Explaining and Forecasting Currency Crises in Developed and Emerging Markets' Economies

Thesis submitted for the degree of
Doctor of Philosophy (Ph.D.) by María Mercedes Tudela
registered at the London School of Economics

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ProQuest LLC
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106-1346

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Abstract

The series of banking and currency crises occurring in the 1990s have stimulated the study of financial crises. The research for this thesis has been conducted in the midst of this cluster of events: the Asian flu in 1997–98 and the disturbances in the Russian and Brazilian markets in 1998 and 1999, respectively. The aim of this work is to provide some empirical evidence on the general and systematic factors driving currency crises.

After a summary of the literature on currency crises conducted in Chapter 1, the second chapter analyses the determinants of currency crises for 20 OECD countries for the period from 1970 to 1997. We use duration models in order to investigate the causes behind the duration of non-crises periods. Fundamentals are revealed as important determinants in assessing the likelihood of currency crises. Variables concerning the state of the external sector (exports, imports, degree of openness), the REER, foreign portfolio investment and net claims on central government help explain the onset of currency crises.

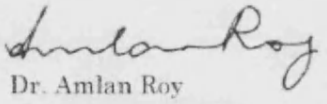
Following historical events, the subsequent chapters in this thesis study currency crises in developing and emerging markets' economies. Chapter 3 develops an indicator called the *Emerging Markets Risk Indicator*, whose monthly scores reflect the currency risk for 36 emerging markets. We evaluate the contribution of the explanatory variables of this model to the probability of the main crisis events. In order to judge the forecasting power of this model, we estimate two reduced samples: the first one until December 1996 and the second one until December 1997. With these two models we can study the predictive power of the model on the onset of the Asian crisis in 1997 and the Russian and Brazilian crises in 1998–99, respectively. The results shows that had this model been used at those times, it would have predicted those crises.

Chapters 4 and 5 analyse the joint occurrence of banking and currency crises, i.e. contribute to the debate on *twin* crises. In Chapter 4, we develop a currency crisis model with explicit reference to banking crisis indicators as possible determinants of currency crises. Deepening the subject of twin crises, Chapter 5 endogenises the banking crisis variable and *jointly* estimates two equations, one for banking crises and another for currency crises. This procedure allows us to fully test the interdependence of banking and currency crises, i.e. the direction of a causal link (if any) between both types of crisis. The results indicates the existence of bidirectional causal link between banking and currency crises. The phenomenon of twin crises is rather a case of banking and currency crises being closely intertwined. Which crisis type occurs first is a matter of circumstance.

Declaration

1. No part of this work has been presented to any University for any degree.
2. Chapter 3, "A Methodology for Assessing the Likelihood of Currency Crises in Emerging Markets", was conducted as a joint work with Dr. Amlan Roy when I was part-time consultant at Credit Suisse First Boston, London (October, 1999-April 2001). My contribution in this paper was 50%. A statement from my co-author confirming this is given below.
3. Chapter 5, "Banking and Currency Crises: Are they intertwined?" was undertaken as a joint work with Elisabetta Falcetti. My contribution to this paper was 50%. A statement from my co-author confirming this is given below.

- I confirm the above declaration (point 2) referring to joint work carried out with María M. Tudela.



Dr. Amlan Roy
June 01, 2001

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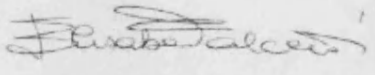

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0.1 Introduction

Research on financial crises has been stimulated by the series of currency and banking crises occurring in the 1990s: the turbulence of the European Exchange Rate Mechanism (ERM) in 1992–93, the meltdown in Mexico 1994, the Asian flu in 1997–98 and the disturbances of the Russian currency markets in 1998 and the Brazilian real in 1999. The fact is that each wave of crises seems to elicit a new "generation" or style of theoretical models to explain such a crisis.[1]

This thesis has been conducted in the midst of these events, and, in a way, moulded by the new episodes of financial crises. The aim of this work is to provide some empirical evidence on the factors driving currency crises. The emphasis is made on *general* and *systematic* determinants of the probability of a currency crisis. The consideration of large samples, over time and across countries, allow us the characterisation of the systemic causes driving currency crises.

Before the technical analysis is made, in Chapter 1 we offer an overview of the theoretical and empirical literature on the subject. We review the "first-generation" models of speculative attacks initiated by Krugman (1979). These models stress the fact that excessive expansionary fiscal and monetary policies result in a persistent loss of international reserves, ultimately forcing authorities to abandon a fixed exchange rate. "Second-generation" models state that currency crises can be self-fulfilling if agents expect the government to switch to an inflationary domestic credit policy in the presence of a speculative attack. These models were pioneered by Obstfeld (1986). The 1997–98 Asian crisis has produced a new generation of models, in which emphasis is laid on moral hazard problems and liquidity constraints.

We also undertake a brief survey of the empirical literature on financial crises, differentiating among several approaches to the problem: descriptive studies, the probabilistic approach to the occurrence of a currency crisis, the leading indicators methodology, and the analysis of linkages between banking and currency crises.

The second chapter of this thesis is devoted to currency crises in developed countries. This work has been motivated by the episodes surrounding the ERM in 1992–93. For 20 OECD countries we construct a data set for the period 1970–97. We adopt a duration model approach towards the determination of the origins of a currency crisis event. The use of duration models allows to account for duration dependence among the determinants for the likelihood of speculative attacks, without neglecting time-varying explanatory vari-

[1] As Eichengreen, Rose and Wyplosz (1995) have already suggested.

ables as used by previous studies. The aim of employing duration models is to investigate the duration pattern of non-crisis periods.

The results point to the existence of a negative duration pattern, meaning that the probability of a currency crisis is always higher for new exchange rate agreements, decreasing with the credibility earned through the functioning of the exchange rate system. Economic variables such as export growth, import growth, openness, exchange rate overvaluation, capital inflows in the form of portfolio investment, claims on government and bank deposits help to explain the occurrence of currency crises for developed countries.

Following historical events, the subsequent chapters in this thesis concentrate on developing and emerging markets' economies. The goal of Chapter 3 is to assess a methodology to help forecast currency crises for a group of 36 emerging markets. We construct an indicator called the *Emerging Markets Risk Indicator (EMRI)*, whose monthly scores reflect the currency risk in these markets. We also evaluate the contribution of the explanatory variables of our model to the probability of the main crisis events. To appraise the forecasting power of our model, we estimate two reduced samples. The first one restricts the sample to end in December 1996 with the aim of studying the predictive power prior to the 1997 Asian crisis. The second exercise estimates our model with sample data ending in December 1997 in order to evaluate the predictive power prior to the Russian and Brazilian crises. The results show that had this model been used at those times, it would have predicted those currency crises. This is depicted in the increasing values of our *EMRI* indicator ahead of the events.

Subsequent to the debate on twin crises —the joint occurrence of banking and currency crises— Chapters 4 and 5 consider the linkages and chains of causality between these two types of financial crises. In Chapter 4, we develop a currency crisis model with explicit reference to banking crisis indicators as possible determinants of currency crises. This study focuses on 92 developing and emerging markets' economies for the period 1975–97, with quarterly observations. Empirically, we test whether episodes of banking system unsoundness lead to currency crises by estimating a multiperiod dynamic probit model with maximum smoothly simulated likelihood techniques.

The main feature of this type of econometric model lies in the dynamic component. This is specified by introducing a lagged dependent variable among the regressors, which requires the explicit consideration of unobservable heterogeneity and autocorrelated errors. With these components, we want to test the possible presence of state dependence, i.e. if past occurrences of currency crises influence the probability of a future currency crisis. The unobservable heterogeneity reflects political, historical and institutional factors, which are

country-specific and time-invariant, as well as difficult to control by traditional variables. The autocorrelated structure of the error term captures country-specific but time-varying factors. These two determinants are needed in order to avoid spurious state dependence.

The main results of Chapter 4 can be summarised as follows. Domestic macroeconomic and financial variables are important determinants of instances of currency crises. Global factors such as the international level of interest rates and commodity prices help explain currency crises. There is statistical evidence of banking crises leading currency crises. This result is robust across different specifications of the model and reinforces the results of Kaminsky and Reinhart (1999) given the more stringent temporal window adopted in our work. Kaminsky and Reinhart (1999) allow for a period of 48 months when analysing the power of banking crises as a leading indicator of currency crises, whereas we restrict that period to 12 months only. Moreover, the determinants of currency crises differ according to the type of exchange rate regime. Currency crisis episodes under fixed exchange systems are less frequent and require a greater deterioration of domestic fundamentals. Finally, the panel structure of the model (allowing for unobservable heterogeneity and autocorrelated errors) is revealed to be of crucial importance. If we omit this panel structure and pool together all the observations, the banking crisis indicator substantially increases its significance. This questions the robustness of results obtained in previous studies.

Finally, Chapter 5 deepens the examination of twin crises. In this chapter we endogenise the banking crisis variable. With this aim, we estimate a simultaneous equation system with two equations (of the kind used in Chapter 4), one for currency crises and another for banking crises. We explore the causal link from banking to currency crises, controlling for leading and contemporaneous effects of the banking variable on the currency event, as well as for common causes of both events. Within this structure, we can also reverse the causal link and allow for currency crises leading banking crises, and study the effect of past and contemporaneous currency crises on the likelihood of banking crises. In this way, we can further test the existence of chains of causality vs. the mere fact that both types of crises are predicated on the same determinants and it is a matter of circumstance which occurs first.

Summarising the main results, we can state that, after the liberalisation of financial markets, banking and currency crises become closely intertwined with a slight tendency for currency crises to precede banking crises. Nevertheless, we cannot find an exclusive unidirectional and general causal link between currency and banking crises. Both types of crises share common factors, and which crisis surfaces first is often only a matter of circumstance.

0.2 Overall Conclusions

Overall, the evidence from this thesis is suggestive of the following:

- When studying the determinants of currency crises in developed countries, we find evidence of the importance of economic fundamentals. Variables concerning the state of the external sector (exports, imports, degree of openness), the REER, foreign portfolio investment and net claims on central government help predict the onset of currency crises.

- Regarding the duration dependence that characterises the non-crisis periods for the same set of countries, there is a clear negative duration dependence. The highest probability of exit into a crisis period is given at the start of the peg. This probability decreases after the first year of the currency peg. This fact may suggest the existence of a political cost of realignment that changes over the duration of the peg: growing credibility surrounding an exchange-rate-based stabilisation program might reduce the probability that the peg will be abandoned.

- To forecast the likelihood of currency devaluation for 36 emerging markets, we use a small set of economic variables. Our *Emerging Markets Risk Indicator* reflects monthly currency risks, and can be used in sovereign risk analysis or in current portfolio investment decisions. The exercises done in order to evaluate the predictive capacity of the model show that had this model been used to predict the Asian 1997, Russian 1998 and Brazilian 1999 crises, it would have forecasted those events.

- In an empirical test to assess whether banking crises lead currency crises in a set of 92 developing and emerging markets' economies from 1975 to 1997, we find that banking crises occurring a year before a currency crisis event help predict that crisis event.

- For the same set of countries, we find that domestic macroeconomic and financial variables are important determinants of instances of currency crises. Furthermore, an overvalued exchange rate increases the probability of a currency crash. An increase in the stock of external debt can undermine the stability of the domestic currency. The composition and maturity of this debt are also key determinants. Changes in the global macroeconomic conditions (international interest rates, US inflation, commodity prices) help explain currency crises.

- Interestingly, the determinants of currency crises differ according to the type of exchange rate regime. Currency crisis episodes under fixed exchange rates are less frequent and require a much greater deterioration in domestic fundamentals to be

triggered. Also, the international macroeconomic environment seems to have a stronger impact on pegged exchange rates than flexible regimes.

- Endogenising banking crises and estimating a system of two equations, one for banking crises and another for currency crises, allows us to compare the factors behind those two crises. Both crises are driven by several economic fundamentals. Our results raise doubts about the self-fulfilling nature attributed to financial crises by second-generation models.

- The real sector (output growth) plays a more important role in determining banking than currency crises. Another important difference between the two types of crises lies in the relevant component of the domestic credit variable to explain crisis probabilities. Claims on the private sector help explain banking crises, whereas it is the net claims on the central government ratio the relevant one to explain currency crises.

- Judging the causal link between banking and currency crises requires a careful investigation of all the possible determinants of crises and the consideration of enough crisis lags. Once we control for a sufficient number of lags of the dependent variable (past currency crises in the currency equation and past banking crises in the banking equation), the causal link between crises vanishes. Notwithstanding, we can still find evidence of a causal link running from currency crises to banking crises, however only for the 1990s. Moreover, if we include unsuccessful attacks in the definition of currency crises or if we consider severe currency crises (depreciation of the currency above a 15 percent threshold), this causal link holds: currency crises precede banking crises. These results let us conclude that there is not a unidirectional and general link between banking and currency crises. Both type of crises seem to be closely intertwined and which crisis occurs first is mainly a matter of circumstance.

Chapter 1

Literature Review on Currency Crises

1.1 Introduction

New research on currency crises has been developed both on the theoretical and empirical fronts following the crisis events of the 1990s. It has been stimulated both by the frequency and the magnitude of these episodes of financial stability. The aim of this chapter is to provide some perspective on this research from both sides, the theory and the empirics of currency crises.[1]

In the theory of currency crises a collection of "new generation" models for currency crises has thrived since the early study by Krugman (1979). The "first generation" of speculative attacks models, pioneered by Krugman (1979), have stressed the fact that crises are caused by weak economic fundamentals. Excessive expansionary fiscal and monetary policies result in a persistent loss of international reserves that ultimately force authorities to abandon the exchange rate parity.

The development of "second-generation" models was prompted by the 1992–93 European Exchange Rate Mechanism (ERM) crisis. Here, other factors are cited as responsible for the ERM crisis. These models, initiated by Obstfeld (1986) —adopting a framework developed by Flood and Garber (1984)—, state that currency crises can be self-fulfilling if agents expect the government to switch to an inflationary domestic credit policy in the presence of a speculative attack.

As a result of the 'unexpected' Asian crisis in 1997–98, a "third generation" of models has been studied. These models highlight the importance of moral hazard and liquidity

[1] A more extensive survey on currency crises can be found in Flood and Marion (1998). More recently, Chui (2000) provides a comprehensive review of the balance-of-payments crises literature.

considerations as determinants of currency crises.

The empirical literature debates whether first- or second-generation models are more valid. Empirical papers on currency crisis try to explain and/or forecast currency crises in order to provide policy makers with advice to ward off crises. We can differentiate among four strands of research according to the methodology employed. A first group of studies rely mainly on purely descriptive statistics and are primarily concerned with particular episodes of currency distress.

The second group uses a probabilistic approach. After grouping the country and time observations into crisis and tranquil periods, a probability distribution function of these episodes is used to evaluate the likelihood of a currency crisis conditional on a set of indicators. The most well-known study in this particular context is by Eichengreen, Rose and Wyplosz (1996c).

An early warning system constitutes the third group and is initially proposed by Kaminsky, Lizondo and Reinhart (1998). This methodology involves monitoring the evolution of several indicators that tend to exhibit an unusual behaviour in the periods preceding a currency crisis. Every time an indicator exceeds a certain threshold value, this is interpreted as a warning signal that a currency crisis may take place within the following 24 months.

The fourth category of studies on currency crises analyses the joint occurrence of banking and currency crises. These studies claim that both types of crises are intertwined. Few papers can be grouped under this category, exceptions are Miller (1996) and, the more well-known, Kaminsky (1998).

In the next two sections we briefly summarise the main theoretical and empirical works on currency crises.

1.2 Theories of Speculative Attacks

Exemplary of the first-generation models, Krugman (1979) assumes that an exogenous government budget deficit lies at the root of the balance-of-payments crisis. Domestic credit expansion in excess of money demand growth leads to a gradual but persistent loss of international reserves and, ultimately, to a speculative attack on the currency. This attack immediately depletes reserves and forces the authorities to abandon exchange rate parity.

In Krugman's words,

> "the logic of a currency crisis is the same as that of a speculative attack on a commodity stock. Suppose speculators were to wait until the reserves are exhausted in the natural course of events. At that point they would know that the price of foreign exchange, fixed until then, must rise. This would make holding foreign exchange more attractive than holding domestic currency, leading to a jump in the exchange rate. Foresighted speculators, realising that such a jump is in prospect, sell domestic currency just before the exhaustion of reserves —and in doing so advance the date of that exhaustion, leading speculators to sell even earlier. The result is that when reserves fall to some critical level —perhaps a level that might seem large enough to finance years of payments deficits— there is an abrupt speculative attack which quickly drives those reserves to zero and forces an abandonment of the fixed exchange rate."

The empirical implication of this model is that one should observe expansionary fiscal and monetary policies prior to speculative attacks. Those policies should be accompanied by a gradual decline in international reserves.

Flood and Garber (1984) extend Krugman (1979)'s model by introducing uncertainty about the rate of domestic credit creation. Unanticipated increases in domestic credit can cause the shadow exchange rate to exceed the pegged rate temporarily. Speculators attack the peg as soon as this situation makes arbitrage profits possible. But as domestic credit grows, an attack becomes increasingly likely. This widens the differential between domestic and foreign interest rates accompanied by a growing forward discount on the domestic currency. Moreover, the greater the uncertainty about the central bank's credit policy, the faster reserves should be depleted.

Other research has focused in relaxing some of Krugman's assumptions regarding the degree of capital mobility. For example, Wyplosz (1986) analyses devaluations in the presence of capital controls which limit capital mobility. The more stringent the controls, the longer the pre-attack period over which the standard correlation of speculative crises will persist. With sufficiently stringent controls, collapses of the peg can be averted.

Obstfeld (1986) and Obstfeld (1994) have provided examples of multiple equilibria and self-fulfilling attacks in foreign exchange markets, constituting the second-generation models of currency crises. This view offers a whole new perspective on the causes of currency crises.

A crucial assumption in the second-generation models is that economic policies are not exogenous, but instead respond to changes in the economy. Economic agents take this relationship into account in forming their expectations. At the same time, the expectations and actions of economic agents affect some variables to which economic policies respond. This circularity creates the scope for multiple equilibria, and the economy may move from one equilibrium to another without a change in the fundamentals. Thus, the economy may initially be in an equilibrium consistent with a fixed exchange rate, but a sudden worsening of expectations may lead to changes in policies that result in a collapse of the exchange rate regime, thereby validating agents' expectations. A fixed rate is costly to defend if people now expect that it will be depreciated in the future. To defend the currency in the face of expectations of future depreciation requires high short-term rates. But such high rates may either worsen the cash flow of the government or depress output and employment.

After the Asian crisis of 1997–98 and the failure of the currency crisis models to anticipate this crisis, a new wave of models has emerged. Krugman (1998) states that the adoption of a new approach different from that of the traditional models of currency crises is needed to understand the nature of the Asian crisis. According to Krugman (1998), the type of crisis experienced by Asia were part of a broader financial crisis. To understand this crisis we need to focus our analysis in the role of financial intermediaries (moral hazard issues), and the prices of real assets such as capital and land. The Asian financial institutions were accumulating liabilities that, apparently, were perceived as government guaranteed. But these institutions were mostly unregulated and subject to severe moral hazard problems. This lending practice by the financial intermediaries, based in excessive risk, created asset price inflation. The proliferation of risky lending raised the price of risky assets, making the financial condition of the intermediaries seem sounder that it really was. This process went on until the bubble created this way burst. At that point, the insolvency of intermediaries was visible, deflating asset prices even more. The currency crisis that followed was more of a symptom than a cause of this process.

Chang and Velasco (1998) focus on an open version of the banking model by Bryant (1980) and Diamond and Dybvig (1983). Their argument places *international illiquidity* at the center of the problem. International illiquidity is defined as a situation in which the financial system's potential short term obligations exceed the liquidation value of its assets. Using this model, the authors show that capital flows from abroad, after an opening of the capital account and/or an increase in the country's access to international credit, can amplify the illiquidity problem. Banks are more vulnerable when foreign loans are of the short term nature. A panic by creditors, and therefore a refusal to roll over the short term loans, may cause a self-fulfilling bank run. Financial liberalisation can exacerbate

the maturity mismatch between assets and liabilities for commercial banks. Distorting government policies (such as government deposit guarantees and investment subsidies that lead to overinvestment and overborrowing) increase financial fragility. The authors also claim that "the combination of an illiquid financial system and fixed exchange rates can be lethal". Central banks acting as lender of last resort may avoid a bank run but cause a currency crisis. But if the central bank does not act as a lender of last resort bank runs are unavoidable.[2]

Corsetti, Pesenti and Roubini (1999b) emphasise the role of the moral hazard as a crucial factor in the Asian crisis. National banks were borrowing excessively from abroad — following financial liberalisation— and lending excessively at home. Even in the absence of explicit promises to "bail-out", the close links between private and public institutions, as well as regulatory inadequacies, provided strong incentives to undertake risky projects. Capital inflows were directed to real estate and the stock markets. The banking system was clearly undercapitalised and accumulating a growing share of non-performing loans. Regarding policy, there was no commitment to structural reforms. These financial and real imbalances made the region very vulnerable to market sentiments. When in 1997 asset prices collapsed, wide losses and defaults in the corporate and financial sectors emerged. The reversal of capital inflows in the summer of 1997 led to the collapse of the domestic currencies.

Similarly, Corsetti, Pesenti and Roubini (1999a) analyse the Asian crisis by developing a model of financial and currency crises focused on "moral hazard as the common source of overinvestment, excessive external borrrowing, and current account deficits in an economy with a poorly supervised and regulated financial sector." The authors claim that it was the complex web of structural distorsions and fundamental weaknesses that caused the Asian crisis in the summer of 1997. Foreign creditors were willing to lend under the implicit assumption that there existed public guarantees on corporate and financial investements, that is, a public bail-out was expected if things went wrong. This led to excessive borrowing and investment in unprofitable projects. Such a process translated into an unsustainable path of current account deficits. When things went wrong and the low profitability of the investments was revealed, the eventual refusal of foreign creditors to refinance the country's cumulative losses forced the government to intervene. The government needed to guarantee the outstanding stock of external liabilities. To guarantee solvency, fiscal reforms were needed, with the possible recourse to seigniorage revenues through money creation. This created inflationary expectations and speculative attacks in the foreign exchange market, causing the collapse of the currency and anticipating the

[2]In a similar paper, Chang and Velasco (1999), the same authors analyse the same problem of illiquidity but focusing in its policy implications.

event of a financial crisis.

Burnside, Eichenbaum and Rebelo (2000) propose a theory to link banking and currency crises. The authors claim that both fundamentals and self-fulfilling beliefs play crucial roles. The relevant fundamentals are government guarantees to domestic banks' foreign creditors in the presence of a devaluation. This implies that banks expose themselves to exchange rate risk and declare bankruptcy when a devaluation occurs. These guarantees create the possibility of self-fulfilling crises. When the market participants believe that a devaluation is imminent and the government will bail-out the banking system, they will exchange domestic currency for foreign currency to the point of devaluation. The result of these expectations is a currency crisis and a banking crisis. In this sense fundamentals —government guarantees— determine whether a crisis will occur, and self-fulfilling beliefs determine the timing.

Aghion, Bacchetta and Banerjee (2001) develop an explicitly dynamic monetary model with nominal rigidities as a key factor. "If nominal prices are rigid in the short run, a currency depreciation leads to an increase in the foreign currency debt repayment obligations of the firms, and consequently a fall in profits. Since lower profits reduce net worth, it may result in less investment and lower output in the next period. This, in turn, brings a fall in the demand for money, and thus a currency depreciation. But arbitrage in the foreign exchange market then implies that the currency must depreciate in the current period as well. In other words, if people believe that the currency will depreciate, it may indeed depreciate. Multiple short-run equilibria in the market for foreign exchange are thus possible. A currency crisis occurs either when expectations change or when a real shock shifts the economy to the 'bad' equilibrium". Aghion et al. (2001) conclude that the proportion of foreign currency debt is a key determinant in the likelihood of a currency crisis. Given that the primary source of a currency crisis is the deteriorating balance sheet of private firms, currency crises may occur independently of the exchange rate regime in place. Public sector imbalances are determinants of currency crises via crowding-out effects. Whenever credit supply does not strongly react to changes in nominal interest rates it is desirable to increase interest rates as a mechanism to avoid a currency crisis. Finally, restrictive monetary policy will always produce a debt-burden effect on medium-term economic activity.

Agénor, Miller, Vines and Weber (1999) is a selection of academic papers covering the causes, consequences and remedies of the Asian financial crisis. The authors intend to answer questions related to (a) the interconnection between currency crises and financial crises and the effect of twin crises on the economy; (b) the contagion mechanisms; and (c) what can be done after the crises have taken place. The editors in their introduction

to the book consider four parts. The different chapters in part one provide a systematic overview of the Asian crisis. The first chapter emphasises the role of an inappropriate macroeconomic policy to bear the large capital inflows in a weak domestic financial system and poor governance. In a second chapter the interconnections between financial and currency crises are analysed. "In the wake of the liberalisation of the late 1980s and early 1990s there was a wave of very substantial borrowing, encouraged by the widespread perception that financial systems would be bailed out in the event of difficulty. Given quasi-fixed exchange rates, this borrowing was done in foreign currency and unhedged. Once a shock caused the domestic currency to depreciate significantly, the increase in the domestic-currency value of foreign debt provoked financial crisis." Chapters 3 and 4 revisited the moral hazard problem.

Part two is a collection of theoretical papers analysing aspects such as the boom-and-bust feature of rapid investment in combination with financial liberalisation, the role of capital inflows in an economy where the financial sector is liberalised but underregualted and the consequences of a capital reversal, and multiple equilibria issues.

Part three deals with the controversial issue of contagion, its definition and role in the Asian crisis. Theoretical and empirical analysis is presented.

Finally, part four of the book studies policy alternatives toward crisis resolution with special emphasis in redesigning world financial institutions, the unsustainability of continuous creditor bail-outs as a solution, and the inefficiency of financial markets and the need of national governments playing a key regulatory role in the functioning of successful financial markets.

1.3 Empirical Studies of Currency Crises

Aziz, Caramazza and Salgado (2000) have sought to identify common characteristics among a variety of macroeconomic and financial variables for a large sample (50 countries, covering the period 1957–97) of currency crises in industrial countries and emerging market economies. Their definition of a currency crisis is based on an index of foreign exchange market pressure constructed as a weighted average of (detrended) monthly exchange rate and reserve changes. The weights are chosen so as to equalise the variance of the two components.

Aziz et al. (2000) do not use an econometric model but instead conduct graphical analysis. To do this, they first define a crisis window as some number of periods centered on each crisis date. They divide the sample into crisis and tranquil observations. Next,

they compute the averages of the explanatory variables across all crisis events for each period in the crisis window. These averages for the crisis window are then plotted against the averages for the entire period. Aziz et al. (2000) conclude that prior to a currency crisis the economy is overheated, inflation is relatively high and the domestic currency overvalued, affecting the export sector and the current account balance. Monetary policy is significantly expansionary, with domestic credit growing strongly. The financial vulnerability of the economy is increasing, with rising liabilities of the banking system (unbacked by foreign reserves) and falling asset prices. Furthermore, some trigger, such as increasing world real interest rates or declining terms of trade, usually exacerbates the vulnerability of an economy to a crisis. However, these results are not robust across all crisis sub-samples.

Eichengreen et al. (1995) are among the first to *systematically* investigate the causes and determinants of speculative attacks.[3] The authors analyse currency crises in a sample of panel observations for OECD countries since 1959. They construct a measure of speculative attacks that excludes devaluations and flotations short of a crisis but tries to capture unsuccessful attacks. Their index of crisis is a weighted average of changes in the exchange rate, changes in international reserves and changes in the interest rate differential. The last two variables are included to take into account the government's response to a speculative attack. In fact, an increase in interest rates or the depletion of international reserves are the two main instruments at the disposal of the central bank to defend the currency. This method of identifying instances of currency crises has been widely used in the subsequent literature and is known as the *Exchange Market Pressure* (EMP) index approach. Eichengreen et al. (1995) find that countries which devalue are more prone to experience problems on the external balance, reserve losses, high levels of unemployment and have loose monetary policy.

In a subsequent paper Eichengreen, Rose and Wyplosz (1996b) use the same indicator to identify currency crises in a panel of quarterly data on 20 industrial countries for the period 1959–93. To analyse possible contagion effects, they ask whether the probability of a crisis in a country at a point in time is correlated with the incidence of crises in other countries at the same time, after controlling for the effects of political and economic fundamentals. The results of their probit estimations suggest that a crisis elsewhere in the world increases the probability of a speculative attack, even after controlling for economic and political factors. Notwithstanding, their fundamentals —with the exception of unemployment and inflation— are not significant in determining the probability of a currency crisis.

[3] The emphasis is on "systematic" because all the previous studies referred to a single historical episode, like Sweden 1992 or Mexico 1994.

Frankel and Rose (1996) use a different approach to identify episodes of currency crises in a sample of developing countries. Their argument behind the definition of a currency crash is that

> "...it is much more difficult to identify successful defenses against speculative attacks. Reserve movements are notoriously noisy measures of exchange market intervention for developing countries. In addition, few countries have market-determined short-term interest rates for long periods of time. The standard defenses against speculative attacks of interest rate hikes and reserve expenditures may also be less relevant in these countries than sudden tightening of reserve requirements, emergency rescue packages from the IMF or other foreign institutions, and especially the imposition of formal or informal controls on capital outflows."

Using annual data, Frankel and Rose (1996) define currency crises as a depreciation of the domestic currency of at least 25 percent. To deal with countries that satisfy this criterion year after year, they impose a second condition: the depreciation in one particular year has to exceed the depreciation of the previous year by a margin of at least 10 percent. To assess the importance of a set of explanatory variables that are possible determinants of currency crises, the authors use a probit estimation approach, as in Eichengreen et al. (1996b). They find that crashes tend to occur when foreign direct investments dry up, reserves are low, domestic credit is high, interest rates in developed countries rise and the real exchange rate is overvalued. Government and current account deficits are not significant in their specification.

Sachs, Tornell and Velasco (1996) ask why some emerging markets in 1995 were hit by financial crises while some others were not. The concepts of weak fundamentals and low reserves are used to assess the relationship between the REER, a lending boom, and the resulting incidence of a currency crash. Their main conclusion is that some degree of previous misbehavior was a necessary condition for crisis. This misbehavior took the form of overvalued real exchange rates and recent lending booms, coupled with low reserves relative to the central bank's short term commitments. These results support the idea that the level for central banks' reserves relative to short-term liabilities is important in determining whether a country is vulnerable to a self-fulfilling attack. Moreover, Sachs et al. (1996) also found that some common explanations for the occurrence of financial crises are not supported by the data from their sample of 20 emerging markets. The behavior, during the period 1990–94, of current accounts, the size of capital inflows and fiscal policy stances in and of themselves do not help explain why some countries experienced greater financial crises than others.

Kaminsky et al. (1998) examine the empirical evidence on currency crises and propose a specific early warning system. The paper compares the merits of alternative approaches in providing early indications of currency crises and, based on this comparison, proposes a methodology for the design of such a system. Their methodology involves monitoring the evolution of several indicators that tend to exhibit unusual behaviour in the periods preceding a crisis. Every time an indicator exceeds a certain threshold value, this is interpreted as a warning signal that a currency crisis may take place within the following 24 months. The threshold values are calculated so as to strike a balance between the risk of having false signals versus the risk of missing crises. The authors find that exports, deviations of the real exchange rate from trend, the ratio of broad money to gross international reserves, output, and equity prices are the variables with the best track record in anticipating crises.

Berg and Patillo (1998) examine the models of Kaminsky et al. (1998), Frankel and Rose (1996) and Sachs et al. (1996). Berg and Patillo's objective was to test the capability of those models to predict the 1997 crises. For each model, they try to reproduce as closely as possible the original specification and then test some reasonable modifications.

According to Berg and Patillo (1998), Kaminsky, Lizondo and Reinhart's model issued an alarm during the 1995:5 to 1996:12 period. The forecasted cross-country ranking of the severity of crisis was a significant predictor of the actual ranking. In contrast they find that the models of Frankel and Rose, and Sachs, Tornell and Velasco, would have been of little use in predicting the 1997 currency crises.

Modifications to the three models perform differently. Adding variables to Kaminsky, Lizondo and Reinhart's model, such as current account and M2 over reserves ratio, improved the performance of this model, whereas plausible modifications to the Sachs, Tornell and Velasco and Frankel and Rose's models did not yield useful forecast improvements. Berg and Patillo also estimated a set of alternative probit models using data and a crisis definition borrowed from Kaminsky, Lizondo and Reinhart. Those models provided generally better forecasts than the model by Kaminsky, Lizondo and Reinhart.

A different stream of the empirical literature on currency crises considers banking crises as possible determinants of currency crises. The works by Rossi (1999), Kaminsky and Reinhart (1999) and Glick and Hutchison (1999) can be classified within this group.

Kaminsky and Reinhart (1999) examine currency and banking crisis episodes for industrial and developing countries from the 1970's throughout 1995. In order to investigate if banking crises help to explain currency crises, Kaminsky and Reinhart (1999) calculate

conditional probabilities. The authors claim that if knowing that there is a banking crisis within the past 24 months helps predict a currency crisis then the probability of a currency crisis, conditioned on the previous occurrence of a banking crisis, should be higher than the unconditional probability of a currency crisis. The conditional probability takes on a value of 46 percent, whereas the unconditional one is 29 percent. The conclusion is, therefore, that knowing that a banking crisis was underway helps to predict a future currency crisis.

To further investigate this problem of twin crises, Kaminsky and Reinhart (1999) analyse the evolution of 16 macroeconomic and financial variables around the time of the crises. This time their results point to common causes for banking and currency crises. Both crises are preceded by recessions or below normal economic growth, an overvalued exchange rate, an increasing cost of credit and a fall in exports. Whether the currency or the banking problems surface first is only a matter of circumstance.

Rossi (1999) estimates a logit model of currency crises for a sample of 15 developing countries over the period 1990–97. After including some temporal dummies (to account for the fact that currency crises tend to be clustered in time), real growth, terms of trade, the quality of institutions, the degree of liberalisation of capital outflows, the banking supervisory framework and the degree of depositors' safety, the emergence of banking problems or the occurrence of a banking crises help predict a balance-of-payments crisis, especially within a two-year period. In a similar equation to explain banking crises a currency crisis indicator do not help forecast banking crises.

Glick and Hutchison (1999) empirically investigate the causal linkages between banking and currency crises for a sample of 90 industrial and developing countries over the period 1975–97, using annual data. Glick and Hutchison (1999) use a simultaneous equation methodology, following Maddala (1983), to estimate the structural coefficients and standard errors in a two-equation system where both dependent binary variables (in a probit context) are endogeneous. Their results suggest a very strong and robust contemporaneous correlation among the onset of banking and currency crises in emerging market countries. There is a much weaker evidence of this contemporaneous link with a broader sample of developing countries and for the full sample of countries. The other strong result, found by the authors, is that banking crises are a statistically significant leading indicator of currency crises in emerging markets. Currency crises, by contrast, are not a good leading indicator of impending banking problems.[4]

[4]Other interesting papers on financial crises are Gourinchas, Valdés and Landerretche (1999), Weller (1999), Burkart and Courdet (1998), Goldstein, Kaminsky and Reinhart (2000) and Moreno and Trehan (2000).

Chapter 2

A Duration Model Approach for Currency Crises

2.1 Introduction

In this chapter we seek to explain the origins of currency crises for a group of developed countries. Specifically, we attempt to illustrate the mechanism that generates currency crises by relating their occurrence first, to realisations of explanatory variables and, second, to the duration pattern of the non-crisis periods.

For 20 OECD countries we construct a data set for the period 1970–97, consisting of 68 periods of tranquility . These spells are defined as those episodes for which a particular currency does not suffer from a speculative attack. In a broad sense, we can talk of a spell as synonymous of peg peg.[1] We define a tranquil state or episode as a period of time in which there is no pressure on the currency, while a crisis state is defined as a period characterised by the presence of a speculative attack, either successful or not.

We use duration analysis to study the countries' probability to leave a tranquil state by exiting into a currency crisis state. The use of duration models is an innovative strategy for estimating the probability of exiting a currency peg. This method allows us not only to study the determinants of the likelihood of a currency crash, but also the duration of spells of tranquility, how much this varies over the business cycle and how the duration of tranquil states varies across countries.[2] We are looking for the determinants of the length of time a currency spends in a tranquil state. The duration of the spells of tranquility is important in assessing currency stability. Exchange rate credibility depends not only on the reaction to a speculative attack, but also on the time already spent in a

[1] We use the expression currency peg understood as an episode of currency stability.

[2] These are the classical questions that Kiefer (1988) raised in his seminal paper on duration methods applied to unemployment data.

tranquil episode.

The real world is characterised by the existence of non-stationarities. The characteristics of, say, financial markets change over time, therefore, the probabilities of exit into a currency crisis state also change with the length of the spell.

Traditional models of currency crises —of the probit and logit nature— include time-dependent explanatory variables in order to incorporate those non-stationarities. But these models miss duration dependence as a second kind of non-stationarity. A duration model approach of the type proposed here permits us to capture both kinds of non-stationarity.

Duration models allow us to test for the length of time already spent on the spell as a determinant of the likelihood of exit into a turbulent episode. The specific pattern of the duration dependence lets us test if the likelihood of a devaluation is higher for tranquil periods, say, in the first quarters, than for periods that have lasted longer, after controlling for other time-varying factors. We can argue that the political costs of realignment change over the duration of the spell, maybe due to changes in the credibility of the peg. Growing credibility surrounding an exchange-rate-based stabilisation program might reduce the probability that the peg will be abandoned. In short, we would like to understand the role played by the time spent on the peg in determining the likelihood of exit into a currency crisis.

Klein and Marion (1997) suggest that, even if some of the determinants for the duration of a fixed exchange-rate spell may remain constant over a spell, others will change. A simple correlation of the length of each spell with some constant measure of each explanatory variable (*e.g.* the value of the variable at the beginning or at the end of a spell or its change over the spell or its average value during the spell) fails to capture important information about the time path of the variable during the spell. Therefore, they call for an empirical approach that allows the consideration of time-varying determinants, rejecting explicitly the use of ordinary least squares or duration analysis. They use logit models instead.[3] Nevertheless, in this chapter we propose more sophisticated duration models with the added feature of time-varying variables, so we do not miss the explanatory power of time-varying determinants and, moreover, incorporate duration dependence as a second class of non-stationarity within spells.

The remainder of of this chapter is organised as follows. Section 2.2 concentrates on

[3]Their model is estimated for sixteen Latin American countries and Jamaica during the 1957–91 period.

methodological issues. Section 2.3 depicts the measure of speculative pressure used to analyse the empirics of speculative attacks. We describe the data in Section 2.4. In Section 2.5 we present the main results, and Section 2.6 concludes.

2.2 Methodological Issues

In analysing the process of transition from a tranquil state to a crisis state, we define a tranquil state as a period of time in which there is no pressure on the currency. A crisis state is defined as a period characterised by the presence of a speculative attack, whether this is successful or not. This process generates a sequence of points on the time axis: the times at which speculative attacks occur and, therefore, at which the transitions are made. These movements are random, so the evolution of the state of a country over time is a realisation of a stochastic point process.

Following Eichengreen et al. (1996b), we do not identify currency crises with actual devaluations, revaluations and instances in which the currency is floated. The reason for this is twofold. First, not all speculative attacks are successful. The currency may be supported by the intervention of the national central bank via expenditure of reserves, or by foreign central banks and governments or, even, by the threat or actual imposition of capital controls. The use of interest rates and austerity policies are other alternatives to repel an attack. Second, realignments are undertaken in tranquil periods in order to preclude future attacks.

Since the monetary authority can accommodate the exchange market pressure by running down its international reserves or by raising interest rates, a measure of speculative attacks has to reflect those possibilities. For that reason, we adopt a measure of exchange market pressure similar to that of Eichengreen et al. (1996b).[4]

For the specification of the duration model,[5] we use the Cox (1972) approach of proportional hazards.

The proportional hazard specification in continuous time leads to a hazard function[6] of the form:

$$\lambda\left(t, x\left(t\right), \beta, \lambda_0\right) = \phi\left(x\left(t\right), \beta\right) \lambda_0\left(t\right). \tag{2.1}$$

[4]The concrete specification of this measure is presented in the next section.

[5]See Kiefer (1988) and Lancaster (1990) for a discussion of these models. See also Narendranathan and Stewart (1993) as an application of this type of models.

[6]That is, the part of the hazard (the conditional probability) that is common for all individuals in a proportional hazard model.

Here $x(t)$ denotes time dependent variables, β is a vector of unknown coefficients and $\lambda_0(t)$ is the base-line hazard corresponding to $\phi(.) = 1$. The first component of Equation (2.1), $\phi(.)$, describes the way in which λ shifts between individuals endowed with different $x's$ at given length of time t spent on the peg. The second component, the base-line hazard, is a functional form for the dependence of λ on t.

A commonly used specification of ϕ is:

$$\phi(x(t), \beta) = \exp\left(x(t)'\beta\right) \tag{2.2}$$

This specification is convenient because the non-negativity of ϕ does not impose restrictions on β. Moreover, the vector of coefficients can be interpreted as the constant proportional effect of x on the conditional probability of ending the spell. This is the analogue, in a hazard setting, of the usual partial derivative interpretation of a linear regression coefficient.

In the discrete specification used for the estimation the hazard function denotes the probability of moving to a crisis state in period $t+1$ conditional on being in a tranquil state until period t. Assuming that the covariates are constant between t and $t+1$ we can write the hazard function as:

$$h(t) = 1 - \exp\{-\exp\left(x(t)'\beta + \gamma(t)\right)\} \tag{2.3}$$

Where

$$\gamma(t) = \ln \int_t^{t+1} \lambda(u)du \tag{2.4}$$

This follows directly from the proportional hazard specification without any further distributional assumptions.

We have to express these probabilities in terms of a likelihood function to be estimated.

The contribution to log likelihood made by the i^{th} observation, which fails or is censored[7] in the interval t_j (that is, t_j is the i^{th} observation, either completed or censored) is:

[7] A spell is censored when we do not observe the duration of the spell until its conclusion. We do not have information on the transition to a currency crisis state.

$$L_i(\theta) = d_i \ln(h_i(t_j)) + \sum_{t=1}^{t_j-1} \ln(1 - h_i(t)) \quad (2.5)$$

$$= d_i \ln\left\{1 - \exp\left[-\exp\left(x_i(t_j)'\beta + \gamma(t_j)\right)\right]\right\} - \sum_{t=1}^{t_j-1} \exp\left[\left(x_i(t)'\beta\right) + \gamma(t)\right] \quad (2.6)$$

where $d_i = 1$ if the i^{th} spell is uncensored —the transition from a traquil state to a currency crisis state is observed—, and $d_i = 0$ if censored —the transition is not observed.

