Department is responsible for risk management operations. All the currency exchange operations, including financing and hedging decisions inside the company or with the company's subsidiaries are approved there. In the company's annual report of 2003, one finds the following paragraph defining the objectives of its risk management policy: "we use financial instruments, such as derivatives, in order to achieve the main goals established by our Board of Directors to minimize the cost of capital and maximize the returns on financial assets, while observing, as determined by our Board of Directors, parameters of credit and risk. Only well-understood, conventional derivative instruments are used for these purposes. These include futures and options traded on regulated exchanges and 'over-the-counter' swaps, options and forward contracts". This statement suggests that the company hedging objective is to minimize the cost of capital in the presence of uncertainty about exchange rate and interest rates.

The company borrows foreign currency debt denominated mainly in dollars, yen and euros. Table 4.3 shows the composition of foreign currency debt and the types of financial derivatives used to hedge these positions. As can be seen from this table, most foreign currency debt is held in U.S. dollars (80%). On the other hand, the company has used financial derivatives, mostly cross-currency swaps, to hedge transaction exposure since 1999. [3] Table 4.3 also shows that in 2004, the company started to change the composition of its currency derivatives. That year, the firm purchased one-month dollar-real futures contracts listed at BM&F (Brazilian derivatives exchange market) instead of the over the counter 360-day dollar-real swap contracts it was using before. This change in its derivative hedging program may have been

[3] The company used U.S. dollar/yen options and other cross-country swaps with its foreign subsidiaries between 2000 and 2002, which are not shown in the table.

consistent with increased volatility in foreign exchange markets and the fact that the Brazilian real could depreciate or appreciate during shorter horizons. In this situation, short-term instruments and the marking to market strategy of future contracts could have been be preferable.

Table 4.4 measures the company's transaction exposure to the U.S. dollar in the way the company refers to in its reports and footnotes to financial statements. This table shows that the company hedged part of its foreign exchange exposure using holdings of dollar assets, which include U.S. dollar cash, U.S. dollar deposits and government bonds indexed to the U.S. dollar in the form of treasury notes and central bank notes.

Table 4.4 also suggests that the company reduced its exposure after 1999 and has been engaged more actively in financial derivatives following the currency crisis. Consistent with predictions of the model of debt composition and hedging, the company seemed to substitute away from U.S. dollar assets in favor of long positions in swap contracts. As percentage of its dollar debt, dollar assets decreased from 36% in 1998 to 20% in 2004 while currency derivatives increased from 13% in 1998 to 66% in 2004. Note that this measure of the extent of hedging currency exposure could be misleading because, due to annual reporting requirements, it takes into account derivative usage only at the end of the year, whereas hedging transactions may have occurred at any time during the year.

In its annual report to the US Securities and Exchange Commission in year 2001, the company provides more details about the features of its derivative hedging. The report mentions that hedging operations are aimed "to match the gains from investing the proceeds of borrowing and loans with exchange losses resulting from the devaluation of the Brazilian real against the US dollar and the Japanese yen". Fur-

thermore, this rather unclear statement is complemented with the following claim: "We also manage interest costs through a balance between lower-cost floating rate debt in foreign currency (with inherently higher risk) and more expensive, but lower risk, fixed-rate debt in domestic currency". [4]

These two statements combined seem to suggest that the administration used hedging operations (in particular cross currency interest rate swaps) to match the rates of its foreign currency borrowing with the return of its short-term investments at the market rate in Brazil (CD rate in local currency).

The previous sentence may appear contradictory at first sight. If the hedging program's objective is to equate the cost of its foreign currency borrowing to the CD rate in domestic currency, then all the company would need to do is obtain loans in domestic currency only. However, as observed in data from financing and borrowing transactions, the company borrowed in domestic currency (only 10% of total debt on average) at a cost usually greater than the CD rate. For example, in 2001 the company raised domestic funds in the form of debentures at the CD rate plus 2.75%. Importantly, the fact that the company borrowed domestically at a higher cost is consistent with the notion that domestic credit in Brazil has been more expensive than foreign credit, perhaps as a result of imperfections in the domestic banking sector.

4.3.4 A concrete example

The following example, taken from the footnotes to financial statements in 2001, illustrates this specific hedging strategy through the use of cross-currency swaps. In the footnotes one reads "in September 2001, with a negative perspective about the situation in Argentina and a stronger concern of further devaluation, the company en-

[4] This is exactly the trade off between foreign currency debt less costly but risky and domestic debt more expensive but less risky mentioned in the analytical model of the second chapter.

tered into swap contracts with a rate of approximately R$2.75=US$1.00 to exchange U.S. dollar debt at a cost of approximately 7% per year with real-denominated debt at an average rate of 19% a year".

As of September 30, 2001 the company reported the following hedging operations:

Derivative	Maturity	Notional value (Million US$)
Exchange rate hedge	11/07/2001 and 12/10/2001	70.0
Forward contracts	10/05/2001 and 09/20/2002	81.3
Currency swap	01/02/2002	100.0

In September 2001, the spot exchange rate was $S(R\$/US\$) = 2.6713$. Taking the currency swap operation with 3-month maturity, it can be seen that indeed the company entered into this transaction using a forward rate $F(R\$/US\$) = 2.75$, which is consistent with the interest rates in domestic and foreign currency mentioned above:

Domestic interest rate: i = 0.19 per annum

Foreign interest rate: i*=0.07 per annum

Spot Exchange rate: S=2.6713

Using the relationship between forward rate, spot rate and interest rates appropriately quoted for a 3-month contract then,

$$F(R\$/US\$) = \frac{S(R\$/US\$) * (1+i)}{(1+i^*)} = \frac{2.6713 * (1+0.19/4)}{(1+0.07/4)} = 2.75$$

With this forward rate one concludes that markets were expecting a currency depreciation of 2.9% in the next 3 months and of 12% in the next 12 months. In this swap contract, the company exchanged US$ 100 million debt at 7% for R$ 275

million debt at 19% for three months. At maturity, the company payed the bank real-interest of R$ 13 million and received from the bank U.S. dollar-interest for US$ 1.75 million (R$ 4 million) used to pay interest on its offshore U.S. dollar debt.

In addition, the company payed the bank the notional value of R$ 275 million and received US$ 100 million. Note that at maturity, with a spot rate of $S = 2.3204$ the swap contract generated a loss of (2.3204 - 2.75)*100 = R$ 43 million.

In its books, the loss from the swap is recorded on the income statement as negative financial income, which compensated for monetary and foreign exchange gain on the U.S. debt. In this particular example, the income statement would have the following movements in R$ million:

Financial Income	-39
Gain/loss on Swap	-43
Interest received in US$	4
Financial Expense	17
Interest on Swap in R$	13
Interest on US$ debt	4
Net Financial Income	-56
Exchange rate gain/loss	43
Net Income	-13

As a counterpart, gains and losses on swap contracts would be recorded on the balance sheet as assets or liabilities, depending on whether the difference between what the firm pays to the bank and what it receives from the bank is positive or negative. In the example, the company recorded the loss from the swap R$ 43 as a liability.

The previous example illustrates two points. First, in September 2001 the company was expecting a further depreciation of the real during the next three months

and as a result decided to take a long position in swap contracts. Second, although expectations were wrong, this swap contract fully offset the effects of currency fluctuations. [5] Losses associated with the hedging contract were fully compensated by the exchange rate gain so that company earnings reflect only interest payments on debt (R$ 13 million). Of course, had the company been unhedged it would have obtained a positive net income of R$ 39 million, resulting from financial expenses of R$ 4 million on its U.S. dollar debt and exchange rate gains of R$ 43 million.

A closer evaluation of the company's hedging operations indicates that the swap loss associated with the strength of the real in the last quarter of 2001 also offset the initial gain in other short term contracts the company entered in previous months. These contracts expired before the end of the year. As of December 31, the stock of swap contracts was only US$ 100 million, compared to US$ 1056 million in year 2000.

It is worth mentioning that although these hedging transactions are intended to minimize the exchange rate risk, they are not at free-cost due to the counterparty credit risk. In its annual reports, the company says they manage credit risk exposure by restricting the counterparties on derivatives to major financial institutions with high credit quality.

Cross currency swaps have been actively used in more recent years. During 2002, a year of large exchange rate volatility, swap operations had a positive impact of R$ 760 million that partly offset the exchange rate losses caused by the 52% currency depreciation. The appreciation of the real in 2002 and 2003 caused losses in hedging operations. These losses were partly compensated with foreign exchange gains in the

[5]The report mentions that derivatives are used for hedging purposes and not for speculative reasons because the risk exposure created by financial derivatives is fully offset by the opposite exposure arising from the liability being hedged. This is consistent with anecdotal evidence by Brown (2001) for a US multinational company. Brown argues that hedging operations require identification of an underlying foreign currency exposure before a derivative is entered to, which from an accounting perspective, can not be viewed as speculative trading.

income statement as shown in Table 4.5.

