EAST ASIAN FINANCIAL CRISIS OF 1997 REVISITED: IS IT POSSIBLE TO DEVISE AN EARLY WARNING SYSTEM?

1. Introduction

The East Asian financial crisis began in Bangkok in mid-1997 and rapidly spread to the rest of the region, resulting in both currency and financial system crises. Due to the importance of the East Asian region in the world economy, the crisis had an enormous impact on a global scale, adversely affecting financial markets all around the world. Even countries such as Australia, India, and New Zealand, which have not usually been identified with the crisis saw sharp depreciations in their exchange rates vis-a-vis the U.S. dollar during 1997. Local countries that suffered most from the crisis were Thailand, Indonesia, Singapore, Malaysia and the Philippines. In these countries, the crisis started from the currency crisis, and was followed by financial and economic crises, which resulted in plunges in the stock markets in the East Asian countries from mid-1997 to mid-1998. This led to severe financial sector difficulties, prolonged deterioration in economic activity, and increased unemployment during the years following the crisis.

This study examines the causes of the East Asian financial crisis and builds an early warning system (EWS) based on data from Malaysia, Indonesia, Thailand, Singapore, and Philippines during 1982:1–1998:1 through a panel probit regression model using 20 macroeconomic and financial sector variables. This article is structured as follows. Section 2 reviews the literature on financial crises as well as on EWS. Section 3 provides a brief account of the East Asian economies prior to the crisis of 1997. Section 4 presents the data and introduces the methodology followed. The last section points out the conclusions that emerge from the study.

2. Literature review

Literature on financial crises is categorized into three mainstream models, namely first-,, second- and third-generation models. In the

"first-generation" models (Krugman 1979; Flood and Garber 1984), a government with persistent money-financed budget deficits is assumed to use a limited stock of reserves to peg its exchange rate and the attempts of investors to anticipate the inevitable collapse generates a speculative attack on the currency when reserves fall to some critical level.

In "second-generation" models (Obstfeld 1994, 1996, Ozkan and Sutherland 1995, Radelet and Sachs 1998), policy is less mechanical: a government chooses whether or not to defend a pegged exchange rate by making a tradeoff between short-run macroeconomic flexibility and longer-term credibility. The crisis then arises from the fact that defending parity is more expensive as it requires higher interest rates. Should the market believe that defense will ultimately fail, a speculative attack on a currency develops either as a result of a predicted future deterioration in macro fundamentals, or purely through self-fulfilling prediction.

The need for third generation models became apparent in the 1990s with the Mexican Tequila crisis of 1994 and the East Asian crisis of 1997. A number of new approaches have emerged to explain how these crises evolved and how they spread from country to country. Third-generation models (Dooley 1997, Krugman 1998, Radelet and Sachs 1998) are categorized into three different groups such as herd-behavior, contagion, and moral hazard.

There have been numerous studies in the literature on EWS of financial crises**.** Although studies differ in terms of the econometric method followed, variables employed, definition of financial crisis, and the time span on which the EWS is built, the literature can conveniently be categorized into two main groups. The first group consists of studies based on a model known as Signals Approach, which involves observing the behavior of a number of indicators as they issue signals when they exceed certain threshold values. The second approach is based on a logit or probit model and uses lagged values of early warning indicators and a crisis dummy variable designed to predict crises.

The signals approach was developed by Kaminsky *et al*. (1998) and consists of a bilateral model where a set of high frequency economic variables during a specified period is compared, one at a time, with a crisis index so that when one of these variables deviates from its normal level beyond a specific threshold value prior to a crisis, it issues binary signals for a possible currency crisis. The model devised by Kaminsky *et al*. (1998) consists of 15 variables with optimal