2.3 Measuring Exchange Market Pressure

The first issue in any empirical analysis of currency crises is to define speculative attacks. As stated previously, we do not want to limit this study to successful speculative attacks, that is, to the cases in which the exchange rate regime was altered (and the currency was either devalued or floated). Studies of this type are Milesi-Ferreti and Razin (1998) and Frankel and Rose (1996). These works define currency crises based only on unusual movements of the exchange rates.

With our definition of currency crises, we want to capture those unsuccessful attacks that have been warded off by central banks and governments. The monetary authorities may accommodate the pressure on the financial markets by running down their international reserves or deter the attack by raising interest rates. In these circumstances, currency market pressures will be translated into steep increases in domestic interest rates and/or great losses of foreign exchange reserves. Therefore, a measure of speculative attacks should capture these three different forms of currency market turbulences.

Eichengreen et al. (1996c) construct a measure of speculative pressure by means of an index. This index is a weighted average of exchange rate changes, changes in reserves, and interest rate changes. The index of exchange market pressures is defined as:

$$EMP_{i,t} = a\Delta e_{i,t} + b\Delta(i_{i,t} - i_t^*) - c(\Delta r_{i,t} - \Delta r_t^*) \quad (2.7)$$

where a, b and c are the chosen weights, $\Delta e_{i,t}$ is the change in the exchange rate, $i_{i,t}$ denotes the domestic interest rate, i_t^* corresponds to the same variable but for the country of reference, $r_{i,t}$ is the ratio of foreign reserves to domestic money for the domestic country and, r_t^* denotes the same concept for the country of reference.

This is a common measure used in several studies by the same authors (Eichengreen

et al. (1996b), Eichengreen, Rose and Wyplosz (1996a)) and by Sachs et al. (1996) as well as Kaminsky et al. (1998), with variations in the weights given to the three components.

Defining the EMP index of Equation (2.7) as an unweighted measure has the obvious advantage of simplicity. The disadvantage is that the volatility of exchange rates, interests rates and reserves are very different.[8] Eichengreen et al. (1996c), Eichengreen et al. (1996b), Eichengreen et al. (1996a) and Kaminsky et al. (1998) work with the EMP index weighting the three components so as to equalise their volatilities. In this way they prevent any of the components from dominating the index.

The next step is the identification of a currency crisis using the EMP indicator. Eichengreen, Rose and Wyplosz identify quarters in which their index is at least one and a half standard deviations above the sample mean as instances of speculative attacks. To avoid counting the same crisis more than once, they exclude the later observation(s) when two (or more) crises occur in successive quarters.

We believe that this way of defining a currency crisis is faulty for the sample considered. Here first, the unweighted EMP index is defective because it disregards the inherent different volatility of its three components. Second, the weighted EMP measure (according to the particular volatilities of its components) is inadequate because it cannot capture those episodes in which the monetary authorities were very successful in controlling a speculative attack but, however, ended with an important loss of reserves.

For these reasons we construct a *third measure* of speculative pressure. We use the same three indicators (exchange rate changes, changes in reserves, and interest rate changes[9]) but in a rather different way. Episodes where changes in the exchange rate are greater than +1.5 standard deviations over the means are selected first as episodes of speculative attacks. For the remaining episodes we look at the reserves indicator. If changes in relative foreign reserves are below the -1.5 standard deviation band, we clasify them as crisis episodes. As new episodes of currency crisis I add those ones for which the change in the interest rate differential is above the +1.5 standard deviation band.

The remaining observations are classified as periods of tranquility. Some remarks are in order here. First, whenever we find that only one of the three variables lies outside

[8]The volatility of the percentage changes in the reserves (scaled by the monetary base) is several times the conditional volatility of the percentage change in the exchange rate, which is several times the percentage change in the interest differential.

[9]These variables are measured in relative terms with those prevailing either in Germany or in the US, depending on the country of interest. Australia, Canada, New Zealand and Japan are related to the US dollar.

the band, we look at the deviation from the band and the behavior of the two other variables. If the case is such that the deviation from the band is marginal and the two other variables show a normal behavior, we disqualify that episode as a turbulent one and it is classified as a tranquil period. If, on the contrary, we observe that the three variables are in the margin of the band, we qualify the episode as turbulent. In order to prevent the continuation of a speculative episode from being identified as a new episode, I exclude the later observation(s) when two (or more crises) occur in successive quarters.

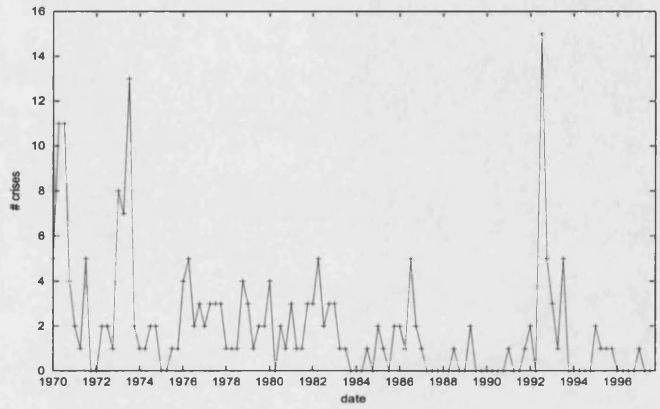
Tables A.1 to A.7 in Appendix A report the identified turbulent episodes by the three measures. Tables A.8 to A.14 and A.15 to A.20 (see Appendix A) report the official currency events and the identification of a turbulent period and the associated official event when applicable. In that way, we can check for the appropriateness of the measure of speculative pressure proposed here when the attacks were successful, and the location of the unsuccessful speculative attacks.

From these tables we can conclude the superiority of the *third measure* over the other two. The first index, the unweighted EMP, identifies too few crises according to the official events. The second measure, the weighted EMP (weighted in order to equalise the volatility of its three components) misses, mainly, unsuccessful speculative attacks that were faced by unusual movements in foreign reserves. A clear example is Denmark in 1992 and 1993 at the time of the tensions in the European Exchange Rate Mechanism (ERM). In late 1992, Denmark warded off attacks by a huge loss in foreign reserves. This is what we call an unsuccessful speculative attack and should be included in this study. An EMP index of the type of Eichengreen, Rose and Wyplosz would miss these crises since relative foreign reserves have the largest volatility (of the three components) and given that the three indicators are weighted in order to equalise their volatilities, foreign reserves lose quite a lot of their importance, failing to capture this kind of crisis.

Another example along the same lines is France in 1992. Using an index of the type proposed by Eichengreen, Rose and Wyplosz, we do not identify the events of 1992 as a speculative attack for France. Whereas, if we use our proposed measure, we do classify the episode as a speculative attack, given the huge loss in reserves that took place at that moment in order to prevent the crisis.

To shed some light on the characteristics of speculative pressure episodes we report the proportion of times that a change in either the exchange rate, relative foreign reserves or relative short term rates is the criterion that qualifies an episode as a period of speculative pressure. A total of 62 percent of turbulent episodes is explained by unusual behavior in the real exchange rate. Relative reserves identify 29 percent of the crises, and the rest, 9

Figure 2.1: Crises per Quarter



percent, is due to extreme movements of the short-term interest rate.

Since episodes that are classified as turbulent ones due to unusual movements in either relative reserves or relative interest rates are not accompanied by large adjustments in exchange rates (according to our measure of speculative attacks), we can state that monetary authorities have intervened actively in foreign exchange markets, using reserves and interest rates, to face speculative pressures 38 percent of the time. That is, monetary authorities have succeed in those occasions to prevent large movements of the exchange rate. This is what we call unsuccessful speculative attacks.

In Figure 2.1 we report the distribution of the currency crises along the time axis and Table 2.1 shows the number of crises identified by countries. Denmark, France, Sweden and the UK are the countries with the greatest number of speculative attacks. At the other extreme, Canada, Portugal, the Netherlands and Australia have the smallest number of currency crises.

Before explaining the results of our estimates, we have to report some of the characteristics of the duration of the spells. Remember that a spell is defined as that period when a particular currency does not suffer from a speculative attack.

Information about the duration of the spells is provided in Table 2.2. The number of crises identified was 149, but in the econometric analysis we only considered 68 due to data restrictions regarding the explanatory variables (see Table 2.3).[10]

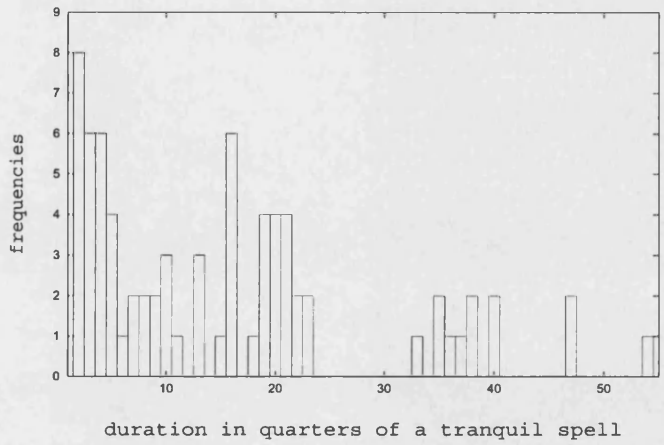
[10]This is unlikely to generate any selection bias since the data restrictions in the explanatory variables are randomly distributed across countries.

Table 2.1: Number of Crises by Country

Country	Number of Crises[1]
Denmark	16
France	15
Sweden	14
UK	14
Belgium	13
USA	13
Austria	11
Ireland	11
Italy	11
Norway	11
Finland	10
New Zealand	9
Switzerland	9
Greece	9
Japan	9
Spain	9
Australia	8
The Netherlands	7
Portugal	7
Canada	5
mean	10.6
standard deviation	2.9

[1]Number of total crises, we do not have excluded consecutive crises yet.

Figure 2.2: Duration Frequencies



It is assumed that a tranquil state ends when the country leaves that state to enter another one (here a currency crisis state), otherwise the spell is right censored. Censored observations are easily handle within the likelihood framework.

From Tables 2.2, 2.3, and Figure 2.2, we see that the exit rate into a turbulent episode is higher in the early quarters of the peg. One third of the tranquil states in the sample end, or are right censored in the first year of the peg, and half of them end or are right censored within two years and a half. In addition, 64 percent of the durations are below four years in length. According to these proportions and given the limited number of crises, we concentrate the estimates for the behavior of the base-line hazard (that is, of the duration parameters) in the four years since the beginning of the peg. This argument is reinforced for the completed spells, with 70% of the population ending spells in four years time.

2.4 The Data

We have assembled quarterly data from 1970 through 1997 for twenty OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The data base is constructed from the *International Financial Statistics* (IFS) published by the International Monetary Fund and the *Main Economic Indicators* dataset published by the OECD.

To define the indices of speculative pressure, we use data from the IFS. The exchange rate is expressed in terms of the national currency of country i at time t over DM or US dollar.

Table 2.2: Distribution of Total Tranquil Spells

Duration of Spell in Quarters	Frequency	Percent	Cum.
1	7	8.64	08.64
2	8	9.88	18.52
3	6	7.41	25.93
4	6	7.41	33.33
5	4	4.94	38.27
6	1	1.23	39.51
7	2	2.47	41.98
8	2	2.47	44.44
9	2	2.47	46.91
10	3	3.70	50.62
11	1	1.23	51.85
13	3	3.70	55.56
15	1	1.23	56.79
16	6	7.41	64.20
18	1	1.23	65.43
19	4	4.94	70.37
20	4	4.94	75.31
21	4	4.94	80.25
22	2	2.47	82.72
23	2	2.47	85.19
33	1	1.23	86.42
35	2	2.47	88.89
36	1	1.23	90.12
37	1	1.23	91.36
38	2	2.47	93.83
40	2	2.47	96.30
47	2	2.47	98.77
54	1	1.23	100
Total	81		
Mean	14		
Median	17		
Standard Deviation	13		
Range	[1,54]		

Table 2.3: Distribution of Completed Tranquil Spells

Duration of Spell in Quarters	Frequency	Percent	Cum.
1	7	10.29	10.29
2	8	11.76	22.06
3	6	8.82	30.88
4	6	8.82	39.71
5	4	5.88	45.59
6	1	1.47	47.06
7	2	2.94	50.00
8	2	2.94	52.94
9	1	1.47	54.41
10	3	4.41	58.82
11	1	1.47	60.29
13	3	4.41	64.71
15	1	1.47	66.18
16	2	2.94	69.12
19	3	4.41	73.53
21	4	5.88	79.41
22	2	2.94	82.35
23	2	2.94	85.29
35	2	2.94	88.24
36	1	1.47	89.71
37	1	1.47	91.18
38	2	2.94	94.12
40	2	2.94	97.06
47	1	1.47	98.53
54	1	1.47	100
Total	68		
Mean	13		
Standard Deviation	13		

We use market rates, that is the exchange rate determined largely by market forces and defined as period averages.

The discount rate, preferably, or the money market rate, depending on the availability of data, is the measure of the interest rate entering the definition of the EMP index.

International reserves enter the EMP index as a ratio of reserves (excluding gold) to narrow money (M1).

The independent variables can be grouped as follows. As indicators of the economic domestic conditions we introduce *real GDP growth* at 1990 prices, the Consumer Price Index (CPI), with base year 1990, to construct the *inflation* indicator, and the rate of *unemployment.*

To measure the external conditions we consider merchandise *exports* (f.o.b.) and merchandise *imports* (c.i.f.), both in terms of growth rates and defined over GDP. We also consider an indicator of the degree of *openness* of the country, constructed as exports plus imports over GDP.

A *Real Effective Exchange Rate index* (REER) is defined as the nominal effective exchange rate index adjusted for relative movements in a national cost indicator of relative normalised unit labor costs in manufacturing. The nominal effective exchange rate is an index of the period average exchange rate of the currency in question to a weighted geometric average of exchange rates for the currencies of selected countries. The weights are derived from trade in manufactured goods among industrial countries over the period 1989–91.

As an indicator of the domestic monetary condition we include *domestic deposits.* This variable is defined as demand deposits plus time and saving deposits, deflated by GDP and in terms of rate of growth. *Domestic credit, claims on government*, and *claims on private sector* are our indicators of a possible credit expansion or lending booms.

To take into consideration the debate on capital account liberalisation and the extent to which measures to increase transaction costs may alter the composition of capital flows and influence the vulnerability to sudden outflows, we include *portfolio flows* and *Foreign Direct Investment* (FDI) in the analysis.

We have to keep in mind that quarterly observations may not be a good periodicity to identify every speculative attack, especially unsuccessful ones. Pressure against pegged

Table 2.4: Maximum Likelihood Estimates

Parameters	Estimates	Est./s.e.	Expected sign
Growth	-0.06	-0.76	-
Inflation	0.08	0.90	+
Unemployment	0.01	0.47	+
Export Growth	-0.04**	-1.97	-
Import Growth	0.03**	1.92	+
Openness	-0.01**	-1.81	-
REER (deviation from trend)	-0.08***	-2.38	-
Deposits/GDP (rate of growth)	-0.05*	-1.47	-
Claims on Government/GDP	0.01*	1.49	+
Portfolio Investment/GDP	0.06***	2.41	+
FDI/GDP	-0.01	-0.08	-

*, ** and *** indicate significance at 10%, 5% and 1% respectively.
Note: the inclusion of a dummy variable to account for lagged duration dependence turns out to be not significant, so we excluded it from our analysis.

currencies can occur and be repelled quickly through a rise in interest rates or foreign-exchange-market intervention within the quarter. When an attack occurs and is repelled with immediate action, the average behavior of both interest rates and international reserves over the quarter are probably not going to reflect the intensity of speculative pressures. But the availability of data restricts the frequency data to quarterly observations in order to capture the maximum spectrum of countries throughout a long time period.

2.5 Results

The results are reported in Table 2.4. The dependent variable is the conditional probability of leaving a tranquil state. The estimates for the parameters of the model are shown in the second column with their standard errors in the third column. The expected sign for the coefficients of the explanatory variables are reported in the last column.

The use of a proportional hazard model allows for an easy interpretation of the estimated parameters. If the sign is positive, the effect on the hazard rate will be positive (shorter durations). If it is negative, the effect will be negative (larger durations).

The baseline rate has been defined through a set of dummy variables, one for each quarter till the fifth. From the sixth to the eleventh it has been defined with a dummy for every two quarters. One more dummy is introduced for the next five quarters. From then on, we do not include any more duration dummies, since we only estimate the base-line hazard for the four first years due to the reasons stated previously. The main feature of this kind

of function (also known as piecewise constant hazard rate) is that it is constant in each interval, but may vary from one interval to the other. The first interval is used as the reference level.

2.5.1 Time-Varying Variables

Variables from quarter t are used to determine the probability of exit in quarter $t+1$ in order to avoid feedback effects of the occurrence of a currency crash into the macroeconomic variables.[11]

Consider the first variable, GDP growth. The negative sign of the estimated parameter indicates that a decline in GDP growth leads to an increase in the probability of ending the spell of tranquility. That is, a weakening in economic activity is likely to be associated with an increase in the vulnerability of the currency to attacks. The underlying explanation of this result is the following: an increasing rate of growth may generate buoyancy in the domestic asset markets, attracting capital inflows and, therefore, supporting the currency. Conversely, if growth is declining there would be pressures to ease financial policies, among them currency depreciation, to stimulate activity. Notwithstanding, the coefficient is not significant.

The inflation variable has the expected sign but it is not significant. High inflation increases the likelihood of exit into a turbulent period. Kumar, Moorthy and Perraudin (1998) argue that high inflation can increase vulnerability to crises through an impact on resource allocation, competitiveness, and macroeconomic stability. In an exchange rate peg (or relatively inflexible nominal exchange rate regime) a higher level of inflation than that of partner countries can lead to significant overvaluation in the real exchange rate.

A possible justification of the non-significance of the inflation variables lies in the inclusion of the REER variable. When we do not include REER in the model, the inflation variable is significant. In previous studies, inflation is significant either when REER is excluded, as in Eichengreen et al. (1996b), or when the inflation variable is substituted by a dummy variable that takes on the value of unity for periods of abnormal high inflation and zero otherwise, as in Kumar et al. (1998).

As expected, high unemployment increases the vulnerability to crises. The slump in economic activity, reflected in a rise of unemployment, makes the central bank more attentive to domestic objectives, compromising the exchange rate target. But the coeffi-

[11] See Agenor, Bhandari and Flood (1992), Flood and Garber (1984), Garber and Svensoon (1995), Krugman (1979) and Wyplosz (1986) for a review of the theoretical models on currency crises.

cient is not significant. We have included this variable in the final specification in rates of growth to take into account the historical different levels of unemployment rates in the countries under study. The inclusion of the variable in levels changes neither its sign, its significance, nor the behavior of the other variables.

As variables that reflect the health of the foreign sector we have included: exports, imports and an indicator of openness. The export variable is included in relative terms to GDP and in rate of growth. The different studies on currency crises emphasise the role of a sharp slowdown in export growth as a key contributor to currency vulnerability. A slowdown in exports is likely to increase the probability of a crisis. This result is confirmed here: the sign for the coefficient of the export variable is negative and significant, a result consistent with Kumar et al. (1998).

According to our estimates, import growth increases in advance of a speculative attack, reflected by the positive sign and significant coefficient. Therefore, an increase in import growth helps to predict the probability of the occurrence of a currency crisis event.[12]

Milesi-Ferreti and Razin (1998) argue that more open economies are less likely to suffer an exchange rate crash. The benefits of trade openness outweigh the higher vulnerability to external shocks. Openness reflects how connected the economy is to the rest of the world and stands here for trade liberalisation. It is proxied by exports plus imports over GDP. As expected, we obtain a negative and significant sign, in line with Milesi-Ferreti and Razin's argument, and with the results of Kumar et al. (1998).

The REER is found to be one of the most important indicators in assessing likely pressures against a currency (Kaminsky et al. (1998)). We can consider the REER as a possible proxy for the loss of international price competitiveness as well as for exchange rate misalignment. Following Kumar et al. (1998), REER can act as a channel for the contagion effect via a competitiveness effect: when one currency is devalued, the trading partners' position deteriorates *vis à vis* that economy. This would show up in the trade accounts with some lag, but investors act on the expectation of the impact and increases in the pressure on the other currencies may follow immediately. A higher value of the exchange rate index implies a more appreciated domestic real exchange rate. Therefore, we expect the coefficient on the real effective exchange rate index to be positive.

On the other hand, an appreciation of the real exchange rate relative to its historical value increases the degree of misalignment. Trend measures of the REER (based on the

[12]Some could argue that higher import growth is a consequence rather than a causal factor of currency crises because rising expectations of a crisis make importers accelerate deliveries.

Hodrick Prescott filter) can provide an approximate measure of significant disequilibrium in the real exchange rate. We introduce the variable REER as deviations from this trend therefore, expecting a negative sign.

According to Table 2.4, the deviation of the REER from its trend variable is significant and has the correct sign. Table A.21 in Appendix A includes REER instead of its deviations from trend. Again, the sign is as expected and the coefficient is significant. Including REER or its deviation from trend has no effect either on the rest of the variables or on the shape of the base-line hazard function. Therefore, with both REER and deviations of REER from its historical trend, we support the hypothesis of REER as, first, a competitiveness indicator, with deteriorations of that indicator leading to higher probabilities of speculative attacks, and, second, as a measure of exchange rate misalignment, appreciations beyond its natural trend result in stronger likelihood of exit into a turbulent episode.

Extending the previously mentioned studies, we introduce deposits over GDP (in terms of their growth rate) that serve as a proxy for the existence of deposit runs and loss of confidence in the banking system, or of the shrinkage of banks' balance sheets for other reasons. The results show that the coefficient for this variable has the expected sign and that it is statistically significant. The absence of falling deposits is reflected in a lower probability of a currency crisis event, reflecting the influence of the banking sector on the likelihood of a currency crisis.[13]

In order to capture Krugman's effect[14] (domestic credit expansion) on the likelihood of a speculative attack, past empirical studies include the domestic credit variable. This variable is the sum of claims on central government, local governments, nonfinancial public enterprises, private sector, other banking institutions and non-bank financial institutions. But what Krugman emphasises is not the behavior of all those components of the total domestic credit, but the credit to the government; the credit expansion due to the monetisation of the government budget deficit. In order to capture the effect of this variable on the likelihood of a speculative attack, we should take into consideration only the claims on government (in net terms) by the central bank and other banks. We have not seen any study that makes such a consideration.

The coefficient for the claims on government to GDP ratio is positive and statistically significant. An increase of this ratio raises the likelihood of exit into a currency crisis state.

[13]Some theoretical models argue that a higher rate of growth of bank deposits tends to increase vulnerability to crisis, because the financial intermediation system cannnot cope effectively with the influx of funds, and that this predisposes to a 'twin' crisis'.

[14]See Krugman (1979).

In order to check the accuracy of this result, we have also estimated the model using domestic credit instead of claims on government. The result is shown in Table A.22 of Appendix A: domestic credit has the wrong sign and it is not significant.

To double check, we have also estimated the model including both claims on government and claims on the private sector. The first remains significant and with the correct sign, but the latter is not significant. Moreover, Eichengreen et al. (1996b) introduce credit growth and fail to find a significant influence of this variable on the likelihood of occurrence of a currency crisis. Therefore, we conclude that claims on government is the variable that better reflects Krugman's effect.

The last two variables included in the regression analysis reflect the composition of capital inflows: portfolio investment and FDI, both variables deflated by domestic GDP. As Frankel and Rose (1996) and Kumar et al. (1998) argue, the hypothesis is that FDI is a safer way to finance investment than is portfolio investment. First, FDI is said to be directly tied to real investment in plants, equipment and infrastructure; whereas the other type of investment goes to consumption and, therefore, does not help to add productive capacity to the system, which is necessary to generate exports that go into the service of debt in the future. Second, the difference between these two types of capital inflows may be an important factor in determining the vulnerability of a country to its capital inflows. Portfolio flows are very sensitive to any changes in the international financial environment as well as to changes in investor sentiment. In the event of a crash, investors can suddenly dump portfolio investments, but multinational corporations cannot quickly sell their factories.

Portfolio investment is highly significant and has the expected sign: increases in portfolio investment raise the probability of occurrence of a currency crisis. Nonetheless, FDI is not significant, even if it has the expected sign. We can only compare these results with those of Kumar et al. (1998), since Eichengreen et al. (1996b) do not consider the effects of these kind of variables. Kumar et al. (1998) obtain the same effect regarding portfolio investment variable, a positive and significant effect. Regarding FDI, Kumar et al. (1998) find a significant effect but negative, meaning that increases in FDI result in higher likelihood of a crisis. The reason is probably due to the different group of countries under study: emerging markets in their work, OECD countries in ours.

Summarising and comparing with Eichengreen et al. (1996b) (that is the closest paper to this one, both in terms of country sample and the construction of the dependent variable based on an EMP index), we find a wide range of significant variables, in contrast to Eichengreen, Rose and Wyplosz's two macroeconomic significant variables (unemploy-

ment rate and inflation) plus the contagion variable.

In the next section, we discuss the estimation of the base-line hazard and the corresponding hypothesis of duration dependence for episodes of exchange rate tranquility.

2.5.2 Estimated Base-Line Hazard

The scaled[15] estimated base-line hazard for our semiparametric function model is plotted in Figure 2.3. With the base-line hazard we want to test whether time already spent on the peg has an independent effect on the likelihood of a currency crisis event, that is, whether there is a duration dependence beyond the control of time-varying variables.

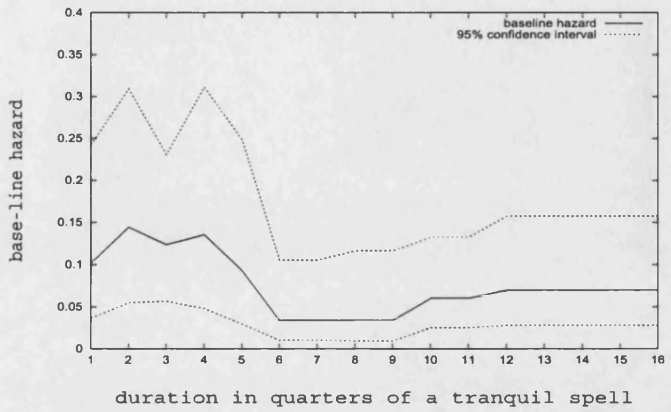
The base-line hazard function shows a general downward slope from the second quarter after the start of the peg. That is, the likelihood of exit into a currency crisis state declines with the length of the peg. Therefore, we can clearly state a negative duration dependence: the probability of leaving the peg decreases with duration.[16] Our hypothesis on the existence of duration dependence, even after controlling for time-varying factors, is confirmed, and hence, the use of duration analysis to model the likelihood of currency crises is the correct approach.

More specifically, in the first quarter, the probability of a speculative attack is lower than in the second quarter. That probability increases from the second quarter and remains around that level for the first year of the peg. These two facts seem to show that at the very beginning of the peg the agents are not very confident in it. After the first quarter, agents test the exchange rate regime resulting in a higher likelihood of breaking the peg in that quarter. After the first year, the probability of exit into a currency crisis state declines sharply, stabilising by the end of the second year of the peg, to recover a little bit in the initial months of the third year and turning into a flat line afterwards. Concluding, this general downward slope of the base-line hazard indicates that agents give more confidence to the peg as this progress. This may suggest that a policy-maker gains credibility over time with the functioning of the peg, changing the political cost of

[15]The baseline hazard is scaled to the characteristics of a *standard country*, defined by setting the covariates to their sample mean (see Narendranathan and Stewart (1993) for a similar exercise).

[16]We have conducted a likelihood ratio (LR) test to assess the overall significance of the duration parameters. We reject the null hypothesis of all duration parameters being equal to zero at the standard significance levels. We also compare a model that imposes all duration parameters to have the same value with a model that allows two different duration parameters, one for the five first quarters and another for the sixth quarter onwards (since we claim that the probability of exit into a currency crisis state declines sharply after 5 quarters in a tranquil period). Applying a LR test we reject the null hypothesis of both parameters being equal. A third LR test was conducted to test the equality of the coefficients for the fourth and the sixth quarters of the peg. Again, the null hypothesis of equality between these two coefficients is rejected at the standard significance levels. These tests indicate that the probability of exiting into a currency crisis state is significantly different during the first quarters of the peg.

Figure 2.3: Estimated Base-line Hazard



realignment over the duration of the spell.

2.6 Concluding Remarks

In this chapter, we have adopted a duration model approach towards the determination of the origins of a currency crisis event. We concentrate on the likelihood of a crisis for a country in a given period related to some explanatory variables. We differ, then, from the traditional empirical studies on currency crises that adopt probit or logit models in their specifications. The use of duration models allows us to account for duration dependence among the determinants of the likelihood of speculative attacks, without neglecting the use of time-varying explanatory variables as used by other researchers. One of the main objectives of this study is to test for time dependence, that is, the length of the time already spent on the peg as a determinant of the probability of exit into a crisis state.

- From our estimates, we first state the influence of some important macroeconomic variables on the likelihood of exit into a turbulent state. Increases in the rate of growth of exports, decreases in the rate of growth of imports, and openness are associated with a decrease in the vulnerability of the currency to attacks. REER overvaluation increases the likelihood of the occurrence of a currency crisis. Increases in capital inflows in the form of portfolio investment help to explain currency crises. Claims on government contribute to predict the likelihood of a speculative attack, increases in that credit position raise the likelihood of exit into a turbulent state; whereas increases in the rate of growth of deposits over GDP decrease the probability of a crisis event.

- Regarding the duration dependence which characterises our data, the maximum probabilities of exit are given at the start of the peg (tranquil period), but with a

clear tendency to decrease after the first year of the peg. That is, we can clearly state a negative and highly significant duration dependence. This fact may suggest the existence of a political cost of realignment that changes over the duration of the spell: growing credibility surrounding an exchange-rate-based stabilisation program might reduce the probability that the peg will be abandoned.

Chapter 3

A Methodology for Assessing the Likelihood of Currency Crises in Emerging Markets[1]

3.1 Introduction

It is important to regularly monitor the foreign exchange risks in emerging markets given the impact of currency crises. Typically, a currency crisis results in a GDP growth loss of 4–8 percent and lasts between twelve to eighteen months, at great cost to both domestic and foreign investors.

In this chapter we develop a statistical and econometric framework to assess the likelihood of currency devaluation over a one-month horizon for thirty-six emerging markets in five regions. The framework used takes into account the effect of country-specific economic and financial factors, as well as global indicators of currency risk. We construct a composite indicator called the *Emerging Markets Risk Indicator (EMRI)*, whose monthly scores reflect the currency risks in these markets. *EMRI* provides monthly risk scores that can be used in the sovereign risk analysis or in currency portfolio investment decisions.

Our objective was to build a parsimonious, rigorous and transparent framework to quantitatively assess the risks of foreign exchange crises. Such a framework can then be used to assist in portfolio allocation decisions. *EMRI* facilitates a consistent comparison of emerging market economies that are very diverse in terms of their histories and the current state of their fundamentals. Having a systematic way of evaluating the risks faced by economies is potentially useful to investors in these markets.

[1] This research was conducted when I was a part-time consultant at Credit Suisse First Boston, London, October, 1999–April, 2001. The dataset used in this chapter remains property of Credit Suisse First Boston.

For our estimations, we use monthly data pooled across thirty-six emerging markets. Our framework relies on estimations within a logit framework using an unbalanced panel across countries. The countries with the longest historical sample have fifteen years of data.

This chapter is organised as follows. Section 3.2 contains a description of the methodology used. In Section 3.3 we define our currency crisis variable, describe the data sources and the independent variables. We also present and discuss our sample. The main results and applications of *EMRI* are examined in Section 3.4. Finally, Section 3.5 concludes.

3.2 Summary of Methodology

The goal of our estimation procedure is to arrive at a good fit for explaining the variation in the dependent crisis variable (which is binary and takes on a value of one during a crisis period and zero otherwise). The independent or explanatory variables are chosen from a list of macroeconomic and financial variables, both global and country-specific. Parsimony is essential for good estimation and inclusion of too many variables makes the estimation fraught with problems of non-convergence. By using previous studies in the literature as a guide, we focus on variables with the greatest forecasting power.

After selecting a small set of variables that are likely to explain currency crises[2], the next step is the definition of the dependent variable; i.e. the crisis definition. We then proceed with the econometric estimation. This is based on the *logit* model —one of a class of models for limited dependent variables. We use maximum likelihood estimation techniques: estimation based on choosing the coefficients that actually maximise the probability of observing the sample data in hand.

The estimated results are used to obtain probabilities of devaluation for each emerging market. In this way *EMRI* can help highlight the vulnerability of a currency. High levels of crisis probability, or of changes in this probability, can be used as inputs to specific trading strategies for emerging market investors. Formally, these probabilities, under the logistic distribution, are calculated as follows

$$P = \frac{\exp(\beta' x)}{1 + \exp(\beta' x)} \tag{3.1}$$

where the β's denote the regression coefficients corresponding to the variables from the

[2]See section 3.3 for a complete definition of these variables.

estimation and the x's denote the values of the explanatory variables.

To annualise this crisis probability we simply apply the following formula

$$P_{ann} = 1 - (1 - P)^{12} \tag{3.2}$$

In addition, a measure of the contribution of the explanatory variables to the probability of a crisis is obtained. There are two measures that can help us in this direction. If we are interested in looking at the contribution of a variable in simple and intuitive terms, we compute the *raw contribution* of a given factor. This raw contribution for a given factor, say j, is calculated as follows

$$RC = \frac{\beta_j x_j}{\sum_{i=1}^{N} \mid \beta_i x_i \mid} \tag{3.3}$$

The raw contribution is calculated for any given month. Note that N represents the number of explanatory variables in the model. This measure is not the most accurate but presents in an intuitive way the share (in crude terms) of the factor of the total sum of all the factors contributing to the crisis probability or *risk score.*

However, the technically more accurate yet less intuitive version of how much a factor contributes towards the risk score is given by the *marginal contribution* of a given factor. The computation of the marginal contribution of a factor j requires the calculation of the following expression

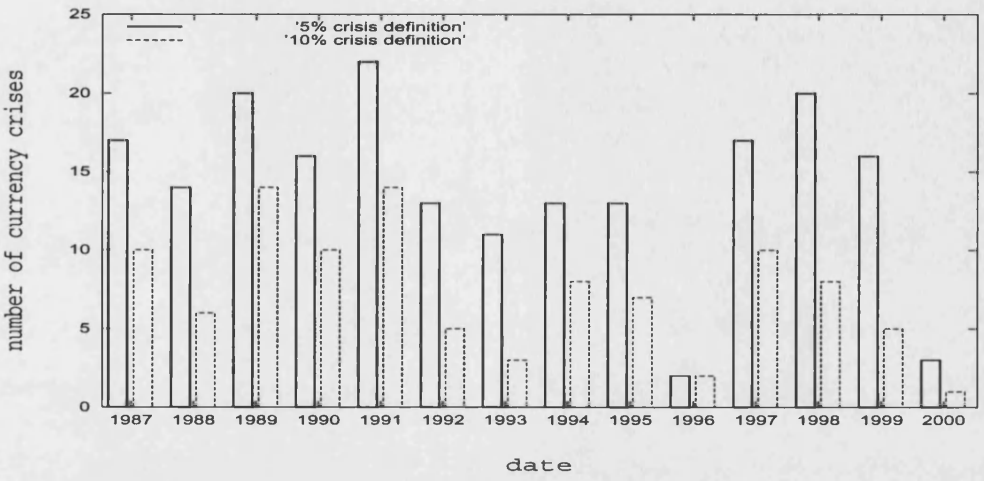
$$\frac{\delta P}{\delta x_j} = \frac{\exp(\sum_{i=1}^{N} \beta_i x_i)}{(1 + \exp(\sum_{i=1}^{N} \beta_i x_i))^2} \beta_j \tag{3.4}$$

From this formula it is evident that the relative marginal contribution for two given factors, say j and k, is given by the ratio of the two respective coefficients

$$\frac{\beta_j}{\beta_k} \tag{3.5}$$

Throughout the paper we use the raw contribution to discuss the impact of the different factors included in our estimations of the likelihood of currency devaluation and describe the contribution of some of these factors to the main historical currency events.

Figure 3.1: Frequency of Currency Crises over Time



3.3 Crisis Definition, Explanatory Variables and Data

3.3.1 Crisis Definition

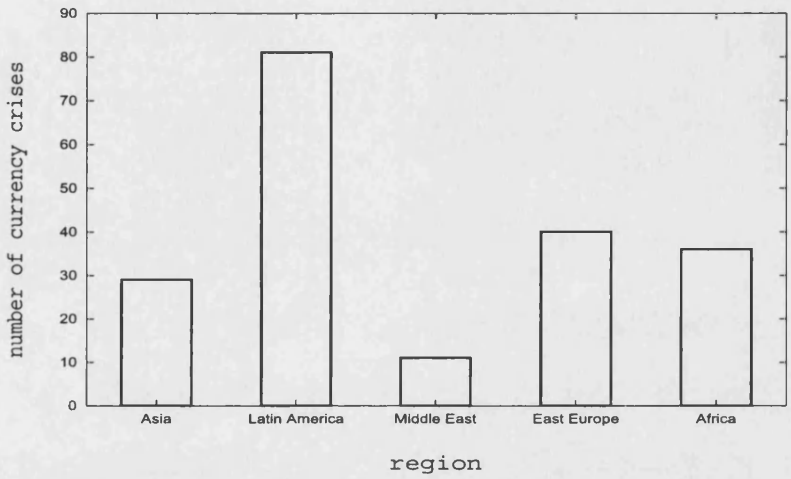
Any analysis of the possible likelihood, extent and frequency of currency crises is contingent on a clear definition of currency crisis. We use the concept of depreciation for our crisis definition and impose two conditions that need to be satisfied in a crisis month: (a) a currency depreciation in any one month exceeds a given cut-off (generally 5 percent, although we also study results from a 2.5 percent cut-off to a 10 percent cut-off) and, (b) an increase in the rate of depreciation greater than the rate of depreciation of the previous month by a certain factor (generally 2). Formally, we express these two conditions as follows

$$\Delta e_t = (\frac{e_t}{e_{t-1}} - 1) \cdot 100 > \alpha$$
$$\frac{\Delta e_t}{\Delta e_{t-1}} \geq (1 + \varphi)$$

where e_t denotes the exchange rate in month t measured in domestic currency units per US dollar; α denotes the monthly depreciation rate cut-off (default case is taken as 5 percent); and φ denotes the rate of acceleration (here taken to be 100 percent, that is 1).

We are interested in moves and changes in the exchange rate that are not pre-announced or expected. We aim to exclude cases of managed depreciation by central banks that are pre-announced. This is achieved by imposing the second criterion that looks at acceleration in the rate of depreciation. This criterion allows us to rule out cases where the depreciation in a given month might be quite high relative to the cut-off, but not double

Figure 3.2: Currency Crises across Regions



that in the previous month.

Using a 5 and a 10 percent cut-off for depreciations and a rate of acceleration of 1, the frequency of currency crises over our sample is as shown in Figure 3.1. These crises are calculated for the period 1987:1–2000:3. Using the 10 percent cut-off definition yields fewer crises over the same period. This has implications for the estimation of the crisis probability. We need to find a fine balance between enough observations of the dependent variable —the crisis dummy— and too many crisis observations that might include an element of noise in the maximum likelihood estimations. A very stringent crisis cut-off such as 15 percent yields too few crisis observations whereas a very loose cut-off such as 2.5 percent leads to too many observations being labelled as crisis.

In Figure 3.2 we represent the number of crises by region. Clearly, Latin America is the region with the highest frequency of crises in the sample period 1987–2000. Once we proceed with estimation, the sample size is reduced due to the limited availability of macroeconomic data for some countries.[3]

Tables B.1 and B.2 in Appendix B present the exact date of occurrence of crises for the different countries under study, for both the 5 percent and the 10 percent cut-offs.

[3]The sample size for the estimations is specified in the next subsection. We also define there the countries enclosed in each of the regions depicted in Figure 3.2.

3.3.2 Sample

For the model to be of practical use, we need to employ relatively high frequency data. For this reason, we construct a large monthly data set of macroeconomic and financial variables that may affect the incidence of currency crises. Table 3.1 shows the start dates used in the estimations for each of the 36 countries in our data set (the end date is March 2000 for all 36 countries). Going further back with the initial dates would create inconsistencies in the monthly data, as those figures are either difficult to obtain or not very reliable.

We conducted two out-of-sample experiments to test the model performance. First, we estimated the model with data until December 1996 to assess how it does on the eve of the Asian crisis. Then we estimated the model with data until December 1997 to test how the model performed prior to the Russian and Brazilian crises.

Most of the data we use are on a monthly basis and are compiled from various regional economist teams at Credit Suisse First Boston (CSFB). IMF, Bloomberg and national data publications are other sources for the data. Some of the data are on an annual frequency, and we use cubic spline interpolation methods to construct monthly series from them.

Given the relatively low number of observations, we proceed with combined time-series and cross-sectional estimation, pooling together the whole set of country observations.

3.3.3 Explanatory Variables

Out of the vast array of variables that the currency crisis literature has identified, we selectively use the subsets presented in Table 3.2 for each of the estimated models. In the following paragraphs we summarise the expected relationship between those explanatory variables and the occurrence of a currency crisis.

It is worth mentioning at this stage that the raw macroeconomic and equity variables for each country mentioned above undergo two stages of transformation. First, they are mostly converted in terms of changes which is done on a year-on-year basis or a month-on-month basis. Next, the variables are standardised using the historical country-specific means and standard deviations for each variable. The reason for standardising the variables is optimisation. Standardised variables are easier to use in optimisation and this facilitates both the speed of convergence as well as the robustness of estimations. All the macro variables enter the estimations, after being standardised, with two lags. The equity price and oil price variables enter the estimations with a single lag.

