STOCK MARKET AND CURRENCY CRISES IN EMERGING ECONOMIES: A SIMULTANEOUS APPROACH

By

SAKIR GORMUS

Bachelor of Science
Istanbul University
Istanbul, Turkey
1993

Master of Science
University of Illinois at Urbana-Champaign
Urbana-Champaign, Illinois
1997

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Thesis Approved:

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Thesis Adviser

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Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Emerging market currency crises have become a central debate issue in international finance since the early 1980s when many developing countries suffered from foreign debt crises and high inflation. The currency crises literature focuses mainly on the reasons behind those crises and their severity. Emerging stock markets' (ESM) returns have become a central issue in international finance since the early 1990s when many developing countries completed their transition and adjustment from import-substitution development strategies to export-led development strategies in various levels. As a result, capitalization, trading, return, risk, predictability, and integration of ESMs rose. Therefore, studies related to ESMs have increased since the early 1990s. The ESMs literature focuses mainly on the relationship between stock returns and related domestic and international (global) variables.

Until the 1980s, many developing countries adopted import-substitution development strategies with high protection of domestic goods market, government control of public goods prices, exchange rates, capital movement controls, and interest rates. Following the first and second oil shocks in 1973 and 1979, many developing countries went into a foreign debt crisis betweens 1979-1983. At the same time, financing the huge budget deficit by printing money caused high inflation.

After the failure of import-substitution development strategies, most of the developing countries adopted export-led development strategies to respond to their economic problems. The great success of export-led development strategies in the East Asian countries encouraged them to launch compreherensive stabilization and structural adjustment programs. By the end of the 1990s, many developing countries had completed their transition and adjustment progress by adapting a major exchange rate devaluation and then by fixing or a crawling peg for their exchange rates to fight inflation, placing restrictions on central bank financing of the budget deficit, removing interest rate ceilings, price controls on public goods, quantity controls on imports, and restrictions on capital movements, etc.

Empirical studies related to stock market returns can be divided into two groups. First, studies used the Granger causality test, the cointegration test, and variance autoregression models and focused on the relationship between stock market returns and selected macroeconomic variables, such as inflation or exchange rates (Malliaris and Urrutia, 1992; Habibullah and Baharumshah, 1996; Abdalla and Murinde, 1997; Nieh and Lee, 2001). Second, multifactor models used regression analysis and focused on the relationship between stock market returns and a variety of macroeconomic variables such as inflation rates, exchange rates, interest rates, industrial production, interest rate term structure, money supply, and oil prices etc to explain stock market returns. Also, some empirical studies used political risk factors and contagion effect as explanatory variables (Chen, Roll, and Ross, 1986; Kwon and Bacon, 1997; Bilson, Brailsford, and Hooper, 2001; Perotti and Oijen, 2001).

There are two approaches in the literature to explain the determinants of currency crises. The first-generation model was developed by Krugman (1979) and extended by Flood and Garber (1984) in response to currency crises in developing countries in the 1980s. According to the first-generation currency crises model, expansionary fiscal and monetary policies are inconsistent with fixed exchange rate policies. When the fiscal deficit is financed by expansion of domestic credit, reserves decrease to defend the fixed exchange rate and significant loss of reserves forces the authorities either to devalue or float the domestic currency.

Second-generation models are due to Obstfeld (1986) and later extended by him (1994, 1996) to respond to currency crises when the fundamentals of an economy were sound, as in the 1990s. According to second-generation models, changes in the government's objective function change agents' expectation and trigger currency crises. In Obstfeld's (1994, 1996) model, the government favors lower unemployment and higher output: hence when the costs of defending the peg (such as higher interest rates, higher unemployment, lower growth) are more than the benefit of defending the peg (such as gaining credibility and lower inflation) the government devalues even if macroeconomic fundamentals such as foreign debt, budget deficit, reserves etc are sound.

There are a lot of studies related to the relationship between stock market returns and macroeconomic variables in developed economies. There are few studies related to the relationship between stock market returns and macroeconomic variables in emerging economies. Earlier studies did not focus on emerging stock markets until the 1990's for the following reasons: lack of data, lower capitalization and trading, fixed exchange rates, capital controls, ceiling on interest rates, trade controls, and so on.

