

## An Anatomy of Currency Crises

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### Abstract

*We investigate the hypothesis that currency crises are linked to a breakdown in a set of macroeconomic fundamentals, which sparks a speculative attack. A conditional logit model is estimated for 27 countries experiencing crises over the period 1980 to 1997. This sample includes countries from the Latin American, European and Asian Pacific regions. The results support the fundamentals hypothesis with characteristics such as domestic credit, international reserves, the real exchange rate, foreign currency ratings and the choice of the exchange rate regime impacting on the crisis probability. The differing impacts of particular characteristics through time and across regions are emphasised.*

- **JEL Classifications:** G15
- **Key words:** Crises, Fundamentals, Logit, Credit, Deficit, International financial markets

### I. Introduction

Research interest in explaining the causes of currency crises received a fresh stimulus in the wake of the Asian crisis. Some indicators of earlier crises such as low growth, high budget and current account deficits, inflationary pressure, low savings and investment were less evident in Asia. In these respects, the Asian crisis surprised several commentators and has led to a search for further explanations.

Our purpose is to determine if there are a common set of fundamentals, which are instrumental in explaining crises generally and in particular to determine if

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additional explanations apply to the recent Asian episode.

For this purpose, a crisis is defined as a speculative attack which affects the value of currencies forcing domestic monetary authorities to defend, either by raising interest rates or taking alternative policy measures designed to preserve international reserves.

The crisis measure applied throughout the analysis is a crisis index drawn from the literature on crises. The index is used as a basis for measuring a nation's degree of exposure to crises through the probability of a crisis. It is this variable which is explained by a set of macroeconomic and country specific variables in a conditional logit framework. Twenty-seven country individual crisis episodes occurring over the period 1980 to 1997 are covered in this study.

The focus of the study is strongly influenced by the arguments of Krueger (1998) who stresses the potential importance of a small set of macroeconomic fundamentals as indicators of currency crises. We test Krueger's proposition by analysing the effects of those fundamentals identified by her in the twenty-seven individual countries comprising the analysis. It is the breadth of this study which constitutes its contribution to the literature on financial crises. Most studies of this issue are confined to an analysis of a single crisis episode. The novelty of the present study is that several episodes are studied enabling regional comparisons to be drawn. Thus, scholars in the field are able to compare the explanations of crises across regions and through time. This gives fresh impetus to the quest for generic explanations of financial crises if these exist.

## **II. The Literature about Currency Crises**

Salant and Henderson (1978) develop the first modern explanation of balance of payments crises based on speculative attacks in commodity markets. They argue that the impetus for such attacks is provided by government attempts to control gold prices. Salant and Henderson show that defensive schemes in which governments use resource stockpiles for price stabilisation end in speculative attacks which exhaust stocks. This parallels a government's use of reserves to stabilise the exchange rate. Krugman (1979) applied some of these principles in an analysis of currency crises in small countries operating fixed exchange rate regimes, then the only defence to such an attack is to allow international reserves to fall. Krugman's analysis involves a small economy experiencing fiscal imbalance. The government in question finances its deficit by expanding domestic

credit through monetary expansion. This action decreases the nations level of foreign reserves making it more vulnerable to speculative attack. The speculators move in once this vulnerability is observed and all remaining domestic reserves are exhausted and ultimately the fixed exchange rate regime is abandoned. The policy implication is that fiscal, monetary and credit expansion must be controlled if a speculative attack is to be avoided.

This first generation of currency crisis modelling is open to criticism in relation to the mechanical treatment of government policy and an incapacity to accommodate the constraints or objectives of central banks. Later crises could not be explained by these first generation models. For example, the stresses leading to the breakdown of the European monetary mechanism in 1992-93 are not evident in the rapid adjustment of international reserves: these played a limited role only. Exchange Rate Mechanism (ERM) members were not subject to large budget deficits, nor were they experiencing exceptional credit growth, so foreign reserves were not tied to the maintenance of fixed rates.

Obstfeld (1994) explains the European experience of 1992 in terms of a cost benefit analysis of maintaining a fixed exchange rate. Domestic policy authorities may abandon fixity because it is less costly than preserving it in terms of macroeconomic effects such as unemployment. Britain's withdrawal from the ERM in November 1992 was prompted by the domestic costs of maintaining parity with other European domestic currencies.

Expectations play a central role here. Consider a vulnerable economy required to defend its currency. The monetary authority of the country may choose to increase domestic interest rates which then impacts on the domestic economy. Alternatively, the government may choose devaluation if the exchange rate is fixed. This will encourage speculators to sell the currency in anticipation of the devaluation to avoid capital losses. Expected devaluation engenders the sale of the currency forcing abandonment of the fixed exchange rate regime. It follows that any event which suggests a government's vulnerability can trigger a speculative attack. Crises of this kind are generated partly by self fulfilling expectations, however, attacks are much more likely in countries with weak fundamentals. In summary, this second generation adds the effects of expectations upon the probability of speculative attack while preserving the role of economic fundamentals suggested in first generation models. In addition second generation models are non linear in contrast to the linear nature of first generation models.

