Financial Crises and Monetary Policy

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PROEFSCHRIFT

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door

Benedikt Vital Godelieve Goderis,

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PROMOTOR: Prof. dr. S.C.W. Eijffinger

To my parents,

Preface

This thesis is the result of several years of research at Tilburg University, the Ministry of Finance of the Netherlands, and the University of Cambridge. I have greatly enjoyed these years and would like to express my gratitude to the people that have supported me throughout this period.

My foremost thanks go to my supervisor Sylvester Eijffinger. I first met Sylvester during my undergraduate studies, during which he played a major role in the development of my academic interests. It is with great gratitude and appreciation that I look back on the many times he provided valuable insights into research and kindly stood ready to discuss my future. Over the last couple of years, Sylvester has continued his support and created the ideal environment for me to undertake my research. He enabled me to combine my Ph.D. at Tilburg University with an appointment of two days a week at the Ministry of Finance. He has also facilitated my participation in several top conferences and arranged for me to work together with other researchers as well. Perhaps more importantly, he expressed a continuous commitment to my final goal, which for a young researcher can be very comforting and sometimes much needed.

I also feel greatly indebted to my parents. They have expressed a continuous and seemingly inexhaustible interest in my work. A Ph.D. is a long and sometimes lonely journey and I feel gratitude for the numerous occasions on which they stood ready to listen, discuss, and provide advice, while always respecting and supporting my choices. I have also greatly benefited from their help in areas outside research. This ranges from their help during times of exams to their help with me changing residence several times over the last years, the last time overseas. I feel very fortunate and I truly believe that without their support I would not be where I am today. I also thank my sweet sister for her support and attention. And I am grateful to my late grandfather, my grandfather, my grandmothers, and all other family for their support over the years.

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improvement and I am strongly determined to further develop myself in the future.

Wolf has been a close colleague over the last eight months since my move to Cambridge and has become a good friend as well. I would like to thank him for his efforts to make me feel at home in a new city and a new job. I also thank him for working with me. I have learned a lot from him, especially in the field of theoretical modeling. Next to Wolf, I want to thank my other colleagues in Cambridge as well.

As mentioned above, I combined my Ph.D. with a part-time appointment at the Foreign Financial Relations directorate of the Ministry of Finance. My special thanks go to Wouter Raab and Kees van Dijkhuizen for making this possible and supporting me all through the way. I also want to thank Arjen van Gijssel, Robert Haffner, Gita Salden and Ernst van Koesveld for their cooperation. Last but not least, I want to express gratitude to my colleagues from the international economics section: Willem Kooi (also paranymph), Emile Spijkerman, Pieter Jansen, and Michael Kuijper. The nice atmosphere and chemistry in this group and the great sense of humour made it a very pleasant period. I could not have wished for better colleagues.

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Finally, I thank my girlfriend Mila for her loving care and support. I am grateful for her understanding and patience and wish her all the best with her own graduate studies. I can finally return the favour.

Contents

Chapter 1

Introduction

The history of financial crises goes back a long time. It was already in 1863, that the author Joseph Holbrey, in response to a crisis in England in 1857, expressed his desire to identify their cause and find the most likely remedy. From his conclusions it follows that crises were no less harmful in those periods than they are today: “The present system, every now and then, brings a crisis which carries ruin and desolation to many who are innocent, as well as to those who are more or less guilty; while it is the cause of wide-spread misery to both, it is not, even to the guilty, in proportion to their guilt.”[1] Over the last decades, many countries and regions around the world have suffered from financial crises. Mexico (’73-’82) and Argentina (’78-’81) were early examples. In the nineties, several countries in Europe (’92-’93), again Mexico (’94-’95), East Asia (’97-’98), Russia (’98), and Brazil (’99) followed. More recently, Turkey (’00-’01) and Argentina (’01-’02) were hit by this painful event. Although these crises have already been subject to many debates among both policymakers and academics, their origin remains the source of much controversy. From an academic perspective, an extensive economic literature has evolved, both theoretical and empirical.

Three types of financial crises are generally distinguished: currency crises, banking crises, and debt crises. The main part of this thesis (Part I) focuses on currency crises[2] whereas Part II deals with debt crises.

The structure of the thesis is as follows. The remainder of this introduction provides a review of currency crisis literature and outlines the chapters of the thesis, the research questions they pose, and their main conclusions. Part I of the thesis, which deals with currency crises,

[1] Holbrey (1863), p. 366

[2] although shortly touching on other types of crises as well, as currency crises are not seldomly accompanied by problems in the banking sector or by defaults on sovereign debt. The simultaneous occurrence of two different crisis types is often referred to as ‘twin crises’. See for example Kaminsky and Reinhart (1999) for the combination of banking and currency crises.

monetary policy, and balance sheet vulnerabilities, consists of Chapters 2 to 4. Part II focuses on debt crises and sovereign credit derivatives (Chapter 5). Chapter 6 provides a summary and conclusions.

Literature Review

In order to motivate the research questions and to place the thesis among existing lines of work, it is useful to shortly review the currency crises literature.

This literature started with the works of Krugman (1979) and Flood and Garber (1984), which are now often referred to as the 'first-generation models of currency crises'.[3] These models were developed in response to crises in Latin America in the 1970s and early 1980s, which were characterized by preceding periods of overly expansive budgetary policies combined with fixed exchange rate regimes. The models show how the monetary financing of structural government deficits leads to a gradual depletion of the central bank's foreign reserves, as under the fixed exchange rate the central bank stands ready to buy the excess domestic money in return for foreign money. At some point in time, a speculative attack occurs which wipes out the central bank's remaining stock of foreign reserves and leads to a collapse of the fixed exchange rate regime.

Although well explaining the early crises in Latin America, first-generation models suffered from some weaknesses. The most important one related to the assumptions of exogenous government policy and structural deficit financing. This shortcoming became particularly clear during the crises in the European Monetary System (EMS) in 1992 and 1993, which were not preceded by structural government deficits and gradual foreign reserves depletion. Instead, governments widened their exchange rate bands due to sudden severe speculative attacks on their currencies. In response to these crises, Obstfeld (1995) argued that the maintenance or abandonment of a fixed exchange rate corresponds to a policy trade-off rather than a simple process of foreign reserves depletion. Possible benefits from defending a fixed exchange rate relate to maintaining credibility and enhancing international trade and capital flows. Possible costs stem for example from the loss of an independent monetary policy which makes it impossible to lower interest rates in case of unemployment, as experienced by some of the EMS countries. In addition, Obstfeld argues that these costs increase when market participants expect the fixed exchange rate to be abandoned. This is because if speculative

[3] Other contributions include Blanco and Garber (1986), Dornbusch (1987), Obstfeld (1984), Agénor et. al. (1992), Willman (1988), Van Wijnbergen (1991), Wyplosz (1986), and Edwards and Montiel (1989). A survey is provided by Agénor et. al. (1992).

pressures are rising due to devaluation expectations, so does the level of the interest rate or the amount of foreign reserves needed to successfully defend the fixed exchange rate. Hence, speculation makes an interest rate defense more expensive or sometimes even impossible and thus policymaker's behavior is no longer exogenous but depends, among other things, on the market's beliefs about the future. This results in the possibility of self-fulfilling speculative attacks in which speculation against the currency makes it prohibitively costly for the central bank to defend the exchange rate and thus results in a collapse of the fixed exchange rate, consistent with prior expectations. Models that contain the characteristics above are often referred to as 'second-generation models of currency crises'.[4]

Whereas the onset of crises in first-generation models clearly follows from deteriorating fundamentals caused by inconsistent government policies, the onset of crises in second-generation literature is less straightforward.[5] The models explain that multiple equilibria exist but do not provide an explanation of what determines which equilibrium prevails. Two possible solutions have been proposed. Morris and Shin (1998) show how multiple equilibria can be eliminated by assuming that market participants do not have common knowledge about fundamentals. Banerjee (1992), Bikchandani et al. (1992), and Calvo and Mendoza (2000) explain how so-called 'information cascades' and 'herding' behavior can lead to unique equilibria in which market participants do not base their decisions on their own information but on the actions of others.

Although first- and second-generation models have proved reasonably capable of explaining many past crisis episodes[6], it is widely agreed that these models were less relevant in the East Asian 1997/1998 crisis countries. These countries did not experience any first-generation alike fiscal problems nor did they face the policy trade-off between exchange rate stability and unemployment, as some EMS crisis countries did in 1992 and 1993. Hence, new models were needed and the first attempts to develop such models focused on problems in the banking sector. Krugman (1998) and Corsetti et al. (1999) argued that implicit government guarantees led to moral hazard and an excessive level of investment, which after some time collapsed when governments were no longer willing or able to cover the losses. In contrast, Chang and Velasco (1998) focused on a shortage of liquidity in the banking system caused by a loss of confidence amongst investors, analogue to the classic bank run in Diamond and Dybvig (1983).

However, it was not long until an alternative view emerged, which soon led to a new

[4] In addition to Obstfeld (1995), contributions include Obstfeld (1986) and Obstfeld (1996).

[5] Flood and Marion (1998)

[6] and some more recent ones, like for example the 1998 Russian crisis, which exhibited first-generation characteristics.

strand of literature. This view, first put forward by Dornbusch (1999) and Krugman (1999), stresses the importance of countries' balance sheet weaknesses and international capital flows in explaining the crises in East Asia, where corporate balance sheets were fragile, and Mexico ('94-'95) and Brazil ('99), where governments' balance sheets were fragile. Balance sheet weaknesses can arise from maturity mismatches, currency mismatches, capital structure problems (for example because of high debt to equity ratios), and solvency problems, stemming from excessive borrowing or investing in low-yielding assets (Allen et al., 2002).

Balance sheet crisis literature has seen two classes of models (Jeanne and Zettelmeyer, 2002). The first class of models considers a combination of currency and maturity mismatches on banks' balance sheets, where crises are characterized by runs on short-term foreign currency debt (Chang and Velasco, 2000; Burnside et al., 2001a, 2001b, 2004; Jeanne and Wyplosz, 2001). The second class of models only considers a currency mismatch in corporate balance sheets, where crises are characterized by a credit crunch and a drop in investment (Krugman, 1999; Aghion et al., 2000, 2001, 2004; Schneider and Tornell, 2004). In both cases, crises can be self-fulfilling, as the depreciation of the real exchange rate inflates foreign currency debt on balance sheets, which has severe adverse effects that validate prior crisis expectations.

Part I: Currency Crises, Monetary Policy, and Balance Sheet Vulnerabilities

The main aim of Chapter 2 is to study how the exposure of a country's corporate sector to changes in the short-term interest rate and the exchange rate affects the decision of monetary authorities to maintain or abandon a fixed exchange rate. In particular, it models the costs of maintenance and the costs of abandonment in terms of deviations of output and inflation from their desired levels. It then analyses the effects of high levels of domestic and foreign currency debt on the probability of crisis.

Chapter 2 shows how higher domestic currency debt increases the costs of maintaining a fixed exchange rate by raising the risk premium that firms have to pay on external funds. This higher risk premium depresses investments and output, which makes it more costly for the monetary authorities to keep the exchange rate fixed. In addition, higher domestic currency debt also lowers the costs of abandonment as the impact of an interest rate cut on output increases. This is because, aside from the initial interest rate cut, the interest rate drops further through the impact on the risk premium. As firms are heavily exposed to the short-term interest rate, cutting this interest rate improves their balance sheet position and lowers the required risk premium on their external funds. Hence, higher domestic currency debt increases the costs of maintenance and lowers the costs of abandonment. As a result, the probability of a crisis, defined as an abandonment of the fixed exchange rate, increases for higher levels of domestic debt.

By contrast, the effect of foreign currency debt on the probability of crisis is shown to be ambiguous. Higher foreign currency debt also increases the costs of maintenance by raising the risk premium that firms pay on external funds. However, it also increases the costs of abandonment. This is because the depreciation that typically succeeds the abandonment of the fixed exchange rate has adverse balance sheet effects for firms with a currency mismatch. These adverse effects lead to a higher risk premium on external funds, which again depresses output. With both the costs of maintenance and the costs of abandonment increasing, the effect on the probability of a currency crisis is ambiguous.

Chapter 2 concludes that corporate balance sheet vulnerabilities can play an important role in the collapse of fixed exchange rate regimes. In order to limit a country's vulnerability to crises, the exposure of firms and banks to interest rate and exchange rate changes should be limited. This can for example be accomplished by further developing equity markets and enhancing financial supervision and regulation.

Chapters 3 and 4 study the impact of monetary policy on exchange rates empirically. These chapters relate to debates among both policymakers and academics about the appropriate stance of monetary policy both during speculative attacks and in the aftermath of fixed exchange rate collapses. According to the so-called 'traditional view', a tighter monetary policy is necessary to discourage the outflow of capital and thus prevent a devaluation of the exchange rate. The 'revisionist view' argues that when speculative attacks are accompanied by substantial balance-sheet problems in the private sector, a tightening of monetary policy may actually have a counterproductive effect on the exchange rate.

Chapter 3 examines whether the efficacy of monetary policy to defend a fixed exchange rate during speculative attacks depends on the level of a country's short-term corporate debt. The central hypothesis is that an interest rate defense of a fixed exchange rate has larger adverse effects and is therefore less effective in countries where the corporate sector is more short-term indebted. In order to test this hypothesis, a dataset is constructed that includes an aggregate indicator of short-term debt and alternative measures of monetary policy for countries with fixed exchange rate regimes that faced severe speculation against their currency during the period 1986-2002. The estimation results confirm that the efficacy of monetary policy in defending a fixed exchange rate depends on the level of short-term corporate debt. For levels of short-term debt that are not too high, raising interest rates lowers the probability of a successful speculative attack ('currency crisis'). This effect decreases and eventually changes sign for higher levels of debt. These results provide evidence that the opposite views on raising interest rates are not mutually exclusive. They also provide a possible explanation for some of the mixed findings in the empirical literature.

Whereas Chapter 3 looks at the relationship between monetary policy and currency crises from an ex-ante perspective, i.e. before a crisis potentially strikes, Chapter 4 considers the role of monetary policy in the aftermath of currency crises when the currency is floating. The central hypothesis is again that the impact of monetary policy depends on the indebtedness of the corporate sector, which is confirmed by the results. Whereas raising interest rates appreciates the exchange rate when short-term debt levels are relatively low, this effect becomes weaker and changes sign for higher levels of short-term debt. The results hold for both the impact on the nominal exchange rate and the impact on the real exchange rate.

Summarizing, Chapters 3 and 4 find strong evidence of a non-linear effect of monetary policy on exchange rates, both during speculative attack episodes preceding possible crises and episodes in the aftermath of such crises.

Part II: Debt Crises and Sovereign Credit Derivatives

An important part of the wide range of financial innovations that has recently been introduced in financial markets, relates to so-called 'credit derivatives'. These derivatives represent contracts under which a so-called protection seller promises to pay an agreed sum to the protection buyer in case the reference bond does not perform. Hence, they provide bondholders with insurance against credit risk. The market for credit derivatives has grown substantially over the last years and sovereign credit derivatives, which provide protection on sovereign bonds, constitute a significant part of this fast-growing market.

The availability of credit protection can have important implications for the resolution of debt crises. Insured bondholders have less incentives to accept a change of the initial terms of the bonds, as they are fully insured against possible non-performance. This could make it more difficult for sovereign borrowers to restructure their debt by reaching an agreement with bondholders. Although the arrival of credit derivatives has gained interest of both policymakers and academics, the implications of credit derivatives for sovereign debt restructuring have not yet been analyzed theoretically. Chapter 5 of this thesis presents a first attempt to provide such an analysis.

In particular, Chapter 5 assesses the welfare implications of credit derivatives through their impact on i) the ex-ante incentives of sovereigns to avoid a crisis and ii) the ex-post crisis resolution. These issues are studied in a model of sovereign debt financing in which a sovereign is running an ongoing project but is unable to service its outstanding debt. We distinguish between two possible states of the economy. If the economy is in the high state, the output from the project (if continued) exceeds its liquidation value. By contrast, if the economy is in the low state, the output is lower than its liquidation value. From an ex-post view, socially efficient crisis resolution in our model requires therefore a debt restructuring - which enables the sovereign to continue the project - in the high state, but a default - which forces the sovereign to terminate the project - in the low state. Hence, efficient crisis resolution requires *conditional* crisis resolution.

The main findings of Chapter 5 are that in most cases credit protection improves sovereigns' incentives to avoid crises ex-ante by increasing the outside option of bondholders. Furthermore, even though possible, in most cases credit protection does not change the efficiency of crisis resolution as bondholders do not have an incentive to induce inefficient levels of protection. Under asymmetric information and costly litigation, protection under certain conditions even induces a switch from inefficient unconditional crisis resolution to socially efficient conditional crisis resolution. Nevertheless, the bondholder does not always choose the socially efficient level of protection: in some cases under asymmetric information, long-term protection might be used as an intervention device to improve the efficiency of crisis resolution.

Part I Currency Crises, Monetary Policy, and Balance Sheet Vulnerabilities

Chapter 2

Currency Crises, Monetary Policy, and Financial Fragility

2.1 Introduction

As outlined in the introduction to this thesis, the failure of first- and second-generation literature to explain the crises in East Asia in 1997 and 1998 has led to a number of studies that focus on currency and maturity mismatches as possible causes of crisis. The main aim of this chapter is to study how the exposure of a country's corporate sector to changes in the short-term interest rate and the exchange rate affects the decision of monetary authorities to maintain or abandon a fixed exchange rate.

To analyze this question, we present a model that defines currency crises as situations in which the costs of maintaining a fixed exchange rate exceed the benefits. Existing studies that use a similar crisis definition (e.g. Obstfeld, 1995) focus on costs of maintenance that relate to the government's fiscal position or the inability to respond to output shocks. In this chapter we instead relate the costs of maintenance to the exposure of the country's corporate sector to the *short-term interest rate*. The costs of lacking an independent monetary policy increase when the corporate sector suffers more heavily from high interest rates.

In addition, we also look at the impact of the corporate sector's *exchange rate* exposure on the costs of maintenance and abandonment. In particular, we show that countries with corporate sectors that hold high levels of foreign currency debt face higher costs of abandonment as the devaluation of the exchange rate has adverse balance sheet effects.

Aside from the theoretical crisis literature, this chapter is also closely related to the empir-

[0] This chapter is coauthored by Sylvester Eijffinger. An earlier version appeared as CEPR Discussion Paper no. 3637 (2002) and is resubmitted at the German Economic Review.

ical literature and the policy debates on the impact of monetary policy on the exchange rate. In particular the role of monetary policy before and after the collapse of the fixed exchange rates in East Asia has been the source of much controversy.

According to the so-called 'traditional view', tighter monetary policy was needed to defend the fixed value of the currency and restore market confidence. This was also the policy that the IMF initially prescribed. On the other hand, a 'revisionist view' emerged, which argued that when speculative attacks are accompanied by substantial balance-sheet problems in the financial and corporate sectors, raising interest rates might actually have a reverse effect on the exchange rate. In this respect, the high interest rate and exchange rate exposures in the financial and corporate sectors of the Asian crisis countries are remarkable. Especially in comparison with Mexico in 1994 that was able to survive interest rates as high as 75 % annually without collapsing, the Asian economies were more vulnerable because their corporate and banking sector were much more leveraged.[1] A number of recent empirical studies[2] have attempted to find evidence on the effect of monetary policy on the exchange rate with mixed results. Chapters 3 and 4 of this thesis add to this empirical literature by providing evidence that the efficacy of monetary policy in supporting the exchange rate depends on the indebtedness of the corporate sector.

The remainder of this chapter is organized as follows. Section 2.2 describes the basic set-up of the model and explains how the risk premium and the monetary authorities' preferences are modelled. Section 2.3 shows the equilibria under a floating exchange rate (discretionary equilibrium) and an initially fixed exchange rate. It then shows the effects of the variables in the model on the probability that a crisis occurs. Section 2.4 concludes.

2.2 The model

We use an extended version of the Dornbusch (1976) sticky-price monetary model for the exchange rate to study a small open economy that initially runs a fixed exchange rate. The model has three periods. In period t-1, the monetary authorities are credibly committed to the fixed exchange rate and the economy is in long-run equilibrium. In period t, they either maintain the fixed exchange rate or abandon it. Prices are sticky throughout this period and the economy can temporarily deviate from its long-run equilibrium. Finally, in period t+1, prices adjust and the economy returns to long-run equilibrium with either a fixed or a floating

[1] In Korea, for example, the debt to equity ratio in the corporate sector had been rising to 6.4 in 1996 (Berg, 1999).

[2] See chapters 3 and 4 for an overview.

exchange rate, depending on the monetary authorities' decision in period t.

We assume that, if the monetary authorities maintain the fixed exchange rate in period t, market participants will expect them to maintain it throughout period t+1 as well. Only if the monetary authorities abandon the fixed exchange rate in period t, market participants' expectations adjust and will be reflected in the period t+1 price level.

The model assumes the following conditions to hold in period t. Symbols that are marked by asterisks refer to the foreign country and are assumed exogenous.[3]

$$M_t - \bar{p}_t = \gamma - \beta \ (i_t - RP_t) \quad (2.1)$$

$$y_t = y_n - \lambda \ (r_t - r_n) + \theta \ (S_t - \bar{p}_t) \quad (2.2)$$

$$r_n = r^* = i^* = c \quad (2.3)$$

$$i_t = i^* + (S_{t+1} - S_t) + RP_t \quad (2.4)$$

$$S_{t+1} = p_{t+1} \quad (2.5)$$

$$i_t = r_t + \dot{p}_{t+1} \quad (2.6)$$

where γ, β, λ, θ,and c are strictly positive constants.

Notation

All variables in logarithms; in the remainder of this chapter, we will use a circumflex to denote the non-logarithmic form of the variables (e.g. $\hat{M}_t$), unless mentioned otherwise.

[3] Since we study a small open economy, we assume that the foreign interest rates are exogenous. The foreign country in our model represents the anchor country to which the home country has fixed its exchange rate.

M_t	domestic nominal money supply in period t
$\bar{p}_t$	domestic price level in period t (fixed)
i_t	$(1+i_t)$, where i_t denotes the domestic nominal interest rate in period t
RP_t	$(1+RP_t)$, where RP_t denotes the default risk premium on domestic debt relative to foreign debt in period t
y_t	domestic real output in period t
y_n	natural level of domestic real output
r_t	$(1+r_t)$, where r_t denotes the domestic real interest rate in period t
r_n	$(1+r_n)$ where r_n denotes the natural domestic real interest rate
r^*	$(1+r^*)$, where r^* denotes the foreign real interest rate (fixed)
S_t	exchange rate in period t (initially fixed), defined as the price of foreign currency in terms of home currency
i^*	$(1+i^*)$, where i^* denotes the foreign nominal interest rate (fixed)
S_{t+1}	exchange rate in period t+1 corresponding to the maturity of the interest rate
$\dot{p}_{t+1}$	level of inflation in period t+1 ($= p_{t+1} - \bar{p}_t$)

Equation 2.1 represents equilibrium in the domestic money market. We assume demand for real money to depend on the expected return on domestic assets, which equals the nominal return i_t minus the risk premium RP_t.[4] Equation 2.2 denotes goods market equilibrium. Deviations of the real interest rate from its natural level and the exchange rate from its purchasing power parity (PPP) level[5] may cause a deviation of output from its natural level. The former reflects the negative effect of higher interest rates on investment as part of aggregate demand. The latter reflects the positive effect of a real exchange rate depreciation on the current account in the short-run. Equation 2.3 states that the natural real interest rate equals the (fixed) foreign real interest rate, which we assume to be constant and equal to the nominal foreign interest rate (i.e. inflation in the foreign country is zero). Equation 2.4 shows a revised version of the uncovered interest rate parity condition. We assume imperfect substitutability of domestic and foreign assets. We think of this as reflecting differences in default risk, which require a risk premium (section 2.2.1). As in period t+1 the economy is in long-run equilibrium, the expected t+1 exchange rate in period t equals the actual exchange rate in period t+1.

[4] Section 2.2.1 explains the determinants of the risk premium in our model.

[5] The log of the foreign price level is assumed to be zero.

I.e., once market participants are informed about the decision of the monetary authorities in period t, they have perfect foresight as to the period t+1 price level and, hence, the period t+1 exchange rate (purchasing power parity). Equation 2.5 represents the assumption of purchasing power parity in period t+1. Equation 2.6 illustrates that the nominal interest rate in period t+1 equals the sum of the real interest rate and the level of inflation in period t+1.

2.2.1 Financial fragility and the risk premium

We assume the risk premium on domestic assets to depend on the degree of financial fragility in the economy. In our model, financial fragility relates to the state of the balance sheets in the corporate sector. In particular, we define financial fragility as the degree to which the net worth of the corporate sector is vulnerable to increases in the domestic interest rate and/or devaluations of the currency. Higher financial fragility therefore corresponds to higher levels of (consolidated[6]) domestic currency short-term debt (domestic debt) and/or higher levels of (consolidated) foreign currency debt (foreign debt).

The microeconomic underpinning of the risk premium that we use in our model follows from Céspedes et al. (2004) and Bernanke et al. (2000). They assume asymmetric information between borrowers and lenders of capital. Borrowers have complete insight into the returns of investments whereas lenders cannot observe these returns unless they pay a proportional monitoring cost. Referring to Williamson (1987), the authors assume a debt contract with a fixed repayment. As long as borrowers pay off their debt, lenders have no incentive to monitor the realized return on investment. However, if borrowers renege on the debt contract, lenders will monitor the outcome and claim the whole return on investment. The question of whether borrowers can meet their obligations depends on the realized return on investment, which Céspedes et al. assume to be independently and identically distributed. Given the level of debt and the required return on this debt, one can determine a minimum threshold level of the realized return for which the borrower is still able to pay off his debt. If the realized return falls short of this minimum level, bankruptcy will follow shortly thereafter and the lender will have to incur monitoring costs. These possible costs of monitoring give rise to the existence of a risk premium on debt titles. The level of these expected monitoring costs is shown to be depending on the level of investment relative to the level of net worth of the borrower. The higher the proportion of net worth in total investment, the lower the part of the investment

[6] We assume the supply side of the domestic economy to consist of a positive number of identical firms. The equations hereafter not only apply to firms at the individual level but also refer to the entire economy at the consolidated level.

that is externally financed, and the lower the minimum threshold value of the realized return for which the borrower can still repay his debt. Hence, higher net worth is associated with a lower probability of bankruptcy, lower expected monitoring costs and therefore a lower risk premium. Formally, we assume that the risk premium is given by:

$$\begin{aligned} \ln \ Risk\ Premium_t &= \ln \left(\frac{Investment_t}{Net\ Worth_t} \right) \\ &= \ln Investment_t - \ln NetWorth_t \end{aligned} \tag{2.7}$$

All variables in non-logarithmic forms.

Equation 2.2 showed that the level of (real) investment is negatively related to the deviation of the real interest rate from its natural level. For simplicity, we assume the level of investment in 2.7 to be given by:

$$\ln \ Investment_t = \psi - \delta \ (r_t - r_n) \tag{2.8}$$

where ψ and δ are positive constants.

Net worth is given by:

$$\ln \ Net\ Worth_t = \ln \ (\hat{\phi}_t \ - \ \hat{r}_t \, \hat{d}_t^d \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}}) \ \hat{d}_t^f) \tag{2.9}$$

Notation

$\hat{\phi}_t$	consolidated total assets at the beginning of period t (equal to the sum of debt and net worth)
$\hat{d}_t^d$	consolidated domestic debt at the beginning of period t, maturing in 1 period.
$\hat{S}^{fix}$	level of the (initially) fixed exchange rate at the beginning of period t.
$\hat{d}_t^f$	consolidated foreign debt at the beginning of period t.

Equation 2.9 shows that net worth in period t depends on the levels of the real interest rate and the real exchange rate[7]. First, a higher real interest rate - which is assumed to be under control of the monetary authorities - increases debt service obligations for borrowers. As a result, the real present value of debt increases and, for a given value of total assets, the level of real net worth falls. Second, a devaluation of the real exchange rate also lowers net worth, as the real domestic currency value of foreign currency debt increases.

[7] The level of the fixed exchange rate equals the period t price level as market participants expected the fixed exchange rate to be maintained. Therefore, under maintenance PPP must hold.

Substituting 2.8 and 2.9 into 2.7 yields the following for the domestic risk premium:

$$\ln\ \textit{domestic risk premium}_t \ = \psi \ - \ \delta\,(r_t - r_n) \ - \ \ln\ (\hat{\phi}_t \ - \ \hat{r}_t\, \hat{d}_t^d \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \hat{d}_t^f) \qquad (2.10)$$

For simplicity, we assume that in the foreign country the real exchange rate equals its long-run equilibrium level and that domestic and foreign debt are zero, which yields the following for the foreign risk premium:

$$\ln\ \textit{foreign risk premium}_t \ = \psi \ - \ \ln \hat{\phi}_t \qquad (2.11)$$

The relative risk premium, RP_t[8], can be found by subtracting 2.11 from 2.10:

$$\begin{aligned} RP_t \ &= \ \ln\ \textit{domestic risk premium}_t - \ln\ \textit{foreign risk premium}_t \\ &= \ -\ \delta\,(r_t - r_n) \ - \ \ln\ (1 - \ \hat{r}_t\, \frac{\hat{d}_t^d}{\hat{\phi}_t} \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \end{aligned} \qquad (2.12)$$

Using the approximation $\ln(1 + x) \approx x$ we can rewrite 2.12 as:

$$RP_t \ = \ - \ \delta\,(r_t - r_n) \ + \ \hat{r}_t\, \frac{\hat{d}_t^d}{\hat{\phi}_t} \ + \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \qquad (2.13)$$

With the same approximation, $\hat{r}_t$ can be written as $(1 + r_t)$ and $(\frac{\hat{S}_t}{\hat{S}^{fix}})$ can be rewritten as $(1 + S_t - S^{fix})$:

$$RP_t \ = \ - \ \delta\,(r_t - r_n) \ + \ (1 + r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} \ + \ (1 + S_t - S^{fix})\ \frac{\hat{d}_t^f}{\hat{\phi}_t} \qquad (2.14)$$

2.2.2 The monetary authorities

We assume that, prior to period t, the monetary authorities have been maintaining a fixed exchange rate regime. This implies that any change in the nominal interest rate - needed to maintain the equality in 2.4, given the fixed exchange rate - is automatically facilitated by an adjustment of the money supply. If, for example, the foreign interest rate rises, market participants will want to sell domestic assets, exchange the receipts for foreign currency and buy foreign assets. Under a floating exchange rate, this would cause a depreciation of the home currency. Under a fixed exchange rate, the monetary authorities stand ready to buy the excess supply of domestic currency in return for foreign currency. As a result, foreign reserves

[8] Recall that RP_t denotes the logarithm of $(1+\mathrm{RP_t})$, where $\mathrm{RP_t}$ denotes the default risk premium on domestic debt relative to foreign debt in period t.

drop and the domestic money supply falls. The resulting higher domestic interest rate restores the equilibrium in 2.4 and, hence, safeguards the fixed exchange rate. Since monetary policy has to ensure the fixed value of the currency, it is no longer autonomous and cannot be used to stimulate output.