In addition to the current information from the company's income statement, Table 4.5 presents a counterfactual exercise. It shows the company's pre-tax income in the absence of the derivative hedging program. It is clear from the table that the variation of pre-tax income and net income would have been greater had the company not entered the swap contracts. Pre-tax income volatility during the 4 years shown in the table, measured by the standard deviation, is R$ 1515 million with the swap contract whereas it is R$ 1998 if no swap contracts were used. As a result, in the absence of hedging the effect of exchange rate fluctuations on shareholder's equity would have been also significant. Therefore, as suggested by theory, hedging helped the company smooth its earnings and reduce the volatility of the market value of its equity.

4.3.5 Evaluation of the Company's hedging strategy

Evaluation of the effectiveness of hedging strategies is a hard task when done in isolation or for individual companies because the benchmark for comparison is difficult to set up. Is the hedging strategy effective with respect to what? The approach used in this section emphasizes how effective hedging is to reduce transaction exposure, to contribute to earnings smoothing, to increase foreign currency capacity and to help the company meet its investment plans.

Before 1999, during the fixed exchange rate regime, CSN had no incentives to hedge using financial derivatives since there was no currency exposure. Revenues from exports (20% of total revenues) in U.S. dollars and holdings of U.S. dollar assets seemed to be adequate hedges to deal with any possibility of currency depreciation. This strategy appeared to work fine, helping the company survive the effects of the currency crisis in 1999.

As a measure of economic exposure, it is interesting to observe that the firm's gross margin increased from 35% during the fixed exchange rate regime to 45% in the floating exchange regime (between 2000 and 2004). On average, the company had a gross margin ratio of 42%, significantly greater than the 29% of the companies operating in the steel industry in Brazil. Consistent with the model's predictions, net exports seemed to act as a natural hedge during periods of currency depreciation allowing the company increase its gross margin. Furthermore, it can be seen that returns from productive investment were larger than returns from financial investment (the CD rate never exceeded 20% while Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA) as a fraction of revenues was 32% on average), which is also consistent with the model assumptions.

As suggested by Table 4.4, the company reduced its transaction exposure by participating more actively in financial derivatives and substituting away from investment in foreign assets. As a percentage of net debt, transaction exposure dropped from 80% in 1999 to less than 20% in 2004. In addition, as seen from Table 4.5, proceeds from hedging operations partly offset exchange rate losses that otherwise would have further depleted shareholder's equity. Regarding the firm's debt capacity, the company has remained highly leveraged. Total debt represented approximately 41% of its total assets, a figure significantly greater than that of the rest of firms in its sector (24%). Even during the periods of large exchange rate volatility, the company managed to obtain dollar loans from international markets and to keep its ratio of foreign debt to total debt equal to 90% on average, above the 53% of firms in its sector.

The firm was also able to undertake its investment programs. As part of its expansion and modernization plans, in 1997 CSN acquired Companhia Vale do Rio

Doce, an important steel complex in Brazil. This operation required an investment of R$ 1195 million and was funded almost entirely with foreign currency borrowing at a cost equal to LIBOR plus 3.2%, approximately 8.9% per year. As shown in Table 4.6, even during years of high volatility in foreign exchange markets, the company was able to maintain its capital expenditures. Between 1998 and 2004 capital expenditure represented 10% of fixed assets.

Regarding specific investment plans, the company managed to execute planned investment programs even during times of high exchange rate volatility. For example, in 2000 the company had plans to invest US$ 320 million in the Technology Upgrade program during 2001. In 2001, the company invested US$ 275 million (86% of its planned investment). In 2001, CSN had plans to execute US$ 80 million in the same program during 2002 and ended up investing US$ 174, more than doubled the planned investment. By the end of 2004, the company announced an ambitious plan for different investment projects up to US$ 820 million to be made through 2007. Out of this amount, it invested US$ 340 million in 2004.

In summary, the overall evidence seems to show that hedging activities helped mitigate the effect of exchange rate on the company's earnings and shareholder's equity. With smoothed earnings the company seemed to be able to generate internal funds and borrowed cheaper funds from foreign capital markets to finance investment plans and grow over time.

4.4 Case Study in Votorantim Celulose e Papel

Votorantim Celulose e Papel S.A. (VCP) is one of the leading pulp and paper corporations in Brazil. The company is part of the Votorantim Group, one of the largest industrial investors in Latin America, headquartered in São Paulo. The

company's production process is fully integrated, starting from wood production at its own eucalyptus forests to its two main pulp and paper mills in Jacarei and Luiz Antonio, and two facilities exclusively devoted to paper production in Piracicaba and Mogi da Cruzes, all of them located in São Paulo.

VCP started operations in 1988 when the Votorantim Group bought Celpav Celulose a Paper, an important pulp and paper maker in São Paulo. During the 1990s the company has expanded operations, acquiring and merging with local paper makers. In 2001, VCP purchased 28% of voting shares of Aracruz Celulose S.A., a leading paper maker and exporter in Brazil. More recently, in 2004 VCP signed a venture agreement with Suzano Bahia Sul Papel and Celulose S.A. to acquire Ripasa S.A., another important paper and pulp producer in the country.

4.4.1 Market Share, customers, competitors and Exports

Votorantim is one of the largest pulp and paper companies and the leading producer of wood-free printing and writing papers in Brazil. As an integrated pulp and paper producer selling goods worldwide, the company faces a highly competitive market, comprising a large number of integrated and sophisticated producers. In 2004 the company sold 61% of its pulp production and used the remainder to manufacture a wide range of printing and writing paper products, including coated and uncoated printing and writing papers, thermal papers and carbonless papers.

In 2004 approximately 91% of its market pulp and 30% of its paper products were exported. Exports accounted for 49% of the company's revenues. As seen from Table 4.7 foreign sales of its market pulp were shipped mainly to European and Asian countries while its paper products were mostly sold in North America.

Thanks to its very particular geography with vast woods and forests, Brazil has a natural comparative advantage in forestry, which makes it one of the world's lowest-

cost producers of pulp. Furthermore, Brazilian eucalyptus is one of the finest pulping trees species which has evolved more rapidly over recent years, resulting in a significant improvement in its productivity. As a consequence, Brazil has developed a well diversified and modern industry in both domestic and foreign markets. Brazil is the eleventh largest paper producer and the sixth pulp producer in the world.

In the Brazilian market, *VCP* is one of the five largest makers of pulp and paper. Other important competitors include Lwarcel Celulose e Papel S.A., Suzano Bahia Sul, Riocell S.A. and Klabin S.A. As reported in Table 4.8, the pulp and paper industry in Brazil has shown a steady growth in recent years. *VCP* pulp and paper production is counted among the five top producers and in 2004 it represented 11% of domestic production (mainly in pulp production with a 14% market share).

4.4.2 Exchange rate and Interest rate exposure

Due to its international business *VCP* is exposed to various market risks, including changes in foreign exchange rates and interest rates. The company is exposed to exchange rate risk because a significant portion of its revenues and assets are denominated in local currency while it holds a large fraction of its debt in foreign currency. From 1997 to 2004 the company held on average 84% of its total debt in foreign currency debt. Exports represented on average 34% of its revenues. The foreign currency-denominated component of its paper costs did not exceed 10% of total costs, and were mainly covered with revenues from exports. Then, currency depreciation mostly affected non-operating income, in particular, financial costs due to foreign debt and exchange rate losses resulting from the difference between assets and liabilities in foreign currency.

Almost all of the company's foreign debt is denominated in dollars, which the company borrows from offshore markets at the LIBOR rate plus a margin between 1

and 4 percentage points. Therefore, interest rate risk primarily comes from variations in floating rates such as LIBOR and the long term domestic rate TJLP. Returns on cash holdings and held-to-maturity investment denominated in reals are based on the CD rate, also a floating rate. As seen from Table 4.9, the line "Monetary and exchange rate loss, net" shows that exchange rate variations caused losses of R$ 75 million in 2001 and R$ 90 million in 2002 after currency deprecation of 19% and 52% respectively. Compared to Companhia Siderurgica Nacional, exchange rate losses were smaller and seemed to indicate that Votorantim was able to better absorb the impact of the devaluation of the real. These net losses or gains were partially offset by the net financial income (or expense) resulting from the gain (or loss) on hedging operations.

4.4.3 Company's risk management

Financial decisions, including borrowing and hedging operations are made by the company's Treasury department. This department establishes internal policies about currency exposure positions and revises these policies from time to time in response to new information on the macroeconomic environment. To manage its risk exposure the company invests part of its funds in dollar assets and also uses financial derivatives as a general financial strategy designed to optimize market opportunities.

The company describes its hedging strategy as follows: "hedge contracts mitigate these risks by committing the counterparties and ourselves to positions in foreign currency, thereby offsetting, to the extent of these contracts, the effects of currency fluctuations on our foreign currency debts. The management of our net exposure position takes into account a number of current and projected economic factors and market conditions".