The Asian crisis has sparked renewed interest in the causes and consequences

of currency crises. We refer to this new literature as third generation modelling. Corsetti, Pesenti and Roubini's (1998) model is based on the Asian experience and focuses on moral hazards such as over investment, investment in the wrong sectors or excessive external borrowing and large current account deficits. Generally, moral hazards create a sequence of events beginning with an expansion of credit and ending in unsustainable current account deficits. Institutional or government bail out guarantees encouraged credit expansion and lead to the misallocation of investment to non traded sectors of the economy such as CBD real estate development<sup>1</sup> creating a bubble in asset prices. Further, the domestic banks confidence in the governments capacity to maintain parity encouraged offshore borrowing. However, if foreign investors perceived the fixed exchange rate to be overvalued and the domestic banks were carrying many non-performing loans, speculators attacked upon the realisation that the government did not have the reserves required to maintain a fixed exchange rate. The asset bubble burst and crisis became inevitable.

Redalet and Sachs (1998) and Yellen (1998) place a different perspective on the Asian crisis by arguing that the Asian crisis was caused by an old fashioned style bank run. A lack of confidence in the local financial institutions forced the premature liquidation of institutional investments and a run by depositors on the institutions. This view is challenged by Krugman (1999) who argues that the Asian crisis was caused by the vulnerability of corporate balance sheets given poor investment decisions and the nexus of these with the effects of capital flows on real exchange rates and corporate vulnerability.

Our final thoughts on the Asian crisis are drawn from Krueger (1998) who lays the blame on the breakdown of macroeconomic fundamentals rather than the self-fulfilling expectations explanation. Krueger identifies three critical fundamentals: i) the degree of flexibility of exchange rate mechanisms; ii) the sustainable expansion of domestic credit and iii) tolerable levels of bad paper. According to Krueger, the recipe for survival in a regional crisis is strength in these three macroeconomic magnitudes. We explore the relevance of these factors along with others in the remaining sections of the paper.

The empirical evidence tends to support the fundamentals approach to crises. Blanco and Garber (1986) pioneer the use of logit and probit models in their study of Mexican peso devaluations brought on by attacks on the currency. These

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<sup>1</sup>For example, Malaysia's domestic credit expanded by 30 per cent in 1996 alone. Much of the new credit supported investment in the non traded sector of the Malaysian economy.

authors reinforce Krugmans (1979) link between domestic credit growth and exchange rate policy. Following Blanco and Garber, Klein and Marion (1994) use panel data to analyse 80 devaluation episodes in Latin America over the period 1957 to 1991. These authors find that the monthly probability of abandoning fixed exchange rates increases with real overvaluation, is smaller, the larger is the size of the stock of international reserves. Blanco and Garber also find that the tenure and stability of domestic governments is an important political factor. Frankel and Rose (1996) apply probit techniques to the study of crises in developing countries over the years 1971 to 1992 and find that credit growth, an overvalued currency, the depth of foreign reserves and foreign debt exposure are leading indicators of crises in the developing world. European crises occurring in the period 1959-1993 are a subject of the study by Eichengreen, Rose and Wyplosz (1995). These researchers using multivariate logit techniques find that the excessive growth of domestic money stocks, high inflation, associated wages growth and unemployment are the key explanators of European episodes.

Departures from a latent variable technique can be found in the multiple regression modelling of Sachs, Tornell and Velasco (1996) in their study of crises in 20 emerging market countries. The emphasis in this study is focused on the impacts of the 1994 Mexican crisis in other countries. These authors find that fundamentals such as an appreciating real exchange rate, a weak banking system and low levels of foreign reserves influence the cross country impact in addition to contagion effects. An interesting conclusion here is that the size of capital flow, fiscal policy and current account deficits do not directly affect the impact of the Mexican crisis on neighbouring countries rather, the impact of these is channelled through the real exchange rate and private sector credit. Corsetti, Pesenti and Roubini (1998) extend the Sachs, Tornell and Velasco framework to consideration of the Asian crisis and find that weak fundamentals were at the centre of this crisis also. Their analysis reveals that the most important determinants of the Asian crisis were those associated with non performing loans supporting the contention of the third generation of crisis modelling which stresses the role of the banking sector and moral hazard in the generation of crises.