However, the fixed exchange rate regime is not irreversible. We assume that, as in second-generation models of currency crises, the maintenance of a fixed exchange rate is a matter of trade-off. As long as the costs of maintenance do not exceed the costs of abandonment of this regime, the authorities choose to maintain the fixed value. If this is no longer the case, they abandon the peg and allow the exchange rate to float. The costs of maintenance and abandonment are dependent on the monetary authorities' preferences, which are modeled by the following loss function for period t:

$$L_t^{CB} = \frac{\chi}{\eta}\,\dot{p}_{t+1}^2 + (y_t - y_n - k)^2 \tag{2.15}$$

All variables in logarithms, except for χ and η;

χ, η and k assumed to be strictly positive

Notation

- χ relative weight put on price stabilization (degree of conservativeness of the monetary authorities)
- η (1+n), where n denotes the monetary authorities' rate of time preference
- k positive wedge between the output level targeted by the monetary authorities and the natural output level

We assume the monetary authorities to care about inflation and output. Since we assume inflation in period t and t-1 to be zero, costs of inflation can only arise from possible non-zero inflation in period t+1. The importance of the costs of inflation depends on both the conservativeness and the rate of time preference of the monetary authorities.

The output costs stem from possible deviations of output from the monetary authorities' desired level, $y_n + k$. Since output in period t-1 and t+1 equals its natural level and cannot be influenced by the monetary authorities, we only include period t output in the loss function. Possible rationales for the positive wedge k between the desired output level and the natural output level are the existence of political business cycles or an imperfectly functioning labour market.

We assume that the monetary authorities decide in period t on whether or not to maintain the fixed exchange rate. If they do, the fixed exchange rate is maintained throughout period t and period t+1. If they do not, the peg is abandoned. We assume that in case of abandonment, the exchange rate is allowed to float and the monetary authorities cannot credibly commit to a new peg or any intermediate exchange rate regime.

The trade-off between costs of maintenance and costs of abandonment closely relates to the literature on rules and discretion in monetary policy. In particular, the 'temptation' to stimulate output above its natural level versus the 'enforcement' through higher future inflation was first introduced by Barro and Gordon (1983). Earlier, Kydland and Prescott (1977) argued in favor of formal monetary policy rules to limit the inflationary bias resulting from discretionary policy.

2.3 Solving the model

To solve the model we first derive the discretionary equilibrium, that is the long-run equilibrium that would prevail under a floating exchange rate regime, which yields us the rate of inflation under floating. We then consider an initially fixed exchange rate regime and derive two alternative equilibria: the equilibrium that prevails if the monetary authorities maintain the fixed exchange rate in period t and the equilibrium that prevails if they abandon the fixed exchange rate in period t.

Next, we compare the monetary authorities' payoffs under both equilibria to determine the conditions under which the peg is abandoned, i.e. to identify the determinants of currency crises.

2.3.1 Discretionary equilibrium

Under a floating exchange rate and in long-run equilibrium, we assume market participants to fully anticipate monetary policy. We also assume that they can set prices in accordance, ensuring that output does not deviate from its natural level. Since the desired output for the monetary authorities exceeds the natural output level, they have an incentive to use monetary policy to lift output above the natural level. Market participants foresee this and set prices accordingly. The result is positive inflation without any output gain, i.e. an inflationary bias. We define this inflationary bias as π^n, which could be understood as 'the natural rate of inflation' under rational expectations.

Appendix 1 shows the derivation of the discretionary equilibrium. The optimal level of the money supply is shown to be:

$$M_t = M_{t-1} + \frac{X}{\frac{\chi}{\eta}} \cdot k \tag{2.16}$$
$$where\ X = (\lambda + \theta)\left(\frac{1+\beta}{\beta}\right)$$

with the inflationary bias being:

$$\pi^n = \frac{X}{\left(\frac{\chi}{\eta}\right)} \cdot k \tag{2.17}$$

The inflationary bias is positively depending on λ and θ because these coefficients imply the efficacy of activist monetary policy through the 'interest rate' and 'exchange rate' channels, respectively. The inflationary bias is negatively depending on β, which indicates the inverse of the impact of money supply changes on the level of the interest rate. Higher levels of β correspond to a lower impact of monetary easening on the interest rate and reduce the monetary authorities' incentive to cheat. The inflationary bias decreases with the monetary authorities' degree of conservativeness, χ, as inflation becomes more costly. A higher rate of the monetary authorities' time preference, η, leads instead to a higher inflationary bias, as the costs of inflation decrease in present value terms. Finally, the positive wedge k between the monetary authorities' desired output level and the natural output level, which is the root cause of the inflationary bias, has a positive effect on its size.

2.3.2 Equilibria under an initially fixed exchange rate

We now derive the equilibria under maintenance and abandonment of the fixed exchange rate regime. We assume the exchange rate to be fixed throughout period t-1 and the economy to be in long-run equilibrium in period t-1. As explained earlier, we assume the peg to be credible, i.e. market participants set period t prices in accordance with their expectation that the fixed exchange rate will be maintained in period t. However, we allow for deviations of domestic and foreign debt levels from their equilibrium values, which changes the monetary authorities' trade-off. If the monetary authorities decide to maintain the peg, the economy remains in long-run equilibrium in period t. If they decide to abandon the peg, there will be a temporary deviation from long-run equilibrium. We consider the conditions under which abandonment ('currency crisis') takes place and, in particular, how the levels of debt relate to this possible abandonment.

Maintenance of the fixed exchange rate

Appendix 2A shows the derivation of the equilibrium in case of maintenance of the fixed exchange rate throughout period t. The costs of maintenance are shown to be equal to:

$$L_t^{CB} = \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \right) + k \right)^2 \tag{2.18}$$

If debt levels equal their natural levels, the costs of maintenance simply equal k^2. Equation 2.18 shows how deviations of the domestic and foreign debt levels increase the costs of maintaining a fixed exchange rate. Intuitively, the higher debt levels correspond to higher risk premiums on domestic assets. For any given level of the money supply, the domestic real interest rate increases and, as a result, output falls below its natural level, increasing the output costs of maintenance.

Abandonment of the fixed exchange rate

Appendix 2B shows the derivation of the equilibrium in case of abandonment of the fixed exchange rate in period t. The costs of abandonment are shown to be equal to:

$$\begin{aligned} L_t^{CB} &= \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta} + A^2} \left(A \cdot \pi^n + \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \right) + k \right) \right)^2 \qquad (2.19) \\ where\ A &= \frac{(1+\beta)}{\beta} \left(\frac{\lambda \left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} + \theta \right) \end{aligned}$$

Maintenance or Collapse?

Equation 2.18 and 2.19 showed the costs of maintenance and abandonment of a fixed exchange rate regime, respectively. As long as the costs of maintenance do not exceed the costs of abandonment, the fixed exchange rate regime will survive. However, as soon as the costs of maintenance do exceed the costs of abandonment, the monetary authorities will choose to abandon the peg and install a floating exchange rate. Appendix 2C shows that this will be the case if:

$$\Omega = \left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A} \right) \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \right) + k \right) - \pi^n > 0 \tag{2.20}$$

The function Ω contains several variables that together determine whether the fixed exchange rate survives. In the next section we derive first-order derivatives to identify the separate effects of every variable on the probability of crisis, which we think of as positively depending on the size of Ω.[9]

2.3.3 Determinants of currency crises

We now use the result in 2.20 to determine the effects of several variables on the probability of a currency collapse. First and foremost, we want to show the influence of domestic and foreign currency denominated debt levels on the probability of collapse.

Domestic debt levels

The effect that the domestic debt level, $\frac{\hat{d}_t^d}{\hat{\phi}_t}$, has on the probability of collapse is given by the first-order derivative, as derived in Appendix 2D:

$$\frac{\partial\, \Omega}{\partial \left(\frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} > 0 \tag{2.21}$$

The positive sign of the first-order derivative implies that a higher level of domestic currency denominated debt increases the probability of a currency crisis. From Appendix 2 and equation 2.20 it can be shown that the positive effect of a higher domestic debt level on the probability of collapse consists of two components.

On the one hand, higher domestic debt levels raise the costs of maintenance due to the increase in the risk premium that borrowers have to pay. The level of investment falls and, as a result, output drops further below the targeted level. This output cost can be compensated for by abandoning the fixed exchange rate and lowering the real interest rate. In equation 2.20, this component is reflected in the second part (between brackets) of the right-hand side, $\left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \right) + k \right)$. We will refer to this component as the **'need for stabiliza-**

[9] Since we did not introduce any stochastic elements, the probability of crisis is strictly speaking either 1 or 0. However, it is easy to add for example a stochastic shock which would introduce the possibility of crisis probabilities between 0 and 1.

tion'. Higher output costs of maintenance make it more urgent for the monetary authorities to compensate for this output loss.

On the other hand, higher domestic debt levels also influence the impact of a lower interest rate. Equation 2.84 in Appendix 2B shows that the efficacy of output loss compensation by monetary easening is positively depending on A. Since a higher level of domestic debt corresponds to a higher level of A, the efficacy of abandoning the fixed exchange rate increases for higher domestic debt levels. In equation 2.20, the efficacy of abandonment is reflected in the first part (between brackets) on the right-hand side, $\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)$. Appendix 2D shows that this part depends positively on A, reflecting the efficacy argument above. Intuitively, a higher level of domestic debt makes an interest rate cut more effective, as it adds a larger decline of the risk premium to the initial cut. As a result, the positive effect on output will be stronger. We will refer to this component as the **'efficacy of abandonment'**.

Summarizing, a higher level of domestic currency denominated debt increases the probability of a currency crisis for two reasons. First, it increases the costs of maintenance, which creates a stronger incentive to compensate for the output loss. And second, it makes monetary easening more effective, creating a second incentive to abandon the currency peg.

Foreign debt levels

Whereas the effect of higher domestic debt levels on the probability of currency crises is rather straightforward, the effect of higher foreign currency denominated debt levels is more complex. Appendix 2D shows the first-order derivative:

$$
\begin{aligned}
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \\
&\quad\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right) \\
&\quad+\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \\
&\gtrless\ 0
\end{aligned} \tag{2.22}
$$

It can be shown that all right-hand side terms in equation 2.22 have positive signs, except for the second, $\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)$. The sign of the effect of foreign debt on the probability of crisis is undetermined. However, again, a distinction can be made between the 'need for stabilization' and the 'efficacy of abandonment'. As in the case of higher domestic debt, the costs of maintenance increase, resulting in a stronger incentive to compensate for the output loss. This component refers to the part $\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)$ in equation 2.20. The efficacy of monetary easening, however, decreases for higher levels of foreign debt, creating a reverse incentive. This follows from the first part of the right-hand side of 2.20, $\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)$ and the negative relation between foreign debt and A. Intuitively, higher levels of foreign debt partially cancel the effect of an interest rate decline by raising the risk premium through the effect of the devaluation on net worth.

Summarizing, the net effect of higher foreign currency denominated debt on the probability of a currency crisis equals the sum of two opposite effects. On the one hand, it increases the costs of maintenance and, hence, the 'need for stabilization'. On the other hand, it makes monetary easening less effective, creating an incentive to maintain the peg.

Other variables

Appendix 2D shows the effect of changes in the other model variables on the probability of crisis. First, the sign of the net effect of the monetary authorities' degree of conservativeness is shown to be ambiguous. On the one hand, more conservativeness lowers the inflationary bias, which makes a floating exchange rate less costly and, hence, increases the probability of crisis. On the other hand, even though the inflationary bias is lower, inflation is more costly to the monetary authorities which reduces the probability of crisis.

Analogues, a higher monetary authorities' rate of time preference increases the inflationary bias and lowers the costs of abandonment because the present value of the future costs of inflation decreases, causing the sign of the net effect to be ambiguous.

As for the level of targeted output (relative to natural output), the sign of the impact on the probability of crisis is also ambiguous. First, a higher output target increases the inflationary bias because the monetary authorities are more inclined to use monetary policy to stimulate output. This decreases the probability of crisis. However, a higher output target also increases the costs of maintenance, which increases the probability of crisis.

The effects of the natural interest rate and the interest rate elasticity of investment are straightforward. A higher natural domestic real interest rate lowers firms' net worth, which leads to a higher risk premium and, hence, higher costs of maintenance and a higher probability of crisis. A higher interest rate elasticity of investment, δ, means that the decline in net worth from an interest rate increase will to a larger degree be compensated by lower investments. As a result, the net effect of an interest rate change on the risk premium is smaller and, hence, the probability of crisis goes down.

The impact of the real exchange rate elasticity of output is twofold. A higher exchange rate elasticity of output increases the impact of a devaluation on output. However, the inflationary bias also increases because the monetary authorities are more inclined to use monetary policy to stimulate output through the exchange rate. As a result, the impact on the probability of crisis is ambiguous.

The impact of the real interest rate elasticity of output, λ, is somewhat similar. It increases the impact of an interest rate cut on output but also increases the inflationary bias. In addition, it raises the costs of maintenance as for given levels of the interest rate, the drop in output is larger. The sign of the net effect is again ambiguous.

The nominal interest rate elasticity of money demand, β, determines the impact of changes in the money supply on the interest rate. For higher β's, this impact is weaker, which means monetary policy is less effective. On the other hand, it lowers the inflationary bias for the same reason. As a result, the sign of the net effect on the probability of crisis is ambiguous.

2.4 Conclusions

In this chapter we have presented a model that shows how the exposure of a country's corporate sector to changes in the short-term interest rate and the exchange rate affects the decision of monetary authorities to maintain or abandon a fixed exchange rate. We have shown that the level of *domestic* currency denominated debt increases the probability of crisis, whereas the effect of higher levels of *foreign* currency denominated debt on the likelihood of crisis is ambiguous.

As for the first, higher levels of domestic currency denominated debt lead to higher risk premiums on external funds. This higher cost of capital depresses investments and output. Since the monetary authorities care about domestic output, the lower output increases the costs of maintaining the fixed exchange rate and, hence, raises the probability of a currency crisis.

Also, because more indebted firms are more exposed to interest rate changes, the impact of monetary policy on output increases as the initial interest rate cut is magnified through its effect on the risk premium. This lowers the costs of abandonment, which further increases the probability of crisis.

Second, higher foreign currency debt also leads to higher risk premiums on external funds and, hence, also increases the costs of maintenance, analogues to the domestic debt case. However, higher foreign debt lowers the impact of monetary policy on output, as the initial interest rate cut is now (partly) cancelled through the increase in the risk premium that results from the devaluation of the currency. This increases the costs of abandonment. As a result, the effect on the probability of crisis is ambiguous as both the costs of maintenance and the costs of abandonment increase.

The analysis in this chapter suggests that, in order to reduce the probability and the output costs of currency crises, countries should limit the exposure of their corporate and banking sectors to changes in the short-term interest rate and the exchange rate. This might for example be accomplished by further developing local equity markets in emerging market countries. Such markets reduce the leverage of corporates by allowing them to finance themselves through the stock market rather than solely through banks or bond markets. Equity provides a more *permanent* source of finance, as opposed to for example bank lending, which is in most cases short-term and thus needs to be rolled over. It has also shown to be a relatively *resilient* source of new financing during the Asian crisis. Both of these characteristics make corporates that finance themselves through equity, more resistant against short-term interest rate increases and/or a sudden stop of bank lending (credit crunch).[10] Financial supervision and regulation can also reduce the exposures of banks and corporates. Requirements as to how much reserve capital banks and corporates should hold, how much short-term funding they may obtain, and how much of their liabilities can be in foreign currency, could provide some safeguards against the risk of crises and the social externalities that go with them.

[10] IMF (2002).

Appendix 1 Discretionary long-run equilibrium

To derive the period t equilibrium, we first consider period t-1, period t, and period t+1.

Period t-1

Recalling equation 2.4, the domestic t-1 interest rate is given by:

$$i_{t-1} = i^* + S_t - S_{t-1} + RP_{t-1} \tag{2.23}$$

The foreign nominal interest rate equals c. Given purchasing power parity in all periods and perfect foresight, $S_t - S_{t-1}$ equals π^n. Furthermore, since the domestic economy is in long-run equilibrium, the absolute domestic risk premium equals the absolute foreign risk premium (=0). Recalling 2.14, this implies that the domestic real interest rate and the debt ratios[11] equal their long-run equilibrium levels. As a consequence, $RP_{t-1} = 0$. Equation 2.23 can be rewritten as:

$$i_{t-1} = c + \pi^n \tag{2.24}$$

This yields the following money market equilibrium (equation 2.1):

$$M_{t-1} - p_{t-1} = \gamma - \beta \ (c + \pi^n) \tag{2.25}$$

Period t

The price level in period t simply equals the sum of the t-1 price level and the natural inflation rate:

$$p_t = p_{t-1} + \pi^n \tag{2.26}$$

Money market equilibrium in period t is similar to equation 2.1[12], with $RP_t = 0$.

$$M_t = p_t + \gamma - \beta \cdot i_t \tag{2.27}$$

[11] For simplicity, we assume the long-run equilibrium debt ratios to be equal to zero.

[12] In equation 2.1 the price level was denoted as fixed. We assume, throughout this paper, that the price level cannot be adjusted throughout period t. However, the price level in equation 2.1 was assumed to be fixed as long as the fixed exchange rate regime was maintained. Here, monetary policy is discretionary and the price level changes every period.

Substituting 2.25 and 2.26 into 2.27 yields:

$$M_t = M_{t-1} + \pi^n - \beta(i_t - c - \pi^n) \tag{2.28}$$

2.28 shows how the existence of rational expectations influences the money market equilibrium. First of all, the nominal money supply in period t has to exceed the level in the previous period in order to keep up with the expected 'natural rate of inflation' (π^n). In addition, deviations of the money supply from its long-run equilibrium supporting value correspond to deviations of i_t from its equilibrium value $c + \pi^n$.

Period t+1

We assume that in period t+1 the economy is in long-run equilibrium:

$$M_{t+1} - p_{t+1} = \gamma - \beta\ (c + \pi^n) \tag{2.29}$$

Since the period t+1 price level is set to ensure that output will be at its natural level, it equals the sum of the price level that supports the equilibrium, given the period t money supply, and the natural rate of inflation:

$$p_{t+1} = \pi^n + M_t - \gamma + \beta\ (c + \pi^n) \tag{2.30}$$

Equilibrium

Rewriting equation 2.27 yields the following expression for the period t price level.

$$p_t = M_t - \gamma + \beta \cdot i_t \tag{2.31}$$

For the level of inflation in period t+1 this implies:

$$p_{t+1} - p_t = \pi^n + \beta(c + \pi^n - i_t) \tag{2.32}$$

Rewriting equation 2.28 yields:

$$i_t = -\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + c + \pi^n \tag{2.33}$$

Substituting 2.33 into 2.32 and rearranging yields:

$$p_{t+1} - p_t = M_t - M_{t-1} \tag{2.34}$$

Equation 2.34 defines the first part of the monetary authorities' loss function in terms of the money supply, M_t. Turning to the second part of the monetary authorities' loss function, the effect of monetary policy on output in period t runs through the real interest rate, r_t, and through the nominal exchange rate, S_t.

$$y_t \; = y_n \; - \; \lambda \; (r_t - r_n) \; + \; \theta \; (S_t \; - p_t) \tag{2.35}$$

We first consider the 'interest rate channel', $-\,\lambda\,(r_t - r_n)$. Recall 2.33:

$$i_t = -\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + c + \pi^n \tag{2.36}$$

Also recall that:

$$i_t = r_t + \dot{p}_{t+1} = r_t + M_t - M_{t-1} \tag{2.37}$$

Substituting 2.37 in 2.36 and rearranging yields:

$$r_t = -\frac{1+\beta}{\beta}\,(M_t - M_{t-1} - \pi^n) + c \tag{2.38}$$

Turning to the exchange rate effect of monetary policy on output in period t, $S_t - p_t$, recall equation 2.4:

$$i_t \; = \; i^* + \; (S_{t+1} - \; S_t) \; + \; RP_t \tag{2.39}$$

With $RP_t = 0$ and $i^* = c$, 2.39 can be rewritten as:

$$S_t = S_{t+1} - (i_t - c) \tag{2.40}$$

Recall that we assumed long-run equilibrium in period t+1, where purchasing power parity holds. Consequently, S_{t+1} equals p_{t+1}. Subtracting p_t yields:

$$S_t - p_t = p_{t+1} - p_t - (i_t - c) \tag{2.41}$$

Substituting 2.33 and 2.34 in 2.41 yields:

$$\begin{aligned} S_t - p_t &= M_t - M_{t-1} - \left(-\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + \pi^n \right) \\ &= \frac{1+\beta}{\beta}\,(M_t - M_{t-1} - \pi^n) \end{aligned} \tag{2.42}$$

We can now write the monetary authorities' loss function in terms of the nominal money supply and solve for the optimal level of the money supply.

Recall from 2.2 and 2.15 that:

$$L_t^{CB} = \frac{\chi}{\eta}\,\dot{p}_{t+1}^2 + (-\lambda\ (r_t - r_n) + \theta\ (S_t - p_t) - k)^2 \tag{2.43}$$

Substituting the results in 2.34, 2.38, and 2.42 in 2.43 yields:

$$\begin{aligned} L_t^{CB} &= \frac{\chi}{\eta}(M_t - M_{t-1})^2 \\ &+ \left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)(M_t - M_{t-1} - \pi^n) - k\right)^2 \end{aligned} \tag{2.44}$$

Minimization of the monetary authorities' loss function yields the optimal level of the money supply:

$$\begin{aligned} \frac{\partial L_t^{CB}}{\partial M_t} &= 2\frac{\chi}{\eta}(M_t - M_{t-1}) \\ &+2\left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)(M_t - M_{t-1} - \pi^n) - k\right)(\lambda+\theta)\left(\frac{1+\beta}{\beta}\right) \\ &= 0 \end{aligned} \tag{2.45}$$

$$\begin{aligned} (M_t - M_{t-1})\left(\frac{\chi}{\eta} + \left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\right)^2\right) &= \pi^n\left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\right)^2 \\ &+ (\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\cdot k \\ &= 0 \end{aligned} \tag{2.46}$$

The resulting optimal level of the nominal money supply is:

$$\begin{aligned} M_t &= M_{t-1} + \frac{X^2}{\frac{\chi}{\eta} + X^2}\cdot\pi^n + \frac{X}{\frac{\chi}{\eta} + X^2}\cdot k \\ where\ X &= (\lambda+\theta)\left(\frac{1+\beta}{\beta}\right) \end{aligned} \tag{2.47}$$

The inflationary bias, π^n, can now be made explicit. We assumed perfect foresight, hence:

$$\pi^n = \dot{p}_{t+1} = M_t - M_{t-1} \tag{2.48}$$

Substituting 2.48 into 2.47 and solving for M_t yields:

$$M_t = M_{t-1} + \frac{X}{\frac{X}{\eta}} \cdot k \quad (2.49)$$

2.48 and 2.49 imply the following for the inflationary bias:

$$\pi^n = \frac{X}{\left(\frac{X}{\eta}\right)} \cdot k \quad (2.50)$$

Appendix 2 Equilibria under an initially fixed exchange rate

A Maintenance of the fixed exchange rate

Again, we consider periods t-1, t, and t+1, but now under the assumption that the monetary authorities have been running a fixed exchange rate in period t-1 and continue to do so in period t and t+1.

Period t-1

Assuming long-run equilibrium, the risk premium is assumed to be zero ($RP_{t-1} = 0$). Furthermore, since the monetary authorities maintain the peg, the exchange rate remains constant. Consequently, equation 2.4 can be reduced to:

$$i_{t-1} \ = \ c \quad (2.51)$$

For the money market equilibrium this implies the following:

$$M_{t-1} \ - \ \bar{p}_{t-1} \ = \ \gamma \ - \ \beta \cdot c \quad (2.52)$$

Period t

Assuming a fixed exchange rate and allowing for deviations of debt levels from their natural levels, equation 2.4 can be reduced to:

$$i_t \ = \ c + RP_t \quad (2.53)$$

Money market equilibrium now implies:

$$M_t \ = \ \bar{p}_t + \gamma \ - \ \beta \cdot c \quad (2.54)$$

and, since the price level has not changed:

$$M_t = M_{t-1} \tag{2.55}$$

Period t+1

Under the assumptions that the fixed exchange rate is maintained throughout period t and the debt levels return to their natural levels, the equilibrium in period t is similar to the period t-1 equilibrium:

$$i_{t+1} \ = \ c \tag{2.56}$$

Since the price level has not changed, money market equilibrium is identical to period t-1:

$$M_{t+1} \ - \ \bar{p}_{t+1} \ = \ \gamma \ - \ \beta \cdot c \tag{2.57}$$

Equilibrium

Since we have assumed that the monetary authorities maintain the peg, we can calculate the costs of maintenance from the monetary authorities' loss function:

$$L_t^{CB} \ = \frac{\chi}{\eta} \ \dot{p}_{t+1}^2 \ + \ (- \ \lambda \ (r_t - r_n) \ + \ \theta \ (S_t \ - p_t) - \ k)^2 \tag{2.58}$$

As shown above, the price level remains fixed. Consequently, period t+1 inflation equals zero. Moreover, the level of the exchange rate also remains fixed. Given the assumption of purchasing power parity in period t-1, this implies that the period t price level equals the period t level of the exchange rate. Equation 2.58 can therefore be reduced to:

$$L_t^{CB} \ = (- \ \lambda \ (r_t - r_n) \ - \ k)^2 \tag{2.59}$$

Since inflation is zero, the domestic real interest rate equals the domestic nominal interest rate.

$$r_t = i_t \ = \ c + RP_t \tag{2.60}$$

Substituting 2.14 into 2.60 yields:

$$r_t = c - \ \delta \, (r_t - r_n) \ + \ (1 + r_t) \, \frac{\hat{d}_t^d}{\hat{\phi}_t} \ + \ (1 + S_t - S^{fix}) \ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{2.61}$$

For $S_t - S^{fix} = 0$, rearranging yields:

$$r_t = \frac{(1+\delta)\cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \tag{2.62}$$

For the costs of maintenance 2.59 this implies:

$$L_t^{CB} = \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right)^2 \tag{2.63}$$

B Abandonment of the fixed exchange rate

We now consider the case where the monetary authorities abandon the fixed exchange rate in period t. Period t-1 is unchanged.

Period t

By abandoning the peg, the monetary authorities regain their monetary policy autonomy and set the money supply so as to minimize their loss function. Given the possible deviation of debt levels in period t, money market equilibrium denotes the following:

$$M_t - \bar{p}_t = \gamma - \beta(i_t - RP_t) \tag{2.64}$$

Given that $\bar{p}_t = \bar{p}_{t-1}$, 2.64 can be rewritten as:

$$(i_t - RP_t) = -\frac{(M_t - \bar{p}_t - \gamma)}{\beta} = -\frac{(M_t - M_{t-1})}{\beta} + c \tag{2.65}$$

Recall equation 2.4 for the revised uncovered interest parity condition:

$$i_t = i^* + (S_{t+1} - S_t) + RP_t \tag{2.66}$$

Period t+1

We assume that, given the abandonment of the fixed exchange rate in period t, the economy will adjust to its new long-run equilibrium in period t+1. Therefore, the t+1 price level equals the equilibrium level in case the money supply stays at its period t level, plus the anticipated money supply change[13].