thresholds estimated for each country in relation to percentiles of the distribution of observations of the indicator maximizing the correct signals and minimizing the false ones. They set their signal horizon at 24 months and defined a currency crisis as a sharp depreciation of the currency or a large decline in international reserves that exceeds the mean by more than three standard deviations. The percentage of correct signals to the percentage of false signals, on the other hand, gives an indication of the accuracy of each indicator. They used monthly data of 15 developing and 5 industrial countries from 1970 to 1995 and detected an average of 61 crises during this period. Their best indicators, based on noise-to-signal ratio, are real exchange rate, banking crises dummy, exports, stock prices, and M2/international reserves. This model was later improved by Kaminsky and Reinhart (1999), who used the same sample as in Kaminsky *et al*. (1998). Their model identified a total of 26 banking and 76 currency crises, 18 of which were twin crises. They found that the occurrence of both types of crises has increased sharply since the early 1980s with only one twin crisis taking place before 1980. In their study Kaminsky and Reinhart (1999) also found out that banking and currency crises had common causes, with the former usually preceding the latter and following a particular pattern where the peaks of banking crises follow the currency crises.

Probit and logit models, pioneered by Frankel and Rose (1996), use limited dependent variable models known as probit or logit regressions to identify the causes of crises and to predict future ones. This approach defines a crisis indicator equal to one or zero depending on whether a currency crisis does or does not occur within the specified time period. Frankel and Rose (1996) attempted to find out how international debt structure and external factors affected the probability of currency crises. They used a number of external, internal and foreign macroeconomic variables in a multivariate probit model specified for 105 developing countries, covering annual data from 1971 to 1992. They defined a crisis as at least a 25% depreciation of the nominal exchange rate, which also exceeds the previous year's depreciation level by at least 10%, and constructed a dummy crisis variable according to that rule. Results of their model indicate that the significant variables are output growth, foreign direct investment/total debt, reserves, domestic credit growth, external debt and foreign interest rates.

Sachs, Tornell and Velasco (1996) also used a probit model to analyze currency crises, particularly the Mexican Tequila Crisis of 1995, using a sample of 20 emerging countries that were vulnerable

to contagion effect. They used the weighted sum of the percent decrease in reserves and the percent depreciation of the exchange rate as their crisis index. They found that crises occurred in countries with weak fundamentals such as low reserves, fragile banking systems and overvalued exchange rate. They also found evidence showing that short-term capital inflows do not matter when reserves and fundamentals are strong, whilst government consumption and current account deficits matter only in the countries with weak fundamentals and weak reserves.

TABLE 1 - *Literature Review on Financial Crises*

Study	Kaminsky, Lizondo, Reinhart (1998)	Sachs. Tornell, Velasco (1996)	Kaminsky, Reinhart (1999)	Berg, Patillo (1999)	Frankel, Rose (1996)	Komulainen and Lukkarila (2003)
Approach	Signals approach	Probit model	Signals approach	Both approaches	Probit Model	Probit Model
Data	1970-1975 monthly data from 15 developing and 5 industrial countries	Monthly data from 20 emerging markets.	Same sample as Kaminsky, Lizondo, Reinhart (1998)	Same variables as Kaminsky, Lizondo, Reinhart (1998) plus M2/ reserves and CA/GDP	1971-1992 annual data from 105 developing countries	1980-2001 monthly data from 31 emerging and developing countries
Crisis Index	Weighted average of exchange rate and reserve changes with a threshold of mean +3 standard deviation.	Weighted sum of percent decrease in reserves and the percent depreciation of the exchange rates	Weighted average of exchange rate changes and reserves	Same as Kaminsky, Lizondo, Reinhart (1998)	Exchange rate change over 25%, at least 10% higher than previous year	Equally weighted exchange rate depreciation and loss of reserves with a threshold of +2 standard deviations
Significant Variables	Real exchange rate, exports, banking crises dummy, stock prices, M2/ international reserves	Low reserves, fragile banking systems, overvalued exchange rate	Banking and currency crises have common causes	Real exchange rate, current account, reserve, export, and M2/ reserves	Output growth, foreign direct investment/ total debt, reserves, domestic credit growth, external debt and foreign interest rates	Private sector liabilities, public debt, foreign liabilities of banks, unemployment, inflation, and US interest rates

Berg and Pattillo (1999) tested models offered by Kaminsky, Lizondo and Reinhart (1998), Frankel and Rose (1996) and Sachs, Tornell, Velasco (1996) to see if these models could predict the Asian Crisis using information available at the end of 1996. They found out that the models offered by Sachs, Tornell, Velasco (1996) and Frankel and Rose (1996) were ineffective in forecasting the Asian Crisis. The Kaminsky, Lizondo and Reinhart (1998) model, on the other hand, proved to be successful. Crisis probabilities generated by this model for the period between May 1995 and December 1996 were statistically significant predictors of actual crisis occurrence over the following 24 months. Berg and Pattillo (1999) also found that in all three approaches, the probability of a currency crisis increases when domestic credit growth is high, the real exchange rate is overvalued relative to trend, and the ratio of M2 to reserves is high.