Kaminsky and Reinhart (1996) analyse the parallels between banking and balance of payment crises in their "signals" approach to crises in five developed and fifteen developing countries over the period 1970-1995. Signalling involves the monitoring of a number of economic indicators to spot changes in their behaviour prior to a crisis. When an indicator crosses a particular threshold level

then it serves as a warning signal of impending crisis.

The findings from this “signals” approach is that crises occur as an economy enters recession following a prolonged boom fuelled by rapid credit creation and capital inflows. It also indicates that banking precede currency crises and that a breakdown in economic fundamentals and speculative attacks may occur as these fundamentals deteriorate.

Berg and Patillo (1998) test the capacity of the Kaminsky and Reinhart (1996), Sachs et al (1996) and Frankel and Rose (1996) models to predict the Asian crisis. Each fundamental possessed some predictive capacity, but each would have issued several false alarms to the Asian countries concerned. The Kaminsky and Reinhart model provided a slightly better basis for prediction of the Asian crisis in comparison with Frankel and Rose.

The general conclusion which emerges from this literature is evident in Kaminsky, Lizondo and Reinhart’s (1998) survey of the crisis literature. These authors claim that a broad range of indicators is needed. These include foreign reserve levels, the real exchange rate level, credit expansion, domestic inflation, the trade balance, export performance, money and real GDP growth and the size of fiscal deficits. Note that the current account balance is insignificant in most studies.

The preceding review of the literature indicates that there is a need for a comparative study of the causes of crises in different regions of the world economy including the recent crisis in Asia.

### **III. Methodology and Data**

The econometric framework applied to this analysis involves the use of a conditional logit model which is capable of explaining the probability of a country falling into crisis. The literature review above indicates that conditional logit modelling is popular among researchers studying crises. The technique does provide the following advantages: it summarises information about the likelihood of a crisis in a single number, the probability of a crisis; it measures the contributions of individual characteristics to crisis probabilities without the need to accommodate simultaneity in a multiple equation framework and its structure allows the researcher to discriminate between significant and non significant indicators. So conditional logit modelling appeals as the appropriate technique for this study.

The following brief mathematical summary motivates the formal analysis. Let  $i = 1, 2, \dots, n$  denote the groups (countries) included in each data panel and  $t = 1, 2, \dots, T_i$  be the time series observations for each panel. Further, let  $y_i = (y_{i1}, y_{i2}, \dots, y_{iT_i})$  be the crisis indicator. This assumes a value zero if there is no crisis and one if there is a crisis. Further, let  $k_{it} = \sum_{t=1}^{T_i} y_{it}$  be the observed number of 1's for the dependent variable in the  $i^{\text{th}}$  group. The appropriate model takes the following form:

$$P_r \left( y_i | k_{i1} = \sum_{t=1}^{T_i} y_{it} \right) = \frac{\exp \left( \sum_{t=1}^{T_i} y_{it} x_{it} \beta \right)}{\sum_{d_i \in S_i} \exp \left( \sum_{t=1}^{T_i} d_{it} x_{it} \beta \right)} \quad (1)$$

where  $S_i$  is the set of each possible combinations of  $k_{1i}$  ones and  $k_{2i}$  zeroes,  $d_{it}$  is either equal to one or zero with  $k_{it} = \sum_{t=1}^{T_i} d_{it}$  and  $x_{it}$  is a row vector of independent characteristic variables while  $\beta$  is a vector of fixed coefficients common to all groups.

The logit model (1) postulates a relationship between the probability of a country experiencing a currency crisis conditional on  $k_{it}$  and a vector of characteristic crisis indicators  $x_{it}$ .

The relevant characteristic variables include the following: the real exchange rate (RER), the ratio of private sector domestic credit to GDP (DC GDP), the ratio of domestic money ( $M_2$ ) to international reserves ( $M_2\text{RES}$ ); the relevant share price index (PSHARE), the ratio of the current account balance to GDP (CABGDP), Standard and Poor's currency credit rating (SP) and a dummy variable representing the effect of the prevailing exchange rate regime on the probability of crisis (EXCREG).

These explanatory variables capture the major influences identified in earlier research, which is summarised in the preceding literature review. The RER appears as a determinant of crises in most preceding studies and this applies also to the strength of international reserves which in this study is represented by the ratio of  $M_2$  to the value of foreign reserves ( $M_2\text{RES}$ ). The strength of a nation's foreign reserve position serves as a basis for inter country comparisons when foreign reserves are benchmarked against some measure of the domestic money stock:  $M_2$  is the usual measure. The rapid expansion of domestic credit is cited by many researchers as contributing to the prospect of speculative attack through adverse selection of new loans. Domestic credit extended to the private sector is a second best assessment of a lending boom, a superior measure is the non

performing loans of the banking system, however, this variable is not available as a uniform, comprehensive measure for all of the countries included in this study and we select the summary ratio private sector credit to GDP (DCGDP) as an alternative. Share price movements (PSHARE) are a summary measure of asset values which may signal an attack. A lack of confidence in domestic markets including the forex market, which is taken by predators to be an opportunity for attack, may incite an attack.