[13] Recall that this anticipated change simply equals the level of the inflationary bias, as derived in Appendix 1.

$$p_{t+1} = \pi^n + M_t - \gamma + \beta\ (c + \pi^n) \tag{2.67}$$

Further, the money market equilibrium and uncovered interest parity equations are given by:

$$M_{t+1} - p_{t+1} = \gamma - \beta(c + \pi^n) \tag{2.68}$$

$$i_{t+1} = c + \pi^n \tag{2.69}$$

Equilibrium

We calculate the costs of abandonment according to the monetary authorities' loss function:

$$L_t^{CB} = \frac{\chi}{\eta}\ \dot{p}_{t+1}^2 + (-\lambda\ (r_t - r_n) + \theta\ (S_t - p_t) - k)^2 \tag{2.70}$$

Starting with inflation, combining 2.64 and 2.67 yields:

$$\begin{aligned} p_{t+1} - \bar{p}_t &= \pi^n + M_t - \gamma + \beta\ (c + \pi^n) - M_t + \gamma - \beta(i_t - RP_t) \\ &= \pi^n - \beta(i_t - RP_t - (c + \pi^n)) \end{aligned} \tag{2.71}$$

Substituting 2.65 in 2.71 yields:

$$p_{t+1} - \bar{p}_t = (1 + \beta)\ \pi^n + M_t - M_{t-1} \tag{2.72}$$

Turning to the second part of the monetary authorities' loss function, the effect of monetary policy on output in period t runs through the real interest rate, r_t, and through the nominal exchange rate, S_t.

$$y_t = y_n - \lambda\ (r_t - r_n) + \theta\ (S_t - \bar{p}_t) \tag{2.73}$$

We will first consider the 'interest rate channel'. Recall 2.65:

$$i_t = -\frac{(M_t - M_{t-1})}{\beta} + c + RP_t \tag{2.74}$$

Equation 2.14 defined the risk premium:

$$RP_t = -\delta\,(r_t - r_n) + (1 + r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} + (1 + S_t - S^{fix})\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{2.75}$$

The term $S_t - S^{fix}$ is not exogenous as it is depending on the interest rate. Rewriting equation 2.4 yields:

$$S_t = -(i_t - RP_t - i^*) + S_{t+1} \tag{2.76}$$

Given $i^* = c$ and $S_{t+1} = p_{t+1}$, and substituting 2.65, 2.76 can be written as:

$$S_t = \frac{(M_t - M_{t-1})}{\beta} + p_{t+1} \tag{2.77}$$

Recall that $S^{fix} = \bar{p}_t$; substituting 2.72 for the level of inflation yields:

$$S_t - S^{fix} = \frac{(M_t - M_{t-1})}{\beta} + p_{t+1} - \bar{p}_t = \frac{(1+\beta)}{\beta}\,(M_t - M_{t-1} + \beta \cdot \pi^n) \tag{2.78}$$

Substituting 2.78 in 2.75 yields the following:

$$\begin{aligned} RP_t \quad = \quad & -\;\delta\,(r_t - r_n) \;+\; (1+r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} \\ & + \left(1 + \frac{(1+\beta)}{\beta}\,(M_t - M_{t-1} + \beta \cdot \pi^n)\right)\frac{\hat{d}_t^f}{\hat{\phi}_t}) \end{aligned} \tag{2.79}$$

Substituting this result into 2.74:

$$\begin{aligned} i_t \quad = \quad & -\frac{(M_t - M_{t-1})}{\beta} + c - \;\delta\,(r_t - r_n) \;+\; (1+r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} \\ & + \left(1 + \frac{(1+\beta)}{\beta}\,(M_t - M_{t-1} + \beta \cdot \pi^n)\right)\frac{\hat{d}_t^f}{\hat{\phi}_t}) \end{aligned} \tag{2.80}$$

Recall that, once period t monetary policy is known, the t+1 level of inflation and, consequently, the period t real interest rate is also known.

$$i_t = r_t + \dot{p}_{t+1} = r_t + (1+\beta)\,\pi^n + (M_t - M_{t-1}) \tag{2.81}$$

Combining 2.80 and 2.81 and rearranging:

$$r_t = \frac{(1+\delta)\cdot c + \frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} - \frac{(1+\beta)}{\beta}\,\frac{\left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\,(M_t - M_{t-1} + \beta \cdot \pi^n) \tag{2.82}$$

Turning to the exchange rate effect of monetary policy on output in period t, $S_t\ - p_t$ $(= S_t - S^{fix})$, recall equation 2.78:

$$S_t - p_t = \frac{(1+\beta)}{\beta}\left(M_t - M_{t-1} + \beta \cdot \pi^n\right) \tag{2.83}$$

Using 2.72, 2.82, and 2.83, we can now write the monetary authorities' loss function 2.70 in terms of the nominal money supply and solve for the optimal level.

$$\begin{aligned} L_t^{CB} &= \frac{\chi}{\eta}\left((1+\beta)\,\pi^n + M_t - M_{t-1}\right)^2 \\ &\quad + \left(-\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + A\left(M_t - M_{t-1} + \beta\cdot\pi^n\right) - k\right)^2 \\ \textit{where } A &= \frac{(1+\beta)}{\beta}\left(\frac{\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} + \theta\right) \end{aligned} \tag{2.84}$$

Minimization of the monetary authorities' loss function yields the optimal level of the money supply:

$$\begin{aligned} \frac{\partial L_t^{CB}}{\partial M_t} &= 2\frac{\chi}{\eta}\left((1+\beta)\,\pi^n + M_t - M_{t-1}\right) \\ &\quad +2\left(-\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + A\left(M_t - M_{t-1} + \beta\cdot\pi^n\right) - k\right)\cdot A \\ &= 0 \end{aligned} \tag{2.85}$$

$$\begin{aligned} \left(\frac{\chi}{\eta} + A^2\right)\left(M_t - M_{t-1}\right) &= -\frac{\chi}{\eta}\,(1+\beta)\,\pi^n - A^2\cdot\beta\cdot\pi^n \\ &\quad +A\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) \end{aligned} \tag{2.86}$$

$$M_t = M_{t-1} - \left(\beta + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{A}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) \tag{2.87}$$

Substituting the optimal money supply into 2.84 yields:

$$
\begin{aligned}
L_t^{CB} &= \frac{\chi}{\eta}\left(\left(\frac{A^2}{\frac{\chi}{\eta}+A^2}\right)\cdot\pi^n + \frac{A}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \\
&+\left(-\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n - \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2
\end{aligned}
\tag{2.88}
$$

Rearranging yields:

$$
\begin{aligned}
L_t^{CB} &= \frac{A^2}{\frac{\chi}{\eta}}\left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \\
&+\left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2
\end{aligned}
\tag{2.89}
$$

or shorter:

$$
L_t^{CB} = \left(\frac{A^2}{\frac{\chi}{\eta}}+1\right)\left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \tag{2.90}
$$

Finally, 2.90 can be further simplified to:

$$
L_t^{CB} = \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(A\cdot\pi^n + \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \tag{2.91}
$$

C Maintenance or Collapse?

The monetary authorities will abandon the fixed exchange rate regime if the costs of maintenance exceed the costs of abandonment. Recalling equation 2.18 and 2.19, this implies:

$$
\begin{aligned}
&\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)^2 \\
&> \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(A\cdot\pi^n + \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2
\end{aligned}
\tag{2.92}
$$

rewriting:

$$\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)$$

$$> \quad \sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\left(A\cdot\pi^n+\quad\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right) \tag{2.93}$$

rewriting:

$$\left(1-\sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)>\sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\cdot\;A\cdot\pi^n \tag{2.94}$$

$$\left(\sqrt{\frac{\frac{\chi}{\eta}+A^2}{\frac{\chi}{\eta}}}-1\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)>A\cdot\pi^n \tag{2.95}$$

$$\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)-\;\pi^n\;>0 \tag{2.96}$$

$$where\ A=\frac{(1+\beta)}{\beta}\left(\frac{\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}+\theta\right)$$

For simplicity, we will define the left-hand side of 2.96 as follows:

$$\Omega=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)-\;\pi^n \tag{2.97}$$

D Crisis determinants

Domestic debt level

The first-order derivative of Ω in terms of the domestic debt level is given by:

$$\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}=\frac{\partial\left(\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)-\;\pi^n\right)}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \tag{2.98}$$

Using the product rule, 2.98 can be rewritten as:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} &= f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)\cdot g\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) \\ &\quad + f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)\cdot g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) - \frac{\partial \pi^n}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \qquad (2.99) \\ \textit{where } f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right) \\ \textit{and } g\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)\end{aligned}$$

Since the inflationary bias is not depending on the debt levels, the last part of the right-hand side of 2.99 is equal to zero. Furthermore, $f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)$ and $g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)$ are given by:

$$\begin{aligned}f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \frac{\partial\, f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}{\partial A}\cdot\frac{\partial A}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \\ &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(\frac{(1+\beta)\;\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta\;\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right) \qquad (2.100)\end{aligned}$$

$$g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) = \frac{\lambda\left((1+\delta)\,(1+c)+\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \qquad (2.101)$$

Substituting 2.100 and 2.101 into 2.99 yields:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(\frac{(1+\beta)\;\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta\;\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right) \\ &\quad\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right) \\ &\quad+\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\frac{\lambda\left((1+\delta)\,(1+c)+\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \qquad (2.102)\end{aligned}$$

Given the specified ranges of possible values for the variables and coefficients, all right-hand side parts are strictly positive. As a result:

$$\frac{\partial\, \Omega}{\partial \left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} > 0 \tag{2.103}$$

Foreign debt level

The first-order derivative of Ω in terms of the foreign debt level is given by:

$$\frac{\partial\, \Omega}{\partial \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} = \frac{\partial \left(\left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A}\right)\left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) - \pi^n\right)}{\partial \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} \tag{2.104}$$

Using the product rule, 2.104 can be rewritten as:

$$\begin{aligned}
\frac{\partial\, \Omega}{\partial \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} &= F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)\cdot G\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) \\
&\quad + F\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)\cdot G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) - \frac{\partial \pi^n}{\partial \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} \qquad (2.105)\\
\text{where } F\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A}\right) \\
\text{and } G\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right)
\end{aligned}$$

Since the inflationary bias is not depending on the debt levels, the last part of the right-hand side of 2.105 is equal to zero. Furthermore, $F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)$ and $G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)$ are given by:

$$\begin{aligned}
F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \frac{\partial\, f\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\partial A}\cdot \frac{\partial A}{\partial \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} \\
&= \left(-\frac{1}{\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}}\cdot A^3} + \frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \qquad (2.106)
\end{aligned}$$

$$G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)=\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \tag{2.107}$$

Substituting 2.106 and 2.107 into 2.105 yields:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} = & \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \\ & \cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right) \\ & +\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\gtrless 0\end{aligned} \tag{2.108}$$

Other variables

Conservativeness and time preference

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\chi}{\eta}\right)} = & -\frac{1}{2\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}}\cdot\frac{1}{\left(\frac{\chi}{\eta}\right)^2}\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right) \\ & +(\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\frac{k}{\left(\frac{\chi}{\eta}\right)^2} \\ \gtrless & \ 0\end{aligned} \tag{2.109}$$

Wedge between targeted output and natural output

$$\frac{\partial\,\Omega}{\partial k}=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\lambda-\frac{(\lambda+\theta)}{\left(\frac{\chi}{\eta}\right)}\left(\frac{1+\beta}{\beta}\right)\gtrless 0 \tag{2.110}$$

The natural domestic real interest rate

$$\frac{\partial\,\Omega}{\partial c}=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\left(\lambda\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)>0 \tag{2.111}$$

The interest rate elasticity of investment

$$
\begin{aligned}
\frac{\partial\ \Omega}{\partial \delta} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} \cdot A^3} + \frac{1}{A^2} \right) \left(-\frac{(1+\beta)\,\lambda \left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta \left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \right) \\
&\quad \cdot \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) \ + \ k \right) \\
&\quad - \left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A} \right) \lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \right) \\
&< \ 0 \qquad (2.112)
\end{aligned}
$$

The real exchange rate elasticity of output

$$
\begin{aligned}
\frac{\partial\ \Omega}{\partial \theta} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} \cdot A^3} + \frac{1}{A^2} \right) \cdot \left(\frac{1+\beta}{\beta} \right) \\
&\quad \cdot \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) \ + \ k \right) \\
&\quad - \left(\frac{1+\beta}{\beta} \right) \frac{k}{\left(\frac{\chi}{\eta}\right)} \\
&\gtrless \ 0 \qquad (2.113)
\end{aligned}
$$

The domestic real interest rate elasticity of output

$$
\begin{aligned}
\frac{\partial\ \Omega}{\partial \lambda} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} \cdot A^3} + \frac{1}{A^2} \right) \frac{(1+\beta)}{\beta} \left(\frac{\left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) \\
&\quad \cdot \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) \ + \ k \right) \\
&\quad + \left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A} \right) \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \ + \ k \right) \\
&\quad - \left(\frac{1+\beta}{\beta} \right) \frac{k}{\left(\frac{\chi}{\eta}\right)} \\
&\gtrless \ 0 \qquad (2.114)
\end{aligned}
$$

The nominal interest rate elasticity of money demand

$$
\begin{aligned}
\frac{\partial\,\Omega}{\partial\beta} \;=\;& -\left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(\frac{\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}+\theta\right)\cdot\frac{1}{\beta^2} \\
&\cdot\left(\lambda\;\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\;+\;k\right)+\left((\lambda+\theta)\,\frac{k}{\left(\frac{\chi}{\eta}\right)}\right)\frac{1}{\beta^2} \\
\gtrless\;& 0
\end{aligned}
\tag{2.115}
$$

Chapter 3

Do High Interest Rates Defend Currencies During Speculative Attacks?

3.1 Introduction

During the last thirty years both developed and developing countries with fixed exchange rate regimes have suffered significantly from speculative attacks against their currencies. To prevent a speculative attack from developing into a currency crisis, academics and policymakers around the world have been investigating the appropriate policy responses to such an attack. In the context of this investigation, an important question is whether tightening monetary policy could help a country defend a fixed exchange rate.

The traditional view argues that an increase in interest rates could help a country defend its exchange rate since it could make it prohibitively expensive for speculators to take short positions in the currency under attack. This view, however, has recently come under scrutiny, especially in the aftermath of the Asian crises, as a revisionist view emerged. This view argues that in order to make it prohibitively expensive for investors to shorten the currency, interest rates must be raised to very high levels, unless a relatively small increase signals that the monetary authority is willing and able to defend its exchange rate. However, the signaling value of such increases is also under question. In particular, as Kraay (2003) puts it, "although signals must be costly in order to be credible, often they impose costs that are too high for the monetary authority to take in stride. Moreover, as the costs of high interest rates

[0]This chapter is coauthored by Vasso Ioannidou.

mount, the monetary authority's signal can become less credible over time, raising devaluation expectations", which lead to further increases in interest rates, and thus causing a spiral that ends with the devaluation of the currency.

There are many reasons for which higher interest rates can be costly.[1] For example, high interest rates lead to lower credit availability and thus lower investment and output. In addition, high interest rates increase the probability that borrowers will default on their debt, compromising the health of the banking system and the economy more generally. Finally, high interest rates deteriorate a country's fiscal position by increasing the cost of servicing its debt. Recently a small but growing theoretical literature has started to investigate the effects of these channels on the outcome of speculative attacks.[2]

The empirical literature, however, does not find a clear and systematic impact of monetary policy on the outcome of a speculative attack.[3] Some studies find that monetary tightening supports the exchange rate.[4] Others, instead, find that under certain conditions monetary tightening leads to a depreciation of the exchange rate.[5] Several others, however, fail to find any systematic impact of monetary policy on the exchange rate.[6] This evidence suggests that if there is an effect of monetary policy on the outcome of an attack, it is likely to depend on the country-specific circumstances. This possibility has received only limited attention in the empirical literature.[7] Kraay (2003), for example, tests whether the efficacy of monetary policy in defending a fixed exchange rate depends on several fundamentals, such as the recent occurrence of a banking crisis, the extent to which the exchange rate is overvalued, the level of international reserves, the country's external payments position, and the business cycle. However, none of these variables is found to affect the degree to which monetary policy affects the outcome of a speculative attack.

In light of the evidence from the literature on the credit-channel of monetary policy, we believe that short-term debt could be an important determinant of the efficacy of monetary policy in defending a currency. Everything else equal, the higher a country's short-term debt, the larger the adverse effect from increasing interest rates, and thus the less likely it is that

[1] For an extensive discussion on the costs of higher interest rates see, among others, Radelet and Sachs (1998) and Furman and Stiglitz (1998).

[2] See, among others, Bensaid and Jeanne (1997), Drazen (2000 and 2003), Drazen and Masson (1994), Flood and Jeanne (2005), and Lahiri and Vegh (2003a and 2003b).

[3] For a more extensive review of this literature, see Chapter 4.

[4] See, for example, Caporale et al. (2005) for non-crisis periods, Zettelmeyer (2004), Goldfajn and Gupta (2003), Dekle et al. (2002), Basurto and Ghosh (2001), and Tanner (2001).

[5] See, for example, Furman and Stiglitz (1998) for low-inflation countries and Caporale et al. (2005) for the Asian crises countries.

[6] Goldfajn and Baig (2002), Gould and Kamin (2001) and Kraay (2003).

[7] Kraay (2003), Goldfajn and Gupta (2003), Caporale et al. (2005), and Furman and Stiglitz (1998).

a given increase would defend an exchange rate. To test this hypothesis, we constructed a dataset for a cross-section of countries with fixed exchange rates during the period 1986-2002 for which data on short-term corporate debt are available. To approximate a country's short-term debt, we use data on short-term corporate debt, since data on short-term public debt are not publicly available. To some extent this is not a big caveat since the corporate sector is much more sensitive to short-term changes in interest rates than most governments. In general, it is more likely that a firm will be credit-rationed or go bankrupt than a government. Hence, the adverse effects emphasized by these theories are more relevant for corporations than for governments.

Our results confirm that the efficacy of monetary policy in defending a fixed exchange rate depends on the level of short-term debt. For levels of short-term debt that are not too high, raising interest rates lowers the probability of a successful speculative attack. This effect decreases and eventually changes sign for higher levels of debt. These results provide evidence that the opposite views on raising interest rates are not mutually exclusive. They also provide one possible explanation for some of the mixed findings in the empirical literature.

The empirical analysis in this chapter is very closely related to Kraay (2003). In particular, we use Kraay's methodology in order to identify whether and when a currency has come under a speculative attack. We also follow Kraay in order to construct indicators of the response of monetary policy to an attack. However, we also introduced some additional indicators, which we think could better capture the stance or the response of monetary policy and we compared them with those of Kraay. Specifically, we introduced an alternative timing, an alternative specification, and alternative underlining interest rates. The results highlight that these modifications are very important for the results and model's goodness of fit.

The remainder of this chapter is organized as follows. Section 3.2 uses a simple theoretical framework to present more formally the various channels through which changes in interest rates affect the exchange rate. Section 3.3 describes the empirical analysis. In particular, it describes in detail the methodology used in order to identify episodes of speculative attack, the data, and the variables constructed for the analysis. Section 3.4 describes and discusses extensively the results and section 3.5 concludes.

3.2 Theoretical Framework

The relationship between interest rates and exchange rates can be analyzed using the uncovered interest rate parity (UIP). In particular, in the absence of arbitrage opportunities, the following condition must hold

$$(1 + i_t) = \frac{E_t(e_{t+1})}{e_t} \cdot (1 + i_t^*), \tag{3.1}$$

where i_t is the domestic nominal interest rate in period t, $E_t(e_{t+1})$ is the expected nominal exchange rate in $t + 1$ at time t, e_t is the nominal exchange rate in period t, and i_t^* is the foreign nominal interest rate in period t. The exchange rate e_t is defined so that an increase in e_t implies depreciation of the domestic currency.

Using the UIP, it is straightforward to see the rational behind the traditional view. Assuming everything else constant, a higher domestic interest rate increases the expected return on domestic assets. This increases the demand for domestic currency, which immediately appreciates the nominal exchange rate. Correspondingly, equation (3.1) shows that everything else constant, a higher interest rate i_t leads to an appreciation of the exchange rate e_t. As emphasized by Furman and Stiglitz (1998), this only accounts for a *temporary* defense (i.e., assuming everything else constant, it lasts for as long as the interest rate is kept at its higher level). A temporary increase in i_t, however, could *permanently* strengthen the exchange rate if it has an effect on $E_t(e_{t+1})$. For example, higher interest rates could signal a credible commitment to the fixed exchange rate, provide time to implement reforms, or serve as a coordination device to establish the desired equilibrium in case of multiple equilibria and thus lead to a lower $E_t(e_{t+1})$.

As emphasized by critics of the traditional view, higher interest rates might actually cause the exchange rate to depreciate instead of appreciate (e.g., Furman and Stiglitz, 1998; Gould and Kamin, 2001; Goldfajn and Baig, 2002, etc.). Apart from the conventional negative effect of a monetary tightening on aggregate spending, raising interest rates leads to a higher probability of default since it increases the service costs of debt. Higher interest rates also lower the net worth of debtors which further increases their cost of borrowing, leading to even lower aggregate spending and higher default probabilities.[8] Higher interest rates also have a negative impact on the health of the banking system, which is naturally exposed to changes in the short-term interest rate, leading to decreases in credit availability and thus further decreases in investment and output. The adverse effects of higher interest rates are larger, the higher the short-term corporate debt in the economy.

To allow for an endogenous probability of default and an endogenous risk premium, the UIP can be augmented as follows

$$(1 - p_t)(1 + i_t) = \frac{E_t(e_{t+1})}{e_t} \cdot (1 + i_t^*) \cdot (1 + \rho_t) \tag{3.2}$$

[8] See for example, Bernanke and Gertler (1995), Bernanke et al. (2000) and Céspedes et al. (2004).

$$p_t = f(i_t), \quad f'(i_t) > 0$$
$$\rho_t = g(i_t), \quad g'(i_t) > 0,$$

where p_t is the probability of default in period t and ρ_t is the risk premium in period t. In the context of equation (3.2) it is easy to see that if p_t and ρ_t depend positively on i_t, an increase in i_t does not necessarily have to be followed by a decrease in e_t. In fact, if the increase in p_t and ρ_t is high enough, an increase in interest rates may actually lead to a depreciation of the domestic currency (i.e., an increase in e_t). As emphasized earlier, a given increase in interest rates will lead to a larger increase in p_t and ρ_t, the higher the level of short-term debt corporate debt. This brings us back to our central hypothesis. An interest rate defense of a fixed exchange rate has larger adverse effects and is therefore less effective in countries where the short-term corporate debt is high.

3.3 The Empirical Analysis

The probability of a successful speculative attack is analyzed using the following Probit model:

$$P(Y_{i,t} = 1) = F(\beta_0 + \beta_1 X_{i,t-k} + \beta_2 Z_{i,t-k} + \beta_3 X'_{i,t-k} Z_{i,t-k}) + \epsilon_{i,t}, \tag{3.3}$$

where $F(.)$ is assumed to be a standard normal distribution. $Y_{i,t}$ is equal to one if during month t there was a successful speculative attack in country i and is equal to zero if there was a failed speculative attack. $X_{i,t-k}$ is an indicator that captures changes in the stance of monetary policy in response to speculative pressures, where $k = 0, 1, ...n$. Matrix $Z_{i,t-k}$ includes episode-specific fundamentals that are expected to affect the outcome of a speculative attack (e.g., the level of international reserves, the growth rate of real GDP, short-term corporate debt, etc.). The interaction term between $X_{i,t-k}$ and $Z_{i,t-k}$ captures how the effect of monetary policy changes for different levels of fundamentals. This chapter's central hypothesis is tested using the interaction between monetary policy and short-term corporate debt. Next, we discuss how the key components of equation (3.3) have been constructed.

3.3.1 Identifying episodes of speculative attacks

The dependent variable $Y_{i,t}$ is constructed following the methodology developed by Kraay (2003). In particular, a *successful speculative attack* is defined as a situation where a large nominal depreciation was preceded by a relatively fixed nominal exchange rate.[9] Instead, a

[9]Following Kraay, we do not require the exchange rate to be perfectly fixed prior to the attack, in order to be able to identify episodes in which narrow target zones or tightly-managed crawling pegs were abandoned.

failed speculative attack is defined as a situation where there were downward spikes in reserves or upward spikes in the spread between the short-term interest rates in the home country and the short-term interest rate in the anchor country that occurred during periods of relatively fixed exchange rates and were not followed by a devaluation for at least three months.

More formally, a successful speculative attack is identified as:

$$(i,t)\,|de_{i,t} > \omega_i^e \text{ and } \overline{de}_{i,t} < \overline{\omega}_i^e, \tag{3.4}$$

where $de_{i,t}$ is the monthly percentage change in the exchange rate in country i during month t. ω_i^e is the threshold determining the minimum size of the devaluation, $\overline{de}_{i,t}$ is the average value of the absolute percentage changes in the exchange rate in the twelve months prior to month t, and $\overline{\omega}_i^e$ is a threshold determining the maximum size of the "allowable" exchange rate volatility prior to the devaluation. Following Kraay, ω_i^e is set equal to 5% for OECD countries and 10% for non-OECD countries, while $\overline{\omega}_i^e$ is set equal to 1% for OECD countries and 2.5% for non-OECD countries. Similarly, a failed speculative attack is identified as:

$$(i,t)|\begin{cases} \overline{de}_{i,t} < \overline{\omega}_i^e \text{ and } de_{i,t+j} < \overline{\omega}_i^e, \text{ where } j=0,1,2,3 \\ r_{i,t} = \min(r_{i,t-3,\ldots,}r_{i,t+3}) \text{ and } r_{i,t} < \omega_i^r \cdot \overline{r}_{i,t-3} \text{ or} \\ s_{i,t} = \max(s_{i,t-3,\ldots,}s_{i,t+3}) \text{ and } s_{i,t} > \omega_i^s \cdot \overline{s}_{i,t-3}\ , \end{cases} \tag{3.5}$$

where $r_{i,t}$ is the level of real non-gold reserves in country i at time t, $\overline{r}_{i,t-3}$ is the average level of reserves in the three months prior to period $t-3$, ω_i^r is a threshold between 0 and 1 determining the minimum decrease in reserves that is necessary to qualify as a spike. For example, if ω_i^r is set equal to 0.75, then for $r_{i,t}$ to qualify for a downward spike in reserves it must be that $r_{i,t}$ is at most 75% of $\overline{r}_{i,t-3}$. Hence, this threshold eliminates situations where the difference between $r_{i,t}$ and $\overline{r}_{i,t-3}$ is small. $s_{i,t}$ is the spread between the short-term interest rate in the home country and the anchor country. $\overline{s}_{i,t-3}$ is the average spread during the three months prior to period $t-3$, and ω_i^s is a threshold determining the minimum increase in the spread that is necessary to qualify as a spike. For example, if ω_i^s is set equal to 1.25 then it must be that $s_{i,t}$ is at least 25% higher than $\overline{s}_{i,t-3}$. Following Kraay, ω_i^r is set equal to 0.75 for OECD countries and 0.5 for non-OECD countries, while ω_i^s is set equal to 1.25 for OECD countries and 1.5 for non-OECD countries.

This procedure yields a primary list of episodes, which is then reduced by applying two additional restrictions following Kraay. First, all episodes that occurred within twelve months from another episode are eliminated in order to avoid possible double-counting. Second, if the value of $\overline{s}_{i,t-3}$ is very small, the identification procedure described above allows for small increases in the spread to qualify for potential episodes of speculative attacks. To eliminate such cases we require that the following condition also holds: $s_{i,t} \geqslant 5\%$ if $\overline{s}_{i,t-3} \leqslant 2\%$.

This identification procedure has been applied on a sample of countries for which data on short-term corporate debt and monetary policy (our key variables) were available. Table 1 reports the resulting list of episodes during the sample period 1986:1 to 2002:12. From 1986 to 1999—the common sample period with Kraay— our results are exactly the same.[10] For the remaining period up to 2002, the analysis identified ten more episodes, four of which were successful. In total we have 65 episodes of speculative attacks: 24 successful and 41 failed attacks.

3.3.2 Indicators of Monetary Policy

To examine whether raising interest rates (or more generally, tightening monetary policy) reduces the likelihood of a successful attack, we must construct an indicator that captures changes in the stance of monetary policy in response to speculative pressures. This involves two controversial steps: i) choosing a variable that captures best the stance of monetary policy, and ii) making assumptions about the timing of speculative pressures and the outcome of a speculative attack.

Unfortunately, there is no consensus in the literature as to which variable captures best the stance of monetary policy. Over the years, a number of indicators has been proposed, most of which are short-term interest rates (e.g., discount rates, interbank rates, etc.). Any given interest rate, however, is only a noisy signal of monetary policy (i.e., variations in short-term interest rates are not only due to changes in monetary policy, but also to any other factor that affects the market of that instrument). Hence, there is a great deal of disagreement as to which variable captures best the stance of monetary policy. Kraay, for example, argues that discount rates, compared to other interest rates, are less noisy since they are under the direct control of the monetary authorities. Hence, he uses the discount rate for every episode in his sample. Instead, Goldfajn and Gupta (2003) argue that "discount rates tend to remain flat and often do not reflect short run tight policies". As an example they mention the 500% increase in the Swedish interest rates in September 1992 which was not reflected at all in the discount rate.

Choosing the "best indicator" of monetary policy in a cross-country analysis is even more

[10] The episodes that we identified for the sub-period 1986 to 1999 were previously identified by Kraay and our timing and classification (i.e., successful or failed) is the same. Compared to Kraay our sample is much smaller: Kraay has 192 episodes, while we only have 65 episodes. The number of episodes in our sample is mainly constrained by data availability on short-term corporate debt; our key variable.

difficult since the most "appropriate" indicator is not necessarily the same across countries and/or time.[11] To deal with this problem, we collected information on the most appropriate indicator of monetary policy for each episode in our sample. This information was obtained from: i) the websites of the monetary authorities, ii) direct contact with the monetary authorities, and iii) other empirical studies. Table 2 reports the instrument that was identified as the best indicator of monetary policy for each episode in our sample as well as information on how each indicator was chosen. As can be seen in Table 2, all indicators are short-term interest rates. Most of them are interbank rates and only few of them are discount rates.

Next we will use the interest rates from Table 2 (our indicator) and the discount rates (Kraay's indicator) to create two alternative measures of how monetary policy responds to speculative pressures.[12] To do that we proceed as follows. First the nominal interest rates that capture the stance of monetary policy are deflated using the consumer price index.[13] The deflated series are then expressed as a spread over the anchor country's corresponding interest rates. These two steps take into account variations due to changes in the inflation rates and changes in the anchor country's interest rates. The resulting spreads are then used to calculate the response of monetary policy to speculative pressures by calculating changes in the spread from one month to another.

This last step involves some controversial assumptions about the timing of speculative pressures and the outcome of an attack. For example, Kraay takes the *change* in monetary policy in the month in which speculative pressures peak. For successful attacks, he assumes that speculative pressures peak in the month prior to the large devaluation and thus he calculates the change in the spread between $t-1$ and $t-2$. For failed attacks, he assumes that speculative pressures peak in month t and thus he takes the difference between t and $t-1$.

Hence, Kraay's indicator is calculated as follows:

$$X_{i,t-k} = \begin{cases} (s_{i,t-1} - s_{i,t-2}) & \text{if } Y_{i,t} = 1 \\ (s_{i,t} - s_{i,t-1}) & \text{if } Y_{i,t} = 0, \end{cases} \tag{3.6}$$

where t is the month of the attack, $s_{i,t}$ is the difference between the real interest rate that captures the stance of monetary policy in country i at time t and the corresponding interest rate of the anchor country. Applying equation (3.6) we got two alternative measures: one using the interest rate of Table 2, MP_1, and another using the discount rates, $DISC_1$.

For sensitivity, we also experiment with modified versions of equation (3.6). The first

[11] The instruments of the various central banks are not necessarily the same, hence, the most appropriate indicators of monetary policy can also differ.

[12] The discount rates are obtained from the International Financial Statistics (IFS) database, line 60.

[13] The consumer price index is obtained from the IFS database, line 64.

modification uses an *alternative timing* and the second one uses the *percentage change* in the spread instead of the change. Both of them are discussed in turn below. When there is a successful attack at time t, speculative pressures probably peak sometime between t and $t-1$. Given the monthly frequency of the data and the fact that it takes some time before changes in monetary policy affect the exchange rate, it is not unreasonable to use the change in the spread between $t-1$ and $t-2$. Moreover, using the difference between t and $t-1$ would have been more problematic since the spread at t might already reflect the response of monetary policy after the devaluation. For failed attacks, Kraay assumes that pressures peak in month t and thus takes the difference between t and $t-1$. It should be pointed out that this is not really an assumption since it follows from his definition of a failed attack (see equation 3.5). For sensitivity, however, it would be useful to also experiment with the difference between $t-1$ and $t-2$. If one believes that it takes some time before monetary policy has an impact on the exchange rate, then monetary authorities would be most effective if they act before speculation reaches its peak (i.e., when the procedure identifies a speculative attack). Hence, we create two more measures, MP_2 and $DISC_2$, using:

$$X_{i,t-k} = s_{i,t-1} - s_{i,t-2.} \tag{3.7}$$

Finally, the *percentage change* in the spread, instead of the *change*, might be a more appropriate measure if one wants to capture the extent to which monetary policy tightens. For example, an increase of the interest rate from 1% to 11% is not equivalent to an increase from 10% to 20%. Hence, using the following equations:

$$X_{i,t-k} = \begin{cases} (s_{i,t-1} - s_{i,t-2})/s_{i,t-2} & \text{if } Y_{i,t} = 1 \\ (s_{i,t} - s_{i,t-1})/s_{i,t-1} & \text{if } Y_{i,t} = 0 \end{cases} \tag{3.8}$$

and

$$X_{i,t-k} = (s_{i,t-1} - s_{i,t-2})/s_{i,t-1} \tag{3.9}$$

we create four more measures: $\widetilde{MP}_1$, $\widetilde{DISC}_1$, $\widetilde{MP}_2$, and $\widetilde{DISC}_2$.[14] When these measures are used, the initial level of the spread is also included as a control variable.