In a recent study, Komulainen and Lukkarila (2003) examined the causes of financial crises in 31 emerging market countries during 1980-2001 using a probit model based on 23 variables. Their findings show that financial crises occur together with banking crises and an increase in private sector liabilities, public debt, foreign liabilities of banks, unemployment, inflation, and US interest rates raises the probability of a crisis. Table 1 summarizes the empirical literature on financial crises.

3. Background of the East Asian economy

Before the crisis in 1997, Malaysia, Singapore, Thailand, Indonesia and Philippines (hereafter referred to as ASEAN-5 countries) had strong conventional macroeconomic fundamentals such as high savings rates, net capital inflows, investment, and GDP growth rates. They also had moderate levels of inflation, ample foreign exchange reserves, remarkable fiscal surpluses, low public debts, and low levels of unemployment. As a result, no one had any reason to suspect an upcoming crisis in 1997.

However, as pointed out by Bustelo *et al*. (1999), East Asian countries had a number of common weaknesses. To begin with, financial liberalization, in terms of inadequate governmental regulation and prudential supervision, allowed domestic firms to borrow recklessly both domestically and abroad. It also increased fragilities in the domestic financial sector through excessive risk-taking, high domestic and foreign exposure, inadequate bank sheets, maturity and currency mismatches between borrowing and lending, and short-term external debt.

Financial liberalization reduced the quality of risk-assessment as low capital adequacy limits and high legal lending limits contributed to bank overlending. In particular, foreign borrowing in short-term funds denominated in foreign currencies contributed to excessive bank lending on a long-term basis in domestic currency. As a result, balance sheets in banks and other financial institutions featured a growing maturity and currency mismatch between liabilities and assets. In the case of bank borrowing, obtaining capital from abroad at low interest rates on a short-term basis to lend in the domestic market at high interest rates on a long-term basis was profitable and therefore contributed, in addition to the maturity mismatch between liabilities and assets, to a substantial short-term foreign debt. In the case of bank lending, due to increased competition in the domestic market, most banks tended to direct their loans to the stock market and to the commercial and residential property market contributing to growth of an asset bubble in those sectors (Bustelo *et al*. 1999).

East Asian manufacturing firms had an easy access to credit. As a result, they were highly leveraged. Both borrowing respective to investment and debt respective to equity were abnormally high. Moreover, debt-to-equity ratios in the corporate sector rose in the two years preceding the crisis in Malaysia, the Philippines and Thailand.

Both banks and firms were also excessively indebted in foreign short-term liabilities, while the change in foreign exchange reserves was not matching the latter. Furthermore, short-term foreign debt as a proportion of international reserves increased noticeably in Thailand and Malaysia 1994 and 1997.

In addition, financial liberalization contributed to substantial net capital inflows most of which were short-term bank loans or portfolio investments. High net capital inflows provoked the real appreciation of currency due also to differentials in inflation rates and to the rise in the US dollar, which led to a significant slowdown in exports and, subsequently, to an increase in current account deficits.

4. Data and methodology

The model is estimated for a panel of monthly observations for the ASEAN-5 countries and covers the period 1982:1 – 1998:1. Most data are gathered from International Financial Statistics. The data for government debt figures come from several sources, including

IFS, the World Bank's WDI and IMF country reports. The tested 20 indicators are selected on the basis of currency crisis theories and previous empirical literature. In addition to the traditional macroeconomic variables, we include several indicators describing the vulnerability of domestic banks. These indicators include the growth of bank deposits, the ratio of the lending rate to the deposit rate, and the ratio of bank reserves to assets. We also employ variables that indicate vulnerability to a sudden stop of capital inflows. These variables are public debt, broad money to reserves, and private sector liabilities. To study foreign influences on crises, we include the US interest rate. Since we study all these variables simultaneously, we hope to distinguish those indicators that reflect actual causes of the recent crises in emerging markets. We further attempt to verify the correctness of findings of earlier studies. Table 2 shows the explanatory variables.

