

ABSTRACT

Title of Dissertation: CURRENCY MISMATCHES IN EMERGING MARKETS:
CAUSES AND IMPLICATIONS FOR FIRMS'
INVESTMENT DURING CURRENCY CRISES

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This thesis studies two related issues that have gained relevance as a consequence of several of the major currency crises of the 1990s. The first is the impact that devaluations have on investment when domestic firms have currency mismatches, i.e., debt denominated in foreign currency and assets and revenues in domestic currency. The second has to do with the causes behind the widespread presence of currency mismatches in many economies of the world.

Chapter 2 analyzes the first issue using firm level data for Thailand to test for the impact of currency mismatches on firms' investment during the Asian crisis. A key feature of the analysis is that it exploits the heterogeneity that exists in the degree of currency mismatch across firms in order to identify the mentioned impact.

The results of this chapter suggest that currency mismatches played a statistically significant role in explaining the investment decline observed in Thailand during and after the Asian crisis, and, as a result, that a balance sheet channel may have operated during the crisis. The results also suggest that omitting complementary explanations of the Asian crisis, in particular the presence of over-investment prior to the crisis, produces an artificially high impact of currency mismatches on investment. This result occurs due to the co-movement that investment and currency mismatches have in the period preceding the crisis.

Chapter 3 assesses the generality of the results of the previous chapter by analyzing other three countries that were involved in the Asian crisis: Indonesia, Malaysia, and South Korea. Although less robust due to data limitations, the analysis is still very insightful.

Chapter 4 deals with the second issue mentioned in the first paragraph. The chapter proposes a model that emphasizes the incentives of domestic governments to generate opportunistic devaluations in order to transfer resources from foreign lenders to domestic borrowers in case debt contracts were denominated in domestic currency. The model is not only able to explain why firms end up having currency mismatches, but it is also consistent with several of the stylized facts associated with international capital movements.

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DEDICATION

To María José, because this is one of our fruits.

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Chapter 1. Introduction

The currency crises of the 1990's exhibited features that were mostly absent in the crises episodes of the 1970's and the 1980's. The characteristic that has attracted most of the attention is that firms and financial institutions of the crisis countries were highly indebted in foreign currency. Most of the foreign currency denominated debt was not hedged and, as a result, currency mismatches were pervasive in the private sector.

As a direct consequence of currency mismatches, firms and financial institutions faced large increases in the cost of debt that significantly weakened their balance sheets when the currency crises occurred. It has been argued that the deterioration of firms and financial institutions balance sheets limited the access of these agents to the credit market and, as a result, forced them to curtail investment, which impacted negatively the economies' current and future output.

From now on we will use the term balance sheet channel of devaluations to refer to the just mentioned dynamics through which devaluations affect negatively investment and output via the adverse impact that devaluations have on private sector's balance sheets.¹

¹ The channel is not new to the literature (see for instance Agenor and Montiel, 1996, chapter 7). However, it has received much more attention now than in the past for at least two reasons. First, it seems to have played a role in several of the recent currency crises. Second, international capital flows among private agents was much more larger in the 90s than what has been in previous decades.

Many researchers have argued that the balance sheet channel of devaluations contributed to deepen the recession in the crisis countries in several of the currency crises of the 1990s. For instance, Cho and Ree (2000) claim that: (In Asia) “Many factors contributed to the sharp fall. The magnitude of the capital flow reversal was remarkable and the concurrent huge depreciation of the currencies worsened the balance sheets of financial institutions and corporations that had large unhedged foreign currency liabilities.”

Table 1.1, 1.2a, 1.2b, 1.2c, and 1.2d show that indeed some of the dynamics observed in recent currency crises are in line with the predictions of the balance sheet channel of devaluations.

Table 1.1 presents a measure of the net foreign assets that the countries that were involved in the most important currency crises of the 1990s had right before their respective crises. Given that international financial transactions are mostly done in a small group of “hard” currencies, this measure can be used as a proxy of the country-wide degree of currency mismatch.² For all the countries included, this measure shows negative net foreign assets of at least 10 percent of country’s GDP and can be even as high as 55.9 percent as was the case in Thailand.

² The proxy, however, is not taking into account neither the distribution of currency mismatches across different industries of the economy nor the degree of hedging that the economy may have. These issues will be addressed in chapter 2. Despite these omissions, table 1 still gives us some important information, namely: that foreign currency denominated debt was an important instrument that the private sector of the countries included in table 1 used to raise funds and, to the extent that a fraction of that was not hedged, we could expect major financial problems if a shock occurs such that foreign currency becomes more expensive in terms of domestic goods/currency.

Tables 1.2a, 1.2b, 1.2c, and 1.2d present the dynamics of the nominal exchange rate, output, and investment to output ratio around the time of the crises for the same group of countries covered in table 1.1. It can be seen that the devaluation/depreciation of the currencies coincides with a decline in economic activity and that investment falls by more than output (i.e., the investment to output ratio falls).

The combination of data as the one just presented with anecdotal evidence, and the inability of traditional currency crisis models to explain recent currency crisis has given the balance sheet channel of devaluations an important place in the policy debate that has followed the Mexican and Asian crises.³

In fact, there is currently a rapid growing literature trying to analyze the implications of the balance sheet channel of devaluations for important topics in international economics, such as: the optimal exchange rate regime for a country (Céspedes, Chang, and Velasco, 2000) and the propensity of a country to develop a self-fulfilling currency crisis (Aghion, Bacchetta, and Banerjee, 2001).⁴

Even though progress has been made on the implications of the balance sheet channel of devaluations much less has been achieved on more basic but very important issues such as: 1) Is the balance sheet channel of devaluations empirically important? For instance, the patterns shown in tables 1.2a, 1.2b, 1.2c, and 1.2d could very well be

³ For instance, traditional models a la Krugman (1979) and Flood and Garber (1984) are driven by the monetary financing of the fiscal deficit. However, the governments of the countries included in Table 1.1 had followed relatively sound fiscal policies prior to the crises. In addition, this kind of models have nothing to say about the depth and persistence of the recessions observed during the crises.

⁴ Allen and others (2002) present a summary of recent academic research on what they call the *balance sheet approach to financial crises*.

caused by productivity shocks to the countries' terms of trade. 2) Given that the balance sheet channel of devaluations affects the private sector, then, why do private agents are exposed to currency risk? If indeed their access to credit markets depends on net worth then one would expect them to hedge against the currency risk, which would make the balance sheet channel of devaluations inexistent

This thesis deals precisely with these two questions. Therefore, its objective is to contribute to the understanding of the causes of currency mismatches and empirical importance of the balance sheet channel and to provide the theoretical literature with a point of reference that allows it to assess to what extent one should expect the implications of the models to be seen in practice.

Chapters 2 and 3 deal with the first question. They both use firm level data from a group of countries whose currencies suffered major devaluations during the Asian crisis. The use of data at the firm level offers one important advantage to test for the balance sheet channel of devaluations, namely: that it is possible to use the heterogeneity in firms' net worth changes caused by the devaluations that hit the countries in our sample to test whether or not that change affected firms' investment rates. That is, we can use information at the firm level to test the link between balance sheets and investment.

In chapter 2, we construct for a group of Thai firms a measure of firms' loss of net worth due to the devaluation episode that occurred in Thailand in 1997. We then test whether or not those firms that lost a higher proportion of their net worth had to reduce their contemporaneous and future investment by more than those firms that experienced a lower loss. In the tests we pay a lot of attention to controlling for other

possible explanations of firms' investment so as to be able to assess to what extent weak balance sheets actually affect firms' investment dynamics.

The results of this exercise are very interesting. On the one hand they suggest that the balance sheet channel of devaluations played a role in explaining the depth and persistence of the investment decline of Thai firms during and after the crisis. On the other hand they also suggest that other factors, such as over-investment in the period preceding the crisis, also played an important role in shaping the dynamic of investment, and that overlooking them causes us to overstate the actual importance of the balance sheet channel of devaluations.

Chapter 3 is an attempt to extend the results of chapter 2 to other countries. More precisely, we bring into the picture to Indonesia, South Korea, and Malaysia, which also were severely affected by the Asian crisis, in order to test whether the connection between balance sheet shocks and investment decline was also present in these countries.

This generalization, however, comes at the sacrifice of some precision since data limitations make it difficult to measure the shocks to firms net worth caused by devaluations for the new group of countries. As a result, we are forced to use a proxy for our empirical analysis, which makes the results less robust than those of chapter 2 but not for that less interesting. The results of this chapter mostly reinforce the main conclusions of the preceding chapter.

Chapter 4 tackles the second question posed above, namely: why do private agents accept to be exposed to currency risk if that makes them exposed to the adverse effects of the balance sheet channel of devaluations?

In this chapter we argue that the incentives of domestic governments play an important role in determining firms exposure to currency risk when firms are borrowing from abroad, as was the case in the countries presented in table 1.1. The chapter shows that the role of the government remains important even under circumstances that some have argued would nullify the incidence of the government.⁵

More specifically, the chapter shows that the incentives that the domestic government would have to transfer wealth from foreigners to domestic agents through a devaluation in case private foreign debt were denominated in domestic currency is an important determinant even when private agents are atomistic and, therefore, do not internalize the government's reaction function.

⁵ See the discussion in Calvo (2001).

Chapter 2. On the Impact of Devaluations on Investment When Firms Have Currency Mismatches: Evidence from Thai Firms

As was mentioned in the previous chapter, the balance sheet channel of devaluations is currently being incorporated to more traditional models of international economics to study its implications on issues like the optimal exchange rate regime of one country, the propensity of economies to develop self-fulfilling crisis, among others.

Despite the questions being different, all the models that are part of this line of research rely on the following dynamics: Devaluations weaken firms' balance sheets→ weaker balance sheets reduce firms' access to the credit market and, as a consequence, investment falls→Lower investment means lower future output and lower expected profits which keeps the access of firms to the credit market before pre-devaluation standards→Investment in future periods recovers slowly to pre-devaluation levels as a consequence of weaker balance sheets.⁶

It is surprising that even though the balance sheet channel of devaluations is the cornerstone of this line of research there has been little empirical work on the actual importance of it, especially given that there are several reasons that suggest that the channel should be weak in practice.

⁶ It can be seen that the channel at play is what Bernanke, Gertler, and Gilchrist (1998) call a *financial accelerator*, which can be put in motion by devaluations when firms have currency mismatches and their access to credit markets is imperfect (i.e., their net worth position affects the firms access to credit markets).

The argument goes as follows:

- i) The strength of the balance sheet channel of devaluations depends on two conditions. First, firms need to be exposed to currency risk (i.e., they have to have currency mismatches). Second, those firms exposed to currency risk face an imperfect credit market (i.e., a firm's net worth affects its access to the credit market).
- ii) There is no reason to assume that the previous two conditions will hold simultaneously. In fact, if firms face an imperfect credit market they will try to avoid exposing themselves to currency risk.

The need of more empirical research becomes even clearer in light of the results of the existing empirical work, which has obtained mixed results and has not been able to shed light on some of the key features of the balance sheet channel such as its dynamic implications.

The present chapter attempts to analyze more deeply the balance sheet channel of devaluations in order to contribute to fill this gap. The strategy followed in the chapter is to test one of the key implications of the balance sheet channel, namely: the causality that exists at the firm level from changes in firms' net worth to changes in investment.

Based on the mentioned strategy, we use firm level data from Thailand, one of the countries involved in the recent Asian crisis, to test whether or not those firms whose balance sheets were more affected by the devaluation of the currency during the crisis indeed had to curtail investment by more than less affected firms.

The empirical analysis is similar in nature to the empirical literature on credit market imperfections in the United States (see for instance the influential paper by Fazzari, Hubbard, and Petersen, 1988) and, in consequence, tries to control for other variables affecting firms' investment decision such as the productivity of capital.

The analysis presented in this chapter tries to improve upon the existing empirical literature on two grounds. The first is the use of a measure of currency mismatches (CM) that includes firms' hedging policies. The existing work uses only the currency composition of firms' liabilities and, as a result, has an incomplete measure of CM. The second is the study of the persistence of the impact of changes in net worth on investment, an issue that the existing work has not addressed.

Another interesting aspect of the empirical analysis developed in this chapter is that it explores alternative explanations of the investment collapse observed in Thailand during the Asian crisis in order to assess the robustness of the balance sheet channel as a determinant of the investment dynamics. In consequence, the empirical analysis also sheds lights on the relative importance of alternative explanations of that crisis.

The rest of the chapter is organized as follows: Section 2.1 presents the related empirical literature and how this paper fits into it. Section 2.2 describes the methodology. In that section we also present a brief review of the shock to net worth used in the paper to test for the relevance of the balance sheet channel of devaluations in our sample. Section 2.3 discusses the data and the measurement of CM. Section 2.4 describes the behavior of investment during the period of study and some statistics showing how investment co-moves with other relevant variables, as well as the

regression analysis. Section 2.5 assesses the economic importance of the channel under study. The conclusions are presented in Section 2.6.

2.1 Related Empirical Literature

The empirical literature on the balance sheet channel of devaluations has mostly used firm level data to test whether those firms with the highest exposure to currency risk reduce their investment after a currency crisis more than those firms with a lower exposure. The use of firm level data is an appropriate strategy given the information obtained from a cross-section of firms can potentially be very rich.

2.1.1 Findings and Methodologies of the Related Work

There are two papers that are closely related to the empirical analysis presented in this chapter.

- a) Aguiar (2002) studies a cross-section of Mexican firms after the collapse of the Peso in December of 1994. The paper uses data from firms' financial statements, and its dataset is rich enough to include information on the amount of foreign currency denominated debt prior to the crisis. The paper estimates by OLS a one period Euler equation using annual data for 1995 and finds that those firms with heavy exposure to short term foreign currency debt before the devaluation experienced relatively low levels of post-devaluation (fixed) investment.

b) Bleakly and Cowan (2002) use information from the financial statements of firms from five Latin American countries (Argentina, Brazil, Colombia, Chile and Mexico) during the period 1990-1999. The dataset also contains information on the currency composition of firms' debt. The paper uses OLS regressions (although they report that the results hold using other techniques such as fixed effects) to test whether those firms with the highest fraction of debt denominated in foreign currency reduced their next-period investment (fixed investment and inventory investment) more than those firms with a lower fraction of debt denominated in foreign currency. Bleakly and Cowan find a negative answer (actually they find that firms with the highest exposure tend to invest more after the crisis) and, as a result, argue that there is a favorable competitiveness effect that offsets the adverse effect of a higher debt service (because exposed firms are also those whose revenue side benefits the most from devaluations).

2.1.2 Shortcomings of the Related Work

The previous papers provide interesting insights to the episodes that they study but they are not exempt from shortcomings. The shortcomings are both general and specific. We present the main ones below.

At a general level both papers are unable to take into account the hedging practices of the firms and, as a result, they must rely on the leverage in foreign currency as their measure of currency mismatch. Even though one could argue that

this is not a problem if hedging was rare, it is also true that the uncertainty about the accuracy of foreign currency denominated debt as a measure of CM remains.⁷

The mentioned papers also fail to shed light on the dynamic implications of the balance sheet channel. In particular, as we mentioned at the beginning of this chapter, balance sheet effects are supposed to be long lasting given that the impact of devaluations reduce exposed firms' net worth and it takes firms time to restore the health of their balance sheets.

There are also some shortcomings that are specific to each paper. For instance, Aguiar (2002) does not have information to construct a proxy of Tobin's Q which leaves open the question of whether the observed decline in investment was not due to a change in the productivity of capital after the crisis. In addition, the results are obtained from a one-year cross-section, which may not allow a correct estimation of the impact of other variables on investment.