The first panel of Table 3 reports correlations between the various indicators of monetary policy that we just introduced. If we only change the underlying interest rate that is used to calculate the spread, the correlations between the resulting measures are quite high (e.g., see correlations between MP_1 and $DISC_1$, MP_2 and $DISC_2$, etc.) Instead, if we only change the timing over which we calculate the change in the spread, the correlations between the measures

[14] The notation is similar to the one introduced above (i.e., index 1 refers to the timing introduced by Kraay and index 2 refers to our alternative timing). The symbol ~ is used to denote percentage changes.

are significantly lower than those where the only difference is the underlying interest rate (see MP_1 and MP_2, $DISC_1$ and $DISC_2$). Using the percentage change as opposed to the change in the spread, results in even lower correlations (see MP_1 and $\widetilde{MP}_1$, $DISC_1$ and $\widetilde{DISC}_1$). Hence, combining a different timing and the percentage change in the spread as opposed to the change, results in very low correlations (see MP_1 and $\widetilde{MP}_2$, $DISC_1$ and $\widetilde{DISC}_2$, etc.).

The second panel of Table 3 provides summary statistics for each measure. Comparing the first four measures, it seems that monetary policy is more responsive when the spread is calculated using our indicator instead of the discount rate. The average change in the spread and the standard deviation are much larger for MP_1 and MP_2 than for $DISC_1$ and $DISC_2$. This feature is consistent with Goldfajn and Gupta's argument. However, when the percentage change in the spread is used (as opposed to the change) the indicators constructed using the discount rate seem more responsive. This suggests that the initial spreads are smaller when the spreads are calculated using the discount rates as opposed to our interest rates. Finally, it seems that our alternative timing captures more variation in monetary policy than the timing used by Kraay. In particular, the means and the standard deviations of indicators calculated using Kraay's timing are always smaller than those calculated using our timing (e.g., $\widetilde{MP}_1$ vs. $\widetilde{MP}_2$, $\widetilde{DISC}_1$ vs. $\widetilde{DISC}_2$, etc.).

The third panel of Table 3 provides a simple classification between the response of monetary policy and the outcome of an attack. For each outcome, we report the number of attacks and the fraction of which monetary policy tightened. Regardless of which measure is used, the results suggest that monetary policy tightens equally often during successful and failed attacks. This is in line with Kraay's findings on a much larger sample, suggesting that our subsample is similar to Kraay's with respect to the outcome of an attack and the response of monetary policy.

3.3.3 Episode-Specific Fundamentals

To estimate equation (3.3) we include a number of episode-specific characteristics that are expected to have a (direct and indirect) effect on the outcome of a speculative attack. These variables—with the exception of short term corporate debt— are taken from previous studies.

Four indicators are taken from Kraay. In particular, to capture the extent to which a currency is overvalued we include the average growth rate of a country's real exchange rate (with respect to the U.S. dollar) in the twelve months before the attack (i.e., from $t-1$ to $t-12$).[15] Regardless of the response of monetary policy, it is more likely that an attack

[15] The exchange rates series are obtained from IFS line rf; the real exchange rate is defined so that an increase

will be successful if a currency is overvalued ($\widehat{\beta}_2 < 0$). At the same time, a given monetary policy response will be less effective if a currency is overvalued ($\widehat{\beta}_3 < 0$). The ratio of non-gold reserves to total imports is also included in order to capture the ability of the monetary authorities to defend the exchange rate.[16] The higher this ratio, the lower the probability that an attack will be successful ($\widehat{\beta}_2 < 0$) and the higher the probability that monetary policy will be effective ($\widehat{\beta}_3 < 0$). As an indicator of a country's external payments position, we include the average loans from the International Monetary Fund in the twelve months before the attack, expressed as a percentage of that country's quota.[17] A high foreign indebtedness limits a country's ability to obtain additional funds. Hence, the higher this ratio, the higher the probability that an attack will be successful ($\widehat{\beta}_2 > 0$) and the lower the effectiveness of a given monetary policy ($\widehat{\beta}_3 > 0$). Finally, to capture the state of the domestic economy, we include deviations of the growth rate of real per capita GDP one year before the attack from its average in the previous five years.[18] The higher this variable, the lower the probability that an attack will be successful ($\widehat{\beta}_2 < 0$), since the economy is stronger. In addition, the higher this ratio, the higher the effectiveness of a given monetary policy ($\widehat{\beta}_3 < 0$), since the economy is better able to withstand any adverse effects from higher interest rates.

Apart from Kraay's variables, we also included two variables that were previously found to have a statistically significant effect in at least two studies: the current account balance as percentage of GDP and the growth rate of exports.[19] Both variables are dated one year before the attack. The higher these ratios, the lower the probability that an attack will be successful ($\widehat{\beta}_2 < 0$) and the higher the effectiveness of monetary policy ($\widehat{\beta}_3 < 0$). In particular, a current account deficit is often financed by net capital inflows. When external financing is no longer available, the current account deficit must be reversed, increasing the probability of a devaluation. Instead, the higher the growth rate of exports, the higher a country's competitiveness in the international goods markets and thus the higher its ability to defend a given exchange rate.

To capture the degree to which a country's corporate sector is leveraged we use the "representative" firm's ratio of short-term debt to total assets. Data on short-term debt and total assets were obtained from the Thomson Financial's Worldscope database. This database contains information for a large number of publicly listed companies in developed and emerging

refers to a real depreciation.

[16] The non-gold reserves series are taken from IFS line 11.d, while total imports are taken from IFS line 71.d.

[17] The IMF loans as percentage of a country's quota are obtained from IFS lines 2tl and 2f.s.

[18] Data for real per capita GDP are taken from the World Bank's World Development Indicators.

[19] Our selection was based on an article by Lestano et al. (2003). The reviewed studies for currency crises are: Kaminsky et al. (1998), Berg and Patillo (1999), Kamin et al. (2001), and Edison (2003). Finally, the data for both variables are obtained from the World Development Indicators.

markets. The information is provided at the level of the individual companies. The frequency of the data is annual. Using this information we constructed a measure of the degree to which a country's corporate sector is leveraged by taking the average of the individual short-term debt to total assets ratios one year before the attack. The higher this ratio, the higher the probability that an attack will be successful ($\widehat{\beta}_2 > 0$) and the lower the effectiveness of monetary policy ($\widehat{\beta}_3 > 0$).

In Table 4 we compare the average values of our fundamentals for successful and failed attacks. Whereas some indicators are remarkably similar—exchange rate growth, reserves to total imports, growth rate of exports, and debt to total assets— others show large differences that are consistent with prior expectations. In particular, the ratio of IMF loans to quota is much higher for successful attacks than for failed attacks. This is consistent with the hypothesis that the higher this ratio the more difficult it is for a country to obtain additional funding and thus the more vulnerable it is to a speculative attack. Deviations from GDP trend are on average positive and larger for failed attacks, consistent with the hypothesis that the better the state of the economy the easier it is for a country to defend its exchange rate. Current account balances are on average positive for failed attacks and negative for successful attacks, which is consistent with the hypothesis that current account deficits increase the probability of a successful attack. Finally, the initial level of the spread is higher for successful attacks than for failed attacks, suggesting that countries with relatively high initial interest rates are more vulnerable.

3.4 Estimation Results

Table 5 provides estimation results from a benchmark specification of equation 3.3 with no interaction terms. The eight columns of Table 5 correspond to our alternative indicators of monetary policy, where $DISC_1$ is Kraay's indicator and $\widetilde{MP}_2$ is our preferred indicator. For each regressors we report the estimated coefficient from a Probit model, the standard error of the estimated coefficient, and the change in the probability of a successful attack if the corresponding regressor increases by one standard deviation from its sample mean (i.e., the marginal effect of each coefficient). At the bottom of each column we also report the probability of a successful attack if all regressors are set at their sample mean, P_0, so that the marginal effects can also be expressed in percentage terms.

As can be seen in Table 5 we fail to find any statistically significant effect of monetary policy on the outcome of a speculative attack. None of the eight indicators of monetary policy yields a statistically significant coefficient. This result is consistent with Kraay's findings in similar specifications (see Table 3 in Kraay). Overall, these findings suggest that our sub-sample has similar properties with Kraay's sample and that Kraay's benchmark results are robust to our alternative indicators of monetary policy. Finally, although most control variables enter with the expected sign, they are not statistically significant. The only exception is the ratio of IMF loans to quota. This indicator is statistically significant in seven out of eight specifications and enters with a positive sign, suggesting that difficulties to obtain extra funding increase the probability of a successful attack. This effect is not only statistically significant, but also economically relevant. Depending on the specification, an increase in this ratio by one standard deviation (i.e., by 5 percent) leads to an increase in the probability of a successful attack by 41 to 83 percent, with the average being 62 percent across specifications with a statistically significant marginal effect.[20]

Although most control variables enter with the expected sign, they are not statistically significant so they should be viewed with caution. In particular, the level of short-term debt to total assets enters with a positive sign in seven out of eight specifications, indicating that everything else equal a higher aggregate level of short-term debt to total assets increases the probability of a successful attack. Deviations from GDP trend enter always with a negative sign, indicating that during periods of economic slowdown or recessions the probability that an attack will be successful is higher. The current account balance enters with a negative sign in six out of the eight specifications, which implies that, everything else equal, a higher current account deficit increases the probability of a successful attack. In some specifications, the marginal effect of this regressor is statistically significant at 10 percent, even though the estimated coefficients from the Probit model are insignificant.[21] These are cases in which the p-values of the estimated coefficients are slightly above the 10 percent cut-off point. The signs of the coefficients for the initial level of the spread and reserves to total imports are mixed, whereas the real exchange rate growth and the growth rate of exports do not have the expected sign in most specifications.

The bottom portion of Table 5 contains information regarding the model's goodness of fit. We report the Pseudo R-square and information regarding the model's ability to distinguish a successful and a failed attack. As expected from the results above, the model's goodness

[20] These numbers are calculated using the probability of a successful attack evaluated at the mean of all regressors, P_0, reported at the bottom of each column.

[21] The standard errors of the marginal effects are calculated using the Delta method. Hence, the statistical significance of the estimated coefficient from the Probit model can be different from the statistical significance of the marginal effect. This is due to the nonlinear nature of the Probit model.

of fit is rather poor. The pseudo R-square is quite low and the model has a high probability of predicting a failed attack, even when an attack was successful (i.e., on average, 44 percent of successful attacks is wrongly classified as a failed attack). Given that most independent variables are not statistically significant, the model is biased towards predicting a failed attack.

To investigate whether the effect of monetary policy depends on the level of short-term debt, in Table 6 we allow for an interaction term between the indicators of monetary policy and short-term debt. Overall, the results confirm our prior expectations. We find that an increase in interest rates leads to a decrease in the probability of a successful attack, but the extent to which this is true depends on the level of short-term debt. The higher the level of short-term debt, the lower the probability that a given increase in interest rates will defend the currency under attack.

It should be emphasized that this result depends crucially on the way we measure the response of monetary policy. The relevant coefficients are statistically significant only when $\widetilde{DISC}_2$ and $\widetilde{MP}_2$ are used. This suggests that using the percentage change as opposed to the change in the spread and our timing as opposed to Kraay's timing is very important. Using our country-specific interest rates as opposed to the discount rate is also important, since it increases the statistical significance of the coefficients of interest from 5 percent to 1 percent and it improves significantly the model's goodness of fit. Although the Pseudo R-square is already much higher for $\widetilde{DISC}_2$, the model's ability to distinguish between a successful and a failed attack increases significantly when $\widetilde{MP}_2$ is used (i.e., both type I and type II errors are relatively small when $\widetilde{MP}_2$ is used).

Summarizing, the results in Table 6 show that if we allow for the possibility that it takes some time for monetary policy to have an effect and if we use the percentage change in the spread as a monetary policy indicator, we find strong evidence of a non-linear effect of monetary policy on the outcome of a speculative attack. In countries with relatively low levels of short-term debt, raising interest rates is an effective tool to defend a fixed exchange rate against speculative attacks, which supports the traditional view. For higher levels of debt, raising interest rates becomes less effective due to the reverse effects of higher interest rates. For sufficiently high debt levels, the reverse effects of higher interest rates start to dominate and raising interest rates will only increase the probability that a speculative attack ends up in a collapse of the fixed exchange rate. This supports the revisionist view that tighter monetary policy is counterproductive in defending a peg.

Figure 1 depicts graphically the non-linear effect of monetary policy on the outcome of a speculative attack using our preferred indicator. In particular, Figure 1 shows the percentage change in the probability of a successful attack if $\widetilde{MP}_2$ increases by one standard deviation, for different levels of short-term debt; all other indicators are evaluated are their sample mean. For levels of short-term debt that are equal to or less than 13 percent, a monetary policy tightening decreases the probability of a successful attack. Instead, for levels of short term debt that are equal to or higher than 16 percent, a monetary policy tightening increases the probability that an attack will succeed. For levels of debt that are in between these numbers, the two channels of monetary policy cancel each other and thus lead to a statistically insignificant effect.

3.5 Conclusions

This chapter examined whether the efficacy of monetary policy to defend a fixed exchange rate during speculative attacks depends on the level of a country's short-term corporate debt. The central hypothesis is that an interest rate defense of a fixed exchange rate has larger adverse effects and is therefore less effective in countries where the corporate sector is more short-term indebted.

This chapter improves upon previous studies in at least two ways. First, we construct an aggregate indicator of short-term debt to measure the corporate sector's exposure to higher interest rates. Second, we consider alternative measures of monetary policy by varying the timing, specification, and underlying interest rate.

The estimation results confirm that the efficacy of monetary policy in defending a fixed exchange rate depends on the level of short-term corporate debt. For levels of short-term debt that are not too high, raising interest rates lowers the probability of a successful speculative attack. This effect decreases and eventually changes sign for higher levels of debt. These results provide evidence that the opposite views on raising interest rates are not mutually exclusive. They also provide a possible explanation for some of the mixed findings in the empirical literature.

Our results have important policy implications. Tightening monetary policy can only be used as a tool for crisis prevention in countries that have relatively low corporate debt levels. If debt is high, monetary policy will be ineffective and could even increase the probability of an attack ending up in a currency crisis. From a more long-term perspective, our results suggest that strengthening the balance sheet position of the corporate sector, i.e. limiting exposure to interest-rate changes, could be an important means of reducing vulnerability to speculative attacks that end up in costly currency crises.

Table 1: Successful and failed speculative attacks during the period 1986:12-2002:12

Country	Successful Attacks	Failed Attacks	
		Reserves	Spreads
Argentina	2002:1		1992:12, 1995:3, 2001:3
Brazil	1999:1		1997:11
Canada			1990:5
Colombia			1995:12
Denmark	1993:8	1998:8	1987:2, 1989:11, 1993:2
Finland	1991:11	1991:5, 1996:6, 1998:3	1990:11
France		1993:11	
Hong Kong			1991:12, 1998:8
Indonesia	1986:9, 1997:8		1988:5, 1991:3
Ireland	1986:8, 1993:2	1986:1, 1989:6	
Korea	1997:11, 2000:12		1989:11, 1996:8
Mexico	1994:12, 1998:9		1994:5
Norway	1986:5	1992:12	
Philippines	1997:9	1986:2	2000:11
Portugal			1990:10
Russia	1998:9		1996:3, 2001:2
Slovakia	1998:10		
South Africa	1998:7, 2001:12		2001:5
Spain	1995:3		1987:5
Sweden	1992:12	1991:11, 1998:2	1988:5, 1990:2
Thailand	1997:7		1990:9, 1992:9, 1994:6
United Kingdom	1992:9		
Venezuela	1995:12, 2002:2		2000:5, 2001:9

Notes: Slovakia 1993:7 was also identified as a successful attack. However, this episode is excluded since it is due to the separation of Czechoslovakia into the Czech and Slovak Republic.

Table 2: Monetary Policy Interest Rates

Country	Monetary Policy Interest Rate	Identification	Source of Data
Argentina	Interbank 7 day-middle rate	Other	Datastream
Brazil	Financing overnight-middle rate	Other Studies*	Datastream
Canada	Bank rate as at Wed-middle rate	Central Bank-W	Datastream
Colombia	Interbank overnight-middle rate	Other	Datastream
Denmark	Discount-middle rate	Central Bank-W	Datastream
Finland	Key tender-middle rate	Central Bank-W	Datastream
France	Intervention rate-middle rate	Central Bank-W	Datastream
Hong Kong	Interbank call-offered rate	Central Bank-C	Datastream
Indonesia	SBI 90 day-middle rate	Central Bank-W	Datastream
Ireland	Discount rate	Central Bank-W	Datastream
Korea	Call overnight- middle rate	Central Bank-W	Datastream
Mexico, 1994:5	Cetes 28 day min. auction-middle rate	Central Bank-W	Datastream
Mexico, 1994:12	Cetes 28 day min. auction-middle rate	Central Bank-W	Datastream
Mexico, 1998:9	Cetes 28 day avg. auction-middle rate	Central Bank-W	Datastream
Norway, 1986:5	Daily interbank nominal-middle rate	Central Bank-W	Datastream
Norway, 1992:12	Sight deposit nominal-middle rate	Central Bank-W	Datastream
Philippines	Interbank call loan rate-middle rate	Other Studies**	Datastream
Portugal	Central bank reference rate	Central Bank-W	Datastream
Russia	Discount (refinancing)-middle rate	Central Bank-W	Datastream
Slovakia	Basic NBS interest rate	Central Bank-W	Central Bank
South Africa	Prime overdraft-middle rate	Central Bank-W	Datastream
Spain	Intervention-middle rate	Central Bank-W	Datastream
Sweden	Repo-middle rate	Central Bank-W	Datastream
Thailand	Repo 14 day-middle rate	Central Bank-W	Datastream
United Kingdom	Base rate	Central Bank-W	Central Bank
Venezuela	Discount Rate	Central Bank-W	IFS

Notes: Central Bank-W = Central Bank Website; Central Bank-C = Central Bank Contact by Email.
* From Furman and Stiglitz (1998); ** from Caporale et al. (2005).

Table 3: Indicators of Monetary Policy

Panel 1: Correlations

	MP_1	$DISC_1$	MP_2	$DISC_2$	$\widetilde{MP}_1$	$\widetilde{DISC}_1$	$\widetilde{MP}_2$	$\widetilde{DISC}_2$
MP_1	1.00							
$DISC_1$	0.97	1.00						
MP_2	0.67	0.54	1.00					
$DISC_2$	0.60	0.48	0.98	1.00				
$\widetilde{MP}_1$	0.41	0.42	0.17	0.14	1.00			
$\widetilde{DISC}_1$	0.41	0.44	0.11	0.07	0.77	1.00		
$\widetilde{MP}_2$	0.09	0.01	0.50	0.53	0.41	0.01	1.00	
$\widetilde{DISC}_2$	0.04	-0.01	0.30	0.34	0.05	-0.02	0.72	1.00

Panel 2: Summary Statistics

	mean	st. dev.	min	max
MP_1	0.07	0.56	-0.70	3.61
$DISC_1$	-0.01	0.13	-0.55	0.28
MP_2	0.08	0.57	-0.70	3.61
$DISC_2$	0.01	0.14	-0.55	0.31
$\widetilde{MP}_1$	0.38	1.91	-1.90	9.96
$\widetilde{DISC}_1$	1.45	5.22	-3.10	27.61
$\widetilde{MP}_2$	1.06	3.04	-4.65	12.08
$\widetilde{DISC}_2$	2.20	6.46	-6.80	27.61

Panel 3: Monetary policy and the outcome of a speculative attack

	Successful		Failed	
	Number	Tightening	Number	Tightening
MP_1	19	0.53	25	0.56
$DISC_1$	17	0.53	29	0.45
MP_2	19	0.53	25	0.64
$DISC_2$	17	0.53	29	0.66
$\widetilde{MP}_1$	19	0.53	25	0.57
$\widetilde{DISC}_1$	17	0.53	29	0.45
$\widetilde{MP}_2$	19	0.53	25	0.64
$\widetilde{DISC}_2$	17	0.53	29	0.66

Table 4: Summary Statistics for the Episode-Specific Fundamentals

Variables	Successful Attacks		Failed Attacks		All Attacks	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Exchange rate growth	0.00	0.01	0.00	0.01	0.00	0.01
Reserves to imports	4.64	3.26	4.71	2.69	4.68	2.89
IMF loans to quota	0.81	1.29	0.32	0.64	0.51	0.96
Business Cycle	0.00	0.04	0.01	0.04	0.01	0.04
Current Account to GDP	-0.00	0.04	0.00	0.05	-0.01	0.05
Growth rate of exports	0.06	0.07	0.06	0.07	0.06	0.07
Debt to total assets	0.13	0.05	0.12	0.04	0.13	0.05
Level of MP at $t-2$	0.15	0.27	0.04	0.08	0.09	0.19
Level of MP at $t-1$	0.28	1.06	0.08	0.09	0.16	0.69
Level of $DISC$ at $t-2$	0.08	0.17	0.04	0.08	0.05	0.12
Level of $DISC$ at $t-1$	0.05	0.14	0.07	0.12	0.06	0.13

Table 5: Benchmark Regressions

	Kraay's timing				Alternative timing			
	change		% change		change		% change	
	$DISC_1$	MP_1	$\widetilde{DISC}_1$	$\widetilde{MP}_1$	$DISC_2$	MP_2	$\widetilde{DISC}_2$	$\widetilde{MP}_2$
Monetary policy	0.27	0.04	0.06	0.06	0.36	0.07	0.04	-0.02
	(1.82)	(0.44)	(0.04)	(0.13)	(1.59)	(0.38)	(0.03)	(0.09)
	0.01	0.01	0.11	0.05	0.02	0.01	0.09	-0.02
Initial level of spread			-0.35	1.41			-0.29	3.12
			(1.69)	(1.50)			(2.48)	(2.10)
			-0.02	0.11			-0.01	0.23
Debt to total assets	0.53	3.94	-0.04	3.80	0.60	2.77	0.96	3.90
	(5.03)	(4.83)	(5.03)	(5.48)	(4.89)	(4.82)	(5.09)	(5.08)
	0.01	0.08	-0.01	0.08	0.01	0.06	0.02	0.08
Exchange rate growth	30.9	23.53	31.36	15.26	31.56	11.41	32.66	-8.92
	(32.65)	(33.01)	(34.83)	(35.77)	(32.94)	(30.96)	(37.09)	(33.69)
	0.09	0.07	0.09	0.05	0.09	0.03	0.10	-0.03
Reserves to imports	0.04	-0.10	0.05	-0.12	0.04	-0.08	0.06	-0.11
	(0.10)	(0.09)	(0.10)	(0.08)	(0.10)	(0.08)	(0.10)	(0.08)
	0.03	-0.12	0.04	-0.14	0.03	-0.09	0.04	-0.13
IMF loans to quota	1.09**	0.52*	1.08**	0.44*	1.12**	0.43*	0.18**	0.32
	(0.46)	(0.27)	(0.45)	(0.26)	(0.54)	(0.24)	(0.54)	(0.24)
	0.27**	0.21**	0.26**	0.18*	0.27**	0.17*	0.29**	0.13
Business Cycle	-7.43	-4.89	-5.05	-5.94	-7.91	-3.30	-7.62	-2.35
	(8.60)	(6.38)	(8.52)	(5.89)	(8.61)	(5.77)	(8.13)	(6.87)
	-0.09	-0.08	-0.06	-0.10	-0.10	-0.05	-0.09	-0.04
Current Account to GDP	-8.06	0.34	-7.56	1.40	-8.12	-3.31	-8.10	-2.01
	(5.09)	(4.63)	(4.88)	(4.85)	(5.05)	(4.44)	(5.10)	(4.40)
	-0.14*	0.01	-0.13*	0.03	-.014*	-0.07	-0.14*	-0.04
Growth rate of exports	0.62	-1.26	0.81	0.10	0.74	-0.75	1.19	0.07
	(3.16)	(3.19)	(3.38)	(3.61)	(3.14)	(3.12)	(3.17)	(3.89)
	0.02	-0.04	0.02	0.00	0.02	-0.02	0.03	0.00
Goodness of fit								
Pseudo R-Square	0.16	0.11	0.18	0.12	0.16	0.10	0.17	0.15
Predicted=1, Actual=1	52.9	47.4	47.1	47.4	52.9	47.4	52.9	52.6
Predicted=1, Actual=0	10.4	13.0	6.9	21.7	10.4	12.0	10.4	20.0
Predicted=0, Actual=0	89.7	87.0	93.1	78.3	89.7	88.0	89.7	80.0
Predicted=0, Actual=1	47.1	52.6	52.9	52.6	47.1	52.6	47.1	47.4
Observations	46	42	46	42	46	44	46	44
P_0	0.35	0.45	0.36	0.46	0.35	0.43	0.36	0.44

Notes: for each regressor we report the estimated coefficient from the probit model, the robust standard error of the estimated coefficient, and the change in probability of a successful attack if a regressor increases by 1-standard deviation from its sample mean. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
P_0 is the probability of a successful attack if all regressors are evaluated at their sample mean. To determine whether the model predicts a successful attack (i.e., predicted=1) we use 0.5 as a cut off point.

Table 6: Benchmark Regressions plus interaction of monetary policy and debt

	Kraay's timing				Alternative timing			
	change		% change		change		% change	
	$DISC_1$	MP_1	$\widetilde{DISC}_1$	$\widetilde{MP}_1$	$DISC_2$	MP_2	$\widetilde{DISC}_2$	$\widetilde{MP}_2$
Monetary policy	2.24	-1.84	0.12	-0.39	-3.48	-12.38	-0.58*	-2.19***
	(4.35)	(2.63)	(0.19)	(0.55)	(5.33)	(9.99)	(0.31)	(0.61)
	0.11	-0.33	0.24	-0.26	-0.16	-0.48***	-0.35***	-0.33***
Debt to total assets	0.83	3.67	0.46	2.73	-0.32	-0.20	-4.25	-9.63
	(5.01)	(4.81)	(5.43)	(5.52)	(4.72)	(4.99)	(6.82)	(6.61)
	0.02	0.07	0.01	0.06	-0.01	-0.00	-0.07	-0.15*
Monetary policy*debt	-18.89	13.88	-0.47	2.42	35.40	90.65	5.70**	15.15***
	(37.37)	(18.52)	(1.58)	(2.65)	(44.52)	(70.99)	(2.89)	(4.30)
	-0.08	0.38	-0.11	0.32	0.20	0.52***	0.66***	0.67***
Exchange rate growth	30.21	22.80	31.11	19.16	34.64	11.25	28.68	-7.26
	(32.90)	(32.47)	(35.07)	(34.18)	(32.32)	(27.49)	(34.46)	(30.93)
	0.09	0.07	0.09	0.06	0.10	0.03	0.08	-0.02
Reserves to imports	0.03	-0.09	0.05	-0.08	0.07	-0.03	0.05	0.01
	(0.10)	(0.09)	(0.10)	(0.09)	(0.10)	(0.08)	(0.11)	(0.10)
	0.02	-0.11	0.04	-0.10	0.06	-0.04	0.04	0.01
IMF loans to quota	1.18**	0.46*	1.10**	0.47*	0.99*	0.20	0.89**	0.05
	(0.55)	(0.28)	(0.45)	(0.27)	(0.52)	(0.25)	(0.46)	(0.25)
	0.29**	0.19*	0.27**	0.19*	0.24*	0.08	0.22*	0.02
Business Cycle	-6.81	-5.02	-4.89	-5.76	-8.86	0.91	-9.64	2.24
	(8.78)	(6.35)	(8.60)	(5.74)	(8.58)	(6.26)	(7.88)	(8.34)
	-0.08	-0.08	-0.06	-0.09	0.11	0.01	-0.11	0.03
Current Account to GDP	-8.68	0.29	-7.94	1.21	-8.10*	-5.24	-5.00	-6.59
	(5.29)	(4.67)	(4.91)	(4.78)	(4.91)	(4.47)	(4.82)	(5.49)
	-0.15**	0.01	-0.14*	0.02	-0.14*	-0.11	-0.09	-0.12
Growth rate of exports	0.27	-0.84	0.68	0.53	1.95	1.10	6.57	9.73*
	(3.38)	(3.34)	(3.49)	(3.62)	(3.65)	(3.41)	(4.21)	(5.26)
	0.01	-0.02	0.02	0.02	0.05	0.03	0.19	0.27*
Initial level of spread			-0.42	1.27			1.83	4.18
			(1.70)	(1.46)			(2.68)	(3.30)
			0.02	0.10			0.08	0.31
Goodness of Fit								
Pseudo R-square	0.16	0.12	0.18	0.14	0.17	0.16	0.29	0.37
Predicted=1, Actual=1	41.2	47.4	47.1	52.6	47.1	52.6	58.8	73.7
Predicted=1, Actual=0	10.3	13.0	6.9	8.7	10.4	8.0	6.9	20.0
Predicted=0, Actual=0	89.7	87.0	93.1	91.3	89.7	92.0	93.1	80.0
Predicted=0, Actual=1	58.8	52.6	52.9	47.4	52.9	47.4	41.2	26.3
Observations	46	42	46	42	46	44	46	44
P_0	0.35	0.46	0.36	0.46	0.36	0.48	0.35	0.34

Notes: for each regressor we report the estimated coefficient from the probit model, the robust standard error of the estimated coefficient, and the change in probability of a successful attack if a regressor increases by 1-standard deviation from its sample mean. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. P_0 is the probability of a successful attack if all regressors are evaluated at their sample mean. To determine whether the model predicts a successful attack (i.e., predicted=1) we use 0.5 as a cut off point.