We use a panel regression model to estimate the main reasons for financial crises in the ASEAN-5 countries. Given our indicators, the model estimates the probability for crisis. The estimated model takes the form:

$$Prob\ (y_{it} = 1 \mid x_t\ ,\ \beta_t) = F(x_t\ ,\ \beta_t) \tag{1}$$

where x_t corresponds to our set of indicators and β_t is a vector of unknown parameters. The observed variable y_{it} receives a value of 0 or 1 depending on whether a crisis has occurred or not. With a probit or logit model, the right-hand side of the model is constrained between 0 and 1, and is compared to the observed value y_{it}. The probit model assumes that the probability distribution function (y_{it} conditional on x_{it}) corresponds to normal distribution. Since in a currency crisis situation a successful attack leads to sharp currency depreciation and substantial reserve losses, both the signal approach and limited dependent models traditionally define a currency crisis as a discrete event. One common technique is to construct an index of exchange market pressure as a weighted average of exchange rate changes and reserves changes (as well as interest rates in some cases). The crisis is said to occur when the index exceeds a country-specific threshold level.

We calculate an exchange market pressure index (EMP) for each country. The index includes exchange rate depreciation and loss of reserves, which are weighted to influence equally. The exchange market pressure index takes the form:

$$EMP = \Delta e - (\sigma_e/\sigma_r)*\Delta r \tag{2}$$

where Δe denotes the change in exchange rate and Δr in international

TABLE 2 - *Explanatory Variables*

Indicator & Expected Sign		Explanation
Inflation	+	Inflation is associated with high nominal interest rates and may proxy macroeconomic mismanagement that adversely affects the economy and the banking system (Demirguc-Kunt and Detragiache 1997).
Real Exchange Rate	-	Currency overvaluation may lead to deteriorations in the current account and have historically been associated with currency crises (Berg *et al*. 1999).
Export Growth	-	Weak exports may lead to deteriorations in the current account and have often been associated with currency crises (Dowling and Zhuang, 2000).
Import Growth	+	Excessive import growth could lead to worsening in the current account and have been related with currency crises (Berg and Patillo 1999)
M1	+	Growth of M1 indicates excess liquidity, which may invoke speculative attacks on the currency thus leading to a currency crisis (Eichengreen *et al*. 1995).
Domestic Credit/GDP	+	High levels of domestic credit indicate the fragility of a banking system (Kaminsky and Reinhart, 1998).
Stock Prices	-	Recessions and a burst in asset price bubbles often precede currency crises (Kaminsky and Reinhart, 1999).
Terms of Trade	-	Increases in terms of trade strengthen a country's balance of payments position and lower the probability of a crisis (Kaminsky *et al*. 1998).
Public Debt/GDP	+	Higher indebtedness is expected to raise vulnerability to a reversal in capital inflows, and hence to raise the probability of a crisis (Lanoie and Lemarbre, 1996).
Foreign direct investment/GDP	+	Shows net inflows in the reporting economy. East Asian countries had been dependent on net capital inflows over the decade preceding the crisis
US Interest rates	+	International interest rate increases are often associated with capital outflows (Edison, 2003)
Bank Reserves/Bank Assets	-	Shows the liquidity of the banking system. Adverse macroeconomic shocks are less likely to lead to crises in countries where the banking system is liquid (Demirguc-Kunt and Detragiache, 1997).
Lending Rate-Deposit Rate	+	An increase of this indicator reflects a deterioration in credit risk as banks are unwilling to lend or a decline in loan equity (Kaminsky *et al*. 1998)
Real interest rate	+	Used as a proxy of financial liberalization. The liberalization process itself tends to lead to high real rates. High real interest rates have been increased to repel a speculative attack (Kaminsky *et al*. 1998).
Foreign exchange reserves	-	Most currency collapses are preceded by a period of increased efforts to defend the exchange rate, which are marked by declining foreign exchange reserves (Kaminsky *et al*. 1998).
Current Account/GDP	-	An increase in the current account is associated with large capital inflows which indicate a diminished probability to devalue and thus to lower the probability of a crisis (Berg and Patillo 1999).
M2/Foreign Exchange reserves	+	Indicates to what extent the liabilities of the banking system are backed by foreign reserves. It also captures the ability of the central bank to meet sudden domestic foreign exchange demands (Berg and Patillo 1999).
Fiscal Balance/GDP	+	Higher fiscal deficits are expected to raise the probability of crisis since they increase the vulnerability to shocks and investor's confidence (Demirguc-Kunt and Detragiache, 1997).
GDP per capita	-	Deterioration of the domestic economic activity is expected to increase the likelihood of crises (Lanoie and Lemarbre 1996).
National Saving Growth	-	High national savings may be expected to lower the probability of debt rescheduling (Lanoie and Lemarbre 1996).