In the case of Bleakly and Cowan's paper, it is important to point out that the sample may pose some problems to their attempt to assess the importance of the impact of CM on investment for at least two reasons. First, the sample has firms from five countries but the foreign currency debt shares vary widely across countries. Therefore, it is likely that movements along the foreign currency denominated debt

⁷ It is necessary to recognize that data on firms' hedging practices is difficult to obtain. Indeed, data on composition of the debt is difficult to find. The comment presented above does not pretend to take away any merit from the data used in the mentioned papers but simply to point out an area of improvement.

dimension are also movements along the country dimension.⁸ In addition, it is unlikely that this effect could be captured by the use of country dummies.

In addition, Bleakly and Cowan's sample is dominated by Brazilian firms (about 50 percent of the sample), which makes one wonder whether there is a "Brazil effect" behind the results (i.e., maybe Brazil is a special case). This point becomes more important given that Aguiar (2002) analyses the case of Mexico (a country in Bleakly and Cowan's sample) and finds balance sheet effects to be important.

2.1.3 Contributions of this chapter

The empirical exercise presented in this chapter tries to address several of the shortcomings presented in the previous subsection. In particular, the major intended contributions are:

- a) The use of a measure of CM that takes into account the hedging practices of firms: The reason why this is possible is because for the sample under study we are able to observe the *net* losses incurred by firms as a result of the devaluation of the currency.
- b) Analysis of the dynamic effects of the impact of the devaluation on firms' net worth: Instead of focusing exclusively on the one-period-ahead impact of devaluations on investment the empirical analysis keeps track of the impact of the current-period devaluation over investment along several periods. The idea

⁸ In a previous version of their paper the authors show that in their sample the average firms' shares of foreign currency debt to total debt (by country) are as follow: Argentina 64%, Mexico 46%, Brazil 13%, Colombia 7%, and Chile 5%.

is to test to what extent the impact is persistent as predicted by the balance sheet channel.

This chapter focuses on a case study, Thai firms before, during and after the Asian crisis. Even though focusing on a case study has the disadvantage of not allowing the derivation of stylized facts it also has several major advantages that, arguably, more than compensate for the possible loss of generality. The main advantage is that by focusing on a well-known episode we are able to incorporate alternative explanations of the event that have been suggested in other work, which helps us to test for the robustness of our results.

In addition, the case study the this chapter looks at has the advantage of having good quality data, which allows to observe relations between the variables under analysis that could later be of help when analyzing cases with data of lower quality. In fact, chapter 3 uses some knowledge learned from the present chapter in order to construct a proxy of CM for three additional countries.

2.2 Methodology

2.2.1 General Strategy

The methodology used in this paper is closely related to the empirical macro literature on credit market imperfections pioneered by the influential paper of Fazzari, Hubbard and Petersen (1988), FHP hereafter. In that paper the authors estimate the following

equation for four groups of firms that a priori are affected differently by credit market imperfections.⁹

$$\left(\frac{I}{K}\right)_{i,t} = \beta_0 + \beta_1 * (Q)_{i,t-1} + \beta_2 * \left(\frac{CashFlow}{K}\right)_{i,t} + \beta_3 * \left(\frac{CashFlow}{K}\right)_{i,t-1} + \gamma_i + \varepsilon_{i,t} \quad (1)$$

Under the assumption of perfect capital markets, Q (Tobin's Q) should be a sufficient statistic for firms' investment decision and, as a result, β_2 and β_3 should not be significantly different from zero. FHP use cash flow as a proxy for changes in net worth and argue that if credit market imperfections were relevant for investment decisions then β_2 and β_3 should be larger for those firms that a priori are more likely to be financially constrained. The authors test their hypothesis using a panel of 421 US manufacturing firms and find evidence supporting it.

One difficulty that tests a la FHP have faced is that it is difficult to identify exogenous changes in net worth. FHP relied, as many other researchers after them, on cash flow but that approach has one major disadvantage, namely: changes in cash flow and changes in investment may be both affected by productivity shocks. If that is the case, the correlation between cash flow and investment may not be a good measure of the imperfections in the credit market.

Given, the mentioned shortcoming many researchers have tried to improve upon FHP's test. The line of research most relevant for this paper is the one that has

⁹ Abstracting from the terms that depend on cash flow, equation (1) can be obtained using a framework of profit maximizing firms, perfect capital markets and quadratic adjustment costs. FHP add the cash flow terms arguing that under the assumptions just mentioned their impact on investment should be nil.

focused on finding other proxies for changes in firms net worth different from cash flow (see for instance Shin and Stulz, 1996, and Lamont, 1997).¹⁰

In order to test for the impact of devaluations on investment this chapter estimates an equation similar to equation (1) but introducing two modifications. The first one is the use of losses due to devaluations as proxies for changes in firms' net worth. The second modification is that the equation to be estimated will keep track not only of the impact of net worth shocks on contemporaneous investment but also on future investment.

Given that the modification we are introducing to equation (1) is in the measurement of the shock to net worth, it is convenient to present the shock in more detail, which, in addition, will help us to motivate the estimation strategy.

2.2.2 The Source of Shocks to Net Worth: Thailand Before and During the Asian Crisis

The Asian crisis started in July of 1997 when precisely Thailand announced the abandonment of a regime of peg to a basket of currencies to move to a system of managed floating. By December of that year the Thai Baht had depreciated about 82 percent. Between 1992 and June of 1997 the nominal exchange rate of Thailand had barely changed, so the crisis meant an abrupt change with respect to the policy of stable currency followed during the previous years.

¹⁰ See also the discussion in subsection 4c of Hubbard (1997) where it is suggested, page 36, that the use of a measure of shocks to net worth similar to the one employed in this paper could be a good way to test for credit market imperfections.

There were several factors behind the Thai crisis. Below we present the main ones. For a more detailed chronology see Corbett and Vines (1999).

Pre-crisis

The pre-crisis period was characterized by high economic growth (10 percent per year between 1988-96), and financial deregulation. More specifically, GDP grew by an average of 10 percent per year between 1988 and 1996 while foreign capital controls and interest rates were relaxed in the early 1990s. In addition, banking licenses became easier to get and the number of finance companies and other non-bank financial intermediaries increased and assets in the financial sector increased fourfold from 1990 to 1996.

As foreign capital inflows increased the Bank of Thailand tried to sterilize. Sterilization, however, was incomplete, which resulted in: increasing levels of foreign exchange reserves, high current account deficits, increases in prices of non-tradables relative to tradables (a real appreciation), increased capital inflows.

The Triggers

Export growth collapsed in 1995–6. The greatest falls occurred in exports to Japan, North American Free Trade Area and China. As a result, current account deficits increased. The increase in real wages occurred between 1990 and 1994 contributed to a deterioration of the competitiveness of the economy.

The speculative attacks began in 1996. Solvency problems of corporations started to be clear when a Thai company (Somprasong) defaults on foreign debt. Between

March and May of 1997, revelations about the size of bad loans at finance companies induce the government to set up agency to resolve property-loan problems. Moves to save Finance One (largest finance company) fails. In June of 1997, the Bank of Thailand suspends operations of 16 finance companies.

The Crisis

July 2 of 1997 constitutes the end of the fixed exchange rate regime, which is substituted by a “managed float” of the Baht. The Baht devalues by 15 percent, and 20 percent in off-shore markets. Financial problems continue and in December of 1997 the government closes 56 out of 58 suspended finance companies.

As can be seen, the devaluation of the Thai Baht was caused by a combination of shocks to the profitability of firms and of weaknesses in the financial sector, which implies that the measure of the net worth shock may not be completely exogenous from the profitability shock faced by firms. For this reason, it is important to control for shocks to firms’ profitability. Indeed, we will explore extensively in subsection 4.2 whether our results could be explained by measurement error in our controls of the profitability shock.

Although we will describe the sample more carefully in the next section it is convenient to mention that the sample used in this paper goes from 1992 to 2001. Therefore, the devaluation of the Thai Baht occurs in the middle of the sample period, which allows us to study the impact of the devaluation on firms’ contemporaneous and future investment decisions.

2.2.3 Estimation Strategy

Following the strategy outlined in subsection 2.2.1 and the particularities of the Thai case we write the investment process during the period under study as being described by the following two equations:

$$\left(\frac{I}{K}\right)_{i,t} = \beta_0 + \beta_1 * (Q)_{i,t-1} + \gamma_i + \lambda_t + \varepsilon_{i,t} \quad , \text{ for } t < 1997 \quad (1.1)$$

$$\left(\frac{I}{K}\right)_{i,t} = \beta_0 + \beta_1 * (Q)_{i,t-1} + \beta_t * (NetWorthShock)_{i,1997} + \gamma_i + \lambda_t + \varepsilon_{i,t}, \quad \text{for}$$

1997 ≤ t ≤ 2001

the last equation will be equation (1.2).

The idea behind writing the investment process in the preceding way is to test for the Q model of investment versus a model in which net worth becomes a determinant of investment during and after the crisis.

Under the null hypothesis of perfect capital markets the shock to net worth should have no impact on investment. In such a case the coefficients β_{1997} , β_{1998} , β_{1999} , β_{2000} and β_{2001} should not be statistically different from zero. However, if firms' net worth affects firms' access to credit markets there should be an inverse, and persistent,

relationship between net worth and investment (i.e., the coefficients should be negative and significantly different from zero).

Notice that in equation (1.2) the shock to net worth is that of year 1997 (the year of the devaluation). However, *we keep track of the impact of that shock on current and future investment*. That is the reason the coefficient associated to the net worth shock is time variant even though the measure of the shock is not. In this sense the treatment of the impact of the net worth shock is similar to the treatment of time dummies but with a very important difference: the net worth shock has a different value for each firm, which allows it to capture a cross-sectional effect.

It is important to stress that equations (1.1) and (1.2) include firm specific and time dummies. The role of time dummies is especially important since they capture aggregate shocks and help to identify the impact of currency mismatches on investment through the cross-section of firms.

The previous equations also help to compare the empirical strategy followed in this chapter with those presented in Section 2.1. Leaving the issue of measurement of the shock to net worth aside, the papers presented above restrict their attention to the immediate impact of the shock on investment (i.e., to the coefficients equivalent to β_{1997} or β_{1998}). However, given that persistence is one of the implications of the models of credit market imperfections, it is important to go some periods beyond the initial shock and test for its persistence.

Given that there are not net worth shocks before the 1997's devaluation, equations (1.1) and (1.2) can be estimated simply by estimating equation (1.2) for the

whole period but assigning a value of zero to the net worth shock variable before 1997.

However, before estimating the equation it is necessary to discuss the data used and the measurement of the shock to net worth originated by the devaluation in the presence of currency mismatches.

2.3. Data and Measurement of CM

2.3.1 Dataset

The primary dataset uses financial statements of a group of 96 manufacturing non-financial Thai firms.¹¹ The fiscal year of all the firms ends in December, which makes the financial statements comparable. We restrict our attention to manufacturing firms in order to minimize the heterogeneity of the firms in other areas different from the currency composition of their debt. In addition, focusing on manufacturing firms has been common practice in the empirical macro literature on credit market imperfections. Given that the estimation strategy of this chapter consists in applying a methodology originated in the mentioned literature, it seems safe to minimize the deviations from it in order to facilitate the interpretation of the results.

The choice of the country was dictated by data availability. As we will see in the next subsection, the measurement of the CM relies on very detailed information taken from the income statements of the firms, and Thailand is the only country of

¹¹ The number of firms in the sample varies over time. However, 96 is the number of firms for which we were able to calculate the currency mismatch measure.

those involved in the Asian crisis whose firms present the information in such a detailed way. However, there are other less perfect, but still efficient, ways to measure CM. This is done for other Asian countries in chapter 3.

The data come primarily from THOMSON ANALYTICS, which provides information on Balance Sheets, Income Statements, Funds Flow, and some standard financial ratios for publicly traded firms. Two other sources of information were used to complement the dataset; in particular to verify the accuracy of our measure of CM.¹² The first one is the annual reports of the firms during 1997 and/or 1998 taken from the database IFSONLINE. More specifically, 118 annual reports were used to check the losses firms had as a consequence of 1997's devaluation and compare them with those obtained from the primary dataset.¹³ The information of both datasets is very similar. The discrepancies found were very small, and, when occurred, the information of the annual reports was used.

The second source of complementary information is Moody's International Manual (1998-2000), which has information on balance sheets and income statements of publicly traded firms. This source was also used to verify the accuracy of our measure of CM and its information is also very similar to the one obtained from the primary dataset. However, for some firms the degree of detail of the Financial

¹² Even though we are very confident about the quality of the information of the primary dataset it is convenient to check it because there could be differences in the accounting practices of the firms. In subsection 2.3.2 we will see why this could occur. However, after checking the complementary sources it becomes clear that firms were following general accounting procedures.

¹³ Some firms for which we were able to obtain annual reports belong to the nonmanufacturing sector. That is the reason the number of firms with annual reports is larger than the number of firms in our sample.

Statements published by Moody's International Manual is higher than the one of the primary dataset, which allows verifications in case it is necessary. As with the other source, if discrepancies appear the information from the complementary source was used.

The period under study is 1992-2001. This period allows us to have a good number of firms in the sample and, at the same time, to have information pre, during, and post crisis. As we have mentioned before, having data for years before and after the crisis allows us to test for the persistence of the balance sheet channel.

2.3.2 Measurement of CM

Measuring the exposure of firms to currency risk using information coming from firms' balance sheets is not an easy task given that very detailed information is needed. Ideally, one would like to know the value of net liabilities denominated in foreign currency and the hedging practices of the firms. However, as was pointed out above, one would need information on variables like assets and debt denominated in foreign currency and currency derivatives, which is not commonly reported by firms.

In crises periods one possibility to bypass all that detailed information is to look at firms' income statements. The reason is that, under a detailed enough presentation, firms declare gains/losses (both realized and unrealized) due to changes in the nominal exchange rate.¹⁴ The declared foreign exchange gains/losses are

¹⁴ An unrealized loss occurs when the firm has long term debt denominated in foreign currency. If a devaluation of the currency occurs the firm has a loss because the value

changes in the value of net foreign assets that take into account any form of hedging that firms may have, such as currency derivatives and predetermined forward exchange rates for some transactions. In this chapter we use declared foreign exchange gains/losses to construct a measure of exposure to currency risk.

Given that firms declare both realized and unrealized gains/losses we can use a one period example to illustrate the measure:

Let E be the nominal exchange rate. Let B denote liabilities and A Assets. Assets and liabilities are measured in units of the domestic currency. Let B^f and A^f be the component of debt and assets denominated in foreign currency.¹⁵ Then, the loss due to changes in the nominal exchange rate can be obtained as follows.

$$FXloss_{t+1} = (E_{t+1} - E_t)(1+r)(B_t^f - A_t^f) \quad (2)$$

Dividing both sides by A_t .¹⁶

$$\frac{FXloss_{t+1}}{A_t} = \frac{(E_{t+1} - E_t)(1+r)(B_t^f - A_t^f)}{A_t} \quad (3)$$

of the debt went up measured in domestic currency, however, the loss is unrealized because the debt has not been paid yet.

¹⁵ The assets in this example include any hedging instrument owned by the firm.

¹⁶ An alternative is to divide by the equity of the firm in order to get a measure of the losses as a proportion of the net worth of the firm. The results from using this variable in the empirical section are mostly identical to those obtained with the variable in the text and are available from the author upon request.

Even though the variables that conform the right hand side of the equation are not easily observable (assets and liabilities are rarely decomposed in their domestic and foreign currency components and there is little information on off balance sheets operations), the left hand side of it can be observed under a detailed enough presentation of the financial statements as it is the case in our sample.

In addition, the left hand side of equation (3) is a measure of the degree of CM of a firm given that it measures the fraction of a firm's total assets that suddenly become slashed away by the increase in the real value of the liabilities.

The proposed measure of CM has both advantages and disadvantages. The main advantage is that it takes into consideration the many ways that firms have to deal with currency risk. The main disadvantage is that it is only observed ex-post and when movements of the exchange rate occur, which makes the proposed measure inappropriate as a monitoring tool of the currency exposure of the firms. Despite this shortcoming, our measure is well suited for the purpose of the present paper given that it helps us to quantify the impact of the devaluation on firms' balance sheets.