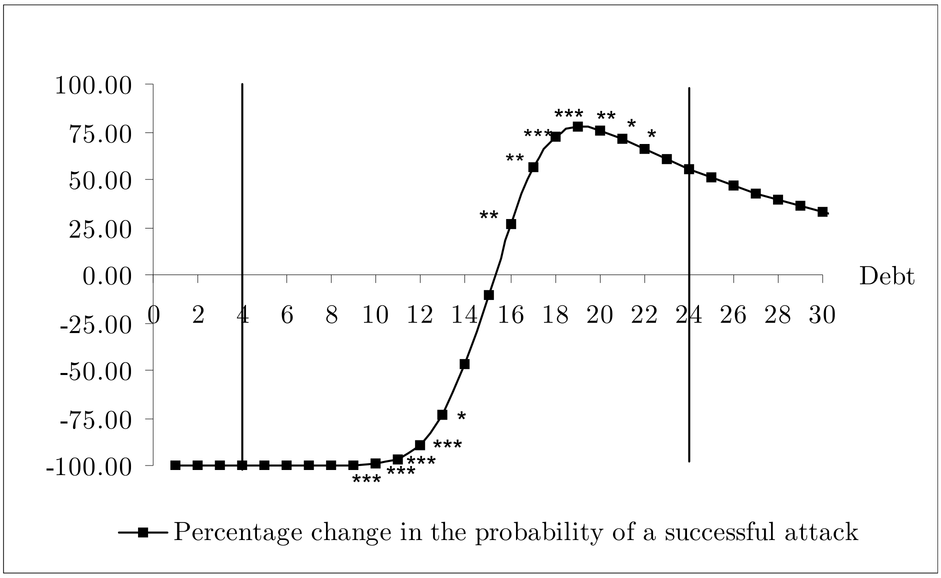

Figure 1: The effect of monetary policy for various levels of short-term debt

Notes: Figure 1 is constructed using the model specification shown in the last column of Table 6. It shows the percentage change in the probability of a successful attack if $\widetilde{MP}_2$ increases by one standard deviation from its sample mean, for different levels of short-term debt. All other regressors are set at their sample mean. The vertical lines at the left and the right end of the figure show the minimum and the maximum values of short-term debt in the sample. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Chapter 4

The Effect of Monetary Policy on Exchange Rates During Currency Crises

4.1 Introduction

The debate on the role of monetary policy during financial crises has not restricted itself to the ex-ante perspective, discussed in Chapter 3. Even when the fixed exchange rate has been abandoned and the currency is floating, the question of which monetary policy stance is most appropriate remains highly relevant.

The large depreciations in Thailand, Korea, Indonesia, and the Philippines in 1997 and 1998 had detrimental effects on the balance sheets of banks and firms with outstanding US dollar loans. This resulted in large-scale banking sector distress and economic downturn. Some argued that monetary policy should be tightened to limit the degree of nominal depreciation and to limit the level of inflation. This view, analogues to the traditional view outlined in Chapter 3, - which also marked the position of the IMF – argued that higher interest rates make it more costly to shorten the domestic currency. This will discourage capital outflows and, assuming everything else constant, appreciate the exchange rate.

Although this view seems to get broad support during 'normal' times, some argue that monetary tightening during times of crisis will have the opposite effect of further depreciating the exchange rate.[1] This 'revisionist' view argues that higher interest rates deteriorate the balance sheets of firms and banks that are adversely exposed to short-term interest rate

[0] This chapter is coauthored by Sylvester Eijffinger and will appear shortly as CEPR Discussion Paper.

[1] For example Radelet and Sachs (1998) and Furman and Stiglitz (1998).

changes. This increases the probability of defaults and bankruptcy and induces (further) capital outflows and depreciation of the exchange rate.

The growing empirical literature on the efficacy of monetary policy in supporting the exchange rate does not find a clear and systematic impact of monetary policy on exchange rates. Two approaches can be distinguished. Studies based on time-series include Goldfajn and Baig (2002) who, based on daily data, find no evidence of either an appreciating or a depreciating effect of interest rates on exchange rates in the Asian crisis countries. Gould and Kamin (2001), based on weekly data for Thailand, Indonesia, Korea, Malaysia, Philippines, and Mexico, also find no significant impact of monetary policy on exchange rates. Dekle et al. (2002) use weekly data and show a small supportive effect of interest rates on nominal exchange rates during the crises in Korea, Malaysia, and Thailand. Caporale et al. (2005) use monthly data for four Asian countries and find that while tight monetary policy helped to defend the exchange rate during tranquil periods, it had the opposite effect during the Asian crisis.

Studies based on panel data or cross-sections include Goldfajn and Gupta (2003) who ask whether a monetary tightening made it more likely that the post-crisis real appreciation would occur through an appreciation of the nominal exchange rate rather than through the price level. Using monthly data from 80 countries during the period 1980-1998, they find that monetary tightening appreciates the nominal exchange rate, but only in countries with strong banking sectors. Kraay (2003) looks at whether high interest rates defend fixed exchange rates during speculative attacks. Using monthly data on speculative attack episodes in 54 developed and developing countries, he finds that interest rates do not significantly affect the outcome of speculative attacks. Furman and Stiglitz (1998) examine episodes of sustained high interest rates in nine developing countries in the nineties and find that higher interest rates depreciate the exchange rate in low-inflation countries. Tanner (2001) uses monthly data and looks at an index of exchange market pressure, composed of exchange rate depreciation and reserve outflows. He finds that monetary tightening reduced exchange market pressure in Brazil, Chile, Mexico, Indonesia, Korea, and Thailand. Zettelmeyer (2004) studies the impact effect of monetary policy shocks on the exchange rate in Australia, Canada, and New Zealand during the 1990s. Using daily data, he finds that monetary tightening appreciates the exchange rate.

The main aim of this chapter is to investigate whether the efficacy of monetary policy depends on the level of short-term debt in the corporate sector. The central hypothesis is that raising interest rates to support the exchange rate in the aftermath of a fixed exchange rate collapse has larger adverse effects and is therefore less effective in countries where the corporate sector is more exposed to short-term interest rate changes. To test this hypothesis, we constructed a dataset which includes 18 episodes of currency crises during the sample period 1986-2002. The dataset includes an aggregate indicator of short-term corporate debt and a country-specific monetary policy indicator.

The estimation results confirm that the impact of monetary policy on the exchange rate is non-linear and non-monotonic. Whereas raising interest rates appreciates the exchange rate when short-term debt levels are relatively low, this effect becomes weaker and ultimately changes sign for higher levels of short-term debt.

The remainder of this chapter is organized as follows. Section 4.2 describes the empirical analysis, in particular the estimated model, methodology and data used. Section 4.3 provides a description and interpretation of the estimation results. Section 4.4 concludes.

4.2 Empirical Analysis

The impact of monetary policy on the exchange rate during currency crises is analyzed using the following model:

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t-1} + \beta_2 Z_{i,t-k} + \beta_3 X'_{i,t-1} Z_{i,t-k} + \epsilon_{i,t}, \tag{4.1}$$

where $Y_{i,t}$ is an indicator that captures the change in the exchange rate in period t for country i.[2] $X_{i,t-k}$ is an indicator that captures changes in the stance of monetary policy at $t-1$ in country i. Matrix $Z_{i,t-k}$ includes episode-specific fundamentals that are expected to affect the exchange rate (e.g. international reserves, short-term debt etc.), where $k = 0, 1, ..n$. Finally, the interaction term of $X_{i,t-1}$ and $Z_{i,t-k}$ captures how the effect of monetary policy changes for different levels of fundamentals. The interaction term of monetary policy and short-term debt is used to test the central hypothesis of this chapter: Raising the interest rate to support the exchange rate has larger adverse effects and is therefore less effective in countries where the corporate sector is more short-term indebted. Next, we explain how crises episodes are identified and regression variables are constructed

[2] The change in period t refers to the change between period t and t-1.

4.2.1 Identifying Episodes of Currency Crisis

Start Date

Since we are interested in the impact of monetary policy during currency crises, we first need to identify currency crisis episodes. Following Kraay (2003), we identify the beginnings of currency crises as large nominal depreciations or devaluations preceded by relatively fixed nominal exchange rates:

$$(i,t)\,|de_{i,t} > k_i \text{ and } \overline{de}_{i,t} < \overline{k}_i \tag{4.2}$$

where $de_{i,t}$ is the monthly percentage change in the nominal exchange rate in country i between period t and period t-1. We use the exchange rate vis-a-vis the currency of the anchor country to which the home currency was pegged.[3] k_i is the threshold determining the minimum size of the devaluation. $\overline{de}_{i,t}$ is the average absolute percentage change in the exchange rate in country i in the 12 months prior to period t. $\overline{k}_i$ is the threshold determining the maximum size of the "allowable" exchange rate volatility prior to the devaluation. Following Kraay (2003), k_i is set to 5% for OECD countries and 10% for non-OECD countries, while $\overline{k}_i$ is set to 1% for non-OECD countries and 2.5% for non-OECD countries. To prevent double-counting, Kraay eliminates episodes that were preceded by episodes in the preceding 12 months.

End Date

As to the end of the currency crisis episodes, Gould and Kamin (2001), for the Asian crisis countries and Mexico, and Dekle et al. (2002), for Korea, Malaysia, and Thailand, consider the course of events and choose an end date that seems reasonable for their sample countries. As our sample is somewhat larger and does not only contain episodes in the same time range, we need a more formal definition of endings. Therefore, for currency crises starting in month t, we define endings as the first month $t+s$ ($s>0$) for which the following three conditions are satisfied:

$$s_{i,t+s+j} < \bar{s}_{i,t} + 0.25 * (s_{i,t}^{MAX} - \bar{s}_{i,t}), \text{ where } j = 0,1,2 \tag{4.3}$$

[3] As, in the past, European countries typically pegged to the German mark whereas non-european countries often pegged to the US dollar, we use the monthly average local currency price of the German mark for European countries, and the local currency price of the US dollar for all other countries. (International Financial Statistics (IFS); line rf)

where $s_{i,t+s+j}$ is the nominal money market interest rate[4] spread over the US Federal Funds rate in country i and month $t+s+j$ where t and s denote the starting month and the length of the crisis, respectively. $\bar{s}_{i,t}$ is the average spread[5] in the 24 months preceding month t, and $s_{i,t}^{MAX}$ is the mean of the 3 highest levels of spreads in month t and the 5 succeeding months.

This methodology identifies the end of a crisis as the first post-crisis three-month period in which the nominal money market interest rate spread is constantly below a threshold, defined as $\bar{s}_{i,t} + 0.25 * (s_{i,t}^{MAX} - \bar{s}_{i,t})$, implying that speculative pressures have substantially diminished compared to their earlier crisis peaks. Since we are interested in the efficacy of monetary policy during *crisis* episodes, we exclude episodes that are not characterized by some degree of speculative pressure against the currency. Therefore, we exclude episodes for which the difference between $s_{i,t}^{MAX}$ and $\bar{s}_{i,t}$ does not exceed three percentage points, as they exhibit only a limited degree of speculation. As a result, 6 episodes[6] are dropped.

Table 1 shows the resulting 18 currency crises episodes during the sample period 1986-2002, for which data on short-term debt and monetary policy are available.

4.2.2 Regression Variables

We now turn to the construction of our regression variables. The sections below deal with all the variables used in the analysis. Table 2 provides an overview of the variables and their definitions, frequencies, and sources.

Indicators of Exchange Rate Changes

Once a fixed exchange rate is abandoned and the currency is allowed to float, the monetary authorities usually remain concerned about the nominal value of the currency. First, domestic firms and banks are often adversely exposed to exchange rate depreciations through their outstanding foreign currency denominated liabilities. Hence, monetary authorities may want to limit depreciation to prevent defaults and bankruptcies. Second, large depreciations often cause high levels of inflation through exchange-rate pass-through. Limiting nominal depreciation decreases the degree of real appreciation that has to take place through the price level and, therefore, avoids high (and perhaps persistent) inflation.

[4] IFS line 60b

[5] In some cases this 24-month average might be heavily influenced by episodes of distress, related to the upcoming crisis. Since we will use the average as an indicator of the level of spreads in 'normal' times, we exclude observations that lie more than 2 standard deviations above the 24-month mean.

[6] Denmark 1993, Ireland 1993, Korea 2000, Spain 1995, Sweden 1992, and United Kingdom 1992

Since the currency was formerly pegged to the anchor country's currency, we use the exchange rate vis-a-vis this anchor country's currency as a dependent variable. In particular, we use the percentage change in the monthly average local currency price of the German mark for European countries, and the local currency price of the US dollar for all other countries.[7] We also check the robustness of our results when using the monthly percentage change in the real exchange rate, i.e. the nominal exchange rate corrected for consumer prices at home and abroad.[8] Hence, we use two indicators of exchange rate change which we call NE and RE for the nominal and real exchange rate changes, respectively.

Indicators of Monetary Policy

The literature is divided as to which variable is the best indicator of monetary policy. Kraay (2003) uses the discount rate since it is the interest rate that is most heavily controlled by the monetary authorities and is therefore the least noisy one. Kraay argues that short-term money market interest rates are less useful as they are also affected by other factors. Goldfajn and Gupta (2003) argue, however, that discount rates tend to remain flat and often do not reflect short-run monetary policy changes. As an example they mention the 500% Swedish interest rate defense in September 1992 which was not reflected in the discount rate.

In addition to these arguments, the best available indicator of monetary policy is not necessarily the same across countries or time, which makes it difficult to choose an indicator in a cross-country analysis. In order to use the best possible indicator, we collected information on the most appropriate monetary policy interest rates for each episode in our sample. This information was obtained from the websites of monetary authorities, direct contact with the monetary authorities, and other empirical studies. Table 3 reports the instrument that we identified as the best indicator of monetary policy for each episode in our sample. It also provides information on how each indicator was identified and the source from which the data were obtained.

Some authors (e.g. Kraay, 2003) propose to use *real* exchange rates as a measure of monetary policy in order to control for expectations of inflation. Expectations of inflation are hard to measure and in practice one often uses ex-post inflation instead. As long as one considers monetary policy under a fixed exchange rate this is not unreasonable, as inflation is often low and fairly constant. However, when looking at the aftermath of fixed exchange rate collapses,

[7] International Financial Statistics (IFS); line rf

[8] IFS line 64

depreciations can cause substantial increases in levels of inflation and inflation variability. Hence, using ex-post levels of inflation causes real interest rates to drop substantially or even to turn negative. Gould and Kamin (2001) point in this respect to crises in Mexico in 1995 and Korea in 1997 as examples where nominal interest rates were very high while real interest rates fell below zero. They argue that, given the effect of high nominal interest rates on the cash-flow position of firms and consumers with short-term debt, it would seem unreasonable to define the monetary policy stance in these episodes as loosening. Following Gould and Kamin, we use nominal interest rates in our analysis.

The indicators of monetary policy used in the analysis are constructed as follows. First, since many of the other variables in our analysis are only available at monthly frequency, we constructed monthly averages of our daily nominal interest rate data.[9] The monthly series were then used to calculate the spread between the nominal interest rate in the home country and the anchor country. This second step takes out changes in the domestic monetary policy stance that resulted from changes in the monetary policy of the anchor country. We then calculate the *percentage change* in the spread from one month to another to capture the monetary policy change. We use the percentage change instead of the change because we believe an interest rate cut from 2% to 1% is not equivalent to a change from 12% to 11%. Finally, we need to determine an appropriate lag structure for monetary policy. If one believes that it takes some time for monetary policy to have an effect on the exchange rate, then monetary authorities would be most effective if they act some time before the desired effect on the exchange rate should occur. Following Gould and Kamin (2001), we use the (percentage) change in the spread between period $t-2$ and $t-1$. This yields our main monetary policy indicator, which we denote as MP. We also check the robustness of our results when using the discount rate, as in Kraay (2003), instead of our most appropriate country-specific indicator. This yields a second monetary policy indicator, which we denote as $DISC$. For both measures of monetary policy, we also include the initial level of the spread as a control variable.

Table 4 shows correlation and summary statistics for the two measures of monetary policy. Not surprisingly, we find MP and $DISC$ to be positively correlated (0.49), although far from perfect. The earlier argument that discount rates tend to remain flatter than other monetary policy indicators, is reflected in Panel B of Table 4, which shows that the standard deviation of $DISC$ is only half as large as the standard deviation of MP.

[9] This accounts for possible intra-monthly fluctuations, which are ignored when using end-of-month data.

Episode-Specific Fundamentals

Next to monetary policy, we include a number of other variables that are expected to affect the exchange rate.

First, we include a measure of short-term corporate debt. The level of domestic currency denominated short-term corporate debt, 'short-term debt', is measured as the representative firm's ratio of short-term debt to total assets, expressed as a percentage. Data on short-term debt and total assets were obtained from the Thomson Financial's Worldscope database. This database provides annual data on a large number of publicly listed companies in many developed and developing countries. We construct an aggregate measure of a country's short-term debt by taking the mean of the individual short-term debt to total assets ratios in the year before the exchange rate change.[10]

A methodological problem that may arise, results from the possible correlation between monetary policy and the error term in equation 4.1. This might be due to omitted variable bias, reverse causation, or measurement error. Using the lagged monetary policy interest rate might take away part of the problem but does not fully eliminate it. Error terms might for example be correlated over time because news about fundamentals is correlated over time. An often used approach to deal with this problem is to use instrumental variables. Kraay (2003) uses the percentage change in real international reserves as an instrument for monetary policy. However, this instrument is a rather poor predictor of monetary policy in our sample. Given that we cannot identify other suitable instruments, we use the approach of Gould and Kamin (2001) and attempt to control for as much of the unexplained variation as possible, *"thereby (hopefully) shrinking the variability of the error term sufficiently to minimize endogeneity problems"*.[11]

Therefore, next to monetary policy, short-term debt and the interaction of both, we include a number of other fundamentals that possibly affect the exchange rate (Table 2). Following Kraay (2003) we include the following four variables. First, as an indicator of real exchange rate overvaluation, we include the average growth rate of the real exchange rate vis-a-vis the anchor currency during the previous 12 months, expressed as a percentage. An average real appreciation implies a deterioration of a country's international competitiveness and increases the likelihood of a depreciation in the near future to restore competitiveness. Secondly, we include the level of non-gold reserves as a percentage of total imports in the previous month.

[10] This measure of a country's short-term debt to total assets ratio was earlier used by Mulder et al. (2002) to test its impact on the likelihood and depth of financial crises.

[11] Gould and Kamin (2001)

This reflects the degree to which monetary authorities can support the exchange rate in times of speculation against the currency or a sudden stop in the financing of current account deficits by foreign countries. Thirdly, as an indicator of a country's external payments position, we include the average of a country's outstanding IMF loans as a percentage of a country's IMF quota in the previous twelve months. A high level of external debt might discourage international investors to lend to a country or persuade those already present to leave the country. Both effects will tend to depreciate the exchange rate. Fourth, we include the deviation of the real per capita GDP growth in the previous calendar year from the average of the five years before, expressed as percentage points. Lower economic growth might lower international investors' expectations of future returns. Also, it might make it more difficult for a country to meet its external debt service obligations. Again, this could lead to a decrease in demand for the domestic currency, causing a depreciation of the exchange rate.

In addition to the variables in Kraay (2003) we include two additional possible determinants of exchange rates: the monthly percentage changes of real exports and imports in the previous month. An increase in exports implies an increase in foreign currency revenues which lowers a country's vulnerability to possible future balance of payments problems and, hence, strengthens the exchange rate. Alternatively, a higher level of imports increases demand for foreign currency. This demand will be met by borrowing abroad or drawing on foreign reserves, both of which might have a depreciating effect on the exchange rate.

Table 5 divides the sample in two subsamples and provides summary statistics for the dependent variable, the fundamentals, and the monetary policy measures in each of the subsamples. The first subsample includes all episodes in which the nominal exchange rate appreciated, the second refers to episodes of nominal depreciation. Whereas the means of the fundamentals do not differ much between the two subsamples, the average tightening of monetary policy is larger for episodes of depreciation. This could indicate a reverse effect of monetary policy on the exchange rate but could also result from endogeneity of monetary policy.

The nominal and real exchange rate depreciation in Indonesia in January 1998, 96.8% and 84.5% respectively, represents an outlier in our data, as it is more than double the size of the next largest depreciation. Hence, we eliminate this observation from our sample.[12]

[12] For sensitivity, we also tried eliminating the top and bottom 1% of appreciations and depreciations and found results similar to the ones reported in this paper.

4.3 Estimation results

Table 6 provides pooled estimates for six alternative specifications of equation 4.1.[13]It also shows the number of observations and the adjusted R-squared. The specifications in columns (1) and (2) represent benchmark regressions that include a monetary policy measure and the episode-specific fundamentals. Column (1) shows the results when using the monetary policy measure $DISC$ used by Kraay. We fail to find any significant impact of monetary policy on the nominal exchange rate during currency crises. This result is consistent with Kraay, who fails to find any impact of monetary policy on the outcome of speculative attacks. Half of the control variables enter with expected signs but all variables are statistically insignificant so should be viewed with caution. In particular, the coefficient for exchange rate overvaluation is negative, indicating that everything else equal, a less overvalued currency leads to an appreciation of the home currency. The external payments position of a country enters with a positive sign, indicating that everything else equal, a higher external indebtedness leads to a depreciation of the home currency. Also, the growth rate of exports enters with a negative sign, suggesting that a higher level of exports leads to an appreciation of the home currency. The initial level of the spread enters positive, suggesting that a higher initial level of the spread leads to a depreciation of the home currency. The level of debt to assets, reserves to imports, deviations of GDP growth, and the growth of imports do not have the expected sign.

Column (2) shows the results when using our monetary policy measure MP. We now find that everything else constant an increase in interest rates leads to a depreciation of the home currency. The monetary policy coefficient is statistically significant at the 5% level and provides support of the revisionist view, which argues that raising interest rates during episodes of financial distress weakens the home currency. The coefficients of the control variables have somewhat changed but are still statistically insignificant, except for one. The initial level of the spread enters positive and statistically significant at the 1% level, indicating that a higher initial level of the interest rate leads to a depreciation of the home currency.

In columns (3) and (4) we add interaction terms of monetary policy and fundamentals to test whether the effect of monetary policy depends on these fundamentals. Our central hypothesis - the effect of monetary tightening to support the exchange rate has larger adverse effects and is therefore less effective in countries where the corporate sector is more short-term indebted - is tested using the interaction term of monetary policy and short-term debt to

[13]We performed a Hausman test, F-test, and Lagrange multiplier test to compare fixed effects, random effects, and pooled estimation. The results did not reject the use of a pooled estimation.

assets. Column (3) shows results when using the discount rate as a monetary policy measure. As in column (1) we do not find any systematic association between monetary policy and the exchange rate. Both the coefficient for monetary policy and the coefficient for the interaction term of monetary policy and debt enter statistically insignificant. The control variables enter with the same signs as in column (1), except for GDP growth. However, all control variables remain statistically insignificant, except for one. The level of debt to total assets now enters statistically significant at the 5% level but not with the expected sign. Three of the interaction terms enter with the expected sign, although all statistically insignificant. In particular, the interactions of monetary policy and the external payments position, exports growth, and imports growth have the expected signs. Only the interaction of monetary policy and the deviation of GDP growth enters slightly significant at the 10% level but with the non-expected sign.

Column (4) shows results when we use our preferred monetary policy indicator MP. Monetary policy now enters negative and statistically significant at the 5% level, indicating that a higher interest rate leads to an appreciation of the nominal exchange rate. The size of the coefficient suggests that the effect is economically relevant. A 1 percentage point increase in the interest rate leads to a nominal appreciation of 0.15 percentage points. Next to the monetary policy coefficient, the interaction of monetary policy with debt to total assets enters positive and highly statistically significant at the 1% level. This indicates that the effect of monetary policy on the nominal exchange rate is non-linear. For higher levels of debt to assets, the supportive effect of monetary policy on the nominal exchange rate becomes weaker. The control variables and the other interaction terms enter statistically insignificant except for the initial level of the spread, which again enters positive and highly statistically significant at the 1% level. As for the explanatory power of the regression, adding the interaction terms increases the adjusted R-squared from 0.15 in column (2) to 0.20 in column (4).

Columns (5) and (6) provide two alternative specifications to test the robustness of the results in column (4). First, we tested for serial correlation in the dependent variable and found weak evidence of first-order serial correlation. In column (5) we therefore add the lagged percentage change in the nominal exchange rate, which enters positive and slightly statistically significant at the 10% level. The results show little change compared to column (4). In particular, it is reassuring that our findings on the effect of monetary policy and the interaction of monetary policy with short-term debt remain unchanged.

Column (6) repeats the specification in column (4) when using the percentage change in the *real* exchange rate instead of the percentage change in the *nominal* exchange rate. This allows for a possible impact of monetary policy on the level of inflation, in addition to its impact on the nominal exchange rate. Our results are robust to this change in the dependent variable. The coefficients of monetary policy and the interaction of monetary policy with short-term debt to assets remain unchanged. This suggests that the impact of monetary policy on the real exchange rate works solely through its impact on the nominal exchange rate. The results for the other variables also remain unchanged, except for one. The indicator of exchange rate overvaluation enters again with the expected sign but is now slightly statistically significant at the 10% level, suggesting that everything else equal a less overvalued currency leads to an appreciation of the currency.

In order to investigate for which levels of short-term debt to assets a monetary tightening appreciates the exchange rate, depreciates the exchange rate, or leaves the exchange rate unchanged, we proceed as follows. From equation 4.1 we can calculate the marginal effect of monetary policy:

$$\frac{\partial Y_{i,t}}{\partial X_{i,t-1}} = \beta_1 + \beta_3 \cdot Z_{i,t-k} \tag{4.4}$$

where β_1 is the coefficient for monetary policy and β_3 is a vector of coefficients for the interaction terms. Since we are mainly interested in the interaction of monetary policy and debt to assets, we will evaluate the marginal effect of monetary policy for different levels of debt, while assuming the other fundamentals to be at their sample means. We find that for levels of aggregate short-term debt to total assets between 0 and 11.7, raising the interest rate appreciates the exchange rate. For a debt to assets level of 11.7, monetary tightening leaves the exchange rate unchanged. And for debt to asset levels above 11.7, raising the interest rate depreciates the exchange rate. The threshold level 11.7 lies below the sample mean 17.7 and the sample median 16.2. In particular, the threshold level lies between the 22nd and 23rd percentile. This result indicates that for the countries and years with debt levels in the lowest 22 percent of the distribution, raising the interest rate appreciates the exchange rate whereas for countries and years with debt levels in the highest 77 percent of the distribution, raising the interest rate depreciates the exchange rate.

Summarizing, our results provide strong evidence that the impact of monetary policy depends on the level of short-term debt to assets. For relatively low levels of debt, raising the interest rate appreciates the exchange rate, supportive of the traditional view. This effect becomes weaker and eventually changes sign for higher levels of debt, supportive of the revisionist view. These results support the central hypothesis of this chapter: the impact of higher interest rates on the exchange rate depends on the extent to which banks and companies are adversely exposed to interest rate changes. The higher the ratio of short-term debt to total assets, the more banks and companies suffer from interest rate increases and, hence, the lower the efficacy of monetary policy in supporting the exchange rate.

4.4 Conclusions

This chapter examined whether the efficacy of monetary policy in supporting the exchange rate in the aftermath of a fixed exchange rate collapse depends on the level of a country's short-term corporate debt. The central hypothesis of this chapter is that raising the interest rate to support the exchange rate has larger adverse effects and is therefore less effective in countries and periods where the corporate sector is more short-term indebted.

This chapter improves upon existing studies in at least two ways. First, we construct an aggregate indicator of short-term debt to measure the corporate sector's exposure to higher interest rates in the aftermath of fixed exchange rate collapses. Second, we construct a country-specific monetary policy variable that best represents the stance of monetary policy in our sample countries and periods.

The estimation results confirm that the impact of monetary policy on the exchange rate is non-linear and non-monotonic. Whereas raising interest rates appreciates the exchange rate when short-term debt levels are relatively low, this effect becomes weaker and ultimately changes sign for higher levels of short-term debt. These results provide evidence that the opposite views on raising interest rates are not mutually exclusive. They also provide a possible explanation for some of the mixed findings in the empirical literature.

Our results have important policy implications. During episodes of crisis in the aftermath of fixed exchange rate collapses, monetary policy tightening to support the exchange rate is only effective in countries with relatively low debt levels in the corporate sector. If debt is high, monetary tightening is not only ineffective but even depreciates the exchange rate.

Table 1: Episodes of currency crises

Country	Start	End
Argentina	2002:1	2002:10
Brazil	1999:1	1999:5
Finland	1991:11	1993:2
Indonesia	1986:9	1989:2
Indonesia	1997:8	1999:6
Ireland	1986:8	1987:5
Korea	1997:11	1998:7
Mexico	1994:12	1996:8
Mexico	1998:9	1999:4
Norway	1986:5	1988:8
Philippines	1997:9	1997:12
Russia	1998:9	1998:11
Slovakia	1998:10	1999:12*
South Africa	1998:7	1999:3
South Africa	2001:12	2004:6**
Thailand	1997:7	1998:7
Venezuela	1995:12	1996:6*
Venezuela	2002:2	2003:7

*Due to lack of data on money market interest rates in Slovakia (1998-99) and Venezuela (1995-96), we used real non-gold reserves as an alternative indicator of speculative pressure, analogues to the methodology for interest rate spreads. The end date for Venezuela (1995-96) can be explained by Venezuela's Stand-By Arrangement with the IMF in July 1996, which caused a substantial rise in reserves.

**As this episode has not ended yet, we use the most recent month in which data were available.

Note: Slovakia 1993:7 was identified as the beginning of a crisis. This episode is excluded since it is due to the separation of Czechoslovakia into the Czech and Slovak Republic.

Table 2: Variables, Definitions, Frequency, and Source

Variables	Definitions	Frequency/Source
A. Dependent variable		
NE	Percentage change in the monthly average local currency price of the German mark for European countries, and the local currency price of the US dollar for all other countries (%).	Monthly IFS[1] line rf
RE	Analogues to NE but corrected for domestic and German/US price levels (%).	Monthly IFS line rf/64
B. Independent variables: Indicators of Monetary Policy		
MP	Monetary policy indicator calculated using the interest rate identified as the best indicator for that particular episode (section 3.3) (%)	Monthly Table 3
$DISC$	Monetary policy indicator calculated using the discount rate (section 3.3) (%)	Monthly IFS line 60
C. Independent variables: Fundamentals		
Debt to total assets	Ratio of short-term debt to total assets in previous calendar year; mean of individual companies (%)	Annual WS[2]
Exchange rate overvaluation	Average growth rate of the real exchange rate during the previous 12 months (%)	Monthly IFS line RF/64
Reserves to imports	Non-gold reserves as percentage of total imports in the previous month (%)	Monthly IFS line 1L.D/71.D
External payments position	IMF loans as percentage of a country's quota, averaged over the previous twelve months (%)	Monthly IFS line 2TL/2F.S
Deviation GDP growth	Deviation of the real per capita GDP growth in the previous calendar year from the average of the five years before (%)	Annual WDI[3]
Exports growth	Monthly percentage change of merchandise exports in constant US dollars in the previous month (%)	Monthly IFS line 70..D
Imports growth	Monthly percentage change of merchandise imports in constant US dollars in the previous month (%)	Monthly IFS line 71..D
Level of MP/DISC at $t-2$	Initial level of the monetary policy spread at $t-2$	Monthly Table 3/IFS line 60

[1] IFS: International Financial Statistics [2] WS: Worldscope [3] WDI: World Development Indicators

Table 3: Monetary Policy Interest Rates

Country	Monetary Policy Interest Rate	Identification	Source of Data
Argentina	Interbank 7 day-middle rate	Other	Datastream
Brazil	Financing overnight-middle rate	Other Studies*	Datastream
Finland	Key tender-middle rate	Central Bank-W	Datastream
Indonesia	SBI 90 day-middle rate	Central Bank-W	Datastream
Ireland	Discount rate	Central Bank-W	Datastream
Korea	Call overnight- middle rate	Central Bank-W	Datastream
Mexico, 1994:12	Cetes 28 day min. auction-middle rate	Central Bank-W	Datastream
Mexico, 1998:9	Cetes 28 day avg. auction-middle rate	Central Bank-W	Datastream
Norway, 1986:5	Daily interbank nominal-middle rate	Central Bank-W	Datastream
Philippines	Interbank call loan rate-middle rate	Other Studies**	Datastream
Russia	Discount (refinancing)-middle rate	Central Bank-W	Datastream
Slovakia	Basic NBS interest rate	Central Bank-W	Central Bank
South Africa	Prime overdraft-middle rate	Central Bank-W	Datastream
Thailand	Repo 14 day-middle rate	Central Bank-W	Datastream
Venezuela	Discount Rate***	Central Bank-W	IFS

Central Bank-W = Central Bank Website; Central Bank-C = Central Bank Contact (email).