The ratio of the current account balance to GDP (CABCDP) is included even though the results for this variable in previous research are mixed. A rapidly growing country can experience large current account deficits (CADs) as it finances high rates of investment. Relatively high CADs to GDP are not problematic provided private sector investment is correctly applied to projects which enhance the growth of exports in future periods<sup>2</sup>. Alternatively, CADs may arise from the deficiency of domestic aggregate supply in relation to aggregate demand, or because the economy is globally non competitive. Then the CAD can signal a speculative attack. For this reason we include CABGDP as one of the potential indicators of an attack.

The final variable included in the set of characteristics is Standard and Poors international credit rating index (SP). These ratings are influenced by some of those economy wide factors thought to be important as determinants of a crisis and so the independent assessment of an individual nation's credit standing is included as a potential indicator. Ratings range from AAA to D. These values were converted into dummies assuming the value zero when the country in question had a rating of A or above. The value of one was assigned if the country's SP rating was less than A.

The dependent variable in the estimation of (1) is the probability of crisis (0 if no crisis, 1 if there was a crisis) and was constructed following calculation and observation of the crisis index. This index is a weighted average of the percentage change in the real exchange rate, and the percentage change of international reserves minus gold measured in US dollars. Gold is excluded because it is less liquid than the currencies constituting the bulk of the nations reserve stocks. The crisis index makes use of the real exchange rate in preference to its nominal counterpart. We follow a substantial literature in making this choice in particular

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<sup>2</sup>Investment funded by foreign borrowing and invested in the sheltered sectors of the economy, for example, real estate produce a potential long run balance of payments problem in the form of larger debt servicing costs without any increase in exports.

Kaminsky, Lizondo and Reinhart (1998) who show that the real exchange rate features prominently as a well performing indicator of currency crises in thirty six international studies of this phenomenon. Data sources are indicated in the data appendix for this dependent and all explanatory variables; although the majority of data is drawn from the IMF's *International Financial Statistics*. The weights used in construction of the crisis index are measured so that both the exchange rate and reserve levels have the same conditional variance. This does not mean that variations of the exchange rate and the reserve level are equally weighted.

A crisis is indicated when the crisis index is more than two standard deviations below the mean crisis index for the sample of countries taken as a whole. No crisis is indicated if the crisis index is less than two standard deviations below the mean and one otherwise.

One further adjustment of the crisis index was required. This adjustment was motivated by the presence of high inflation in some sampled countries. A depreciating currency may reflect past trends in addition to speculative pressure. The literature suggests quarterly inflation rates exceeding 15 percent should be distinguished from nations with inflation running at less than this level. This distinction is made by dividing the sample into two groups  $> 15\%$  inflation and weightings applied separately to the two groups. This adjustment is made despite the presence of real exchange depreciation in the crisis index. It is conceivable that purchasing parity power does not hold so that real depreciation fails to adjust fully for excessive domestic inflation in the short run.

In a final check, the crisis episodes identified by the crisis index are compared with documented episodes in each country to be sure that our representation of crises is valid.

The parameter vector in expression (1) must satisfy a priori restrictions: real exchange rate depreciation (RER), domestic credit expansion (DCGDP) and high CADs to GDP (CABGDP) will all increase the probability of a crisis; the sign of on the RER is negative, while is positive for DCGDP and CABGDP. However, the strength of international reserves reflected in low values of  $M_2$  to reserves ( $M_2RES$ ) will lessen the probability of a currency crises, while a fall in domestic share prices (SP) will increase the probability of a crisis. The two dummy variables representing the exchange rate regime (EXCREG) and the international credit rating (SP) have no sign restriction.

The following 27 countries constitute the full sample of nations: Australia, Canada, Chile, Colombia, France, Finland, Germany, India, Indonesia, Ireland,

Italy, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Philippines, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, USA, UK, and Venezuela. Each of these countries experienced crisis episode(s) according to the crisis index in the reference period covering the years 1980 to 1997. All data are observed quarterly.

The sources of data for variables in this study are included in a data appendix along with a description of how individual variables are constructed, where these are not described in the text.