An example can illustrate how our measure is computed and the advantages it has over those that only consider the currency denomination of firms' liabilities. The example is taken from the Annual Report of the year 1997 of Bangkok Expressway. The firm reported the following transactions due to the devaluation of the Thai Baht during that year:

On 2 July 1997 the Ministry of Finance has announced the adoption of managed float system. The exchange loss for the year 1997 is made up of:

	Baht
Unrealized Exchange Loss	3,447,593,800
Realized Exchange Loss	54,155,221
Gain on Forward Contract	3,258,019,970
Net Loss	243,729,051

As can be seen, omitting the gain on forward contract (i.e., working only with the value of the liabilities) would greatly affect the measurement of CM. However, using the net loss to measure the CM correctly tells us how affected the firm was by the devaluation.

Most of the firms in our sample registered the foreign exchange losses as an extraordinary item in their income statements following the recommendation of the Institute of Certified Accountants and Auditors of Thailand issued on September 19 of 1997 (see for instance the annual report of Thai Wah Foods of 1998). For some firms, the information was missing and the use of the complementary data sources was used (as described in the previous subsection) to complete the information.

In addition, the complementary data sources, specially the annual reports, were used to verify that the firms were indeed following the recommendation of the Institute of Certified Accountants and Auditors of Thailand and that they were not including any other concepts in the category associated with extraordinary items. As was mentioned in the previous subsection, the information contained in the annual reports allowed us to verify that firms were following the recommendation mentioned

above and that no losses beyond the foreign exchange losses were included as an extraordinary item in the income statements.

In the following section we will use the ratio of foreign exchange losses to total assets as a measure of the CM of the firms and, as a result, this variable will be the measure of the shock to net worth to be included in the estimation of the investment equation obtained from putting together equations (1.1) and (1.2). It is important to stress that, as mentioned in subsection 2.2.3, the net worth shock is the one of 1997 and it is kept constant for the years following the crisis.

2.3.3 Is the Dataset Representative of What Happened in Thailand During the Asian Crisis?

Before presenting the empirical analysis, it is convenient to get an idea of to what extent the dataset used in this chapter is representative of Thai firms in general given that this would allow us to assess the explanatory power of the results for the Thai crisis.

The first important feature of the dataset that needs to be discussed is the coverage of the sample. As was mentioned in section 2.3.1, the dataset only covers publicly traded firms, which is a consequence of data availability. Even though it is true that by focusing on publicly traded firms we are leaving out of the analysis a large part of the firms' distribution, it is also true that publicly traded firms are probably the best firms to study the importance of net worth shocks caused by depreciations. Why? Because as Claessens and Djankov (2000) and Kawai, Hahm, and Iarossi (2000)

document, foreign currency denominated debt was much higher in publicly traded firms than in non-publicly traded firms.

A second feature of the dataset that can help us to assess how representative the dataset is of the whole economy is the behavior of the key variable, investment, at the aggregate level and in the dataset used in this chapter. Table 2.1 describes the behavior of aggregate private investment during and after the crisis and compares it with the behavior of investment of the median firm of our dataset.¹⁷ It can be seen that the movements of both measures go always in the same direction and that the magnitudes do not differ much (the exemption seems to be 1997 where the decline in investment in the median firm of the dataset is much larger than the decline of aggregate investment).

Overall, even though the sample only focuses on a part of the distribution of firms (publicly traded firms), the dataset used in this chapter seems well suited to analyze the impact of net worth shocks on investment. In addition, given that the behavior of investment in the dataset resembles the behavior of aggregate investment, the results of the following sections can shed some light on the causes of aggregate investment decline during the Thai crisis.

2.4. Results

This section is divided in three subsections. The first one presents the behavior of firms' investment during the period under study and how it is correlated to the net

¹⁷ The median was preferred to the mean given that the sample is small, which makes the calculations of the mean substantially affected by outliers.

worth shock during and after the crisis. The mentioned correlation constitutes a first approximation to the role played by the balance sheet channel in the determination of investment. The second subsection presents a first part of the regression analysis. In this part we test for the Q model of investment following the strategy presented in subsection 2.1.3.

The third subsection completes the regression analysis by testing for alternative explanations of the results obtained in the previous subsection. In particular, we test whether the results obtained are due to a balance sheet channel being operative in our sample or whether they can be reconciled with the Q model of investment.

2.4.1 Summary Statistics

Table 2.2 describes the behavior of the investment rate during the period 1992-2001 for the firms in our sample. It can be observed that the investment rate falls dramatically in 1997 and 1998 and remains below the pre-crisis levels for the rest of the period. The anecdotal evidence presented at the beginning of this paper suggests that the presence of currency mismatches in firms' balance sheets may be an important factor behind the decline in the investment rate. Therefore, it is natural to ask whether or not CM play a role in the investment decline just described.

Table 2.3 shows the correlation between the investment rate and the currency mismatch variable from 1997 to 2001. Notice that the correlation is slightly positive in

1997 but turns large and negative in the following two years. The correlation remains negative in the years 2000 and 2001 but its absolute value declines over time.

The results in table 2.3 suggest that firms with higher CM reduced their investment rate by more in the years after the crisis. In addition, the correlation between currency mismatches and investment seems close immediately after the crisis and declines over time after, presumably, firms had time to repaid part of its debt and clean their balance sheets. These results are consistent with the balance sheet playing a role in the determination on investment and provide an initial support to the anecdotal evidence linking the decline in investment to the weakening of firms' balance sheets caused by the devaluation of the domestic currency, the Thai Baht in our sample.

It is important to point out that the correlation between the investment rate and the currency mismatch variable provides us with a very important information given that it reflects a purely cross-sectional pattern, and one of the implications of the balance sheet channel is, precisely, that firms with weaker balance sheets will have, other things equal, a lower access to the credit market and, as a result, will have to cut investment by more.

Even though the correlations are informative, it is well known that they do not take into account the impact of other variables. The next two subsections try present a more formal test of the influence of currency mismatches on investment.

2.4.2 Testing for the Q model

The Q theory of investment argues that Q is a sufficient statistic to describe the investment decision of the firms. Under this hypothesis, the coefficients associated to the net worth shock in equation (1.2) should not be significantly different from zero.¹⁸

The tables 2.4a and 2.4b present the results of estimating equation (1.2). The estimation method is fixed effects and the White correction has been used to obtain robust standard errors of the estimated coefficients.

The second column of Table 2.4a shows that even though Tobin's Q is significant, the coefficients associated to the shock to net worth are significantly different from zero as well. In addition, the results show that the impact of net worth on investment seems persistent and affects investment several periods after the onset of the crisis. These results are consistent with the correlation patterns reported in the previous subsection.

It is important to remember that the equation estimated includes time dummies, which, in principle, absorb any aggregate shock that could affect our sample of firms over time. Therefore, the effect captured by the shock to net worth is an effect derived from the cross section of firms.

The results presented in Table 2.4a suggest that the Q model of investment is incomplete and favor explanations that include net worth as a determinant of investment, such as the balance sheet channel. The results also provide empirical support to the financial accelerator channel put in motion by devaluations that is at the heart of the research agenda mentioned in the first section of the paper.

¹⁸ Our measure of Tobin's Q follows FHP (1988) and it is described in the Appendix.

A criticism that the methodology used in this paper has received (see for instance Poterba, 1988) is that Tobin's Q may be a poor proxy of the investment opportunities of the firms and, as a result, the net worth variable may be reflecting shocks to the productivity of capital.

For instance, Gilchrist and Himmelberg (1995) show that tests *a la* FHP tend to detect excess sensitivity of investment to cash flow for a group of firms that based on other methodologies do not seem to be liquidity constrained. This result is interpreted by them as evidence of insufficiency of Tobin's Q to account for investment opportunities. In addition, Tobin's Q is a variable measured at the beginning of the period, while the investment decision is made during the period, which inevitably causes Tobin's Q to omit any new information received by the firm during the period investment spending is executed.

In order to account for these problems, we add to the estimation a measure of the contemporaneous profitability of the firm. The idea of using this variable is twofold. On the one hand, it is a good indicator of how well the firm is doing during the year the investment decision is executed and, in consequence, of the potential productivity of capital. On the other hand, any contemporaneous shock to the revenues or costs of the firm would be reflected in the earnings of the firm, which makes this variable to contain information about news affecting the productivity of capital.

More specifically, we use a measure of the basic earning power of the firm. The measure is simply the earnings before interest and taxes of the firm divided by (beginning of period) total assets. Using the earnings before interest and taxes has the

advantage of avoiding the incidence that the capital structure has over other measures of profitability such as net profits.

The third column of Table 2.4a shows that the measure of the profitability of the firm is indeed significant. However, the impact of the net worth remains highly significant, which suggests that the importance of net worth does not seem to be due to an imprecise measure of firms' contemporaneous investment opportunities.

Despite the previous result, it is important to stress that the problems arising from an imperfectly measured Tobin's Q are of especial importance for this paper because there are sound economic arguments that predict that Tobin's Q and the exposure to currency risk (the variable that captures the net worth shock) may be correlated. In consequence, an imperfectly measured Tobin's Q may result in an artificial significance of the net worth variable. For this reason, in the next subsection we explore more deeply how to test whether the results obtained in columns two and three of table 2.4a are indeed attributable to a balance sheet channel or simply a consequence of imperfectly measured investment opportunities.

2.4.3 Extending the Q Model to Account for Measurement Error in Tobin's Q

There are several reasons why Tobin's Q may not adequately reflect the actual productivity of capital. One reason is that our measure uses the book value of the debt to proxy for the market value of the debt. This strategy may work well when there is a low probability of default, but would definitely have problems when the probability of default increases, as is the case during a crisis. Another reason is that stock markets

may not be fully efficient and, as a result, the stock market valuation may deviate from the fundamental value of the firm (see Bond and Cummins, 2002, for support to this argument).

Below we explore the implications these two issues may have for our results. More specifically, we analyze two alternative interpretations that can be given to the results presented in the first two columns of table 3, and present some tests that try to disentangle whether or not the balance sheet channel remains significant after accounting for these alternative interpretations.

In addition, we analyze whether firms in exporting sectors behaved different from firms in non-exporting sectors. The idea behind the last exercise is that if we are not able to control for firms' investment opportunities then it is convenient to include other proxies of such variable. A priori, firms in exporting sectors should be in a better condition to invest during a currency crisis given that they have access to foreign currency and that they can benefit from the depreciation of the real exchange rate.

2.4.3.1. Change in the Market Value of the Debt

It is reasonable to assume that at the moment of the crisis there is an aggregate increase in the probability of default because the marginal productivity of capital of all the firms is likely to have gone down. In such a case, the market value of the debt declines and so does the value of the firm (which is the measure that we are trying to use to proxy for the productivity of capital).

However, given that our measure of Tobin's Q is calculated using the book value of the debt instead of the market value, we would be underestimating the actual decline in the value of the firm and, as a result, the actual decline in the productivity of capital. The underestimation would be larger the higher the leverage of the firm.

Suppose now that firms with higher CM were also firms with higher leverage. In such a case, a high CM (i.e., a large shock to net worth in our empirical exercise) might be associated with a large decline in investment because the currency mismatch variable could be picking up the effect of the underestimation of the decline in the value of the firm and not because there is a balance sheet effect. In our sample, CM and leverage have a correlation of 0.35, which makes the possibility just described a real one and, as a result, one that needs to be tested.

In order to test whether the variable measuring currency mismatches is just picking up the effect of the underestimation of the decline in the value of the firm we construct a variable exactly in the same way that the currency mismatch variable (see section 2.2.3) but instead of using each firm's currency mismatch as the magnitude affecting firm's investment we use firm's leverage in 1996.

The fourth column of Table 2.4a presents the results of adding the leverage of the firm before the crisis (i.e., in 1996) as an explanatory variable of the investment rate during and after the crisis. As can be seen, the currency mismatch remains a very significant determinant of investment and only the impact on the 2001's investment rate loses significance when firms' leverage is taken into account. Therefore, the *currency composition* of the debt seems to be an important determinant of investment

in this sample independently of the leverage of the firm, which gives support to the balance sheet channel.

2.4.3.2 Real Shocks and the Co-movement of Investment and Financial Variables

Several researchers have argued that over-investment by Asian corporations was a major cause of the Asian crisis. For instance, Pomerleano (1998) argues in his analysis of the Asian crisis the following:

“A thematic point that comes across in all the results of the corporate financial analysis is unsustainable rapid (and probably excessive) investment in fixed assets financed by excess borrowing in some Asian countries- e.g. Indonesia, Korea and Thailand.”

Therefore, an alternative explanation of the results presented in Table 3 is the following:

Some firms were expecting a high marginal productivity of capital in the future and started to invest heavily in fixed assets in order to increase their future production capacity. In order to invest, they borrowed from international capital markets and the currency denomination of the debt ended up being in foreign currency because firms were indifferent about the composition (because they do not face capital market imperfections) but lenders preferred foreign currency denominated debt because it is less risky. However, at some point those firms that were investing realized that the

future marginal productivity of capital was going to be lower than initially expected and had to severely curtail investment for several periods in order to return to the optimal level of capital stock. If the perception of high future profitability was widespread, then the reduction of investment may be large enough to cause a crisis in the country and a deterioration of the nominal (and real) exchange rate.

Notice that the firms that had to curtail investment were also those firms highly indebted in foreign currency (because they borrowed in order to invest), which produces a correlation between high foreign currency debt at the moment of the crisis and a low future investment. The interesting point is that this correlation emerges without the presence of a balance sheet channel.

If Tobin's Q is a good measure of the investment opportunities then regressions like (1.2) would be well specified. However, if Tobin's Q is an imperfect measure of investment opportunities then the net worth variables could be picking up the co-movement described in the previous paragraphs (end of the alternative explanation).

Is this alternative explanation a plausible one for our results? In principle it is. For instance, the correlation between the CM variable and the average of firms' investment between 1992 and 1996 is 0.23, which suggests that those firms with CM in their balance sheets were also those that had been investing more.

In order to test whether the variable measuring CM is just picking up the effect of the joint co-movement between investment and financial decisions we construct a variable exactly in the same way that the currency mismatch variable (again, see section 2.2.3) but instead of using each firm's currency mismatch as the magnitude

affecting firm's investment we use firm's average investment rate over the pre-crisis period (i.e., 1992–1996).

The first column of table 2.4b presents the results. It can be seen that the variable accounting for the effect of over-investment is highly significant and its effect is also very persistent. The impact of the currency mismatch variable on the investment rate of the years following the crisis (1998, 1999, and 2000) remains significantly different from zero. However, it is important to point out that although the impact of CM remains significantly different from zero, its magnitude declines substantially when the over-investment effect is taken into account.

2.4.3.3 The Behavior of Exporting and Non-exporting Sectors During the Crisis

As we mentioned before, a priori, firms in exporting sectors should be in a better shape to invest during a currency crisis given that they have access to foreign currency and that they can benefit from the depreciation of the real exchange rate. If we were not able to control properly for firms' investment opportunities (as may be the case in our present analysis given the imperfect measure of Tobin's Q), then our regression analysis would not capture this effect. Below, we test for the presence of this differentiated behavior.

For this exercise firms were classified as exporting or non-exporting. Two methods were used to classify firms. The first one was the sector the firm belonged to the year of the crisis. Firms in predominantly exporting sectors (according to Thailand's balance of payments) were classified as exporters while firms in other

sectors were classified as non-exporters. The sectors classified as exporters were: garments, footwear, computers and parts, electrical appliances, vehicles and parts, and food products. As a result, the sample got divided in 37 exporting firms and 60 non-exporting firms.