Perotti and Oijen (2001) report that, according to the International Financial Corporation, the aggregate market capitalization in emerging markets increased 445 %, from US$488 billion in 1988 to US$2.225 Trillions in 1996 and trading in emerging markets increased 385 %, from US$411 billion to US$1.586 Trillions in the same period. Also, foreign investment in the emerging stock markets has increased since 1990.

Although there are theoretical and empirical studies related to the macroeconomic determinants of currency crises, there is no single theoretical and empirical study related to the macroeconomic determinants of emerging stock market crises.

Patel and Sarkar (1998) divided stock market crises in three categories: The first were the stock market crises in developed markets: the 1973-74 crisis, the 1980-81 crisis, and the crisis of 1987. Secondly, there were the stock market crises in Asian markets: the 1979-80 crisis, the 1990 crisis, and the crisis of 1996. The last were the stock market crises in Latin American markets: the 1980-81 crises, the 1986-87 crisis, and the crisis of 1994-95. Also, we can include following crises: the 1998 Russian crisis, the 2001 Turkish crisis, and the 2002 Argentina crisis. If we observe the timing of stock market crises and currency crises, we can conclude that currency crises and stock market crises occurred at the same time or appeared closely timed in the last decade (Latin America 1994, Asia 1997, Turkey 2001 etc).

The main purpose of this study is to examine the potential linkages between stock market and currency crises and the macroeconomic determinants of stock market crises and currency crises in emerging markets. In so doing, this paper offers several contributions to the literature. First, this study focuses on the macroeconomic determinants of stock market crises rather than stock market returns in emerging markets.

This will be the first study to determine the macroeconomic determinant of stock market crises and estimate the probability of stock market crises. Stock market crises are defined as a binary variable to estimate the probability of stock market crises. Second, currency crises are treated as an endogenous variable in the stock market crises model and stock market crises are treated as an endogenous variable in the currency crises model, because earlier empirical studies related to stock returns and exchange rates showed that there is a feedback system between stock prices and exchange rates. Third, we use the bivariate probit model estimation method to investigate existence of correlation between stock market crises and currency crises, using data from emerging economies. Finally, we use the simultaneous equation probit model estimation method to account for the simultaneous nature of the relationship and to see direct causality between stock market and currency crises.

The organization of this paper is as follows: Section 2 reviews the links between the stock market crises and currency crises through the stock market returns and exchange rates. Section 3 reviews the literature on currency crises models. Section 4 explains the definition of currency crises and stock market crises, specifies the stock market crises and currency crises models, and empirical methodology. Section 5 represents the descriptive statistic and empirical results. The final section concludes the dissertation.

CHAPTER II

THE LINK BETWEEN STOCK MARKET CRISES AND CURENCY CRISES THROUGH STOCK MARKET RETURNS AND EXCHANGE RATES

Previous studies showed that stock market returns and currency crises are driven by a set of common factors (money supply, industrial production, political risk factor, capital inflows, inflation, contagion etc.). Therefore, both stock market returns and currency crises should simultaneously respond to changes in those common factors. In the last decade, many of the countries that have had currency crises have also had stock market crises around the time when they were experiencing problems in their foreign exchange market, with recent examples including Mexico 1994, Thailand 1997 and Turkey 2001.

2.1 Influence of exchange rates on stock returns

Most empirical studies argue that exchange rates would affect stock market returns through two channels. First, a depreciation of the domestic currency increases exports and decrease imports. An increase in export raises earning expectations of the domestic export firms, leading to increases in domestic export firms' stock prices. Therefore, export-dominated economies' stock market return increases while import-dominated economies' stock market return decreases. Second, a depreciation of the domestic currency lowers returns on domestic currency-denominated assets relative to dollar-denominated assets. Therefore, investors will prefer dollar-denominated assets to equity, which is a domestic currency-denominated asset. At the same time, exchange rate risk is priced factor for foreign investors in the stock market return model and a depreciation of the domestic currency causes foreign investment shifts from stock market to foreign currencies. As a result, a depreciation of domestic currency lowers stock prices and increases the probability of stock market crisis.