There are several replications of (1) in each case estimated by the maximum likelihood procedures described by Chamberlain (1980). The *first replication* involves the estimation of (1) for all 27 countries included in the sample. This will determine if the selected group of fundamentals, the RER, DCGDP, SP, PSHARE, CABGDP and EXCREG, determine the incidence a crisis ( $y_{it}$ ) in general. The *second replication* is designed to capture the differing crises experiences of developing (industrial) and developed countries. This is followed by *three regional analyses* for the Latin American, European and Asian countries included in the sample. The third of these is truly a study of the 1997 Asian crisis because it includes Thailand, Indonesia, Philippines, Malaysia, Singapore, Korea and Japan on a time series dating from 1994. To determine if the relevant determining characteristics of a crisis have changed over time we fit the entire data set in two subintervals: 1980 to 1988 and 1989 to 1997. We label these Interval 1 and 2 respectively.

#### IV. Results

Our first replication of expression (1) involves estimates for the full sample of twenty seven nations and the full sample period 1980 to 1997. The results of full sample estimation are reported on Table 1. In addition Table 1 contains estimates of (1) for the full panel of countries in two subperiods: 1980 to 1988 and 1989 to 1997.

$$\text{Estimate of: } P_r \left( y_i | k_{i1} = \sum_{t=1}^{T_i} y_{it} \right) = \frac{\exp \left( \sum_{t=1}^{T_i} y_{it} x_{it} \beta \right)}{\sum_{di \in s_i} \exp \left( \sum_{t=1}^{T_i} d_{it} x_{it} \beta \right)} \quad (1)$$

The results on Table 1, Column 2 suggest that five variables make a significant contribution to the probability of a crisis in general: the RER (T-stat = -3.967),

**Table 1.** Full Sample and subperiod Estimation

Independent Variables	Estimated Coefficient: Tratios <sup>1</sup>		
	Full Sample: 1980-1997	Interval 1: 1980-1988	Interval 2: 1989-1997
1	2	3	4
RER	-0.052* (-3.967)	-0.196 (-1.456)	-0.921** (-2.606)
M <sub>2</sub> RES	0.023** (2.498)	0.129* (3.572)	0.037* (2.715)
DCGDP	1.947** (2.550)	0.011 (0.511)	3.326* (2.812)
SP	5.845* (3.701)	-33.597 (-0.001)	39.825 (0.002)
CABGDP	0.016 (0.964)	0.016 (0.732)	0.073 (0.401)
PSHARE	-0.001 (-0.016)	-0.013* (-1.646)	-0.013 (-0.947)
EXCREG	1.478** (2.335)	n/a	n/a
No of Observations:	1,944	972	972
Con. Log Lik:	-163.86	-57.78	-69.21
Max Log Lik:	-139.18	-48.93	-58.06
Pseudo :	0.1513	0.2144	0.2726

\* Significant at 1% level ( $\alpha 0.01 = \pm 2.611$ ).

\*\* Significant at 5% level ( $\alpha_{0.05} = \pm 2.000$ ).

\*\*\*Significant at 10% level ( $\alpha_{0.10} = \pm 1.642$ ).

M<sub>2</sub>RES ( $T = 2.498$ ), DCGDP ( $T$ -stat = 2.550), SP ( $T = 3.701$ ) and EXCREG ( $T = 2.335$ ). The outcome from Table 1 for the full sample is that real exchange rate depreciation<sup>3</sup> signals a higher probability of crisis and so does a reduction of foreign reserves which increases the magnitude of M<sub>2</sub>RES, while the expansion of credit to the private sector (PCGDP) also increases the risk of a crisis occurring. In this full sample estimation, the SP credit rating also matters and the prevailing exchange rate regime is influential in determining the chances of a crisis. A notable outcome of full sample estimation is the insignificance of the current account balance to GDP (CABGDP) and of asset prices (PSHARE). The likelihood ratio test provides formal confirmation of the fact that the chances of a crisis occurring are determined by the group of variables RER, M<sub>2</sub>RES, DCGDP,

<sup>3</sup>Changes of the RER are one of the components of the dependent crisis index while the level of the RER is included among the explanators. This does not affect fit and other diagnostic characteristics unless the change and the level of the RER are closely correlated. There is no evidence for this in the study.

SP and EXCREG. The null hypothesis for this test is that the subset of coefficients associated with this group of variables is zero. Goodness of fit characteristics applying to qualitative response models, such as the conditional logit model applied in this paper are often based on the likelihood ratio index defined as follows:

$$1 - \frac{1_n \hat{L}}{1_n L_o} \quad (2)$$

where  $1_n \hat{L}$  is the maximum value of the log likelihood function and  $1_n L_o$  is the log likelihood derived from a model in which all slope coefficients have the value zero. The larger is the maximum value  $1_n \hat{L}$  of the log likelihood function, the better the fit provided by the model. Clearly from expression (2), the larger is the ratio of  $1_n \hat{L}/1_n L_o$ , the smaller is  $\rho^2$ , so smaller values of  $\rho^2$  indicate stronger goodness of fit characteristics<sup>4</sup>. The comparatively small value of pseudo  $\rho^2$  (0.1513) indicates more than adequate explanatory power.