The second method consisted in reading the profiles of the firms included in the dataset and find out what firms were exporting the year of the crisis (unfortunately, no data for firms exports is available in the dataset). Under this classification, 51 firms were classified as exporting and 46 as non-exporting.

The empirical analysis presented in the previous subsections estimates the equations using fixed effects, which prevents the inclusion of new firm specific dummies (such as a exporting sector dummy). Therefore, any sector specific impact on investment has to be estimated by interacting the sector specific dummies with other variables.

Given that the idea of the exercise is to determine whether exporting firms behaved different from non-exporting firms during and after the crisis, column 2 of table 2.4b presents an equation in which the exporting dummy (constructed using the first method) was interacted with the time dummy for the years 1997 to 2001. The results show that investment behavior was similar for exporting and non-exporting firms from 1997 to 1999. However, exporting firms invested more than their counterparts during the years 2000 and 2001.

Other equations were estimated in which exporting dummy was interacted with other variables such as the net worth shock and the profitability shock. However, these interactions were not significant, and therefore these other equations are not reported.

Using the second method has no effect on the results presented in the previous subsections and the coefficients associated to the exporting effect are always not significantly different from zero. For this reason, we do not report these results here. A possible explanation of the weaker results obtained using the second method is that it includes firms that, although exporting, may have relied heavily on the domestic market (recall that this method classifies 51 firms as exporting while the other classified only 37).

Overall, the inclusion of dummy variables to differentiate exporting from non-exporting firms slightly improves the results although there are no major differences from those obtained in previous subsections. A deeper analysis of the behavior of exporting and non-exporting firms would require going beyond the use of dummy variables and construct a measure of the exact reliance of firms on the domestic market. Unfortunately, the information required is not available in the dataset used in this chapter.

2.5. Evaluating the Empirical Importance of the Balance Sheet Channel

The objective of the methodology used in this chapter is to test whether or not the Q model is sufficient to explain the investment behavior of firms and whether or not shocks to net worth caused by devaluations are important to explain the investment behavior of firms. The empirical exercise presented in previous sections provides an answer to these questions but the quantitative implications of the estimations have to be analyzed with care.

Given that the estimations presented in the paper suggest that the balance sheet channel is important to determine firms' investment, it is tempting to ask how large this impact is. However, the difficulty that we may face is that the balance sheet channel may have some indirect effects acting through other variables of the model such as the market value of the firm.

However, it is possible at least to calculate the direct effect from the results obtained in the previous sections. This direct effect can be obtained from the coefficients that link the currency mismatch variable with the investment rate and constitutes a lower bound of the magnitude of the balance sheet channel put in motion by devaluations when firms have currency mismatches.

From table 2.2 we know that firms' investment rate declined substantially during and after the Asian crisis. More specifically, the average investment rate in 1998 was about 16.5 percentage points below its 1996 level and investment remained well below its pre crisis levels even in the year 2001.

Table 2.5 presents indicators of the average magnitude of the currency mismatches (remember that they are measured as the fraction of total assets lost as a consequence of the devaluation). This table shows that on average the firms in our sample lost around 17.1 percent of their assets as a consequence of the devaluation.

In order to assess the direct impact of the balance sheet channel on investment we can calculate how large the decline in investment attributable to the balance sheet channel was. To do this, we use the coefficients obtained in the first column of table 2.4b because they suggest that the importance of the over-investment effect cannot be dismissed.

By multiplying the average currency mismatch (0.171) by the coefficient associated with the impact of the currency mismatch on 1998's investment rate (i.e., $\beta_{1998}=0.146$) we obtain that the direct impact of the balance sheet channel caused a decline in investment of 2.5 percentage points for a firm with an average exposure.

The decline in investment caused by the balance sheet channel seems modest when compared to the observed total decline in investment. Based on our previous results, the reduction in investment attributable to the balance sheet channel was approximately 15 percent of the total decline in investment (i.e., $2.5/16.5$).

In addition, the calculations show the importance of taking into account the over-investment effect. For instance, had we used the coefficients of the third column of table 2.4a we had come up with an impact of the balance sheet channel in 1998 more than twice as high as the one reported above. However, it is necessary to recall that the impact just calculated constitutes the direct impact only and, as a result, needs to be interpreted as a lower bound of the magnitude of the balance sheet channel.

2.6. Conclusions

The empirical analysis has used firm level data from Thailand, one of the countries involved in the recent Asian crisis, to test for the adverse effects of devaluations on investment. The results suggest that firms with larger currency mismatches reduced their investment more, which gives support to the idea of net worth being an important determinant of investment, at least in crisis periods.

In addition, the results presented suggest that the inverse relation between currency mismatches and investment is, at least in part, caused by the presence of a balance sheet channel given that currency mismatches remain a significant determinant of investment even after taking into account alternative explanations of the investment decline.

Another interesting result obtained in the paper is that the shocks to net worth seem to have a persistent effect on investment. More specifically, the results suggest that, for our sample of Thai manufacturing firms, the reductions in net worth originated from the devaluation of the Thai Baht in 1997 had an impact over firms' investment even in the year 2000.

The chapter also explored some alternative explanations of the inverse correlation between CM and investment. On this issue, it was obtained that even though the impact of CM remains significant its magnitude changes substantially when one of the alternative explanations is taken into account. In particular, the results suggest that firms' over-investment in the period prior to the crisis needs to be taken into account in order to obtain an appropriate measure of the impact of devaluations on investment and to account for the decline of investment during and after the Asian crisis.

After taking into account the impact of the productivity of capital and the incidence of over-investment the magnitude of the impact of currency mismatches on investment looks lower than what is obtained when such factors are left outside the analysis.

More specifically, the results suggest that a firm with an average degree of currency mismatch (i.e., a firm that lost around 17.1 percent of its assets due to the devaluation) reduced its investment in 1998 in around 2.5 percentage points more than those firms with zero currency mismatch. The estimated value would be around twice as high if the impact of over-investment were not taken into account.

The results obtained in this chapter post a challenge for the theoretical literature mentioned in the first chapter. In particular, that literature should try to calculate more precisely the level from which the impact of devaluations on investment starts to produce the results the literature relies upon.

Interestingly, a byproduct of the tests for the importance of currency mismatches for investment constitutes a contribution of this chapter, namely: the chapter is able to compare the quantitative importance of two very widely accepted explanations of the investment decline during and after the Asian crisis. The two explanations we refer to are: over-investment before the crisis and weak balance sheets due to the presence of unhedged foreign currency denominated debt. The results suggest that the first had a much larger contribution to explain the mentioned investment decline, at least in the case of Thai manufacturing firms.

Chapter 3. Balance Sheets and Investment in Episodes of Crises:

Evidence from Four Asian Countries

The present chapter tries to extend the results of the previous one by applying the same methodology developed in that chapter to three other countries that were part of the Asian crisis, namely: Indonesia, Korea, and Malaysia.¹⁹

One of the advantages of the empirical analysis presented in chapter 2 is that it uses very detailed information on the losses caused on firms by the devaluation of the currency, the Thai Baht in that case. This detailed information is, unfortunately, not available for the three countries mentioned above which forces us to pursue the empirical analysis using a proxy for firms balance sheets' exposure to devaluations.

The variable that will be used to proxy for firms balance sheets' exposure to devaluations is firms' leverage at the beginning of the crisis. There are two reasons for selecting this variable, they are:

- a) The Thai data analyzed in chapter 2 shows that there is a positive correlation between firms' losses due to the devaluation of the currency and firms' leverage (the correlation is 0.35).
- b) Pre-crisis-leverage is an indicator of how likely firms will be affected by credit market imperfections during a crisis. Therefore, if this variable turned out to be important for the determination of investment that would be an indication that balance sheet variables likely played a role.

¹⁹ The Philippines was also part of the Asian crisis but the sample of firms available for this country was too small to allow a serious analysis.

The second reason is particularly important because it suggests that the use of pre-crisis-leverage as a variable that helps determine the importance of balance sheet effects is justified even if it were a poor proxy of the exposure of firms' balance sheets to devaluations.

A word of caution is, however, in order. As chapter 2 shows in subsection 2.4.3.1, pre-crisis-leverage may be correlated with investment because it may reflect a change in the market value of debt when the crisis occurs and not balance sheet effects. This alternative interpretation cannot be ruled out in the empirical analysis presented in this chapter because there is no information available on the currency composition of firms' debt. In consequence, the results presented below have to be interpreted as follows: First, they constitute a necessary condition for the presence of a balance sheet channel but not a sufficient condition. Second, they help to quantify an upper bound of the balance sheet channel. On the last issue, it is convenient to stress that the coefficients associated to pre-crisis-leverage will likely reflect two impacts that go in the same direction, namely: the impact of the balance sheet effect and the change in the market value of debt.

However, it is important to point out that the information obtained using pre-crisis leverage instead of pre-crisis exposure to currency risk is still very important because it helps to quantify the potential importance of the balance sheet channel, which, as explained in the previous two chapters, is an essential piece of information for the theoretical literature.

Given that the variable that will be used to help determine the significance of balance sheet effects is different from the one used in chapter 2, it is convenient to include Thailand in the analysis as well, so that the results can be more easily compared with those of the mentioned chapter.

The rest of the chapter is organized as follows: Section 3.1 describes the data while section 3.2 presents some summary statistics and the results of the estimations for each of the four countries included. Section 3.3 evaluates the empirical importance of the balance sheet channel and section 3.4 concludes.

3.1 Data

The primary dataset uses financial statements of a group of 326 manufacturing non-financial firms.²⁰ The fiscal year of all the firms ends in December, which makes the financial statements comparable. As in the precedent chapter, attention will be restricted to manufacturing firms in order to minimize the heterogeneity of the firms in other areas different from the currency composition of their debt.

The data come primarily from THOMSON ANALYTICS, which provides information on Balance Sheets, Income Statements, Funds Flow, and some standard financial ratios for publicly traded firms

The period under study is 1992-2001. This period allows us to have a good number of firms in the sample and, at the same time, to have information pre, during,

²⁰ The number of firms per country for which we were able to calculate pre-crisis-leverage and pre-crisis over-investment is: Indonesia, 60, Korea, 111, Malaysia, 64, and Thailand, 91.

and post crisis. As we have mentioned before, having data for years before and after the crisis allows us to test for the persistence of the balance sheet channel.

3.2 Empirical Analysis

This section is divided in two subsections. The first one presents some summary statistics for each of the countries. The statistics include pre-crisis average leverage for each of the countries and the behavior of firms' investment during the period of study. The subsection also includes some basic correlations between pre-crisis leverage and contemporaneous and future investment.

The second subsection presents the estimation of the equations presented in chapter 2 but applied to other countries and with the already described change in the variable that captures the shock to firms' net worth at the moment of the crisis.

3.2.1 Summary Statistics

Table 3.1 presents the leverage of the firms by country in 1996, the year before the crisis erupted. As can be seen, Korea and Thailand had the largest pre-crisis average leverage followed by Indonesia and then Malaysia.

Tables 3.2a and 3.2b show the behavior of the investment rate during the period of study. It can be seen that in 1997 investment only declined substantially in Thailand, where the crisis began. However, in 1998, when the crisis had become regional, all the countries had suffered major declines in investment and such declines turned out to persist during the years following the crisis.

The important issue for this paper is to what extent the decline of the investment rate can be attributed to the adverse affects that firms' balance sheets suffered during the crisis. The next subsection offers a formal test of the issue but the correlations shown in Tables 3.3a and 3.3b are also revealing.

Tables 3.3a and 3.3b show the correlation of pre-crisis leverage with investment rate during and after the crisis. It can be seen that the correlation is mostly negative and large for Korea and Thailand, while it is much lower in absolute value (and close to zero) for Indonesia and Malaysia.

An interesting feature of the results of tables 3.3a and 3.3b is that pre-crisis leverage is more correlated with investment precisely in those countries with the highest pre-crisis leverage, namely: Korea and Thailand. This result suggests that the deterioration of balance sheets may have played a role in the decline of investment in these countries. The next subsection presents a more formal test of the role of balance sheets in the determination of investment during and after the crisis.

3.2.2 Estimations

This subsection presents the results of estimating equation (1.2) of chapter 2 for each of the countries in the sample. Tables 3.4a, 3.4b, 3.4c, and 3.4d present a picture similar to the one of Tables 3.3a and 3.3b. More precisely, pre-crisis leverage is a significant determinant of contemporaneous and post-crisis investment rate for Korea and Thailand but not for Indonesia and Malaysia.

The results also reinforce the perception that balance sheet shocks may have played a role in determining investment given that, as was mentioned before, Korea and Thailand were precisely the countries with highest leverage of the sample. It is also striking that Korea, the country with the highest average leverage, is also the one in which the impact of pre-crisis leverage on investment is the highest.

At this point it is convenient to recall the word of caution that was raised in the introduction, namely: “Pre-crisis-leverage may be correlated with investment because it may reflect a change in the market value of debt when the crisis occurs and not balance sheet effects. This alternative interpretation cannot be ruled out in the present paper because there is no information available on the currency composition of firms’ debt. In consequence, the results (...) have to be interpreted as follows: First, they constitute a necessary condition for the presence of a balance sheet channel but not a sufficient condition. Second, they help to quantify an upper bound of the balance sheet channel. On the last issue, it is convenient to stress that the coefficients associated to pre-crisis-leverage will likely reflect two impacts to go in the same direction, namely: the impact of the balance sheet effect and the change in the market value of debt.”

In consequence, tables 3.4a, 3.4b, 3.4c, and 3.4d suggest that if balance sheet effects had an impact on investment it was only in Korea and Thailand. In addition, the mentioned tables can give us an idea of the upper bound of this impact. To this last calculation we turn in the next section.

3.3 Evaluating the Empirical Importance of the Balance Sheet Channel

As was mentioned in the previous subsection, the impact of pre-crisis leverage on investment likely reflects two forces that go in the same direction and that due to data limitations cannot be separated. Fortunately, it is still possible to extract some information about the importance of balance sheets for investment during the episode under study. The strategy that will be followed in this section is simple. If all the impact of pre-crisis leverage were assigned to the balance sheet channel we could at least have an estimation of the upper bound of this channel.

For instance, we can calculate the investment decline that the average firm experimented as a consequence of the balance sheet channel when compared to the less exposed firm. For the case of Korea, average pre-crisis leverage was 69.20 percent while the lowest pre-crisis leverage was 20.6 percent. Therefore, the difference in the investment rate that can be attributed to the balance sheet effect for 1998 is 8.67 percentage points ($= -0.1787958 \times [0.6920 - 0.2069]$). In the case of Thailand, the numbers are 56.21 percent and 10.23 percent, which gives the balance sheet effect an impact of about 5.30 percentage points ($= -0.1152 \times [0.5621 - 0.1023]$).²¹

We can also calculate the upper bound of the contribution of the balance sheet channel to explain the decline in investment. As Tables 3.2a and 3.2b show, from 1996 to 1998 the investment rate fell 15.79 and 16.5 percentage points in Korea and

²¹ The coefficients used to calculate the impact of the balance sheet effect in 1998 are those obtained in the last columns of Tables 3.4b and 3.4d for the impact of pre-crisis leverage on 1998's investment rate.

Thailand, respectively. We already know that, in 1998, the average decline in investment that can be attributed to the balance sheet channel is 12.37 percentage points ($= -0.1787958 \times 0.6920$) and 6.48 percentage points ($= -0.1152 \times 0.5621$) in Korea and Thailand, respectively. These numbers constitute about 79 percent of the investment decline in Korea and 40 percent of the investment decline in Thailand.

The previous calculations suggest that there is room for the balance sheet channel to have played a role in the determination of investment in these two countries during and after the Asian crisis. However, we must not forget that the numbers just calculated are upper bounds and, as a result, do not tell us exactly the magnitude of the balance sheet channel (in fact, we already know that they likely overestimate the strength of the balance sheet channel).