Using the Arbitrage Pricing Theory (APT), Thorbecke (1994) showed that a trade deficit was a source of systematic risk in the US market for several reasons. First, the trade deficit is a sign that net exports from the US (demand for US good) decreased and thus the earnings of US companies will decrease. Second, the trade deficit is a sign that demand for foreign goods increased (prices of foreign good increased) and caused inflatio. Therefore, an increase in the trade deficit will increase an investor's risk in holding stock causing stock prices to decrease. Using monthly data from January 1984 to December 1988, his result from multivariate autoregression and autoregressive-moving average models show the existence of exchange rate risk premium associated with trade deficits.

In their two-country world model using perfect capital mobility, Ma and Kao (1990) claimed that the relationship between stock market prices and change in exchange rates depends on the direction of the foreign trade balance. Using monthly data from January 1973 to December 1983 for 6 major industrialized economies, they concluded that a depreciation of the domestic currency would increase stock prices in export-dominated (trade surplus) economies and decrease stock prices in import-dominated (trade deficit) economies.

Using the Granger-Causality test based on the Bivariate Vector Autoregressive (BVAR) and Error Correction Model (ERM), Abdalla and Murinde (1997) investigated causality between stock prices and real effective exchange rates for India, Pakistan, Korea, and The Philippines. Their results, based on data from January 1985 to July 1994, showed that exchange rates Granger influenced stock prices in Korea, Pakistan and India while stock prices Granger influenced exchange rates in the Philippines.

Using a world market portfolio in the Capital Asset Pricing Model (CAPM), Solnik (1974) developed the International Capital Asset Pricing Model (ICAPM), which also includes international systematic risk (exchange rate risk). In his model, the differences of risk-free assets rates available to investors from different countries represent exchange risk because of departures from Purchasing Power Parity. Using monthly data from March 1970 to December 1991, Dumas and Solnik (1995) examined the relationship between excess return on equity and currency holding for the US, the UK, Japan and Germany[1]. They found a significant relationship between excess return on equity and currency holding and concluded that ICAPM has more explanatory power than CAPM in the existence of foreign exchange risk premium.

The Arbitrage Pricing Model (APM) explains systematic risks by consideration of several factors such as industrial production, changes in both the expected and unexpected component of inflation changes, and the term structure. In the international APM (IAPM), exchange rates may be risk factors because of the usage of common currency return in the model and also because of the imperfections in domestic and international capital markets, such as asymmetric information and transaction costs. In their multi-factor IAPM, Ferson and Harvey (1994) examined returns on 18 national

[1] Excess returns on equity and currency holdings are measured in a common currency, the U.S. dollar.

equity markets using monthly data from February 1970 to December 1989 with the following variables: world excess return, change in Eurodollar-Treasury yield, change in exchange rate, unexpected inflation rate, change in oil prices, real interest rate, and changes in industrial production[2]. Their result showed that the effect of world excess returns is significant and positive for all countries while exchange rate risk is significant and positive for 7 countries and significant and negative for the U.S.

Aggarwal (1981) empirically examined the relationship between stock prices and exchange rates in the U.S. using monthly data from July 1974 to December 1978. His result showed that there is a significant and positive relationship between stock prices and both contemporaneous and lagged values of the weighted average dollar values. He argued that an increase in exchange rates will increase exporter firms' profit and then stock prices will increase.

Jorion (1991) used the Chen, Roll, and Ross (1986) model to test the relationship between stock prices and exchange rates in 20 different industries in the U.S. using monthly data from January 1971 to December 1987. The results showed that there is a significant positive relationship between stock prices and exchange rate fluctuations in exports industries such as chemical and machinery while there is a significant negative relationship between stock prices and exchange rate fluctuations in import industries such as textiles and department stores.