Table 3.1: Sample Estimations

Country	Start	Country	Start	Country	Start
		Asia			
China	Apr-92	Hong Kong	Jan-88	India	Jan-87
Indonesia	Jan-87	Korea	Jan-87	Malaysia	Jan-87
Pakistan	Jan-87	Philippines	Jan-87	Singapore	Jan-87
Sri Lanka	Jan-87	Thailand	Jan-87	Taiwan	Jul-87
		Latin America			
Argentina	Jan-87	Brazil	Jan-87	Chile	Jan-87
Colombia	Jan-87	Ecuador	Jan-95	Mexico	Jan-87
Peru	Jan-87	Venezuela	Jan-87		
		Middle East			
Egypt	Jan-94	Israel	Oct-86	Jordan	Nov-89
Kuwait	Jan-87				
		Eastern Europe			
Hungary	Jan-92	Poland	Apr-92	Russia	Jan-96
Turkey	Jul-91	Czech Republic	Apr-95	Slovakia	Jan-97
Croatia	Oct-97				
		Africa			
Kenya	Jan-87	Morocco	Apr-94	Nigeria	Jan-87
South Africa	Jan-87	Zimbabwe	Jan-90		

As a measure of economic activity we use *real GDP growth.* A decline in growth translates into pressures to ease financial policies to stimulate economic activity. Among these measures the monetary authorities may consider depreciation as an economic policy option. On the other hand, positive GDP growth generates an optimistic environment in the domestic asset markets attracting external capital and reinforcing the value of the currency. Hence, we expect a negative sign for this variable: the greater is growth, the lower is the likelihood of a currency crisis. We use real GDP on an annual basis interpolated by means of cubic spline techniques. The growth measure is constructed with year-on-year changes over the interpolated series. We incorporate this variable with a lag of two months.

To account for the path of credit expansion, we introduce the variable *credit to the private sector.* Given the 1997–98 financial crisis in Asia, this variable has received considerable attention. It was evident for the months preceding the 1997 Asian crisis that the existence of an excessive credit expansion favored the monetary environment and economic growth. In this environment, banks tended to extend credit without a proper study of the risks and quality of loans, that is, the lending standards were very lax. This increased the vulnerability of the economy to a slowdown in activity. We also consider another monetary variable, *narrow money growth,* as an explanatory variable for currency risk. Excessive

Table 3.2: Explanatory Variables

Definition	Expected sign
Global Model & Asian Model	
Weighted regional contagion dummy	positive
Foreign exchange reserves over imports	negative
External Debt over exports	positive
Credit to the private sector year-on-year changes	positive
Equity prices month-on-month changes	negative
Real GDP year-on-year changes	negative
REER overvaluation	positive
Oil prices changes measured as deviations from a 18 months moving average (only for exporters of oil)	negative
Latin American Model	
Weighted regional contagion dummy	positive
Foreign exchange reserves over imports	negative
Budget balance over GDP	negative
Narrow money year-on-year changes	positive
Equity prices month-on-month changes	negative
Real GDP year-on-year changes	negative
REER overvaluation	positive
Oil prices changes measured as deviations from a 18 months moving average (only for exporters of oil)	negative
Metal prices changes measured as deviations from a 18 months moving average (only for importers of metal)	positive
US industrial production year-on-year changes	negative
US 3-month interest rate month-on-month changes	positive

All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month. The reason for that is that equity prices and oil prices are variables available to the user before the other variables included in the model. Moreover, equity and oil prices have effects that dissipate very quickly after the first lag.

money growth plays a role in exacerbating economic imbalances. We use year-on-year changes of both these variables in our estimations.

An excessive *government budget deficit* is said to have been a key factor underlying the financial problems for the Latin American countries in the late 1980s and early 1990s. If a growing budget deficit is financed via monetisation, it tends to create economic imbalances, with excessive money creation weakening the currency. The role of a growing budget deficit is an important determinant of a currency crisis. The alternative of issuing debt to finance the budget deficit can lead to vulnerability as well. Issuing debt on a hard currency on a short-term basis can also increase the risk premium of a country. The creation of additional domestic debt tends to increase the likelihood of future tax increases and therefore has potential adverse effects too. The budget deficit variable considered in this paper is an interpolated series from the original annual data and is expressed relative to nominal GDP.

To take into account the effect of *external debt*, we introduce this variable as a ratio to exports. High levels of the external debt to exports ratio can lead to a loss of confidence by domestic and foreign investors as payment difficulties on debt interest arise. This creates pressures on the currency leading to a loss of trade competitiveness. A cubic splining technique was applied to the annual data to obtain the monthly data series used in the estimations. An appreciable increase of this ratio was observed in Korea and Thailand in the year prior to the 1997 crisis.

The level of international reserves is a key indicator of the sustainability of a currency peg in any given exchange rate regime. If a country has a high level of *reserves relative to imports* the probability of a speculative attack against its currency is lower (maintaining all the other factors at the same level). That is, investors' confidence may depend on the level of reserves a country holds.

A variable that has received considerable attention in the crisis literature is the *Real Effective Exchange rate* (REER). Most empirical studies that include this variable among the determinants of a currency crisis find it to be significant and overvalued prior to a crisis. We would expect that an overvalued REER increases the likelihood of a currency crisis since[4] the higher the REER relative to its equilibrium value, the greater the adjustment required in the nominal exchange rate to ensure external balance. In order to measure this overvaluation we use the Hodrick-Prescott filter to calculate a historical trend. Deviations from this trend are indicative of an overvaluation. Kaminsky and Reinhart (1999) stress the importance of this variable, considering it to be one of the key leading indicators of

[4]As Ahluwalia (2000) points out.

currency crises. The REER is constructed using bilateral nominal exchange rates, deflated by relative price indices and weighted by bilateral trade. It is a measure of relative competitiveness *vis-à-vis* the main trading partners. If either inflation increases or the nominal exchange rate appreciates, we observe an increase in the REER index, denoting an appreciation. Overvaluation relative to trend is measured with a positive sign in our analysis and as it relates positively to the likelihood of a crisis, we expect the variable to have a positive sign in our estimation.

To include a variable that is forward looking and captures the state and sentiment in financial markets, we consider *equity prices.* Sharp and repeated increases in stock prices may be indicative of the build-up of a bubble, but regular increases, on the contrary, represent the state of financial markets in a fundamental asset pricing sense. We introduce this variable in terms of monthly changes in stock prices expecting a negative sign.

The influence of industrial countries on the economies of emerging markets has increased in recent years. Global macroeconomics and the international financial environment also have an impact on the emerging market economies. For this reason we consider global variables such as the *US industrial production index* and the *3-month US interest rate* within our set of explanatory variables. One contributory factor to the Mexican crisis was the tightening of US monetary policy, with a series of increasing interest rates (the already troubled Mexican economy was significantly affected by this tightening). We introduce the interest rate variable in terms of month-on-month changes. The US industrial production variable is included as year-on-year changes.

For many emerging market economies, an important share of revenues comes from trade in primary commodities. On the other hand, several emerging market countries are net importers and are therefore vulnerable to commodity price shocks. This justifies the inclusion of a commodity price dummy variable to differentiate net importers from net exporters. Given the importance of oil and metal commodities for the Asian and Latin American countries, we choose these indices as explanatory variables in our model. These variables are considered in terms of deviations of the current commodity price from the recent 18-month average. The oil price variable is multiplied by a dummy variable that takes on the value of 1 for oil exporters, and 0 for oil importers. Therefore, an increase in the value of oil prices variable should translate to a lower probability of occurrence of a currency crash. Similarly, the metals price variable is multiplied by a dummy variable that captures the condition of being a net importer[5] of metals. We expect a positive

[5]We create the dummy for metals by setting its value to 1 for net importers given the absence of net exporters of metal among our selected sample of Asian countries. This way we avoid the problem of a nearly singular matrix in the estimation procedure.

sign on the coefficient for the variable as high values for the variable tend to increase the likelihood of currency crises.

Finally, we introduce a *weighted regional contagion* dummy variable to capture the spillover effects of pressures from one currency to another. We model this variable in a very simple way. The approach taken here is one of regional contagion. We have five regions: Asia, Latin America, Middle East, Eastern Europe and Africa, and we create a weighted regional contagion dummy variable for each region. The contagion variable is based on crisis occurrence in countries within the region with a lag of two months. This takes into account the number of countries within a region that have had a crisis two months prior, i.e. if 5 countries out of 10 had a crisis in region 1 in May 1998, the contagion variable would take on a value of 5/10 in July 1998.

3.4 Empirical Results and Applications

3.4.1 Estimation Results — Global Model

We have conducted several estimations based on varying sample sizes (across time and across countries), variables included in the model, and methods of standardising the variables. The baseline model is estimated for the whole sample of countries and for the sample ending in March 2000. Within the estimation, we include the independent variables in standardised form so that they have a mean of zero and a standard deviation of one. This is done on a country-by-country basis. We refer to this model specification as the *global model* specification.

The estimation results pertaining to the global model can be seen in Table 3.3. We present the estimated coefficients along with the z-statistic.[6] We have estimated alternate models with different levels of depreciation cut-offs, 10, 8 and 5 percent levels, but we focus our attention on the 5 percent model.

The regional contagion dummy variable turns out to be highly significant and with a positive sign. This indicates that the occurrence of a crisis somewhere else in the region increases the likelihood of a crisis for the rest of the countries in the same region in the next two months.

The global factor oil prices has an important effect on the likelihood of a currency crisis.

[6]The significance of the parameter estimates can be assessed using a "one-tailed" test based on the Normal approximation. Given the size of our sample, the t-statistic is virtually Normally distributed. Then we can use the t-tables to assess significance. We use the critical values for the 1, 5 and 10 percent significance level, which are 2.326, 1.645 and 1.282, respectively.

Table 3.3: Estimations Results — Global Model

Variable	10% cut-off	8% cut-off	5% cut-off
Constant	−4.56***	−4.32***	−3.73***
	(−28.21)	(−29.66)	(−34.56)
Contagion	2.86***	1.44	2.97***
	(2.34)	(1.21)	(3.92)
Oil prices	−0.12	−0.17	−0.27**
	(−0.55)	(−0.87)	(−1.64)
Credit to the private sector change	0.44***	0.33***	0.20***
	(4.09)	(3.18)	(2.33)
REER overvaluation	0.32***	0.38***	0.34***
	(3.43)	(4.33)	(4.58)
Real GDP growth	−0.67***	−0.67***	−0.56***
	(−6.37)	(−7.01)	(−7.21)
Import cover	−0.39***	−0.32***	−0.21***
	(−3.35)	(−3.07)	(−2.56)
Equity price change	−0.29***	−0.32***	−0.22***
	(−2.61)	(−3.10)	(−2.60)
Debt to exports ratio	0.18***	0.17***	0.10***
	(2.63)	(2.74)	(2.16)
Log likelihood	−352.37	−411.39	−612.17
Avg. log likelihood	−0.08	−0.09	−0.14

*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
Numbers in parenthesis denote the z-statistics.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

This denotes that commodity exports still play an important role in foreign currency revenues, even allowing for significant economic transformations and diversification of trade by the emerging market economies. Oil prices have the expected negative sign. The increase of oil prices in relation to the recent history for net exporters of oil reduces the likelihood of a currency crash.

The next variable in Table 3.3 is credit to the private sector. The effect of year-on-year changes of this variable tends to influence risk positively and significantly enhance the odds of a currency crisis. As pointed in the last section, this may indicate imbalances of credit growth. If excessive credit growth is not carefully monitored (as it seems to have been the case in the Asian crisis), the banking sector tends to extend credit without regard to risk and quality of loans especially during what they consider to be good economic conditions. This eventually culminates in unsustainable increases in the pace of domestic activity, inflationary pressures, the build-up of external imbalances and asset price bubbles.

An overvalued REER is highly significant, increasing the probability of currency crises. This is consistent with the results of Kaminsky et al. (1998). They found the REER to be the main leading indicator of currency crises. This variable may also reflect some contagion via the competitiveness effect, which is that the devaluation of one currency in a given country deteriorates the trading partner's position.

A slowdown in economic activity captured by real GDP growth significantly increases the likelihood of currency crises. This can be seen in Table 3.3 where the coefficient of real GDP growth takes on a negative and highly significant value. The vulnerability of a currency to external pressures increases when the domestic economy suffers from a recession or a slowdown in economic activity.

According to the sign of the equity price variable, we can state that on average increases in equity prices were seen as positive in reducing the vulnerability of currencies to crises. The increase in stock prices creates a favourable environment, attracting foreign capital and helping to reinforce the currency.

The external debt to exports ratio shows a positive and significant sign and the results indicate what we expect: high levels of debt not covered by a sufficiently high level of exports result in a higher likelihood of a currency collapse. This is reflected in the positive and significant sign of the debt to exports ratio in Table 3.3.

Table 3.4: Type I & II Errors — Global Model

	10% cut-off*			5% cut-off*		
		Actual			Actual	
		Crises	Non-Crises		Crises	Non-Crises
Predicted	Crises	78.48	34.44	Crises	70.59	34.99
	Non-Crises	21.52	65.56	Non-Crises	29.41	65.01

* The cut-off for correct calls is based on the 65^{th} percentile of the risk scores for the entire sample.

3.4.2 Prediction Classification — Global Model

One way to evaluate the accuracy of the models is to look at the prediction classifications of the model for crises and non-crises. We want to see how well the model performs by predicting a crisis when the actual crisis occurs, and how well it predicts a non-crisis when there is in fact no crisis. We need to evaluate the performance on both hypothesis simultaneously, as we can always improve one of these hypotheses at the expense of the other, that is, we cannot improve both at the same time.

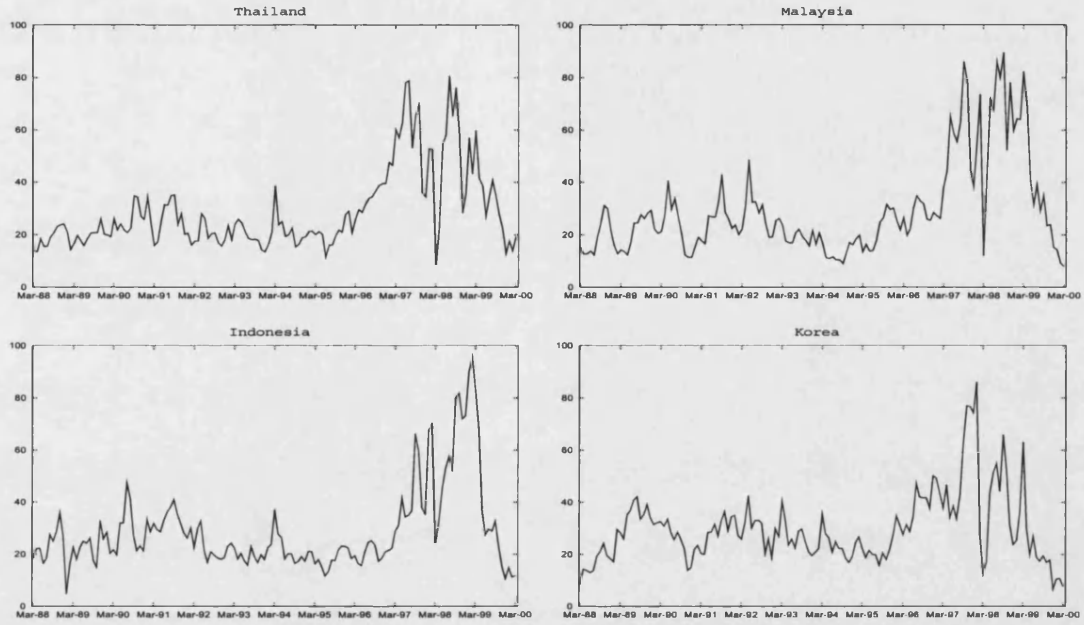
To perform this test we have chosen a 65^{th} percentile of the fitted values as the cut-off to consider an event to be a crisis. If this probability cut-off is low, we will obtain a high number of crises predicted accurately, but a substantial number of non-crises will be categorised as crises. On the other hand, if the cut-off chosen is high, a high number of non-crises will be predicted accurately with an important number of crises considered as non-crises.

Table 3.4 shows that the 10 percent global model predicts 78.48 percent of the crises, while 65.56 percent of non-crises are predicted accurately. These figures are 70.59 and 65.01 percent, respectively, for the 5 percent model. We prefer to use the 5 percent model as the currency moves post the Asian crisis and collapse of pegged exchange rates seem to range within much narrower bands. If we were to use the 10 percent crisis cut-off, while it would be historically very good, it might help us capture fewer incidences of currency pressures in the near future.

3.4.3 Country Risk Scores — Global Model

In this section we present the crisis probabilities or risk scores for selected countries. The crisis probabilities are calculated using data on explanatory variables and the estimated coefficients following Equation 3.1 and these are then annualised using Equation 3.2. We interpret the annualised probability as the probability of at least one crisis during the

Figure 3.3: Crisis Probabilities — Global Model (Asia)



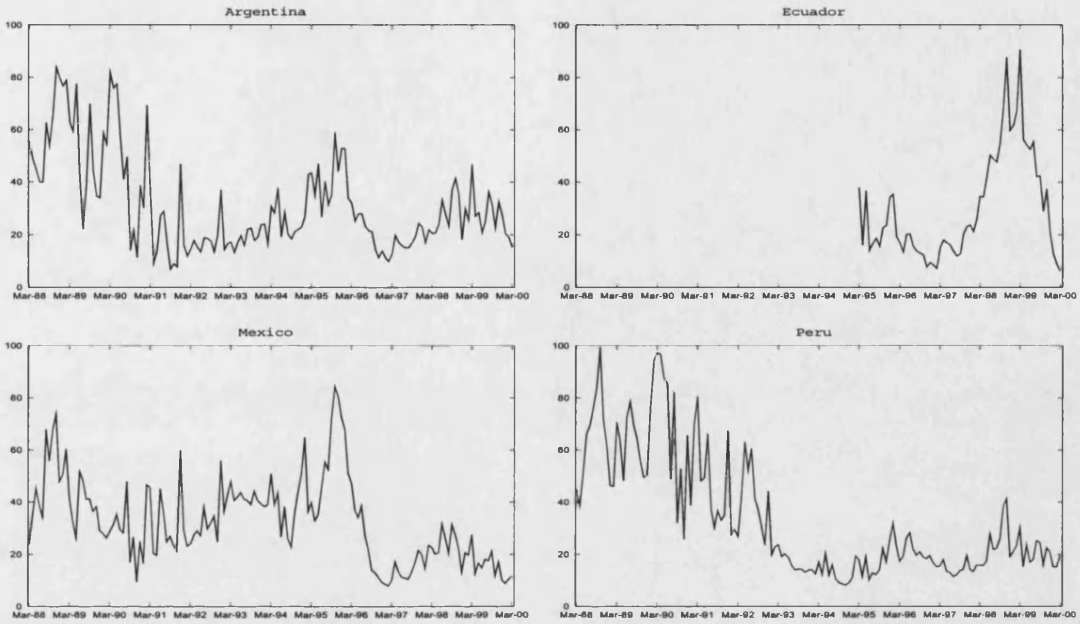
course of a year. We assume that economic conditions and the values of the independent variables remain as during the month (for which the probability is computed) throughout the remainder of the year.

Figure 3.3 shows the evolution of country risk scores for a sample of the Asian countries based on the 5 percent cut-off depreciation global model. For these countries we can see how the risk score was starting to increase before the 1997 Asian crisis. The chart for Thailand shows that the probability of crisis began to increase towards mid 1996. The risk score for June and July 1997 was 3.75 times the risk scores at the end of 1995. These values remain high relative to historical values for Thailand indicating the possibility of further crises (as did occur in December 1997 and June 1998). Similarly, values of the risk score index were roughly 3 times higher for the repeated currency crisis in June 1998.

In the case of Malaysia, the risk score started picking up towards the second half of 1996, achieving relatively high values (the scores almost tripled) at the onset of the 1997 crisis. The scores for Indonesia started increasing a bit later, at the beginning of 1997, but remained at high levels for a longer period, capturing the repeated depreciations along 1997, 1998 and 1999. Only at the beginning of 2000 did the crisis probabilities come back to within the normal range for Indonesia.

Korean risk scores started increasing at the end of 1996 but stabilised at relatively high

Figure 3.4: Crisis Probabilities — Global Model (Latin America)



values. In September 1997 the risk scores started to pick up again. After that, risk score values decreased, increasing again from May 1998.

Figure 3.4 shows the risk score trajectories for some Latin American countries. It clearly shows higher levels of risk scores for Argentina before adopting a currency board in April 1, 1991. The only increases are observed in 1995 and 1996 following major currency adjustments in Latin American countries. By the second half of 1998 and at the beginning of 1999 we again observe some increase in the crisis probabilities after the problems in Brazil. In Ecuador the reviving of the crisis probability is obvious from mid 1998, when soon after that a chain of devaluations occurred. The Ecuadorian scores remain at high levels until the end of 1999, when crisis probabilities return to historical values. The highest Mexican risk scores are observed mainly at the end of 1994 and the beginning of 1995 when the Mexican currency crisis took place. Peruvian risk scores behave in a completely different way before 1993 and after that year. From 1988 till 1993 the average risk score is 57 percent, whereas the average risk scores drops to 18 percent in the 1993–2000 period.

Figure 3.5 displays risk scores for Russia and the Czech Republic. Russian scores started to pick up by the end of 1997, going from values of 19 percent in November 1997 to 62 percent just before the onset of the currency crisis in August 1998. Only from July 1999 did the risk scores came back to the levels prior to the Russian turbulence. The risk scores for the Czech Republic started increasing in the last quarter of 1998, anticipating

the February 1999 depreciation of the currency. From May 1999 risk scores returned to the normal range of values as in 1997.

3.4.4 Factor Contribution — Global Model

In order to investigate the factors behind crises, we look at the raw factor contributions of the variables. Figure 3.6 shows a series of graphs for Thailand raw factor contributions on different dates. The dates are chosen to show the different impact of variables used in our model to predict the 1997–98 Asian crisis. The top two panels depict the main factors behind the first wave of the Asian crisis for Thailand in July 1997. In those panels we observe the role played by credit to the private sector, the REER and the debt to exports ratio prior to the July 1997 devaluation (factors that contribute to the May and June 1996 risk scores, when the probability of a currency crisis was increasing, signalling the July 1997 crisis).

The next two panels show a rather different picture. We have chosen September and October 1997 to show the factors anticipating the December 1997 devaluation of the baht. The variables that contribute to an increase in the likelihood of a currency crisis are of the more traditional nature: a slowdown in real GDP growth and equity prices. Note that real GDP growth before the July 1997 devaluation was lowering the risk score as the economy was undergoing a boom period. We also note the role played by the contagion variable in increasing the probability of a currency crisis. This variable is switched on after devaluations in other Asian countries. These charts also show the effects of the first devaluation slowing down the economic activity in Thailand and the immediate effect of the baht devaluation in the behaviour of foreign exchange reserves-imports ratio. Stock markets also did reflect the low attraction of investors to the Thai economy and contribute towards increasing the risk score prior to the crisis.

The two bottom panels reflect the raw factor contribution in June and July 1999 to

Figure 3.5: Crisis Probabilities — Global Model (East Europe)

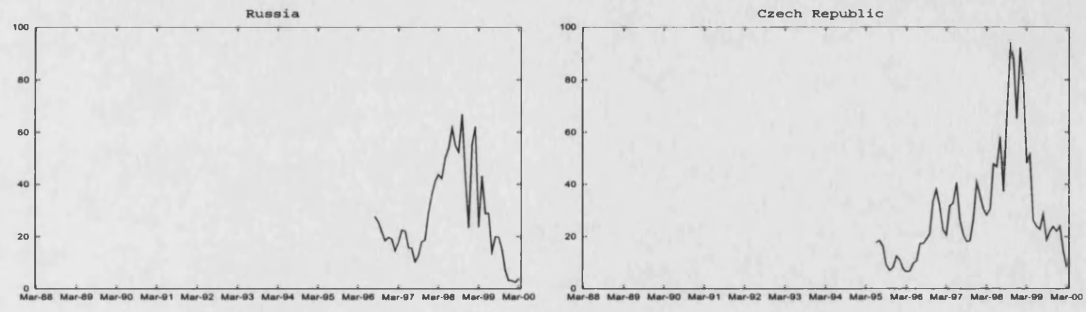


Figure 3.6: Raw Factor Contribution — Global Model (Thailand)

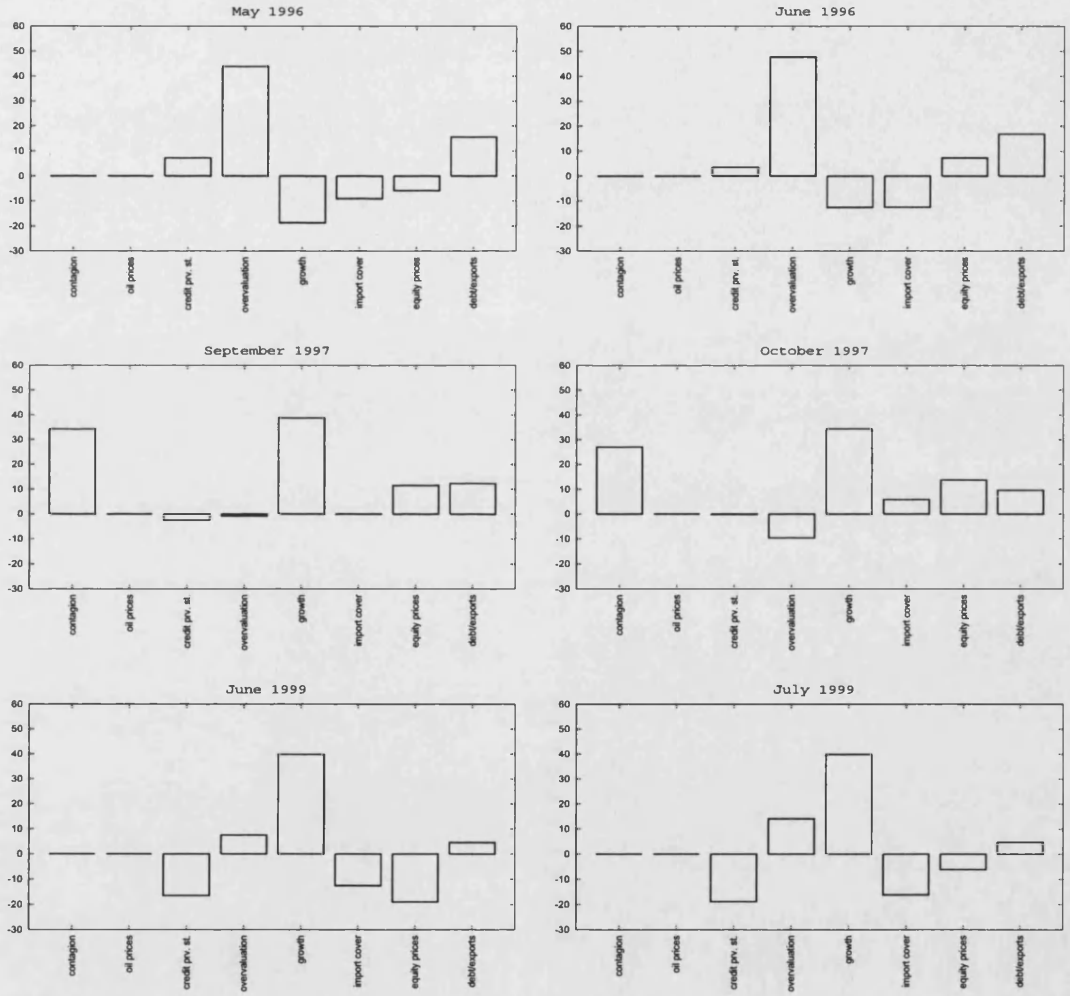
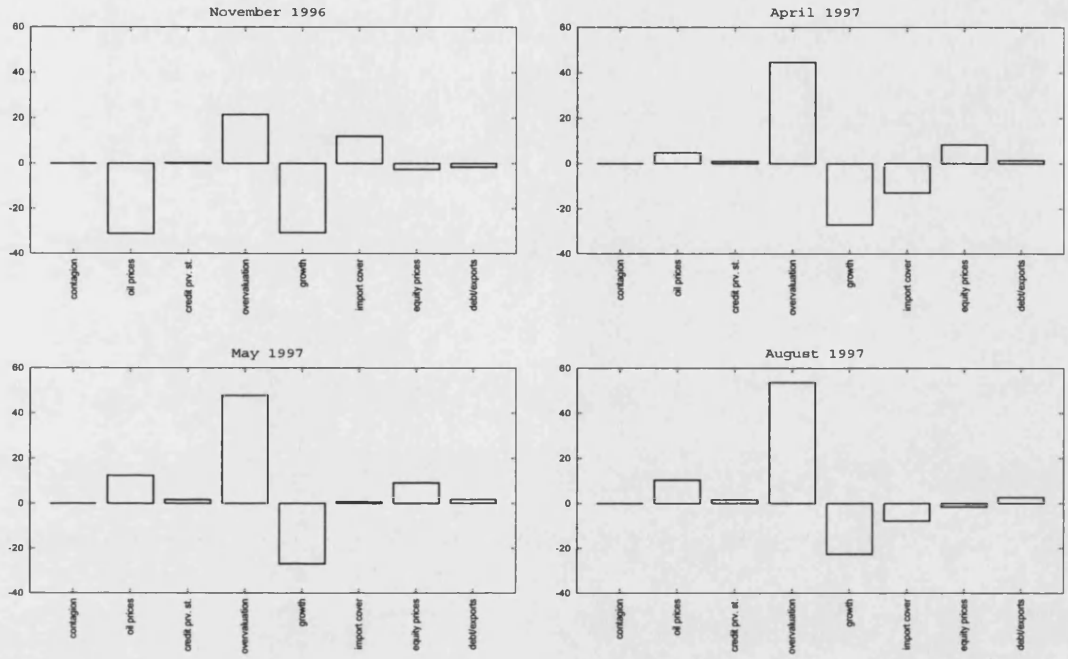


Figure 3.7: Raw Factor Contribution — Global Model (Indonesia)



explain the September 1999 crisis. Again, real GDP growth is the main contributor of the increase in risk scores prior to September events.

When discussing the Indonesian risk score charts, we pointed out that risk scores started to pick up later than for the rest of the Asian countries. To find an explanation for this fact we graph the raw contribution behind the August 1997 devaluation. One thing is clear, the favourable evolution of oil prices before April 1997 contributed to lower risk scores, preventing a clear signal of the currency crisis well before it occurred. It is only from April that oil prices act to increase risk scores (see Figure 3.7). Moreover, the contribution of credit to the private sector is smaller than in the Thai case.

To determine the factors behind the Russian 1998 crisis, we present the raw contributions from November 1997 to the onset of the crisis in August 1998 in Figure 3.8. We would like to highlight the role of oil prices. Since early November 1997 this factor contributed to increase the risk scores for Russia and its importance seems to increase the closer we get to the onset of the Russian crisis. Moreover, from March 1998 on almost all the factors considered in our model contribute positively to the risk score values. The slowdown in economic activity is marked by the positive contribution to the risk scores of real GDP growth.

Figure 3.8: Raw Factor Contribution — Global Model (Russia)

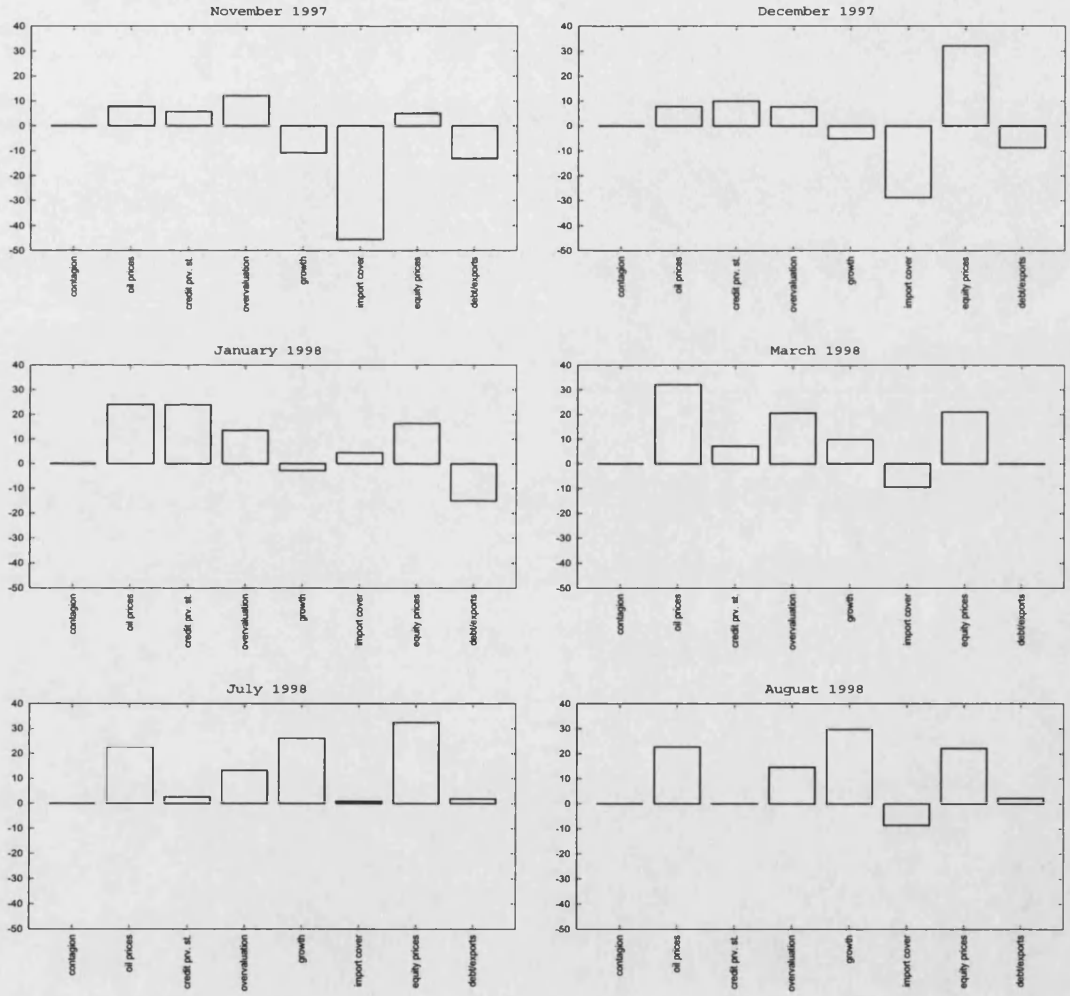
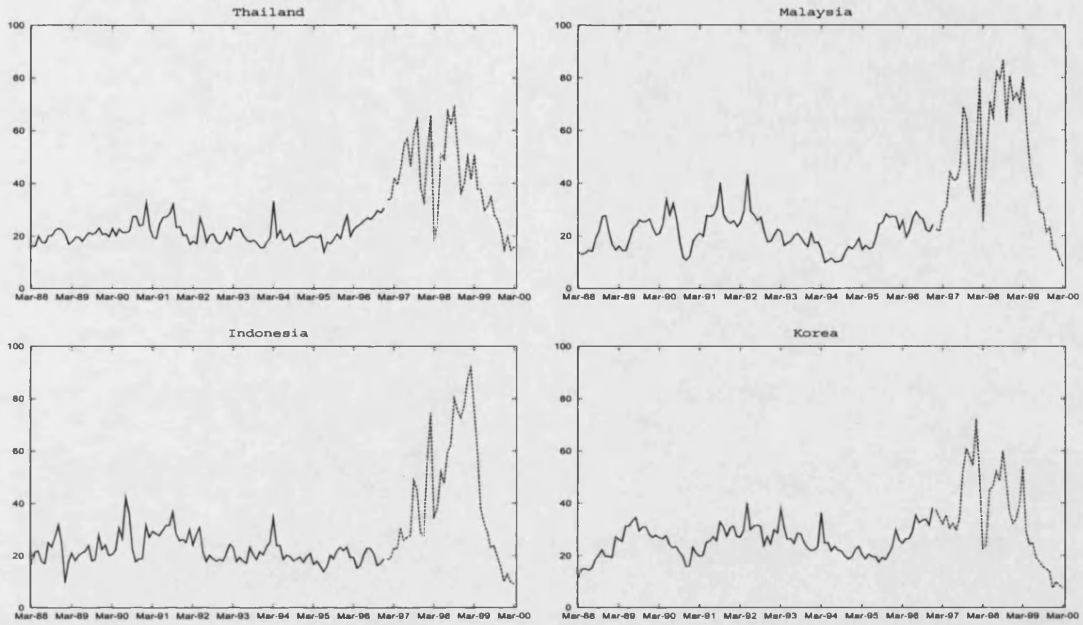


Figure 3.9: Crisis Probabilities — Sample Ending December 1996



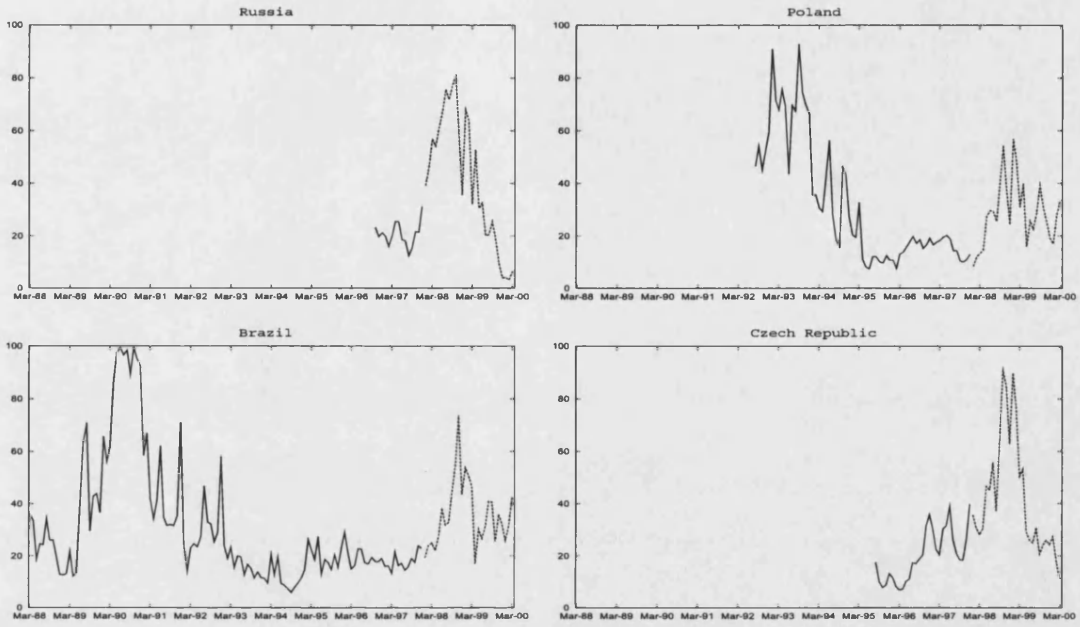
3.4.5 Reduced Sample Estimations

To assess the forecasting power of our model we have estimated two reduced samples. The first one restricts the sample to end in December 1996 with the aim of studying the predictive power prior to the 1997 Asian crisis. The second exercise estimates our model with sample data ending in December 1997 in order to evaluate predictive power prior to the Russian crisis and the Brazilian crisis. The estimated parameters for these models are represented in Tables B.3 and B.4 in Appendix B.

Figure 3.9 illustrates the risk scores for the main Asian countries involved in the 1997 crisis. The dashed line represents forecasted risk scores from January 1997. All four countries in Figure 3.9 had higher risk scores before the onset of the 1997 crisis. Only Indonesian scores seemed to increase more slowly, but, nevertheless they too did signal the upcoming currency crisis. We can therefore say that, had we applied this model prior to the Asian financial crisis, we could have predicted that crisis.

A similar exercise was done to evaluate the main events of the currency disturbances of 1998 starting with the Russian crisis. If we look at the graphs brought together in Figure 3.10 we can appreciate the evolution of the risk score series for Russia, and see that the 1998 crisis was very strongly anticipated by the fundamentals. From the beginning of 1998 the risk scores increased dramatically, from an average of a 20 percent risk score to a maximum of 81 percent. For Poland, risk scores started increasing in the second half

Figure 3.10: Crisis Probabilities — Sample Ending December 1997



of 1998 anticipating the February 1999 currency crisis. The January 1999 Brazilian high depreciation was predicted correctly; note that the risk score line started increasing in the second half of the year prior to the crisis from values of around a 20 percent probability to values of over 70 percent with the onset of the crisis. Those values have not yet gone back to their initial levels, but have remained in a range between 30 and 40 percent. Lastly, the crisis probabilities for the Czech Republic singled out the February 1999 crisis as the scores started increasing in mid 1998.

3.4.6 Whole Panel Standardisation

The reason for conducting an estimation with a different method of standardisation of the explanatory variables is to show the sensitivity of our results. The method of country-by-country standardisation of variables based on a country's own history provides a more consistent risk score history for any particular country, whereas the whole panel standardisation method allows for a better cross-country risk score comparison.

In Table B.5 of Appendix B we present the estimated parameters for the global model using a 5 percent cut-off depreciation and the whole panel standardisation method. In Table B.6 we depict the Type I and Type II errors to assess the prediction classification of the model estimated in this way.

The risk score evolution for the different countries resulting from the whole panel stan-

Table 3.5: Estimations Results — Asian Model

Variable	Coefficient	z-statistic
Constant	−4.70***	−17.36
Contagion	2.45	0.63
Oil prices	−0.767*	−1.4
Credit to the private sector change	0.23	1.03
REER overvaluation	0.31**	1.93
Real GDP growth	−0.41**	−2.24
Import cover	−0.05	−0.23
Equity price change	−0.56***	−3.13
Debt to exports ratio	0.52***	2.55
Log likelihood	−126.71	
Avg. log likelihood	−0.07	

*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

dardisation method follows a similar pattern to the one calculated using the country-by-country standardisation process, but with this new standardisation we can compare risk scores across countries to assess vulnerability to a currency crisis across countries.

3.4.7 Regional Models

In this section we present the results for the regional models. We estimate regional models to try and find a better fit taking into account region-specific characteristics. We only estimate regional models for Asia and Latin America as the frequency of crises in the other regions is too low to permit robust estimation. The regional models are estimated for the 5 percent cut-off depreciation. The 10 percent depreciation cut-off gave far too few crises, yielding less robust statistical results.

Asia

The Asian model uses the same specification (in terms of the variables included in the equation) as the global model. The estimated parameters are reported in Table 3.5. The signs of the variables are as expected, and consistent with those corresponding to the global model.