reserves, σ_e and σ_r denote the standard deviation of exchange rate alteration and reserves, respectively. We determine the values of the EMP index more than two standard deviations above the mean as a crisis. Since macroeconomic variables often worsen prior to the actual crisis, we define as a crisis not only the crisis month but also the eleven months before. In other words, we use a one-year window for our variables.

5. Empirical results

As Table 3 indicates, the signs of the variables are mostly in line with our expectations, with the exception of foreign direct investment, public debt, inflation, bank reserves / bank assets, and lending and deposit rate spread. The significant variables are current account / GDP, domestic credit / GDP, terms of trade, lending and deposit rate spread, and foreign direct investment / GDP. Table 4 summarizes the results of the study.

Table 3 - *Probit Model*

Variable	Coefficient	Z-statistic	Variable	Coefficient	Z-statistic
Inflation	-21.12972	0.734324	US interest rates	0.046622	0.752002
Real exchange rate	-19.82623	0.652324	FDI / GDP	-1.052321	1.650247*
Export growth	-6.351832	-2.8824***	National savings	-26.23422	0.620348
Import growth	3.262232	-0.206142	Real interest rate	23.23214	0.335374
M1	5.232541	1.886332	Public debt / GDP	-26.30143	0.513563
Domestic credit / GDP	12.32318	1.759732*	Current account/ GDP	-5.221995	2.97558***
Stock prices	-4.077323	-2.493133	GDP per capita	-12.82362	0.635830
Terms of trade	-5.421333	-2.722332*	Fiscal balance / GDP	16.32734	0.799392
Lending and deposit rate spread	-3.512232	1.662322*	M2 / foreign exchange reserves	20.33837	0.436260
Bank reserves / bank assets	-4.090540	0.522342	Foreign exchange reserves	-6.552059	0.765437

* Significant at the 10% level
** Significant at the 5% level,
*** Significant at the 1% level.

TABLE 4

Variable	Expected Sign	Found Sign	Significance	Variable	Expected Sign	Found Sign	Significance
Inflation	+	-		US interest rates	+	+	
Real Exchange Rate	-	-		FDI / GDP	+	-	*
Export Growth	-	-	***	National savings	-	-	
Import Growth	+	+		Real interest rate	+	+	
M1	+	+	*	Public debt / GDP	+	-	
Domestic Credit/GDP	+	+	*	Current account/GDP	-	-	***
Stock Prices	-	-	**	GDP per capita	-	-	
Terms of Trade	-	-	***	Fiscal balance / GDP	+	+	
Lending and deposit rate spread	+	-	*	M2 / foreign exchange reserves	+	+	
Bank reserves / bank assets	+	-		Foreign exchange reserves	-	-	

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

We find that the probability of the crisis increases along with increases in domestic credit/GDP, M1, imports, and foreign direct investment/GDP. The probability of the crisis increases with a decrease in exports, stock prices, terms of trade, current account/GDP, and lending and deposit rate spread. Table 4 summarizes the results of the study.