* From Furman and Stiglitz (1998)

** from Caporale et al. (2005)

*** End-of-month monthly series.

Table 4: Measures of monetary policy

Panel A: Correlation

	MP	$DISC$
MP	1.00	
$DISC$	0.49	1.00

Panel B: Summary statistics

	Mean	St. dev.	Min	Max
MP	5.8	33.3	-86.7	204.2
$DISC$	3.2	16.9	-27.4	96.1

Table 5: Summary statistics

Variables	Episodes of appreciation				Episodes of depreciation			
	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
A. Dependent variable								
NE	-3.9	4.4	-23.6	-0.01	8.4	10.9	0	44.7
RE	-5.0	4.9	-23.2	0.2	6.1	9.9	-6.8	41.0
B. Monetary Policy								
MP	0.8	13.8	-33.0	90.8	10.0	43.0	-86.7	204.2
$DISC$	0.2	8.3	-18.8	33.8	5.8	21.5	-27.4	96.1
C. Fundamentals								
Debt to total assets	18.8	8.7	4.9	44.8	16.8	8.7	3.9	44.8
Exchange rate overvaluation	2.0	3.9	-3.4	13.5	2.7	3.1	-3.8	14.1
Reserves to imports	538.7	373.8	104.3	1712.3	690.4	506.9	68.0	2214.5
External payments position	115.6	171.2	0	663.2	125.5	174.1	0	574.9
Deviation GDP growth	-1.7	5.0	-19.9	5.2	-2.4	5.4	-19.9	9.7
Exports growth	0.8	15.4	-64.1	43.4	0.5	13.3	-71.4	34.2
Imports growth	2.0	16.8	-50.4	54.4	-2.8	15.3	-52.2	40.8
Initial level of spread (MP)	20.0	11.6	6.3	67.4	29.3	55.0	4.7	460.4
Initial level of spread ($DISC$)	18.0	16.1	0	65.8	19.8	16.6	0	55.0

Table 6: Estimation results

For regressions (1)-(5): dependent variable=NE (nominal exchange rate change)

For regression (6): dependent variable=RE (real exchange rate change)

	(1)	(2)	(3)	(4)	(5)	(6)
Monetary policy						
MP		0.05**		-0.17**	-0.17**	-0.17**
		(0.02)		(0.04)	(0.04)	(0.02)
$DISC$	0.08		0.11			
	(0.18)		(0.64)			
Fundamentals						
Debt to total assets	-0.15	-0.10	-0.22**	-0.13	-0.11	-0.09
	(0.12)	(0.23)	(0.02)	(0.13)	(0.20)	(0.25)
Exchange rate overvaluation	-0.11	0.03	-0.17	-0.21	-0.37	-0.49*
	(0.75)	(0.92)	(0.55)	(0.42)	(0.18)	(0.07)
Reserves to imports	0.00	0.00	0.00	0.00	0.00	0.00
	(0.26)	(0.78)	(0.35)	(0.75)	(0.62)	(0.99)
External payments position	0.01	-0.00	0.00	-0.00	0.00	-0.00
	(0.59)	(0.44)	(0.79)	(0.99)	(0.87)	(0.78)
Deviation GDP growth	0.08	-0.01	-0.05	-0.01	-0.02	-0.06
	(0.58)	(0.94)	(0.71)	(0.93)	(0.88)	(0.64)
Exports growth	-0.06	-0.06	-0.03	-0.06	-0.07	-0.06
	(0.28)	(0.34)	(0.57)	(0.34)	(0.30)	(0.32)
Imports growth	-0.05	-0.07	-0.07	-0.07	-0.03	-0.06
	(0.34)	(0.17)	(0.21)	(0.21)	(0.57)	(0.18)
Initial level of spread (MP)		0.08***		0.07***	0.06***	0.07***
		(0.00)		(0.00)	(0.00)	(0.00)
Initial level of spread ($DISC$)	0.02		0.00			
	(0.87)		(0.97)			
Monetary Policy×Fundamentals						
Monetary Policy×Debt to total assets			-0.01	0.01***	0.01***	0.01***
			(0.29)	(0.01)	(0.01)	(0.01)
Monetary Policy×Exchange rate overvaluation			0.01	0.01	0.01	0.01
			(0.84)	(0.58)	(0.55)	(0.42)
Monetary Policy×Reserves to imports			0.00	0.00	0.00	0.00
			(0.13)	(0.71)	(0.72)	(0.85)
Monetary Policy×External payments position			0.00	-0.00	-0.00	-0.00
			(0.97)	(0.12)	(0.13)	(0.11)
Monetary Policy×Deviation GDP growth			0.02*	-0.00	-0.00	-0.00
			(0.06)	(0.43)	(0.51)	(0.46)
Monetary Policy×Exports growth			-0.00	0.00	-0.00	0.00
			(0.52)	(0.90)	(0.92)	(0.75)
Monetary Policy×Imports growth			0.00	0.00	0.00	0.00
			(0.72)	(0.27)	(0.27)	(0.23)
Lagged exchange rate change						
NE (lagged)					0.12*	
					(0.09)	
Number of observations	132	163	132	163	163	163
Adjusted R-squared	0.10	0.15	0.21	0.20	0.23	0.19

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Significance levels in parentheses. Standard errors corrected for heteroskedasticity.

Part II Sovereign Debt Crises

Chapter 5

Credit Derivatives and Sovereign Debt Crises

5.1 Introduction

The recent default of Argentina has led to a renewed interest in sovereign debt crises and their resolution. An important part of the debate focuses on the efficiency of the current arrangements for sovereign debt restructuring. Some argue that this restructuring should be made easier to enable countries to avoid the large costs of lengthy negotiation periods. Others argue that these large costs are necessary for governments to have an incentive to repay.[1]

The arrival of *credit derivatives* has added a new dimension to this debate. These derivatives, in their simplest form, represent a contract under which a so-called protection seller promises to pay an agreed sum in case the reference bond does not perform to the protection buyer (typically, the bondholder).[2] The market for credit derivatives, which was almost non-existent ten years ago, has grown from a total outstanding amount of US$ 900 billion at the end of 2000 to more than 5 trillion at the end of 2004 (e.g., BBA, 2004). Sovereign credit derivatives constitute a significant part of this fast-growing market (Packer and Suthiphongchai, 2003, and BIS, 2004). Credit protection is now available for countries such as Brazil, Mexico, Russia, Colombia, Venezuela, South Africa, and Philippines. The fast growth in the market for credit derivatives has also led to considerable interest among policymakers.[3]

The existence of sovereign credit derivatives has implications for the efficiency of sovereign debt restructuring as it can fundamentally change the incentives for bondholders to accept a sovereign's restructuring offer. In particular, bondholders that have insured themselves against

[0] This chapter is coauthored by Wolf Wagner. A shorter version is submitted at the Journal of International Economics.

[1] For an overview of the alternative arguments, see Eichengreen (2003).

[2] For an overview of the different credit derivative instruments, see Kiff et al. (2003).

[3] BIS, 2004; FSA, 2002; IAIS, 2003; IMF, 2002; OECD, 2002; and Bank of England, 2001

default through buying credit derivatives, are likely to be less inclined to accept restructuring offers.[4] This shifts negotiating power from the sovereign to the bondholder[5] and could have important effects on the efficiency of crisis resolution.

The implications of credit derivatives for sovereign debt restructuring have not yet been analyzed theoretically. This chapter presents a first attempt to provide such an analysis. In particular, this chapter assesses the welfare implications of credit derivatives through their impact on i) the ex ante incentives of sovereigns to avoid a crisis and ii) the ex post crisis resolution.

We study these issues in a model of sovereign debt financing, in which a sovereign is running an ongoing project and is for some reason currently unable to service the outstanding debt. We distinguish between liquidity crises and fundamental crises. In a liquidity crisis, the output from the project (if continued) exceeds its liquidation value. By contrast, in a fundamental crisis the output is lower than its liquidation value. From an ex-post view, the efficient resolution of a crisis in our model requires therefore debt restructuring in a liquidity crisis but defaulting in a fundamental crisis.

In order to avoid default, the sovereign can make the representative bondholder a restructuring offer, which involves the promise of a payment in the next period in exchange for the current claims of the bondholder. If the bondholder accepts the offer, debt is successfully restructured and the sovereign can continue the project. If the bondholder rejects the offer, the sovereign is in default. The project is then liquidated and the proceeds are seized by the bondholder, which we initially assume to be possible without costs.

In our model, crisis resolution in the absence of protection is ex-post efficient when the bondholder can observe the type of crisis the country faces. There is restructuring in a liquidity crisis because the project's output exceeds the liquidation value, which enables the sovereign to make a credible restructuring offer that is at least as large as the bondholder's outside option (the liquidation value). By contrast, there is default in a fundamental crisis as the project's output is not sufficient to compensate the bondholder for his outside option and hence the bondholder rejects any restructuring offer.

[4] Krueger (2002).

[5] Because the restructuring offer in our model is accepted on a voluntary basis, it does not trigger the insurance contracts. This is consistent with the recent court ruling of the Southern District of New York that Argentina's 2001 voluntary exchange offer did not constitute a credit event. Hence, insurance can only be exercised after a restructuring offer is rejected. This leaves the decision to accept or reject under full control of the bondholder.

We then consider the impact of credit protection that is chosen by a bondholder for strategic reasons. That is, the bondholder chooses protection in order to affect the outcome of the crisis. This is motivated by the fact that sovereign debtors typically negotiate the terms of restructuring with a group of selected major creditors, after which the majority of bondholders usually accepts (Verdier, 2004). These major creditors hence have some influence over the resolution of crises, and it is their incentives to buy protection we consider.

The main effect of credit protection is that it increases the bondholder's outside option since he can now in principal fully secure the value of his debt by triggering the credit protection through a rejection of the restructuring offer. In spite of this, we show that there are no implications for the resolution of crises. Since in a fundamental crisis there is already rejection in the absence of credit protection, crisis resolution is unchanged. By contrast, in a liquidity crisis there is acceptance under no protection but we show that it is not in the bondholder's interest to choose a level of protection that would lead to default. The reason is that the bondholder suffers from the resulting inefficient liquidation through a higher price of protection, since he now also has to exercise protection in a liquidity crisis.

Although crisis resolution is unchanged, credit protection does have an impact on the sovereign's ex-ante incentives to avoid crises. Since the bondholder's outside option has increased, the return that the sovereign has to offer in the high state in order to have the bondholder accept, has increased accordingly. This raises the cost of a crisis for the country and thus improves ex-ante incentives. Overall, we therefore find that when investors are fully informed about the type of crisis the country is facing, the availability of credit derivatives is welfare improving.

Next we consider the case where the bondholder cannot observe the type of crisis the country faces. In the absence of protection, the sovereign has an incentive to pretend to be in a liquidity crisis, when in fact suffering from a fundamental crisis, to escape the cost of defaulting. Therefore, the bondholder has to base his decision to accept or reject on his priors about the type of crisis. Depending on the parameters of the model, this leads to equilibria where the bondholder either always rejects or always accepts the restructuring offer (pooling equilibria). Hence, crisis resolution is no longer socially efficient.

As before, we find that the bondholder does not choose a level of protection that changes crisis resolution. He only uses protection to improve the sovereign's restructuring offer by increasing his outside option in a default. As before, this has the effect of reducing the sovereign's pay-off in a crisis and improves ex-ante incentives. Welfare is thus again higher than under no protection. Nevertheless, we find that the bondholder does not always choose the socially optimal level of protection: in some cases protection that has a long maturity would be more beneficial by allowing for a socially desirable shift from rejection to acceptance. Thus, there is a potential case for intervention.

We next extend the analysis for litigation costs, i.e., we assume that the bondholder cannot costlessly force the government to liquidate the project and hand over the liquidation value. This has the important implication that when the bondholder's benefits from litigating are low, he may not find it optimal to litigate, implying that the sovereign can then keep the liquidation value, even in a default.

We find that under costly litigation credit protection allows in principal to have an ex-post efficient crisis resolution, even when there is asymmetric information. This is because for sufficiently high levels of protection, the bondholder does not litigate anymore and hence the sovereign's pay-off under default increases. As a result, the sovereign loses his incentive to pretend to be in a liquidity crisis while actually being in a fundamental crisis, which leads to an equilibrium in which the sovereign truthfully reveals the crisis type. We find that the impact on moral hazard is ambiguous, as both the bondholder's pay-off and the joint pay-off increase and hence the change in the sovereign's pay-off can be positive or negative.

Thus, our results suggest that emergence of sovereign credit derivatives is by and large welfare improving because it improves sovereigns' incentives to avoid crises by increasing the outside option of bondholders. Furthermore, even though possible, credit protection does not reduce the efficiency of crisis resolution as bondholders do not have an incentive to choose inefficient levels of protection. Under certain conditions, credit protection even improves crisis resolution by facilitating conditional crisis resolution.

The remainder of this chapter is organized as follows. The next section reviews related literature. Section 5.3 describes the model. Section 5.4 studies the benchmark case of sovereign debt crises in the absence of protection. Section 5.5 describes the case with credit protection. Section 5.6 extends for costly litigation. Conclusions follow in Section 5.7.

5.2 Related Literature

Most contributions to the burgeoning literature on the impact of credit derivatives have focused on the effects of credit derivatives on the incentives of borrowers and lenders. Duffee and Zhou (2001), for example, consider possible adverse selection problems that arise from credit risk transfer and show how the flexibility of credit derivative instruments can be used to mitigate these problems. DeMarzo (2005) shows how pooling and tranching, commonly used in balance sheet credit derivatives, can be used to reduce informational asymmetries. Morrison (forthcoming) has shown that credit derivative markets can reduce banks' incentives to monitor, which can be detrimental to welfare by eroding the certification value of bank loans.

Probably most closely related to this chapter is Arping (2005), who has shown in the context of corporates (rather than sovereigns), that credit risk transfer can actually improve borrower's incentives by leading to a more efficient liquidation. In his paper, as in our model, the presence of credit protection increases the outside option of lenders. This increases the relationship surplus attributable to lenders and thus their incentives to monitor but also has a disciplining effect on the borrower. The latter impact on ex-ante incentives is also present in this chapter. Contrary to Arping's paper, however, this chapter focuses also on the impact of protection on the efficiency of crisis resolution and how this interacts with the lender's incentives to increase his outside option. This has the consequence, for example, that ex-ante incentives are not always improved as it may interfere with an efficient crisis resolution ex-post.[6] Moreover, we also stress the role of credit protection in the presence of asymmetric information about the state of the project.

Another important strand of the literature has analyzed the impact of credit derivatives on financial stability. Santomero and Trester (1998), Instefjord (2005), and Wagner (forthcoming) find that there can be adverse implications for stability because of increased risk taking by banks. Wagner and Marsh (2004) and Allen and Gale (2005) have drawn some implications for systemic risk.

Only few papers of the burgeoning literature on credit derivatives have focused on sovereign debt markets. Packer and Suthiphongchai (2003) analyze the empirical characteristics of the market for sovereign credit derivatives, while Ranciere (2001) focuses on a description of the market participants and the main instruments used. Verdier (2004) provides an extensive analysis of the legal issues posed by credit derivatives, which have been crucial in recent settlements of sovereign credit derivatives. The latter two papers also discuss possible implications for the restructuring process, without providing a formal analysis, however. Finally, this chap-

[6] Another important difference is that in our analysis the borrower (the sovereign) cannot observe the level of protection. As a consequence, the improvement in ex-ante incentives does not stem from lender's incentives to reduce moral hazard but is a by-product of their incentives to extract as much as possible from the borrower in a crisis.

ter is of course also related to the general literature on the resolution of sovereign debt crises, which has gained renewed momentum in the wake of recent crises (see, for example, Krueger, 2002; Eichengreen, 2003; Spiegel, 2005; Haldane et al., forthcoming; and Weinschelbaum and Wynne, forthcoming).

5.3 The Model

We consider a sovereign debtor and a representative bondholder, who are both risk-neutral and maximize their expected payoffs without time preference. The sovereign's country has an ongoing capital project with two possible levels of output: f^H in the high state of the economy (liquidity crisis) and f^L in the low state (fundamental crisis), where $f^H > f^L$.

The model has two periods. The debt contract, which is taken as given for our purpose, specifies an interest payment due in period 0 and a principal due in period 1. At the beginning of period 0, the bondholder decides on which level of protection to buy (if protection is available). Afterwards, nature draws and the liquid assets of the country materialize. When the sovereign's liquid assets in period 0 are insufficient to cover interest payment, a 'debt crisis' occurs, which is the case we are considering.[7] The sovereign then uses the liquid assets to pay as much as possible of the due interest and we simply normalize the remaining value of outstanding debt (i.e., interest plus principal minus liquid assets) to 1.

There are two principal ways in which the crisis can be solved: either the sovereign makes a successful restructuring offer to the bondholder or there is a default[8]. A restructuring offer promises a period-1 return in exchange for the remaining outstanding debt. If the bondholder accepts (i.e., the offer is successful), the sovereign can continue production as normal, yielding f^H or f^L in period 1. If the bondholder rejects, the country is in a default and the bondholder can liquidate the project and seize the liquidation value k. We assume that the liquidation value is not sufficient to allow the bondholder to fully recover his claims, i.e., $k < 1$. The sovereign suffers additional (private) default costs $C > 0$, arising from liquidating the ongoing project. These can be interpreted as social costs, such as from the loss of jobs, social upheaval or political instability.[9]

[7] We do not endogenize the occurrance of crises but think of crises being, at least partly, driven by the behavior of the sovereign and study below sovereign's incentives to avoid crises.

[8] In our analysis a default can occur in two (identical) ways: either the sovereign chooses not to make a restructuring offer or the restructuring offer is unsuccessful.

[9] More broadly, default costs can also be interpreted as being due to reputational losses or sanctions, leading for example to a loss of access to international capital markets or lower aid receipts.

Furthermore, we assume that

$$f^H > k \tag{5.1}$$

i.e. the output of the capital project in the high state exceeds the liquidation value. This implies that restructuring is socially optimal (i.e., the joint payoffs of sovereign and bondholder are maximal) in the high state as the pay-off under acceptance (f^H) is larger than the pay-off from liquidating the project and incurring the default costs ($k - C$). Moreover, we assume that

$$f^L < k - C \tag{5.2}$$

implying that restructuring is not socially optimal in the low state because the joint pay-off from continuing the project (f^L) is lower than the pay-off from liquidating the project and incurring the default costs ($k - C$).

Welfare in our economy is determined by two factors: the efficiency of crisis resolution and sovereign moral hazard in avoiding crises. As to the first, our assumptions above imply that efficient resolution means that there is restructuring in the high state and default in the low state, as this maximizes the joint pay-off of sovereign and bondholder.[10] As to the second, we view crises to (at least partly) result from insufficient incentives for the sovereign to avoid them. Such incentives depend on the sovereign's pay-off in a crisis. We therefore assume that welfare decreases with the sovereign's pay-off in a crisis, as higher payoffs increase moral hazard.

We proceed our analysis as follows. We first study the benchmark case in the absence of protection. Then we introduce protection and study its impact on equilibrium crisis resolution and moral hazard. For both cases, we consider equilibria under both symmetric and asymmetric information. The difference is that under symmetric information both the sovereign and the bondholder are fully informed on the state of the country (high or low state), while under asymmetric information only the sovereign is informed. In this latter case, the bondholder only knows the prior probabilities with which in a crisis the country will be in the high or low state, π^H and $1 - \pi^H$, respectively.

The model is thereby solved backwards: we first identify the conditions under which the bondholder accepts the restructuring offer (i). Given these conditions, we then solve for the restructuring offer that the sovereign chooses to make, that is the offer that maximizes his

[10] The division of the total pay-off between sovereign and bondholder is assumed not to affect welfare. We think of this as resulting from the fact that in competitive bond markets, any changes in the bondholder's pay-off will ultimately be felt by the sovereign through changes in the interest rate.

pay-off (ii). Next, if credit protection is available, we solve for the level of protection that the bondholder chooses, that is the level of protection that maximizes his pay-off (iii).

5.4 Crisis Resolution under No Credit Protection

Table 1 shows the payoffs of the sovereign and the bondholder in the absence of protection for a restructuring offer that promises a return of r. Let us first consider the payoffs if the sovereign makes a successful restructuring offer. If the capital project output (f^H or f^L) in the second period exceeds the promised return r, the sovereign's pay-off equals output minus r and the bondholder's pay-off is r. If not, the sovereign's pay-off is zero, and the bondholder's pay-off equals the capital project output (f^H or f^L). If the restructuring offer is rejected, the capital project is liquidated and the sovereign's pay-off is $-C$ because of the costs of default. The bondholder seizes the liquidation value $k < 1$ of the capital project.

Proposition 5.1 shows that if the bondholder is fully informed about the state of the economy, crises are solved in the appropriate way.

Table 1 Payoffs with no CP

		High State	Low State
Sovereign	Accept	$\max(f^H - r, 0)$	$\max(f^L - r, 0)$
	Reject	$-C$	$-C$
Bondholder	Accept	$\min(r, f^H)$	$\min(r, f^L)$
	Reject	k	k

Proposition 5.1 *In the absence of protection and under symmetric information, crisis resolution is efficient.*

Proof. *(i)* The bondholder accepts in the high state if $\min(r, f^H) \geq k$ and accepts in the low state if $\min(r, f^L) \geq k$. Given that $f^H > k$ and $f^L < k$, this implies that the bondholder accepts in the high state if and only if $r \geq k$ (assuming a weak preference for accepting) and always rejects in the low state. *(ii)* Given $\max(f^H - r, 0) > -C$, the sovereign always prefers restructuring over default in the high state and hence offers the lowest r that makes the bondholder accept: $r = k$. In the low state, any restructuring offer is rejected. Equilibrium crisis resolution is hence restructuring with $r = k$ in the high state and default in the low state, which given equations (5.1) and (5.2) implies that the outcome is socially efficient. ■

Proposition 5.2 shows next that when the bondholder only knows about the prior distribution of the low and the high state, crisis resolution is not efficient anymore. Intuitively, this is because the sovereign always has an incentive to pretend to be in the high state in order to obtain a successful restructuring that avoids the costs of default. Therefore, the crisis can no longer be resolved conditional on the state of the economy, which an efficient outcome would require.

Proposition 5.2 *In the absence of protection and under asymmetric information, crisis resolution is inefficient.*

Proof. Since the bondholder is not informed about the state of the economy, both pooling equilibria (i.e. equilibria in which the restructuring offer is not contingent on the state of the economy) and separating equilibria (i.e. equilibria in which the restructuring offer is state-dependent and hence reveals the state of the economy) are in principal possible. However, a separating equilibrium does not exist as in the low state the sovereign always has an incentive to pretend to be in the high state. If he would not do so, any offer would be rejected (as shown under Proposition 5.1) and his pay-off would be $-C < 0$. In contrast, by pretending to be in the high state and making a sufficient restructuring offer, the sovereign can secure acceptance (as shown in Proposition 5.1) giving him a return of $\max(f^L - r, 0) > -C$. As a result, any equilibrium has to be a pooling equilibrium. This implies that crisis resolution is not dependent on the state of the economy, i.e. there is either default or restructuring, regardless of the country's state. Since socially efficient restructuring is state-conditional, pooling equilibria are therefore inefficient.[11] The detailed solution for the pooling equilibrium is provided in Appendix 1. ■

Note that under either assumption regarding the information the bondholder has about the country, there are issues of moral hazard since even though the bondholder does not fully get his debt repaid, the pay-off of the government is not necessarily zero.

[11] It can be shown that the outcome is inefficient even *within* the class of pooling equilibria: there are cases in which the outcome is a default pooling equilibrium, while actually a restructuring pooling equilibrium would lead to larger joint pay-offs. Intuitively, this is because the default costs C are non-monetary and can therefore not be pledged by the sovereign in a restructuring offer, leading to a 'rejection-bias' (see also Proposition 5.4 below).

5.5 Crisis Resolution under Credit Protection

We now analyze crisis resolution when the bondholder can buy credit protection (CP) using credit derivatives. Standard credit derivatives (such as credit default swaps) allow to insure against non-payment by the debtor. Payments are thereby triggered by a so-called 'credit event'. In our context, a credit event is defined as an event in which the debtor is no longer fulfilling his payment obligations to the bondholder and the bondholder has not voluntarily accepted a change of the repayment terms. Since the restructuring offer in our model is accepted on a voluntary basis, it does not qualify as a credit event. If, however, the debtor is unable to repay his debt in the aftermath of the exchange, this does qualify as a credit event, assuming that the non-delivery on the restructured bond falls within the period for which protection has been bought (see Verdier, 2004).[12]

We assume that credit derivatives can fully insure the bondholder against non-payment by the sovereign. Interpreting the bondholder's debt claims as consisting of a number of bonds and denoting with q the fraction of bonds the bondholder buys protection on, the bondholder is then paid $q \cdot 1 = q$ by the insurance seller when a credit event occurs. In return, the bondholder delivers the insured bonds to the insurance seller. We allow the bondholder to buy two different maturities of credit protection, which we call short term and long term protection. Under short-term CP, the bondholder is only insured throughout period 0, while under long-term CP the bondholder is also insured throughout period 1 (the essential difference for our analysis is that under the latter, the bondholder is also insured against non-delivery on the restructured bond). Furthermore, we assume that the insurance seller is risk neutral and behaves competitively. This implies that the price of protection, denoted p, equals the expected net payments of the insurance seller, that is the expected payment to the bondholder net of the expected receipts from the delivered bonds. In other words, the price of protection matches the future benefits of protection. Hence, the protection seller can be ignored in the welfare analysis, as he breaks even on average. Given that the bondholder is risk neutral and expected payments under the contract exactly match the price of protection paid by the bondholder, he only buys protection for strategic reasons, that is in order to improve his outside option in negotiations with the sovereign.

Table 2 shows the payoffs under short-term CP for a given level of protection q. For com-

[12] It should, however, be mentioned that recent court rulings have substantially increased uncertainty about the legal treatment of restructured bonds.

parability, the table does not include the price of protection p (which is sunk once protection has been obtained and thus does not affect the resolution process). The payoffs are identical to Table 1, except for the bondholder's pay-off from rejection. This is because the bondholder can now exercise insurance on the fraction q of his bonds and collect q from the insurance seller. On the uninsured bonds, the bondholder receives a proportional part of the liquidation value k, that is $(1-q)\cdot k$. The remainder of the liquidation value, $q \cdot k$, is seized by the insurance seller, who received the insured bonds under the insurance contract.

Table 2 Payoffs with short-term CP

		High State	Low State
Debtor	Accept	$\max(f^H - r, 0)$	$\max(f^L - r, 0)$
	Reject	$-C$	$-C$
Bondholder	Accept	$\min(r, f^H)$	$\min(r, f^L)$
	Reject	$q + (1-q)k$	$q + (1-q)k$

Proposition 5.3 compares crisis resolution and moral hazard when CP is available with the outcome in the absence of CP, as characterized by Propositions **??** and **??**.

Proposition 5.3 *Under short-term protection and long-term protection and for both symmetric and asymmetric information, crisis resolution is unchanged and moral hazard is lower compared to the no CP case.*

Proof. *Symmetric information and short-term CP: see Appendix 2*

Asymmetric information and short-term CP:

Crisis resolution:

(i) The bondholder accepts if $\pi^H \cdot \min(r, f^H) + (1-\pi^H)\cdot \min(r, f^L) \geq q + (1-q)k$, which, analogues to the no CP case, we can simplify and rearrange to get $\min(r, f^H) \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$. This leaves two possibilities. If $f^H < q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$, the bondholder always rejects as the needed return r is not feasible; if $f^H \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$, the bondholder accepts if $r \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$.

(ii) Given $\max(f^H - r, 0) > -C$ and $\max(f^L - r, 0) > -C$, the sovereign always prefers restructuring over default and hence offers minimum r that makes the bondholder

accept. If $f^H < q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$, no such r is feasible and there will always be default. If $f^H \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$, the debtor offers $r = q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$ and the bondholder accepts.

(iii) The bondholder strategically chooses q that maximizes his expected pay-off $U_B = \pi^H \left[R \cdot (q + (1-q)k) + (1-R) \cdot r\right] + (1-\pi^H) \left[R \cdot (q + (1-q)k) + (1-R) \cdot f^L\right] - p(q)$, where $R = R(q)$ is a dummy which is 1 for rejection and 0 for acceptance. We know that if $R = 0$, the bondholder is just indifferent between accepting and rejecting, that is $q + (1-q)k = \pi^H \cdot r + (1-\pi^H) \cdot f^L$. Substituting yields $U_B = (q + (1-q)k) - p(q)$. The price of protection is $p(q) = R \cdot (q(1-k))$[13], hence $U_B = (q + (1-q)k) - R \cdot (q(1-k))$. We know that $R = R(q)$ and that for $q = 0$, we are back in the no CP case with two possibilities. If $f^H < k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder always rejects as needed return r is not feasible, so $R(0) = 1$. In this case protection does not matter as there is always rejection, also for $q > 0$. If $f^H \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder accepts and $R(0) = 0$. In this case, protection does matter as the bondholder increases q until $q = \frac{\pi^H \cdot f^H + (1-\pi^H) \cdot f^L - k}{1-k}$. This is the maximum q for which there is acceptance, hence $R = 0$. Further increasing q would cause a shift from restructuring to default and a drop in the bondholder's pay-off from $q + (1-q)k$ to k. Note that the equilibrium q is lower than the equilibrium q in the high state equilibrium under symmetric information. This is because the bondholder cannot push the outside option as high as before, given that his maximum feasible pay-off under acceptance is now $\pi^H \cdot r + (1-\pi^H) \cdot f^L$ whereas it was r in the high state symmetric information case. This stems from the asymmetry of information which makes that the bondholder's pay-off could turn out to be f^L if the country is in the low state. The resolution outcome is unchanged compared to the no CP case as there is the same pooling equilibrium with either restructuring or default.