2.2 Influence of stock returns on exchange rates

Even if most studies consider causality from exchange rates to stock prices, there are some studies that consider the inverse causality. Stock market returns would affect exchange rates through two channels. First, according to the portfolio approach to

[2] World excess return is defined as return on MSCI world equity index minus the U.S. Treasury bill rate.

exchange rate determination, decreasing stock prices decrease foreign portfolio inflows and increase foreign portfolio outflows, leading to lower demand for domestic currencies and depreciation of the exchange rates. In this approach, domestic stock prices affect domestic currencies' values through capital flows between countries. Second, according to the monetary approach to exchange rate determination, a decrease in stock prices lowers the domestic wealth of investors, leading to lower demand for domestic currencies and lower domestic interest rates. As a result of lower domestic interest rates, investors switch their funds from interest bearing domestic assets to foreign currency dominated assets, causing domestic currencies to depreciate. In this approach, domestic stock prices affect domestic currencies' values through a reallocation of wealth. As a result, a decrease in stock market return causes the depreciation of domestic currency and increases the probability of the currency crises.

Bahmani-Oskooee and Sahrabian (1992) employed the Granger causality test to examine the relationship between stock prices and exchange rate changes. They found a dual casual relationship between two variables, at least in the short-run. A decrease in stock prices decreases the domestic wealth of investors, causing lower demand for domestic currencies and depreciation in the domestic currencies. At the same time, a depreciation in the domestic currencies decrease stock prices.

Solnik (1987) claimed that the poor quality and measurement errors of macroeconomic data make estimation of the time series model of exchange rate very difficult. Therefore, stock prices are a good proxy for change in economic activity, and reflect the available information about future economic activity and monetary policy. Therefore, instead of macroeconomic variables, he used stock prices as an explanatory variable in exchange rate models with monthly and quarterly data for eight developed countries from July 1973 to December 1983. His result from multivariate regression model showed that there is a significant and negative relationship between the real exchange rate and real stock returns for all eight developed countries.

Smith (1992) tested the effects of interest rate differentials on both foreign and domestic bonds, money supplies, government debts, current account surplus, and stock prices on exchange rates using quarterly data from 1974 to 1988 for the German Mark-U.S. Dollar and Japanese Yen- U.S. Dollar.. His result showed that stock market returns have a stronger effect on exchange rates than government bonds and money stock and that there is a negative relationship between exchange rates and stock prices.

In their "signal approach models", Kaminksy, Lizondo and Reinhart (1997) found a positive relationship between stock prices and currency crises concluding that a sharp decline in stock market prices was one of the best predictors of currency crises. Also, Kaminksy and Reinhart (1999) found a positive relationship between stock prices and currency crises employing "signal approach models".

We can reach several conclusions from the extant literature. First, there is a significant negative relationship between stock prices and exchange rates. Second, although most of the studies found causality from exchange rates to stock prices, there is feedback system and bi-directional causality between stock prices and exchange rates.

2.3 Stock Market Returns and Selected Explanatory Variables

Most of the explanatory variables in our model come from previous studies related to stock market returns. We assume that markets are partially integrated. Therefore, both internal (local) and external (global) variables may be important in determining stock market crises. In the next section, we will explain the relationship between stock market returns and selected local and global explanatory variables.

2.3.1. Stock Market Returns and Inflation

Empirical studies generally found a negative relationship between inflation and stock market returns. A negative relationship between inflation and stock market returns has been explained by the proxy effect hypothesis, the monetization of the government debt and the decline in real wealth.

Using the quantity theory of money, Fama (1981) concluded a negative relationship between real activity and inflation and a positive relationship between real activity and stock market returns would assure a negative relationship between stock market returns and inflation. This is called the proxy effect hypothesis.

In the first step, he estimated monthly, quarterly and annual inflation rates using the "rational expectation" combination of money demand theory. Money base growth rate, and industrial production growth rate were used as explanatory variables and he found a positive relationship between money base growth rate and inflation, and a negative relationship between industrial production growth and inflation. Money demand theory says that given nominal money supply and the interest rate, an increase in real activity (industrial production growth), results in an increase in real money demand, which lowers price level. Therefore, a negative relationship between industrial production growth rate and inflation in regression analysis is consistent with the money demand model.