Regarding its hedging programs, like Companhia Siderurgica Nacional, Votoran-

tim enters into cross currency interest rate swap agreements exchanging foreign currency debt with local currency debt at a given exchange rate. By exchanging interest payments, that is, paying real-interest (e.g. the CD rate) and receiving dollar-interest (e.g. LIBOR plus spread) the company protects itself from unfavorable exchange rate movements. Table 4.10 shows the company's exposure to the US dollar as reported on footnotes to financial statements. As can be seen, the company also counts on the mix of cross-currency interest rate swaps and investment in dollar assets (mainly Brazilian government bonds indexed to the U.S. dollar). As in the case of CSN, exposure is measured before revenues from exports though VCP usually refers to its transaction exposure in terms of the number of months of exports required to fully cover it.

Noticeably, the company uses significant amounts of dollar assets to hedge its dollar debt. Dollar assets have been on average about 40% of dollar debt. As Table 4.10 suggests, the company reduced its exposure after the currency crisis in 1999. That year, transaction exposure was negative, indicating that the company was over-hedged in US$ 61 million. In the next years, exposure represented on average less than 4 months of export revenues.

Unlike Companhia Siderurgica Nacional, Votorantim uses cross currency swaps as the only type of derivative to hedge its dollar debt. Table 4.11 shows the notional amounts and other specific characteristics of outstanding cross currency swaps.

Spreads between domestic and foreign interest rates, assuming no arbitrage opportunities, seem to indicate that markets were expecting the Brazilian real to depreciate during each year between 2001 and 2004 as shown in the table. Therefore, the later appreciation of the currency in 2003 and 2004 was not anticipated by the market and could have taken by surprise many companies holding long positions in financial

derivatives (as happened to both Votorantim and Siderurgica Nacional).

Regarding the effect of hedging on the company's financial and net income, Table 4.12 shows that the company obtained gains from its swaps of R$ 32 and R$ 26 million in years of currency depreciation, 2001 and 2002 respectively. These gains partly compensated the exchange rate losses of R$ 75 and R$ 90 millions respectively. In years 2003 and 2004, when the real appreciated against the US dollar, net proceeds from swap contracts were negative and equivalent to R$ 84 and R$ 26 million. These losses were compensated with exchange rate gains of R$ 25 and R$ 190 million respectively. [6]

Unlike Companhia Siderurgica Nacional, gains and losses from swap contracts are a small fraction of net income. However, as seen from table 4.12, hedging operations reduced pre-tax income volatility. The standard deviation of pre-tax income when swap contracts were used was R$ 347 million between 2001 and 2004; it would have been R$ 393 million in the absence of hedging, using again the counterfactual exercise. Therefore, although not as much as in the case of CSN, hedging operations helped Votorantim smooth its earnings and mitigate the effect of exchange rate movements on shareholder's equity.

4.4.4 Evaluation of the Company's hedging strategy

Unlike Companhia Siderurgica Nacional, Votorantim was involved in hedging operations with financial derivatives during the fixed exchange rate period in Brazil. A possible explanation for this behavior is that the company had expectations of currency depreciation, most likely as a result of financial crises in Asia in 1997 and

[6] A common accounting practice is not to book the exchange of notional amounts at maturity, but the net loss or gain as an asset or liability. Booking of these transactions within the income statement varies across companies. *CSN* records the gains from swap contracts as part of net financial income and monetary and exchange rate losses in a separate account within other non-operating income. *VCP* records net monetary and exchange rate gains together with proceeds from swaps as net financial income.

Russia in 1998 that hit the Brazilian economy causing large capital outflows and credit contraction. It is worth mentioning, however, that these specific derivative transactions seem to have been used in reality to take advantage of arbitrage opportunities in foreign exchange markets. As the company mentioned in its annual report to the US Securities and Exchange Commission in 2001, "like many other Brazilian exporters, the company has access to dollar-denominated sources of long-term financing in the form of export pre-payments or credits. (Arbitrage) Opportunities arise between the lower interest rates paid on the U.S. dollar-denominated export credit and borrowing, the proceeds of which are invested in real-denominated cash, cash equivalents and held-to-maturity investments, which provide higher yields". [7]

Regarding the company's gross profits, between 1997 and 2004, VCP had an average gross margin ratio of 42%, greater than the 38% of companies in the pulp and paper industry in Brazil. Moreover, the company increased its gross profits during the floating exchange rate period (48%). This was the result of not only the positive effect of currency depreciation on its foreign sales between 1999 and 2002 but also the increase in volume exported.

During years when the real appreciated against the U.S. dollar, the company experienced a significant increase in export revenues, 97% and 27% in 2003 and 2004 respectively. Thanks to its investment plans, the company was able to increase the volume of its sales to foreign markets in 82% in 2003 and 35% in 2004, which more than offset the negative valuation effect brought by the currency appreciation. It seems clear that net exports worked as a natural hedge for the company.

Votorantim main sources of liquidity are cash generated from operations and short-term and long-term borrowing. Internal operating funds, measured through

[7] It is not clear though, why other companies did not take advantage of this situation. Possible explanations in favor of arbitrage opportunities available for only few companies include information asymmetries, transaction costs or limited access to foreign capital markets due to different investor's risk perception across companies.

the ratio of EBITDA to total revenues was on average 42%, greater than the ratio of firms in the paper industry in Brazil (36%). Borrowed funds represented approximately 38% of its total assets, a greater ratio compared to that in its sector (34%). These sources of funds helped the firm keep its capital expenditures. As seen from Table 4.13 *VCP* was able to increase its capital expenditures consistent with investment plans even during years of high volatility in exchange rate markets. Capital expenditure between 1998 and 2004 represented, on average, 16% of the company's fixed assets.

Regarding specific investment plans, *VCP* was able to execute most of its planned investment programs. For example, in 2003 the company completed the expansion of its Jacarei plant with a total spending of US$ 483 million out of an initial investment plan of US$ 495 million. Even during 2002, a difficult year for the Brazilian economy, the company executed investment projects for US$ 317 million (73% of the planned investment for that year). In 2003 the company invested US$ 183 (83% of its planned investment). These investments helped the company's business grow significantly in 2003 and 2004.

As a result of the culmination of the Jacarei plant expansion the company increased its annual pulp production capacity by 67% (from 850,000 tons per year in 2002 to 1.4 million tons per year in 2004). The additional pulp production was sold primarily in foreign markets, which explains the extraordinary increase in exports during 2003 and 2004.

Overall, as in the previous case of Companhia Siderurgica Nacional, it seems that hedging strategies helped Votorantim mitigate the effects of foreign exchange fluctuations on its profits, reducing the volatility of its net income. Smoothed earnings and increased equity definitely contributed to have a better risk profile to the eyes

of foreign investors, which have been providing relatively cheap credit to finance the company's expansion during times of economic downturn. As a result, *VCP* has been able to increase its foreign debt from 79% during the fixed exchange rate period to 85% after the currency crisis in 1999; and has continued making capital expenditures that, on average, represent 16% of its fixed assets.

4.5 Conclusion

By conducting a close examination of footnotes to financial statements, annual reports to the senior administration and reports to the US Securities and Exchange Commission available through the Brazilian stock market (BOVESPA) and firms' web sites, this chapter studies actual hedging strategies implemented by Brazilian companies. Two large corporations, both operating in international markets and using financial hedging, are chosen to illustrate how corporations deal with exchange rate risk. Even though the case study finds that there are no general rules for setting an optimal hedging strategy, it can be concluded that the firm behavior observed in practice is consistent with the model of optimal debt composition and hedging of the first chapter and with theoretical arguments suggested by the corporate hedging literature.

The drastic change in exchange rate policy in Brazil exposed firms to a large degree of currency risk because at the time of the crisis they were heavily indebted in foreign currency. Both firms had about 85% of their debt denominated in foreign currency. In this scenario, both firms seemed to choose hedging operations effectively, which translated into good financial performance even during periods of high volatility in foreign exchange markets.

Companhia Siderurgica Nacional and Votorantim Celulose e Papel obtain a sig-

nificant amount of revenues from foreign sales. In both cases, operating profits are practically unaffected by currency devaluation since export revenues more than offset the costs of imported goods. Therefore, the main impact of exchange rate movements affect the companies' profits by reducing financial income, and this is precisely where derivative hedging appears to work effectively. Both companies use cross-currency interest rate swaps to compensate for the impact of exchange rate losses, recorded in the income statement according to Brazilian corporate laws.

Consistent with theory, hedging contributes to smooth the companies' earnings and help mitigate depletion of shareholder's equity. In turn, this contributes to reduce investor's risk perception about the firm and to increase its access to foreign capital markets. Even though it is hard to establish a direct impact of hedging on the firm's financial performance by studying individual companies, at least one can conclude that hedging may contribute to keep the firm's business growing by allowing it to obtain the necessary funding to meet its investment plans. It would be hard as well to imagine that these two companies could have enjoyed a good financial position in the absence of hedging strategies.