Moral hazard:

If offer is rejected, the sovereign's pay-off is $-(\pi^H \cdot C + (1-\pi^H) \cdot C)$, which is identical to the no CP case. If the offer is accepted, the sovereign's pay-off is $\pi^H \cdot (f^H - r)$. Hence, to show that moral hazard decreases, it suffices to show that the return r has increased. This return r is now $r = q + (1-q)k + \frac{1-\pi^H}{\pi^H}(q + (1-q)k - f^L)$ which exceeds the return r under no CP, $r = k + \frac{1-\pi^H}{\pi^H}(k - f^L)$ for $q > 0$. Hence, moral hazard is lower than in the no CP case.

Long-term CP: see Appendix 3 ■

As crisis resolution is unchanged, the outcome under asymmetric information is still socially

[13] the price of protection equals the expected payment under the insurance contract, $R \cdot q$, net of the expected receipts from the delivered bonds, $R \cdot q \cdot k$.

inefficient. As mentioned earlier, the outcome is even inefficient *within* the class of pooling equilibria, as in some cases restructuring is more efficient but does not take place. Proposition 5.4 shows then that long-term protection can be used to eliminate the latter inefficiency by switching from a socially less efficient 'rejection' equilibrium to an 'acceptance' equilibrium. The reason is that the bondholder is also insured against non-payment in period 1, thus making him more willing to accept a restructuring offer in period 1. However, as Proposition 5.4 also shows, this comes at the cost of increased moral hazard, which is because the joint payoffs for bondholder and sovereign have increased (since crisis resolution becomes more efficient), while the pay-off for the bondholder has not increased (if this were not the case, he would have chosen long-term protection to start with).

Proposition 5.4 *Under asymmetric information, there are parameter values for which the bondholder's choice of protection is not socially optimal in terms of crisis resolution. In such cases, crisis resolution can be improved through appropriate long-term protection; however, this comes at the cost of increased moral hazard.*

Proof. *Crisis resolution:* Consider parameter values (i) $\pi^H(k - C) + (1 - \pi^H)(k - C) < \pi^H \cdot f^H + (1 - \pi^H) \cdot f^L$ and (ii) $k > \pi^H \cdot f^H + (1 - \pi^H) \cdot f^L$. (i) implies that in a pooling equilibrium, acceptance is the socially optimal crisis resolution as the expected joint payoffs of bondholder and sovereign under rejection are lower than under acceptance. (ii) however, implies that the bondholder does not choose acceptance as his expected pay-off under acceptance, $\pi^H \cdot f^H + (1 - \pi^H) \cdot f^L$, is exceeded by his pay-off under rejection, k. We show next that appropriate long-term protection would achieve acceptance instead. Consider to this end long-term protection with $q = 1$. The bondholder's pay-off from rejection in period 0 (where any potential price of protection is sunk cost) is then 1, as he exercises his protection. If the bondholder accepts in the first period and the economy turns out to be in the low state, the bondholder's pay-off in period 1 is also 1, as he again exercises his protection. A restructuring offer of $r \geq 1$ will then secure acceptance since the bondholder's pay-off from doing so is $\pi^H \cdot r + (1 - \pi^H) \cdot 1 \geq 1$. In particular, a restructuring offer $r = 1$ will secure acceptance and is feasible for $f^H \geq 1$. This restructuring offer is also desirable for the sovereign as he always prefers restructuring over default.

Moral hazard: From (i) it follows that the joint pay-off of sovereign and bondholder has increased through the change from rejection to acceptance. Hence, to show that this comes at the cost of increased moral hazard (i.e., a higher pay-off for the sovereign), it suffices to show that the bondholder's pay-off has decreased. This pay-off is now $\pi^H \cdot 1 + (1 - \pi^H) \cdot 1 - p$. The price of protection p equals $(1-\pi^H)(1-f^L)$, so the bondholder's pay-off is $\pi^H \cdot 1 + (1-\pi^H) \cdot f^L$, which given $f^H \geq 1$ is lower than his pay-off k under rejection. Hence, the bondholder's pay-off has decreased and thus moral hazard has increased. ■

5.6 Litigation Costs

We now assume that when the bondholder wants to force the government to liquidate the project, he incurs litigation costs $l > 0$. Moreover, whenever there is a credible threat of litigation, it is assumed that the sovereign prefers to avoid litigation by paying right away. This implies that the litigation costs never materialize as litigation merely acts as a threat.

A litigation threat is credible when the bondholder's share in the liquidation value exceeds the litigation costs , i.e., $(1 - q)k > l$ (we assume that the protection seller never litigates, either because of cash settlement or because his exposure does not justify it). The benefits from litigation are $(1 - q)k$ because the bondholder exercises protection on the insured part of his bonds and hence only benefits from litigation to the extent that he holds a fraction of uninsured bonds $(1 - q)$. By contrast, if the benefits from litigation do not exceed the costs of litigation, the threat of litigation disappears and the sovereign can fully keep the liquidation value. We also assume that litigation costs are not binding in the absence of CP, i.e. $k > l$. We assume furthermore that $k > C$, which implies that if the sovereign can keep the liquidation value k in the low state, he chooses not to make a restructuring offer as his pay-off under no restructuring exceeds his pay-off under restructuring $(k - C > 0)$.

The main effect of CP (compared to a situation where litigation is costless) is that it reduces bondholder's benefits from litigation. This makes litigation less likely, which in turn may reduce sovereigns' pay-off in a crisis and increase moral hazard. However, the next proposition shows litigation costs have no influence on equilibrium outcomes as long as there is no switch to a separating equilibrium.

Proposition 5.5 *As long as there is no switch from a pooling to a separating equilibrium, Proposition 5.3 holds also in the presence of litigation costs, i.e., the introduction of protection does not affect crisis resolution but lowers moral hazard.*

Proof. In the presence of litigation costs, there is no switch from a pooling equilibrium to a separating equilibrium if either (i) the bondholder's benefits from litigation exceed the costs

($(1-q)k > l$) or (ii) the bondholder's costs of litigation do exceed the benefits but there is no separating equilibrium because the sovereign does not only prefer default in the low state but also in the high state, leading to a pooling equilibrium in which there is always default.

First consider (ii): in order for the costs of litigation to exceed the benefits, it must be that $(1-q)k < l$ or $q > 1 - \frac{l}{k}$. As a result, the threat of litigation is no longer credible and the sovereign always keeps the liquidation value k, given that there is always default. The bondholder's pay-off has now changed because of two reasons. First, he does no longer get the proportional part of the liquidation value k on his uninsured bonds, $(1-q)k$. Second, the price of protection increases because the insurance seller does no longer get his proportional part of the liquidation value k on the delivered bonds under the contract, $q \cdot k$, resulting in a price of protection of q. As a result, the bondholder's pay-off equals the payment under the insurance contract, q, minus the price of protection, q, which equals zero. Intuitively, the loss of the liquidation value is fully passed on to the bondholder through a higher price of protection. Given that the bondholder can secure himself a minimum pay-off of k by choosing not to buy protection, he will never choose a level of protection that results in this equilibrium with a zero pay-off.

Now consider (i): $(1-q)k \geq l$ or $q \leq 1 - \frac{l}{k}$. In this case the bondholder chooses protection such that the threat of litigation under default remains credible and the sovereign will fully pay the liquidation value k in case of default. As a result, the payoffs are no different from the cases without litigation costs. Now consider the possible changes in the equilibria for the cases of short-term and long-term CP with symmetric and asymmetric information. Let us define the equilibrium level of protection in any of the cases without litigation costs as q^*. Then if $q^* \leq 1 - \frac{l}{k}$, the equilibrium remains identical after introducing costs of litigation. This is because the level of protection that the bondholder chooses in the absence of litigation costs is lower than the level at which the threat of litigation starts losing credibility. Hence, the costs of litigation are non-binding and do not cause any change in equilibria.

Now consider the cases where $q^* > 1 - \frac{l}{k}$:

(1) Short-term CP and long-term CP under symmetric information: $q^* = \frac{f^H - k}{1-k}$, the equilibrium outcome is restructuring in the high state and default in the low state.

Crisis resolution: In the low state, there is always default and this is unchanged under litigation costs as for any level of protection the outside option exceeds the low-state output. In the high state, however, the bondholder's utility equals the utility in the cases without litigation costs, as long as $q < 1 - \frac{l}{k}$. Given that $q^* > 1 - \frac{l}{k}$, we know that for $q < 1 - \frac{l}{k}$ there is acceptance in the high state. Hence, the bondholder's utility equals:

for $q > 1 - \frac{l}{k}$: $U^B = 0$

for $q \leq 1 - \frac{l}{k}$: $U^B = \pi^H(q + (1-q)k) + (1 - \pi^H) \cdot k$

Maximizing over q thus implies increasing q until $q = 1 - \frac{l}{k}$, as further increasing q would cause a shift from restructuring to default in the high state and a drop in the bondholder's pay-off from $\pi^H(q+(1-q)k) + (1-\pi^H) \cdot k$ to 0. Hence, resolution outcome is still unchanged compared to the no CP case as there is restructuring in the high state and default in the low state, which is socially efficient.

Moral hazard: In the low state, the sovereign's total payoff is $-C$, which equals the pay-off under no protection. In the high state, the sovereign's pay-off is now $f^H - r = f^H - (q + (1-q)k) = f^H - (1 - \frac{l}{k} + l)$. Since $0 < q = 1 - \frac{l}{k} < q^*$ we know that $0 < f^H - r < f^H - k$. Although the sovereign's pay-off is higher than in the case without litigation costs, it is still lower than in the no CP case. Hence, moral hazard is lower than in the no CP case. Intuitively, the bondholder increases protection as much as possible but given the costs of litigation and $q^* > 1 - \frac{l}{k}$, he cannot increase it as much as before. However, he is still able to use protection as a means to increase his outside option and force the sovereign to offer a higher return.

(2) Short-term CP under asymmetric information: Proof shown in Appendix 4

(3) Long-term CP under asymmetric information: Proof shown in Appendix 4 ■

The reason that litigation costs have no influence here is that it is not in the bondholder's interest to choose a level of protection that renders litigation not credible. This is because the government can then keep the liquidation value when it defaults, from which the bondholder would suffer through a higher price of protection.

Proposition 5.6 shows next that there are cases in which the bondholder chooses a level of protection that leads to a loss of a credible litigation because it can create separating equilibria. Such equilibria can occur because if the government can keep the liquidation value k in a default in the low state (because litigation is not credible anymore), it loses its incentive to pretend to be in the high state. Hence, in such cases, credit protection improves crisis resolution. However, as shown in Proposition 5.7, the implications for moral hazard are ambiguous. This is because of two counteracting effects: on the one hand, the bondholder's pay-off has increased (otherwise he would not choose the separating equilibrium) but on the other hand the joint payoffs have also increased (because crisis resolution has improved).

Proposition 5.6 *Under certain conditions, protection improves crisis resolution by allowing for a switch from unconditional crisis resolution (pooling equilibrium) to conditional crisis resolution (separating equilibrium).*

Proof. Consider the following condition: (1) $\pi^H(f^H - (k - C)) \geq 1 - \frac{l}{k} + l$. Assume asymmetric information and suppose the bondholder chooses short-term protection with $q = f^H - (k - C)$. We first show that this leads to a separating equilibrium (i.e., $r^L \neq r^H$, where r^L is the return offered in the low state and r^H is the return offered in the high state), in which there is restructuring in the high state and default in the low state.

Low state: The threat of litigation is no longer credible if $(1 - q)k < l$ or $(1 - f^H + (k - C)) \cdot k < l$ or $f^H > k - C + 1 - \frac{l}{k}$. This is satisfied as from condition (1) it follows that $f^H \geq k - C + \frac{1-\frac{l}{k}+l}{\pi^H}$. Given that litigation is not credible anymore, the sovereign's pay-off under default is now $k - C > 0$. To make the bondholder accept, the sovereign has to offer at least the outside option, which is now q, as the bondholder does no longer receive any payment on his uninsured bonds. It follows that the sovereign's period-1 pay-off under acceptance is $\max(f^L - q, 0) = \max(f^L - (f^H - (k - C)), 0)$, which is lower than the pay-off from default, $k - C$. The sovereign thus offers $r^L < q$, leading to default.

High state: the sovereign's pay-off is $k - C$ under default and $f^H - r = f^H - q = k - C$ under restructuring. Hence, given that the sovereign has a weak preference for acceptance, he offers $r^H = q$ (which is feasible since $q \leq f^H$), leading to acceptance. Note that $r^L \neq r^H$ and hence we have a separating equilibrium.

Next, we show that the bondholder indeed prefers to move into such a separating equilibrium. Consider the highest level of q for which there is still a pooling equilibrium: $(1 - q)k = l$ or $q = 1 - \frac{l}{k}$. In this pooling equilibrium, there will be acceptance if $f^H \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$ (Appendix 1), or $f^H \geq f^L + \frac{k-f^L}{\pi^H}$. From condition (1) it follows that $f^H \geq k - C + \frac{1-\frac{l}{k}+l}{\pi^H}$, which, given that $k - C > f^L$ and $1 - \frac{l}{k} + l = q + (1 - q)k > k - f^L$, implies that $f^H \geq f^L + \frac{k-f^L}{\pi^H}$, hence there is acceptance in the pooling equilibrium. The bondholder's pay-off is then $U_B = q + (1 - q)k = 1 - \frac{l}{k} + l$ since this is the bondholder's outside option. The bondholder's pay-off in the new separating equilibrium is $U_B = \pi^H \cdot r^H = \pi^H(f^H - (k - C))$, since he does not litigate in the low state and thus only benefits in the high state. By condition (1) we have that the bondholder is better off in a separating equilibrium. Hence, crisis resolution is improved because it is now state-conditional. ■

Proposition 5.7 *The impact of a switch to a separating equilibrium on moral hazard is am-*

biguous, i.e., there are cases in which moral hazard increases and cases in which it decreases.

Proof. The sovereign's pay-off under no CP and asymmetric information is $P^{NP} = \pi^H \cdot f^H + (1- \pi^H) \cdot f^L - k$. The sovereign's pay-off in the separating equilibrium above equals $P^{SE} = k - C$. Moral hazard increases if P^{SE} exceeds P^{NP} and vice versa.

$P^{SE} - P^{NP} = k - C - (\pi^H \cdot f^H + (1- \pi^H) \cdot f^L - k)$. We know from condition (1) in the proposition above that $f^H \geq k - C + \frac{1-\frac{l}{k}+l}{\pi^H}$. Substituting yields $P^{SE} - P^{NP} \leq (1-\pi^H) \cdot (k-C) - (1-\frac{l}{k}+l+(1- \pi^H) \cdot f^L - k) = (1-\pi^H) \cdot (k-C-f^L) - (k-l) \cdot (\frac{1-k}{k})$. Given $k - C > f^L$, $k > l$, and $k < 1$, we know that the first part of this term, $(1-\pi^H) \cdot (k-C-f^L)$ is positive whereas the second term, $-(k-l) \cdot (\frac{1-k}{k})$, is negative.

Next, we show that in some cases moral hazard increases and in some cases it decreases. First, consider the case in which the low-state output f^L is infinitely close to $k - C$, hence the first term, $(1 - \pi^H) \cdot (k - C - f^L)$, is infinitely close to zero. As a result, $P^{SE} - P^{NP} < 0$ and hence moral hazard decreases as the sovereign's pay-off in the separating equilibrium is smaller than in the no CP case.

Second, consider the case in which $f^H = k - C + \frac{1-\frac{l}{k}+l}{\pi^H}$, so $P^{SE} - P^{NP} = (1 - \pi^H) \cdot (k - C - f^L) - (k - l) \cdot (\frac{1-k}{k})$. Also, assume that the litigation costs l are infinitely close to k, hence the second term, $-(k-l) \cdot (\frac{1-k}{k})$, is infinitely close to zero. As a result, $P^{SE} - P^{NP} > 0$ and hence moral hazard increases as the sovereign's pay-off in the separating equilibrium is larger than in the no CP case. ∎

5.7 Summary and Conclusions

This chapter has analyzed the implications of credit derivatives for sovereign debt crises. We find that if bondholders are fully informed about the type of crisis the country is facing, the availability of credit derivatives is welfare improving, even though crisis resolution in the absence of protection is already efficient. This is because credit protection improves sovereigns' incentives to avoid crises while at the same time leaving the ex-post efficient crisis resolution unchanged.

The improved incentives arise from the fact that protection allows a bondholder to increase his payoffs in a default. As a result, a sovereign has to offer a higher return for the bondholder to accept a restructuring offer, which forces the sovereign to internalize a larger part of the cost of the crisis and thus improves his incentives to avoid a crisis. However, even though this provides the bondholder with an incentive to increase protection, he has no incentive to choose a level of protection that reduces the efficiency of crisis resolution by leading to an inefficient rejection. This is because the bondholder would suffer from this either directly, through reduced payoffs in a crisis, or indirectly, through a higher price of protection because protection has to be used more often. Hence, a bondholder chooses the highest possible level of protection for which crisis resolution is unchanged so as to extract the maximum possible return from the sovereign.

If bondholders cannot observe the type of crisis (asymmetric information), we find that in the absence of protection, crisis resolution is no longer socially efficient. This is because the sovereign has an incentive to pretend to be in a liquidity crisis when in fact suffering from a fundamental crisis, to escape the cost of defaulting. This leads to pooling equilibria with either acceptance or rejection, i.e. the crisis resolution is unconditional. For similar reasons as before, we find that the bondholder uses protection to improve the sovereign's restructuring offer as much as possible without changing crisis resolution. Sovereign incentives are therefore improved, while crisis efficiency is unchanged. We do find, however, that the bondholder does not always choose the socially optimal level of protection: in some cases long-term protection would be more desirable by allowing for a socially desirable shift from rejection to acceptance. Thus, there is a potential case for intervention.

When allowing for costly litigation, we find that protection under certain conditions improves crisis resolution by leading to a switch from unconditional crisis resolution (pooling equilibrium) to the socially efficient conditional crisis resolution (separating equilibrium). This is because for sufficiently high levels of protection, the bondholder does not litigate anymore and hence the sovereign's pay-off under default increases. As a result, the sovereign loses his incentive to pretend to be in a liquidity crisis while actually being in a fundamental crisis, which can lead to an equilibrium in which the sovereign truthfully reveals the crisis type. The impact on moral hazard is then ambiguous, as both the bondholder's pay-off and the joint pay-off increase and hence the change in the sovereign's pay-off can be positive or negative.

Summarizing, we find that in most cases credit protection improves sovereigns' incentives to avoid crises ex-ante by increasing the outside option of bondholders. Furthermore, even though possible, in most cases credit protection does not change the efficiency of crisis resolution as bondholders do not have an incentive to induce inefficient levels of protection. Under asymmetric information and costly litigation, protection under certain conditions even induces a switch from inefficient unconditional crisis resolution to socially efficient conditional crisis resolution. Nevertheless, the bondholder does not always choose the socially efficient level of protection: in some cases under asymmetric information, long-term protection might be used as an intervention device to improve the efficiency of crisis resolution.

Hence, our analysis suggests that the availability of credit derivatives is in most cases beneficial. It should be kept in mind, however, that our analysis has left out several important aspects of sovereign debt restructuring, such as potential hold-out problems, the potential impact of credit protection on the orderliness of the restructuring process, and the role played by credit protection that is not chosen for strategic reasons. Further research is needed to address these issues.

5.8 Appendices

Appendix 1

Proposition 5.2: Solution for the pooling equilibrium

(i) Given his priors about the state of the economy, the bondholder accepts if his expected payoffs from acceptance are larger than from rejection: $\pi^H \cdot \min(r, f^H) + (1-\pi^H) \cdot \min(r, f^L) \geq k$. Given $f^L < k$, this implies that an acceptance r has to be strictly larger than k, since $\pi^H \cdot k + (1-\pi^H) \cdot f^L < k$. Hence, whenever there is acceptance we have $\min(r, f^L) = f^L$. A bondholder accepts if $\pi^H \cdot \min(r, f^H) + (1-\pi^H) \cdot f^L \geq k$ or if $\min(r, f^H) \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$. This leaves two possibilities. If $f^H < k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder rejects any restructuring offer either because its expected pay-off falls short of k or because it is not credible (i.e. $r > f^H$). On the other hand, if $f^H \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder accepts if $r \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$.

(ii) Given $\max(f^H - r, 0) > -C$ and $\max(f^L - r, 0) > -C$, the sovereign always prefers restructuring over default. If $f^H \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the sovereign offers the minimum r that makes the bondholder accept: $r = k + \frac{1-\pi^H}{\pi^H}(k - f^L)$ and bondholder accepts.. If $f^H < k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, no such r is feasible and there will always be default.

Appendix 2

Proposition 5.3: Proof for symmetric information and short-term CP

Proof. *Symmetric information and short-term CP:*

Crisis resolution:

(i) The bondholder accepts in the high state if $\min(r, f^H) \geq q + (1-q)k$ and accepts in the low state if $\min(r, f^L) \geq q + (1-q)k$. Given that $f^L < k$ and $q + (1-q)k \geq k$, the bondholder always rejects in the low state. If $f^H < q + (1-q)k$, the bondholder also rejects in the high state. If $f^H \geq q + (1-q)k$, the bondholder accepts in the high state if $r \geq q + (1-q)k$.

(ii) Given $\max(f^H - r, 0) > -C$, the sovereign in the high state always prefers restructuring over default and hence offers minimum r that makes the bondholder accept. If $f^H < q + (1-q)k$, no such r is feasible and there will always be default. If $f^H \geq q + (1-q)k$, the debtor offers $r = q + (1-q)k$ and the bondholder accepts. In the low state, any restructuring offer is rejected.

(iii) The bondholder strategically chooses q that maximizes his expected pay-off $U_B = \pi^H \left[R^H \cdot (q + (1-q)k) + (1 - R^H) \cdot (q + (1-q)k)\right] + (1 - \pi^H)\left[q + (1-q)k\right] - p(q)$, where $R^H = R^H(q)$ is a dummy which is 1 for rejection and 0 for acceptance in the high state. $p(q)$ is the price of protection. The price of protection reflects the expected net future payments under the contract. Recall that if the bondholder exercises his insurance, the insurance seller pays the bondholder q and seizes the proportional part of the liquidation value, $q \cdot k$. The price of protection is $p(q) = \pi^H \cdot R^H \cdot (q(1-k)) + (1 - \pi^H) \cdot (q(1-k)) = q(1-k) \cdot [\pi^H \cdot R^H + (1 - \pi^H)]$. Substituting in the bondholder's utility function yields: $U = \pi^H \left[R^H \cdot k + (1 - R^H) \cdot (q + (1-q)k)\right] + (1 - \pi^H) \cdot k$. We know that if $f^H \geq q + (1-q)k$, the bondholder accepts the offer, hence $R^H = 0$. Given that $f^H > k$, this is satisfied for $q = 0$. For higher levels of q, it is also satisfied until q reaches a level for which $f^H < q + (1-q)k$, where the bondholder rejects, hence $R^H = 1$. Returning to the bondholder's utility function, maximizing over q thus implies increasing q until $q = \frac{f^H - k}{1-k}$, as further increasing q would cause a shift from restructuring to default and a drop in the bondholder's high-state pay-off from $q + (1-q)k = f^H$ to k. Hence, resolution outcome is unchanged compared to the no CP case as there is restructuring in the high state and no restructuring in the low state, which is socially efficient.

Moral hazard: In the low state, the sovereign's total payoff is $-C$, which equals the pay-off under no protection. In the high state, the sovereign's pay-off is now zero, while under no protection his pay-off was $f^H - k$. Thus, the sovereign's overall pay-off in a crisis has fallen and hence moral hazard is lower than in the no CP case. ■

Appendix 3

Crisis Resolution under Credit Protection: results for long-term CP

Table 3 shows the payoffs under long-term CP for a bondholder that holds insurance on a fraction q of his bonds. Table 3 differs from Table 2 in two ways. First, to simplify things, Table 3 already implicitly assumes that for any restructuring offer to be potentially successful, it needs to satisfy two conditions. First, the promised return should not exceed the high-state output ($f^H \geq r$) or else the offer is not credible. Second, the promised return should at least equal the liquidation value ($r \geq k$), or else the bondholder never accepts. As a result, the sovereign's pay-off under acceptance is $f^H - r$ or 0 in the high and low state, respectively. Analogues, the bondholder's pay-off under acceptance in the high state is r.

The second way in which Table 3 differs from Table 2 is that the bondholder's pay-off in the low state is now $q + (1-q)f^L$ instead of $\min(r, f^L)$. This is because the bondholder is now (partially) insured throughout period 1 as well. Since $r \geq k$ and $f^L < k$, it follows that in the low state the sovereign is not able to pay the bondholder the promised return r and hence the bondholder exercises his insurance contract. As a result, he receives q from the protection seller and $(1-q)f^L$ from seizing a proportional part of the low-state output f^L.

Again, the price of protection p is a sunk cost at this stage and is therefore not included in the table.

Table 3 Payoffs with long-term CP

		High State	Low State
Debtor	Accept	$f^H - r$	0
	Reject	$-C$	$-C$
Bondholder	Accept	r	$q + (1-q)f^L$
	Reject	$q + (1-q)k$	$q + (1-q)k$

Proof. *Symmetric information and long-term CP:*

Crisis resolution:

(i) The bondholder accepts in the high state if $r \geq q + (1-q)k$ and accepts in the low state if $q + (1-q)f^L \geq q + (1-q)k$. Given that $f^L < k$ and $q \leq 1$, the bondholder always rejects in the low state, analogues to the short-term CP case. If $f^H < q + (1-q)k$, the

bondholder also rejects in the high state. If $f^H \geq q + (1-q)k$, the bondholder accepts in the high state if $r \geq q + (1-q)k$, analogues to short CP case.

(ii) Given $\max(f^H - r, 0) > -C$, the sovereign in the high state always prefers restructuring over default and hence offers minimum r that makes the bondholder accept. If $f^H < q+(1-q)k$, no such r is feasible and there will always be default. If $f^H \geq q+(1-q)k$, the debtor offers $r = q + (1-q)k$ and the bondholder accepts. In the low state, any restructuring offer is rejected.

(iii) The bondholder strategically chooses q that maximizes his expected pay-off

$$U_B = \pi^H \left[R^H \cdot (q + (1-q)k) + (1 - R^H) \cdot (q + (1-q)k)\right] + (1 - \pi^H)\left[q + (1-q)k\right] - p(q),$$

where $R^H = R^H(q)$ is a dummy which is 1 for rejection and 0 for acceptance in the high state. $p(q)$ is the price of protection.

Remainder of proof and equilibrium identical to short-term CP

Moral hazard: identical to short-term CP

Asymmetric information and long-term CP:

Crisis resolution:

(i) The bondholder accepts if $\pi^H \cdot r + (1-\pi^H) \cdot (q + (1-q)f^L) \geq q + (1-q)k$, which we can rearrange to get $r \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$. This leaves two possibilities. If $f^H < q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$, the bondholder always rejects as the needed return r is not feasible; if $f^H \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$, the bondholder accepts if $r \geq q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$.

(ii) Given $\max(f^H - r, 0) > -C$ and $0 > -C$, the sovereign always prefers restructuring over default and hence offers the minimum r that makes the bondholder accept. If $f^H < q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$, no such r is feasible and there will always be default. If $f^H \geq q+(1-q)k+\frac{1-\pi^H}{\pi^H}(1-q)(k-f^L)$, the sovereign offers $r = q+(1-q)k+\frac{1-\pi^H}{\pi^H}(1-q)(k-f^L)$ and the bondholder accepts.

(iii) The bondholder strategically chooses q that maximizes his expected pay-off $U_B = \pi^H \left[R \cdot (q + (1-q)k) + (1-R) \cdot r\right] + (1-\pi^H)\left[R \cdot (q + (1-q)k) + (1-R) \cdot (q + (1-q)f^L)\right] - p(q)$, where $R = R(q)$ is a dummy which is 1 for rejection and 0 for acceptance. We know that if $R = 0$, the bondholder is just indifferent between accepting and rejecting, that is $q + (1-q)k = \pi^H \cdot r + (1-\pi^H) \cdot (q + (1-q)f^L)$. Substituting yields $U_B = (q + (1-q)k) - p(q)$. The price of protection is $p(q) = R \cdot (q(1-k)) + (1-R) \cdot (1-\pi^H) \cdot (q(1-f^L)$[14], hence

[14] the price of protection consists of two parts: the expected payment under the insurance contract, q, net of the expected receipts from the delivered bonds, $q \cdot k$, in case of *rejection* ($R = 1$); and the expected payment q,

$U_B = (q + (1-q)k) - R \cdot (q(1-k)) - (1-R) \cdot (1-\pi^H) \cdot (q(1-f^L)$

We know that $R = R(q)$ and that for $q = 0$, we are back in the no CP case with two possibilities. If $f^H < k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder always rejects as needed return r is not feasible, so $R(0) = 1$. In this case protection does not matter as there is always rejection, also for $q > 0$. If $f^H \geq k + \frac{1-\pi^H}{\pi^H}(k - f^L)$, the bondholder accepts and $R(0) = 0$. In this case, protection does matter as the bondholder increases q until $q = \frac{\pi^H \cdot f^H + (1-\pi^H) \cdot f^L - k}{1-k-(1-\pi^H)(1-f^L)}$.[15] This is the maximum q for which there is acceptance, hence $R = 0$. Further increasing q would cause a shift from restructuring to default and a drop in the bondholder's pay-off from $q + (1-q)k - (1-\pi^H) \cdot (q(1-f^L)$ to k.[16] The resolution outcome is unchanged compared to the no CP case as there is the same pooling equilibrium with either restructuring or default.

Moral hazard: If the offer is rejected, the sovereign's pay-off is $-(\pi^H \cdot C + (1-\pi^H) \cdot C)$, which is identical to the no CP case. If the offer is accepted, the sovereign's pay-off is $\pi^H \cdot (f^H - r)$, analogues to the no CP case. Hence, to show that moral hazard decreases, it suffices to show that the return r has increased. This return r is now $r = q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L)$ which exceeds the return r under no CP, $r = k + \frac{1-\pi^H}{\pi^H}(k - f^L)$ for $q > 0$[17]. Hence, moral hazard is lower than in the no CP case. ■

net of the expected receipts from the delivered bonds, $q \cdot f^L$, in case of acceptance in the low state.