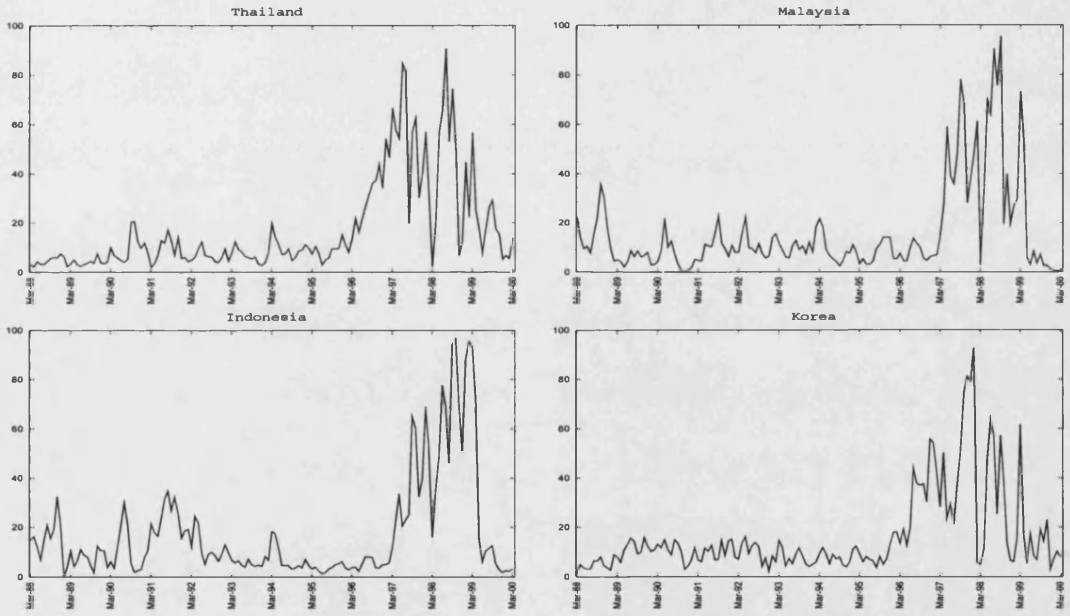
The prediction classification for the Asian model is better than for the global model. Type I and Type II errors are shown in Table 3.6. Notice that we obtain a 75.00 percent of the crises correctly classified and a 69.37 percent of non-crises are predicted accurately.

Table 3.6: Type I & II Errors — Asian Model

5% cut-off*			
		Actual	
		Crises	Non-Crises
Predicted	Crises	75.00	30.63
	Non-Crises	25.00	69.37

* The cut-off for correct calls is based on the 64^{th} percentile of the risk scores for the entire sample.

Figure 3.11: Crisis Probabilities — Regional Model (Asia)



The corresponding classification numbers for the global model using the same 5 percent depreciation cut-off were 70.59 percent and 65.01 percent, respectively.

As an illustration, we plot the regional risk scores for the same group of countries as we did for the global model. We can see from Figure 3.11 that the evolution of the crisis probability is similar to that for the global model. It is worth noting that the values of the probabilities seem to achieve more extreme values than those obtained with the global model specification, perhaps because with the regional model we are able to capture the particular dynamics of a specific region.

Table 3.7: Estimations Results — Latin American Model

Variable	Coefficient	z-statistic
Constant	−3.17***	−17.23
Contagion	0.07	0.05
Narrow money change	0.21**	1.64
REER overvaluation	0.17**	1.68
Real GDP growth	−0.44***	−2.98
Import cover	−0.43***	−3.11
Budget balance	−0.38***	−2.58
Equity price change	−0.31***	−2.41
US industrial production change	−0.53***	−3.65
US 3-month interest rate change	0.26**	1.68
Metal prices	0.19	0.98
Oil prices	−0.16	−0.89
Log likelihood	−234.13	
Avg. log likelihood	−0.20	

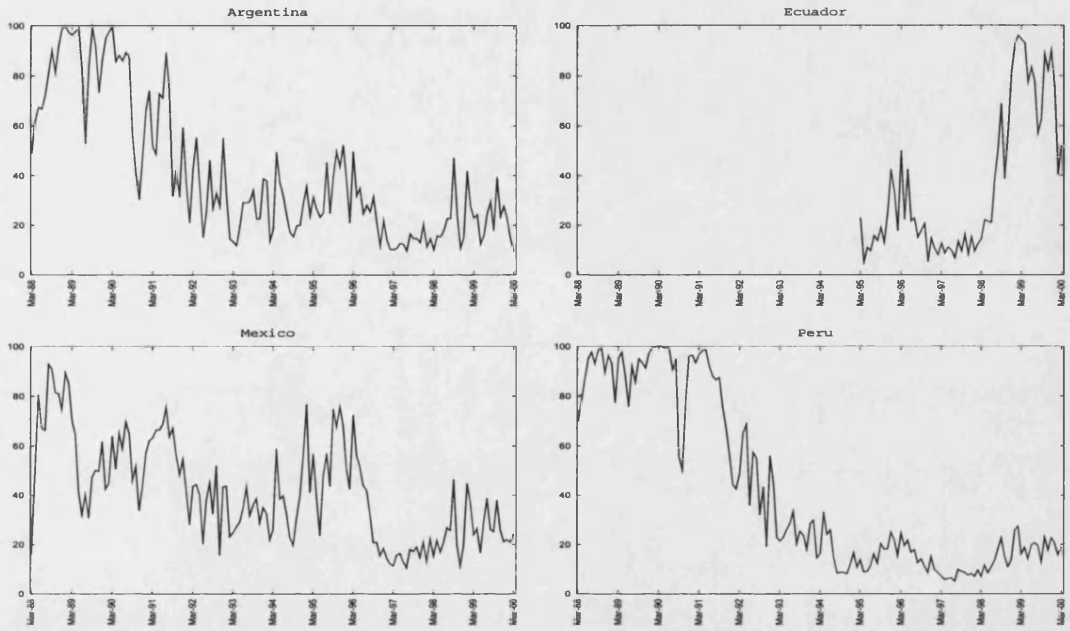
*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

Table 3.8: Type I & II Errors — Latin American Model

5% cut-off*			
		Actual	
		Crises	Non-Crises
Predicted	Crises	78.08	36.42
	Non-Crises	21.92	63.58

* The cut-off for correct calls is based on the 64^{th} percentile of the risk scores for the entire sample.

Figure 3.12: Crisis Probabilities — Regional Model (Latin America)



Latin America

In the Latin American region we include government budget balance, narrow money, the US industrial production (in year-on-year changes) and the US 3-month interest rate (as month-on-month changes). We exclude the debt to export ratio and credit to the private sector variables.

The coefficients from the estimation are presented in Table 3.7. All the variable coefficients have the expected sign as discussed in Section 3.3 earlier. Regarding Type I and Type II errors, we obtain a better fit than that obtained for the global model. In Table 3.8 we predict accurately 78.08 percent of the crises, and 63.58 percent of the non-crises for the Latin American model.

Figure 3.12 displays the crisis probabilities for countries using the Latin American model. It shows higher risk scores during crisis periods than the ones obtained in the global model. However, the path is the same, accounting for the same crises. The movements in the risk scores are sharper in the regional model than in the global model.

In order to test the hypothesis that the government budget deficit was highly responsible for the currency problems of Latin American countries in the late 1980s and early 1990s, we present the raw factor contribution for Argentina and Brazil for those dates in Figure 3.13. We clearly see that the bar corresponding to the public deficit contributes

Figure 3.13: Raw Factor Contribution — Regional Model

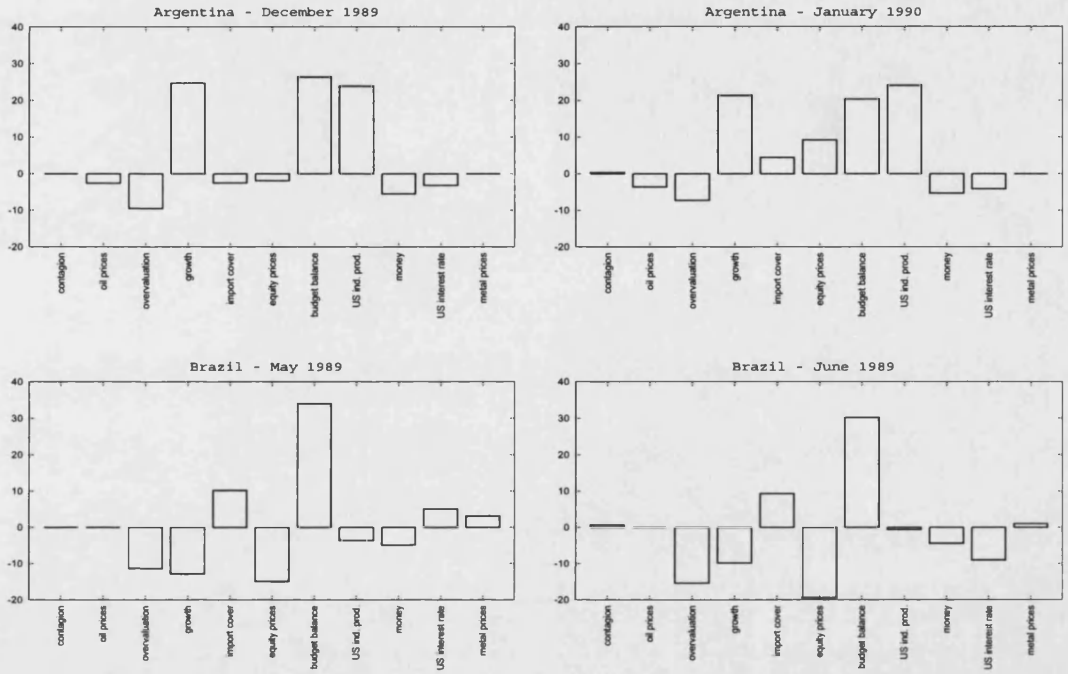
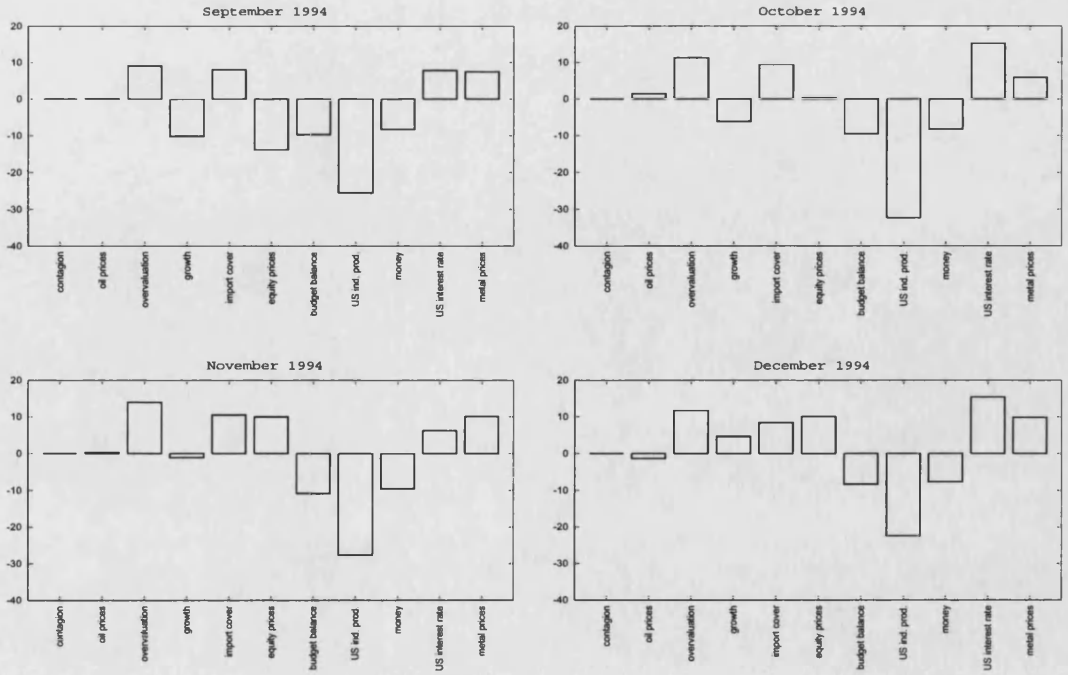


Figure 3.14: Raw Factor Contribution — Regional Model (Mexico)



positively to increase the risk score for both countries at the time of the crises.

The economic literature points out that US interest rates played an important role in the 1994 Mexican currency crisis. In order to check this argument, we use our Latin American model and present the raw factor contribution for the onset of the 1994 Mexican crisis in Figure 3.14. We show four charts corresponding to the three months prior to the December 1994 devaluation and this same month. In all four charts we see the positive contribution of the US 3-month interest rates to the risk scores. It is worth noting that the negative evolution of the metal prices variable and the import cover ratio contributed to enhance the probability of crisis.

3.5 Conclusions

In this chapter we have developed a consistent quantitative framework to assess currency risks across thirty-six emerging markets. This rigorous and transparent framework helps us assess currency risks in a clear fashion. We are able to identify and track the factors that drive and influence currencies during a crisis period. Our risk indicator, *EMRI*, produces monthly risk scores that can also be viewed as a summary indicator of sovereign risk based on a small set of fundamentals.

- The main results point to the relevance of a contagion variable in a model to forecast currency crises. There is strong evidence of spillover effects on the occurrence of a currency crisis.
- Commodity prices (oil and metal prices) help predict the occurrence of currency crises. Higher commodity prices benefit commodity exporters reducing the likelihood of crises.
- Credit to the private sector is an important variable to asses the likelihood of currency crises. In the case of the Asian crisis in 1997–98 this is confirmed in our *factor contribution* charts.
- Following earlier studies, an overvalued REER is indicative of a high probabiliy of a currency crisis. This is highly consistent with the currency crisis empirical literature. An overvalued REER stands for exchange rate misalignments and contagion effects via competitiveness.
- A slowdown in economic activity and lower equity prices help to explain incidences of currency crises. Currency collapses are explained too by high debt related to the level of exports and high imports in relation to the amount of foreign exchange reserves.

Given the relevance of the group of fundamentals to forecast currency crises stated in our model, we can derive an important policy implication: it is crucial for the stability of exchange rates and for avoiding currency crises, to regularly monitor the evolution the macroeconomic indicators here proposed.

Chapter 4

Modelling Currency Crises in Emerging Markets: A Dynamic Probit Model with Unobserved Heterogeneity and Autocorrelated Errors[1]

4.1 Introduction

The debate on the nature of banking and currency crises has intensified in the wake of the financial crises in Asia (1997 and 1998), Russia (1998), and Brazil (1999). Although the empirical literature has mainly focused on currency crises, a parallel stream on the origins of banking crises has also flourished.[2] More recently, the joint occurrence of banking and currency crises associated with the Mexican crisis in 1994 and the Asian financial turmoil[3] has given impetus to a new wave of empirical studies that focus on the casual linkages between banking and currency crises. *Twin crises*, the dual incidence of currency and banking crises, are not a new phenomenon, though: over the last century, for example, the US experienced a series of banking crises, the most severe being the one of 1931 during the Great Depression.

In principle, the causality between the two types of crisis may run in any direction. Banking crises may lead to currency crises, currency crises may cause banking crises, or

[1]The dataset used in this chapter was jointly collected with Elisabetta Falcetti (LSE) and further analysed in Chapter 5 of this Thesis as joint research with Elisabetta Falcetti.

[2]See Caprio and Klingebiel (1996), Demirgüç-Kunt and Detragiache (1998a), Demirgüç-Kunt and Detragiache (1998b), Demirgüç-Kunt and Detragiache (2000), Eichengreen and Rose (1998), González-Hermosillo (1996) and García-Herrero (1997).

[3]Thailand, Indonesia, Malaysia, and Korea in 1997–98.

they can be a joint event, due to common causes.

The case were banks' unsoundness contributes to currency crises has been studied in Calvo (1997), González-Hermosillo (1996), Miller (1999), Obstfeld (1994) and Velasco (1987). Obstfeld (1994) points to the government's trade-off between inflation, fostered by the excessive money creation that is associated with a bailout of the banking system, and exchange rate stability. Policymakers would choose inflation, rather than defend a fixed exchange rate, in order to avoid bankruptcies and impose further strains on the banking sector. In the end, banking sector weaknesses might precipitate a currency crisis if rational speculators anticipate the government's choice of devaluing the currency.

Velasco (1987) presents a model of the interaction of the banking system and the balance of payments in the context of a small open economy. Extending the balance of payments crises literature to a situation in which the private banking system is explicitly modelled, Velasco (1987) shows that the excessive rate of domestic credit creation resulting from a governmental commitment to guarantee the liabilities of the banking system is inconsistent with a stable exchange rate.

González-Hermosillo (1996) argues that a change in the expectations that a banking crisis may occur would increase the relative risk of holding bank deposits. This would lead to a new equilibrium where bank deposits would be withdrawn and converted into cash, both in domestic and foreign currency. The cross-elasticities between the different assets could be such that a significant portion of the deposits withdrawals is directed into foreign currency at the expense of the domestic currency, triggering a currency crisis.

Arguments in favor of the opposite causal link, i.e. currency crises generating banking problems, rely on the assumption that the banking sector is intrinsically vulnerable due to the liquidity mismatch between assets and liabilities. Long-term assets denominated in the national currency are confronted with short-term liabilities denominated in foreign currency and thus the well-being of the banking sector is highly sensitive to currency depreciations or increases in interest rates. The transmission mechanism from currency to banking crises can be direct, due to the deterioration of banks' balance sheets generated by a currency depreciation, or indirect, as in the case of a central bank decision to raise interest rates in order to deter a speculative attack. These type of arguments can be found in Miller (1996), Mishkin (1996), Obstfeld (1994) and Rojas-Suárez and Weisbrod (1996).

A third family of models contends that currency and banking problems are originated by common factors. The macroeconomic developments in Mexico, following the adop-

tion in 1987 of an exchange-rate-based stabilisation program,[4] are a good example of the mechanisms at work behind the occurrence of a twin crisis. The introduction of the stabilisation plan induced a remarkable real exchange-rate appreciation, since national inflation converged to international inflation only gradually. The contemporaneous boom of imports and economic activity was financed by borrowing abroad. This generated a growing current account deficit that became unsustainable and triggered a speculative attack against the domestic currency. The capital outflow that followed the collapse of the domestic currency led to a banking crisis, since banks were relying on foreign capital for their financing.[5]

In spite of the proposed theoretical links between banking and currency crisis events, the empirical literature has seen only few attempts to analyse this phenomenon. Notable are the studies by Kaminsky and Reinhart (1999), Glick and Hutchison (1999) and Rossi (1999).

This chapter contributes to the empirical literature on currency crises by studying the causal link from banking crises to currency crises. Specifically, this study is conducted for 92 developing and emerging markets economies for the 1975–97 period. Using quarterly data we estimate a dynamic probit model and evaluate the hypothesis that banking crises lead currency crises, after controlling for a wide range of economic variables.

The dynamic probit model proposed allows for unobservable heterogeneity and autocorrelation in the error structure. In order to estimate these models we use maximum smoothly simulation likelihood techniques. With this approach we depart from the existent literature on currency crises. A dynamic probit model fully exploits the information contained in a panel dataset. When we identify episodes of currency crises we do not delete the time observations immediately following such an event. This information is incorporated in the model (previous studies on currency crises obviate this information contained in the data). We do this by introducing a lagged dependent variable among the regressors, modifying the error structure to include an unobserved heterogeneity element and to allow for the errors to be autocorrelated over time.

The consideration of the lagged dependent variable on the right hand side of the probit equation allows one to test for the presence of *state dependence*, i.e. if past occurrences of currency crises influence the probability of a future crisis.

The *unobservable heterogeneity* is modelled by a country-specific and time-invariant error

[4] See Kaminsky and Reinhart (1999).

[5] Argument borrowed from Reinhart and Vegh (1995).

term. This term is meant to capture idiosyncratic differences in the institutional, political or historical background of countries. These are factors that cannot be fully explained by economic *fundamentals* but can exacerbate the likelihood of a currency crisis. To avoid the identification of unobserved components as *spurious state dependence*, we also add an $AR(1)$ error term that captures the effect of country differences that may be correlated over time (persistent shocks).

The results show that currency crises in developing and emerging markets are significantly influenced by a set of macroeconomic, debt and global variables. There is weak evidence of state dependence among the episodes of currency crises in the sample we consider here. In fact, the past occurrence of a currency crisis significantly decreases the probability of observing another crisis only in extreme cases, that is, if the first devaluation is particularly severe.

A general result is that past banking crises significantly lead currency crises. This result considerably strengthens the argument originally provided by Kaminsky and Reinhart (1999), because it is based on a multivariate econometric approach and it restricts the twin crisis window to one year only.[6]

We find evidence in the data of some unobserved country-specific heterogeneity that may account for differences in the institutional, political and historical background of these countries.

Finally, we show that the determinants of currency crises differ according to the type of exchange rate regime. The results of the estimations over the two sub-samples of fixed and flexible exchange rates suggest that policymakers are more reluctant to devalue if the exchange rate is pegged. Indeed, the probability of a currency crisis under pegged exchange rates increases significantly only in extreme cases, i.e. if a banking crisis preceded the currency crisis, while the mere existence of symptoms of banking system distress is enough to trigger a crisis under flexible regimes.

The remainder of this chapter is organised as follows. The methodology is explained in Section 4.2. Section 4.3 describes the dataset used in the empirical analysis and the definition of banking and currency crises adopted. The main results are gathered in Section 4.4. Finally, Section 4.5 concludes.

[6]Kaminsky and Reinhart (1999) define a twin crisis as a banking crisis followed by a currency crisis within a period of 48 months since the occurrence of the first event and use univariate approach.

4.2 Empirical Methodology

Using panel data on emerging markets and developing countries to study the determinants of currency crises we estimate a general dynamic limited dependent variable model. This technique allows us to relax the assumption of no intertemporal correlation among unobserved determinants for the occurrence of a currency crisis.[7] The motivation behind this choice is that the occurrence of a crisis is clearly an intertemporal event and its probability should be estimated with panel data and an appropriate econometric specification of the intertemporal linkages. Indeed, if a country experienced a crisis in the past, the probability of observing another crisis will most likely depend on that previous crisis occurrence.

There are two distinct explanations for this empirical regularity.[8] One is that, as a consequence of experiencing the event, constraints or conditions relevant to the occurrence of a currency crisis are altered. In this case, past experience has a genuine behavioral effect, in the sense that an otherwise identical country that did not experience a currency crisis would behave differently from the one that did experience the event. This is what is known as *true state dependence.* To capture this effect we introduce a lagged dependent variable among the regressors.

The second explanation is that countries may differ in their *propensity* to experience a currency crisis. We have to distinguish between two components here. The first is related to the existence of unobserved country-specific attributes that are time-invariant. This is what is called *unobserved heterogeneity* and we control for it by including a time-invariant and country-specific error term. This may reflect political and institutional factors that are difficult to control for. The second component takes into account the fact that countries' differences may be correlated over time, due for example to the existence of persistent shocks. If this problem is not addressed properly, past episodes of currency crises may turn out to be significant solely because they are a proxy for persistent and autocorrelated unobservables. An improper treatment of the structure of the errors may thus give rise to a conditional relationship between future and past experience that is termed *spurious state dependence.* We avoid this problem by assuming an $AR(1)$ structure for the error term.

The problem associated with these techniques is the high-dimensional integration of the associated likelihood function. These econometric models may be estimated in their full generality only by simulation estimation methods. We apply the method of maximum

[7] This restrictive assumption underlies, to our knowledge, all the previous studies on currency crises that make use of probit or logit analysis.

[8] We follow Heckman (1981) and Börsch-Supan, Hajivassiliou, Kotlikoff and Morris (1992) in the explanation of the methodology.

smoothly simulated likelihood (*MSSL*) developed in Börsch-Supan and Hajivassiliou (1993) and Hajivassiliou and McFadden (1998) to estimate these models. An additional complication arises from the treatment of the set of initial conditions that, for simplicity, are assumed to be exogenous.

In the next two subsections we present, following Börsch-Supan et al. (1992), the econometric specification and the estimation procedure.

4.2.1 Econometric Specification of Alternative Error Processes

Let I be the number of discrete events that can occur in each time period and T the number of waves in the panel data. The space of possible outcomes is the set of I^T different sequences of events $\{i_t\}$, $t = 1, \ldots, T$. To structure this problem, we assume that in each period the event i_t occurs if it maximises an unobserved vector u_{it}. This vector is the sum of a deterministic component $\nu_{it} = \nu(x_{it}, \beta)$, which depends on the vector of observable variables x_{it} and a parameter vector β to be estimated, and on a random component ε_{it}:

$$u_{it} = \nu(x_{it}, \beta) + \varepsilon_{it} \tag{4.1}$$

where $\nu(x_{it}, \beta) = x_{it}\beta$.

The probability of a sequence of events $\{i_t\}$ can be expressed as integrals of the differences of the unobserved components of u_{it} relative to the event that has occurred.

Define

$$\omega_{jt} = \varepsilon_{jt} - \varepsilon_{it} \qquad \text{for } i = i_t,\ j \neq i_t \tag{4.2}$$

These $D = (I-1) \times T$ error differences are stacked in the vector ω and have a point cumulative distribution of F.

For the event i to occur, the error differences can be at most as large as the differences in the deterministic components of u_{it}. Because $u_{it} = x_{it}\beta + \varepsilon_{it}$ and $u_{jt} = x_{jt}\beta + \varepsilon_{jt}$ we have $u_{it} > u_{jt}$ if and only if $x_{it}\beta - x_{jt}\beta > \omega_{jt}$.

The areas of integration are therefore:

$$A_j(i) = \{\omega_{jt} | -\infty \leq \omega_{jt} < x_{it}\beta - x_{jt}\beta\} \text{ for } j \neq i \tag{4.3}$$

and the probability of the sequence of events $\{i_t\}$ is:

$$P(\{i_t\}|\{x_{it}\};\beta,F) = \int_{\{\omega_{j1}\in A_j(i_1)|j=1,\ldots,I,j\neq i_1\}} \times \ldots \times \int_{\{\omega_{jT}\in A_j(i_T)|j=1,\ldots,I,j\neq i_T\}} dF(\omega) \quad (4.4)$$

Unless the joint cumulative distribution function F and the area of integration $A_j = A_j(i_j) \times \ldots \times A_j(i_T)$ are particularly benign, the integral in Equation (4.4) will not have a closed form.

Concentrating on the first two moments, we assume a multivariate normal distribution of the ω_{jt} in Equation (4.2), characterised by a covariance matrix M that has $(D+1)\times D/2-1$ significant elements: the correlation among the ω_{jt}, and the variances except one in order to scale the parameter vector β in the deterministic components $\nu(x,\beta)$.

We can estimate this multiperiod-multinomial probit model with different specifications of the covariance matrix M:

- The simplest specification $M = I$ yields a pooled cross-sectional probit model that is subject to the independence of irrelevant alternatives (IIA) restrictions and ignores all intertemporal linkages.

  There are several ways to introduce intertemporal linkages:

- A random-effects structure is imposed by specifying:

  $$\varepsilon_{it} = \alpha_i + \xi_{it} \quad (4.5)$$

  where ξ_{it} are i.i.d., for $i = 1,\ldots,I-1$

  This yields a block-diagonal equicorrelation structure of M with $(I-1)$ parameters $\sigma(\alpha)$ in M that need to be estimated.

- An autoregressive error structure can be incorporated by specifying:

  $$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \xi_{it} \quad (4.6)$$

  where ξ_{it} are i.i.d., for $i = 1,\ldots,I-1$

  Again, this yields a block-diagonal structure of M where each block has the familiar structure of an $AR(1)$ process. The $(I-1)$ parameters ρ_i in M have to be estimated.

- The last two error structures can also be combined by specifying:

$$\varepsilon_{it} = \alpha_i + \eta_{it}, \ \eta_{it} = \rho_i \eta_{it-1} + \xi_{it} \tag{4.7}$$

where ξ_{it} are i.i.d., for $i = 1, \ldots, I-1$

Almost by definition, the limited dependent variable models defined above may embody an error term that is correlated with the explanatory variables on the right hand side (RHS) of the probit equation. This correlation would impair the statistical properties of the estimated coefficients and must therefore be corrected for. We take explicit account of the linear dependence of the RHS variables and the error term, by letting:

$$\alpha_i = \gamma' x_{i\cdot} + \upsilon_i, \tag{4.8}$$

where $x_{i\cdot}$ is the mean value of x_{it} over time, and υ_i is a residual term that will act as the former country specific effect, α_i.

The error specification adopted throughout is the one in Equation (4.7), with α_i defined as in Equation (4.8) in order to take into account the likely correlation between the autocorrelated error term and the regressors.

4.2.2 Estimation Procedure: Simulated Maximum Likelihood

The likelihood function corresponding to the general multiperiod-multinomial problem is the product of the events' probabilities given in Equation (4.4):

$$\mathcal{L}(\beta, M) = \prod_{n=1}^{N} P(\{i_{t,n}\} | \{X_{it,n}\}; \beta, M) \tag{4.9}$$

where the index n denotes an observation in a sample of N countries and the cumulative distribution function F in Equation (4.4) is assumed to be multivariate normal and characterised by the covariance matrix M. Estimating the parameters in Equation (4.4) is a formidable task because it requires, in the most general case, the evaluation of the $D = (I-1) \times T$ dimensional integral in Equation (4.4) for each observation and each iteration in the maximisation process.

One may be tempted to accept the efficiency losses due to an incorrect specification of the error structure and simply ignore the correlations that make the integral in Equation (4.4) so hard to solve. However, unlike the linear model, an incorrect specification of the covariance matrix of the errors M biases not only the standard errors of the estimated coefficients but also the structural coefficients β themselves.

Numerical integration of the integral in (4.4) is not computationally feasible since the number of operations increases with the power of D, the dimension of M. To overcome this problem, we simulate the probabilities $P(\{i_{t,n}\}|\{X_{it,n}\};\beta,M)$ by drawing pseudo-random realisations from the underlying error process.

We use MSSL in conjunction with the Geweke-Hajivassiliou-Keane (GHK) simulator to overcome the computation intractabilities of the multiperiod panel limited-dependent-variable (LDV) models. This method has the additional feature of overcoming the analytical intractabilities associated with LDV models with complicated correlations and endogeneity.

In the next subsection we borrow from Hajivassiliou (2002) the explanation of the GHK approach.

4.2.3 The GHK Simulator

Define q as a mapping that takes a uniform $(0,1)$ random variate into a truncated standard normal random variable on the interval $[a,b]$:

$$q(u,a,b) \equiv \Phi^{-1}(\Phi(a)\cdot(1-u)+\Phi(b)\cdot u) \tag{4.10}$$

where $0 < u < 1$ and $-\infty \leq a < b \leq \infty$ and Φ is the univariate normal cumulative distribution function.

Proposition 1. *Consider the multivariate normal $M \times 1$ random vector $Y \sim N(X\beta,\Omega)$ with Ω positive definite, the linear transformation $Z = FY \sim N(FX\beta,\Sigma)$, with F non-singular and $\Sigma = F\Omega F'$, and the event $\mathbf{B} \equiv \{a^* \leq Z = FY \leq b^*\}$, with $-\infty \leq a* < b* \leq +\infty$.*

Define $P \equiv \int_B n(z;FX\beta,\Sigma)dz$, $a \equiv a^* - FX\beta$, $b \equiv b^* - FX\beta$, and let L denote the lower-triangular Cholesky factor of Σ.

Let $(u_1,\ldots,u_M)$ be a vector of independent uniform $(0,1)$ random variates.
Define recursively for $j = 1,\ldots,M$:

$$e_j = q(u_j,(a_j - L_{j1}e_1 - \ldots - L_{j,j-1}e_{j-1})/L_{jj},(b_j - L_{j1}e_1 - \ldots - L_{j,j-1}e_{j-1})/L_{jj}) \tag{4.11}$$

$$Q_j = \Phi((b_j - L_{j1}e_1 - \ldots - L_{j,j-1}e_{j-1})/L_{jj}) - \Phi((a_j - L_{j1}e_1 - \ldots - L_{j,j-1}e_{j-1})/L_{jj}) \tag{4.12}$$

Define $e \equiv (e_1, \ldots, e_M)'$, $\tilde{Y} \equiv X\beta + F^{-1}Le$ *with covariance* Σ *and subject to* $a^* \leq F\tilde{Y} \leq b^*$, *and* $Q(e) \equiv Q_1 \cdot \ldots \cdot Q_M$. *Then* $\tilde{Y}$ *is a random vector on* $\mathbf{B}$, *and the ratio of the densities of* $\tilde{Y}$ *and* Y *at* $y = X\beta + F^{-1}Le$, *where* e *is any vector satisfying* $a \leq Le \leq b$, *is* $P/Q(e)$. *Therefore, the probability of* $a^* \leq Le \leq b^*$ *is correctly simulated by the probability of* $a \leq Le \leq b$, *that is,* $Q(e)$. *This can be approximated by the simulator*

$$\tilde{l}(y, X; \beta, \Sigma; R) = \frac{1}{R} \sum_{r=1}^{R} Q_i(e_{1r}, \ldots, e_{i-1,r}) \tag{4.13}$$

with e_{ir} *drawn from truncated* $N(0,1)$, *where* R *denotes the number of replications.*

Hajivassiliou and McFadden (1998) prove that the MSSL estimator will be consistent, asymptotically normal, and fully efficient asymptotically, provided R, the number of simulations employed per individual observation rises without bound at least as fast as $\sqrt{N}$, where N is the sample size.

For a complete implementation of the GHK approach we use the procedures written by Vassilis Hajivassiliou. These procedures that return the simulated probability, $\tilde{P}$, are a function of the following arguments:
m = dimension of multivariate normal vector Z;
$mu = E[Z]$;
$w = V[Z]$;
$wi = w^{-1}$
c =Cholesky factor of w;
vectors a and b, defining the restriction region $a < Z < b$;
R = number of replications;
$u = a\ m \times R$ matrix of i.i.d. uniform $[0, 1]$ variates;
and are publically available at `http://econ.lse.ac.uk/~vassilis/pub/simulation`. The procedures used here are written in GAUSS.

Application

To illustrate the application of the MSSL/GHK to our problem let us define a latent dependent variable c_{it}^* and a binary limited dependent variable C_{it} as follows:

$$C_{it} = \begin{cases} 1 & \text{if} \quad c_{it}^* \equiv x_{it}'\beta + \epsilon_{it} > 0 \\ 0 & \text{otherwise} \end{cases}$$

For a typical observation it:

C_{it}	c_{it}^{*}
1	$\epsilon_{it} + x_{it}^{'}\beta > 0$
0	$\epsilon_{it} + x_{it}^{'}\beta < 0$

In terms of the canonical GHK formulation:

$$a^c < \epsilon^c < b^c$$

we obtain the configuration:

C_{it}	a^c	b^c
1	$-x_{it}^{'}\beta$	∞
0	$-\infty$	$-x_{it}^{'}\beta$

We define the vectors a_{it}, b_{it}, and ϵ_{it}. Stacking all the T_i periods of observation for country i gives the $T_i \times T_i$ var-covariance matrix with structure characterised by the precise serial correlation assumptions made on the ϵ_{it}'s. For example, one-factor random effect assumptions will imply and equicorrelated block structure on Σ_ϵ, while our most general assumption of one-factor random effects combined with an $AR(1)$ process implies that Σ_ϵ combines equicorrelated and Toeplitz-matrix features.

Through this representation, the probability of a complete sequence of the observable C behaviour for individual country i:

$$P(C_1, \ldots, C_{T_i})$$

are given by the events of the form:

$$Prob(a_i < \epsilon_i < b_i)$$

Consequently, our approach incorporates fully the one-factor plus $AR(1)$ serial correlations in ϵ_i

4.3 The Data

In this chapter we use a broad country- and time-series dataset. Specifically, we investigate 92 developing and emerging markets' economies for the 1975–97 period. The purpose of such a large sample, which includes countries that have never experienced a currency crisis, is to be able to draw general conclusions on the origins of currency crises and the causal chain from banking to currency crises.

The data is of quarterly frequency and collected from the International Financial Statistics (IFS) publication of the International Monetary Fund (IMF) and from the Global Development and Finance database issued by the World Bank.[9]

4.3.1 Defining Banking and Currency Crises

In the next sections we provide the definitions for currency and banking crises and we summarise some descriptive statistics for these variables.

Currency Crisis Definition

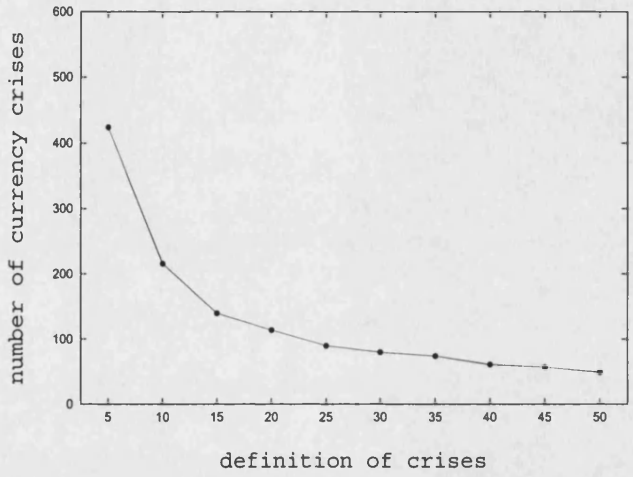
To define currency crises we look at the percentage change —in any given quarter— of the nominal bilateral exchange rate with the US dollar and use two criteria to qualify an episode as currency crisis. The first criterion selects only exchange rate *depreciations* that exceed a 10 percent cut-off level in a single quarter. The second focuses on the *rate of depreciation*, by requiring this same 10 percent depreciation to also be a 25 percent increase in the rate of depreciation with respect to the previous quarter (we shall refer hereafter to the dependent variable so defined as *10% cut-off*). The last condition is added in order to avoid counting as currency crises instances of managed devaluations like the ones announced by Latin American countries during periods of hyperinflation, when the first criterion was met quarter after quarter.[10] (See Tables C.14–C.20 in Appendix C for a detailed classification of currency crisis episodes).

The reason why we focus on this type of measure to define currency crises, instead of using an index of exchange market pressure is mainly that this study refers to developing and emerging markets' economies. Indices of exchange market pressure combine changes in the trajectories of exchange rates, interest rates and central bank reserves by applying some weighting scheme. Periods in which the index is above its mean by a certain threshold times its standard deviation are defined as a crisis. By looking at abnormal behaviours of interest rates and international reserves it would be possible to capture unsuccessful speculative attacks, under the assumption that the monetary authorities would use these two instruments to deter an attack on the currency. Unfortunately, few emerging and developing countries have market-determined short-term interest rates for long periods of time. Additionally, reserve movements in emerging and developing countries are far less important in avoiding a speculative attack than other measures such as the tightening of reserve requirements, emergency rescue packages from international institutions or the

[9] Appendix C contains a complete list of variable definitions, together with their original frequency and source (see Tables C.21–C.23).

[10] A similar procedure is followed by Frankel and Rose (1996), but with different thresholds for the two criteria.

Figure 4.1: Different Definitions of Currency Crises



imposition of controls on capital outflows.[11]

In order to check the sensitivity of the cut-off definition to different threshold levels, we have compared the list of episodes of currency crises that are obtained by progressively increasing the cut-off threshold on the nominal exchange rate depreciation while simultaneously relaxing the second condition on the rate of depreciation. In Figure 4.1 we plot the number of currency crises identified[12] Varying the depreciation level from 5 to 50 percent and the rate of depreciation threshold from 30 to 0 percent. The first measure, the *5% cut-off*, which implies a depreciation of a 5 percent and an increase in the rate of depreciation of 30 percent, identifies too many currency crises events, calling crises periods of only currency distress. The latter definitions includes the well-known episodes of currency crises. It is worth noting that the total number of crises decreases sharply when we move from the *5% cut-off* definition to the *10% cut-off*. The difference between the number of crises identified with the *10% cut-off* definition and the *15% cut-off* —that requires a 15 percent depreciation and a 20 percent increase in the rate of depreciation— is much smaller. What is crucial is that beyond this point the total number of currency crises stabilises independently of the definition adopted. This fact supports our choice of adopting a discrete variable to analyse episodes of currency crises.

[11] Nonetheless, in order to check the sensitivity of the results to the particular definition of currency crisis adopted, we also construct an EMP measure. This index is a weighted average of quarterly changes in the nominal bilateral exchange rate —with respect to the US dollar— and quarterly changes in reserves. The weights are chosen so that the two components of the index have the same conditional volatility. Periods in which the index is above its mean by more that 1.5 standard deviations are defined as crises.

[12] We have used the total number of observations in our initial sample. Notice that for the econometric estimation the number of observations is smaller due to the lack of data for some of the explanatory variables.

Banking Crisis Definition

To identify and date episodes of banking sector distress the banking crises literature relies mainly on the work of Caprio and Klingebiel (1996), Lindgren, García and Saal (1996) and Demirgüç-Kunt and Detragiache (1998a).

Caprio and Klingebiel (1996) gathered data on episodes of bank insolvencies from the late-1970's to 1995 for 69 countries. This information relies upon the assessment of a variety of finance professionals in pulling together characterisations that have caused crises. According to Caprio and Klingebiel (1996) it is difficult to date episodes of bank insolvency. Crises that involve runs on banks and/or on a country's currency are relatively easy to date, nevertheless these are only a subset of the banking crises reviewed by Caprio and Klingebiel (1996). Events in which the banking system has negative worth may persist over longer periods before being detected. It is for these reasons that the accuracy of the dates attached to the crises reviewed is difficult to determine, but they are those generally accepted by finance experts familiar with the countries. Table 1 in Caprio and Klingebiel (1996) presents the entire sample of 69 countries for which information was available, with those countries in which the episode appeared to be systematic, in the sense of much or all of bank capital being exhausted.

Lindgren et al. (1996) distinguish between *banking crises* and *significant banking problems.* They study 181 countries over the period 1980–96. Cases where there were runs or other substantial portfolio shifts, collapses of financial firms, or massive government intervention are termed banking crises. Periods of extensive unsoundness short of a crisis are what Lindgren et al. (1996) call significant problems in the banking sector.

Demirgüç-Kunt and Detragiache (1998a) identify and date episodes of banking sector distress during the period 1980–94. To do so they use previous studies on dating banking crises episodes, among them Caprio and Klingebiel (1996) and Lindgren et al. (1996). According to Demirgüç-Kunt and Detragiache (1998a) it is important to distinguish between fragility in general and crises in particular, as well as between localised crises and systemic crises. With this in mind, Demirgüç-Kunt and Detragiache (1998a) establish that for an episode of distress to be classified as a full-fledged crisis at least one of the following conditions must hold: (a) the fraction of non-performing assets in the banking system exceeds 10 percent; (b) the cost of the rescue operation comprises at least 2 percent of GDP; (c) the banking sector problems result in a large scale nationalisation of banks; (d) extensive bank runs take place or emergency measures are enacted by the government in response to the crisis.

In order to identify episodes of banking crises for this study, we have borrowed the episodes provided in Table 2 of Lindgren et al. (1996). This work is the most detailed in terms of information given about the nature of the banking crises identified and inclusive in terms of the number of countries covered. Notwithstanding, and for the purpose of fixing the quarter in which the banking crisis occurred and, in order to cover the entire sample period, 1975–97, for all the 92 countries, we have investigated additional sources: the IMF and the Economist Intelligence Unit country reports.

In this way banking crises are identified if one of the following events occurs:

- A bank run with consistent deposits withdrawals.
- The license withdrawal, closure, liquidation or take over of one or more financial institutions.
- The adoption of emergency measures like deposits freeze or prolonged bank holidays.
- Government intervention to recapitalise, reform or partially take over troubled banks.