There are too many factors involved in the firm risk management policy and having a full understanding of all these possible factors is beyond the scope of the case study. There are still many unresolved questions about the hedging process of companies in Brazil. For example, issues such as the right motivations to use a particular type of derivative instrument or whether the extent of hedging is optimal have not been addressed and may serve as motivation for further studies. However, by studying a particular aspect of risk management activities of corporations, such as transactional exposure management, the case studies find that firm behavior regarding borrowing and hedging is broadly consistent with what the corporate finance theory suggests.

Table 4.1: Brazil: Main Steel Producers

Company	2003		2004	
	Ranking	Production (Million of Tons)	Ranking	Production (Million of Tons)
Gerdau SA	1	7.0	1	7.3
CSN	2	5.3	2	5.5
Siderurgica Tubarao	3	4.8	3	5.0
Usiminas	4	4.5	4	4.7
Belgo Mineira	5	4.1	5	4.2
Others		2.5		2.9
Total		31.1		32.9

Source: Annual report to the US Securities and Exchange Commission.

Table 4.2: Companhia Siderurgica Nacional: Main Performance Indicators

	1997	1998	1999	2000	2001	2002	2003	2004
Operations (Thousands of Tons)								
Production	4.793	4.705	4.846	4.782	4.048	5.107	5.318	5.518
Sales	4.538	4.064	4.545	4.311	4.045	4.97	5.000	4.744
Financial Data (Thousand of million of R$)								
Revenues	3034	3155	3537	4264	4832	6108	8292	12251
Domestic Sales	2478	2640	2834	3665	4252	4532	5940	9260
Foreign Sales 1/	556	515	703	599	580	1576	2352	2991
Net Revenue	2579	2658	2936	3472	3982	5165	6977	9800
Gross Profit	904	948	1157	1375	1702	2417	3140	4802
EBITDA	816	857	1441	1330	1698	2276	3002	4789
Operating Profit	567	551	749	938	1273	1730	2312	3951
Net Financial Income	-366	-116	-764	35	-975	-2525	-1234	-1146
Monetary and ER gain (loss), net	-98	-131	-219	-398	-396	-2904	782	229
Net Income	457	435	197	602	300	-195	1031	1982
Total Assets	8729	8484	12503	15281	13433	15434	22522	24705
Total Debt	3649	3378	4563	5158	5571	6786	8957	8470
Domestic debt	382	261	224	226	242	1275	2019	1712
Foreign debt	3267	3117	4339	4932	5329	5511	6938	6758
Shareholder's Equity	4389	4555	5852	5704	5118	4895	7419	6655
Financial Ratios (percent)								
$GrossProfit/NetRevenue$	35.0	35.6	39.4	39.6	42.7	46.8	45.0	49.0
$EBITDA/NetRevenue$	31.6	32.2	49.1	38.3	42.6	44.1	43.0	48.9
$NetIncome/NetRevenue$	17.7	16.4	6.7	17.3	7.5	-3.8	14.8	20.2
$CurrentAsset/CurrentLiabilities$	1.2	1.7	0.8	1.3	0.8	0.9	1.5	1.4
$ForeignDebt/TotalDebt$	89.5	92.3	95.1	95.6	95.6	81.2	77.5	79.8
$TotalDebt/TotalAsset$	41.8	39.8	36.5	33.8	41.5	44.0	39.8	34.3

1/ Exports from Brazil and Sales from foreign subsidiaries.

Net Financial income includes Monetary and Exchange Rate loss or gain.

EBITDA is Earnings Before Interest, Taxes, Depreciation and Amortization.

Source: Company's annual report, various years.

Table 4.3: Companhia Siderurgica Nacional: Foreign Currency Debt and Derivatives (US$ million)

	1997	1998	1999	2000	2001	2002	2003	2004
Foreign Currency Debt	2927	2579	2425	2522	2297	1560	2401	2546
Short Term	1456	798	1428	1033	1147	806	748	584
Long Term	1471	1781	997	1489	1150	754	1653	1962
Debt Composition								
U.S. Dollar	2825	2460	2231	2318	2086	1427	2229	1587
Yen	93	20	153	150	156	78	72	874
Other	9	99	41	54	55	55	100	85
Currency Derivatives	0	0	290	1056	100	791	1286	1047
Swaps	0	0	290	0	100	786	1286	31
Options	0	0	0	770	0	0	0	0
Forward	0	0	0	286	0	5	0	0
Futures	0	0	0	0	0	0	0	1016

Source: Footnotes to the company's financial statements.

Table 4.4: Companhia Siderurgica Nacional: Transaction Exposure to the U.S. Dollar (US$ million)

	1997	1998	1999	2000	2001	2002	2003	2004
US Dollar Debt	2825	2460	2231	2318	2086	1427	2229	1587
US Dollar Assets	600	930	799	581	194	227	441	317
Net Debt	2225	1530	1431	1737	1892	1200	1788	1270
Dollar derivatives	0	0	290	1056	100	791	1286	1047
Transaction Exposure	2225	1530	1141	681	1792	409	502	223
Exposure/Dollar debt (%)	79	62	51	29	86	29	23	14
Dollar Asset/Dollar Debt (%)	21	38	36	25	9	16	20	20
Dollar Derivative/Dollar Debt (%)	0	0	13	46	5	55	58	66

Source: Footnotes to the company's financial statements.

Table 4.5: Companhia Siderurgica Nacional: Effect of Currency Swaps on Income Statement

	2001	2002	2003	2004
Operating Profit	1273	1730	2312	3951
(+)Financial Income	117	1333	-786	-38
Swap contracts	0	760	-841	-229
Other	117	573	55	191
(-)Financial Expenses	482	667	250	884
(+)Net Non Operational Income	-611	-3191	-198	-224
Monetary and ER loss	-396	-2904	782	229
Other	-215	-287	-980	-453
Pre-Tax Income				
With Swap	297	-795	1078	2805
Without Swap	297	-1555	1919	3034

Source: Footnotes to the company's financial statements.

Table 4.6: Companhia Siderurgica Nacional: Capital Expenditure (US$ Million)

Year	Capital Expenditure	(%) of Fixed Assets
1998	379	11.1
1999	444	11.1
2000	414	10.7
2001	430	12.3
2002	264	10.4
2003	210	4.6
2004	518	10.1

Source: Annual report to the US Securities and Exchange Commission.

Table 4.7: Votorantim Celulose e Papel: Exports of Pulp and Paper by destination in 2004

Destination	Pulp		Paper	
	Thousand Tons	(%)	Thousand Tons	(%)
North America	85.544	11.2	62.726	34.9
Latin America	3.044	0.4	43.756	24.4
Europe	347.371	45.4	53.889	30.0
Asia and Africa	328.404	43.0	19.158	10.7
Total	764.363	100	179.529	100

Source: Annual report to the US Securities and Exchange Commission.

Table 4.8: Brazil: Pulp and Paper Production (Thousands of Tons)

	2004	2003	2002
Pulp Production			
Brazil	9620	9104	8012
VCP	1347	1166	823
Paper Production			
Brazil	8452	7811	7661
VCP	661	673	571
Total Pulp and Paper production			
Brazil	18073	16915	15673
Top five domestic producers	10978	10547	9811
VCP	2008	1839	1394

Source: Annual report to the US Securities and Exchange Commission.

Table 4.9: Votorantim Celulose e Papel: Main Performance Indicators

	1997	1998	1999	2000	2001	2002	2003	2004
Operations (Thousands of Tons)								
Sales	680	747	825	870	912	906	1175	1459
Domestic market	389	396	454	525	522	521	477	515
Foreign market	291	351	371	345	390	385	698	944
Financial Data (Thousand of million of R$)								
Revenues	777	823	1264	1618	1736	2317	3240	3773
Domestic Sales	547	576	854	1183	1249	1576	1782	1924
Foreign Sales 1/	230	247	410	435	487	741	1458	1849
Net Revenues	684	731	1123	1437	1554	2061	2926	3403
Gross Profit	171	186	487	729	720	966	1446	1671
EBITDA	171	195	480	756	707	940	1387	1613
Operating Profit	48	57	323	568	510	685	1067	1169
Net Financial Income	-9	-41	-120	-106	36	-97	-76	-136
Monetary and ER gain (loss), net	0	0	-56	n.d.	-75	-90	25	190
Net Income	17	-7	161	394	376	283	853	790
Total Asset	2929	3049	3289	3487	5259	7345	7949	7650
Total Debt	889	1045	1075	887	2259	3803	3679	2834
Domestic debt	192	200	163	116	217	534	602	554
Foreign debt	697	845	912	771	2042	3269	3077	2281
Shareholder's Equity	1894	1855	1985	2318	2602	2796	3415	3917
Ratios (percent)								
$GrossProfit/NetRevenue$	24.9	25.5	43.4	50.7	46.3	46.8	49.4	49.1
$EBIDTA/NetRevenue$	25.0	26.7	42.8	52.6	45.5	45.6	47.4	47.4
$NetIncome/NetRevenue$	2.5	-1.0	14.4	27.4	24.2	13.7	29.1	23.2
$CurrentAsset/CurrentLiabilities$	2.8	3.4	3.1	3.6	0.9	0.9	1.1	1.1
$ForeignDebt/TotalDebt$	78.4	80.8	84.9	86.9	90.4	86.0	83.6	80.5
$TotalDebt/TotalAsset$	30.3	34.3	32.7	25.4	42.9	51.8	46.3	37.0

1/ Exports from Brazil and Sales from foreign subsidiaries.