It is interesting to compare the results obtained for Thailand with those of the previous chapter in order to have an idea about the magnitude of the overestimation problem that we incur when we assign the whole impact of pre-crisis leverage to the balance sheet channel. In chapter 2 it was estimated that the balance sheet channel explains around 15 percent of the decline of investment in Thailand, which is much lower than the upper bound (40 percent) that we calculated above.

3.4 Conclusions

The empirical analysis presented in this chapter has used firm level data for four of the countries involved in the Asian crisis, Indonesia, Korea, Malaysia, and Thailand, to test whether balance sheet effects played a role in the large decline in investment that

these economies experienced during the Asian crisis. The analysis also pretends to shed light on the generality of the results obtained in chapter 2 on the importance of net worth shocks for firms' investment decisions.

The results suggest that the decline in investment in those economies with low leverage, Indonesia and Malaysia, was not affected by the deterioration of firms' balance sheets. However, balance sheets seem to have played a role in the most heavily indebted countries, Korea and Thailand, and the results show that the potential explanatory power of the balance sheet channel could be large, although data limitations do not allow a precise estimation.

This chapter also sheds light on another finding of chapter 2. In particular, over-investment during the period preceding the crisis is always a significant variable to explain the path of investment during and after the crisis. In addition, the inclusion of the over-investment variable reduces the explanatory power of the balance sheet channel, which suggests that part of the inverse correlation observed between pre-crisis leverage and investment is a consequence of the co-movement between investment and leverage that occurred prior to the crisis.

Chapter 4. Government's Incentives and Currency Composition of Firms' Debt

The empirical studies undertaken in the previous two chapters suggest that shocks to net worth caused by devaluations forced firms to reduce their investment beyond what fundamentals would predict, which, arguably, contributed to deepen the recessions witnessed by the countries in our sample during the Asian crisis.

An important question is then, why do firms accept to be exposed to the adverse effects that net worth shocks have for them? Presumably, firms should be able to insure the exchange risk away given that the nominal exchange rate is an observable variable and, as a result, contracts could be written contingent on it.

There is a growing theoretical literature that has focused on answering this question. The literature has focused on the distortions originated in the private sector that affect its decision on the currency composition of its debt and has paid little attention to the role of the government in affecting the denomination of private sector's debt. In this sense, this literature is not connected with the literature on the currency composition of government's public debt, which emphasizes that the incentives of the government to inflate in order to reduce the real value of its debt determine the currency composition of the debt.

The lack of attention to the incentives of the government to inflate as determinants of the currency composition of the private sector's debt is even more surprising once we recall the information presented in table 1.1, namely: recognize that the private sector of the countries that went into crises in the 1990s were highly

indebted with foreigners. As table 1.1 indicates, in all the episodes both firms and banks were net debtors against foreigners and the magnitudes were important in economic terms.

Therefore, if such debts were denominated in domestic currency, the government would have strong incentives to inflate and transfer resources from foreigners to domestic agents. From now on, we will call the Opportunistic Inflation Channel (OIC) to the mechanism through which the government deliberately causes high inflation/devaluation in order to transfer resources from foreign to domestic agents.

A natural question is then, why has the recent literature paid so little attention to the role of the government? Two reasons are important:

- a) The governments in Mexico and East Asia had been following relatively sound economic policies prior to their respective crises.
- b) The perception that government's incentives to inflate should not affect the private sector decision regarding the optimal currency composition of its debt. Why? Calvo (2001) puts it clearly: "Consider the case in which external private sector debt is positive. Then the government will have incentives to devalue giving rise to excessive inflation, (...). However, this does not necessarily lead the private sector to change its debt denomination to dollars. The reason is that the private sector is atomistic and, therefore, does not

internalize the government's reaction function. Thus, again, the model falls short of target.”²²

However, as this chapter will show, even in the case described by Calvo (atomistic private agents), the OIC remains an important determinant of private sector's currency denomination of debt. Why? First, the government reaction function may affect differently borrowers and lenders. Second, aggregate variables may convey information to the credit market that allows it to internalize the government reaction function.

In addition, the chapter also shows that the disciplined behavior of the government may be a consequence, and not a cause, of the currency composition of the debt (because when the debt is denominated in FC it is not possible to use inflation to transfer resources from foreigners to domestic agents).

Another important reason the OIC should receive more attention is that, as the next section describes, those models that rely exclusively on the distortions originated in the private sector have a hard time explaining other empirical regularities associated with international capital flows and debt's currency composition across different sectors of the economy. On the other hand, the OIC offers a plausible explanation for those issues.²³

²² This argument is also embraced by Caballero and Krishnamurty (2001).

²³ More specifically, the OIC is also able to explain why capital flows are smaller than what risk sharing considerations would predict and why the currency composition of liabilities is similar for sectors with very different probabilities of being bailed out in case of a crisis.

The rest of the chapter is organized as follows: Section 4.1 presents the related literature and the shortcomings that it has. Section 4.2 presents definitions and the basic features of the model. Section 4.3 solves the model and discusses its implications. Finally, Section 4.4 concludes and presents some possible extensions of the model.

4.1 Related Literature

The literature on the determinants of the currency composition of the private sector debt has emphasized many different channels, and most of them rely on distortions originated in the behavior of the private sector.

4.1.1 Channels Emphasized in the Related Literature

- a) *Moral hazard due to government bailouts*: Schneider and Tornell (2000) and Burnside, Eichenbaum, and Rebelo (2001) argue that if banks expect that the government or international financial institutions are going to bail them out if they go bankrupt, then they may borrow in foreign currency (FC) because when everything goes okay they enjoy a low cost debt while when they face an adverse shock the government is who pays the costs.
- b) *Underinsurance due to mispricing of the social value of domestic currency debt*: Caballero and Krishnamurty (2001) present a model in which firms have to post “tradable collateral” to borrow from foreigners. However, the amount of foreign collateral is limited at the economy level. In their model firms do not

internalize that their collateral has also a social value and, as a result, tend to post “too much” of their “tradable collateral”. The externality present in the model produces that the economy will end up with an inefficiently high level of foreign currency debt (i.e., debt denominated in tradable goods).

- c) *Foreign currency debt as a commitment device*: Jeanne (2000) argues that firms may use FC debt to show investors that they (the firms) are not expecting any government help and that are willing to work hard to obtain a good return from the project.
- d) *Foreign currency debt as a signaling device*: Jeanne (1999) presents a model in which firms borrow in FC to convey lenders information about the quality of their projects. In his model the level of foreign currency borrowing becomes excessive under laissez-faire and taxing foreign debt may be optimal.
- e) *Instability of the nominal exchange rate*: Jeanne (2001) shows that when the government pursues a discretionary exchange rate policy whose objective is to favor a particular sector, and firms do not know what sector is going to be the selected one, then firms may prefer to borrow in foreign currency to avoid the high ex post real interest rates that the domestic currency denominated debt may end up having when a devaluation does not take place.
- f) *Dilution effect*: In Chamon (2001) devaluations and bankruptcies occur jointly. If creditors cannot control the currency composition of firms’ debt then, once they have lent the money, creditors are exposed to firms borrowing additional resources in foreign currency which dilutes the resources that are available for the initial creditors’ in case of bankruptcy.

In addition to the channels described in these models, there are other arguments to justify excessive levels of unhedged FC denominated debt. For instance, Eichengreen and Hausmann (1999) present this quote from a report by the BIS (1999), along with similar quotes from reports of the IMF and World Bank:

(In Asia) “Long standing policies of fixed or quasi-fixed exchange rates probably nurtured a misperception of exchange rate risk. With a flexible exchange rate, and frequent movements in both directions, firms and households learn from their daily experience to take account of exchange rate risk.” This kind of argument has sparked a debate on the effect of the foreign exchange regime on the private sector hedging decisions (see for instance Arteta, 2002).

4.1.2 Shortcomings of the Related Literature

The channel that has received more attention is the one that relies on moral hazard due to government bailouts. However, this channel has a hard time explaining several empirical regularities. First, as table 1.1 shows, FC denominated debt was a phenomenon present in both the financial and non-financial sectors, even though both sectors arguably have very different probabilities of receiving a bailout. Second, moral hazard due to bailouts would predict that capital flows should be higher than what risk sharing considerations would predict but it has been documented that capital flows are

much less than what such standard would predict (see Eichengreen and Hausmann, 1999).

The channel based on the mispricing of the social value of domestic currency debt potentially can apply to any agent of the private sector but its empirical relevance is difficult to assess because it relies on a very specific structure of the credit market and also of the shocks. In addition, it could be argued that this channel would be weak if the productivity shocks affected all the firms in the same way, instead of assuming, as it is the case in the paper, that only a fraction of the firms is affected.

The channels that argue that FC debt can be used as a signaling or a commitment device left unexplained whether firms do not have other ways to commit or to signal its intentions to lenders. In addition, very little is known empirically about the use by firms of the currency composition of its debt to affect the perception of lenders about the intentions of the firm.

The channel based on the dilution effect ultimately depends on the bankruptcy procedures of the country and especially on how the government treats foreign lenders when domestic firms go bankrupt. However, despite the importance of the role of the government, its behavior is not modeled in the paper.

The instability of the nominal exchange rate is a channel that potentially has a lot of explanatory power given that countries that have experienced periods of high inflation have seen that the use of their currencies to diminish substantially both as mean of exchange and even more as store of value. In addition, this channel can explain why the presence of unhedged FC debt is a phenomenon mostly of developing countries. In this last channel the instability of the nominal exchange rate is caused by

the monetary policy followed by the government but this agent is not modeled here either.

The model presented in this chapter is related to the last channel given that the ability of the government to manipulate the nominal exchange rate is what ultimately causes firms to borrow in FC. However, the model presented below goes one step beyond since it describes a channel through which the incentives of the government interact with the behavior of the private sector to determine the currency composition of firms' debt.

4.2 The Model

4.2.1 Ingredients of the Model

Before presenting the model in detail it is convenient to explain the main ingredients of the model because this may help to obtain a broad picture of the main effects that are at play.

- 1) Domestic firms need net worth to improve access to the credit market. This assumption is necessary to give firms an incentive to hedge the currency risk (otherwise the currency composition of the debt is irrelevant).
- 2) Firms need to keep money balances in order to produce, which exposes firms' net worth to changes in the price level. This assumption allows the introduction of money in the model and, with the latter, potential losses for the firms when devaluations occur.

- 3) The foreign capital market is composed of risk neutral atomistic lenders. This feature of the international capital market potentially allows domestic agents to diversify away all the risk stemming from changes in the price level (or nominal exchange rate). The diversification process is simple: firms choose the currency composition of their debts in order to match the reduction in the real value of their revenues that occurs when the price level increases with a reduction in the real value of their liabilities.
- 4) The diversification opportunities can be illustrated by presenting what will be understood by currency composition of the private debt. A graph may be very useful to clarify the issue. In figure 4.1, curve AA denotes a debt that is fully denominated in foreign currency (i.e., goods) while curves BB and CC represent debts that have a domestic component. It is clear that the debt structure represented by CC has a larger component of domestic debt because its *real* value is more sensitive to changes in the *nominal* exchange rate. One could define the currency composition of the debt more formally using the slope of the curves but it is not necessary now and it will prove better to wait in order to define currency composition in the context of the model. At this point, it suffices to say that if a firm wanted to match a reduction in the value of its assets stemming from an increase in the price level (nominal exchange rate) it could do so by choosing the appropriate repayment schedule as a function of the mentioned variable.
- 5) Risk sharing opportunities are, however, limited by the fact that increases in the price level (or nominal exchange rate) *may* affect differently domestic

borrowers and foreign lenders. This asymmetry is simply a consequence of the opportunistic behavior that the government may follow in order to expropriate foreigners and increase domestic firms' net worth. The asymmetry can be summarized simply by saying that if foreigners have assets denominated in domestic currency they always lose when devaluations take place, while if domestic agents have assets denominated in domestic currency they may or may not lose when devaluations occur given that they may benefit from the transfers of the government.²⁴

- 6) Private agents of the domestic economy are divided in two sectors and the transfers of the government can be directed to any of them. In consequence, firms in each sector know that with some probability increases in the price level (nominal exchange rate) will not affect their net worth (given that they will receive the transfer from the government).
- 7) The model makes endogenous both the currency composition of private debt and government behavior and shows that, in equilibrium, there is a unique solution that has as one of its features that domestic firms face part of the inflation (devaluation) risk. As a result, firms' performance (profits and investment) is exposed to movements in the aggregate price level (nominal exchange rate) via the impact that the latter variable has on firms' net worth.

²⁴ The probabilistic nature of the impact is very important. If agents knew with certainty the impact of changes in the price level on firms profits they would choose a currency composition of its debt that would fully insure them against the shocks.

It is also important to mention that the economy that will be analyzed only produces and consumes one tradable good. Given that the good is tradable purchasing power parity (PPP) holds. If we normalize the foreign price of the good to one, the domestic price level and the nominal exchange rate become equal. Given that we are interested in analyzing the currency composition of firms' debt, we will work with the nominal exchange rate instead of with the price level and we will use P to denote the nominal exchange rate.

4.2.2 Horizon

The economy that we describe has three dates, denoted as 0, 1, and 2. The objective of all private agents is to maximize their date 2 expected wealth and in order to do that they use dates 0 and 1 to produce (the production process takes one period). No consumption takes place at dates 0 and 1.

The model is a monetary model, so there has to be a rationality to hold money. As will be explained below in more detail, it is assumed that domestic agents face a cash in advance constraint and that the money balances have a value (determined by the policies of the government) at date 2. To justify the value of the money balances we could either assume that a new generation of domestic agents is born at date 2 and that this new generation needs to hold money (as in an overlapping generations model) or that the government buys back all the nominal balances at date 2. Both assumptions would work fine and would not change the behavior of the agents of the model.

4.2.3 Agents

The economy is composed of four types of agents: foreign lenders, domestic gatherers, domestic firms, and the government. Most of the action of the model takes place between the last two agents, so we will describe them after introducing the first two:

Foreign Lenders: This group is composed of atomistic, risk neutral, deep pocket investors that have access to a risk free technology with rate of return equal to r . Without loss of generality assume that each lender lends to only one firm. So, foreign lenders are willing to lend an amount b to a domestic firm as long as:

$$E_{t-1}[d(P_t)] = (1 + r)b_{t-1} \quad (1)$$

where E_{t-1} denotes the expected value operator taken as of date $t-1$, $d(P_t)$ denotes the amount of goods that the lender receives at time t when the nominal exchange rate is P_t , and r is the risk free rate of return. Notice that the dependence of the real payments on P_t means that the debt may have a domestic component.²⁵

Domestic Gatherers: This group consists of risk neutral agents with access to the same risk free technology as foreign lenders. However, this group has three particularities. First, given that they are domestic agents, they need to hold money to make transactions. Second, in a particular state of the world they *must* receive a

²⁵ In other words, the debt can be made contingent on the realization of the nominal exchange rate.

transfer from the government (this will be explained in more detail in the description of the government).

Third, they do not lend to domestic firms.²⁶

Domestic gatherers face a cash in advance (CIA) constraint that forces them to have a fraction ϕ of their wealth in domestic currency. The rest of their wealth $(1-\phi)$ is allocated to the risk free technology. So, the money demand of each particular gatherer is (the individual identifier subscript is suppressed to avoid excessive notation):

$$m_t^{DG} = \phi h_t^{DG} \quad (2)$$

where m and h denote real money balances and real wealth, respectively.

The real wealth of a domestic gatherer at date t is given by:

$$h_t^{DG} = m_{t-1}^{DG} \left(\frac{P_{t-1}}{P_t} \right) + (1+r)(1-\phi)h_{t-1}^{DG} + \tau_t^{DG} \quad (3)$$

where τ_t^{DG} denotes the government lump-sum transfer to domestic gatherers.

²⁶ This last assumption is not essential and is made only for analytical convenience. The only requirement that needs to be satisfied is that the resources of this group is not enough to satisfy the credit demand that comes from domestic firms.