In order to evaluate the predictive power of the model, we use prediction cutoff levels of 40%, 30%, 20% and 10% for the probability of a crisis. Each observation is classified as having a predicted probability that lies above or below these cut-offs. Table 5 indicates the efficiency of the model in terms of predicting the crises.

Table 5

	Crisis	Tranquil	
Cut-off prob. 40%			
Predicts crisis	91.4%	72.5%	
Predicts tranquil	8.6%	27.5%	
Observations correctly called			88.7%
Cut-off prob. 30%			
Predicts crisis	83.5%	63.7%	
Predicts tranquil	16.5%	36.3%	
Observations correctly called			83.4%
Cut-off prob. 20%			
Predicts crisis	71.4%	34.7%	
Predicts tranquil	28.6%	65.3%	
Observations correctly called			78.1%
Cut-off prob. 10%			
Predicts crisis	63.4%	22.8%	
Predicts tranquil	36.6%	77.2%	
Observations correctly called			69.4%

Given the cut-off probability of 40%, the model correctly calls 91% of the crises and 28% of the tranquil periods. When the cut-off probability is lowered to 30%, the model correctly indicates 84% of the crises and 36% of the tranquil periods. With the cut-off probability of 20%, the model correctly calls 72% of the crises and 65% of the tranquil periods. Finally, when the cut-off probability is lowered to 10%, the model correctly indicates 64% of the crises and 77% of the tranquil periods.

6. Conclusions

This study analyzed the causes of the East Asian financial crisis in ASEAN-5 countries during 1980:1–2001:12. It estimated a probit model using 20 macroeconomic and financial sector indicators. Results indicate that the significant variables are current account / GDP, domestic credit / GDP, terms of trade, lending and deposit rate spread, and foreign direct investment / GDP. Evidence further suggests that the probability of the crisis increases along with increases in domestic credit / GDP, M1, imports, and foreign direct investment / GDP. The probability of the crisis increases with a decrease in exports, stock prices, terms of trade, current account, and lending and deposit rate spread.

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ABSTRACT

This study examines the causes of the East Asian financial crisis and presents an early warning system based on data from Malaysia, Indonesia, Thailand, Singapore, and Philippines during 1982:1–1998:1 through a panel probit regression model using 20 monthly macroeconomic and financial sector variables. Results indicate that the significant variables are current account/GDP, domestic credit/GDP, terms of trade, lending and deposit rate spread, and foreign direct investment/GDP. Evidence further suggests that the probability of the crisis increases with an increase in domestic credit/GDP, M1, imports, and foreign direct investment/GDP. The probability of the crisis increases with a decrease in exports, stock prices, terms of trade, current account, and lending and deposit rate spread. The model correctly indicates 64% of the crises and 77% of the tranquil periods even with a cut-off probability of 10%,

Keywords**:** Asian financial crisis, probit model, early warning systems
JEL Classification: C51, O54

RIASSUNTO

Le crisi finanziarie dell'Asia orientale rivisitate: è possibile concepire un sistema di indicatori anticipatori?

Questo studio esamina le cause delle crisi finanziarie dell'Asia orientale e presenta un sistema di indicatori anticipatori basato sui dati della Malesia, dell'Indonesia, della Tailandia, di Singapore e delle Filippine durante il periodo compreso tra gennaio del 1982 e gennaio del 1998. Viene svolta un'analisi probit che analizza 20 variabili mensili macroeconomiche e finanziarie. I risultati indicano che le variabili significative sono il rapporto tra la bilancia dei pagamenti di parte corrente e il Prodotto Interno Lordo, le ragioni di scambio, lo spread tra il tasso sui prestiti e il tasso sui depositi e il rapporto tra gli investimenti diretti esteri e il Prodotto Interno Lordo.

L'evidenza suggerisce inoltre che la probabilità di una crisi aumenta con l'aumento del rapporto tra credito domestico e Prodotto Interno Lordo, con l'aumento di M1, delle importazioni e con la riduzione delle esportazioni, dei prezzi azionari, delle ragioni di scambio, della bilancia dei pagamenti di parte corrente e dello spread tra tassi sui prestiti e tassi sui depositi. Il modello indica correttamente un 64% di periodi di crisi e un 77% di periodi tranquilli.