Following Demirgüç-Kunt and Detragiache (1998a), in addition to the above criteria we impose the following conditions:

- The ratio of non-performing assets in the banking system must exceed 10 percent,
- The cost of the rescue operation must be at least 2 percent of GDP

The total number of banking crises identified in this manner is 205.[13]

4.3.2 Some Descriptive Statistics

In this section we characterise episodes of banking and currency crises by providing some summary statistics.[14] For the purpose of this analysis, we will focus on two measures of currency crises: the so called *10% cut-off* and *15% cut-off*.

Currency crises tend to be evenly distributed over time during the last decades except for the 70's, that are partially covered in our sample and in which we count very few episodes of sharp devaluations. Table 4.1 shows the break down by time and currency crisis definition, as well as for the banking crises. Episodes of banking crises in developing countries

[13]The complete list of episodes, together with a short description of the causes of the crises is presented in Tables C.1–C.13 in the Appendix C.

[14]The summary statistics are calculated for the actual number of observations included in the estimations.

Table 4.1: Distribution of Crises over Time

Period	*10% cut-off*		*15% cut-off*		banking crises		obsv.
	number	percent	number	percent	number	percent	
1970s	1	0.27%	1	0.27%	1	0.27%	376
1980s	77	4.37%	51	2.89%	68	3.85%	1764
1990s	118	5.34%	72	3.26%	136	6.15%	2210
total	196	4.51%	124	2.85%	205	4.71%	4350

Table 4.2: Distribution of Crises across Regions

Region	*10% cut-off*		*15% cut-off*		banking crises		obsv.
	number	percent	number	percent	number	percent	
Asia	25	2.95%	17	0.27%	54	6.38%	847
Latin America	45	3.55%	36	2.84%	44	3.47%	1268
East Europe	28	7.35%	21	5.51%	34	8.92%	381
Middle East	9	2.45%	3	0.82%	5	1.36%	368
Africa	89	5.99%	47	3.16%	68	4.58%	1486
total	196	4.51%	124	2.85%	205	4.71%	4350

have doubled during the last decade, possibly due to the increased financial liberalisation enjoyed by these countries. The practically absence of banking crises during the 1970s is possibly a consequence of the highly regulated financial system of the 1970s.

By looking at the distribution of crises by regions, shown in Table 4.2, it is interesting to note that Africa has the highest absolute number of currency and banking crises, followed by Latin America. The ranking changes if we take into account the total number of observations in each subsample. It is important to note that Eastern Europe here includes not only transition countries, like Bulgaria or Russia, but also Turkey. This consideration can explain the high percentage of currency and banking crises falling into this subsample.[15]

Finally, Table 4.3 focuses on joint episodes of banking and currency crises. The first row reports the percentages of currency crises in our sample that are associated with a simultaneous banking crisis. The remaining rows depict the number of banking crises preceding currency crises, by one quarter and then up to one year.[16] Similarly, we report

[15] If we exclude Turkey from the Eastern European region, the percentage of currency crises falls by about 2 percentage points, from 7.3 to 5 percent in the case of *10% cut-off* and from 5.5 to 3.5 percent for *15% cut-off*.

[16] Contrary to Kaminsky and Reinhart (1999), we have decided to restrict the crisis window to only four quarters in order to minimise the risk of counting as twin crises episodes of banking and currency crises that are not related by a clear causal relationship.

Table 4.3: Twin Crises[1]

	10% cut-off	*15% cut-off*		*10% cut-off*	*15% cut-off*
Contemporaneous Crises					
number	22	15			
% of cc	11.22%	12.10%			
% of bkc	10.73%	7.32%			
Banking Preceding Currency			Currency Preceding Banking		
One Quarter					
number	16	14	number	14	9
% of cc	8.16%	11.29%	% of bkc	6.83%	4.39%
One:Two Quarters					
number	24	21	number	28	21
% of cc	12.24%	16.94%	% of bkc	13.66%	10.24%
One:Three Quarters					
number	35	27	number	43	34
% of cc	17.86%	21.77%	% of bkc	20.98%	16.59%
One:Four Quarters					
number	41	31	number	48	39
% of cc	20.92%	25.00%	% of bkc	23.41%	19.02%

[1]cc stands for currency crises and bkc for banking crises. One:Two Quarters refers to banking(currency) crises that have occurred either one or two quarters before the currency(banking) crisis considered. Similarly, One:Three and One:Four refer to a time interval of three or four quarters before the occurrence of a currency(banking) crisis.

the number and percentages of currency crises preceding banking crises.

If we focus on a one-year interval, the data reported in Table 4.3 show that the number of currency crises in the twelve months preceding a banking crisis is higher than the correspondent number of banking crises preceding currency crises —for both measures of currency crises presented here. Based on this comparison, we may be induced to infer that currency crises are more likely to lead banking crises than *vice-versa*. But a more careful analysis of the data reveals that the same conclusion cannot be drawn if we restrict the time interval to one quarter before a crisis. The choice of the lag structure appears to be crucial when assessing the causal link between banking and currency crisis.

In summary, any tentative conclusion based on descriptive analysis needs further investigation using more sophisticated tools of analysis. The summary statistics presented in this section cannot unanimously solve our original question on what type of interaction, if any, links the various episodes of currency and banking crises in our sample. Furthermore, the mere existence of a temporal relationship between crises does not necessarily imply causation. To shed light on this matter we would have to introduce some dynamics between the two and control for the effects of common shocks that may be the driving forces behind the occurrence of financial crises. The results presented in the next section have been derived along these lines.

4.3.3 Explanatory Variables

We classify the explanatory variables into six different groups, depending on their nature. There are macroeconomic variables, monetary and financial variables, bank-specific variables, debt variables, global variables, and control variables.

Macroeconomic Variables

This set of variables includes real GDP growth, inflation, and a measure of real exchange rate (RER) overvaluation.

These real variables are meant to characterise the general domestic conditions of the economy and measure the repayment capacity of each country. In fact, a weakening in economic activity is likely to be associated with an increase in the vulnerability of the currency. When growth is declining, there are pressures on policymakers to implement lax financial policies, such as currency depreciations, to boost economic activity. On the other hand, an increasing rate of growth may generate optimism in the domestic asset market and attract foreign capital in support of the currency. We would thus expect the *real GDP growth* variable to have a negative sign in our estimations.

As argued by Corsetti et al. (1999b), when currency values are fixed or semi-fixed and domestic inflation is above foreign inflation, a real currency appreciation implies a loss of external competitiveness for the domestic country, eventually undermining the credibility of its peg. Therefore, we expect a positive sign on *domestic inflation.*

The RER variable is calculated as follows: we first obtain the Hodrick-Prescott trend from our RER series[17] and then measure the distance of each RER series from this trend. Negative values of this measure indicate that the RER is overvalued with respect to its historical trend. An overvalued RER would harm tradeables' producers and reduce foreign exchange earnings. It might also create the expectation of a future weakening of the currency and lead to a preemptive speculative attack. At the same time, low export growth would increase the incentive for the government to devalue in order to stimulate the economy and increase its competitiveness, thereby validating public expectations. The expected sign for the *RER undervaluation* variable is, hence, negative.

Monetary and Financial Variables

This group includes the import cover ratio —defined as total international reserves over imports—, total domestic credit growth and its sub-components, i.e. total credit to the private sector and net claims on the central government, all expressed as ratios over GDP.

The *import cover ratio* is an indicator of the adequacy of foreign exchange reserves. It measures the government's ability to finance current account deficits. Increases in this ratio should decrease the likelihood of a currency crisis.

The *domestic credit* measure captures the existence of lending booms. Fast increases of domestic credit increase the vulnerability of the financial system. In this context banks' ability to discriminate marginal projects declines and the probability of ending with a large share of non-performing loans in their portfolios increases. Since banks are more vulnerable to fluctuations in the business cycle, central banks may find themselves in the undesirable position of having to choose between bailing out domestic banks and defending the exchange rate peg that is under pressure because of the increase in central bank's domestic liabilities.[18] *Domestic credit to the private sector* is the best candidate to capture this effect and we would expect the estimated coefficient of this variable to be positive.

Net claims on the central government would capture the Krugman effect: credit expansion

[17] The RER series are author's computations, based on nominal exchange rates and relative CPI indexes. Both series were obtained from the IFS statistics of the IMF.

[18] This is also pointed out by Ahluwalia (2000).

due to the monetisation of government's budget deficits. Thus, we would expect increases of this variable to translate into higher probabilities of observing a currency collapse.

Bank-specific Variables

The third group of explanatory variables consists of a series of bank-specific indicators. These include the interest rate *differential between lending and deposit rates*, and the growth rates of *banks' deposits over GDP* and *banks' foreign liabilities over GDP*. The sign of the first of these variables is *a priori* undetermined. On the one hand, it might increase banks' profit margins and thus decrease the probability of a liquidity crisis. On the other hand, an increase in the interest rates on loans might lead to adverse-selection problems and increase the probability of borrowers' default.

A decrease in banks' deposits would signal the existence of bank runs and deposits withdrawals, that might undermine the stability of the currency.

The amount of foreign liabilities measures the degree of the banking system's reliance on off-shore capital to fund its activities and thus captures the systemic vulnerability to a sudden capital inflow reversal.

Global Variables

Here, we focus on real GDP growth and price inflation in the United States, as well as a composite measure of international interest rates, and commodity prices. These variables represent common shocks and may play a major role in inducing pressures on the currencies of several countries simultaneously.[19]

Following Eichengreen and Rose (1998) we have constructed a composite measure of the level of the *world interest rates* by weighting the interest rate series of France, Germany, Japan, Switzerland, the UK and the US.[20] An increase in this variable would imply a higher debt service burden and thus increase the probability of an insolvency crisis. Alternatively, it may cause an outflow of funds and eventually a currency devaluation if the economy is too small and the option of rising interest rates is too costly with respect to the one of devaluing.[21]

Moreno and Trehan (2000) argue that a deflationary shock in the US can have a direct effect on economies that are exporters to the US market because it would lower their

[19] See Caramazza, Ricci and Salgado (2000).

[20] The choice of this particular set of countries is motivated by the high share of external debt denominated in their currencies.

[21] As in Moreno and Trehan (2000).

export revenues and, consequently, domestic economic activity. The resulting unemployment would make it more difficult for them to maintain a pegged currency. Therefore, *disinflation* in a major economy, like the US, could be associated with an increase in the probability of a currency crash.

We have also included as global variables a set of *commodity price indexes*: fuel, metal, raw materials, food and beverages. We multiply these indexes by a dummy variable that takes the value of one if a country relies on one of these commodities for its exports' revenues. Intuitively, an increase in these prices should decrease the probability of a crisis by increasing export revenues.

Debt Variables

We explore different debt indicators: *total external debt* as a ratio of reserves, both in levels and growth rates, to measure the degree of indebtedness of developing countries; *short-term debt* as a ratio of foreign reserves and the shares of *private non-guaranteed* or *publicly and public guaranteed* long term debt to take into account the maturity and structure of external debt.

Control Variables

We control for the effect of financial liberalisation on the probability of experiencing a currency crisis, by defining a dummy variable that takes the value of one during the first three years following the liberalisation of domestic interest rates. The inclusion of this control has been suggested by the stream of literature that focuses on the effects of financial liberalisation and increasing financial fragility.[22] Financial liberalisation tends to increase the probability of a currency crisis, especially in the period right after the deregulation of the domestic interest rates.

4.4 Results

This section reports the results of the estimation by simulated maximum likelihood ($MSSL$) of the dynamic limited dependent variable model specified in Equation (4.9) and applied to currency crises. These are defined according to the cut-off selection criteria described in section 4.3.1. The results reported here are derived for the *10% cut-off* definition, but similar results are obtained using alternative definitions.

[22] See, among others, Demirgüç-Kunt and Detragiache (1998b), Demirgüç-Kunt and Detragiache (2000), and Glick and Hutchison (1999).

Table 4.4: Benchmark Model[1]

Variables	β coeff.[2]	z-stats.
Constant	-0.853^{***}	-27.478
Real GDP growth	-0.027^{*}	-1.445
Foreign reserves over imports	-0.433^{***}	-3.930
Growth of external debt over reserves	0.000^{**}	1.752
Short-term debt over reserves	0.003^{**}	1.955
Growth of domestic credit over GDP	0.274^{***}	3.540
Inflation for fuel prices	-0.008	-1.179
Inflation for metal prices	-0.090^{***}	-2.287
World interest rate	0.044^{***}	2.352
US CPI inflation	-0.298^{***}	-3.725
RER undervaluation	-0.018^{***}	-5.117
Currency crises last quarter	-0.116	-0.383
Banking crisis indicator	0.172^{*}	1.572
σ^2	0.377^{***}	5.534
ρ	0.083	

[1]Dependent variable: *10% cut-off*. Number of observations: 4350. Function value at optimum: -700.511. All variables are lagged one period, unless otherwise specified. The banking crisis indicator is a dummy taking the value of 1 if there is a banking crisis in the year preceding the currency crisis.
σ^2 is the variance of the underlying distribution of the unobserved heterogeneity.
[2]The significance of the parameters can be assessed using the Normal approximation. Given the size of our sample, the t-statistic is virtually Normal. We can therefore use the t-tables to assess significance. We use the critical values for the 1%, 5% and 10% significance levels, which are 2.326, 1.645 and 1.282, respectively, for a "one-tailed" test, and 2.576, 1.960 and 1.645 for a "two-tailed" test.
*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.

4.4.1 Benchmark Model

Table 4.4 shows the results of the benchmark model that includes a wide range of explanatory variables, all lagged (one quarter) in order to avoid endogeneity problems. Indeed, the inclusion of contemporaneous regressors could result in a misleading chain of causality, with the outcomes of a crisis erroneously treated as its precipitating causes. Since market sentiments tend to react quickly to changes in the economic stance of a country and speculative attacks come all of a sudden, we initially use a specification with variables lagged at most one quarter. The results seem to confirm that currency crises react promptly to changes in economic fundamentals and global variables: most of the explanatory variables included in the baseline specification are indeed significant determinants of a crisis one quarter ahead. Contrary to the main existing logit/probit studies, we add to the right hand side of our probit equation the lagged dependent variable —entered with the first lag— and a dummy variable capturing episodes of banking crises that occurred during the four quarters preceding the currency crash.[23]

The results indicate that fundamentals do matter. Real GDP growth is significant at the 10 percent level and has the expected negative sign, meaning that a decline in economic activity increases the probability of occurrence for a currency collapse.

The import-cover ratio is among the variables with the highest elasticities and is strongly significant (at the 1 percent level). As expected, the higher the ratio of reserves to imports, the lower the probability of an attack to the currency.

When turning to the debt variables, the results show that it is not the level of the external debt outstanding but rather its increase that has a positive effect on the likelihood of a currency crash. In fact, the first lag of the change in the ratio of external debt over reserves is significant at the 5 percent level in the baseline specification, while the ratio itself is not. The results also show the importance of debt maturity. The ratio of short-term debt over reserves is also significant at the 5 percent level but has a higher elasticity than the growth of total external debt.

The baseline specification in Table 4.4 also includes the growth rate of domestic credit over GDP, that has a positive coefficient and is highly significant. This result seems to support the view of lending booms driving currency crises.[24]

[23]The results do not change significantly in terms of *fundamentals* if we vary the lag structure of the lagged dependent variable.

[24]We alternatively used the two sub-components of total domestic credit, namely credit to the private sector and net claims on the government. Only the second variable is positive and significant if lagged two periods. This last variable will capture the traditional view of currency crises caused by excessive money creation.

RER overvaluation has been included into the benchmark specification in order to assess the sustainability of the external position of these countries. The estimated coefficient is significant at the 1 percent level and has a negative sign. Indeed, the more undervalued is the RER, the less likely is a speculative attack.[25]

The remaining explanatory variables in the benchmark specification are meant to characterise the external conditions. The first two are commodity indexes, fuel and metal, to proxy for terms-of-trade shocks to exporters of these commodities. Both variables have the expected negative sign, but only metal inflation is significant at the 1 percent level.

US inflation is also a significant determinant of crises probabilities. Its negative sign confirms the predictions that a deflation in the US might be associated with an increase in the likelihood of a crisis because of the relative loss of competitiveness experienced by developing countries.

Finally, we introduce a weighted average of the interest rates in France, Germany, Japan, Switzerland, the US and the UK, as a composite measure of international interest rates. The weights are chosen according to the shares of external debt denominated in each of these currencies and are calculated quarter by quarter. This variable reflects the effects of increased interest rates on the debt repayment capacity of a country. The estimated coefficient is significant but only at the 10 percent level. The sign of the variable is as expected: an increase in the level of international interest rates adds to the debt service burden, fuelling expectations of a future currency devaluation.

The first lag of the dependent variable has a negative sign, implying that once an unexpected attack on the currency has occurred, the probability of observing another speculative attack, one quarter ahead, decreases but is not statistically significant.[26]

The occurrence of a banking crisis in any of the four quarters preceding a currency crisis, significantly increases the probability of a devaluation. This last result reinforces the evidence provided by Kaminsky and Reinhart (1999), because we use a larger sample of countries, adopt a more restrictive crisis window and use a multivariate approach that looks at the effect of past banking crisis episodes on the probability of a currency crisis four quarters ahead, after controlling for a wider range of fundamentals.

[25]The associated elasticity is positive because it is evaluated at the variable mean that is also positive. This means that, on average, real exchange rates were overvalued, increasing the probability of currency crises.

[26]This result is not surprising given the definition of currency crises here adopted that selects only those episodes of depreciation that are also a 25 percent increase in the rate of depreciation with respect to the previous quarter.

Table 4.5: Different Cut-offs to Define Currency Crises[1]

Dependent Variable	*10% cut-off*	*15% cut-off*	*5% cut-off*
Constant	-0.853^{***}	-0.773^{***}	-0.618^{***}
	(-27.478)	(-20.407)	(-24.938)
Real GDP growth	-0.027^{*}	-0.040^{**}	-0.001
	(-1.445)	(-1.859)	(-0.062)
Foreign reserves over imports	-0.433^{***}	-0.495^{***}	-0.252^{***}
	(-3.930)	(-3.516)	(-3.219)
Growth of external debt over reserves	0.000^{**}	0.000^{*}	0.000^{**}
	(1.752)	(1.628)	(1.912)
Short-term debt over reserves	0.003^{**}	0.006^{***}	0.001
	(1.955)	(3.081)	(0.805)
Growth domestic credit over GDP	0.274^{***}	0.426^{***}	0.152^{***}
	(3.540)	(4.352)	(2.339)
Inflation for fuel prices	-0.008	0.003	-0.005
	(-1.179)	(0.624)	(-0.933)
Inflation for metal prices	-0.090^{***}	-0.120^{***}	-0.012
	(-2.287)	(-2.857)	(-0.585)
World interest rate	0.044^{***}	-0.022	0.031^{**}
	(2.352)	(-0.825)	(2.107)
US CPI inflation	-0.298^{***}	-0.181^{**}	-0.178^{***}
	(-3.725)	(-1.770)	(-2.889)
RER undervaluation	-0.018^{***}	-0.016^{***}	-0.017^{***}
	(-5.117)	(-4.149)	(-5.280)
Currency crises last quarter (*10% cut-off*)	-0.116		
	(-0.383)		
Currency crises last quarter (*15% cut-off*)		-0.634^{***}	
		(-3.532)	
Currency crises last quarter (*5% cut-off*)			-0.375
			(-0.863)
Banking crisis indicator	0.172^{*}	0.300^{**}	0.073
	(1.572)	(2.225)	(0.792)
σ^2	0.377^{***}	0.446^{***}	0.326^{***}
	(5.534)	(3.781)	(7.003)
ρ	0.083	0.504^{***}	0.183
	(0.538)	(4.782)	(0.657)
Function value at optimum	-700.511	-469.349	-1226.9257

[1]See comments in Table 4.4.

After controlling for this large set of explanatory variables, we still find a significant effect of the unobserved country-specific and time-invariant component of the error term. This *unobserved heterogeneity* may be due to intrinsic differences in the institutions and political background of the countries included in our sample, or even historical reasons, that are not captured by the other regressors. The autocorrelation structure of the error term is not statistically different from zero.

4.4.2 Alternative Specifications for the Dependent Variable

Table 4.5 reports the estimates of the baseline specification using alternative definitions of the dependent variable in order to check the sensitivity of the results to the currency crisis definition. The first column corresponds to the benchmark specification described above. The results in column 2 are derived by adopting a more restrictive definition of currency crises, *15% cut-off* —that implies 15 and 20 percent thresholds for the depreciation and increase in the rate of depreciation of the nominal exchange rate, respectively.

Interestingly, some of the results are stronger. Domestic GDP growth is now significant at a 5 percent level of significance. The lagged dependent variable becomes significant and has a negative sign. This seems to suggest that past occurrences of currency crises may significantly decrease the probability of observing another crisis only in extreme cases, i.e. if the first devaluation is particularly severe. The banking crises indicator increases in significance, from a 10 percent to a 5 percent level, suggesting a greater role of banking crises in determining the likelihood of a more severe currency crisis. It is worth noting that the autocorrelated structure of the error term is also significant, implying that some unobserved persistent shocks (correlated over time) might be driving the occurrence of severe episodes of currency crisis.

The third column of Table 4.5 reports the same specification but refers to the dependent variable *5% cut-off* (crises identified on the basis of a 5 percent cut-off depreciation and a 30 percent increase in the rate of depreciation). The weaker results are due, in our view, to some inaccuracy in the crises identification process. Indeed, with a 5 percent threshold on the nominal depreciation we may erroneously classify episodes of controlled devaluation.[27]

Table 4.6: Importance of the Error Term Structure[1]

Dependent Variable *10% cut-off*	benchmark model	random effects	pooled data
Constant	−0.853***	−0.973***	−1.462***
	(−27.478)	(−2.430)	(−10.841)
Real GDP growth	−0.027*	−0.029*	−0.036*
	(−1.445)	(−1.517)	(−2.336)
Foreign reserves over imports	−0.433***	−0.410***	−0.271**
	(−3.930)	(−3.848)	(−4.194)
Growth of external debt over reserves	0.000**	0.000**	0.000**
	(1.752)	(1.763)	(1.950)
Short-term debt over reserves	0.003**	0.003**	0.001
	(1.955)	(1.932)	(0.706)
Growth domestic credit over GDP	0.274***	0.278***	−0.024
	(3.540)	(3.637)	(−0.751)
Inflation for fuel prices	−0.008	−0.008	−0.005
	(−1.179)	(−1.175)	(−0.855)
Inflation for metal prices	−0.090***	−0.096***	−0.081***
	(−2.287)	(−2.374)	(−2.473)
World interest rate	0.044***	0.045***	0.032**
	(2.352)	(2.426)	(2.088)
US CPI inflation	−0.298***	−0.301***	−0.301***
	(−3.725)	(−3.754)	(−4.115)
RER undervaluation	−0.018***	−0.018***	−0.017***
	(−5.117)	(−5.157)	(−5.664)
Currency crises last quarter	−0.116	0.024	0.415***
	(−0.383)	(0.155)	(3.013)
Banking crisis indicator	0.172*	0.184**	0.254***
	(1.572)	(1.726)	(2.706)
σ^2	0.377***	0.419***	
	(5.534)	(5.278)	
ρ	0.083		
	(1.537)		
Function value at optimum	−700.511	−702.675	−739.790

[1]See comments in Table 4.4.

4.4.3 Random Effects plus Autorregressive Errors

After checking the robustness of the results with respect to changes in the definition of currency crises, we performed a sensitivity test over the structure of the error term. So far, we have assumed a composite error term as it appears in Equation (4.7), with a country specific error term to control for *unobserved heterogeneity*, and a persistent shock that is autocorrelated over time. While the first element is always significantly different from zero, the second is not. The first column of Table 4.6 shows the baseline results, obtained by estimating a simple random effects model, as specified in Equation (4.5). The baseline results are unaltered and the random effect is still very significant.[28] This table highlights the importance of relaxing the assumption of identically and independently distributed errors (i.i.d.) that underlies most of the existing studies on currency crises that make use of probit or logit analysis. In order to clarify this point, we present in column 3 the results of a simple probit model that assumes i.i.d. errors and pools all the observations together, ignoring the panel dimension of the data.

What is striking is the high z-statistics associated with the banking crisis dummy. This is due to the fact that this variable partially reflects institutional and political characteristics specific of each country that are not controlled for in an i.i.d. error structure. According to these results, the estimates of standard probit models, that stress the importance of banking crises as determinants of currency crises, might have been artificially inflated by omitting the panel structure revealed in this study.

4.4.4 Robustness of the Model

In order to assess the robustness of the baseline specification, we removed and added a few explanatory variables. The results are shown in Table 4.7. The first column shows that the the dummy for past episodes of banking crises remains significant even after the inclusion of variables that have been found to be significant determinants of banking crises. The growth rates of bank deposits and bank liabilities over GDP also have a direct effect on the probability of observing a currency crisis. The associated estimated coefficients are significant at the 5 percent level and have opposite signs. The specification in column 1 is more general than the benchmark specification of Table 4.4 because it also includes domestic inflation and the share of long-term debt that is private and non-guaranteed. The inclusion of inflation is necessary to correct the nominal interest rate differential be-

[27] This might also explain why the number of *5% cut-off* crises is so high compared to *10% cut-off* and *15% cut-off*, as shown in Figure 4.1.

[28] It is worth noting that the coefficient of the lagged dependent variable —once the autocorrelated structure is omitted— turns out to be positive. This indicates that, had it been positive in the first instance, it might have turned to be significant now, due to the omission of the autocorrelated error term, ρ.

Table 4.7: Testing the Robustness of the Specification[1]

Dependent Variable: *10% cut-off*	(1)	(2)	(3)
Constant	−0.908***	−1.219***	−0.913***
	(−27.739)	(−27.541)	(−28.316)
Real GDP growth	−0.023	−0.024	−0.023
	(−1.215)	(−1.265)	(−1.243)
Foreign reserves over imports	−0.468***	−0.469***	−0.451***
	(−4.136)	(−4.377)	(−4.022)
Growth of external debt over reserves	0.000**	0.000**	0.000**
	(1.704)	(1.722)	(1.660)
Short-term debt over reserves	0.003**	0.003**	0.003**
	(2.103)	(2.294)	(2.116)
Private, non-guaranteed debt over	1.445**	1.291**	1.505**
long-term debt	(2.134)	(1.978)	(2.260)
Growth of domestic credit over GDP	0.259***	0.276***	0.256***
	(3.248)	(3.467)	(3.243)
Inflation for fuel prices	−0.010*		−0.010*
	(−1.356)		(−1.411)
Inflation for metal prices	−0.078**		−0.076**
	(−1.992)		(−1.953)
World interest rate	0.038**		0.038**
	(1.990)		(2.028)
US CPI inflation	−0.302***		−0.303***
	(−3.782)		(−3.814)
RER undervaluation	−0.019***	−0.020***	−0.019***
	(−5.247)	(−5.337)	(−5.237)
Inflation (lagged 2 periods)	0.005**	0.004**	0.005**
	(2.278)	(2.199)	(2.271)
Lending minus deposit interest rate	−0.001**	−0.001**	−0.001**
(lagged 2 periods)	(−1.781)	(−1.702)	(−1.821)
Growth of banking liabilities over GDP	0.000**	0.000**	0.000**
(lagged 2 periods)	(1.861)	(1.804)	(1.870)
Growth of banking deposits over GDP	−0.004**	−0.004**	−0.004**
(lagged 4 periods)	(−1.823)	(−1.832)	(−1.789)
Financial liberalisation			0.350**
			(1.671)
Currency crises last quarter	−0.183	−0.245	−0.105
	(−0.746)	(−1.116)	(−0.406)
Banking crisis indicator	0.197**	0.231**	0.192**
	(1.780)	(2.092)	(1.748)
σ^2	0.352***	0.356***	0.343***
	(5.165)	(5.217)	(5.199)
ρ	0.127	0.196**	0.079
	(1.024)	(1.742)	(0.623)
Function value at optimum	−687.120	−699.166	−685.848

[1]See comments in Table 4.4.

tween lending and deposit rates. The other debt component may proxy for the degree of financial openness of these countries and the degree of liquidity of their secondary markets for debt. Indeed, countries where debt is mostly sovereign-guaranteed are likely to be more closed and less vulnerable to capital inflows reversals, while countries with higher shares of private non-guaranteed debt may be relatively more open and 'developed' and thus exposed to speculative attacks.

The second column of Table 4.7 seems to indicate that the omission of the global variables artificially increases the z-statistic associated with the unobserved autocorrelated error component. According to this result, ρ is capturing the effect of the omitted global variables that may act as a proxy for shocks that are correlated over time and have country-specific effects.

Finally, the last column of Table 4.7 controls for the effects of financial liberalisation. Our findings seem to confirm that financial fragility increases in the three years that follow the liberalisation of domestic interest rates.

4.4.5 Exchange Rate Regime

In order to examine whether the determinants of currency crises differ according to the exchange rate regime, we estimated the same specification over different samples. The first column of Table 4.8 refers to the whole sample of 4350 observations, while the estimations reported in columns 2 and 3 are based on the two subsamples of observations characterised by fixed and flexible exchange rate regimes, respectively.[29]

The magnitude and significance of the estimated coefficients in the two subsamples are dissimilar, pointing to the existence of intrinsic differences in the behaviour of crises probabilities, depending on the type of exchange rate regime. Not only are currency crises under fixed exchange rates less frequent than under flexible regimes, but they are also less responsive to changes in domestic fundamentals, as shown by the smaller elasticities. This implies that, other things being equal, fundamentals must be significantly worse under fixed exchange regimes than under flexible exchange regimes, to trigger a crisis.

This finding seems to support the view of the time-inconsistency literature regarding the existence of a credibility cost associated with the decision to abandon a pegged exchange rate. This is also confirmed by the different behaviour of the banking variables. Under fixed exchange rates, the probability of a devaluation increases only when a bank-

[29]The first subsample of fixed exchange rates includes a total of 2514 observations, with 84 episodes of currency crises, while currency crises under flexible exchange rates are 101, out of a total of 1622 observations.

Table 4.8: Exchange Rate Regimes[1]

Dependent Variable: *10% cut-off*	whole sample	fixed FX	float FX
Constant	−0.908***	−1.729***	−0.533***
	(−27.739)	(−18.640)	(−17.859)
Real GDP growth	−0.023	0.001	−0.019
	(−1.215)	(0.028)	(−0.838)
Foreign reserves over imports	−0.468***	−0.213*	−0.736***
	(−4.136)	(−1.302)	(−3.700)
Growth of external debt over reserves	0.000**	0.000	0.000
	(1.704)	(1.249)	(1.169)
Short-term debt over reserves	0.003**	0.003**	0.097*
	(2.103)	(1.670)	(1.641)
Private, non-guaranteed debt over	1.445**	0.112	2.942***
long-term debt	(2.134)	(0.092)	(2.908)
Growth of domestic credit over GDP	0.259***	0.240*	0.265***
	(3.248)	(1.381)	(2.584)
Inflation for fuel prices	−0.010*	−0.029***	0.000
	(−1.356)	(−2.741)	(0.043)
Inflation for metal prices	−0.078**	−0.096	−0.090**
	(−1.992)	(−0.921	(−1.921)
World interest rate	0.038**	0.085***	−0.001
	(1.990)	(3.050)	(−0.040)
US CPI inflation	−0.302***	−0.370***	−0.118
	(−3.782)	(−3.310)	(−0.836)
RER undervaluation	−0.019***	−0.039***	−0.013***
	(−5.247)	(−4.547)	(−2.924)
Inflation (lagged 2 periods)	0.005**	−0.005	0.006***
	(2.278)	(−0.416)	(2.427)
Lending minus deposit interest rate	−0.001**	0.001	−0.001**
(lagged 2 periods)	(−1.781)	(0.273)	(−2.020)
Growth of banking liabilities over GDP	0.000**	0.001*	0.000*
(lagged 2 periods)	(1.861)	(1.413)	(1.406)
Growth of banking deposits over GDP	−0.004**	−0.005	−0.008***
(lagged 4 periods)	(−1.823)	(−0.703)	(−2.326)
Currency crises last quarter	−0.183	0.032	−0.260
	(−0.763)	(0.023)	(−0.900)
Banking crisis indicator	0.197**	0.318**	0.141
	(1.780)	(1.805)	(0.872)
σ^2	0.352***	0.190***	0.340***
	(5.165)	(2.337)	(3.586)
ρ	0.127	−0.057	0.186
	(1.024)	(−0.088)	(1.114)
Function value at optimum	−687.120	−304.998	−321.306

[1]See comments in Table 4.4. The number of observations for the fixed FX equation is 2514; whereas for the float FX regression is 1622.

ing crisis has occurred in the past, while under flexible exchange rates the government may be tempted to let the currency depreciate at the first sign of banking system distress, such as a decrease in banks deposits or an increase in foreign liabilities.

The results of Table 4.8 also suggest that pegs are more sensitive to changes in global variables than flexible rates, maybe due to the presence of speculative behaviours. Overall, these results are important because they show that exchange rates do matter when we assess the probability of a currency crisis.

4.4.6 *EMP* Index to Define Currency Crises

Finally, Table 4.9 compares the results obtained using a different definition of currency crises. The cut-off measure used throughout this chapter, *10% cut-off*, is the dependent variable in the estimations reported in column 1; while in column 2 we use the exchange market pressure index, *EMP1.5*.[30] This last measure is a weighted average of quarterly changes in the nominal bilateral exchange rate —with respect to the dollar— and quarterly changes in reserves. Periods in which the index is above its mean by more than 1.5 standard deviations are defined as crises.

The main results still hold true even if we adopt this second definition of currency crises, but σ^2, the coefficient associated with the unobservable country-specific error term, is not significant any more. This seems to suggest that the country-specific error term in column 1 is a good proxy for the willingness and ability of the central bank to defend the currency. These country-specific characteristics are already incorporated into the definition of the exchange market pressure index. This may explain why the σ^2 coefficient loses significance in the second set of estimations.

4.5 Conclusions

This chapter has analysed the causal linkages between banking and currency crises in a sample of quarterly observations for 92 developing and emerging markets' countries from 1975 to the end of 1997. In particular, we have empirically tested whether episodes of banking system unsoundness lead to currency crises by estimating a multiperiod dynamic probit model of currency crises via maximum smoothly simulated likelihood techniques.

One of the main features of this model, that is also one of the points of departure from the existing literature on currency crises, is the inclusion of the lagged dependent variable on the right hand side of the probit equation to be estimated. In this way we are able to

[30] The number of currency crises this way identified are 210.

Table 4.9: Exchange Market Pressure Index[1]

Dependent Variable:	*10% cut-off*	EMP1.5[2]
Constant	−0.908***	−1.481***
	(−27.739)	(−40.156)
Real GDP growth	−0.023	−0.052***
	(−1.215)	(−3.384)
Foreign reserves over imports	−0.468***	−0.271***
	(−4.136)	(−3.083)
Growth of external debt over reserves	0.000**	−0.001
	(1.704)	(−0.771)
Short-term debt over reserves	0.003**	0.007**
	(2.103)	(3.170)
Private, non-guaranteed debt over	1.445**	0.281
long-term debt	(2.134)	(0.501)
Growth of domestic credit over GDP	0.259***	0.302***
	(3.248)	(4.186)
Inflation for fuel prices	−0.010*	−0.009
	(−1.356)	(−1.250)
Inflation for metal prices	−0.078**	−0.069**
	(−1.992)	(−1.980)
World interest rate	0.038**	0.031***
	(1.990)	(1.855)
US CPI inflation	−0.302***	−0.118**
	(−3.782)	(−1.728)
RER undervaluation	−0.019***	−0.019***
	(−5.247)	(−6.501)
Inflation (lagged 2 periods)	0.005**	0.003
	(2.278)	(1.123)
Lending minus deposit interest rate	−0.001**	0.000
(lagged 2 periods)	(−1.781)	(0.599)
Growth of banking liabilities over GDP	0.000**	0.000
(lagged 2 periods)	(1.861)	(1.262)
Growth of banking deposits over GDP	−0.004**	0.001
(lagged 4 periods)	(−1.823)	(0.534)
Currency crises last quarter	−0.183	0.955***
	(−0.746)	(4.265)
Banking crisis indicator	0.197**	0.115
	(1.780)	(1.075)
σ^2	0.352***	0.000
	(5.165)	(0.058)
ρ	0.127	0.006
	(1.024)	(0.057)
Function value at optimum	−687.120	−719.334

[1]See comments in Table 4.4.

[2]*EMP1.5* means 1.5 standard deviations over the mean of the EMP index. The number of currency crises corresponding to this definition is 210.

test for the presence of *state dependence*, i.e. whether past occurrences of currency crises influence the probability of a future crisis. We have also included among the regressors a dummy variable for past episodes of banking crises, to take into account their possible leading effect on currency crises, as originally found by Kaminsky and Reinhart (1999) in a different sample of emerging and industrial countries. We have made specific assumptions about the structure of the unobserved error term. In particular, the econometric techniques applied here allow us to relax the assumption of no intertemporal correlation among unobserved determinants of the occurrence of a currency crisis that underlies, to our knowledge, all the previous studies on banking and currency crises that follow a logit or probit approach.

The main results of this chapter can be summarised as follows:

- Domestic macroeconomic and financial variables are important determinants of instances of currency crises in developing and emerging markets. Low domestic growth, a low import cover ratio and an increase in domestic credit significantly increase the probability of observing a currency crisis. Furthermore, an overvalued exchange rate increases the probability of a currency crash.

- An increase in the stock of external debt can undermine the stability of domestic currencies. Debt is expressed here as a ratio to reserves, and thus directly measures the ability of a country to pay back its debt. The composition and maturity of this debt are also key determinants of the likelihood of a currency crisis. The higher the share of short-term debt, the higher the probability of a currency crash. The same applies to the share of private non-guaranteed debt.

- Small open economies in developing countries are also subject to changes in global macroeconomic conditions. An increase in the level of international interest rates or a worldwide deflation considerably increase the probability of a domestic financial crisis. Equally, a drop in commodity prices is harmful to the stability of the currency in countries that rely on those commodities for their exports revenues.

- Countries that have experienced sharp devaluations in the past are less likely to experience another crisis.

- We also find that banking crises are good leading indicators of currency crises in our sample.

- The determinants of currency crises differ according to the type of exchange rate regime. Currency crises episodes under fixed exchange rates are less frequent and require a much worse deterioration in domestic fundamentals to be triggered. Also,

the international macroeconomic environment seems to have a stronger impact on pegged exchange rates than under flexible regimes.

- After controlling for this large set of explanatory variables, we still find evidence in the data of some unobserved country-specific heterogeneity, meaning that crises are not all the same across countries due to intrinsic differences in the historical, institutional or political background of the countries included in our sample.

This final result highlights the importance of exploiting the full information content of the data, by adopting panel estimations techniques and relaxing the hypothesis of non-autocorrelated errors. As shown in Table 4.6, should we estimate our benchmark model by pooling all the observations together, without taking into account the intrinsic panel dimension of the data, we would tend to overestimate the importance of banking crises as determinants of currency crises. This result also questions the conclusions of some of the previous studies that make use of simple probit/logit models to estimate the likelihood of currency crises.

Chapter 5

Banking and Currency Crises: Are They Intertwined?

5.1 Introduction

In this chapter we further analyse the phenomenon of twin crises: the joint occurrence of banking and currency crises. We *jointly* estimate the two types of financial crises with two aims in mind. First, we seek to find the underlying common pattern associated with financial crises and the particularities of each type of crisis. Second, we investigate the causal links between banking and currency crises. We determine the causes of banking crises and currency crises by maximising a likelihood function derived from a system of two equations: one for the banking crisis episodes and another for the currency crisis events. In the currency crisis equation, we include an endogeneous variable describing banking crises among the regressors so we can study the contemporaneous linkage between banking and currency crises. Including lagged values of the banking crisis variable into the currency crisis equation allows us to test the hypothesis that banking crises lead currency crises.

Specifically, we define a system of two equations of the type described in Chapter 4. In this way, we have two dynamic probit equations with unobservable heterogeneity and autocorrelated errors. Furthermore, we allow for the error term to be contemporaneously correlated across equations. That is, we are controlling for possible omitted common causes of both types of crisis. The likelihood function derived for this system of two equations is maximised using the method of maximum smoothly simulated likelihood.

In this framework, we can easily reverse the chain of causality and analyse the contemporaneous and leading effects of currency crises on the probability of banking crises.

The countries analysed in this chapter are those of Chapter 4: 92 developing and emerg-

ing markets' economies. The period covered spans the 1970s through 1997. The data frequency is quarterly. For more details on the sample characteristics we refer the reader to Chapter 4, Section 4.3. The definitions of currency and banking crises, as well as the set of independent variables are fully referenced in Chapter 4, Section 4.3 and Appendix C.

The rest of the chapter is organised in the following way. In Section 5.2 we explain the econometric technique we use to model the phenomenon of twin crises. The main results of the econometric analysis are gathered in Section 5.3. Finally, Section 5.4 concludes.

5.2 Econometric Modelling of Twin Crises

Using our sample of 92 developing and emerging markets' economies, we jointly estimate a system of two equations that defines the twin crisis problem. The first equation explains the occurrence of banking crises. It has a probit structure, since an indicator variable identifies whether a country is in a regime of banking crisis or not. The second equation explains the likelihood of observing a currency crisis. We also use a probit equation to address this problem. The indicator variable is constructed to distinguish two regimes: a currency crisis regime and a tranquil regime —i.e. when we do not observe a currency crisis for that period.

Let us define y_{it}^{b} as a vector of limited dependent variables. Where $i = \{1, \ldots, N\}$, with N the number of countries in our sample, and $t = \{1, \ldots, T_i\}$, where T_i is the number of periods (quarters) over which country i is observed. The variable y_{it}^{b} takes on the value of one if a banking crisis is observed for country i in period t, and zero otherwise. Similarly, y_{it}^{c} is a limited dependent variable which has a value of one if country i experiences a currency crisis in period t, and zero otherwise.

We assume that y_{it}^{b} is an indirect observation on a latent vector y_{it}^{b*} according to a many-to-one mapping $y_{it}^{b} = \tau(y_{it}^{b*})$, with y_{it}^{b*} given by a linear model

$$y_{it}^{b*} = X_{it}^{b}\beta^{b} + \varepsilon_{it}^{b}, \tag{5.1}$$

where X_{it}^{b} is an array of explanatory variables, β^{b} is a vector of parameters to be estimated and ε_{it}^{b} is the disturbance vector.