Net Financial income includes Monetary and Exchange Rate loss or gain.

EBITDA is Earnings Before Interest, Taxes, Depreciation and Amortization.

Source: Company's annual report, various years.

Table 4.10: Votorantim Celulose e Papel: Transaction Exposure to the U.S. Dollar (US$ million)

	1997	1998	1999	2000	2001	2002	2003	2004
US Dollar Debt	624	699	510	394	516	545	796	780
US Dollar Assets	91	88	317	108	282	362	308	275
Net Debt	534	611	193	287	233	183	488	505
Dollar derivatives	328	500	254	198	233	155	214	259
Transaction Exposure	206	110	-61	89	0	28	274	246
Export revenues	206	204	229	222	210	210	505	696
Months of exports needed	12	6	0	5	0	2	7	4
Exposure/Dollar debt (%)	33	16	-12	23	0	5	34	32
Dollar Asset/Dollar Debt (%)	15	13	62	27	55	66	39	35
Dollar Derivative/Dollar Debt (%)	52	72	50	50	45	28	27	33

Source: Footnotes to the company's financial statements.

Table 4.11: Votorantim Celulose e Papel: Cross Currency Swap contracts

Year	Notional Value R$ million	Notional Value US$ million	Average Maturity	Paid interest R$(%)	Received interest US$ (%)
2001	541	233		17.43	13.1
2002	548	155	2003-2008	19.05	13.3
2003	618	214	2006-2008	23.27	13.3
2004	687	259	2007-2008	16.17	11.3

Source: Footnotes to the company's financial statements.

Table 4.12: Votorantim Celulose e Papel: Effect of Currency Swaps on Income Statement

	2001	2002	2003	2004
Operating Profit	510	685	1067	1169
(+)Financial Income	198	217	153	92
Swap contracts	32	26	-84	-26
Other	166	191	237	118
(-)Financial Expenses	86	224	254	228
(+)Net Non Operational Income	-118	-299	17	48
Monetary and ER loss	-75	-90	25	190
Other	-42	-209	-8	-141
Pre-Tax Income				
With Swap	504	379	983	1081
Without Swap	472	353	1067	1108

Note: financial income and expenses have been modified to reflect swap income and exchange rate losses
Source: Footnotes to the company's financial statements.

Table 4.13: Votorantim Celulose e Papel: Capital Expenditure (US$ Million)

Year	Capital Expenditure	(%) of Fixed Assets
1998	110	7.5
1999	80	8.1
2000	113	12.2
2001	308	30.0
2002	317	21.0
2003	183	13.6
2004	289	17.6

Source: Annual report to the US Securities and Exchange Commission.

CHAPTER V

Conclusion

This dissertation combines theoretical and empirical work to examine how financial markets and exchange rate regimes affect companies decisions about borrowing and hedging. Financial data for a sample of non-financial firms in Brazil over the period 1996 to 2004 is used to illustrate why the collapse of the fixed exchange rate regime, in early 1999, did not cause major changes in the currency composition of debt. According to the theory, this fact was the result of firms that, in anticipation to the currency devaluation, decided to hedge their currency risk. Since derivative hedging was available in Brazil at the time of the crisis, companies were able to use derivative hedging to maintain and even increase their borrowing in foreign currency. Empirical work using these data finds that, in the presence of foreign exchange risk, derivative hedging becomes important to increase firm's debt capacity and adds considerable value to a firm by smoothing financing and operating policies. When exposed to currency shocks, companies try also alternative hedging strategies such as revenues from net exports acting as a natural hedge and holdings of assets in foreign currency, which provide financial income to compensate for increased interests in foreign currency and to mitigate the depletion of shareholder's equity. As derivative markets develop more firms opt to use derivative hedging.

APPENDICES

APPENDIX A

Chapter II: Model Solution

A.1 Determination of Equilibrium

There are four possible cases in the profit maximization problem of a representative firm. The maximized objective function is different depending on:

i. $1_H = 1$ and $1_L = 1$ if the firm is solvent in both states

ii. $1_H = 1$ and $1_L = 0$ if the firm is solvent only in state H

iii. $1_H = 0$ and $1_L = 1$ if the firm is solvent only in state L

iv. $1_H = 0$ and $1_L = 0$ if the firm is insolvent in both states

Case (iv) is the uninteresting case and is ruled out because no lender will lend the firm any amount so that it cannot undertake the project. Moreover, given the features of the hedging contracts, firms being solvent only in one state of the exchange rate are firms that choose $h = 0$. Therefore, expected profits for the remaining three cases are respectively:

i. $E[\Pi_{TOT}] = P_G[R - R_m - F\ R_u - \phi|h|]$

ii. $E[\Pi_{TOT}] = P_G[q(R - R_m - s_H\ R_u)]$

iii. $E[\Pi_{TOT}] = P_G[(1-q)(R - R_m - s_L\ R_u)]$

Case (ii) is also ruled out because it is always dominated by case (i). To see this, note that when $\phi = 0$ for any $0 < q < 1$ then $s_H > F$ and profits are greater in case (i) than in case (ii). When $\phi > 0$ then the only possibility for profits in case (ii) to exceed profits in case (i) would be if both q and ϕ are large enough. However, these values would imply $q > \overline{q}$ and $\phi > \overline{\phi}$ which would make $h = 0$, in which case profits in case (ii) are again smaller. Intuitively, when the firm is solvent in state H only, it is also solvent in both states H and L even without hedging. Moreover, with positive transaction costs there is no reason to hedge a positive amount when the firm is already solvent in state H.[1] Therefore, the relevant cases to evaluate are only (i) and (iii), which means that in equilibrium, the firm is always solvent in state L ($1_L = 1$) and case (iii) of insolvency in state H happens only when the firm is not hedged at all.

Given that the firm is the residual claimant in debt contracts, it is straight forward to see that constraints (5) through (7) will be binding. This is so because to maximize profits the firm chooses the minimum payments that make its creditors willing to participate financing the project. A representative firm solves its maximization problem at date 0 using the following algorithm:

i. Suppose that given the lower cost of foreign debt the firm decides to borrow directly from foreign banks ($1_m = 0$). Furthermore, suppose the firm judges itself as financially solvent without hedging ($1_H = 1, 1_L = 1$ and $h = 0$). Conditions (5) and (6) jointly determine $I_m = 0$ and $R_m = 0$. Given A and I, the firm finds I_u using (1), which holds with equality, and then R_u is determined by (7). With expected payments R_m and R_u already pinned down, constraint (3) is used to

[1] The only possibility for a firm to hedge if solvent in state H is if it holds negative hedging or sells forward contracts. However, for any positive transaction cost ϕ, negative hedging is also dominated by zero hedging.

verify if the firm is solvent in state H.[2] If it is, then the firm can in fact borrow directly from foreign markets without hedging.

ii. When the firm is not solvent in state H and decides not to hedge then foreign creditors adjust their expected payment. R_u depends on q and is bigger to compensate for the possibility of default. Constraint (8) is binding so that $R_f(s_H) = 0$ (e.g. the residual value of the firm goes to pay for bankruptcy costs if state H occurs). Constraint (2) gives the firm's own payment $R_f(s_L)$. If constraint (4) is met then borrowing in foreign currency without hedging is feasible. Otherwise, the firm could still borrow directly from foreign markets but must use forward contracts to reduce the possibility of default in state H.

iii. If the firm hedges its foreign exchange risk via currency forwards then (2) and (3) combined with (8) and (9) determine an optimal range for hedging $[\underline{h}, \overline{h}]$ given by:

$$\frac{s_H R_u + R_m - R}{s_H - F - \phi} \leq h \leq \frac{R - R_m - s_L R_u}{F - s_L + \phi}$$

Profit maximization implies that for any positive and small ϕ the firm chooses the minimum level to avoid default so that optimal hedging is $h = \underline{h}$ with $R_m = 0$. As a result, constraint (8) is binding and $R_f(s_H) = 0$. Note that when $\phi = 0$ there are multiple solutions for the optimal hedge because the firm is indifferent choosing any value within the range $[\underline{h}, \overline{h}]$. If constraint (4) is met then borrowing in foreign currency and hedging is feasible. The firm determines whether hedging is optimal or not by comparing profits with the not hedging

[2]Two cases of solvency in state H are considered. First, the firm is solvent if it receives the maximum expected payment in state H, that is $R_f(s_H) = B/\Delta p$, even after paying its creditors (constraints (8) and (9) are both non-binding). A less stringent second criterion for solvency is when the firm at least guarantees repayment in state H even though it is left with nothing so that $R_f(s_H) = 0$ (constraint (8) is binding but constraint (9) is not binding).

case. If constraint (4) is not met then the firm cannot borrow directly from foreign markets and must turn to domestic banks first.