Domestic Firms: Domestic firms are risk neutral agents that have access to a production function $Q_t = AF(k_{t-1})$, where k is the amount of physical capital held by the firm. Firms need to hold money to make transactions associated with the production process. In particular, money constitutes a complement to physical capital and each firm has to satisfy the following CIA constraint.

$$k_t = \alpha m_t^{DF} \quad (4)$$

Domestic firms can borrow from foreign lenders but face the following problem:²⁷ Upon receiving the funds from the foreign lender a domestic firm can decide to declare that new research indicates that the project is no longer profitable and that it will not pursue it. In such scenario the domestic firm is able to keep a portion $(1-\xi)$ of the total resources initially intended for the project (its own resources and the borrowed ones) and go to another lender to obtain funds to finance another project. So, for the domestic firm to borrow the following incentive compatibility constraint must be satisfied:²⁸

$$h_t^{DF} \geq (1-\xi)(h_t^{DF} + b_t), \quad (5.1)$$

²⁷ The idea of introducing borrowing constraints is to make firms dependent on their net worth. This dependence is what gives value to hedging activities and makes the analysis of the currency composition of the debt an interesting one.

²⁸ If (5.1) is not satisfied it can be easily shown that $b_t \geq \xi(h_t^{DF} + b_t)$, which means that the lender is better off not lending the money than lending it and collecting just a fraction ξ of total resources when the firm declares that the project is unprofitable.

which simply reduces to:

$$b_t \leq \gamma h_t^{DF} \quad (5.2)$$

where $\gamma = \frac{\xi}{1-\xi}$

The previous constraint makes net worth to be an important variable for firms. As we will see below, the constraint makes firms' date 1 value function concave in wealth despite firms being risk neutral in date 2 wealth. The wealth of the domestic firms is computed as follows:

$$h_t^{DF} = AF(k_{t-1}) + m_{t-1}^{DF} \left(\frac{P_{t-1}}{P_t} \right) + \tau_t^{DF} - d(P_t) \quad (6)$$

Finally, domestic firms also have to satisfy the following budget constraint:

$$k_t + m_t^{DF} = h_t^{DF} + b_t \quad (7)$$

which simply says that firm's resources (own and borrowed) are allocated either to buy physical capital or to hold money.

Government: The objective of the government is to maximize the welfare of the domestic economy. However, with some positive probability, which is assumed exogenous, the government has to give transfers to domestic gatherers. The transfers are made in money and, as a result, will affect the nominal exchange rate unless other actions are taken. The idea behind this transfer is to capture events like financial crises or monetary financing of public sector expenditure. In these two types of events the government gives money to some sectors of the economy and the nominal devaluation caused by the monetary expansion hits adversely those sectors not receiving the transfers. The government can also, but does not have to, give monetary transfers to the domestic firms. Therefore, any decision in this respect will depend on the government incentives to behave opportunistically in order to expropriate foreign lenders.²⁹

One important assumption is that agents (both domestic and foreigners) can observe the total level of transfers that the government makes to domestic agents, but are not able to verify in a court either the level or the composition of the transfers.³⁰ As a result, private agents cannot write contracts contingent on the government's transfers.

The behavior of the government is similar to that proposed in Jeanne (2001) because there the government may follow policies that favor specific sectors. The

²⁹ Notice that we are allowing the government to have control over the money supply. In this sense the concept of government presented here includes the central bank.

³⁰ These assumptions make sense in the present context because it is precisely the government who controls the money supply and foreigners know that with some probability the government can give false information about its value in order to benefit domestic agents.

present model takes that idea and extends it by modeling the decision of the government.

It is important to mention that the government only acts strategically at date 1. This assumption is made for simplicity and is a consequence of the three-date horizon imposed on the model. If we allowed the government to act strategically also in period two the solution of the model would be a bit more complicated and nothing would be added to the main results of the model.

4.2.4 Sequence of Events

Date 0:

- Domestic Gatherers invest in the risk free technology.
- Domestic firms borrow from foreign lenders to invest in the productive technology.

Domestic firms and foreign lenders arrange a repayment schedule of the debt, which can be made contingent on the realizations of the nominal exchange rate (in other words, they arrange the currency composition of the debt). Both agents take into consideration the possibility of the government behaving opportunistically the following period.

Date 1:

-Government learns whether domestic gatherers need a transfer or not. If they do, the government gives them a monetary transfer.³¹ If they do not the government can either give no transfers at all or give transfers to domestic firms to allow a devaluation of the nominal exchange rate to redistribute resources from foreigners to domestic firms assuming that the debt is, at least in part, denominated in domestic currency. The last decision is taken by the strategically by the government and the involved trade-off will be presented later in the paper.

-Domestic gatherers collect the return on their investment and invest again in the risk free technology

-Output of domestic firms materializes and they repay foreign lenders according to the value of the nominal exchange rate and the schedule set at date 0.

-Domestic firms borrow from foreign lenders and invest in the productive technology. The currency composition of the debt becomes irrelevant for date 1's production decision because domestic firms are risk neutral in date 2 wealth.

Date 2:

-Domestic gatherers collect the return on their investment.

-Output of domestic firms materializes and they repay foreign lenders.

-Domestic gatherers and domestic firms consume the wealth accumulated.

³¹ To makes things simple we will only consider one level of monetary transfer. Allowing for a random value of the transfer would make the analysis more general but it is not essential for the argument. Generalizing the model in this direction seems to be an interesting extension.

As can be seen from the sequence of events, date 0 is the interesting date for two reasons. First, the decision on the currency composition of the debt is made. Second, the government will behave strategically the next period.

In addition, this subsection and the previous one make clear that the most relevant agents of the model are domestic firms and the government. The other two agents behave in a way that can be easily described, as we will see below.

Before analyzing agents' behavior and equilibrium formally, it is important to emphasize that it will be assumed that the government can choose only two different levels of transfers. The consequence of this assumption is that the nominal exchange rate can take only two values. Generalizing the analysis would constitute a good extension of the model; however, the simple two-point distribution of the shocks presented here is rich enough to convey the message of the model.

4.3 Solution of the Model

4.3.1 Solution to Agents' Problems

Before solving the model it is convenient to mention what variables are given when agents begin to make their decisions, i.e., at date 0. The variables are: the wealth of domestic gatherers and domestic firms, the nominal exchange rate (which for simplicity it is assumed to be 1) and the nominal money supply.

Now we can start to solve the problem of each of the agents of the model.

a) Foreign Lenders and Domestic Gatherers: The behavior of these two sectors is very simple and was already described in subsection 4.2.2. Equation (1) summarizes the behavior of foreign lenders in dates 0 and 1 of the model. Similarly, equations (2) and (3) describe the behavior of domestic gatherers at dates 0 and 1.

b) Domestic Firms: As of date 0, each firm's problem is to maximize its date 2 wealth (W2) subject to its expected production function, the lenders' participation constraint (equation (1)), restrictions (4) and (5), and the strategic behavior of the government at date 1. The problem of the firm has to be solved backwards. So, we start by solving date's 1 problem.

Firm's Problem at date 1

$$Max E_1 \left[AF(k_1) + m_1^{DF} \left(\frac{P_1}{P_2} \right) - d(P_2) \right], \text{ subject to equations (1), (4), (5.2), and (7)}$$

Substituting equations (4) and (1) into the objective function and equation (4) into (7) we can form the following Lagrangean:

$$L = AF(\alpha m_1^{DF}) + m_1^{DF} E_1 \left(\frac{P_1}{P_2} \right) - (1+r)b_1 + \lambda [\gamma h_1^{DF} - b_1] + \mu [h_1^{DF} + b_1 - m_1(1+\alpha)]$$

Choice variables: b_1, m_1^{DF}

State variables: h_1^{DF}

The solution of this problem is simple. Given that we are interested in the case in which the firm is credit constrained it will be assumed that (5.2) always binds. So,

$$b_t = \gamma h_t^{DF} \quad (8)$$

Using this result in equation (7) we get:

$$m_1^{DF} = \frac{(1+\gamma)}{(1+\alpha)} h_1^{DF} \quad (9)$$

For simplicity, let's assume that there is no inflation at date 2.³² Then, the date 1 value function is³³:

$$V(h_1^{DF}) = AF \left[\frac{\alpha(1+\gamma)}{(1+\alpha)} h_1^{DF} \right] + \left[\frac{(1+\gamma)}{(1+\alpha)} - (1+r)\gamma \right] h_1^{DF} \quad (10)$$

Firm's Problem at date 0

The problem at date 0 is more complicated because we have to consider the strategic decision of the government and because the value function is nonlinear in date 1

³² See subsection 4.2.2 for alternative ways to pin down the date 2 nominal exchange rate.

³³ We obtain the value function substituting the solutions for b and m into the objective function (the first three terms of the Lagrangean).

wealth. Before presenting the equations we have to introduce a little bit of extra notation. Let s index the states of nature. There are two states of nature. In state 2 the government *must* transfer resources to the domestic gatherers. In this case the government gives monetary transfers to that group of agents and the nominal exchange rate jumps from a value of 1 to a value $\bar{P}_1 > 1$. If state 1 occurs the government does not have to transfer resources although it may end up doing it if it finds optimal to behave opportunistically.

If the government decides to behave opportunistically it will expand the money supply as in the other case and will rebate the seignoriage collected to both domestic firms and domestic gatherers. Under some minor assumptions on the relative money demands the present model delivers that the change in the nominal exchange rate only depends on the change in the total amount of monetary transfers and not on the distribution of the monetary transfers.³⁴ Thus, if the government behaves opportunistically it produces exactly the same nominal exchange rate that in the case in which state 2 occurs.

³⁴ This is due to the linearity exhibited by the money demand equations of both types of agents. This feature also makes easy in this model to solve for the actual value of the nominal exchange rate. To obtain the value of the latter variable we only need to aggregate the money demand of all the agents and then use the money market equilibrium condition (money demand=money supply). Despite this simplicity we do not need to solve for the actual nominal exchange rate.

Let q denote the probability of occurrence of state 1 and π the probability that the government will not behave opportunistically.³⁵ Then, the Lagrangean that describes the problem of the firm is:

$$L = q\{\pi V[h_1^{DF}(s=1, P_1=1)] + (1-\pi)V[h_1^{DF}(s=1, P_1=\bar{P})]\} + (1-q)\{V[h_1^{DF}(s=2, P_1=\bar{P})] + \lambda[\gamma h_0^{DF} - b_0] + \mu[h_0^{DF} + b_0 - m_0(1+\alpha)] + \theta[q\pi d(1) + [q(1-\pi) + (1-q)]d(\bar{P}) - (1+r)b_0]\}$$

This Lagrangean is very similar to the one related to the date 1 problem. The only differences are that now the firms' value function is concave and that we have made explicit the lenders' rationality constraint (in the date 1 problem we were able to substitute it directly into the objective function). Using (6) we can easily see that $h_1^{DF}(s, P_1)$ is defined as:

$$h_1^{DF}(s, P_1) = AF(\alpha m_0^{DF}) + m_0^{DF} \left(\frac{P_0}{P_1} \right) + \tau_t^{DG}(s, P_1) - d(P_1) \quad (11)$$

Choice Variables: $m_0^{DF}, b_0, d(1), d(\bar{P})$

State Variables: h_0^{DF}, P_0 . For simplicity P_0 is assumed to be equal to one.

Notice that the firm is choosing not only its level of investment but also how it wants the real debt repayments to be made contingent of the realization of the *nominal*

³⁵ As we have mentioned before, this probability will be endogenously determined in the model.

exchange rate. This means that the firm is choosing the currency composition of its debt. Now we are ready to define the currency composition of the debt.

Definition 1: Let $\Delta \equiv \frac{d(1) - d(\bar{P})}{m_0^{DF} \left(1 - \frac{1}{\bar{P}}\right)}$. We will call Δ the hedge index. This index is a

measure of the currency composition of the debt.

Notice that the denominator of index measures the loss in the real value of the money stock that the firm faces when the nominal exchange rate is devalued from 1 to $\bar{P}$. The numerator measures the reduction in the real value of debt payments when the devaluation of the currency occurs.

When the debt is fully denominated in foreign currency the numerator becomes 0 and so does the hedge index. On the other hand, if the firm is able to hedge its currency risk completely the numerator and denominator are equal and the index takes a value of 1. From now on we will use Δ as the measure of the currency composition of firms' debt.

The first order conditions of the firms' problem are easy to calculate and not all of them need to be considered to solve the problem. As a result, only those that are needed will be made explicit.

First, we will restrict attention to the case in which firms are credit constrained. If the budget constraint is binding the firm will borrow the highest amount of resources that its initial wealth allows and, as a result, the total debt, the stock of

physical capital, and the money holdings depend solely on the firms' initial wealth, h_0^{DF} .

In order to decide the currency composition of its debt, the firm will allocate the payments optimally contingent on the realization of the nominal exchange rate. So, we have to consider the first order conditions with respect to each of the repayments.

$$q\pi V'[h_1^{DF}(s=1, P_1=1)] = \theta q\pi \quad (12)$$

$$q(1-\pi)V'[h_1^{DF}(s=1, P_1=\bar{P})] + (1-q)V'[h_1^{DF}(s=2, P_1=\bar{P})] = \theta[q(1-\pi) + (1-q)] \quad (13)$$

Using equations (12) and (13) we get:

$$\frac{q(1-\pi)}{q(1-\pi) + (1-q)} V'[h_1^{DF}(s=1, P_1=\bar{P})] + \frac{(1-q)}{q(1-\pi) + (1-q)} V'[h_1^{DF}(s=2, P_1=\bar{P})] = V'[h_1^{DF}(s=1, P_1=1)]$$

which we will call equation (14).

The last equation is very familiar and simply tells us that domestic firms will choose $d(1)$ and $d(\bar{P})$ such that they equalize the value of the marginal utility when the nominal exchange rate is equal to one (which for sure means that the economy is in state 1) with expected marginal utility when the nominal exchange rate equals $\bar{P}$.

In order to bring to analyze the allocation of the payments by the firms we could solve equation (14) jointly with the lender's rationality constraint. That procedure, although feasible, is lengthy. Instead, we choose here to use a particular

production function and obtain closed form solutions for the model. We select the production function for its analytical tractability, which allows us to convey the intuition of the main idea of the paper easily. In addition, the results obtained constitute a useful benchmark to compare with those that would appear in more complicated cases.

Let $F(k) = ak - k^2$; then, recalling equation (10), date's 1 value function becomes:

$$V(h_1^{DF}) = A \left\{ a\alpha \frac{(1+\gamma)}{(1+\alpha)} h_1^{DF} - \left[\alpha \frac{(1+\gamma)}{(1+\alpha)} h_1^{DF} \right]^2 \right\} + \left[\frac{(1+\gamma)}{(1+\alpha)} - (1+r) \right] h_1^{DF} \quad (10')$$

Using equation (10'), equation (14) can be reduced to:

$$\begin{aligned} d(1) - d(\bar{P}) &= m_0^{DF} \left(1 - \frac{1}{\bar{P}} \right) + \frac{q(1-\pi)}{q(1-\pi) + (1-q)} [\tau(s=1,1) - \tau(s=1,\bar{P})] \\ &+ \frac{(1-q)}{q(1-\pi) + (1-q)} [\tau(s=1,1) - \tau(s=2,\bar{P})] \end{aligned} \quad (15)$$

As we have mentioned before, the government only gives transfers to firms when it behaves opportunistically. Therefore, $\tau(s=1,\bar{P}) > 0$, while the other three transfers equal zero. Equation (15) then simplifies to:

$$d(1) - d(\bar{P}) = m_0^{DF} \left(1 - \frac{1}{\bar{P}} \right) - \frac{q(1-\pi)}{q(1-\pi) + (1-q)} \tau(s=1, \bar{P}) \quad (15')$$

Equation (15') is very intuitive. If the government never behaves opportunistically (i.e., if $\pi=1$) firms will set a debt repayment schedule that would exactly compensate them for the losses that would face in case of a devaluation of the currency. However, the opportunistic behavior of the government distorts firms' hedging decision and leads them to choose incomplete insurance.³⁶ Dividing both sides of (15') by $m_0^{DF} \left(1 - \frac{1}{\bar{P}} \right)$ and using the definition of the hedge index we get:

$$\Delta = 1 - \frac{q(1-\pi)}{q(1-\pi) + (1-q)} y(s=1, \bar{P}) \quad (16)$$

where $y(s=1, \bar{P}) \equiv \frac{\tau(s=1, \bar{P})}{m_0^{DF} \left(1 - \frac{1}{\bar{P}} \right)}$ is the fraction of the loss due to the devaluation that

the government rebates to firms (recall that this transfer only occurs in state 1 and when the government behaves opportunistically).