The results of subperiod estimation are shown in columns (3) and (4) of Table 1. Subperiod 1 relates to the years 1980-1988, the only variables contributing to the probability of a crisis are  $M_2RES$  dependent on the depth of an individual countries foreign reserves and asset prices (PSHARE) which are significant at the 10 percent level. The remaining explanatory variables are insignificant while the inclusion of the exchange rate regime dummy is considered inappropriate.

The significance of asset prices (PSHARE) in studies of those crises occurring prior to 1989 reflects the impact of the global share market crash in October 1987 as many of the crises in this pre 1989 period occur in the wake of the crash. The likelihood ratio test reveals that PSHARE and  $M_2RES$  do explain the probability of a crisis, while the (0.2144) reveals that the explanatory variables in the model are related to the incidence of a crisis in developed countries.

The factors explaining the probability of a crisis change in the nineties. These changes are evident in column (4) of Table 1, where the results of estimating (1) in subperiod 2 are shown. This second subperiod covers crises occurring over the years 1989 to 1997. The variables which are significant in this interval, but which are insignificant in subperiod 1, are real exchange depreciation (RER) and the proxy for credit expansion (DCGDP). The emergence of RER as a factor, in the nineties, may reflect the effects of forex market deregulation occurring in many of the twenty seven countries comprising the full panel, while in the late eighties and

<sup>4</sup>See the discussion of the properties of in Greene (1990, p. 682).

nineties credit controls become less prudent in many of the banking systems of the sampled nations. The outcome, too often, was a lending boom in some countries accompanied by adverse selection and moral hazard. Asset prices (PSHARE), which were significant pre 1989 were insignificant post 1989 for the full panel, while the current account balance (CABGDP) and international credit rating (SP) proxies play no role pre or post 1989. To confirm these post 1989 results, RER, M<sub>2</sub>RES and DCGDP are all individually significant at the 1% level while the log-likelihood ratio test suggests that these three variables act collectively to explain the chances of a crisis post 1989. The likelihood ratio index (0.2726) suggests the model offers a substantial explanation of crisis probability in the nineties.

Is there a difference between the determinants of crisis probabilities in the developed and developing countries? To answer this question, we have split the sample into two sub samples: Developed and Developing Countries. The following sixteen countries are included in the Developed group of countries: Australia, Canada, France, Finland, Germany, Iceland, Italy, Japan, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, USA and the UK. The “Developing” group is comprised of the following: Chile, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Philippines, South Africa, Thailand, Venezuela. The model (1) is estimated for these two subgroups over the period 1980 to 1997 and the results are shown in Table 2.

$$P_r \left( y_i | k_{i1} = \sum_{t=1}^{T_i} y_{it} \right) = \frac{\exp \left( \sum_{t=1}^{T_i} y_{it} x_{it} \beta \right)}{\sum_{di \in s_i} \exp \left( \sum_{t=1}^{T_i} d_{it} x_{it} \beta \right)} \quad (1)$$

The results contained in Table 2 indicate substantial differences in the causes of crisis probabilities in Developed and Developing nations. In the developed world, the real exchange (RER) and credit expansion (DCGDP) are the only variables influencing the probability of a crisis: Significant at the 1 and 10% levels respectively. The log likelihood ratio test confirms that RER and DCGDP are simultaneously significant determinants of crisis probabilities while the likelihood ratio index  $\tilde{\rho}^2 = 0.13$  indicates that the model offers a sound explanation of the chances of a crisis occurring.

Results for the “developing” group of countries resemble those for the whole panel (Table 1). In the case of the developing countries, we must add the size of

**Table 2.** Estimation of Expression for Developed and Developing Countries

Variable	Developed		Developing	
	Estimated Coefficient	T ratio	Estimated Coefficient	T ratio
RER	-0.057**	-2.092	-0.036*	-2.825
M <sub>2</sub> RES	0.004	0.033	0.111*	3.582
PCGDP	1.840***	1.667	2.444**	2.582
PCSHARE	0.025	0.952	-0.002	-0.154
CABGDP	0.152	0.377	-0.227	-0.135
SP <sup>(1)</sup>	n/a		4.215*	2.800*
Observations:		782		568
Constrained Log Likelihood:		-73.33		-80.77
Max Log Likelihood:		-63.33		-59.29
Pseudo :		0.13		0.26

<sup>(1)</sup>All developed countries were rated A or above, so this variable is always observed as zero.

\* Significant at 1% level ( $\alpha 0.01 = \pm 2.611$ ).

\*\* Significant at 5% level ( $\alpha_{0.05} = \pm 2.000$ ).