iv. Suppose the firm borrows from domestic banks ($1_m = 1$) and believes it is financially solvent without hedging ($1_H = 1, 1_L = 1$ and $h = 0$). As before, constraints (5) and (6) jointly determine I_m and R_m. These two variables are now:

$$R_m = \frac{C}{\Delta p(1 - q + 1_H q)},\ I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p}$$

Notice that when the firm is solvent in state H, R_m does not depend on q. Given I and A, and having determined I_m then: if $A + I_m > I$ then resource constraint (1) is not binding, the firm borrows in domestic currency only and invests excess funds $I - A - I_m$ at the market rate r^f. If $A + I_m \leq I$ then constraint (1) is binding and the firm uses it to determine I_u so that the currency composition of debt is pinned down. As in steps (ii) and (iii) of this algorithm, the firm can borrow now in both currencies without hedging if it is solvent in state H or can face higher payments if it is not solvent in state H and does not hedge. Whether the firm must hedge or not depends on exogenous parameters (in particular q and ϕ). The firm solves for its optimal hedging decision by comparing profits in each case. If the firm must hedge the optimal range for hedging is $[\underline{h}, \overline{h}]$ with $R_m > 0$. As before, the minimum level $h = \underline{h}$ is chosen when $\phi > 0$ or any level within $[\underline{h}, \overline{h}]$ when $\phi = 0$. Finally, if constraint (4) is not met even with a positive level of hedging then the firm is poorly capitalized (too small net worth) and will not be able to borrow at all.

A.2 Determination of the firm's minimum net worth requirements in equilibrium

To find the minimum net worth requirements under different hedging strategies suppose that instead of using its initial assets as an exogenous variable, the entrepreneur wants to determine the size of A necessary to maximize expected profits and meet all the constraints. Net worth A can then be treated as an additional endogenous variable that the entrepreneur finds in equilibrium and compare with her initial assets, renamed as A_0, to determine for example if the firm is solvent without hedging, or if the firm needs to borrow form local banks and be hedged.

1. The firm borrows a mixture of domestic and foreign currency debt ($1_m = 1$) so that constraint (1) is binding. There are four different cases:

   a. The firm is solvent in both states only if hedged ($1_H = 1$ and $1_L = 1$). There are 9 constraints to solve for 8 unknowns ($h, I_m, I_u, R_m, R_u, R_f(s_L), R_f(s_H), A$) so that one constraint is non-binding. Constraints (2) and (3) combined with (8) and (9) defines the range $[\underline{h}, \overline{h}]$ for optimal hedging h and for any positive and small transaction cost ϕ, the firm chooses $h = \underline{h}$. This condition is equivalent to have constraint (8) binding and (9) non-binding. Therefore, the firm hedges enough to avoid default and it gets zero cash flow in the devaluation state. Having constraints (1) through (8) holding with equality, in equilibrium:

$$R_f(s_L) = \frac{b}{\Delta p(1-q)},\ R_f(s_H) = 0,\ R_m = \frac{C}{\Delta p},\ I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p}$$

$$R_u = \frac{1}{F+\phi}[R - \frac{b+C}{\Delta p} + \frac{b\phi}{\Delta p(1-q)(s_H - s_L)}]$$

$$I_u = \frac{P_G}{r^*}\frac{1}{F+\phi}[R - \frac{b+C}{\Delta p} + \frac{b\phi}{\Delta p(1-q)(s_H - s_L)}]$$

$$h = \frac{1}{F+\phi}[R - \frac{C}{\Delta p} - \frac{b}{\Delta p}\frac{s_H}{(1-q)(s_H - s_L)}]$$

The minimum A required by foreign banks is:

$$\underline{A}_H(r^*, q, \phi) = I - \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p} - \frac{P_G}{r^*}\frac{s_L}{F+\phi}[R - \frac{b+C}{\Delta p} + \frac{b\phi}{\Delta p(1-q)(s_H - s_L)}]$$

b. The firm is solvent in both states even if it is not hedged: ($1_H = 1, 1_L = 1$ and $h = 0$). This situation requires higher net worth A. The first criterion for solvency is that the firm is at least able to pay its debt even if it has to give up its own expected payment during the depreciation state, that is $R_f(s_H) = 0$. A firm will be able to invest if in return it expects to get higher payments during the non-depreciation state. Therefore constraints (4) and (9) are non-binding and there are 7 binding constraints to solve for 7 unknowns ($I_m, I_u, R_m, R_u, R_f(s_L), R_f(s_H), A$). The equilibrium solutions in this case are:

$$R_f(s_L) = (R - \frac{C}{\Delta p})(\frac{s_H - s_L}{s_L}),\ R_f(s_H) = 0,\ h = 0,\ R_m = \frac{C}{\Delta p}$$

$$I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p},\ R_u = \frac{1}{s_H}(R - \frac{C}{\Delta p}),\ I_u = \frac{1}{s_H}\frac{P_G}{r^*}[R - \frac{C}{\Delta p}]$$

The minimum A required by foreign banks is now:

$$\underline{A}_{SNH}(r^*) = I - \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p} - \frac{P_G}{r^*}\frac{s_L}{s_H}[R - \frac{C}{\Delta p}]$$

As can be seen, when $h > 0$ then $\underline{A}_H < \underline{A}_{SNH}$ which means that creditors would demand higher net worth compared to the case when firms must hedge to be solvent. Also the firm gets a higher payment in the good state, that is, $R_f(s_L) > b/[\Delta p(1-q)]$, as expected.

c. The firm is solvent in both states even if it is not hedged ($1_H = 1, 1_L = 1$ and $h = 0$) but in this case the firm still gets the maximum expected payment during the depreciation state, that is, $R_f(s_H) = b/\Delta p$ and the firm gets higher payments during the non-depreciation state. Unlike the previous case, now the net worth required is greater than $\underline{A}_{SNH}$. Constraints (4), (8) and (9) are non-binding so that there are 6 binding constraints to solve for 6 unknowns $(I_m, I_u, R_m, R_u, R_f(s_L), A)$. The equilibrium solutions in this case are:

$$R_f(s_L) = (R - \frac{C}{\Delta p})(\frac{s_H - s_L}{s_L}) + \frac{s_L}{s_H}\frac{b}{\Delta p},\ R_f(s_H) = \frac{b}{\Delta p},\ h = 0,\ R_m = \frac{C}{\Delta p}$$

$$I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p},\ R_u = \frac{1}{s_H}(R - \frac{b+C}{\Delta p}),\ I_u = \frac{P_G}{r^*}\frac{1}{s_H}[R - \frac{b+C}{\Delta p}]$$

The minimum A required by foreign banks is now:

$$\underline{A}_S(r^*, q) = I - \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p} - \frac{P_G}{r^*}\frac{s_L}{s_H}[R - \frac{b+C}{\Delta p}]$$

As can be seen, $\underline{A}_{SNH} < \underline{A}_S$ which means that this is an even higher net worth compared to the case when the firm is solvent but gets zero expected payment. As expected $R_f(s_L) > b/[\Delta p(1-q)]$. In all the previous cases, it is assumed that the monitoring technology is socially valuable.[3] As a result

[3]Monitoring is valuable when $C[P_G - \frac{s_L}{F}P_B] < P_G[B - b]$

$\underline{A}_H < \overline{A}_H$, $\underline{A}_{NH} < \overline{A}_{NH}$ and $\underline{A}_S < \overline{A}_S$.

d. The firm is not solvent if it is not hedged ($1_H = 0, 1_L = 1$ and $h = 0$). Since the firm is not solvent in state H then (3) is ruled out and (8) is binding so that $R_f(s_H) = 0$. Moreover, (9) is non-binding so that $R_f(s_L) > 0$. Therefore, there are 7 binding constraints to solve for 7 unknowns $(I_m, I_u, R_m, R_u, R_f(s_L), R_f(s_H), A)$. The equilibrium solution is:

$$R_f(s_L) = \frac{b}{\Delta p(1-q)},\ R_f(s_H) = 0,\ h = 0,\ R_m = \frac{C}{\Delta p(1-q)}$$

$$I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p},\ R_u = \frac{1}{s_L}(R - \frac{b+C}{\Delta p(1-q)}),\ I_u = \frac{P_G}{r^*}\frac{1-q}{s_L}[R - \frac{b+C}{\Delta p(1-q)}]$$

The minimum net worth requirement is:

$$\underline{A}_{NH}(r^*, q) = I - \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p} - \frac{P_G}{r^*}(1-q)[R - \frac{b+C}{\Delta p(1-q)}]$$