[15] In contrast to earlier cases, the equilibrium level of q can be negative. Intuitively, this is because higher protection not only increases the bondholder's pay-off under rejection (his outside option) but also increases his pay-off under acceptance in the low state. If the second effect dominates the first $(1-\pi^H) \cdot (1-f^L) > 1-k$), the return r that the sovereign has to offer to make the bondholder accept, actually goes down for higher levels of q. Since this would mean that long-term CP would never be bought, we rule out this possibility by assumption.

[16] Note that the equilibrium q is higher than the equilibrium q in the short-term CP case. Again, this is because increasing long-term CP not only improves the bondholder's outside option but also his pay-off under acceptance in the low state. Given this higher pay-off, the return r that the sovereign has to offer to make the bondholder accept, is lower for given q. Hence, to extract the maximum possible r, the bondholder has to increase protection beyond the short-term CP equilibrium value.

[17] $q + (1-q)k + \frac{1-\pi^H}{\pi^H}(1-q)(k - f^L) - k + \frac{1-\pi^H}{\pi^H}(k - f^L) = q(1 - f^L - \frac{1}{\pi^H}(k - f^L))$.

given our earlier assumption that $(1-\pi^H) \cdot (1-f^L) \leq 1-k$ or $\frac{k-f^L}{\pi^H} \leq 1 - f^L$, it follows that $q(1 - f^L - \frac{1}{\pi^H}(k - f^L)) \geq 0$

Appendix 4

Remainder of proof Proposition 5.5:

Proof. (2) Short-term CP under asymmetric information: $q^* = \frac{\pi^H \cdot f^H + (1-\pi^H) \cdot f^L - k}{1-k}$, the equilibrium outcome is a pooling equilibrium with either restructuring or default.

Crisis resolution: If there is default in the case without litigation costs, protection does not matter as there is always rejection. Introducing litigation costs does not change this. If there is a pooling equilibrium with acceptance, however, and given that $q^* > 1 - \frac{l}{k}$, we know that for $q \leq 1 - \frac{l}{k}$, there is also acceptance. Hence, the bondholder's utility equals:

for $q > 1 - \frac{l}{k}$: $U^B = 0$ (analogues to (1))

for $q \leq 1 - \frac{l}{k}$: $U^B = q + (1-q)k$

Maximizing over q thus implies increasing q until $q = 1 - \frac{l}{k}$, as further increasing q would cause a shift from restructuring to default and a drop in the bondholder's pay-off from $q + (1-q)k$ to 0. Hence, resolution outcome is unchanged compared to the no CP case as there is still the same pooling equilibrium with either restructuring or default.

Moral hazard: If the offer is rejected, the sovereign's pay-off is $-(\pi^H \cdot C + (1-\pi^H) \cdot C)$, which is identical to the no CP case. If the offer is accepted, the sovereign's pay-off is $\pi^H \cdot (f^H - r)$, analogues to the no CP case. Hence, to show that moral hazard decreases, it again suffices to show that the return r has increased. We know that $\pi^H \cdot r + (1-\pi^H) \cdot f^L = q + (1-q)k = 1 - \frac{l}{k} + l$. It follows that $r = \frac{1 - \frac{l}{k} + l - f^L}{\pi^H} + f^L$. We also know that the return r under no CP equals $r = k + \frac{1-\pi^H}{\pi^H}(k - f^L) = \frac{k - f^L}{\pi^H} + f^L$. Given that $q + (1-q)k = 1 - \frac{l}{k} + l > k$ for $q > 0$, it follows that the return r has increased. Hence, moral hazard is lower than in the no CP case.

Intuitively, the bondholder again increases protection as far as possible but given the costs of litigation and $q^* > 1 - \frac{l}{k}$, he cannot increase it as much as before. However, he is still able to use protection as a means to increase his outside option and force the sovereign to offer a higher return.

(3) Long-term CP under asymmetric information: $q^* = \frac{\pi^H \cdot f^H + (1-\pi^H) \cdot f^L - k}{1-k-(1-\pi^H)(1-f^L)}$, the equilibrium outcome is a pooling equilibrium with either restructuring or default.

Crisis resolution: If there is default in the case without litigation costs, protection does not matter as there is always rejection. Introducing litigation costs does not change this. If there is a pooling equilibrium with acceptance, however, and given that $q^* > 1 - \frac{l}{k}$, we know that for $q \leq 1 - \frac{l}{k}$, there is also acceptance. Hence, the bondholder's utility equals:

for $q > 1 - \frac{l}{k}$: $U^B = 0$ (analogues to (1))

for $q \leq 1 - \frac{l}{k}$: $U^B = q + (1-q)k - (1-\pi^H) \cdot (q(1-f^L)$

Maximizing over q thus implies increasing q until $q = 1 - \frac{l}{k}$, as further increasing q would cause a shift from restructuring to default and a drop in the bondholder's pay-off from $q + (1-q)k - (1-\pi^H) \cdot (q(1-f^L)$ to 0. Hence, resolution outcome is unchanged compared to the no CP case as there is still the same pooling equilibrium with either restructuring or default.

Moral hazard: If the offer is rejected, the sovereign's pay-off is $-(\pi^H \cdot C + (1-\pi^H) \cdot C)$, which is identical to the no CP case. If the offer is accepted, the sovereign's pay-off is $\pi^H \cdot (f^H - r)$, analogues to the no CP case. Hence, to show that moral hazard decreases, it again suffices to show that the return r has increased. We know that $\pi^H \cdot r + (1-\pi^H) \cdot (q + (1-q)f^L) = q + (1-q)k = 1 - \frac{l}{k} + l$. It follows that $r = \frac{q+(1-q)k-(1-\pi^H)\cdot(q+(1-q)f^L)}{\pi^H}$. We also know that the return r under no CP equals $r = \frac{k-(1-\pi^H)\cdot f^L}{\pi^H}$. Hence, the return has increased if $\frac{(1-k)\cdot q}{\pi^H} > \frac{(1-\pi^H)\cdot(1-f^L)\cdot q}{\pi^H}$ or if $(1-k) > (1-\pi^H) \cdot (1-f^L)$, which holds by assumption (Appendix 3). ■

Chapter 6

Summary and Conclusions

Over the last decades, many countries and regions around the world have suffered from financial crises. Mexico ('73-'82) and Argentina ('78-'81) were early examples. In the nineties, several countries in Europe ('92-'93), again Mexico ('94-'95), East Asia ('97-'98), Russia ('98), and Brazil ('99) followed. More recently, Turkey ('00-'01) and Argentina ('01-'02) were hit by this painful event. Although these crises have already been subject to many debates among both policymakers and academics, their origin remains the source of much controversy. From an academic perspective, an extensive economic literature has evolved, both theoretical and empirical. Financial crises are often divided in currency crises, banking crises, and debt crises. This thesis consists, next to an introductory chapter and a concluding chapter, of two parts that each focus on a different type of crisis. Part I (Chapters 2 to 4) focused on the linkages between currency crises, monetary policy, and financial fragility. Part II (Chapter 5) shifted the focus towards debt crises.

Chapter 1 provided an introduction to the topic and a literature review. It explained how first-generation models of currency crises, developed in response to crises in Latin America in the 1970s and early 1980s, focus on the monetary financing of structural government deficits which leads to a gradual depletion of the central bank's foreign reserves. At some point in time, a speculative attack occurs which wipes out the central bank's remaining stock of foreign reserves and leads to a collapse of the fixed exchange rate regime.

Although well explaining the early crises in Latin America, first-generation models suffered from some weaknesses. This became particularly apparent after the crisis in the European Monetary System (EMS) in 1992 and 1993, which was not preceded by structural government deficits or a gradual depletion of foreign reserves. Instead, governments widened their exchange rate bands due to sudden severe speculative attacks on their currencies. This raised questions on whether the crises could be explained solely by fundamentals or whether speculative attacks contained self-fulfilling features. In response to these questions, a new strand of 'second-generation' models emerged. These models show that if policymakers face a trade-off between exchange rate stability and other objectives[1], the future level of the exchange rate may be subject to multiple equilibria. If the market does not expect a devaluation, the costs of maintaining a fixed exchange rate remain low and the policymakers choose to hold on to it. However, if market participants do expect a devaluation, this expectation can become self-fulfilling because it increases the costs of maintenance by forcing policymakers to raise the interest rate.

Although first- and second-generation models have done reasonably well in explaining many past crisis episodes, they do not seem to fully explain the more recent crisis in East Asia ('97-'98). On July 2nd 1997 the Thai central bank decided to abandon the fixed exchange rate of the baht with the US dollar. This ushered in the start of the East Asian crisis in 1997 and 1998. Again, the crisis was characterized by features that were not central to earlier crises episodes. Hence, new models were needed and it was not long until a new strand of literature emerged. This literature, sometimes referred to as 'third-generation literature', stresses the importance of balance sheet vulnerabilities and international capital flows. Balance sheet crisis literature has seen two classes of models. The first class of models considers a combination of currency and maturity mismatches on banks' balance sheets, where crises are characterized by runs on short-term foreign currency debt. The second class of models only considers a currency mismatch in corporate balance sheets, where crises are characterized by a credit crunch and a drop in investment. In both cases, crises can be self-fulfilling, as the depreciation of the real exchange rate inflates foreign currency debt on balance sheets, which has severe adverse effects that validate prior crisis expectations.

Chapter 2 added to this balance sheet crisis literature by studying how the exposure of a country's corporate sector to changes in the short-term interest rate and the exchange rate affects the decision of monetary authorities to maintain or abandon a fixed exchange rate. In particular, it modelled the costs of maintenance and the costs of abandonment in terms of deviations of output and inflation from their desired levels. It then analyzed the effects of high levels of domestic and foreign currency debt on the probability of crisis.

[1] In the case of the EMS crisis, mounting unemployment in several participating countries eroded their commitment to the exchange rate mechanism and increased the costs of an interest rate defense.

Higher domestic currency debt increases the costs of maintenance through its positive effect on the risk premium paid on external funds, which depresses investments and output. It also lowers the costs of abandonment as the impact of an interest rate cut on output increases. This is because, aside from the initial interest rate cut, the interest rate drops further through the impact on the risk premium. As firms are heavily exposed to the short-term interest rate, cutting this interest rate improves their balance sheet position and lowers the required risk premium on their external finance.

Hence, higher domestic currency debt increases the costs of maintenance and lowers the costs of abandonment. As a result, the probability of a crisis, defined as an abandonment of the fixed exchange rate, increases for higher levels of domestic debt.

By contrast, the effect of *foreign currency debt* on the probability of crisis is shown to be ambiguous. Whereas it increases the costs of maintenance, analogues to the case of domestic debt, it also increases the costs of abandonment as the depreciation that follows from it has adverse balance sheet effects that lead to higher risk premiums.

The analysis in Chapter 2 concluded that, to reduce the probability and the output costs of currency crises, countries might want to limit the maturity and currency mismatch on the balance sheet of their corporate sectors. Possible solutions are the development of local equity markets and the introduction of adequate financial supervision and regulation.

Chapters 3 and 4 shed some light on the debate among both policymakers and academics about the appropriate stance of monetary policy both during speculative attacks and in the aftermath of fixed exchange rate collapses. According to the so-called 'traditional view', a tighter monetary policy is necessary to discourage the outflow of capital and thus prevent a devaluation of the exchange rate. The 'revisionist view' argues that when speculative attacks are accompanied by substantial balance-sheet problems in the private sector, a tightening of monetary policy may actually have a counterproductive effect on the exchange rate. The chapters assessed both views empirically by studying the impact of monetary policy on exchange rates, again in relation to corporate balance sheets. The central hypothesis of both chapters is that raising the interest rate to support the exchange rate has larger adverse effects and is therefore less effective in countries where the corporate sector is more short-term indebted.

In particular, **Chapter 3** looked at the impact of monetary policy *ex ante*, i.e. before a potential crisis occurs. It asked whether the efficacy of monetary policy to defend a fixed exchange rate during speculative attacks depends on the level of a country's short-term corporate debt. In order to test this hypothesis, a dataset was constructed that includes an aggregate indicator of short-term debt and alternative measures of monetary policy for countries with fixed exchange rate regimes that faced severe speculation against their currency during the period 1986-2002. The estimation results confirm that the efficacy of monetary policy in defending a fixed exchange rate depends on the level of short-term corporate debt. For levels of short-term debt that are not too high, raising interest rates lowers the probability of a successful speculative attack ('currency crisis'). This effect decreases and eventually changes sign for higher levels of debt.

In contrast to Chapter 3, **Chapter 4** considers the impact of monetary policy *ex post*, i.e. in the aftermath of fixed exchange rate collapses ('currency crises') when the currency is floating. The central hypothesis is again that the impact of monetary policy depends on the indebtedness of the corporate sector, which is confirmed by the results. Whereas raising interest rates appreciates the exchange rate when short-term debt levels are relatively low, this effect becomes weaker and changes sign for higher levels of short-term debt. The results hold for both the impact on the nominal exchange rate and the impact on the real exchange rate.

Summarizing, **Chapters 3 and 4** provide strong evidence of a non-linear effect of monetary policy on exchange rates, both during speculative attacks preceding currency crises and in the aftermath of such crises. The results showed that the traditional and revisionist views are not mutually exclusive. They also provided a possible explanation for some of the mixed findings in the empirical literature.

Part II shifted the focus towards debt crises. **Chapter 5** theoretically analyzed the implications of credit derivatives for sovereign debt restructuring. An important part of the wide range of financial innovations that has recently been introduced in financial markets, relates to so-called 'credit derivatives'. These derivatives represent contracts under which a so-called protection seller promises to pay an agreed sum to the protection buyer in case the reference bond does not perform. Hence, they provide bondholders with insurance against credit risk. The market for credit derivatives has grown substantially over the last years and sovereign credit derivatives, which provide protection on sovereign bonds, constitute a significant part of this fast-growing market. **Chapter 5** argued that the introduction of credit derivatives can have important implications for the efficiency of sovereign debt restructuring, as it can fundamentally change the incentives for bondholders to accept a sovereign's restructuring offer. In particular, bondholders that have insured themselves against default through buying credit derivatives are likely to be less inclined to accept restructuring offers. This shifts negotiating power from the sovereign to the bondholder and could alter the efficiency of crisis resolution. The main finding is that in most cases credit protection improves sovereigns' incentives to avoid crises ex-ante by increasing the outside option of bondholders. Furthermore, even though possible, in most cases credit protection does not change the efficiency of crisis resolution as bondholders do not have an incentive to induce inefficient levels of protection. Under asymmetric information and costly litigation, protection under certain conditions even induces a switch from inefficient unconditional crisis resolution to socially efficient conditional crisis resolution. Nevertheless, the bondholder does not always choose the socially efficient level of protection: in some cases under asymmetric information, long-term protection might be used as an intervention device to improve the efficiency of crisis resolution.

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Summary in Dutch

De geschiedenis van financiële crises gaat ver terug in de tijd. Reeds in 1863 schreef Joseph Holbrey naar aanleiding van een crisis in Engeland in 1857 dat het toenmalige financiële systeem eens in de zoveel tijd een crisis voortbrengt die veel onschuldige mensen treft. Zijn woorden hebben nauwelijks aan actualiteit verloren. In de afgelopen drie decennia hebben veel landen en regio's te maken gehad met financiële crises. Mexico ('73-'82) en Argentinië ('78-'81) waren vroege voorbeelden. In de jaren negentig volgden verscheidene landen in Europa ('92-'93), opnieuw Mexico ('94-'95), Oost-Azië ('97-'98), Rusland ('98), en Brazilië ('99). Meer recent werden Turkije ('00-'01) en Argentinië ('01-'02) getroffen. De oorsprong van financiële crises wekt al lange tijd de belangstelling van beleidsmakers en academici en kan buigen op een uitgebreide literatuur, zowel theoretisch als empirisch. Toch zijn nog niet alle vragen beantwoord. Met name de constatering dat financiële crises zich vaak in nieuwe gedaanten voordoen, maakt dat steeds naar nieuwe verklaringen moet worden gezocht. Dit heeft geleid tot meerdere generaties van crisis-literatuur.

Bij financiële crises wordt vaak een onderscheid gemaakt tussen zogenaamde 'valutacrises', 'bankencrises', en 'schuldencrises'. Dit proefschrift bestaat naast een inleidend en afsluitend hoofdstuk (hoofdstuk 1 en hoofdstuk 6) uit twee delen die zich elk op een ander type crises richten. Deel I (Hoofdstuk 2 tot en met 4) behandelt valutacrises. Deel II (Hoofdstuk 5) richt zich op schuldencrises.

De theoretische valutacrisisliteratuur startte met het werk van Krugman (1979) en Flood en Garber (1984), vaak betiteld als de 'eerste generatie' van valutacrisismodellen. Deze modellen werden ontwikkeld naar aanleiding van de crises in Latijns-Amerika in de jaren '70 en '80, die werden gekarakteriseerd door voorafgaande periodes van excessief verruimend budgettair beleid in combinatie met vaste wisselkoersregimes. De modellen laten zien hoe het monetair financieren van structurele overheidstekorten leidt tot een geleidelijke uitputting van de internationale reserves van de centrale bank, omdat de centrale bank onder de vaste wisselkoers het surplus aan binnenlands geld wisselt voor buitenlands geld. Op enig moment vindt dan een speculatieve aanval plaats waarin de resterende voorraad internationale reserves van de centrale bank wordt opgekocht en de vaste wisselkoers niet langer houdbaar is. Dit resulteert in een valutacrisis.

Alhoewel de eerste generatie van crisismodellen goed in staat was de crises in Latijns-Amerika te verklaren, was zij minder relevant bij latere crisisperioden. Dit werd in het bijzonder duidelijk na de crisis in het Europees Monetair Systeem (EMS) in 1992 en 1993, die niet werd voorafgegaan door structurele overheidstekorten of een geleidelijke uitputting van internationale reserves. In plaats daarvan verruimden beleidsmakers de fluctuatiemarges in reactie op plotselinge speculatieve aanvallen op hun munten. Dit leidde tot de vraag of crises verklaard kunnen worden door fundamentele waarden in de economie, of dat speculatieve aanvallen een zichzelf versterkend effect met zich meedragen. In het laatste geval zou zelfs een crisis kunnen ontstaan als daar geen sterke aanwijzingen voor zijn, simpelweg omdat de verwachtingen van een crisis zichzelf waarmaken. In antwoord op deze vraag ontstond een 'tweede generatie' van crisismodellen. Deze modellen lieten zien dat als voor beleidsmakers een afruil bestaat tussen wisselkoersstabiliteit en andere beleidsdoelen, de wisselkoersontwikkeling zich kan kenmerken door 'meervoudige evenwichten'. Zolang de markt geen devaluatie verwacht, blijven de kosten van handhaving van de vaste wisselkoers voor beleidsmakers laag en zullen ze er dus voor kiezen de vaste wisselkoers te blijven ondersteunen. Echter, zodra marktparticipanten een devaluatie verwachten, kan deze verwachting zichzelf waarmaken omdat zij de handhavingskosten van de vaste wisselkoers verhoogt door beleidsmakers te dwingen om de rente te verhogen. In het geval van de crisis in het EMS was het niveau van werkeloosheid in een aantal deelnemende landen stijgende waardoor een renteverhoging extra pijnlijk was. Dit leidde tot een afnemende bereidheid om de vaste wisselkoers te blijven verdedigen.

De ontwikkeling van tweede-generatie modellen, hoewel zeer relevant en nuttig, zou niet het einde betekenen van de crisisliteratuur. Op 2 juli 1997 besloot de Thaise centrale bank om de koppeling van de baht aan de Amerikaanse dollar op te geven. Dit luidde het begin in van de crisis in Oost-Azië in 1997 en 1998. Wederom werden economen geconfronteerd met nieuwe kenmerken die niet direct centraal stonden in eerdere crisisperioden. Nieuwe modellen waren nodig en richtten zich in eerste instantie op problemen in de bankensector. Krugman (1998) en Corsetti et al. (1999) beargumenteerden dat het bestaan van impliciete overheidsgaranties op leningen leidde tot moral hazard en een overmatig investeringsniveau. Toen de overheden na verloop van tijd niet meer bereid of in staat waren de toenemende verliezen te dekken, leidde dit tot instorting van het bancaire systeem en recessie. Chang en Velasco (1998) richtten zich op een tekort aan liquiditeit in het bancaire systeem veroorzaakt door vertrouwensverlies onder investeerders, naar analogie van de klassieke run op de banken in Diamond en Dybvig (1983). Echter, het zou niet lang duren voor een nieuwe stroming literatuur zou opkomen, waarnaar soms verwezen wordt als 'derde-generatie literatuur'. Deze literatuur benadrukt het belang van kwetsbaarheden op de balansen van banken, bedrijven en overheden en de rol van internationale kapitaalstromen. Zij kent twee substromingen. De eerste substroming richt zich op een combinatie van een valuta en looptijd mismatch op de balansen van banken. Hierbij wordt een crisis gekarakteriseerd als een run op korte-termijn schuld gedenomineerd in buitenlandse valuta. De tweede substroming beschouwt enkel een valuta mismatch op de balansen van bedrijven en karakteriseert een crisis als een plotselinge sterke terugloop of volledige uitputting van kredieten en een sterke val van het investeringsniveau. In beide substromingen kunnen crises een zichzelf waarmakend karakter dragen doordat een sterke waardevermindering van de binnenlandse munt de buitenlandse schuld op balansen opblaast met sterk negatieve gevolgen voor bedrijven, waardoor voorafgaande sombere voorspellingen ex-post uitkomen.

Hoofdstuk 2 van dit proefschrift houdt verband met deze derde-generatie literatuur maar analyseert het onderwerp vanuit een nieuwe invalshoek. Het hoofdstuk bestudeert de kwetsbaarheid van de particuliere sector van een land voor veranderingen in de korte rente en de wisselkoers. Het kijkt daarbij naar de invloed van deze kwetsbaarheid op de beleidsafruil tussen wisselkoers- en prijsstabiliteit enerzijds en economische groei anderzijds. De analyse laat zien hoe een hoog niveau van kortlopende schuld gedenomineerd in binnenlandse valuta leidt tot hogere kosten van handhaving van de vaste wisselkoers door de hogere risicopremie die bedrijven betalen over hun schuld. Deze hogere risicopremie heeft een neerwaarts effect op investeringen en economische groei. Dit wordt door de monetaire autoriteiten negatief gewaardeerd. Daarnaast heeft een hoog binnenlands schuldniveau een verlagend effect op de kosten van afschaffing van de vaste wisselkoers omdat het positieve effect van een renteverlaging op economische groei in omvang toeneemt. Dit komt omdat de initiële renteverlaging leidt tot een verbetering in de balanspositie van bedrijven en daardoor tot een lagere risicopremie. Dit draagt bij aan een verdere verlaging van de rente. Samenvattend leidt een hoog niveau van binnenlandse schuld dus tot hogere kosten van handhaving en lagere kosten van afschaffing van de vaste wisselkoers. Hiermee neemt de kans op afschaffing van de vaste wisselkoers (crisis) toe.

In tegenstelling tot binnenlandse schuld is het effect van buitenlandse schuld - schuld gedenomineerd in buitenlandse valuta - tweeledig. Hogere buitenlandse schuld leidt ook nu weer tot hogere kosten van handhaving van het wisselkoersregime door de hogere risicopremie die bedrijven betalen op hun schuld. Echter, het heeft ook een verhogend effect op de kosten van afschaffing van de vaste wisselkoers. Dit komt omdat de depreciatie die doorgaans plaatsvindt na afschaffing van een vaste wisselkoers negatieve gevolgen heeft voor de balanspositie van bedrijven met een valuta mismatch op hun balans. Deze verslechterde balanspositie leidt tot een hogere risicopremie op extern kapitaal en dus een lagere economische groei. Omdat zowel de kosten van handhaving als de kosten van afschaffing van een vaste wisselkoers toenemen met het niveau van buitenlandse schuld, is het teken van het netto effect op de kans van een crisis onbepaald.

De conclusie van hoofdstuk 2 is dat een kwetsbare balanspositie van bedrijven een belangrijke rol kan spelen bij het instorten van een vast wisselkoersregime. Om deze kwetsbaarheid te beperken, dienen bedrijven minder afhankelijk te worden gemaakt van rente- en wisselkoersveranderingen. Mogelijke manieren om dit te bewerkstelligen, zijn de ontwikkeling van locale aandelenmarkten en het bevorderen van financieel toezicht en financiële regulering.

In hoofdstuk 3 en 4 wordt het effect van monetair beleid op de wisselkoers empirisch getoetst. Deze hoofdstukken sluiten aan bij recente discussies onder zowel beleidsmakers als academici over het optimale monetaire beleid tijdens speculatieve aanvallen en in de periode nadat een vaste wisselkoers is gevallen. De traditionele zienswijze is dat een monetair verkrappend beleid nodig is om speculatie af te remmen en een waardevermindering van de munt te voorkomen of te beperken. De recent door sommigen uitgedragen alternatieve of revisionistische zienswijze betoogt dat als speculatieve aanvallen gepaard gaan met kwetsbare balansposities in de particuliere sector, een monetaire verkrapping de waarde van de munt juist ondermijnt. Hoofdstuk 3 en 4 vormen een empirische toetsing van beide zienswijzen.

In hoofdstuk 3 staat de effectiviteit van monetair beleid in de verdediging van een vaste wisselkoers tijdens speculatieve aanvallen centraal. De centrale hypothese is dat een renteverhoging sterkere negatieve effecten heeft en daardoor minder effectief is in landen waar de particuliere sector meer korte-termijn schulden heeft en dus kwetsbaarder is voor renteverhogingen. Om deze hypothese te testen, wordt een dataset geconstrueerd met een geaggregeerde indicator voor korte-termijn schuld in de particuliere sector van een land. Daarnaast bevat de dataset verschillende maatstaven van monetair beleid voor landen met een vast wisselkoersregime die geconfronteerd werden met speculatieve aanvallen tegen hun munt in de periode 1986 tot 2002. De regressieresultaten bevestigen de centrale hypothese van het hoofdstuk.

Wanneer het niveau van schuld niet te hoog ligt, leidt een verhoging van de rente tot een kleinere kans op een valutacrisis. Dit effect neemt af en verandert uiteindelijk van teken voor hogere niveaus van schuld.

Waar hoofdstuk 3 kijkt naar de relatie tussen monetair beleid en valutacrises vanuit een ex-ante perspectief, dat wil zeggen voordat een vast wisselkoersregime valt, kijkt hoofdstuk 4 naar de rol van monetair beleid ter ondersteuning van de wisselkoers in de periode na de val van het wisselkoersregime. Opnieuw is de centrale hypothese dat een renteverhoging sterkere negatieve effecten heeft en daardoor minder effectief is in landen waar de particuliere sector meer korte-termijn schulden heeft en dus kwetsbaarder is voor renteverhogingen. Dit wordt bevestigd door de resultaten. Deze resultaten zijn niet afhankelijk van het gebruik van de nominale of de reële wisselkoers.

Samenvattend leveren hoofdstuk 3 en 4 sterk bewijs voor een niet-lineair effect van monetair beleid op de wisselkoers, zowel tijdens speculatieve aanvallen voorafgaand aan een eventuele val van een vast wisselkoersregime als tijdens de periodes na de val van een vast wisselkoersregime. Deze resultaten laten zien dat de twee tegengestelde zienswijzen over het verhogen van de rente ter ondersteuning van de wisselkoers elkaar niet uitsluiten. Ze bieden ook een mogelijke reden voor de gemengde resultaten in de empirische literatuur.

In deel II (hoofdstuk 5) verschuift de aandacht naar schuldencrises. Een belangrijk deel van het brede scala aan financiële innovaties dat recent is geïntroduceerd in financiële markten, bestaat uit de zogenaamde 'kredietderivaten'. Deze derivaten hebben betrekking op contracten waarin de verkoper van een kredietrisicoverzekering toezegt een afgesproken som geld te betalen aan de koper van de kredietrisicoverzekering in het geval de onderliggende schuldtitel niet het verwachte rendement biedt. Op deze wijze is de koper verzekerd voor kredietrisico. De markt voor kredietderivaten is sterk gegroeid in de afgelopen jaren en 'soevereine' kredietderivaten, die verzekering bieden voor kredietrisico op staatsobligaties van (veelal) opkomende economieën, vormen een significant deel van deze snel groeiende markt. De beschikbaarheid van kredietderivaten kan belangrijke gevolgen hebben voor de afwikkeling van schuldencrises. Verzekerde obligatiehouders hebben minder prikkels om een verandering in de voorwaarden van de obligatie te accepteren, aangezien ze volledig verzekerd zijn voor kredietrisico. Dit maakt het moeilijker voor opkomende economieën om een akkoord te bereiken met obligatiehouders over schuldherstructurering. Hoewel de introductie van kredietderivaten de interesse heeft gewekt van zowel beleidsmakers als academici, zijn de implicaties van kredietderivaten voor de schuldherstructurering van opkomende economieën nog niet theoretisch geanalyzeerd. Hoofdstuk 5 van dit proefschrift vormt een eerste poging voor een dergelijke analyse.

Centraal in het hoofdstuk staan de welvaartsimplicaties van kredietderivaten door hun effect op de ex-ante prikkels voor opkomende economieën om een schuldencrisis te voorkomen en hun effect op de ex-post afwikkeling van de crisis. Deze implicaties worden bestudeerd in een model waarin een opkomende economie een project runt maar niet in staat is om aan haar uitstaande schuldverplichtingen te voldoen. Er wordt een onderscheid gemaakt tussen twee mogelijke standen van de economie. Als de economie zich in de gunstige 'hoge' stand bevindt, overstijgt de opbrengst van het project (indien dit voortgezet kan worden) haar liquidatiewaarde. Als de economie zich daarentegen in de 'lage' stand bevindt, is de opbrengst van het project kleiner dan de liquidatiewaarde. Vanuit een ex-post perspectief is de sociaal efficiënte crisisafwikkeling daarom een schuldherstructurering in de hoge stand van de economie en een liquidatie in de lage stand van de economie.

De belangrijkste resultaten van hoofdstuk 5 zijn dat kredietderivaten in de meeste gevallen de prikkels voor opkomende economieën om schuldencrises te voorkomen, versterken en moral hazard verminderen, door de onderhandelingsmacht van obligatiehouders te vergroten. Omdat obligatiehouders verzekerd zijn voor kredietrisico zullen ze minder snel akkoord gaan met een herstructureringsvoorstel. Als gevolg hiervan zal de opkomende economie een hoger rendement moeten bieden om de obligatiehouder tot acceptatie over te halen. Dit betekent dat ze een groter deel van de kosten van een schuldencrisis internaliseert wat leidt tot minder moral hazard en sterkere prikkels voor crisispreventie. Tegelijkertijd hebben kredietderivaten in de meeste gevallen geen gevolgen voor de efficiëntie van de crisisafwikkeling omdat obligatiehouders geen prikkels hebben om zich sociaal inefficiënt hoog te verzekeren.