In Equation (5.1), X_{it}^{b} includes, among other regressors, lagged values of both y_{it}^{b} and y_{it}^{c}. With the lagged values of y_{it}^{b}, we want to test whether past instances of banking crises have an influence on the probability of a banking crisis occurring. This is called *state dependence* and means that if a country has experienced a banking crisis in the past,

the probability of observing another banking crisis would likely depend on that previous crisis. The lagged values of y_{it}^c are included to test for a leading effect of currency crises on banking crises. The concrete specification for the lagged values of y_{it}^c is $\mathbf{1}(\sum_{s=1}^{4} y_{i,t-s}^c > 0)$, where $\mathbf{1}(\cdot)$ is the usual indicator function (it takes on the value of one if the argument is true, and zero otherwise). With this indicator we want to asses the effect on a banking crisis of currency crises occurred in any of the four quarters preceding that banking crisis.

In a similar way we define y_{it}^c as an indirect observation of the latent vector y_{it}^{c*}. Here, y_{it}^{c*} is given by

$$y_{it}^{c*} = y_{it}^b \gamma + X_{it}^c \beta^c + \varepsilon_{it}^c \tag{5.2}$$

The term $y_{it}^b \gamma$ captures the contemporaneous relationship between banking crises and currency crises: the effect of a banking crisis on the probability of a currency crisis in the same period. The rest of terms of Equation (5.2) are defined in a similar way to those of Equation (5.1). The variable X_{it}^c includes lagged values of y_{it}^c and y_{it}^b (in the form of and indicator of the type $\mathbf{1}(\sum_{s=1}^{4} y_{i,t-s}^b > 0)$). The lagged values of the dependent variable are included in order to test for *state dependence* among currency crisis events. The consideration of lagged values of y_{it}^b allows us to test the hypothesis of banking crises leading currency crises.

It still remains to fix a concrete specification for the error term, $\varepsilon_{it} = [\varepsilon_{it}^b,\ \varepsilon_{it}^c]$. For the banking crisis equation we define

$$\varepsilon_{it}^b = \mu_i^b + \nu_{it}^b, \qquad \nu_{it}^b = \rho^b \nu_{it-1}^b + \xi_{it}^b \tag{5.3}$$

where

$$\mu_i^b \sim N(0, \sigma_{\mu^b}^2), \qquad \xi_{it}^b \sim N(0,1), \qquad \nu_{i0}^b \sim N(0, \sigma_{0^b}^2),$$

stationarity implies that $\sigma_{0^b}^2 = \sigma_{\nu^b}^2 = 1/(1-\rho^b)$, μ_{it}^b and ν_i^b are independent

Correspondingly, for the currency crisis equation we define

$$\varepsilon_{it}^c = \mu_i^c + \nu_{it}^c, \qquad \nu_{it}^c = \rho^c \nu_{it-1}^c + \xi_{it}^c \tag{5.4}$$

where

$$\mu_i^c \sim N(0, \sigma_{\mu^c}^2), \qquad \xi_{it}^c \sim N(0,1), \qquad \nu_{i0}^c \sim N(0, \sigma_{0^c}^2),$$

stationarity implies that $\sigma_{0^c}^2 = \sigma_{\nu^c}^2 = 1/(1-\rho^c)$, μ_{it}^c and ν_i^c are independent

Moreover, we allow for a contemporaneous correlation between the terms ξ_{it}^b and ξ_{it}^c:

$$\rho_{\xi_{it}^b, \xi_{it}^c} \neq 0 \tag{5.5}$$

The μ_i terms represent what is called *unobservable heterogeneity.* These terms in the error structure are meant to capture the fact that countries may differ in their *propensity* to experience a financial crisis (a banking crisis or a currency crisis). These different propensities may be due either to the existence of unobserved country-specific attributes that are time-invariant, given by μ_i, or to countries' differences that are correlated over time. For this last reason we need to include the AR(1) component in the disturbance, i.e. the ν_{it} terms as previously defined. If this problem is not addressed properly, past episodes of financial crises may turn out to be significant solely because they are a good proxy for persistent and autocorrelated unobservables. The dynamic discrete choice models' literature refers to this as *spurious state dependence.*

In economics terms, μ_i may reflect political, institutional and historical factors that are difficult to control for with traditional economic variables, and ν_{it} may reflect the existence of persistent shocks, not captured by the explanatory variables.

The contemporaneous correlation between the terms ξ_{it}^b and ξ_{it}^c is meant to capture common causes to banking crises and currency crises that we fail to explain with the economic variables included in the two-system equation.

Due to the intertemporal linkages allowed in our model, classical estimation by the method of maximum likelihood is computationally intractable. The intertemporal correlation that we allow in our model necessitates the calculation of probabilities that are given by high-dimensional integrals, requiring the use of recently developed simulation estimation methods. See Börsch-Supan and Hajivassiliou (1993), Hajivassiliou and McFadden (1998) and Börsch-Supan et al. (1992) for an explanation of these techniques. We specifically apply the MSSL/GHK approach to overcome these difficulties

5.2.1 The GHK approach

To explain the application of the GHK approach to this particular problem, we follow Hajivassiliou (2002). Consider the two latent variables y_{it}^{c*} and y_{it}^{b*}, and the two binary limited dependent variables y_{it}^c and y_{it}^b as defined above. For the sake of illustration we strip out the banking crisis indicator from the matrix X_{it}^c and the currency crisis indicator

from the matrix X_{it}^b so we can write:

$$y_{it}^c = \begin{cases} 1 & \text{if } \; y_{it}^{c*} \equiv y_{it}^b\gamma + Z_{it}^c\beta_z^c + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^b > 0)\delta^c + \varepsilon_{it}^c > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$y_{it}^b = \begin{cases} 1 & \text{if } \; y_{it}^{b*} \equiv Z_{it}^b\beta_z^b + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^c > 0)\delta^b + \varepsilon_{it}^b > 0 \\ 0 & \text{otherwise} \end{cases}$$

Consider the probability expression:

$$Prob(y_{i5}^c, y_{i5}^b, \ldots, y_{iT_i}^c, y_{iT_i}^b | Z_i^c, Z_i^b, y_{i1}^c, \ldots, y_{i4}^c, y_{i1}^b, \ldots, y_{i4}^b, \theta)$$

where θ summarises all the parameters to be estimated.

For a typical observation it:

$y_{it}^c = 1$	$y_{it}^{c*} > 0$	$\varepsilon_{it}^c + y_{it}^b\gamma + Z_{it}^c\beta_z^c + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^b > 0)\delta^c > 0$
$y_{it}^c = 0$	$y_{it}^{c*} < 0$	$\varepsilon_{it}^c + y_{it}^b\gamma + Z_{it}^c\beta_z^c + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^b > 0)\delta^c < 0$
$y_{it}^b = 1$	$y_{it}^{b*} > 0$	$\varepsilon_{it}^b + Z_{it}^b\beta_z^b + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^c > 0)\delta^b > 0$
$y_{it}^b = 0$	$y_{it}^{b*} < 0$	$\varepsilon_{it}^b + Z_{it}^b\beta_z^b + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^c > 0)\delta^b < 0$

Therefore:

$$\begin{aligned} Prob(y_{it}^c, y_{it}^b, \ldots | Z_i^c, Z_i^b, y_{i1}^c, \ldots, y_{i4}^c, y_{i1}^b, \ldots, y_{i4}^b, \theta) \; = \\ Prob\{(1-2y_{it}^c)[\varepsilon_{it}^c + y_{it}^b\gamma + Z_{it}^c\beta_z^c + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^b > 0)\delta^c] < 0, \\ (1-2y_{it}^b)[\varepsilon_{it}^b + Z_{it}^b\beta_z^b + \mathbf{1}(\sum_{s=1}^4 y_{i,t-s}^c > 0)\delta^b] < 0, \ldots\} \end{aligned}$$

In terms of the canonical GHK formulation:

$$\begin{pmatrix} a^c \\ a^b \end{pmatrix} < \begin{pmatrix} \varepsilon^c \\ \varepsilon^b \end{pmatrix} < \begin{pmatrix} b^c \\ b^b \end{pmatrix}$$

we obtain the configuration:

y_{it}^c	y_{it}^b	a^c	b^c	a^b	b^b
0	0	$-\infty$	$-(y_{it}^b\gamma + Z_{it}^c\beta_z^c + Hy_{it}^b\delta^c)$	$-\infty$	$-(Z_{it}^b\beta_z^b + Hy_{it}^c\delta^b)$
0	1	$-\infty$	$-(y_{it}^b\gamma + Z_{it}^c\beta_z^c + Hy_{it}^b\delta^c)$	$-(Z_{it}^b\beta_z^b + Hy_{it}^c\delta^b)$	∞
1	0	$-(y_{it}^b\gamma + Z_{it}^c\beta_z^c + Hy_{it}^b\delta^c)$	∞	$-\infty$	$-(Z_{it}^b\beta_z^b + Hy_{it}^c\delta^b)$
1	1	$-(y_{it}^b\gamma + Z_{it}^c\beta_z^c + Hy_{it}^b\delta^c)$	∞	$-(Z_{it}^b\beta_z^b + Hy_{it}^c\delta^b)$	∞

where $Hy_{it}^{b} \equiv \mathbf{1}(\sum_{s=1}^{4} y_{i,t-s}^{b} > 0)$ and $Hy_{it}^{c} \equiv \mathbf{1}(\sum_{s=1}^{4} y_{i,t-s}^{c} > 0)$

We have described how the probability of a pair (y_{it}^{c}, y_{it}^{b}) can be represented in terms of the GHK implementation through the linear inequality:

$$\begin{pmatrix} a_{it}^{c} \\ a_{it}^{b} \end{pmatrix} < \begin{pmatrix} \varepsilon_{it}^{c} \\ \varepsilon_{it}^{b} \end{pmatrix} < \begin{pmatrix} b_{it}^{c} \\ b_{it}^{b} \end{pmatrix}$$

- Define the 2×1 vectors a_{it}, b_{it}, and ε_{it}. Stacking all the T_i periods of observation for individual country i gives the $2 \cdot T_i \times 1$ vectors a_i, b_i, and ε_i, where ε_i has the $2 \cdot T_i \times 2 \cdot T_i$ var-covariance matrix with structure characterised by the precise serial correlation assumptions made on the $\varepsilon_{it}^{'}$s.
- For example, one-factor random effect assumptions will imply and equicorrelated block structure on Σ_{ε}, while our most general assumption of one-factor random effects combined with an $AR(1)$ process implies that Σ_{ε} combines equicorrelated and Toeplitz-matrix features.
- Through this representation, the probability of a complete sequence of the observable (y^{c}, y^{b}) behaviour for an individual country i:

  $$P(y_1^{c}, \ldots, y_{T_i}^{c}, y_1^{b}, \ldots, y_{T_i}^{b})$$

  is given by events of the form:

  $$Prob(a_i < \varepsilon_i < b_i)$$

- Consequently, our approach incorporates fully
  1. the contemporaneous correlations in ε_{it},
  2. the one-factor plus $AR(1)$ serial correlations in ε_{it},
  3. the dependency of y_{it}^{c} on y_{it}^{b}, and
  4. the dependency of y_{it}^{c} on past occurrences of y_{i}^{b} and *vice versa.*

5.3 Econometric Results

In this section we present the main results of the simultaneous estimation of the two dynamic-probit equations. We analyse the determinants of the twin crises and the causal links between banking and currency crises. More precisely, we estimate Equations (5.1)

and (5.2) allowing for an error structure as defined in Equations (5.3), (5.4) and (5.5) using MSSL methods.

To test the hypothesis that banking crises are a leading indicator of currency crises, we introduce the banking crisis dummy variable lagged by a certain number of periods into the currency crisis equation. If the coefficient associated with this variable is significant, we can conclude that banking crises lead currency crises. Departing from previous studies which have sought to test on the value of this hypothesis —mainly Kaminsky and Reinhart (1999)—, we restrict the leading indicator characteristic to one year only. Kaminsky and Reinhart (1999) allow for a period of *four years* between a banking and a currency crisis event, defining the former as a leading indicator of the latter. Moreover, we test for changes in the lag structure of the banking crisis dummy variable as well as controlling for the effect of previous currency crisis events on this causal chain. This lag structure is revealed to be of crucial importance.

The contemporaneous banking crisis dummy variable included in the currency crisis equation allows us to test for a causal link from banking crises to currency crises occurring in the same quarter. Moreover, the term $\rho_{\xi^b_{it},\xi^c_{it}}$ defined in Equation (5.5), captures all those factors common to banking and currency crises that we have not controlled for with explanatory variables.

Some of the explanatory variables included in the estimations are common to both equations, while others are banking or currency specific and are therefore included in only one of them. The variables are selected according to the theory of financial crises and data availability. Note that because the model is a fully parametric non-linear model and the errors are jointly normally distributed the model is identified regardless of parameters exclusion condition. Notwithstanding, the currency crisis equation contains some exogenous variables that are not included in the banking crisis equation and the banking crisis equation contains some exogenous variables that are not included in the currency crisis equation. Therefore, we do not have to rely on the normality/non-linearity property of the model to assure identification of the model.[1]

The estimation results present five additional parameters derived from the specific assumptions on the error structure of the two-equation system. The parameters $\sigma^2_{\mu^b}$ and $\sigma^2_{\mu^c}$ allow for unobservable heterogeneity that is country-specific and time-invariant in

[1] Also note that the system contains two structural equations (dictated by economic theory), one for currency crises and another for banking crises. But the banking crisis equation is equivalent to a reduced form equation (in the sense that it does not contain the conditioning currency crisis endogenous variable). We do not consider a contemporaneous currency crisis dummy in the banking crisis equation because banking crises need some time to develop and cannot occur as fast as currency crises do.

the banking and currency equations, respectively. To allow for persistent shocks correlated over time that have not been identified by the explanatory variables, we include the parameters ρ^b and ρ^c. Finally, $\rho_{\xi_{it}^b,\xi_{it}^c}$, controls for causes common to both banking and currency crises that we fail to capture with the included explanatory variables.

5.3.1 Benchmark Model

In Table 5.1 we present the results for our benchmark model. The first panel in the table collects the results for the banking crisis equation. The results for the currency side are presented in the second panel. A third panel is introduced to summarise the structure of the error term.

All the variables are lagged by at least one period (quarter) to avoid the problems of endogeneity.

We now proceed to explain the results presented in Table 5.1, highlighting the main differences between the banking and the currency equations. To do this we have to bear in mind that for those variables included in both equations the coefficients reported in the tables reflect the *direct effects* of those variable on the probability of a currency crisis. The *total effect* is obtained by adding to the direct effect the *indirect effect.* The indirect effect is derived by multiplying the coefficient for the contemporaneous banking crisis variable by the coefficient of our variable of interest reported in the banking crisis equation. We do not report these effects in the tables but we explain the coefficients and significance of these effects.[2]

As the coefficient for the real GDP growth variable in Table 5.1 shows, a deterioration of economic activity significantly increases the likelihood of a banking crisis. A slowdown of growth tends to be correlated with greater difficulties for bank borrowers to service their loans. This result is consistent with the findings of Rossi (1999). Nonetheless, variations in output growth do not have a direct effect (nor a significant total effect) on the occurrence of currency crises, and this is independent of the lag considered in this variable and across specifications (including more variables). Kaminsky and Reinhart (1999) have found a similar result. They point to the role of the real sector as one key difference between banking and currency crises which, according to their results, appears to be considerably more important for banking crises.

[2]Please note that in all the specifications estimated, the signs of the total effects are the same as the signs of the direct effects. This feature facilitates the interpretation of the coefficients reported in Table 5.1 towards their contribution to increases/decreases in the likelihood of a currency crisis.

Table 5.1: Benchmark Model[1]

Variables	β coeff.[2]	z-stats.
Banking Crisis Equation		
Constant	−0.976***	−34.531
Real GDP growth (lagged 2 periods)	−0.042***	−2.633
M2 over CB reserves	0.079***	2.540
Real deposit interest rate (lagged 2 periods)	0.000**	1.778
Growth of claims on private sector over GDP (lagged 3 periods)	0.003***	2.425
Growth of banking deposits over GDP (lagged 3 periods)	−0.005**	−1.662
Growth of banking foreign liabilities over GDP (lagged 2 periods)	0.000**	2.171
Change in US interest rate	1.186***	3.198
US CPI inflation	−0.204***	−2.964
RER undervaluation	−0.007**	−1.877
Banking crises last quarter	2.030***	17.359
Currency crisis indicator[3]	0.144*	1.350
Currency Crisis Equation		
Constant	−1.146***	−19.945
Real GDP growth (lagged 2 periods)	−0.014	−0.793
FX reserves over imports	−0.466***	−4.563
Growth of net claims on government over GDP (lagged 2 periods)	0.000**	1.888
Growth of external debt over reserves	0.000**	1.664
Short term debt over reserves	0.003**	2.273
Private non-guaranteed external debt over l.t. debt	1.343**	2.195
World interest rate	0.039**	2.132
US CPI inflation	−0.332***	−4.084
RER undervaluation	−0.017***	−4.708
Inflation for fuel prices	−0.009	−1.271
Inflation for metal prices	−0.085**	−2.232
Currency crises last quarter	0.124	0.439
Banking crisis indicator[4]	0.162*	1.394
Contemporaneous banking crisis	0.166**	1.659
Error Term Structure		
$\sigma^2_{\mu^b}$	0.195***	5.879
$\sigma^2_{\mu^c}$	0.357***	4.970
ρ^b	−0.363***	−7.113
ρ^c	−0.071	−0.571
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.352***	4.538

continued on next page

Table 5.1: *continued*

[1]Currency crisis definition: *10% cut-off*. Number of observations: 4350. Number of banking crisis observations: 205. Number of currency crisis observations: 196. Function value at optimum: −1331.848. All variables are lagged one period, unless otherwise specified.
[2]The significance of the parameters can be assessed using the Normal approximation. Given the size of our sample, the t-statistic is virtually Normal. We can therefore use the t-tables to assess significance. We use the critical values for the 1%, 5% and 10% significance levels, which are 2.326, 1.645 and 1.282, respectively, for a "one-tailed" test, and 2.576, 1.960 and 1.645 for a "two-tailed" test.
*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
[3]The currency crisis indicator is a dummy taking the value of 1 if there is a currency crisis in at least 1 of the 4 quarters preceding the occurrence of the banking crisis, and 0 otherwise.
[4]The banking crisis indicator is a dummy taking the value of 1 if there is a banking crisis in at least 1 of the 4 quarters preceding the occurrence of the currency crisis, and 0 otherwise.

Another difference between banking and currency crises lies in the role of the ratios of M2 over central bank reserves and of foreign exchange reserves over imports. The first of these two ratios is a liquidity indicator of the financial system. Our results indicate that the higher the value of this ratio, the higher the probability of observing a banking crisis; whereas it does not have a direct effect on the likelihood of currency crises.[3] Our explanation for this fact is that an increase in the ratio of M2 to central bank reserves implies a decline in the amount of central bank resources backing the short-term domestic currency liabilities of the banking system, i.e. it is at the root of banking distress. The second ratio, foreign exchange reserves over imports, is an indicator of foreign reserve adequacy. It measures the government's ability to finance current account deficits and is, therefore, a better indicator for currency stability. Higher values of this indicator significantly decrease the likelihood of currency crises.[4]

Following Rossi (1999), we consider the real interest rate on banks' deposits among the explanatory variables of banking crises. According to Rossi (1999), banking problems are more likely to surface when real interest rates are high. This is because banks may be unable to extract the higher return paid on their liabilities from borrowers, and, even if they can, the quality of their loan portfolio may deteriorate because high real interest rates not only make it harder for good borrowers to stay current on repayments, but also worsen the average quality of borrowers (this is what is called adverse selection). Our results indicate that an increase in the real interest rate on banks' deposits significantly increases the probability of banking crises.[5] There is not a significant indirect effect of

[3]M2 over central bank reserves ratio is not significant if we introduce it into the currency crisis equation. The indirect effect coming from the banking crisis equations in not significant either.
[4]If in the banking equation we include this ratio, instead of the M2 over central bank reserves ratio, it fails to be significant.
[5]Alternatively, the inclusion of the lending-deposits rates ratio does not yield significant results.

this variable on the probability of currency crises either.

An important difference between banking and currency crises lies in the relevant component of the domestic credit variable to explain crisis probabilities. This is given by claims on the private sector for banking crises and by claims on the government for currency crises. These results are widely consistent with the financial crisis literature. Growth in the ratio of claims on the private sector to GDP are a proxy for lending booms. In a context of fast growth of private domestic credit and in the absence of appropriate banking supervision, banks' ability to discriminate marginal projects declines, increasing the probability of ending with a large share of non-performing loans in their portfolios. In this way the condition of the banking system is aggravated.[6] On the other hand, changes in the net claims on the central government over GDP capture the Krugman effect: credit expansion due to the monetisation of the government's budget deficit as a factor determining currency crises.

If we consider claims on the private sector among the determinants of currency crises, this variable is not significant (the indirect effect is not significant either). That is, claims on the private sector have only an impact on the occurrence of a currency crisis via the effect of this variable in the banking crisis equation (*indirect effect*). The same is true for claims on the central government for the banking crisis equation. Moreover, changes in the ratio of total domestic credit over GDP fail to be significant in any of the two equations if this variable is included.

As banking specific variables we have included the growth of banking deposits over GDP, and the growth of banking foreign liabilities over GDP. Banking deposits are introduced in the specification as an indicator of deposit withdrawals and onsetting bank runs. Decreases in the growth of banks' deposits over GDP significantly increase the probability of a banking crisis. Banking foreign liabilities are an indicator of the banking system's dependence on foreign resources. Specifically, it measures the degree to which the banking system relies on off-shore capital to fund its activities and thus captures the system vulnerability to a sudden capital inflow reversal. We find that the higher the value of this variable, the higher the probability of observing a banking crisis. These variables do not have a significant indirect effect on the likelihood of currency crises.

In this benchmark model, we have included debt variables only in the currency crisis equation. The results point to the importance of the amount of debt relative to reserves and its composition. When the debt is short term and/or private and non-guaranteed, the likelihood of currency crises increases significantly.

[6] This argument has been emphasised after the Asian financial crisis.

As a determinant of currency crises, we also include what we call world interest rates. As explained in Chapter 4, this variable is constructed by weighting the interest rate time series of France, Germany, Japan, Switzerland, the UK and the US according to the share of external debt denominated in the currencies of those countries. An increase in the world interest rate significantly increases the probability of a currency crisis. An increase in the world interest rate defined in this way will raise the cost of servicing variable-rate debt, and therefore raise doubts about a country's ability to meet its external obligations. It may also cause an outflow of capital. For small open economies it may be too costly to counter this risk by raising domestic interest rates, resulting in a currency collapse.[7]

The world interest rate variable has a counterintuitive negative sign if we include it in the banking equation. What is relevant, though, for the explanation of banking crises is the changes in the US interest rate. This variable has a positive and significant sign in the banking equation (and a positive and significant indirect effect also on currency crises).

In both equations, we include the inflation observed in the US. We follow Moreno and Trehan (2000) who argue that a deflationary shock in the US can have an effect on economies that are exporters to the US market because it would lower their export revenues and, consequently, domestic economic activity. Our results indicate that this variable has the expected sign and it is significant in both equations. The direct effect of the US inflation on the occurrence of currency crises is reinforced by the indirect effect via the banking crisis equation, being the total effect negative and significant.

A Real Exchange Rate (RER) undervaluation measure is included in both equations. The negative and significant coefficient in the banking and in the currency equations means that the less overvalued the RER, the lower the probability of a financial crisis. An overvalued RER increases the probability of a banking crisis perhaps because it is anticipating a currency crisis. The link between RER overvaluation and currency crises lies in the competitiveness effect derived from an overvalued RER. An overvalued RER harms tradeables' producers and, in this way, reduces foreign exchange earnings. At the same time, it might create the expectation of a future weakening of the currency and lead to a preemptive speculative attack. But we cannot find a total significant effect of RER overvaluation on the probability of currency crises.

In the currency crisis equation, we include two additional global variables: inflation for fuel prices and inflation for metal prices. The inflation for fuel prices is multiplied by a dummy variable that has a value of one for exporters of oil, and zero otherwise. The

[7]This argument has been proposed by Moreno and Trehan (2000).

inflation for metal prices variable is multiplied by an analogous dummy variable. Only the metal price variable is significant, with a negative sign. This indicates that the higher the value of metals, the lower the probability of a currency crisis, which is due to the higher export revenues derived from the metal exports.

Looking at the coefficient for the lagged dependent variable in the banking equation, we can infer the existence of state dependence among episodes of banking crises. The coefficient for the variable corresponding to banking crisis in the previous quarter is positive and highly significant, even after controlling for unobservable heterogeneity and autocorrelated errors. The fact that a country has experienced a banking crisis in the previous quarter increases the probability of a banking crisis in the current quarter.

We cannot say the same for the currency crisis equation: the variable corresponding to a currency crisis in the previous quarter is not significant. There is, therefore, no evidence of state dependence among currency crisis events. This is not surprising due to the way we define currency crises. We require a certain level of depreciation and an increase in the rate of depreciation with respect to the previous quarter.

In order to test for the causal link between banking and currency crises, we have included a currency crisis indicator in the banking crisis equation and, similarly, a banking crisis indicator in the currency crisis equation. The currency(banking) crisis indicator take on the value of one if in any of the four quarters preceding a banking(currency) crisis a currency(banking) crisis took place. As we see in Table 5.1 we cannot draw any definite conclusion about the chain of causality between banking and currency crises. That the currency crisis indicator is significant at the 10 percent level of significance in the banking equation would indicate that currency crises precede banking crises. But the banking crisis indicator is significant at the same level of significance in the currency equation. This result would indicate that banking crises are a leading indicator of currency crises. Moreover, contemporaneous banking crises are significant at a 5 percent level of significance and with a positive sign in the currency equation. The occurrence of a banking crisis in the current quarter helps to explain the probability of a currency crisis in the same quarter, i.e. we can find evidence of twin crises. We further analyse this problem in the subsections below.

These results about the direction of causality between banking and currency crises are completed if we look at the error structure. The coefficient $\rho_{\xi^b_{it},\xi^c_{it}}$ is highly significant and positive. This indicates the existence of common causes to banking and currency crises that are omitted in our set of explanatory variables. We could, therefore, conclude that rather than one type of crisis leading the other, what we have is common causes behind

both types of crises, i.e. twin crises driven by common factors.

From the other components of the error term, we can conclude the existence of unobserved heterogeneity[8] (e.g. political, institutional or historical factors difficult to control for with traditional explanatory variables) in both equations and of autocorrelated errors in the banking equation (persistent shocks that help predict banking crises and that we have not included among the regressors in the banking crisis equation). Omitting this panel structure would cause severe biases in the standard errors as well as in the estimated coefficients.

5.3.2 Robustness Exercises

Debt and Banking Variables

In order to test for the robustness of the results of our benchmark model, we have added some new variables. We, first, estimate the benchmark model adding some debt variables in the banking equation. The results of this model are presented in Table 5.2, in the column labelled as (1). Furthermore, to this more complete model we add a couple of banking variables to the currency equation. The results are those presented in Table 5.2, column (2). With this model we try to test if whether once we have controlled for banking sector variables, the banking crisis indicator is still significant.

According to column (1) of Table 5.2, the debt variables included in the banking equation turn out to be significant determinants of the probability of observing a banking crisis. For banking crises, it is the debt service paid over exports that is significant. In contrast, the stock of debt is the significant variable in the currency crises equation. This is consistent with the fact that a temporary liquidity shortage can lead to an insolvency crisis if a country cannot generate enough export revenues to pay back its debt. Moreover, short-term debt is significant; whereas the fact that the debt is private and non-guaranteed is not a significant determinant in assessing the likelihood of banking crises.

An important observation is the fact that the inclusion of debt variables into the banking crisis equation causes the currency crisis indicator to become insignificant. This suggest that in the benchmark model the currency crisis indicator was acting as a proxy for the debt variables. We can state, then, that currency crises do not significantly lead banking crises. Moreover, the banking crisis indicator is still significant in the currency crisis equation. From this we conclude that banking crises seem to lead currency crises and not *vice-versa.*

[8]The inclusion of regional dummy variables does not affect the significance of the unobservable heterogeneity.

Table 5.2: Alternative Specifications (I)[1]

Variables	(1)	(2)
Banking Crisis Equation		
Constant	−1.144***	−1.122***
	(−34.674)	(−34.390)
Real GDP growth	−0.040***	−0.040***
(lagged 2 periods)	(−2.442)	(−2.443)
M2 over CB reserves	0.082***	0.082***
	(2.556)	(2.545)
Real deposit interest rate	0.000**	0.000**
(lagged 2 periods)	(1.781)	(1.802)
Growth of claims on private sector over	0.003**	0.003**
GDP (lagged 3 periods)	(2.227)	(2.232)
Growth of banking deposits over GDP	−0.005**	−0.005
(lagged 3 periods)	(−1.657)	(−1.714)
Growth of foreign banking liabilities over	0.000**	−0.000**
GDP (lagged 3 periods)	(1.976)	(2.179)
Change in US interest rate	1.216***	1.220***
	(3.235)	(3.243)
US CPI inflation	−0.195***	−0.197***
	(−2.795)	(−2.807)
RER undervaluation	−0.007**	−0.007**
	(−1.849)	(−1.828)
Debt service paid over exports	0.718**	0.722**
(lagged 2 periods)	(1.909)	(1.904)
S.t. debt over reserves	0.003**	0.003**
	(2.286)	(2.261)
Private non-guaranteed external debt	0.229	0.220
over l.t. debt	(0.414)	(0.398)
Banking crises last quarter	1.977***	1.973***
	(16.731)	(16.217)
Currency crisis indicator	0.092	0.094
	(0.849)	(0.861)
Currency Crisis Equation		
Constant	−1.291***	−1.307***
	(−19.746)	(−18.910)
Real GDP growth	−0.014	−0.013
(lagged 2 periods)	(−0.791)	(−0.720)
FX reserves over imports	−0.468***	−0.470***
	(−4.587)	(−4.576)
Growth of net claims on government	0.000**	0.000**

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Table 5.2: *continued*

over GDP (lagged 2 periods)	(1.881)	(1.853)
Growth of external debt over reserves	0.000*	0.000**
	(1.615)	(1.852)
S.t debt over reserves	0.004***	0.003***
	(2.562)	(2.450)
Private non-guaranteed debt over	1.377**	1.372**
l.t. debt	(2.242)	(2.211)
World interest rate	0.040**	0.038**
	(2.163)	(2.012)
US CPI inflation	−0.332***	−0.334***
	(−4.094)	(−4.087)
RER undervaluation	−0.017***	−0.017***
	(−4.730)	(−4.667)
Inflation for fuel prices	−0.008	−0.010*
	(−1.242)	(−1.360)
Inflation for metal prices	−0.085**	−0.089**
	(−2.230)	(−2.284)
Growth of banking deposits over GDP		−0.006***
(lagged 4 periods)		(−2.603)
Growth of banking foreign liabilities		0.000**
over GDP (lagged 2 periods)		(1.753)
Currency crises last quarter	0.154	0.107
	(0.538)	(0.343)
Banking crisis indicator	0.159*	0.189*
	(1.376)	(1.622)
Contemporaneous banking crises	0.158*	0.181*
	(1.559)	(1.636)
Error Term Structure		
$\sigma^2_{\mu^b}$	0.185***	0.186***
	(5.489)	(5.463)
$\sigma^2_{\mu^c}$	0.356***	0.366***
	(5.103)	(4.897)
ρ^b	−0.356***	−0.353***
	(−6.735)	(−6.142)
ρ^c	−0.084	−0.065
	(−0.659)	(−0.422)
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.349***	0.358***
	(4.344)	(3.924)
Function value at optimum	−1322.004	−1314.356

[1]See comments in Table 5.1.

This last result is confirmed in column (2) of Table 5.2. In this augmented benchmark model we have included banks' deposits and banks' foreign liabilities as regressors in the

currency crisis equation. The banking crisis indicator is still significant even after the inclusion of variables that control for the health of the banking system and that have been found to be significant indicators in predicting banking crises.

We can conclude from this section that it is very important to control for a wide set of explanatory variables before deriving any definite conclusion on the direction of the causal link (if any) between banking and currency crises. This calls into question the reliability of results obtained from past studies using a univariate anyalysis (e.g. conditional probabilities) or even multivariate analysis but with few controls.

Financial Liberalisation

To the model of Table 5.2, column (2), we have added two dummy variables in both equations: capital account restrictions and domestic financial liberalisation. These results are collected in Table 5.3, column (1), and we refer to this model as the *augmented benchmark model.* The capital account restrictions variable is a dummy variable that takes on the value of one for those periods characterised by the imposition of restrictions in the capital account. This variable is only significant in the currency crisis equation. Its positive sign indicates that the existence of capital restrictions increases the probability of a currency crisis. Rossi (1999) obtains a similar result. He argues that the limitations on capital movements can be circumvented by setting up offshore or other types of operations that can eventually expose the financial system to worse risk. Moreover, the empirical evidence suggests that capital account controls are largely applied by countries with unregulated and poorly supervised financial systems, and which are thus more vulnerable to speculative attacks.

The domestic financial liberalisation dummy variable takes on the value of one for those periods in which domestic interest rates are liberalised. This variable significantly increases the likelihood of currency crises. The reason for this result is that financial liberalisation increases the fragility of the financial system.

Banking Crises Indicators by Decade

In column (2) of Table 5.3, we modify the augmented benchmark model by differentiating the banking crisis indicator included in the currency crisis equation by decade. The variables *"Banking crisis indicator (1980s)"* and *"Banking crisis indicator (1990s)"* are constructed in a similar way to the *"Banking crisis indicator"* variable of our benchmark model, but distinguishing whether the banking crisis took place in the 1980s or in the 1990s. The 1970s are taken as the decade of reference. The coefficient for the banking crisis indicator in the 1980s is not significant, whereas the one for the 1990s is positive

and significant at the 5 percent level of significance. The z-statistic increases relative to the one corresponding to a unique banking crisis indicator. This means that banking crises occurring in the 1990s compared with those occurring in the 1970s (our reference dummy) significantly increase the probability of a currency crisis, i.e. the banking crises of the 1990s have a significant and positive differential effect on assessing the likelihood of currency crises with respect to the banking crises of the 1970s. We cannot state this significant difference between banking crises occurring in the 1970s and those observed in the 1980s.

Table 5.3: Alternative Specifications (II)[1]

Variables	(1)	(2)	(3)
	Banking Crisis Equation		
Constant	−1.574***	−1.604***	−1.576***
	(−34.754)	(−34.135)	(−31.491)
Real GDP growth	−0.039***	−0.040***	−0.046***
(lagged 2 periods)	(−2.411)	(−2.482)	(−2.758)
M2 over CB reserves	0.081***	0.082***	0.094***
	(2.503)	(2.510)	(2.663)
Real deposit interest rate	0.000**	0.000**	0.000**
(lagged 2 periods)	(1.802)	(1.790)	(1.650)
Growth of claims on private sector	0.003**	0.003**	0.003**
over GDP (lagged 3 periods)	(2.263)	(2.369)	(2.123)
Growth of banking deposits	−0.005**	−0.005**	−0.005**
over GDP (lagged 3 periods)	(−1.737)	(−1.826)	(−1.742)
Growth of foreign banking liabilities	0.000**	−0.000***	−0.000***
over GDP (lagged 3 periods)	(2.207)	(2.429)	(2.411)
Change in US interest rate	1.217***	1.148***	1.227***
	(3.243)	(3.043)	(3.031)
US CPI inflation	−0.188***	−0.182***	−0.206***
	(−2.681)	(−2.581)	(−2.699)
RER undervaluation	−0.007**	−0.007**	−0.008**
	(−1.861)	(−1.932)	(−2.086)
Debt service paid over exports	0.745**	0.822**	0.892**
(lagged 2 periods)	(1.945)	(2.134)	(2.120)
S.t. debt over reserves	0.003**	0.003**	0.003**
	(2.287)	(2.249)	(2.117)
Private non-guaranteed external	0.181	0.218	0.072
debt over l.t. debt	(0.327)	(0.393)	(0.120)
Capital account restrictions	0.058	0.052	0.053
	(0.438)	(0.391)	(0.366)

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Table 5.3: *continued*

Domestic financial liberalisation	0.099	0.076	0.107
	(1.051)	(0.794)	(1.017)
Banking crises last quarter	1.982***	1.964***	1.426***
	(16.348)	(16.167)	(12.270)
Currency crisis indicator	0.091		0.086
	(0.831)		(0.722)
Currency crisis indicator (1980s)		−0.198	
		(−0.970)	
Currency crisis indicator (1990s)		0.198*	
		(1.598)	
Currency Crisis Equation			
Constant	−1.791***	−1.807***	−1.486***
	(−19.207)	(−19.018)	(−18.990)
Real GDP growth	−0.011	−0.012	−0.008
(lagged 2 periods)	(−0.600)	(−0.654)	(−0.430)
FX reserves over imports	−0.462***	−0.476***	−0.469***
	(−4.489)	(−4.571)	(−4.390)
Growth of net claims on government	0.000**	0.000**	0.000**
over GDP (lagged 2 periods)	(1.848)	(1.814)	(2.016)
Growth of external debt over	0.000**	0.000**	0.000**
reserves	(1.762)	(1.770)	(1.773)
S.t debt over reserves	0.004***	0.004***	0.003**
	(2.588)	(2.559)	(2.242)
Private non-guaranteed debt	1.266**	1.349**	1.382**
over l.t. debt	(2.022)	(2.149)	(2.113)
World interest rate	0.053***	0.056***	0.049***
	(2.786)	(2.895)	(2.483)
US CPI inflation	−0.338***	−0.343***	−0.319***
	(−4.089)	(−4.124)	(−3.786)
RER undervaluation	−0.018***	−0.017***	−0.018***
	(−4.717)	(−4.663)	(−4.689)
Inflation for fuel prices	−0.009*	−0.009*	−0.009
	(−1.338)	(−1.323)	(−1.244)
Inflation for metal prices	−0.078**	−0.078**	−0.080**
	(−2.047)	(−2.050)	(−2.017)
Growth of banking deposits	−0.006***	−0.006***	−0.006***
over GDP (lagged 4 periods)	(−2.501)	(−2.482)	(−2.574)
Growth of banking foreign liabilities	0.000**	0.000**	0.000*
over GDP (lagged 2 periods)	(1.762)	(1.757)	(1.603)
Capital account restrictions	0.428***	0.428***	0.442***
	(2.651)	(2.638)	(2.633)
Domestic financial liberalisation	0.332***	0.330***	0.306***

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Table 5.3: *continued*

	(3.208)	(3.159)	(2.794)
Currency crises last quarter	0.120	0.114	0.024
	(0.415)	(0.394)	(0.145)
Banking crisis indicator	0.182*		0.067
	(1.535)		(0.560)
Banking crisis indicator (1980s)		−0.055	
		(−0.222)	
Banking crisis indicator (1990s)		0.245**	
		(1.910)	
Contemporaneous banking crises	0.199**	0.190**	−0.117
	(1.769)	(1.677)	(−1.447)
Error Term Structure			
$\sigma^2_{\mu^b}$	0.178***	0.183***	0.225***
	(5.083)	(5.096)	(4.748)
$\sigma^2_{\mu^c}$	0.336***	0.338***	0.358***
	(4.837)	(4.841)	(5.376)
ρ^b	−0.359***	−0.361***	
	(−6.206)	(−6.240)	
ρ^c	−0.086	−0.084	
	(−0.614)	(−0.594)	
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.362***	0.356***	
	(3.872)	(3.872)	
Function value at optimum	−1305.621	−1303.337	−1319.134

[1]See comments in Table 5.1.

Similarly, we have also constructed two currency crises indicators by decade. We find that currency crises occurring in the 1990s, compared with those of the 1970s, significantly increase the likelihood of observing a banking crisis. The significance level is 10 percent. Moreover, there is still a significant positive effect of banking crises on currency crises occurring in the same quarter. These results are, therefore, not conclusive of a clear direction of causality between banking and currency crises. We explore these results further in the sections below.

Error Term Structure

In order to test the relevance of the autocorrelated structure of the error term of each equation, and the contemporaneous cross-correlation of the error terms between equations, we have also estimated the augmented benchmark model ignoring these correlations. The results are gathered in column (3) of Table 5.3. The effect of the omission of the ρ^b term is obvious in the coefficient for the previous quarter banking crisis variable in the banking equation. The magnitude of both the coefficient and its z-statistic is smaller. This is due

Table 5.4: Controlling for Past Financial Crises[1]

Variables	Banking Crises	Currency Crises
Currency crisis indicator	0.134	0.211**
	(0.985)	(1.678)
Banking crisis indicator	0.435**	0.075
	(2.039)	(0.550)
Contemporaneous banking crises		−0.069
		(−0.354)
$\sigma^2_{\mu^b}$	0.213***	
	(2.835)	
$\sigma^2_{\mu^c}$	0.307***	
	(4.354)	
ρ^b	0.439***	
	(3.097)	
ρ^c	−0.028	
	(−0.340)	
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.060	
	(0.349)	
Function value at optimum	−1323.461	

[1]See comments in Table 5.1.

to the initial negative[9] and significant value of ρ^b. A similar effect is seen in the currency crisis previous quarter variable in the currency crisis equation due to the omission of the ρ^c term.

The effects of eliminating the $\rho_{\xi^b_{it},\xi^c_{it}}$ term are reflected in the contemporaneous effect of banking crises on the probability of observing a currency crisis. This variable now has a negative sign, and it is significant at the 5 percent level if using a one-sided test. Moreover, the banking crisis indicator loses its significance. These results point to the importance of estimating these models with an adequate error term structure, otherwise the results obtained are distorted and not reliable, both in terms of the standard errors and β coefficients.

5.3.3 Further Analysis of the Direction of Causality between Banking and Currency Crises

To further analyse the main question of this chapter, the direction of causality (if any) between banking and currency crises, we have estimated the augmented benchmark model

[9]We analyse the negative sign of ρ^b in further specifications

with a modified lag structure for the past financial crises.

In the banking crisis equation we include our currency crisis indicator, as before, plus a banking crisis indicator of the same nature, i.e. this indicator takes on a value of one if a banking crisis occurred in any of the four previous quarters, and zero otherwise. Similarly, we control for a wider range of currency crises occurred in the past in the currency crisis equation. We include a currency crisis indicator (besides the banking crisis indicator) in the currency crisis equation.

We find that, once we control for a sufficient number of lags of our dependent variables, we cannot state any causal link[10]: the currency crisis indicator is not significant in the banking crisis equation and the banking crisis indicator is not significant in the currency crisis equation. Moreover, we do not observe any contemporaneous linkage either: the contemporaneous banking variable in the currency crisis equation and the contemporaneous correlation across error terms of both equations are no longer significant.