2. The firm borrows only in foreign currency from international banks ($1_m = 0$). As in the previous case, there are four different cases as well:

a. The firm is solvent in both states if hedged ($1_H = 1$ and $1_L = 1$). There are 7 constraints to solve for 6 unknowns $(h, I_u, R_u, R_f(s_L), R_f(s_H), A)$ so that one constraint is non-binding. As before, constraints (2) and (3) combined with (8) and (9) define the range for optimal hedging h. For any positive and small transaction cost ϕ, the firm chooses the minimum level to avoid default so that optimal hedging is $h = \underline{h}$. This result implies that (8) is binding and (9) is non-binding. The firm hedges enough to avoid default and it gets zero cash flow in the devaluation state. In equilibrium:

$$R_f(s_L) = \frac{B}{\Delta p(1-q)},\ R_f(s_H) = 0,\ R_m = 0,\ I_m = 0$$

$$h = \frac{1}{F+\phi}[R - \frac{B}{\Delta p}\frac{s_H}{(1-q)(s_H - s_L)}]$$

$$R_u = \frac{1}{F+\phi}(R - \frac{B}{\Delta p} + \frac{B\phi}{\Delta p(1-q)(s_H - s_L)})$$

$$I_u = \frac{P_G}{r^*}\frac{1}{F+\phi}[R - \frac{B}{\Delta p} + \frac{B\phi}{\Delta p(1-q)(s_H - s_L)}]$$

The minimum A required by foreign banks is:

$$\overline{A}_H(r^*, q, \phi) = I - \frac{P_G}{r^*}\frac{s_L}{F+\phi}[R - \frac{B}{\Delta p} + \frac{B\phi}{\Delta p(1-q)(s_H - s_L)}]$$

b. The firm is solvent in both states even if it is not hedged: ($1_H = 1, 1_L = 1$ and $h = 0$). Intuitively again, this firm has high enough net worth (i.e. higher than the minimum A when it has to hedge to be solvent). As in the case of $1_m = 1$ now constraints (4) and (9) are non-binding and there are 5 binding constraints to solve for 5 unknowns ($I_u, R_u, R_f(s_L), R_f(s_H), A$). The equilibrium solutions are:

$$R_f(s_L) = (R\frac{s_H - s_L}{s_L}),\ R_f(s_H) = 0,\ h = 0,\ R_m = 0,\ R_u = \frac{1}{s_H}R$$

$$I_m = 0,\ I_u = \frac{1}{s_H}\frac{P_G}{r^*}R$$

The minimum A required by foreign banks is now:

$$\overline{A}_{SNH}(r^*) = I - \frac{P_G}{r^*}\frac{s_L}{s_H}R$$

Note that when $h > 0$ then $\overline{A}_H < \overline{A}_{SNH}$ which means that banks demand higher net worth compared to the case when firms must hedged to be solvent. Also, the firm gets a higher payment in the good state, that is, $Rf_(s_L) > B/[\Delta p(1-q)]$, as expected.

c. The firm is solvent in both states even if it is not hedged as before ($1_H = 1, 1_L = 1$ and $h = 0$) but in this case the firm still gets the maximum expected payment during the depreciation state, that is $R_f(s_H) = B/\Delta p$ and the firm gets higher payments during the non-depreciation state. Unlike the previous case, now the net worth required is higher than $\overline{A}_{SNH}$. Constraints (4) and (8) and (9) are non-binding and there are 4 binding constraints to solve for 4 unknowns $(I_u, R_u, R_f(s_L), A)$. The equilibrium solutions are:

$$R_f(s_L) = R(\frac{s_H - s_L}{s_L}) + \frac{s_L}{s_H}\frac{B}{\Delta p},\ R_f(s_H) = \frac{B}{\Delta p},\ h = 0,\ R_m = 0,\ I_m = 0$$

$$R_u = \frac{1}{s_H}(R - \frac{B}{\Delta p}),\ I_u = \frac{P_G}{r^*}\frac{1}{s_H}[R - \frac{B}{\Delta p}]$$

The minimum A required by foreign banks is now:

$$\overline{A}_S(r^*) = I - \frac{P_G}{r^*}\frac{s_L}{s_H}[R - \frac{B}{\Delta p}]$$

As can be seen, $\overline{A}_{SNH} < \overline{A}_S$ and as expected $R_f(s_L) > B/[\Delta p(1-q)]$.

d. The firm is not solvent if it is not hedged ($1_H = 0, 1_L = 1$ and $h = 0$). Constraint (2) is ruled out and constraint (8) is binding so that $R_f(s_H) =$

0. Constraint (9) is non-binding so that $R_f(s_L) > 0$. Therefore, there are 5 constraints to solve for 5 unknowns $(I_u, R_u, R_f(s_L), R_f(s_H), A)$. The equilibrium solution is:

$$R_f(s_L) = \frac{B}{\Delta p(1-q)},\ R_f(s_H) = 0,\ h = 0,\ R_m = 0,\ I_m = 0,$$

$$R_u = \frac{1}{s_L}(R - \frac{B}{\Delta p(1-q)}),\ I_u = \frac{P_G}{r^*}\frac{1-q}{s_L}[R - \frac{B}{\Delta p(1-q)}]$$

and the minimum net worth requirement is:

$$\overline{A}_{NH}(r^*, q) = I - \frac{P_G}{r^*}(1-q)[R - \frac{B}{\Delta p(1-q)}]$$

3. The firm borrows only in domestic currency from local banks: then $R_u = I_u = 0$. It can be shown that the firm is indifferent between hedging and not hedging if $\phi = 0$. Hence, without loss of generality, it can be concluded that in this case the firm is always solvent and does not hedge because it does not need to. Constraints (8) and (9) are non-binding and constraint (7) is not relevant. Profit maximizing firms pay domestic banks just the least banks demand to participate so that constraints (5) and (6) are binding and the only possible non-binding constraint is (4). Therefore, by making constraint (1) bind to solve for the minimum net worth A, there are 5 binding constraints to solve for 5 unknowns $(I_m, R_m, R_f(s_L), R_f(s_H), A)$. The equilibrium solution is given by:

$$R_f(s_L) = R - \frac{C}{\Delta p},\ R_f(s_H) = R - \frac{C}{\Delta p},\ h = 0,\ R_u = 0, I_u = 0$$

$$R_m = \frac{C}{\Delta p},\ I_m = \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p}$$

The minimum net worth requirement is:

$$A_B(r^*, q) = I - \frac{P_B}{r^*}\frac{s_L}{F}\frac{C}{\Delta p}$$

Note that $A_B > \underline{A}_S > \underline{A}_{SNH}$. Furthermore, for firms to demand only domestic currency debt the monitoring cost C must be sufficiently high so that local banks lend relatively high amounts in domestic currency and $A_B < \overline{A}_H$. Otherwise, small domestic debt would imply that $A_B > \overline{A}_H$, in which case firms would never borrow only in domestic currency because they have enough net worth to borrow only in foreign currency at a lower cost.

APPENDIX B

Chapter II: Proofs

B.1 Proof of Lemma 1

Under credible fixed exchange rates: $q = 0$. If $\phi = 0$ then the net worth requirements for being hedged and being not hedged are equal, that is, $\underline{A}_H = \underline{A}_{NH} < \underline{A}_{SNH}$ and $\overline{A}_H = \overline{A}_{NH} < \overline{A}_{SNH}$. Firms with net worth A such that $A \geq \underline{A}_{SNH}$ or $A \geq \overline{A}_{SNH}$ need not hedge. Therefore, the relevant region of net worth requirement for which a firm could hedge are $\underline{A}_H < A < \underline{A}_{SNH}$ if the firm borrows from local banks and $\overline{A}_H < A < \overline{A}_{SNH}$ if the firm borrows directly in foreign currency. For any net worth A within these regions profits are given by:

$$E[\Pi_{TOT}] = P_G[R - R_m - s_L\ R_u - \phi|h|]$$

When $\phi \geq 0$, this expression is strictly lower if the firm is hedged given that $q \leq \overline{q}$ ensures a positive level of hedging when the firm decides to hedge. Therefore, not hedging is preferred to hedging for firms in the above regions.■

B.2 Proof of Lemma 2

When hedging is costless ($\phi = 0$) a hedging firm faces a lower net worth requirement relative to a firm that decides not to hedge, that is, $\underline{A}_H < \underline{A}_{NH}$ and

$\overline{A}_H < \overline{A}_{NH}$. Consider a firm with net worth $\underline{A}_{NH} < A < \underline{A}_{SNH}$ within the monitoring region having to choose between hedging or not. If the firm decides not to hedge then $R_m = \frac{C}{\Delta p(1-q)}$ and $R_u = \frac{r^* I_u}{P_G(1-q)}$, both of which are greater than $R_m = \frac{C}{\Delta p}$ and $R_u = \frac{r^* I_u}{P_G}$ respectively for any $q > 0$ when the firm hedges. Profits are:

$$E[\Pi_{TOT}]^H = P_G[R - \frac{C}{\Delta p} - \frac{F}{P_G} r^* I_u],\ if\ hedged$$

$$E[\Pi_{TOT}]^{NH} = P_G[R(1-q) - \frac{C}{\Delta p} - \frac{s_L}{P_G} r^* I_u],\ if\ not\ hedged$$