The relationship between the hedge index and the probability that the government does not behave opportunistically (i.e., π) is summarized in figure 4.2. Notice that the higher π is, the larger the hedge index. However, a larger hedge index

³⁶ Intuitively, firms do not need full insurance against devaluations if they get some of the benefits (with positive probability) of the devaluation.

increases the benefits for the government to behave opportunistically. Therefore, in order to close the model we need to consider the behavior of the government.

c) Government: As we have mentioned before, the government objective is to maximize the welfare of the domestic economy. For that reason, the government has incentives to expropriate foreigners by giving monetary transfers to domestic agents. Let the number of domestic firms be equal to x . Then the government observes $\Omega \equiv x\Delta$ and realizes that the domestic economy can obtain a gain by expropriating foreigners given by $G(\Omega)$. The properties of $G(\Omega)$ are (Z will be defined later):

$$G'(\Omega) > 0; G(0) = 0; G(x) > Z$$

However, if the government inflates the economy to expropriate foreign lenders, foreign capital markets will realize the type of government that the domestic economy has and will be more cautious in the future when lending to domestic firms. The reaction of foreign capital markets will affect the future welfare of domestic agents and the government has to take that into account when deciding its optimal policy.

So far we have worked with a three-dates economy, which, in principle, makes it difficult to incorporate future losses into the picture. However, we could simply use the overlapping generations interpretation of the model (see section 4.2.2) and say that the government is maximizing the welfare of the current cohort of domestic agents and of a new cohort of domestic agents that will appear after the current cohort has

consumed its date 2 resources. The existence of a new cohort does not affect the decision of domestic firms. However, it will affect the behavior of the government.

In order to make the analysis simple let's consider that the government incurs a fixed welfare loss, whose equivalent in resources is Z , when it behaves opportunistically. The gain that the government receives when it behaves opportunistically depends on the amount of resources that it can expropriate from foreigners. From the problem of domestic firms it is clear that the resources that can be expropriated are an increasing function of the economy-wide hedge index.

As of date 0, agents (foreigners and domestic) have uncertainty about the weights that the government will put gains and losses when making its decision at date 1. More formally, agents know that the government **will not** behave opportunistically as long as:

$\sigma Z \geq G(\Omega)$, where σ is a government specific weight on the losses incurred by behaving opportunistically.

Also as of date 0, agents only now that σ is distributed over the interval $[0,1]$. In consequence, after observing Ω agents are able to calculate the probability that the government **will not** behave opportunistically at date 1. Using the properties of $G(\Omega)$ we can obtain the following properties on the probability that the government **will not** behave opportunistically:

$$\pi(\Omega = 0) \equiv \text{prob}(P_1 = 1 \mid s = 1, \Omega = 0) = 1;$$

$$\pi(\Omega = x) \equiv \text{prob}(P_1 = 1 \mid s = 1, \Omega = x) = 0;$$

$$\frac{\partial}{\partial \Omega}(\pi) < 0$$

Figure 4.3 describes the relationship between π and Ω , which we can simply write as:

$$\pi = \pi(\Omega) \tag{17}$$

4.3.2 Equilibrium

The equilibrium of the model can be obtained using equations (16) and (17). A useful simplification is to normalize x to one and obtain the value of Δ as the one that satisfies both equations simultaneously.³⁷ The solution is simple enough to be illustrated with a graph, and it is presented in figure 4.4.

Notice that the equilibrium, which is simply the intersection of the two curves, exhibits a hedge ratio below one. This means that domestic firms will be underinsured when state 2 occurs, and the government makes transfers to the domestic gatherers. This result is consistent with firms being underinsured when a crisis occurs, as was the case in the recent crises of East Asia and Mexico.

³⁷ By using this simplification we lose some generality because we cannot analyze the impact that the size of the domestic firms' sector (relative to the domestic gatherers) has on the incentives of the government to behave opportunistically. However, the objective of the model (to show how the incentives of the government are internalized by the firms and how the currency composition of firms' debt is affected) is not affected by the simplification.

The possibility of observing both little opportunistic behavior and low hedge index (that is, high π and low Δ) is a striking result that this model can deliver.³⁸ The result is important because it allows the model to explain an empirical regularity observed in the crises of East Asia and Mexico, namely: firms in those countries had low hedge indexes despite their governments had followed disciplined macroeconomic policies.

Notice also that an economy with high π and low Δ would likely exhibit a very stable nominal exchange rate. This type of situation could make observers to argue “the stability of the currency over time led domestic agents to borrow in foreign currency”.³⁹ However, the combination of little opportunistic behavior and small hedge index is not a consequence of the observed behavior of the nominal exchange rate but the cause of it.

4.4 Conclusions

The chapter presented a simple model in which the possibility of the government behaving opportunistically in order to transfer resources from foreign to domestic agents affects the currency composition of the private sector’s debt. The driving force of the model is that foreigners and domestic agents are affected differently by the

³⁸ For instance, increases in the share of resources that the government transfers when it behaves opportunistically reduce the hedge index and increase the probability that the government **will not** behave opportunistically.

³⁹ This type of claim was a very common interpretation of the high shares of foreign currency debt that the private sector exhibited before the Asian crisis. See for instance the quote presented in Eichengreen and Hausmann (1999) that we reproduced in the introduction of the paper.

governments' behavior and that agents are able to internalize the governments' incentives using aggregate variables.

In equilibrium, domestic firms do not hedge all the devaluation risk and, as a consequence, are exposed to monetary shocks through which the government gives monetary transfers to other sectors, such as the financial sector or public enterprises.

The empirical implications of the model are in line with several of the stylized facts associated with international capital flows. In addition, the dynamic implications of the equilibrium of the model can explain several commonly expressed views about the causes of the excessive exposure to foreign currency risk. With respect to the last issue, the model shows that the joint existence of excessive exposure to currency risk and its so called "causes", may just be a natural consequence of the incentives of the government to follow opportunistic policies.

Appendix to Chapter 2: Variables and Definitions

The variables and definitions presented below are closely related to the ones used in the empirical literature on credit market imperfections. See for instance FHP (1988) and Barnett and Sakellaris (1998).

Investment: Capital expenditure on property, plant and equipment minus disposal of fixed assets.

Stock of Capital: Replacement value of (net) property, plant, and equipment.

Investment Rate: Investment divided by lagged (net) property, plant, and Equipment.

Basic Earning Power: Earnings before interests and taxes divided by lagged value of total assets.

Tobin's Q: Following FHP (1988), the numerator is the market value of equity plus the book value of liabilities plus the difference between total assets and the capital stock. The denominator is the stock of capital.

Devaluation: Rate of change of the nominal exchange rate

For those calculations that required taking the ratio of variables measured at different points in time the lagged variable was used as reference and the other variable was deflated using a deflator for investment in fixed assets. The deflator was obtained from the World Development Indicators published by the World Bank (see Tables 4.9 and 4.10). Other deflators, like the CPI, did not behave differently from the investment deflator.

Table 1.1. Net Foreign Assets at the Onset of the Crises (Percent of GDP)

Source	BIS	
	Banks	Firms
Nordic Countries (1992)		
Finland	-8.5	-8.1
Sweden	-18.4	-6.2
Mexico (1994)	-3.8	-8.6
East Asia (1997)		
Indonesia	-6.9	-16.1
Korea	-12.8	-5.2
Malaysia	-11.5	-4.4
Philippines	-8.5	-2.1
Thailand	-48.9	-7.0

Source: Eichenbaum, and Rebelo (2001) and reports the net foreign assets position with respect to OECD banks held by banks and firms of the countries included.

BIS: Bank for International Settlements

OECD: Organization for Economic Cooperation and Development

Note: BIS measures are end-of-quarter. For the Nordic Countries, 1991Q3, for Mexico, 1994Q3, for East Asia, 1997Q2.

Table 1.2a. Exchange Rate, Investment, and Growth During Currency Crises: Finland and Sweden

Year	Finland			Sweden		
	I to GDP	Output Growth	Dev. rate	I to GDP	Output Growth	Dev. rate
1980	26.70			20.15		
1981	26.49	2.14	15.82	18.90	0.03	19.72
1982	26.65	3.14	11.57	18.64	1.11	24.08
1983	26.92	2.74	15.56	18.64	1.81	22.04
1984	25.32	3.42	7.90	18.73	3.98	7.89
1985	25.44	3.10	3.16	19.27	2.22	4.02
1986	25.00	2.49	-18.23	18.53	2.22	-17.21
1987	25.59	4.22	-13.21	19.34	2.85	-10.99
1988	26.91	4.73	-5.00	20.20	2.72	-3.36
1989	29.49	5.14	2.63	21.99	2.38	5.22
1990	28.60	0.03	-10.96	21.51	1.36	-8.19
1991	24.39	-6.26	5.76	19.37	-1.66	2.17
1992	19.90	-3.32	10.89	16.97	-1.42	-3.70
1993	16.37	-1.15	27.46	14.22	-2.22	33.65
1994	15.48	3.95	-8.58	15.06	3.34	-0.87
1995	16.29	3.81	-16.28	15.48	3.69	-7.55
1996	17.02	4.01	5.03	15.73	1.08	-5.99
1997	17.98	6.29	13.07	14.87	1.98	13.85
1998	18.70	5.33	2.89	15.82	2.95	4.13
1999				16.58	3.78	3.93

Note: The crisis occurred in the third quarter of 1992

I to GDP: Investment to GDP ratio (in %)

Dev. Rate: Devaluation Rate (in %)

Table 1.2b. Exchange Rate, Investment, and Growth During Currency Crises: Mexico

Mexico			
Year	I to GDP	Output Growth	Dev. rate
1988	18.52		
1989	17.25	4.20	8.29
1990	17.88	5.07	14.27
1991	18.65	4.22	7.32
1992	19.60	3.63	2.53
1993	18.56	1.95	0.67
1994	19.35	4.41	8.33
1995	16.15	-6.17	90.20
1996	17.86	5.15	18.38
1997	19.52	6.77	4.20
1998	20.90	5.03	15.38
1999	21.24	3.76	4.64

Note: The crisis occurred in December of 1994

I to GDP: Investment to GDP ratio (in %)

Dev. Rate: Devaluation Rate (in %)

Table 1.2c. Exchange Rate, Investment, and Growth During Currency Crises: Indonesia and Korea

Indonesia				Korea		
Year	I to GDP	Output Growth	Dev. rate	I to GDP	Output Growth	Dev. rate
1989	27.39			32.17		
1990	28.32	7.24	4.11	37.30	8.98	5.41
1991	28.08	6.95	5.83	39.03	9.23	3.62
1992	27.25	6.46	4.08	36.96	5.44	6.45
1993	26.28	7.30	2.82	36.16	5.49	2.82
1994	27.57	7.54	3.53	36.00	8.25	0.10
1995	28.43	8.22	4.07	36.69	8.92	-4.00
1996	29.60	7.82	4.17	36.79	6.75	4.30
1997	28.31	4.70	24.21	35.10	5.01	18.25
1998	25.43	-13.13	244.18	29.77	-6.69	47.32
1999	21.65	0.85	-21.56	27.95	10.66	-15.17

Note: The crisis started in July 1997

I to GDP: Investment to GDP ratio (in %)

Dev. Rate: Devaluation Rate (in %)

Table 1.2d. Exchange Rate, Investment, and Growth During Currency Crises:
Malaysia and Thailand

Year	Malaysia			Thailand		
	I to GDP	Output Growth	Dev. rate	I to GDP	Output Growth	Dev. rate
1989	29.08			34.62		
1990	33.04	9.01	-0.15	40.38	11.17	-0.45
1991	36.36	9.55	1.67	41.63	8.56	-0.27
1992	36.63	8.89	-7.37	39.26	8.08	-0.46
1993	38.87	9.89	1.05	39.52	8.71	-0.32
1994	40.25	9.21	1.95	39.90	8.62	-0.67
1995	43.59	9.83	-4.57	41.00	8.83	-0.93
1996	42.50	10.00	0.46	41.09	5.52	1.72
1997	43.06	7.32	11.81	33.35	-0.43	23.76
1998	26.81	-7.37	39.50	22.17	-10.17	31.87
1999	22.29	5.64	-3.17	20.97	3.33	-8.57

Note: The crisis started in July 1997

I to GDP: Investment to GDP ratio (in %)

Dev. Rate: Devaluation Rate (in %)

Table 2.1. Investment Growth at the Aggregate Level and in the Dataset

Year	Investment Growth (%)	
	Median Firm	Aggregate Level
1997	-42.4	-26.3
1998	-48.4	-43.8
1999	-3.2	-9.1
2000	29.5	26.8
2001	25.5	15.3

Investment at the aggregate level is taken from the annual reports of the central bank of Thailand

Table 2.2. Investment Rate over the Period under Study

Year	Median	Mean	Observations
1993	18.8	24.7	60
1994	19.6	24.3	70
1995	22.7	29.1	82
1996	18.3	23.2	88
1997	9.3	15.8	96
1998	3.8	6.7	95
1999	5.9	8.4	96
2000	5.2	11.5	97
2001	7.7	13.7	153

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment.

Table 2.3. Correlation Between Investment Rate and Currency Mismatch

Year	Correlation	Observations
1997	0.09	96
1998	-0.30	95
1999	-0.35	96
2000	-0.18	96
2001	-0.13	94

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment. The currency mismatch variable is measured as the ratio of firms' losses due to devaluation divided by firms' total assets.