\*\*\*Significant at 10% level ( $\alpha_{0.10} = \pm 1.642$ ).

international reserves (M<sub>2</sub>RES) and the international credit rating (SP) to RER and DCGDP as individually significant determinants of crisis probabilities. In neither the developing nor the developed world do the current account balance or asset prices play any apparent role in determining crisis probabilities. The log likelihood ratio test confirms that the four characteristics RER, DCGDP, M<sub>2</sub>RES and SP determine crisis probabilities in the developing countries simultaneously. The likelihood ration index ( $\tilde{\rho} = 0.26$ ) is slightly higher in this case possibly reflecting the effects of a smaller sample on the models' explanatory power.

The following question is posed in conclusion: how does the explanation of crisis probabilities vary in different regions of the world economy? The answer is determined by splitting the sample into three regional groupings: the Latin American, European and Asian groups. The countries comprising these sub groups are as follows:

*Latin America:* Mexico, Chile, Columbia and Venezuela.

*Europe:* UK, Finland, Italy, Sweden, Norway, Switzerland, Spain, Iceland, Germany and France.

*Asia:* Thailand, Indonesia, Philippines, Malaysia, Singapore, Korea and Japan.

The sample for the Asian group is truncated beginning in 1994. This provides

a focus on the experiences of the Asian countries through the Asian crisis. For this reason we label this study of Asia as the “Asian crisis”. Studies for Europe and Latin America are conducted over the period 1980 to 1997.

The results for regional crises are indicated on Table 3.

$$\text{Estimate of: } P_r \left( y_i | k_{i1} = \sum_{t=1}^{T_i} y_{it} \right) = \frac{\exp \left( \sum_{t=1}^{T_i} y_{it} x_{it} \beta \right)}{\sum_{di \in s_i} \exp \left( \sum_{t=1}^{T_i} d_{it} x_{it} \beta \right)} \quad (1)$$

The significant determinants of Latin American crises are real exchange rate flexibility (RER), the size of foreign reserves (M<sub>2</sub> RES) and credit expansion (DCGDP) which are significant at 10%, 1% and 10% respectively and the log likelihood ratio test indicates that these three variables influence the chances of Latin American crisis simultaneously. The likelihood ratio index ( $\rho^2 = 0.1736$ ) indicates that the explanation offered by these three variables is comprehensive.

European crises (Column 3) are different. We can find only one of the fundamental characteristics, credit expansion (DCGDP), which influences the chances of a European crisis. The outstanding recent European episode was the ERM crisis in 1992-93 and an examination of the raw data shows that there are larger than usual increases in credit expansion among the European member countries preceding this crisis. Again,  $\rho^2 = (0.2196)$  is small enough to indicate that the explanation offered by the model (1) is adequate.

This interpretation does not apply to this preliminary analysis of the Asian group through the Asian crisis: pseudo  $\rho^2$  is rather high (0.7696) suggesting that the explanatory power of the model is limited and as a result the results reported on Column (4) of Table 3 must be cautiously interpreted. The results are suggestive with two characteristics, having significant impact on the chances of an Asian crisis arising. These are asset prices (PSHARE) and credit expansion (DCGDP), both significant at the 10% level. The real exchange rate is not significant, possibly reflecting the fixed nature of nominal exchange rate regimes prevailing among our sampled Asian countries prior to the Asian crisis. The strength of international reserves did not lessen the prospect of the Asian crisis while the current account balance played no significant role, consistently with all other studies discussed in the literature review.

**Table 3: Regional Crisis Analysis**

Independent Variables	Estimated Coefficient: T Ratios		
	Latin America	Europe	Asia
1	2	3	4
RER	-0.023*** (-1.780)	-0.097 (-1.457)	-0.302 (-1.189)
M <sub>2</sub> RES	0.124* (2.926)	0.138 (0.943)	0.581 (0.520)
PC SHARE	-0.001 (-0.149)	-0.367 (-0.942)	-0.194*** (-1.656)
SP	0.242 (0.100)	n/a <sup>(1)</sup>	38.622 (0.001)
PC GDP	8.350*** (1.735)	4.815** (1.960)	7.288*** (1.787)
CAB GDP	9.534 (0.376)	0.033 (1.378)	0.386 (0.247)
No of Observations:	284	355	80
Con. Log Lik.	-43.51	-23.08	-12.34
Max Log Lik	-36.10	-24.96	-5.25
Pseudo	0.1736	0.2196	0.7696

<sup>(1)</sup>All sampled European countries have credit ratings exceeding A. The SP variable is always observed as zero and is to be excluded from the European analysis.

\* Significant at 1% level ( $\alpha_{0.01} = \pm 2.611$ ).