Notice that a pair of similar expressions can be obtained for firms with $\overline{A}_{NH} < A < \overline{A}_{SNH}$ borrowing directly from foreign banks (the only difference is that $R_m = 0$ so that $C/\Delta p$ does not appear in the profit expressions). Costless hedging implies that $E[\Pi_{TOT}]^H > E[\Pi_{TOT}]^{NH}$ and hedging is preferred over not hedging, when not hedging implies insolvency in state H. In cases in which and $\underline{A}_{NH} \geq \underline{A}_{SNH}$ and $\overline{A}_{NH} \geq \overline{A}_{SNH}$, net worth requirements $\underline{A}_{NH}$ and $\overline{A}_{NH}$ are irrelevant because any firm with $A \geq \underline{A}_{NH}$ or $A \geq \overline{A}_{NH}$ is solvent enough and need not hedge.■

B.3 Proof of Proposition 1

This proposition refers to monitored firms with $A < \overline{A}_H$. There are three different cases depending on parameters q and ϕ so that each case will be separately proven.

a. When $q \geq \overline{q}$ the optimal decision for a firm within the monitoring region is to borrow in both currencies and not hedge. The result follows from the definition of $\overline{q}$. Recall that when $q \geq \overline{q}$ then $\underline{A}_{SNH} \leq \underline{A}_H < \underline{A}_{NH}$ so that the the minimum net worth in the monitoring region is $\underline{A}_{SNH}$ and any firm within the monitoring region is solvent in state H even without hedging. For any $\phi > 0$ profit maximization implies zero hedging (e.g. any other amount will reduce

profits). If $\phi = 0$ the firm could choose any value of hedging since hedging is a fair game and does not affect its profits (e.g. it could choose a negative amount). Therefore, zero hedging is optimal.

b. When $0 < q < \overline{q}$ and $\phi < (1-q)(s_H - s_L)$ then $\underline{A}_H < \underline{A}_{NH}$ and $\underline{h} > 0$. Two possible cases arise:

b1 If q is sufficiently high such that $\underline{A}_{NH} > \underline{A}_{SNH}$ then $\underline{A}_{NH}$ becomes irrelevant because any firm with $A > \underline{A}_{SNH}$ is solvent without hedging. Therefore, a firm with net worth A such that $\underline{A}_H < A < \underline{A}_{SNH}$ must hedge to be able to borrow in both currencies and $0 < \phi < (1-q)(s_H - s_L)$ guarantees that the lower limit in the optimal hedge range $\underline{h}$ is positive. Hence the minimum net worth defining the the monitoring region is $\underline{A}_H$ so that optimal hedging is positive and preferred over not hedging.

b2 If q is sufficiently small such that both cutoff levels $\underline{A}_{NH}$ and $\underline{A}_H$ are smaller than $\underline{A}_{SNH}$ then the hedging decision depends on whether $\underline{A}_H < \underline{A}_{NH}$ or $\underline{A}_{NH} < \underline{A}_H$. There exists a cost of hedging defined by $\phi^*(q) = \frac{FRq-(F-s_L)(R-b/\Delta p-c/\Delta p)}{(1-q)R-b/\Delta p-c/\Delta p-(s_L b/\Delta p)/(s_H-F)}$ which makes the firm indifferent between hedging and not hedging, that is, $\underline{A}_H = \underline{A}_{NH}$. For any given $0 < q < \overline{q}$ it is the case that $\phi^*(q) < (1-q)(s_H - s_L)$ such that:

i. When $\phi < \phi^*(q) < (1-q)(s_H - s_L)$ then $\underline{A}_H < \underline{A}_{NH}$ and hedging is preferred over not hedging for a firm with net worth A such that $\underline{A}_H < A < \underline{A}_{NH}$. This is similar to case b1.

ii. When $\phi^*(q) < \phi < (1-q)(s_H - s_L)$ then $\underline{A}_{NH} < \underline{A}_H$. In this case, given parameters ϕ and q there exists a net worth A^* with $\underline{A}_H < A^* < \underline{A}_{SNH}$ that makes the firm indifferent between hedging and not hedging so

that:

* If $\underline{A}_H < A < A^*$ then not hedging is preferred over hedging.

* If $A^* < A < \underline{A}_{SNH}$ then hedging is preferred over not hedging.

As can be seen, not all firms with $A > \underline{A}_H$ prefer to hedge, only those with $A > A*$ will do it. On the other hand, firms with net worth A such that $\underline{A}_{NH} < A < \underline{A}_H$ need not hedge. Therefore, only some firms with net worth A such that $\underline{A}_{NH} < A < \underline{A}_{SNH}$ will be hedged.

c. When $\phi \geq (1-q)(s_H - s_L)$ then optimal hedging must be zero because for any given level of q then $\underline{A}_{SNH} \leq \underline{A}_H$ and the firm is always solvent without hedging. Depending on q, the minimum net worth defining the lower limit of the monitoring region could be $\underline{A}_{NH}$ or $\underline{A}_{SNH}$. If $\underline{A}_{SNH} < A < \underline{A}_{NH}$ then the firm borrows in foreign currency and does not hedge because hedging is not affordable. Now q is large enough so that the firm borrows a small amount in foreign currency and has a net worth enough to be solvent in state H even without hedging. If $\underline{A}_{NH} < A < \underline{A}_{SNH}$ then q is small enough so that the firm borrows in foreign currency and does not hedge because hedging is not affordable and state H is less likely. In any case, the optimal decision is not to hedge because hedging is too expensive. ■

B.4 Proof of Proposition 2

The results follow directly from the minimum net worth requirements defining the monitoring region $\underline{A}_H$ and $\overline{A}_H$ (or $\underline{A}_{NH}$ and $\overline{A}_{NH}$ if hedging costs are high but not prohibitive as to make some firms prefer to be unhedged). First, higher q increases the cutoff net worth defining the lower limit of the monitoring region so

that poorly capitalized firms lose their funding implying that aggregate investment drops. Second, higher q also increases the upper limit of the monitoring region so that some firms borrowing only in foreign currency from international banks during the fixed exchange rate regime lie within the monitoring region after q increases. As a result, fewer firms are able to borrow directly from foreign banks and those moving into the monitoring region demand more domestic debt from local banks.■

APPENDIX C

Chapter III: Data

C.1 Description of Variables

The following variables are defined for each firm and each year.

logsize: natural logarithm of sales revenues.

sales growth: growth rate of revenues from year $t-1$ to year t.

margin: ratio of EBIT to total assets.

ebitda: ratio of EBITDA to total assets.

dep/TA: ratio of depreciation and amortization to total assets.

ppe/TA: ratio of permanent assets (the bulk of which are plant, property, and equipment) to total assets.

leverage: ratio of total debt to total assets.

cash: ratio of cash and short-term investments to total assets.

invinc: income from equity investments in other firms.

dderiv: dummy variable set to 1 if firm uses foreign currency derivatives, and zero otherwise.

export: dummy variable set to 1 if firm reports export sales, and zero otherwise.

dol: dummy variable set to 1 if firm reports foreign currency asset holdings, and zero otherwise.

C.2 Foreign currency Operations and Firm Value

This section illustrates the construction of variables related to foreign currency operations using information that Brazilian companies report to BOVESPA. It also illustrates the construction of the firm value variables used in the analysis.

We use Acesita S.A. during 2001 as an example firm. All figures are expressed in thousand of R$. From footnotes to the financial statements the following consolidated information is located under the item "Emprestimos e Financiamentos" (Loans and Financing) :

"Emprestimos e Financiamentos"	2001
"Moeda estrangeira" (Foreign currency)	2074809
"Moeda nacional" (Domestic currency)	330411
Total	2405220
"Passivo circulante" (Short-term)	986655
"Exigibel a longo prazo" (Long-term)	1418565

Under the item "Debentures", the company reports the following information:

"Debentures"	2001
"Total	261835
"Passivo circulante" (Short-term)	200492
"Exigibel a longo prazo" (Long-term)	61343

Under the item "Instrumentos Financeiros" (Financial Instruments) the company reports the following information:

"Instrumentos Financeiros"	2001
"Operacoes de Swap" (currency swap operations)	995404
"Disponibilidades" (foreign currency assets)	269954

In another report called "Relatorio Da Administracao" (Report to the Adminis-

tration) available at BOVESPA the company provides information about total sales. During 2001 revenues from foreign sales are R$ 311500.

Economatica also provides the following information about market value for the company in 2001: equity market value of R$ 492773.35 and book value of equity of R$ 1147423.

With the previous information, we construct the following variables:

Total debt = short-term debt + debentures + long-term debt + long term bonds

Total debt = 2667055

Dollar debt = Foreign Currency debt

Dollar debt = 2074809

Domestic debt = Total debt - dollar debt

Domestic debt = 592246

Dummy variables:

dderiv =1 (holding of dollar derivatives)

export =1 (exporter)

dol= 1 (holding of dollar assets)

Firm value variables:

market-to-book value of assets:

mtb = (total debt + equity market value)/(total debt + book value of equity)

mtb = 3159828.35 / 3814478 = 0.8284

market-to-book value of equity:

mb = equity market value / book value of equity

mb = 492773.35/1147423 = 0.4295

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