Table 2.4a. Impact of Net Worth Shocks Caused by Devaluations on Investment

	(1)	(2)	(3)	(4)
	Investment rate	Investment rate	Investment rate	Investment rate
Tobin's Q	0.0050 (0.0017)**	0.0049 (0.0017)***	0.0047 (0.0017)***	0.0047 (0.0018)***
NWS 1997		0.0397 (0.1129)	0.0184 (0.1119)	0.0822 (0.1266)
NWS 1998		-0.2515 (0.0744)***	-0.3448 (0.0825)***	-0.3194 (0.0845)***
NWS1999		-0.3035 (0.0717)***	-0.3165 (0.0697)***	-0.2948 (0.0776)***
NWS 2000		-0.2803 (0.0748)***	-0.2824 (0.0741)***	-0.2166 (0.0724)***
NWS 2001		-0.2394 (0.1066)**	-0.2721 (0.1073)**	-0.1602 (0.1070)
Basic Earning Power			0.2626 (0.0915)***	0.2692 (0.0890)***
LEV 1997				-0.1558 (0.1025)
LEV 1998				-0.0704 (0.0814)
LEV 1999				-0.0535 (0.0837)
LEV 2000				-0.1807 (0.0921)*
LEV 2001				-0.3181 (0.1024)***
Observations	720	720	720	720
R-squared	0.23	0.25	0.26	0.27

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock

LEV: Leverage Effect

OVI: Over-Investment Effect

Table 2.4b. Impact of Net Worth Shocks Caused by Devaluations on Investment

	(1)	(2)
	Investment rate	Investment rate
Tobin's Q	0.0037 (0.0017)**	0.0037 (0.0016)**
NWS 1997	0.0227 (0.1120)	0.03734 (0.1138)
NWS 1998	-0.1462 (0.0693)**	-0.1377 (0.0718)*
NWS1999	-0.1790 (0.0662)***	-0.1717 (0.0694)**
NWS 2000	-0.1781 (0.0712)**	-0.1394 (0.0666)**
NWS 2001	-0.1077 (0.1138)	-0.0610 (0.1077)
Basic Earning Power	0.1157 (0.0775)	0.0898 (0.0774)
OVI 1997	-0.3898 (0.1526)**	-0.4164 (0.1519)***
OVI 1998	-0.6977 (0.0750)***	-0.7075 (0.0753)***
OVI 1999	-0.7115 (0.0983)***	-0.7273 (0.0976)***
OVI 2000	-0.6659 (0.0893)***	-0.7431 (0.0835)***
OVI 2001	-0.7115 (0.0903)***	-0.7894 (0.0901)***
EXP 1997		0.0363 (0.0367)
EXP 1998		0.0052 (0.0222)
EXP 1999		0.0185 (0.0240)
EXP 2000		0.1078 (0.0314)***
EXP 2001		0.1178 (0.0344)***
Observations	691	691
R-squared	0.37	0.39

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock; LEV: Leverage Effect; OVI: Over-Investment Effect; EXP: Interaction of export dummy with time dummy

Table 2.5. Summary Statistics of Pre-Crisis Currency Mismatch (percent of firms' assets)

Median	Mean	Observations
13.6	17.1	97

Table 3.1. Pre-crisis Leverage of Manufacturing Firms

Leverage in 1996 (%)			
	Median	Mean	Observations
Indonesia	50.95	50.61	68
Korea	71.44	69.20	141
Malaysia	42.28	43.61	72
Thailand	58.97	56.21	97

Table 3.2a. Investment Rate in Indonesia and Korea

Year	Indonesia			Korea		
	Median	Mean	Obs.	Median	Mean	Obs.
1993	24.29	30.68	44	15.38	21.08	48
1994	22.12	28.07	44	15.81	20.69	81
1995	22.95	27.18	47	25.69	30.42	97
1996	22.97	29.48	59	24.46	29.60	109
1997	23.50	25.79	65	20.04	26.14	136
1998	8.59	13.02	70	9.41	13.81	146
1999	3.81	7.60	70	7.89	11.53	191
2000	5.26	9.98	77	7.20	13.13	365
2001	11.08	16.94	92	6.59	12.26	387

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment.

Table 3.2b. Investment Rate in Malaysia and Thailand

Year	Malaysia			Thailand		
	Median	Mean	Obs.	Median	Mean	Obs.
1993	22.75	25.28	33	18.78	24.71	60
1994	17.04	20.63	34	19.61	24.34	70
1995	16.41	19.81	40	22.67	29.11	82
1996	15.65	20.06	62	18.35	23.25	88
1997	13.96	22.80	66	9.28	15.80	96
1998	7.86	14.19	76	3.76	6.75	95
1999	7.12	10.84	76	5.91	8.42	96
2000	3.89	9.21	89	5.21	11.55	97
2001	5.70	12.07	174	7.72	13.72	153

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment.

Table 3.3a. Correlation Between Investment Rate and Pre-crisis Leverage in Indonesia and Korea

Year	Indonesia		Korea	
	Correlation	Observations	Correlation	Observations
1997	0.02	57	0.02	108
1998	-0.03	60	-0.20	111
1999	0.08	59	-0.19	108
2000	0.16	58	-0.17	109
2001	-0.01	53	-0.12	107

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment. Pre-crisis leverage refers to firms' leverage as of the end of 1996.

Table 3.3b. Correlation Between Investment Rate and Pre-crisis Leverage in Malaysia and Thailand

Year	Malaysia		Thailand	
	Correlation	Observations	Correlation	Observations
1997	0.06	60	0.02	91
1998	0.09	64	-0.20	89
1999	-0.08	64	-0.18	90
2000	-0.11	63	-0.15	90
2001	-0.11	63	-0.15	88

Investment rate is defined as the difference between capital expenditure and disposal of fixed assets divided by previous period's (net) property, plant, and equipment. Pre-crisis leverage refers to firms' leverage as of the end of 1996.

Table 3.4a. Impact of Net Worth Shocks Caused by Devaluations on Investment:
Indonesia

	(1)	(2)	(3)
	Investment rate	Investment rate	Investment rate
Tobin's Q	0.0093 (0.0023)***	0.0082 (0.0023)***	0.0060 (0.0021)***
Proxy NWS 1997	0.1006 (0.1022)	0.1388 (0.1136)	0.1386 (0.1022)
Proxy NWS 1998	0.0413 (0.1057)	0.0821 (0.0904)	0.0535 (0.0973)
Proxy NWS1999	0.0962 (0.0731)	0.0820 (0.0804)	0.0411 (0.0724)
Proxy NWS 2000	0.1466 (0.0812)*	0.1700 (0.0853)**	0.1395 (0.0852)
Proxy NWS 2001	0.0064 (0.1247)	0.0088 (0.1248)	-0.0104 (0.0996)
Basic Earning Power		0.4338	0.3559
		(0.0623)***	(0.0630)***
OVI 1997			-0.2157 (0.1520)
OVI 1998			-0.6094 (0.1576)***
OVI 1999			-0.7500 (0.1195)***
OVI 2000			-0.6927 (0.1232)***
OVI 2001			-0.7898 (0.1588)***
Observations	456	450	450
R-squared	0.28	0.34	0.41

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock

OVI: Over-Investment Effect

Table 3.4b. Impact of Net Worth Shocks Caused by Devaluations on Investment:
Korea

	(1)	(2)	(3)
	Investment rate	Investment rate	Investment rate
Tobin's Q	0.0018 (0.0015)	0.0019 (0.0015)	0.0015 (0.0013)
Proxy NWS 1997	-0.0765 (0.0954)	-0.0759 (0.0956)	-0.0266 (0.0957)
Proxy NWS 1998	-0.2675 (0.0934)***	-0.2448 (0.0961)**	-0.1788 (0.0829)**
Proxy NWS1999	-0.2320 (0.0813)***	-0.2350 (0.0820)***	-0.1748 (0.0820)**
Proxy NWS 2000	-0.2246 (0.0738)***	-0.2482 (0.0738)***	-0.1869 (0.0669)***
Proxy NWS 2001	-0.1431 (0.0696)**	-0.1501 (0.0693)**	-0.0879 (0.0551)
Basic Earning Power		0.0895 (0.0408)**	0.0675 (0.0384)*
OVI 1997			-0.4634 (0.1192)***
OVI 1998			-0.8566 (0.0879)***
OVI 1999			-0.7161 (0.0856)***
OVI 2000			-0.6113 (0.0841)***
OVI 2001			-0.7209 (0.0723)***
Observations	865	865	865
R-squared	0.27	0.28	0.39

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock

OVI: Over-Investment Effect

Table 3.4c. Impact of Net Worth Shocks Caused by Devaluations on Investment:
Malaysia

	(1)	(2)	(3)
	Investment rate	Investment rate	Investment rate
Tobin's Q	0.0002 (0.0002)	0.0002 (0.0002)	0.0002 (0.0002)
Proxy NWS 1997	-0.0806 (0.0951)	-0.0115 (0.0963)	0.0446 (0.1049)
Proxy NWS 1998	-0.0330 (0.1269)	0.0206 (0.1255)	0.1522 (0.1349)
Proxy NWS1999	-0.1644 (0.0730)**	-0.1233 (0.0664)*	-0.0248 (0.0667)
Proxy NWS 2000	-0.2197 (0.1228)*	-0.2103 (0.1259)*	-0.0680 (0.1204)
Proxy NWS 2001	-0.1962 (0.0722)***	-0.1540 (0.0767)**	-0.0381 (0.0715)
Basic Earning Power		0.2659 (0.0821)***	0.1541 (0.0810)*
OVI 1997			-0.4661 (0.2325)**
OVI 1998			-0.9418 (0.1712)***
OVI 1999			-0.6845 (0.1270)***
OVI 2000			-0.8823 (0.1362)***
OVI 2001			-0.7922 (0.1291)***
Observations	474	471	471
R-squared	0.16	0.20	0.28

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock

OVI: Over-Investment Effect

Table 3.4d. Impact of Net Worth Shocks Caused by Devaluations on Investment:
Thailand

	(1)	(2)	(3)
	Investment rate	Investment rate	Investment rate
Tobin's Q	0.0049 (0.0017)***	0.0047 (0.0017)***	0.0038 (0.0017)**
Proxy NWS 1997	-0.0831 (0.0877)	-0.0947 (0.0880)	-0.0432 (0.0840)
Proxy NWS 1998	-0.1924 (0.0813)**	-0.2098 (0.0840)**	-0.1152 (0.0645)*
Proxy NWS1999	-0.1952 (0.0854)**	-0.1936 (0.0844)**	-0.0983 (0.0672)
Proxy NWS 2000	-0.2969 (0.0992)***	-0.3025 (0.0997)***	-0.1819 (0.0826)**
Proxy NWS 2001	-0.3062 (0.0922)***	-0.3232 (0.0930)***	-0.1882 (0.0898)**
Basic Earning Power		0.1627 (0.0812)**	0.0977 (0.0726)
OVI 1997			-0.3824 (0.1519)**
OVI 1998			-0.7150 (0.0721)***
OVI 1999			-0.7390 (0.0973)***
OVI 2000			-0.6773 (0.0865)***
OVI 2001			-0.7029 (0.0829)***
Observations	691	691	691
R-squared	0.26	0.26	0.37

Note: The estimation method is fixed effects. White-corrected robust standard errors in parentheses. *, **, and ***, indicate statistical significance at the 0.10, 0.05, and 0.01 confidence levels, respectively. Time dummies included but not reported.

Acronyms:

NWS: Net Worth Shock

OVI: Over-Investment Effect

Figure 1. Currency Composition of Debt

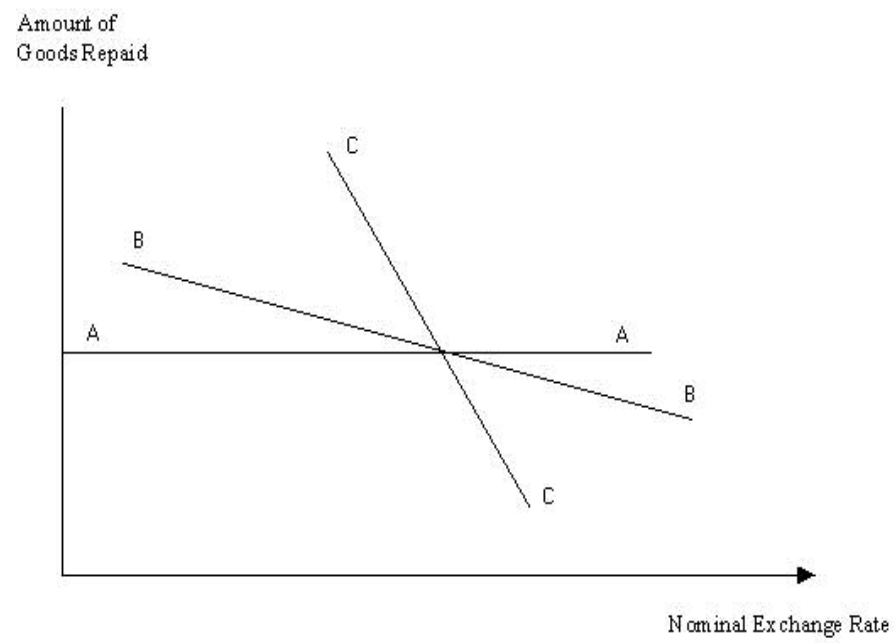


Figure 2. Hedge Index and Behavior of the Government

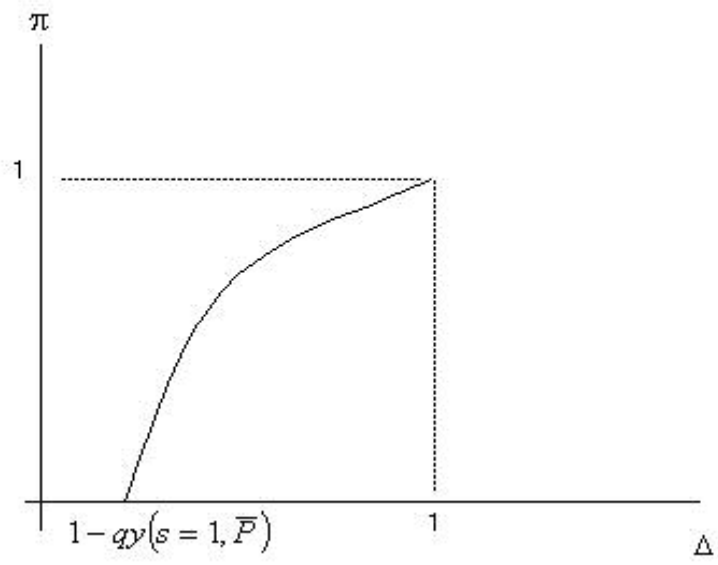


Figure 3. Reaction Function of the Government

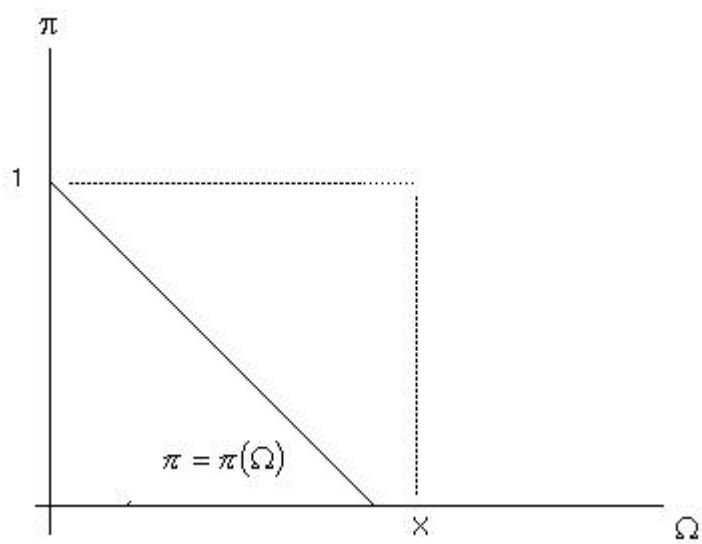
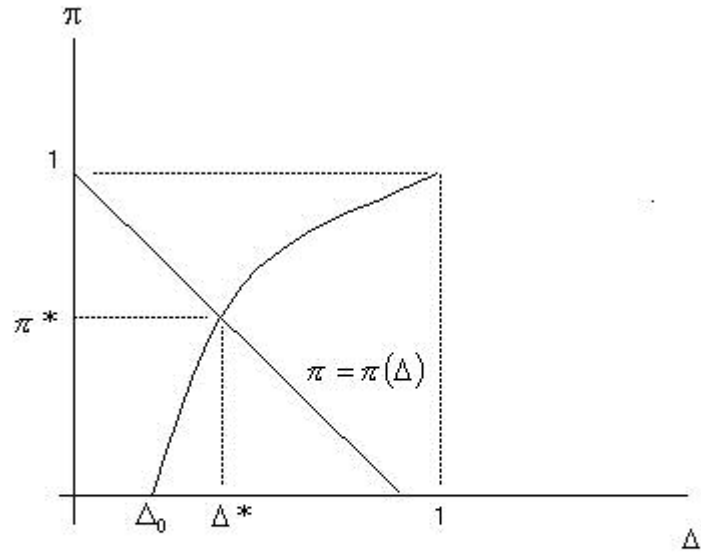


Figure 4. Equilibrium of the Model



$$\Delta_0 = 1 - q\gamma(s = 1, \bar{P})$$

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