The results explained in the following lines are summarised in Tables 5.4 and 5.5. For the shake of brevity, and since the coefficients and significance of our economic fundamentals do not change, we show only the results of the relevant variables for this particular analysis.

To test whether this is the case when we differentiate crises by decade, we re-estimate the same model but with this differentiation. According to our results, we still can state a significant differential effect of currency crises occurring in the 1990s on banking crises. But the differential effect of banking crises occurring in the 1990s on currency crises is no longer significant. The contemporaneous relationship is not significant either.

Also is it important to note the change in sign, from negative to positive, in the ρ^b term once we control for a wider span of past banking crises in the banking crisis equation. This suggest that the new specification is more appropriate. A negative and significant correlation over time in the error term is difficult to justify.

Given the results concerning the direction of causality, we have re-estimated these last two models, but this time including a contemporaneous currency crises in the banking crisis equation and not *vice-versa*. The only difference is that the banking crisis indicator for the 1990s in the currency crisis equation is marginally significant, this is maybe due to the omission of the contemporaneous banking crisis variable in the currency crisis equation.

[10]This is true as well if we include the four lags of the dependent variable separately as opposed to the indicator of past crises.

Table 5.5: Controlling for Past Financial Crises[1] (II)

Variables	Banking Crises	Currency Crises
Currency crisis indicator		−0.213**
		(1.701)
Currency crisis indicator (1980s)	−0.152	
	(−0.607)	
Currency crisis indicator (1990s)	0.240*	
	(1.639)	
Banking crisis indicator	0.423**	
	(2.080)	
Banking crisis indicator (1980s)		−0.231
		(−0.758)
Banking crisis indicator (1990s)		0.145
		(0.991)
Contemporaneous banking crises		−0.082
		(−0.414)
$\sigma^2_{\mu^b}$	0.222***	
	(3.022)	
$\sigma^2_{\mu^c}$	0.305***	
	(4.350)	
ρ^b	0.439***	
	(3.284)	
ρ^c	−0.030	
	(−0.367)	
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.050	
	(0.277)	
Function value at optimum	−1321.334	

[1]See comments in Table 5.1.

We can conclude that there is not a general leading indicator role for banking crises with respect to currency crises. Once we control for currency crises occurred in the recent past, and not only in the previous quarter, the banking crisis indicator fails to predict currency crises in general. Nevertheless, it seems that past currency crises help forecast banking crises, but only for the 1990s.

5.3.4 Alternative Definitions of Currency Crises

Table 5.6 presents the results of re-estimating the augmented benchmark model for alternative definitions of currency crises. In column *EMP1.5%*, the definition of a currency crisis is the one of an exchange market pressure index (EMP) as defined in Chapter 4. Whereas the results in column *15% cut-off* use the same type of currency crisis definition as in the previous estimations, but with a higher cut-off to define crises: a 15 percent level of depreciation (and a 20 percent increase in the rate of depreciation).

Table 5.6: Alternative Definitions of Currency Crises[1]

Variables	$EMP1.5\%$[2]	*15% cut-off*[3]
Banking Crisis Equation		
Constant	−1.389***	−1.503***
	(−29.633)	(−26.482)
Real GDP growth	−0.047***	−0.034***
(lagged 2 periods)	(−2.854)	(−2.323)
M2 over CB reserves	0.129***	0.104***
	(3.252)	(2.738)
Real deposit interest rate	0.000**	0.000**
(lagged 2 periods)	(1.654)	(1.732)
Growth of claims on private sector over	0.003**	0.003**
GDP (lagged 3 periods)	(2.306)	(2.225)
Growth of banking deposits over GDP	−0.005**	−0.005**
(lagged 3 periods)	(−1.681)	(−1.765)
Growth of foreign banking liabilities over	0.000**	0.004***
GDP (lagged 3 periods)	(2.543)	(2.440)
Change in US interest rate	1.054***	1.041***
	(2.463)	(2.489)
US CPI inflation	−0.240***	−0.204***
	(−2.973)	(−2.668)
RER undervaluation	−0.008**	−0.010***
	(−2.114)	(−2.377)
Debt service paid over exports	0.553	0.910**
(lagged 2 periods)	(1.206)	(1.862)

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Table 5.6: *continued*

S.t. debt over reserves	0.003**	0.003**
	(1.901)	(2.016)
Private non-guaranteed external debt	0.133	0.217
over l.t. debt	(0.178)	(0.311)
Banking crises indicator	0.457***	0.350**
	(3.062)	(1.843)
Currency crisis indicator	0.199**	1.286**
	(1.648)	(1.863)
Currency Crisis Equation		
Constant	−1.424***	−1.738***
	(−16.725)	(−14.341)
Real GDP growth	−0.067***	−0.017
(lagged 2 periods)	(−4.238)	(−0.843)
FX reserves over imports	−0.350***	−0.428***
	(−4.021)	(−3.529)
Growth of net claims on government	0.000	0.000***
over GDP (lagged 2 periods)	(0.779)	(2.730)
Growth of external debt over reserves	−0.000	0.000**
	(−0.602)	(2.175)
S.t debt over reserves	0.006***	0.006***
	(3.192)	(2.743)
Private non-guaranteed debt over	0.586	1.269**
l.t. debt	(0.938)	(1.795)
World interest rate	0.023*	−0.008
	(1.287)	(−0.326)
US CPI inflation	−0.144**	−0.258**
	(−2.034)	(−2.369)
RER undervaluation	−0.019***	−0.021***
	(−6.153)	(−4.661)
Inflation for fuel prices	−0.007	0.003
	(−0.974)	(0.624)
Inflation for metal prices	−0.046*	−0.099***
	(−1.557)	(−2.555)
Growth of banking deposits over GDP	−0.000	−0.007***
(lagged 4 periods)	(0.038)	(−2.739)
Growth of banking foreign liabilities	0.000**	0.000*
over GDP (lagged 2 periods)	(1.787)	(−1.289)
Currency crises indicator	0.410***	0.761***
	(3.861)	(5.092)
Banking crisis indicator	0.104	0.027
	(0.883)	(1.184)
Contemporaneous banking crises	0.214*	−0.130

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Table 5.6: *continued*

	(1.630)	(−0.892)
Error Term Structure		
$\sigma^2_{\mu^b}$	0.203***	0.221***
	(3.247)	(3.648)
$\sigma^2_{\mu^c}$	0.000	0.197***
	(0.095)	(3.222)
ρ^b	0.330***	0.497***
	(3.923)	(4.848)
ρ^c	0.230***	−0.052
	(3.748)	(−0.580)
$\rho_{\xi^b_{it},\xi^c_{it}}$	0.239***	−0.034
	(2.096)	(−0.304)
Function value at optimum	−1372.452	−1094.820

[1]See comments in Table 5.1.

[2]$EMP1.5\%$ means 1.5 standard deviations over the mean of the EMP index.
The number of currency crises corresponding to this definition is 210.

[3]The number of currency crises corresponding to this definition is 124.

When using the *EMP1.5%* definition some differences arise in the currency crisis equation. The real sector summarised in output growth has a significant direct effect on the probability of occurrence of a currency crisis. Another important difference lies in the debt variables. Only short-term debt is important in predicting this type of currency crisis.

We note the presence of state dependence among the currency crises defined by the $EMP1.5\%$ index. This is due to the omission of a second condition in the definition of currency crises demanding an increase in the rate of depreciation, which makes currency crises less likely to be correlated over time.

Interestingly enough the bank deposits over GDP ratio is no longer significant. Furthermore, past banking crises do not help forecast currency crises. The banking crisis indicator is no longer significant. Notwithstanding, a currency crisis indicator constructed with the *EMP1.5%* measure of currency crises is significant at the 1 percent level of significance with a positive sign. Nevertheless, there is still a positive and significant effect of banking crises occurring in this quarter on currency crises occurring in the same quarter, and the contemporaneous correlation across the error terms of both equations is still significant. Again, there is not a clear direction of the causality link that we can derive from these results.

The coefficient associated with the unobservable heterogeneity is no longer significant.[11] This suggests that the country-specific and time-invariant error term of the currency equation was depicting the willingness and ability of central banks to defend the currency. These country-specific characteristics are already incorporated into the definition of currency crises using an exchange market pressure index.

Regarding the results for a *15% cut-off* definition, it is worth noting that the currency crisis indicator included in the banking equation is significant at the 5 percent level of significance, even after controlling for the debt variables. This seems to suggest that more severe currency crises (as those indicated by a level of depreciation higher than 15 percent) have a positive and significant impact on the probability of observing a banking crisis in the future. Moreover, the banking crisis indicator in the currency crisis equation is no longer significant. Even the contemporaneous banking crisis variable loses its significance. These last results indicate that when we deal with severe currency crises the chain of causality is reversed: severe currency crises act as a leading indicator of banking crises, and not *vice-versa.*

5.4 Conclusions

In this chapter we have examined the empirical regularities of banking and currency crises for 92 developing and emerging markets' economies from the mid 1970s to the end of the 1990s. Our results shows that financial crises (banking or currency crises) are driven by several economic fundamentals. We doubt the self-fulfilling nature attributed to financial crises by second-generation models.

Banking crises seem, "in general", to cause currency crises in poor specifications, i.e. if we fail to control for a sufficient number of currency crisis lags. Once we control for past occurrences of currency crises, this causal link vanishes. More robust results regarding the linkages between the crises are obtained when we allow for a differential effect by decades of banking crises on currency crises and *vice-versa.* Our analysis shows a statistically significant differential effect on banking crises by currency crises occurring in the 1990s (independently of the specification chosen).

When we enlarge the definition of currency crises to include unsuccessful attacks or when we consider more severe crises (depreciations over a 15 percent threshold), we find a significant leading effect of currency crises on banking crises. Whereas, the causal link from banking crises to currency crises of one of those two types vanishes.

[11] We already obtained this result when we estimated a single equation for this type of currency crises.

Summarising, after the liberalisation of financial markets banking and currency crises become closely intertwined and currency crises seem to precede banking crises. Nevertheless, we cannot find an exclusive unidirectional causal link between currency and banking crises. Both type of crises share some common factors, other factors remain exclusive causes of banking or currency crises, but which crisis surfaces first is only a matter of circumstance.

Appendix A

Appendix for Chapter 2

Table A.1: Identification of Currency Crises (1)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	Australia			
1974:3		yes		yes
1974:4			yes	yes
1979:1		yes		yes
1981:3		yes		yes
1985:1			yes	yes
1985:2			yes	yes
1986:3			yes	yes
1989:2				yes
	Austria			
1970:1			yes	yes
1970:2		yes		yes
1970:3		yes		yes
1970:4				yes
1971:1		yes		yes
1971:3			yes	yes
1973:1		yes		yes
1973:2			yes	yes
1978:4			yes	yes
1981:1		yes		
1992:3		yes		yes
1993:3		yes		yes
	Belgium			
1970:1			yes	yes
1970:2		yes		yes
1970:3		yes		yes
1973:2			yes	yes
1976:1		yes		yes
1979:3			yes	yes
1981:1		yes		yes
1981:4				yes
1982:1			yes	yes
1982:2			yes	yes
1992:3		yes		yes
1993:2				yes
1993:3		yes	yes	yes

Table A.2: Identification of Currency Crises (2)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	Canada			
1977:1			yes	yes
1977:4			yes	
1978:4			yes	
1980:1		yes		
1981:2		yes	yes	yes
1982:2			yes	yes
1984:2			yes	
1992:1			yes	yes
1992:4			yes	yes
1994:2			yes	
1995:1			yes	
	Denmark			
1970:1				yes
1970:2		yes		yes
1971:2		yes	yes	yes
1971:3			yes	yes
1973:3			yes	yes
1976:3		yes		yes
1977:2			yes	yes
1977:3			yes	yes
1977:4		yes	yes	yes
1979:4			yes	yes
1980:1			yes	yes
1982:1			yes	yes
1982:2			yes	yes
1992:3		yes		yes
1993:3				yes
1995:1			yes	yes
	Finland			
1970:1			yes	
1970:3		yes		yes
1973:1		yes		yes
1973:3			yes	yes
1975:1		yes		
1977:2			yes	yes
1982:4				yes
1991:4			yes	yes
1992:1			yes	yes
1992:3		yes	yes	yes
1993:1			yes	yes
1993:3		yes		yes

Table A.3: Identification of Currency Crises (3)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	France			
1971:3				yes
1973:3			yes	yes
1973:4				yes
1974:1		yes	yes	yes
1974:2			yes	yes
1976:1				yes
1976:2			yes	yes
1976:3			yes	yes
1976:4			yes	yes
1978:1			yes	yes
1978:4			yes	yes
1981:4			yes	yes
1982:3			yes	yes
1983:2			yes	yes
1992:3		yes		yes
	Greece			
1971:3		yes	yes	yes
1973:2		yes	yes	yes
1973:3				yes
1973:4				yes
1974:3				yes
1980:1		yes		yes
1982:2		yes	yes	yes
1983:1			yes	yes
1985:4			yes	yes
	Ireland			
1970:2		yes		yes
1970:3		yes		yes
1970:4				yes
1972:2			yes	yes
1972:3				yes
1973:1		yes		yes
1973:3			yes	yes
1976:2				yes
1976:4			yes	yes
1986:3				yes
1992:3		yes	yes	yes

Table A.4: Identification of Currency Crises (4)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	Italy			
1970:2		yes		yes
1970:3		yes		yes
1973:1		yes	yes	
1973:2				yes
1973:3				yes
1974:2		yes		
1974:4			yes	yes
1975:4		yes		
1976:1			yes	yes
1992:3		yes		yes
1992:4				yes
1993:1				yes
1995:1				yes
1995:2				yes
	Japan			
1972:1		yes		
1974:3		yes		
1979:1		yes		yes
1979:2				yes
1979:4				yes
1980:1		yes		yes
1989:2		yes		yes
1989:3		yes		
1990:1		yes		
1991:1			yes	yes
1995:3				yes
1995:4				yes
1997:1				yes
	Netherlands			
1970:2		yes		yes
1970:3		yes		yes
1973:2			yes	yes
1973:3		yes		yes
1978:3			yes	yes
1978:4		yes		
1980:3			yes	yes
1989:3			yes	
1992:3		yes		yes

Table A.5: Identification of Currency Crises (5)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	New Zealand			
1970:4			yes	
1974:2		yes		
1974:3		yes		
1975:3				yes
1975:4				yes
1976:2		yes		yes
1980:1			yes	yes
1980:3			yes	yes
1982:1		yes		yes
1984:3				yes
1985:1		yes	yes	yes
1986:3				yes
1988:3		yes		yes
1989:3		yes		
	Norway			
1970:2		yes		yes
1970:3		yes		yes
1973:1		yes		yes
1973:3			yes	yes
1977:4		yes	yes	yes
1982:3				yes
1982:4			yes	yes
1986:2			yes	yes
1986:3			yes	yes
1986:4			yes	yes
1987:4		yes		
1992:3		yes		yes
	Portugal			
1972:4			yes	
1976:2				yes
1977:1				yes
1977:2			yes	yes
1978:2				yes
1978:4				yes
1983:3			yes	yes
1992:3		yes		yes

Table A.6: Identification of Currency Crises (6)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	Spain			
1970:2				yes
1973:1				yes
1973:3			yes	yes
1976:1			yes	yes
1977:3			yes	yes
1983:1			yes	yes
1992:3		yes	yes	yes
1992:4			yes	yes
1993:3			yes	yes
	Sweden			
1970:1		yes	yes	yes
1970:2		yes		yes
1970:3		yes		yes
1970:4		yes		yes
1973:1		yes		yes
1973:2			yes	yes
1973:3				yes
1977:3				yes
1977:4				yes
1981:4			yes	yes
1982:4			yes	yes
1987:4		yes		
1992:3		yes		yes
1992:4				yes
1993:1				yes
	Switzerland			
1970:1		yes		yes
1970:3		yes		yes
1971:1		yes		yes
1972:4			yes	yes
1973:1		yes		yes
1973:3			yes	yes
1978:4				yes
1979:1				yes
1981:1		yes		yes
1982:2				yes
1992:3				yes

Table A.7: Identification of Currency Crises (7)

Date	Country	EMP index unweighted	EMP index weighted	Third measure
	UK			
1970:2		yes		yes
1970:3		yes		yes
1972:1			yes	
1972:2				yes
1972:3		yes		yes
1973:3				yes
1976:2				yes
1976:4				yes
1981:4			yes	yes
1983:1				yes
1986:1				yes
1986:3				yes
1986:4				yes
1992:3		yes		yes
1992:4			yes	yes
	US			
1970:2		yes		yes
1970:3		yes		yes
1970:4		yes		yes
1971:3		yes	yes	yes
1973:1		yes		yes
1973:2				yes
1973:3				yes
1977:2			yes	
1979:3		yes		yes
1980:4			yes	yes
1985:4				yes
1986:1				yes
1987:1				yes
1992:3		yes	yes	yes

Table A.8: Identification of Currency Crises and Official Events (1)

Date	Events
1967	Devaluation £ Beginning of the events towards the breakdown of Bretton Woods
Early'71	Foreign CB buy $ to prevent the $ from depreciating
May'71	German CB buys a huge amount of $, not useful Suspended intervention German and Dutch authorities float their currency
August'71	US suspension of the link between $ and gold
Dec.'71	Smithsonian agreement: intention of re-instituting a system of stable exchange rates o 8% devaluation $ o 17% revaluation yen o 4% devaluation DM o bands enlarges to 2.25% It lasts 14 months (to February'73)
24 April'72	Basle Agreement: snake in the ($) tunnel: 6 EC members (Germany, France, Italy, Belgium, Luxembourg, The Netherlands) agree to halve the margin of the Smithsonian agreement
1 May'72	Denmark, UK, Ireland join the snake
23 May'72	Norway joins the snake
23 June'72	£ and Irish punt withdraw
27 June'72	Denmark withdraws
June'72	£ floats Speculation against the $ in the following months
10 Oct.'72	Denmark returns
13 Feb.'73	Italy withdraws
Early'73	Swiss franc floats against the $ $ devaluation Yen float against the $ French Franc floats DM floats

Table A.9: Identification of Currency Crises and Official Events (2)

Date	Events
19 March'73	Floating of the $ (end of Bretton Woods), the tunnel disappeared leaving the snake as a joint float for the participants Sweden becomes associated DM revaluation, 3%, because of the depreciation of the $ that creates tensions in the snake, but this is not enough, so in ⇒
June'73	DM revaluation by 5.5% Norwegian krone devalued by 13% Dannish krone devalued by 6% Finnish markka devalued 7%
17 Sept.'73	Dutch guilder revaluation 5%
16 Nov.'73	Norwegian krone revaluation 5%
Middle'73	First oil shock → $ begins to appreciate against DM and yen
19 Jan.'74	France withdraws (because of problems derived from the oil shock) French franc, Belgium-Luxembourg franc and the two Scandinavian currencies of Denmark and Sweden are the weaker currencies; DM and Dutch guilder are the stronger currencies ⇒ Clear division in the snake
10 July'75	France returns
Nov.'75	Rambouliet meeting: legalizes floating
76	IMF legalizes the non-system
9 Feb.'76	Peseta devalued by 13%
15 March'76	France withdraws again (because Chirac implements fiscal expansion in the autumn'75 as recession deepened)
August'76	Bundesbank intervention in favour of the smaller non-German participants in the snake
17 Oct.'76	Frankfurt realignment: o Danish krone devaluation 6% o Dutch guilder devaluation 2% o Belgian Franc devaluation 2% o Norwegian kroner devaluation 3% o Swedish kroner devaluation 3%

Table A.10: Identification of Currency Crises and Official Events (3)

Date	Events
Second half'77	$ begins to weaken
3 July'77	Peseta is allowed to float to a 20% depreciation
78	Kingston (Jamaica): second amendment to IMF articles of agreement takes effect, legalizing the float and reducing the monetary role of gold
Early'78	Despite intervention of American, Germany and Japanese authorities, $ continues to fall Appreciation DM (7%) difficult to handle for the other currencies
13 Feb.'78	Norwegian krone devaluation 8%
17 Oct.'78	DM revaluated 4% Dutch guilder revaluated 2% Belgian franc revaluated 2%
Nov.'78	More interventions to support the $
17 Dec.'78	Norway announces decision to withdraw
13 March'79	EMS comes into being (with the snake participants) Belgium franc, Danish krone, DM, French franc, Irish punt, Lux. Franc and Dutch guilder band of 2.25% and Italian lira band of 6%
July'79	UK joins EMS
Sept.'79	Bundesbank intervenes to support: $, Belgian franc and Danish krone
24 Sept.'79	DM revaluation 2% Danish krone devaluation 2.9%
Oct.'79	Dramatic tightening of monetary policy in US
30 Nov.'79	Dannish krone devalued by 4.8% to restore competitiveness (with respect to ECU)
From Nov'79 to Feb.'81	Fiscal expansion in Germany: interest differential in favour of the weaker currencies → DM near floor of band a lot of times, requiring substantial interventions

Table A.11: Identification of Currency Crises and Official Events (4)

Date	Events
Feb.'81	Bundesbank tights monetary policy: sharp increase in interest rates → DM to the top of the band
22 March'81	Italy 6% devaluation with respect ECU
Oct.'81	DM revaluation 5.5% French franc devaluation 3% Dutch guilder revaluation 5.5% Belgium, Luxembourg, Denmark and Ireland: technically chosen as pivots, but the realignment implied devaluation around 2%
22 Feb.'82	Belgium 8.5% devaluation Denmark 3% devaluation (with respect to ECU)
14 June'82	DM revaluation 4.25% Guilder revaluation 4.25% French franc devaluation 5.75% Lira devaluation 2.75% (with respect ECU)
2 Oct.'82	Sweden devaluation 15.9%
4 Dec.'82	Peseta is devalued by 8%
21 March'83	DM revaluation 5.5% Dutch guilder revaluation 4.25% French franc devaluation 5.75% Italian lira devaluation 2.75% (with respect ECU)
1980-85	Appreciation of the $ because of tight monetary policy
21 July'85	Lira devaluation 8% with respect to DM
Sept.'85	Plaza agreement (G5: France, Germany, Japan, UK and US): Intervention selling $ for DM and yens to stop appreciation $
85	$ starts to depreciate
86	Depreciation $ Appreciation yen

Table A.12: Identification of Currency Crises and Official Events (5)

Date	Events
7 April'86	DM and Dutch gulder revaluation 3% Danish krone and Belgian franc revaluation 1% French franc devaluation 3% (with respect ECU)
4 August'86	Irish punt devaluation 8% (with respect to ECU)
12 May'86	Norwegian krone is devalued by 10.7%
Oct.'86	Governments want to stabilize $-yen exchange rate: they do not want the $ to depreciate further → CBs start to intervene buying $
12 Jan.'87	DM devaluation 3% Guilder devaluation 3% Belgian-Luxembourg franc devaluation 2% (with respect to ECU)
Feb.'87	G5 in Paris, Louvre Accord: CBs intervene buying $
Autumn'87	$ continues to fall Mid October a small increase in DM interest rates very criticized, panic in US → $ falls despite intervention
Oct.'87	French franc falls but reverts in
Nov.'87	By adjustment in interest rate differentials with respect Germany
Early'88	Depreciation $ ends abruptly because of intervention
July'89	Peseta joins EMS, 6% band
7 Jan.'90	Spain and Italy reduce margins to ±2.25% Italian lira devaluation 3.75%
Oct.'90	UK joins EMS (6% band) Norway pegs its currency as it moves towards applying for EU membership
May'91	Sweden and Finland peg their currencies as they move towards applying for EU membership
15 Nov.'91	Finland devaluation 12.3%

Table A.13: Identification of Currency Crises and Official Events (6)

Date	Events
April'92	Portugal joins EMS (6% band)
2 June'92	Tensions in the EMS because of the narrow majority against the Maastricht treaty by Denmark
Summer'92	UK postpones ratification of the treaty Weakness of $
July'92	Increase in German interest rate to 8.5%
8 Sept.'92	Finnish markka has to abandon its ECU peg
10-11 Setp.'92	Lira under pressure: falls below its EMS floor. Massive interventions by Banca d'Italia and Bundesbank
14 Setp.'92	Cut on German interest rate Italian lira devaluation 3.5%
16 Sept'92	Heavy interventions failed to lift sterling from its EMS floor Sweden raise its marginal lending rate Temporarily suspension of both sterling and lira from participation Devaluation 5% of peseta
19 Nov.92	Swedish krona breaks its link
22 Nov.'92	Peseta devaluation 6% (capital controls) Escudo devaluation 6% (follows Spain)
10 Dec.'92	Norway discontinues the peg on the ECU and its currency is allowed to float
30 Jan.'93	Punt devaluation 10%
13 May'93	Peseta devaluation 8% Escudo devaluation 6.5%
July'93	French franc under pressure: intervention Danish krone under pressure: intervention
29 July'93	France, Belgium and Denmark fall below their EMS floor
1 August'93	Widening of the fluctuations margins to 15% Over the first month after the decision Danish krone, French franc and Belgian franc use a substantial part of the new margins

Table A.14: Identification of Currency Crises and Official Events (7)

Date	Events
Autumn'93	Danish krone, French franc and Belgian franc recover
Jan.'95	Austria joins EMS
April-May'95	Falling French franc because Jacques Chirac's campaign promises of more expansionary policies Lira and Swedish krone weak $ depreciates
May'95	Peseta devaluation 7% Escudo devaluation 3.5%
96	French franc most of the time weak Irish Punt strong
Autumn'96	Finnish markka and lira enter EMS

Table A.15: Currency Crises and Associated Events (1)

Beginning of the Currency Crisis	Associated Event (if applicable)
Australia	
1974:3	
1979:1	
1981:3	
1985:1	
1986:3	
1989:2	
Austria	
1970:1	
1971:3	US suspension link $/gold
1973:1	19 March: floating of the $, the tunnel (of the snake) disappears; DM revaluated by 3% because depreciation of the $ that creates tensions in the snake
1978:4	17 Oct. DM revaluated by 4%
1992:3	EMS tensions: cut on German interest rates, 14 Sept.
1993:3	EMS tensions: widening of the fluctuations margins to ±15%
Belgium	
1970:1	
1973:2	DM revaluated by 5.5% (tensions derived from the floating of the $ the previous quarter)
1976:1	(French franc withdraws)
1979:3	Sept. Bundesbank intervenes to support the Belgian
1981:1	franc Feb. Bundesbank tights monetary policy: tensions in the snake
1981:4	Oct. DM revaluated by 5.5% and Belgian franc devalued by 2%
1992:3	EMS tensions: cut on German interest rates, 14 Sept
1993:2	EMS tensions
Canada	
1977:1	
1981:2	
1982:2	
1992:1	
1992:4	

Table A.16: Currency Crises and Associated Events (2)

Beginning of the Currency Crisis	Associated Event (if applicable)
Denmark	
1970:1	
1971:2	May: Bundesbank buy $
1973:3	(June: Dannish krone devalued by 6%)
1976:3	Bundesbank intervention in favour of the smaller non-German participants in the snake
1977:2	
1979:4	30 Nov: Dannish krone devalued by 4.8%
1982:1	22 Feb: Dannish krone devalued by 3%
1992:3	EMS tensions
1993:3	29 July: Dannish krone falls below their EMS floor; widening of the fluctuations margins to ±15%
1995:1	New EMS tensions
Finland	
1970:3	
1973:1	floating of the $; 19 March: DM revaluated by 3%;
1973:3	problems derived from the oil crisis
1977:2	
1982:4	tensions in some EMS currencies
1991:4	15 Nov: Finnish markka devalued by 12.3%
1992:3	EMS tensions: 8 Sept. Finnish markka has to abandon its ECU peg
1993:1	Renewed EMS tensions
1993:3	widening of the fluctuations margins to ±15%
France	
1971:3	August: US suspension of the link $/gold
1973:3	problems derived from the oil shock
1976:1	France withdraws from the snake; Bundesbank interventions
1978:1	Appreciation of the DM by 7%
1978:4	17 Oct. DM revaluated by 4%
1981:4	Oct. French franc devalued by 3%
1982:3	
1983:2	
1992:3	EMS tensions

Table A.17: Currency Crises and Associated Events (3)

Beginning of the Currency Crisis	Associated Event (if applicable)
Greece	
1971:3	August: US suspension of the link $/gold
1973:2	DM revaluated by 5.5% (tensions derived from the floating of the $ the previous quarter)
1974:3	
1980:1	
1982:2	DM revaluated by 4.25%
1983:1	DM revaluated by 5.5%
1985:4	
Ireland	
1970:2	
1972:2	May: joins the snake; June: witdraws
1973:1	floating of the $ creates tensions in the snake
1973:3	problems coming from the oil shock
1976:2	
1976:4	
1986:3	4 August: Irish punt devalued by 8%
1992:3	EMS tensions
Italy	
1970:2	
1973:2	DM revaluated by 5.5%
1974:4	
1976:1	tensions in the snake
1992:3	EMS tensions: 10-11 Sept. Italian lira falls below its EMS floor. Massive interventions by Banca d'Italia and Bundesbank; 14 Sept. Italian lira devalued by 3.5%; 16 Sept. suspension of Italian lira from participation
1995:1	Renewed problems in the EMS
Japan	
1979:1	
1979:4	
1989:2	
1991:1	
1995:3	
1997:1	

Table A.18: Currency Crises and Associated Events (4)

Beginning of the Currency Crisis	Associated Event (if applicable)
Netherlands	
1970:2	
1973:2	DM revalued by 5.5%
1978:3	Interventions to support the $ that translates into ulterior revaluations of the DM
1980:3	
1992:3	EMS tensions
New Zealand	
1975:3	
1976:2	IMF legalize the non-system
1980:1	
1980:3	
1982:1	
1984:3	
1985:1	
1986:3	
1988:3	
Norway	
1970:2	
1973:1	End of Bretton Woods; DM revalued by 3%
1973:3	DM revalued by 5.5%; Norwegian krone devalued by 13%
1977:4	
1982:3	
1986:2	
1992:3	EMS tensions (10 Dec. Norway discontinues the on the ECU and its currency is allowed to float
Portugal	
1976:2	
1977:1	
1978:2	
1978:4	17 Oct. DM revalued by 4%
1982:3	
1992:3	EMS tensions: 22 Nov. Portuguese escudo devalued by 6%

Table A.19: Currency Crises and Associated Events (5)

Beginning of the Currency Crisis	Associated Event (if applicable)
Spain	
1970:2	
1973:1	March: end of Bretton Woods; 19March: DM revalued by 3%
1973:3	June: DM revalued by 5.5%
1976:1	9 Feb. Spanish peseta devalued by 13%
1977:3	July: Spanish peseta is allowed to float to a 20% depreciation
1983:1	21 March: DM revalued by 5.5%
1992:3	EMS tensions: 16 Sept. Spanish peseta devalued by 5%; 22 Nov. new devaluation by 6%
1993:3	(13 May: Spanish peseta devalued by 8%)
Sweden	
1970:1	
1973:1	March: end of Bretton Woods; 19 March: DM revalued by 3% and Sweden becomes associated (of the snake)
1977:3	
1981:4	Oct. DM revalued by 5.5%
1982:4	2 Oct. Sweden devalued by 15.9%
1992:3	EMS tensions: 16 Sept. Sweden raise its marginal lending rate; 19 Nov. Swedish krone breaks its link
Switzerland	
1970:1	
1970:3	
1971:1	
1972:4	Early 73: Swish franc floats against the $
1973:3	
1978:4	17 Oct. DM revalued by 4%; interventions to support the $
1981:1	Bundesbank tights monetary policy
1982:2	14 June: DM revalued by 4.25%
1992:3	EMS tensions

Table A.20: Currency Crises and Associated Events (6)

Beginning of the Currency Crisis	Associated Event (if applicable)
UK	
1970:2	
1972:2	1 May: UK joins snake 23 June: UK withdraws
1973:3	
1976:2	
1976:4	
1981:4	Oct. DM revalued by 5.5% (UK joined EMS in July'79)
1983:1	21 March: DM revalued by 5.5%
1986:1	
1986:3	Depreciation $
1992:3	EMS tensions: 16 Sept. heavy interventions fail to lift sterling from its EMS floor. Temporarily suspension of the sterling participation
US	
1970:2	
1971:3	August: US suspension of the link $/gold
1973:1	March: end of Bretton Woods; 19 March: DM revalued by 3% and Sweden becomes associated (of the snake)
1979:3	Sept. Bundesbank intervenes to support the $
1980:4	
1985:4	Starts depreciation of the $ (after a period of appreciation)
1987:1	Feb. Louvre Accord: G5 intervens buying $
1992:3	weakness of the $

Table A.21: Maximum Likelihood Estimates (1)

Parameters	Estimates	Std. error	Expected sign
Independent Variables			
Growth	-0.07	0.08	-
Inflation	0.10	0.08	+
Unemployment	0.01	0.02	+
Export Growth	-0.04**	0.02	-
Import Growth	0.03**	0.02	+
Openness	-0.01**	0.01	-
REER	0.02*	0.01	+
Deposits/GDP (rate of growth)	-0.05*	0.03	-
Claims on Government/GDP	0.01**	0.01	+
Portfolio Investment/GDP	0.07***	0.03	+
FDI/GDP	-0.01	0.12	-

*, ** and *** indicates significance at 10%, 5% and 1% respectively.

Table A.22: Maximum Likelihood Estimates (2)

Parameters	Estimates	Std. error	Expected sign
Independent Variables			
Growth	-0.07	0.08	-
Inflation	0.80	0.08	+
Unemployment	0.01	0.02	+
Export Growth	-0.04***	0.02	-
Import Growth	0.03***	0.01	+
Openness	-0.01**	0.01	-
REER (deviation from trend)	-0.08***	0.03	-
Deposits/GDP (rate of growth)	-0.05**	0.03	-
Domestic Credit/GDP	-0.002	0.005	+
Portfolio Investment/GDP	0.06***	0.03	+
FDI/GDP	0.002	0.13	-

*, ** and *** indicates significance at 10%, 5% and 1% respectevely.

Appendix B

Appendix for Chapter 3

Table B.1: Crises Occurrence — 5% cut-off

Country	Date			Country	Date		
China	Dec-98	Jan-94		Venezuela	May-87	Aug-88	May-94
India	Jul-91	Mar-92			Sep-87	Nov-89	Dec-95
Indonesia	Aug-97	Mar-98	Aug-99		Jun-88	Oct-92	Apr-96
	Dec-97	May-98	Nov-99	Egypt	Aug-89	Jul-90	Mar-91
	Jan-98	Jan-99		Israel	Jan-89	Mar-90	Nov-92
Korea	Nov-97	Dec-97			Jul-89	Mar-91	Oct-98
Malaysia	Jan-94	Aug-97	Dec-97	Jordan	Oct-88	Feb-89	
Pakistan	Nov-95	Jul-98		Hungary	Mar-87	Dec-89	Jul-93
Philippines	Nov-90	Dec-97			Jul-88	Jan-91	Aug-94
	Sep-97	Jul-97			Apr-89	Nov-92	
Sri Lanka	Jan-93			Poland	Feb-87	Aug-89	Mar-92
Thailand	Dec-97	Jun-98			Feb-88	May-91	Sep-93
	Jul-97	Sep-99			Jun-88	Feb-92	Feb-99
Argentina	May-87	Jul-89	Jun-90	Russia	Jul-91	Jan-93	Aug-98
	Oct-87	Dec-89	Aug-90		Sep-91	Sep-93	Sep-98
	Jan-88	Feb-90	Jan-91		Nov-91	Jan-94	Dec-98
	Apr-89				Jul-92	Oct-94	Apr-99
Brazil	Feb-87	Jun-89	Oct-91	Turkey	Mar-91	Apr-94	Jan-95
	May-87	Oct-90	Mar-95		Oct-93	Sep-94	Nov-98
	May-89	Apr-91	Jan-99	Kenya	Mar-93	May-95	Aug-97
Chile	Oct-90	Dec-90			Dec-94	Jul-97	
Colombia	Jan-91	Aug-95	Sep-98	Morocco	Jun-90	Apr-91	Dec-92
	Oct-91	Feb-97	Jul-99	Nigeria	Jan-87	Nov-88	Feb-93
	Jan-94	Sep-97			Mar-87	Jan-89	Mar-95
Ecuador	Sep-87	Nov-95	Mar-99		May-87	May-91	Apr-95
	Sep-88	Mar-96	Jun-99		May-87	May-91	Apr-95
	May-89	Apr-98	Sep-99		Jul-88	Mar-92	
	Sep-92	Sep-98	Oct-99	South Africa	Jul-88	Jul-98	May-00
	Mar-93	Jan-99	Jan-00		Jun-98		
Mexico	Dec-87	Jan-95	Nov-95	Zimbabwe	Feb-88	Jan-93	May-98
	Mar-94	Mar-95	Aug-98		Mar-91	Jan-94	Aug-98
	Dec-94	Oct-95			Aug-91	Nov-97	Jan-99
Peru	Jan-87	Aug-89	Dec-90		Oct-91		
	Feb-87	Sep-89	Apr-91	Taiwan	Nov-97		
	Nov-87	Jan-90	May-91	Czech R.	Feb-99		
	Sep-88	Mar-90	Oct-91	Slovakia	Jul-93	Aug-98	May-00
	Dec-88	Apr-90	May-92	Croatia	Feb-99		
	Apr-89	Jun-90	Oct-92				
	May-89	Aug-90					

Table B.2: Crises Occurrence — 10% cut-off

Country	Date			Country	Date		
China	Dec-89	Jan-94		Venezuela	May-87	Aug-88	Dec-95
India	Jul-91				Sep-87	May-94	Apr-96
Indonesia	Dec-97	May-98	Jan-99	Russia	Feb-91	Jul-92	Oct-94
	Jan-98				Jul-91	Jan-93	Sep-98
Korea	Nov-97	Oct-97	Dec-97		Nov-91	Jan-94	Dec-98
Malaysia	Dec-97			Turkey	Mar-91	Apr-94	
Philippines	Sep-97	Dec-97		Kenya	Mar-93	May-95	Aug-97
Thailand	Jul-97	Dec-97		Nigeria	Jan-87	Mar-92	Apr-95
Argentina	Oct-87	Jul-89	Aug-90		Jan-89	Mar-95	
	Jan-88	Dec-89	Jan-91	South Africa	Jul-98		
	Apr-89	Feb-90		Zimbabwe	Aug-91	Jan-94	Aug-98
Brazil	Feb-87	Jun-89	Oct-91		Oct-91	Nov-97	
	May-87	Oct-90	Jan-99	Egypt	Aug-89	Jul-90	Mar-91
Colombia	Jan-94	Sep-98		Israel	Jan-89		
Ecuador	Sep-88	Mar-96	Oct-99	Jordan	Feb-89		
	Sep-92	Mar-99	Jan-00	Hungary	Jan-91		
Mexico	Dec-87	Mar-95		Poland	Feb-87	Aug-89	
	Dec-94	Nov-95			Feb-88	Mar-92	
	Jan-95			Slovakia	Jul-93	Aug-98	
Peru	Feb-87	Aug-89	Aug-90				
	Nov-87	Sep-89	Dec-90				
	Sep-88	Jan-90	Apr-91				
	Dec-88	Mar-90	May-91				
	Apr-89	Apr-90	Oct-91				
	May-89	Jun-90	Oct-92				

Table B.3: Reduced Sample December 1996 — Global Model

Variable	Coefficient	z-statistic
Constant	−3.79***	−27.34
Contagion	3.09***	3.74
Oil prices	−0.25	−1.00
Credit to the private sector change	0.15*	1.48
REER overvaluation	0.21**	2.23
Real GDP growth	−0.55***	−5.54
Import cover	−0.24**	−1.90
Equity price change	−0.11	−0.97
Debt to exports ratio	0.06	1.10
Log likelihood	−400.72	
Avg. log likelihood	−0.13	

*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

Table B.4: Reduced Sample December 1997 — Global Model

Variable	Coefficient	z-statistic
Constant	−3.71***	−29.87
Contagion	2.90***	3.51
Oil prices	−0.26	−1.06
Credit to the private sector change	0.17**	1.73
REER overvaluation	0.31***	3.45
Real GDP growth	−0.53***	−5.66
Import cover	−0.21**	−1.87
Equity price change	−0.20**	−1.94
Debt to exports ratio	0.07*	1.34
Log likelihood	−467.85	
Avg. log likelihood	−0.13	

*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

Table B.5: Whole Panel Standardisation — Global Model

Variable	Coefficient	z-statistic
Constant	−3.79***	−34.03
Contagion	2.70***	3.40
Oil prices	−0.26**	−1.71
Credit to the private sector change	0.17***	4.32
REER overvaluation	0.22***	3.66
Real GDP growth	−0.62***	−8.34
Import cover	−0.20**	−2.10
Equity price change	−0.18***	−2.55
Debt to exports ratio	0.27***	3.49
Log likelihood	−589.76	
Avg. log likelihood	−0.13	

*, ** and ***, corresponds to the 10%, 5% and 1% significance levels, respectively.
All variables are included with a two-month lag, except equity prices and oil prices that are lagged only one month.

Table B.6: Type I & II Errors — Whole Panel Standardisation

5% cut-off*			
		Actual	
		Crises	Non-Crises
Predicted	Crises	74.51	34.83
	Non-Crises	25.49	65.17

* The cut-off for correct calls is based on the 65^{th} percentile of the risk scores for the entire sample.

Appendix C

Appendix for Chapter 4

C.1 The Sample Composition

The 92 emerging and developing countries included in our sample are:
Argentina, Armenia, Bangladesh, Barbados, Belarus, Belize, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Congo Republic, Costa Rica, Côte d'Ivoire, Croatia, Czech Republic, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Fiji, Gabon, Gambia, Ghana, Grenada, Guatemala, Guinea-Bissau, Honduras, Hungary, Indonesia, Jamaica, Jordan, Kenya, Korea Republic, Lao PDR, Latvia, Lebanon, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Panama, Paraguay, Peru, Philippines, Poland, Russia, Rwanda, Samoa, Senegal, Seychelles, Slovakia, South Africa, Sri Lanka, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, Uruguay, Vanuatu, Venezuela and Zimbabwe.

The regional classification follows the IMF *World Economic Outlook.* The countries included in 5 subsamples are:

Asia : Bangladesh, Cambodia, China, Fiji, Indonesia, Korea Republic, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Samoa, Sri Lanka, Thailand and Vanuatu.

Central and Eastern Europe : Armenia, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Malta, Moldova, Poland, Russia, Slovakia, Turkey and Ukraine.

Latin America : Argentina, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela.

Middle East : Egypt, Equatorial Guinea, Jordan, Lebanon, Morocco and Tunisia.

Africa : Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo Republic, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Tanzania, Togo, Uganda and Zimbabwe.