\*\* Significant at 5% level ( $\alpha_{0.05} = \pm 2.000$ ).

\*\*\*Significant at 10% level ( $\alpha_{0.10} = \pm 1.642$ ).

## V. Conclusion

The objective of this analysis was to identify those fundamentals which caused currency crises in the global economy. To achieve this purpose a crisis index was constructed and from it, we derived a probability of crisis measure. Several fundamental economic characteristics were trialed as explanations of crises in twenty seven countries over the period 1980 to 1997. A conditional logit model was applied to the full data panel with the following results: real exchange rate depreciation, the strength of a country's international reserve position (M2 to reserves), Standard and Poors credit rating and domestic credit expansion influence the probability of crises in general.

However these characteristics do not always apply in particular cases. There are notable differences in the causes of crisis probabilities when subperiods are estimated. Earlier crises, those occurring in the period 1980 to 1988 are influenced by relevant share prices indices, but this proxy for asset prices in general has less

influence in later Latin American and European crises (1989-1997).

There are important differences between the causes of crises in the developed and developing world. Generally, the chances of a crisis occurring in developed countries is explained by a narrow range of influences, in particular, the real exchange rate and excessive domestic credit expansion. In the developing world, crisis probabilities are explained in addition by the depth of foreign reserves and by the SP international credit ratings.

Regional modelling leads to similar conclusions: the prospects of a European crisis are increased by the rapid expansion of credit based on the crisis occurring in Europe in 1992, but little else, while the probability of Latin American crises is increased by additional characteristics. These are the foreign reserve position of nations and the real exchange rate. The distinguishing characteristic of the Asian crisis was the influence on the crises of asset prices, in particular, relevant share price indices. These do not feature in European or Latin American crises.

An outstanding feature of this study is the failure of the size and sign of the current account balance as a predictor of crises probabilities, however, the nature of a country's exchange rate regime does influence crisis probabilities in general.

### **A. Data Appendix**

The following appendix details the construction of variables used in the empirical analysis. The majority of data was taken from various editions of the International Monetary Fund (IMF) publication *International Finance Statistics* (IFS). Line numbers in parentheses refer to corresponding line numbers of data in the IFS publications.

### **B. Crisis Index**

The index is a weighted average of the percentage change in the real exchange rate (line *reu*) and international reserves minus gold (line 11.*d*), measured in US dollars. Each of the two components is weighted so as to have the same conditional variance.

### **C. International Reserves**

This variable is measured as the level of money plus quasi-money (lines 34 and 35 respectively) measured in dollars of domestic currency as a ratio of international reserves. Money (line 34) is the sum of currency outside banks and demand deposits other than those of the central government. Quasi money equals the sum of savings

and foreign currency deposits of resident sectors other than the central government. Both are measured in units of domestic currency. In IFS international reserves is the sum of the monetary authorities holding of SDR's, reserve position in the fund and foreign exchange in US dollars. International reserves were converted to domestic currency using the period average nominal exchange rate (line rf) which is quoted in IFS as units of national currency per US dollar.

#### **D. Real Exchange Rate**

This variable measures the level of the real exchange rate throughout the sample period. The real effective exchange rate index is defined broadly as a nominal effective exchange rate index adjusted for relative movements in national price or cost indicators of the home country and its partner or competitor countries. An increase in the index reflects an appreciation. For a number of countries in the sample<sup>5</sup> real exchange rate adjusted for changes to wholesale prices (line 63) in relation to US wholesale prices.

#### **E. Domestic Credit**

For each quarter, the ratio of claims to the private sector by deposit money banks and monetary authorities (line 32d) as a ratio of nominal GDP (line 99b) is calculated. Both measures are reported in dollars of domestic currency.

#### **F. Current Account Balance**

The current account balance (line 77a.b) reported in US dollars is converted to domestic currency using the nominal exchange rate. The current account balance is measured as a ratio to nominal GDP.

#### **G. Share Prices**

The percentage change in share prices is calculated from the share price index (line 62) which represents a quarterly average. Data for Thailand, Singapore, Malaysia and Indonesia is not collected in IFS and was obtained from Global Financial Data.

#### **H. Standard and Poor**

The Standard and Poor variable is measured using from the Standard and Poor long-term foreign currency rating and converting it to a dummy variable.

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<sup>5</sup>India, Indonesia, Ireland, Singapore, Thailand and Korea.

## I. Exchange Rate Variable

Information on the exchange rate regime for various countries was obtained from the IMF's annual report *Exchange Arrangements and Exchange Restrictions* (EAER). This publication details a country's exchange rate regime as well as events throughout the year that have led to a change in regime. EAER was assessed for each year beginning in 1980 to identify the exchange rate regime used and changes to regimes for each country in the sample.

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