The dummy for countries depending on commodities for export earnings has been constructed following the IMF classification in Table 1 of Finance & Development (September 1999). The countries included in each category are:

Fuel exporters : Colombia, Congo Republic, Ecuador, Egypt, Equatorial Guinea, Gabon, Indonesia, Mexico, Nigeria, Russia, Trinidad and Tobago and Venezuela.

Metal exporters : Chile, Mauritania, Mongolia and Peru.

Food Exporters : Belize, Costa Rica, Ecuador, Honduras and Mauritius.

Raw materials exporters : Benin, Burkina Faso, Cambodia, Central African Republic, Chad, Equatorial Guinea, Gabon, Ghana, Indonesia, Lao PDR, Latvia, Lebanon, Malawi, Mali, Myanmar, Paraguay, Peru and Zimbabwe.

Beverages exporters : Burundi, Cameroon, Colombia, Côte d'Ivoire, El Salvador, Ghana, Guatemala, Honduras, Kenya, Nicaragua, Rwanda and Uganda.

C.2 Tables

In the following pages we present descriptive tables corresponding to the dependent and explanatory variables.

Table C.1: Banking Crisis Episodes (1)

Crisis date	Description
Argentina: 1991:2–1997:4	
1994:4	The Mexican devaluation led to bank runs which resulted in a 18% decline in deposits between Dec. 1994 and May 1995.
1995:1	About 45/205 institutions were closed or merged through Sep. 1995.
1995:2	
1995:3	
Armenia: 1994:2–1997:4	
1995:3	Sep. 1995: the banking crisis peaked, after the central bank (CNB)had closed half of the active banks since Aug. 1994.
1996:1	A bank rehabilitation programme was launched in early 1996, when most of Armenia's 35 commercial banks were insolvent according to international accounting standards. 3 of the largest problem banks, have been restructured.
Bangladesh: 1975:3–1997:4	
1990:3	Reform of the banking system. The IDA agreed to provide a credit of $US175m to enable commercial banks to operate more efficiently.
1990:4	
1991:1	Debt recovery, especially by the nationalised commercial banks, was very poor in 1991.
1991:2	
1991:3	Overdue repayments to 2 development institutions (Bangladesh Shilpa Bank and Bangladesh Shilpa Rin Sengutha) amounted to $US444m.
1992:2	End of Apr. 1992: the government and the CB suspended the operations of the Bangladesh Commerce and Investment (BCI) company, and investment group which was acting as a deposit taker. As a result, there was a run against the National Credit LTD.
1997:2	Apr. 1997: following the stock market crash in Oct. /Nov. 1996, the government announced a liquidity injection of $US366m into the banking system to avoid a major crisis of confidence.
Barbados: 1972:1–1994:1	
Belarus: 1996:1–1997:4	
1996:1	Sep. 1995: Belarus Bank was merged by Presidential decree with state-owned Sberbank.
Belize: 1986:1–1997:4	
Benin: 1993:2–1997:4	
Bolivia: 1986:2–1997:4	
1987:3	Oct. 1987: the CB liquidated 2 of 12 commercial banks; 7 more reported large losses. Non-performing loans (NPL) reached 30% of banking assets.
1994:4	Nov. 1994: 2 banks with 11% of assets were closed. 3 were also deposit runs.
1997:1	Feb. 1997: one bank was run and fully taken over by the government.

Table C.2: Banking Crisis Episodes (2)

Crisis date	Description
Brazil: 1993:3–1997:4	
1994:3	July 1994: 17 small banks were liquidated, 3 private banks intervened and 5 state banks placed under special administration.
1994:4	Dec. 1994: the CB intervened in Banespa. Losses exceeded $US25bn.
Bulgaria: 1993:1–1997:4	
1993:4	Dec. 1993: the recapitalisation law passed in Dec. and l. t. ZUNK bonds had been issued to replace on the asset side of banks' balance sheet pre-1991 NPL to enterprises.
1994:3	Aug. 1994: the BNB intervened in one of the two major ailing banks.
1994:4	Late 1994: under a new bad loans law the authorities designed a program for restructuring the 2 major ailing banks.
1996:1	Between Jan. and May 1996 there have been intermittent runs on banks, including a drawdown of FX deposits from $US2.2bn to $US1.7bn. Liquidation procedures were initiated against 2 medium sized banks and 4 small banks.
Burkina Faso: 1984:1–1997:4	
1991:1	Early 1991: the banking system has undergone significant restructuring. The National Development Bank was put under a government-controlled administration and provided financial support of about CFAF15bn. 3 other banks (BFCI-B, UREBA and the investment ban,k CAI) were also put under temporary receivership and their NPL transferred to the government.
1993:4	Nov. 1993: the government liquidated the Development Bank and privatised other financial institutions.
1994:4	Nov. 1994: another series of operations was carried out to restructure the balance sheets of the banks in difficulties. Additional NPL were transferred from 3 commercial banks to the government in exchange of 15 years maturity bonds. The total cost was estimated at CFAF48bn (equal to 4.7 percent of GDP in 1994).
Burundi: 1987:1–1997:4	
1995:2	May 1995: the Meridian bank was closed.
1995:3	Sep. 1995: Meridian bank liquidation.
Cambodia: 1996:1–1997:4	
Cameroon: 1975:1–1997:4	
1989:3	Liquidation of SCB in Jul. 1989; BCD and CAMBANK in Aug. 1989; PARIBAS in Sep. 1989.
1991:2	Apr. 1991: liquidation of the BIAOC.
1994:3	BNP closed down and handed over its 34 percent shareholding in the country's largest network (BICIC) to the government for the price of one symbolic franc.
1995:3	Sep. 1995: the government appointed a monitor committee which took under forced administration the BIAO-Meridien Banque du Cameroon, after the liquidation of its main shareholder, the Bahamas-based Meridien International Bank Limited.
1996:3	Sep. 1996: the Commission Bancaire de l'Afrique Centrale announced that Banque Meridien BIAO Cameroon had been placed in liquidation.

Table C.3: Banking Crisis Episodes (3)

Crisis date	Description
1996:4	Oct. 1996: the Credit Agricole du Cameroon was hit by a confidence crisis and faced large scale witdrawals.
1997:1	March 1997: closure of BICIC, Cameroon's leading commercial bank.
Cape Verde: 1994:4-1997:4	
Central African Republic: 1981:2-1997:4	
1990:4	Meridien Bank negotiated to take over most of the African network of the troubled Banque Internationale pour l'Afrique Occidentale (BIAO).
1995:1	March 1995: the financial crisis of the Meridien-BIAO bank led to a depositors' run on the commercial bank and a write-off a CFAF2.1bn claim on its failing parent bank in Luxemburg.
Chad: 1993:4-1997:4	
Chile: 1980:2-1997:4	
1988:4	Nov. 1981: following bank runs the government intervened in 4 banks and 4 *financieras* (non-bank financial insititutions with 33 percent of outstanding loans) that lately failed.
1982:2	June 1982: almost all banks became insolvent and the CB offered to all domestic banks a l. t. repurchase agreement of bad loan portfolios.
1983:1	Jan. 1983: the authorities decided to take over 5 private banks and liquidate 3 other. The 5 banks included the 2 largest business groups which had expanded rapidly between 1975-81.
1985:1	Jan. 1985: recapitalisation programme. Assets of intervened banks were transferred to a publicly owned holding company and the banks subsequently recapitalised. Shares of the recapitalised banks were then sold to the public at favorable prices. The quasi-fiscal losses of the CB amounted to 18 percent of GDP in 1985.
China: 1987:1-1997:4	
1988:4	Financial institutions faced large withdrawals following political uncertainty.
1989:1	The governor of the People's Bank of China ordered the closure of all s. t. finance companies. Insurance firms and rural and urban credit cooperatives were investigated.
1990:4	The government launched a big drive to clear up triangular debts, releasing Rmb60bn and liquidating 60 percent of the outstanding defaults.
Colombia: 1972:1-1997:4	
1982:3	Jul. 1982: the authorities had to assist a number of banks. *Banco Nacional* became the first of 6 major banks and 8 finance companies to be intervened. 4 of them were nationalised.
1997:1	Early 1997: a bank consolidation programme involved mainly commercial finance companies. The number of deposit-taking institutions declined as a consequence of 9 mergers, 3 interventions and 1 voluntary liquidation.
Congo Republic: 1980:1-1997:4	
1994:3	July 1994: the *Banque Nationale pour le Developpement du Congo* experienced a CFA Afr.10bn flight after its problems were revealed.

Table C.4: Banking Crisis Episodes (4)

Crisis date	Description
1994:4	Oct. 1994: the Banque *Commerciale Congolaise* is put into liquidation. Dec. 1994: Regulators approved the liquidation of the *Banque Nationale pour le Developpment du Congo.*
1995:1	Feb. 1995: the government and the World Bank reached an agreement to reform Congo's troubled banking sector.
Costa Rica: 1980:4-1995:2	
1994:4	Dec. 1994: the government closed one of the largest state-owned banks.
Côte I'voire: 1980:1-1997:4	
1990:1	The crisis of the financial sector worsened in the first half of 1990. 4 main banks have been liquidated or closed down.
1990:2	June 1990: the holding company of the BIAO was liquidated. BNP handed over its shares to the Ivorian government on payment of one symbolic franc. A financial stabilisation plan was drafted by the BCEAO governor.
1991:3	Sep. 1991: The *Banque Nationale pour le Developpement Agricole* folded in Sep. , having failed to recoup more than $US201m in bad debts and to rise capital. The government authorised its liquidation on Sep. 25.
Croatia: 1995:3–1997:4	
1995:4	Nov. 1995: The 5^{th} largest bank entered rehabilitation.
1996:3	July 1996: Privredna, the largest Croatian bank, was taken over by the Rehabilitation Agency.
Czech Republic: 1994:2–1997:4	
1994:2	June 1994: liquidation of Kreditni and Prumyslova Banka.
1995:3	Aug. 1995: liquidation of *AB Banka* and *Ceska Banka.* The CNB produced a comprehensive programme for consolidating small banks in order to prevent a domino effect in this sector. 15/18 banks were included in the programme with radical solutions adopted for 9 of them.
Dominica: 1990:1–1997:4	
Dominican Republic: 1992:2–1997:4	
1996:2	April 1996: the Monetary Board intervened in the third largest bank, which represented 7 percent of the total assets of the banking system.
Ecuador: 1991:2–1997:4	
Egypt: 1972:–1997:4	
1993:4	Late 1993: the authorities developed a plan for selling the public sectors' holding in joint venture banks and for privatising one of the four large public sector banks.

Table C.5: Banking Crisis Episodes (5)

Crisis date	Description
El Salvador: 1978:1–1994:2	
1990:4	Nov. 1990: a new legislation was enacted to restructure and privatise the financial system. The *Fondo de Sanamiento* was created in aid or this task.
Equatorial Guinea: 1990:1–1997:4	
Estonia: 1994:1–1997:4	
1994:3	Aug. -Sep. 1994: the BOE lent the equivalent of 6 percent of base money to the troubled Social Bank to meet large deposit withdrawals. The activities of the bank were suspended in mid-August and then re-opened, with a liquidity intervention of EEK231m.
1994:4	Oct. 1994: the BOE merged the Social Bank with another insolvent bank, the Development Bank.
1995:1	March 1995: the BOE concluded agreements to sell parts of Social Bank and convert the reminder to a loan recovery agency. All the depositors accounts were transferred to other banks.
Fiji: 1981:1–1986:4	
Gabon:1987:4–1996:4	
Gambia: 1980:1–1991:4	
1985:1	1985: restructuring of the most important commercial bank, the Gambian Commercial and Development Bank.
1989:1	1989: liquidation of the Agricultural Development Bank.
1991:3	July 1991: offering for sale of the Gambian Commercial and Development Bank.
Ghana: 1980:1–1991:4	
1989:3	July 1989: adoption of a comprehensive restructuring plan for banks to take over NP assets from the banks' balance sheets.
1990:2	May 1990: replacement of banks NPL with government bonds. The total cost of the intervention reached 6 percent of GDP.
1990:4	Dec. 1990: replacement of NP claims on state-owned enterprises by the financially distressed banks with Bank of Ghana bonds.
1991:1	March 1991: replacement of banks' NPL with government bonds.
Grenada: 1988:4–1997:4	
Guatemala: 1978:2–1997:4	
Guinea-Bissau: 1991:2–1995:4	
Honduras: 1984:2–1997:4	

Table C.6: Banking Crisis Episodes (6)

Crisis date	Description
Hungary: 1989:1–1997:4	
1991:4	End 1991: the state granted commercial banks guarantees for doubtful loans worth 10bn forints.
1993:1	March 1993: a loan consolidation programme was carried out. Banks with a capital adequacy ratio lower than $7\frac{1}{4}$ percent sold to the government claims on domestic enterprises that had been classified as "bad". In exchange they received credit consolidations bonds. The total cost of the operation was 4.2 percent of 1992 GDP.
1993:4	End of 1993: the government purchased a significant share of banks claims against a selected group of large-state enterprises and transferred these loans to 2 state asset management companies. 8 banks received a capital injection of FT114bn.
1994:2	May 1994: the 3 largest banks received a capital injection sufficient to rise their capital asset ratio to 4 percent.
1994:4	End 1994: the state proceeded with the third and final stage of the recapitalisation of the 3 largest banks to achieve the 8 percent capital asset ratio.
1997:1	March 1997: bank run on Postbank. As a result, in the 5 months of 1997, real non-cash M3 declined by 6 percent.
Indonesia: 1982:2–1997:4	
1990:3	Sep. 1990: failure of PT Bank Duta.
1992:4	Nov. 1992: a large bank (Bank Summa) collapsed and triggered runs on 3 smaller banks.
1997:4	31 Oct. 1997: 16 commercial banks were closed. Mid Dec. deposit runs on banks accounting for 1/2 of the banking system. The CB support amounted to 5 percent of 1997 GDP.
Jamaica: 1982:2–1991:1	
Kenya: 1977:1–1997:4	
1988:1	Early 1988: start of a major restructuring programme of the financial sector.
1993:1	By early 1993 about 1/3 of banks (accounting for about 63 percent of total bank assets) had been identified as distressed.
1993:2	The stability of the financial sector was restored through a rehabilitation programme launched in April 1993. This involved the closure of 4 commercial banks, the replacement of the management of 2 other banks and the liquidation of 8 non-bank financial institutions.
1993:4	Oct. 1993–Sep. 1994: a new one-year economic programme included further measures to ensure a sound banking system and restructure the National Bank of Kenya, the largest state bank.
1994:1	
1994:2	
1994:3	
1995:2	June 1995: the state participation into the National Bank of Kenya was reduced below 50 percent. The local subsidiary of Merdien BIAO was closed.
Korea Republic: 1977:2–1997:4	
1997:4	Dec. 1997: 14 banks are suspended, 2 large commercial banks taken over by the government.

Table C.7: Banking Crisis Episodes (7)

Crisis date	Description
Lao PDR: 1995:2–1997:4	
Latvia: 1994:4–1997:4	
1995:1	15 licences were revoked in the first 7 months of 1995. The subsequent closure of one of the largest bank (accounting for about 30 percent of deposits) and two other banks triggered a bank crisis in the spring of 1995.
1995:2	
Lebanon: 1991:1–1997:4	
Lithuania: 1994:2–1997:4	
1995:4	Dec. 1995: the 4^{th} largest bank was closed, 12 small banks were liquidated. Large deposit withdrawals took place at the end of 1995.
Macedonia: 1995:2–1997:4	
1997:1	March 1997: failure of the largest saving house, TAT, which was found to have about DM100m in unreported deposits.
Madagascar: 1976:1–1997:4	
1995:4	End 1995: expatriated administrators were appointed to take over the management of both public banks (the National Bank for Rural Development and the National Bank of Commerce) that accumulated losses of FMG114bn (13 percent of their credit portfolios).
Malawi: 1995:1–1997:4	
Mali: 1988:4–1994:2	
1988:4	In 1988–89 steps were taken to restructure the *Banque du Developpement du Mali*, including financial restructuring involving CFAF62.5bn worth of NPL. As a result, the BDM-SA was stablished on June 30, 1989 as a mixed capital company in which the Government holds 20 percent of the shares.
1989:1	
1989:2	
Malaysia: 1976:1–1997:4	
Malta: 1973:1–1997:4	
Mauritania: 1986:4–1997:4	
1993:2	June 1993: the Development Bank was closed.
1993:3	Late 1993: 3 banks were recapitalised on the basis of external audits. The budgetary impact of the programme was of 7.5 percent of GDP.
1993:4	
1994:3	July 1994: the Loan Recovery Agency took over the loan portfolio of the *Union des Banques de Developpement* and the *Banque Nationale de Mauritaine.*

Table C.8: Banking Crisis Episodes (8)

Crisis date	Description
Mauritius: 1991:2–1997:4	
Mexico: 1980:2–1997:4	
1982:3	Sep. 1982: the government took over the troubled banking system, nationalising private banks by Presidential Decree.
1994:3	Sep. 1994: the authorities intervened in 2 banks.
1995:1	Jan. 9, 1995: the authorities announced a scheme to recapitalise banks with capital ratio below the 8 percent minimum. At the end of March, 8 banks had obtained assistance from the deposit-guarantee fund (FOBAPROA) under the temporary capitalisation programme.
Moldova: 1997:1–1997:4	
Mongolia: 1994:1–1997:4	
1996:4	Dec. 1996: the Mongolian financial system underwent major restructuring. 2 large insolvent banks, which together accounted for almost 50 percent of the banking system assets, were closed. A debt recovery agency was also established.
Myanmar: 1992:2–1997:4	
Nepal: 1978:2–1997:4	
1988:1	Early 1988: the reported arrears of 3 banks (95 percent of the financial system) averaged 29 percent of all assets.
Nicaragua: 1994:1–1997:4	
Niger: 1978:3–1997:4	
1988:2	In the late 1980's Niger's banking system faced a severe solvency crisis. The *Caisse Nationale de Credit Agricole* was liquidated on June 1988.
1990:3	Sep. 1990: the decision was taken to liquidate the *Banque du Developpement de la Republique du Niger.*
1994:3	July 1, 1994: closure and complete liquidation of the *Caisse Nationale de Credit Agricole.* The unrecovered portion of its portfolio was transferred to the Treasury.
1994:4	Second-half of 1994: the Meridien BIAO was required to consolidate its own resource base via a capital increase.
Nigeria: 1994:1–1997:1	
1994:4	By the end of 1994 the number of technically insolvent commercial and merchant banks had risen to 34 and an additional 8 banks were deemed illiquid. Combined, they accounted for 10 percent of the deposits liabilities of the banking system.
Panama: 1979:1–1997:4	
1988:1	A bank holiday started in March 1988 and lasted for 9 weeks. As a result of uncertainty and loss of confidence caused by a political crisis, public banks were particularly affected by a loss of deposits and a rapid deterioration in their loan portfolios. 15 banks ceased operations.
1988:2	

Table C.9: Banking Crisis Episodes (9)

Crisis date	Description
Paraguay: 1978:4–1995:3	
1995:2	A banking crisis erupted in May 1995 following a highly publicised accounting discrepancy in the value of local currency held in the CBP's vaults. This event shook public confidence. The 3^{rd} and 4^{th} largest commercial banks (*Banco General* and Bancopar) were unable to meet their obligations and were intervened by the CBP. Following the first intervention, there was a massive withdrawal of deposits from private domestic banks. In June, Bancosur and another finance company were intervened.
1995:3	In July a small commercial bank, *Banco Mercantil*, 2 finance companies and a saving and loans association were intervened. All together these banks amounted to over 15 percent of the financial system's deposits. Government intervention had been estimated to amount to 4 percent of GDP by the end of 1995.
Peru: 1990:4–1995:2	
Philippines: 1978:2–1997:4	
1981:1	Jan-Dec. 1981: a crisis of confidence began when fraud in the commercial paper market resulted in large-scale defaults by borrowers in this market and in bankruptcies among a number of non-financial intermediaries and their holding companies.
1981:2	
1981:3	
1981:4	
1982:1	Jan. 1982–Sep. 1983: intensification of government intervention to non-financial and financial institutions. The government increased its emergency lending and equity contributions, arranged the takeover of troubled private banks by public financial institutions.
1982:2	
1982:3	
1982:4	
1983:1	
1983:2	
1983:3	
1983:4	Oct. 1983: financial panic was provoked by the authorities announcement of a moratorium of their external debt payments to foreign commercial banks, resulting in a series of runs on the banks.
1986:4	Nov. 1986: a further contraction of banking system credit occurred when some 30 percent of the banking system's total assets, representing the NPL of 2 government-owned banks (the Development Bank of the Philippines and the Philippines National Bank), were transferred to a government agency.
1992:4	Dec. 1992: a comprehensive commercial bank debt restructuring programme was launched.
Poland: 1987:2–1997:4	
1991:4	In late 1991, 1 bank was privatised and 7 out of 9 treasury owned banks (with 90 percent share of total credit market) were recapitalised.

Table C.10: Banking Crisis Episodes (10)

Crisis date	Description
1993:3	A law on Financial Restructuring of Enterprises and Banks became effective in March 1993 and established the basis to recapitalise banks by transferring treasury bonds to 7 of them in Sep. 1993. This recapitalisation amounted to ZL11tn.
1993:4	Dec. 1993: the PKO-SA, which deals with consumer foreign deposits and transactions and the Bank for Food Economy (BGZ) were provided with Treasury issued recapitalisation bonds.
1995:1	Since its inception in Feb. 1995, the Bank Guarantee Fund has assisted 3 commercial banks and 88 cooperative banks in their bankruptcy procedures.
Russia: 1995:2–1997:4	
1995:2	A total of 110 banks in 1994 and 96 banks in the first 8 months of 1995 were closed.
1995:3	The interbank crisis in Aug. 1995 demonstrated the liquidity problems of Russian banks.
Rwanda: 1978:1–1997:4	
Samoa: 1980:1–1995:4	
Senegal: 1976:1–1995:4	
1989:2	June 1989: start of a restructuring plan for the *Union Senegalaise de Barques* (USB), which was completed in the following quarter.
1989:3	
1989:4	Oct. 1989: plans to recapitalise 4 state banks were announced.
1990:3	Sep. 1990: the *Banque Senegalo-Koweitienne* (BSK) had its operating licence revoked by the regional CB and closed its doors after 1 year of suspension.
1991:3	July 1991: the Bank of Credit and Commerce International Senegal (CBCCI) is closed.
Seychelles: 1982:2–1996:3	
Slovakia: 1994:2–1997:4	
1997:4	Dec. 1997: the 3^{th} largest bank, (IRB or Investment and Development Bank) was taken under forced administration by the NBS and provided credits to the bank to enable it to pay its depositors.
South Africa: 1996:1–1997:4	
Sri Lanka: 1977:1–1997:4	
1993:1	March 1993: bonds equivalent to 4.8 percent of GDP were issued to recapitalise 2 state-owned commercial banks with NPL equal to 35 percent of their portfolios.
1996:4	As the guaranteed lending turned NP, the government was forced in 1996 to place bonds in the state banks equivalent to 1.8 percent of GDP.
1997:1	March 1997: the first two-year Treasury bond was launched by the CB. These securities were issued primarily to state-owned saving institutions such as the National Saving Bank and the Employees Prevident Fund.

Table C.11: Banking Crisis Episodes (11)

Crisis date	Description
Tanzania: 1978:1–1997:4	
1992:1	Early 1992: following a comprehensive audit of the National Bank of Commerce —the dominant state bank— and the Cooperative and Rural Development Bank, a large amount of their NPL was transferred to the new Loans and Advances Realisation Trust and replaced by government bonds.
1994:1	Beginning of 1994: the authorities commenced the restructuring of the 3 existing state commercial banks, beginning with the NBC, to be followed by the CRDB and the People's Bank of Zanzibar.
1995:2	Mid 1995: the Tanzania Housing Bank was closed.
1997:3	July 1997: the government decided to split the National Bank of Commerce into 2 banks, the NBC (1997) and the NMB and to create a holding company to manage the residual assets and liabilities of the former NBC.
Thailand: 1977:2–1997:4	
1979:1	Early 1979: following the stock market crash, one of the largest finance companies failed and the bail-out of the financial sector began.
1983:4	Oct. 1983: large losses in a finance company lead to runs and government intervention.
1984:1	Between the end of 1983 and 1985 19 finance companies were closed, accompanied by runs. Throughout the period 1984–87, weakness of the financial sector resulted in regulatory intervention or in the CB take over, soft lending, recapitalisation and other support arrangements involving 5 banks that accounted for about 25 percent of total assets of the system.
1984:2	
1984:3	
1984:4	
1985:1	
1985:2	
1985:3	
1985:4	
1986:1	
1986:2	
1986:3	
1986:4	
1987:1	
1987:1	March to June, 1987: 97 finance companies received liquidity support from the CB.
1997:2	June 1997: the CB suspended the activity of 16 finance companies.
1997:3	July 1997: the currency devaluation was accompanied by a bank run.
1997:4	Dec. 1997: closure of 56 previously suspended finance companies.
Togo: 1977:3–1995:3	
1988:1	Jan. 1988: a first programme for restructuring the *Banque Togolaise de Development* was launched. CFAF1bn came from the government.
1990:3	Sep. 1990: the government liquidated the *Caisse Nationale de Credit Agricole.*
1991:2	April 1991: a second tranche disbursed by the government to recapitalise the BTD.

Table C.12: Banking Crisis Episodes (12)

Crisis date	Description
1992:4	Nov. 1992: most banks were closed for more than 6 months, until the summer of 1993, during which time the quality of the assets deteriorated substantially and liquidity in the system was reduced by almost a half.
1993:1	
1993:2	
Trinidad & Tobago:1985:2–1997:4	
Tunisia: 1988:4–1997:4	
1991:4	End 1991: comprehensive prudential regulation introduced strict standards for loan classification and provisioning. As a result most of the commercial banks were undercapitalised.
1993:3	Mid 1993: the CB set detailed terms of reference for external audits and off-site reporting requirements. Intervention in favor of a private commercial bank which had lost a significant proportion of its deposits from public enterprises over a few days.
1996:4	End of 1996: the CB took over a stock of NPL from the Agricolture Bank (BNA), the largest public sector bank, to 2 public enterprises in charge of marketing subsidized foodstuffs.
Turkey: 1987:3–1997:4	
1991:1	Jan. 1991: the start of the Persian war led to massive withdrawals and a run on banks prompting the government to guarantee all deposits.
1994:2	Deposit runs in the spring of 1994 resulted in the closure of 3 medium-sized banks. The government introduced full deposit insurance in May 1994.
Uganda: 1984:1–1997:4	
1993:1	Early 1993: a small bank failed. Several other banks were in difficulties or insolvent, including state-owned banks accounting for more than 40 percent of the banking system total assets.
1995:1	First half of 1995: a credit recovery agency, the Nonperforming Assets Recovery Trust, was established to take over the UCB's NPL and as part of the restructuring operations of the UCB.
1995:2	
Ukraine: 1996:2–1997:4	
Uruguay: 1982:1–1997:4	
1982:1	Early 1982: the *Banco Hipotecario* received substantial financial assistance from the government.
1982:4	From late 1982 to early 1984 the CBU purchased commercial banks' NPL with dollar denominated bonds and promissory notes under the Portfolio Purchase Scheme linked to bank intervention.
1983:1	
1983:2	
1983:1	
1983:4	

Table C.13: Banking Crisis Episodes (13)

Crisis date	Description
1984:1	Beginning 1984: the Banco de Plata was liquidated with deposit being reimbursed.
1984:2	Apr. 1984: the National Office of Asset Recovery was created to try to recover the banks' portfolios of NP assets.
1985:2	May 1985: *Banco de Italia*, one of the 3 largest private banks, was taken over. The CBU oredered the intervention and the *Banco de la República Oriental del Uruguay* (BROU) assumed the majority of the equity.
1985:3	July 1985: the *Banco Pan de Azúcar* was taken over after it became insolvent.
1987:1	March 1987: *Banco Comercial* was recapitalised by the BROU. At the end of the operation roughly 90 percent of its capital was held by BROU. This and the previous interventions led to a de facto nationalisation of the banking sector.
1989:2	June 1989: the government launched and extensive reform of the financial sector. The main objective have been the rehabilitation of 3 of the failed banks absorbed by the BROU.
Vanuatu: 1996:1–1997:4	
Venezuela: 1973:2–1997:4	
1982:4	The *Banco de los Trabajadores* had to be taken over by the government in late 1982.
1993:4	Oct. 1993: rumors spread about the distressed financial situation of *Banco Latino*, the second largest bank in terms of deposits. The bank had to meet major deposit withdrawals through large-scale asset sales and borrowing from the CBV.
1994:1	Jan. 1994: *Banco Latino* was closed.
1994:2	Early June 1994: 8 distressed financial institutions, with about 21 percent of total deposits, had to be intervened. By that date a total of 6 percent of 1994 GDP had already been injected into those banks.
1994:3	Jul-Aug. 1994: rumors about the financial situation of 2 large banks, *Banco Consolidado* and *Banco de Venezuela*, led to deposit runs.
1994:4	Dec. 1994: the government decided to close *Banco del Progreso.*
1995:1	Feb. 1995: 3 other banks had to be closed and their deposits migrated to the banks nationalised during the crisis.
Zimbabwe: 1981:1–1997:4	

References for tables C.1–C.13:

Balino and Sundararajan (1990); Pérez-Campanero and Leone (1991); Doe (1995); Ebrill (1994)

TheEconomist (Various issues); Galbis (1995); García-Herrero (1997); IMF (Various issues); Turtelboom (1991)

Lindgren et al. (1996); Moser, Rogers and vanTill (1997); Nascimento (1990); Valdés (1994)

Table C.14: Currency Crisis Episodes (1)

Country	Sample size	Crisis date	*10% cut-of*	*15% cut-of*
Argentina	1991:2–1997:4			
Armenia	1994:2–1997:4	1994:4	1	1
Bangladesh	1975:3–1997:4			
Barbados	1972:1–1994:1			
Belarus	1996:1–1997:4	1996:3	1	1
		1997:1	1	1
Belize	1986:1–1997:4			
Benin	1993:2–1997:4	1994:1	1	1
Bolivia	1986:2–1997:4			
Brazil	1993:3–1997:4			
Bulgaria	1993:1–1997:4	1993:4	1	0
		1994:1	1	1
		1994:4	1	0
		1996:2	1	1
		1996:3	1	1
		1997:1	1	1
		1997:3	1	0
Burkina Faso	1984:1–1997:4	1991:2	1	0
		1994:1	1	1
Burundi	1987:1–1997:4	1988:2	1	0
		1991:3	1	0
Cambodia	1996:1–1997:4	1997:4	1	0
Cameroon	1975:–1997:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Cape Verde	1994:4–1997:4			
Central African Rep.	1981:2–1997:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1

Table C.15: Currency Crisis Episodes (2)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
Chad	1993:4–1997:4	1994:1	1	1
Chile	1980:2–1997:4	1982:3	1	1
		1984:4	1	1
China	1987:1–1997:4	1990:1	1	1
		1994:1	1	1
Colombia	1972:1–1997:4	1985:2	1	0
		1997:4	1	0
Congo Rep.	1980:1–1997:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Costa Rica	1980:4–1995:2	1981:4	1	1
Côte D'Ivoire	1980:1–1997:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Croatia	1995:3–1997:4			
Czech Rep.	1994:2–1997:4			
Dominica	1990:1–1997:4			
Dominican Rep.	1992:2–1997:4			
Ecuador	1991:2–1994:4	1992:3	1	0
		1992:4	1	0
Egypt	1972:1–1997:4			
El Salvador	1978:1–1994:2			
Equatorial Guinea	1990:1–1997:4	1991:2	1	0
		1994:1	1	1
Estonia	1994:1–1997:4			
Fiji	1981:1–1986:4			

Table C.16: Currency Crisis Episodes (3)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
Gabon	1987:4–1996:4	1991:2	1	0
		1994:1	1	1
Gambia	1980:1–1991:4	1981:2	1	0
		1984:2	1	1
		1991:2		
Ghana	1984:3–1997:4	1984:4	1	1
		1986:1	1	1
		1988:3	1	1
		1992:4	1	0
		1993:3	1	0
		1994:1	1	1
		1995:4	1	0
Grenada	1978:2–1997:4			
Guatemala	1978:2–1997:4	1986:3	1	1
		1989:4	1	0
		1990:1	1	1
Guinea-Bissau	1991:2–1995:4	1991:4	1	1
		1992:3	1	1
		1993:3	1	0
		1994:4	1	0
		1995:3	1	0
Honduras	1984:2–1997:4	1990:2	1	1
		1990:4	1	1
		1993:3	1	0
Hungary	1989:1–1997:4	1989:2	1	0
Indonesia	1982:2–1997:4	1983:2	1	1
		1986:4	1	1
		1997:3	1	0
		1997:4	1	1
Jamaica	1982:2–1991:1	1984:4	1	0
		1989:4	1	1
		1990:4	1	1

Table C.17: Currency Crisis Episodes (4)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
Kenya	1977:1–1997:4	1981:4	1	0
		1983:1	1	0
		1991:2	1	0
		1993:2	1	1
		1995:2	1	0
Korea Republic	1977:2–1997:4	1997:4	1	1
Lao PDR	1995:2–1997:4	1995:3	1	0
		1997:3	1	1
		1997:4	1	1
Latvia	1994:4–1997:4			
Lebanon	1991:1–1997:4	1992:2	1	1
Lithuania	1994:2–1997:4			
Macedonia	1995:2–1997:4	1997:3	1	1
Madagascar	1976:1–1997:4	1982:2	1	0
		1983:4	1	0
		1984:2	1	0
		1987:3	1	1
		1988:3	1	0
		1994:2	1	1
		1997:1	1	0
Malawi	1995:1–1997:4			
Mali	1988:4–1994:2	1991:2	1	0
		1994:1	1	1
Malaysia	1976:1–1997:4	1997:3	1	0
		1997:4	1	1
Malta	1973:1–1997:4			
Mauritania	1986:4–1997:4			
Mauritius	1991:2–1997:4	1991:2	1	0
Mexico	1980:2–1997:4	1982:1	1	1
		1982:3	1	1

Table C.18: Currency Crisis Episodes (5)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
		1983:1	1	1
		1985:3	1	1
		1995:1	1	1
		1995:4	1	1
Moldova	1997:1–1997:4			
Mongolia	1994:1–1997:4	1996:4	1	1
Morocco	1977:1–1997:4	1983:1	1	0
		1991:2	1	0
Myanmar	1992:2–1997:4			
Nepal	1978:2–1997:4	1986:1	1	0
		1991:3	1	1
Nicaragua	1994:1–1997:4			
Niger	1978:3–1997:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Nigeria	1994:1–1997:4			
Panama	1979:1–1997:4			
Paraguay	1978:4–1995:3	1984:2	1	1
		1985:2	1	1
		1987:1	1	1
		1989:2	1	1
Peru	1990:4–1995:2	1991:2	1	1
		1991:4	1	1
Philippines	1978:2–1997:4	1983:4	1	1
		1984:3	1	1
		1990:4	1	0
		1997:3	1	0
		1997:4	1	1
Poland	1987:2–1997:4	1988:1	1	1
		1989:2	1	1
		1989:4	1	1
		1992:2	1	0
		1993:3	1	0

Table C.19: Currency Crisis Episodes (6)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
Russia	1995:2–1997:4			
Rwanda	1978:1–1997:4	1994:1	1	1
		1995:2	1	1
Samoa	1980:1–1995:4	1983:2	1	0
		1984:3	1	1
Senegal	1976:1–1995:4	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Seychelles	1982:2–1996:3			
Slovakia	1994:2–1997:4			
South Africa	1996:1–1997:4	1996:2	1	0
Sri Lanka	1977:1–1997:4	1977:4	1	1
Tanzania	1978:1–1997:4	1982:2	1	0
		1983:3	1	1
		1984:3	1	1
		1986:3	1	1
		1988:1	1	1
		1988:4	1	1
		1989:4	1	0
		1990:1	1	1
		1991:2	1	0
		1992:2	1	1
		1993:3	1	1
Thailand	1977:2–1997:4	1997:3	1	1
Togo	1977:3–1995:3	1982:3	1	0
		1991:2	1	0
		1994:1	1	1
Trinidad & Tobago	1985:2–1997:4	1986:1	1	1
Tunisia	1988:4–1997:4	1991:2	1	0
		1993:1	1	0
Turkey	1987:3-1997:4	1988:1	1	1
		1991:1	1	1

Table C.20: Currency Crisis Episodes (7)

Country	Sample size	Crisis date	*10% cut-off*	*15% cut-off*
		1991:2	1	1
		1992:1	1	0
		1992:4	1	0
		1993:3	1	1
		1994:1	1	1
		1994:2	1	1
		1995:4	1	0
		1996:1	1	1
		1996:4	1	1
Uganda	1984:1–1997:4	1984:3	1	1
		1984:4	1	1
		1985:4	1	1
		1989:1	1	0
		1990:3	1	1
		1991:3	1	1
		1992:2	1	1
Ukraine	1996:2–1997:4			
Uruguay	1982:1–1997:4	1982:4	1	1
		1983:1	1	1
		1983:4	1	0
		1984:1	1	1
		1984:4	1	1
		1984:4	1	1
		1985:1	1	1
		1989:4	1	1
		1990:2	1	1
Vanuatu	1996:1–1997:4			
Venezuela	1973:2–1997:4	1987:1	1	1
		1989:2	1	1
		1992:4	1	0
		1994:2	1	1
		1996:1	1	1
Zimbabwe	1981:1–1997:4	1983:1	1	1
		1984:3	1	0
		1991:2	1	0
		1991:3	1	1
		1991:4	1	1
		1993:1	1	1
		1994:1	1	1
		1997:4	1	1

Table C.21: The Data (1)

Variable Name	Data Source and Definition	Frequency
	Macroeconomic Variables	
Real GDP Growth	World Bank, World Development Indicators (WDI). GDP at constant 1990 prices, in national currency (nc), and growth rates.	Interpolated from annual data applying cubic spline techniques.
Inflation	International Monetary Found - International Financial Statistics (IFS). Growth rate of Consumer Price Index (CPI). IFS line 64.	Quarterly.
Real deposit interest rate	IMF. Deposit interest rate (IFS line 60l) minus CPI inflation (IFS line 64).	Quarterly. We stretch back some of the series by applying the rate growth of the discount rate when deposit rates are not available.
Growth of total exports of goods and services over GDP	IMF. Total exports in \$US (IFS lines $7aad + 78add$), divided by GDP at current prices in \$US from the WDI series. Growth rates.	Quarterly where available, otherwise interpolated from the correspondent annual series applying a linear technique.
Growth of total imports of goods and services over GDP	IMF. total imports in \$US (IFS lines $78abd + 78aed$), divided by GDP at current prices in \$US from WDI. Growth rates.	Quarterly where available, otherwise interpolated from the correspondent annual series applying a linear technique.
Real exchange rate	Calculated by the authors. We use the nominal bilateral exchange rate against the \$US (IFS line rf). We convert these series into real exchange rates using CPI (IFS line 64). To construct the undervaluation/overvaluation measure we first calculate the Hodrick-Prescot trend and then use the deviations from it. A decrease in this indicator means increasing overvaluation.	Quarterly.

Table C.22: The Data (2)

Variable Name	Data Source and Definition	Frequency
	Monetary Variables	
Foreign exchange reserves over total imports	IMF. Reserves of the Central Bank (IFS line 1d.d), divided by total imports (IFS lines $78abd + 78aed$). $US	Quarterly.
Growth of total domestic credit	IMF. Total domestic credit (IFS line 32), divided by GDP at current prices. In nc and growth rates.	Quarterly.
Growth of total credit to the private sector over GDP	IMF. Claims on the private sector (IFS line 32d), divided by GDP at current prices. In nc and growth rates.	Quarterly
Growth of net claims to the government over GDP	IMF. Net claims on central government (IFS line 32an), divided by GDP at current prices. In nc and growth rates.	Quarterly.
	Dummy Variables	
Exchange rate regime	IMF. Exchange Rate Arrangements and Restrictions Reports. Dummy=1 if the exchange rate regime is classified as independently or managed floating, 0 otherwise.	Quarterly. We could identify the exact quarter from the information provided in the annual reports.
Financial liberalization	Demirgüç-Kunt and Detragiache (1998b), Williamson and Mahar (1998), Fanelli and Medhora (1998) and Bisat, Johnston and Sundrarajan (1999). Dummy variable = 1 if domestic interest rates are liberalised. Dummy = 0 if domestic interest rates are not liberalised or information on the process of financial liberalization was not found.	Quarterly
	Global Variables	
Change in the US interest rate	IMF. IFS line 60b.	Quarterly.
US growth	IMF. US nominal GDP (IFS line 99b). Growth rates.	Quarterly.
US inflation	IMF. Based on the US CPI index (IFS line 64).	Quarterly.

Table C.23: The Data (3)

Variable Name	Data Source and Definition	Frequency
Fuel inflation	IMF. Commodity price index 1990 = 100 of fuel (petroleum). IFS line 001.76aad. Growth rates.	Quarterly.
Metals inflation	Commodity price index 1990 = 100 of metals (aluminum, copper, iron, lead, nickel, tin and zinc). IFS line 001.76ayd. Growth rates.	Quarterly.
Food inflation	Commodity price index 1990 = 100 of food (bananas, cereals, meat, vegetable oils and sugar). IFS line 001.76exd. Growth rates.	Quarterly.
Raw materials inflation	Commodity price index 1990 = 100 of raw materials (cotton, hides, rubber, timber, tobacco and wool). IFS line 001.76bxd. Growth rates.	Quarterly.
Beverages inflation	Commodity price index 1990 = 100 of beverages (coffee, cocoa and tea). IFS line 001.76dwd. Growth rates.	Quarterly.
	Debt Variables	
Total external debt over total exports	WDI. Total external debt in current $US, over total exports of good and services.	Annual series. Linear interpolation.
Total external debt over GDP	WDI. Total external debt in current $US, over GDP in current prices and expressed in $US.	Annual series. Linear interpolation.
Total external debt over reserves	WDI. Total external debt in current $US, over reserves excluding gold (IFS line 1d.d)	Annual series. Linear interpolation.
Total debt service payments over GDP	WDI. Total debt service paid in $US over GDP in current prices and in $US.	Annual series. Linear interpolation.
Short-term debt over reserves	WDI. Short-term external debt over total reserves minus gold (IFS line 1d.d), in $US	Annual series. Linear interpolation.
Private non-guaranteed debt over long-term debt	WDI. Private external non-guaranteed debt over total external long-term debt, in $US.	Annual series. Linear interpolation.
Change in the world interest rate	Author's computations. The world interest rate is obtained as a weighted average of the interest rates of US, Japan, the UK, Germany, France and Switzerland. IFS line 60b. The weights corresponds to the shares of total external debt denominated in these currencies.	Quarterly.

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