In the second step, he estimated the change in the average real rate of return on the capital stock ($DROC_t$) using Jongerson's "flexible accelerator" model. The model says that as the general level of real activity increases, the average real rate of return on the capital stock also increases. Industrial production growth rate, expected and unexpected inflation rates are used as explanatory variables to estimate the average real rate of return on capital stock. The regression results show that increases in industrial production growth rate and unexpected inflation rates increase the average real rate of return on capital stock while increases in expected inflation lower the average real rate of return on capital stock.

In final step, he estimated the real stock return using seven different regression models. His results can be summarized, if only expected and unexpected inflation rates are included in the regression there are negative relationships between those variables and real stock market returns, as expected. When current and future industrial production growth rate and money base growth rate variables are added in regression, the explanatory power of model increased and all variables have the expected signs. Finally, when expected inflation and the current industrial production growth rate are dropped from regression, the explanatory power of model increased. It is clear that future industrial production growth rate has new information and its explanatory power on the real stock will be higher. He explained the negative relation between stock return and unexpected inflation by Franco Modigliani and Richard Cohn's hypothesis.

> Their hypothesis is that the stock market is irrational. Nominal discount
> The market to uses rates that vary directly with expected inflation
> price the real payoffs generates by equities. As a consequence, positive
> unexpected inflation, which implies higher future expected inflation in
> a world where expected inflation is approximately a random walk,

produces a decline in stock prices and a negative relation between stock return and unexpected inflation (Fama, 1981, p. 561)

According to Geske and Roll (1983), the monetization of the government debt was the main reason behind the inverse relationship between stock market returns and inflation. They argued that a negative random real shock would lower corporate earnings and the government's tax revenue, while leaving government expenditures unchanged. As a result of those events, the government's deficit increases, resulting increased borrowing, leading to an increased monetary base, which ends in expected inflation increases and stock prices decrease.

According to Stulz (1986), the decline in real wealth was the cause of the inverse relationship between stock returns and expected inflation. He argued that an increase in expected inflation would decrease the real wealth of households causing them to switch their portfolio from nominal assets, nominal bonds, and cash to real assets that will increase. This will decrease demand for nominal assets, nominal bonds and domestic currency, causing their prices to decrease.

2.3.2. Stock market returns and Industrial Production

Also, it is clear that an increase in real activity is a sign of a healthy economy that increases returns on stocks. Industrial production is a good proxy for real activity, especially when quarterly data for GDP are not available. A decrease in the growth rate of the industrial production decreases consumption and then firms' revenues and profit, which increases selling pressure on stocks.

2.3.3. Stock market returns and capital inflows

The emerging economies attracted a large amount of foreign capital in the 1990s for the following reasons. First, capital account liberalization and privatization in emerging economies made investment possible, productive and provided new opportunities for foreign investors. Second, recession and low interest rates in developed countries made emerging economies more attractive for foreign investors. Third, foreign investors were protected from exchange rate risk by adoption of fixed exchange rate regimes. Fourth, technological innovations and investors' desire to diversify their risk increased capital inflows into emerging economies.

The impact of capital inflows on the stock market depends on the causes behind capital flows, their composition, and the policy response of authorities.

An increase in capital inflows increase the supply of foreign currency relative to domestic currency and the exchange rate tends to appreciate, which adversely affect the trade balance. Most of the emerging market economies adopts fixed exchange rates and therefore buy excess foreign currency selling the domestic currency which will increase domestic money supply, this decreases domestic interest rates and thus the relative return of stock market increases. Bond (1999) stated that the monetary authorities attempt to sterilize a capital inflow and may raise interest rate to attract more capital inflow. If government sterilizes (government selling bonds to decrease the money supply) capital inflows, interest rates will increase and increase in domestic interest rate will attract more capital inflows but also will lower the present value of firms and relative return of stocks. Therefore, the impact of capital inflows on stock market returns depends on the policy response of authorities.

The composition of capital inflows can have an impact on stock market returns through different channels. Equity investment goes directly into the stock market, which increases stock market return. Foreign direct investment will increase GDP and stock market return. Capital inflows through the banking system may stimulate economic growth and then stock market return. Also, Patnaik (1994) claimed that capital inflows through the banking system can create excess funds absence of sufficient demand for bank credits and the some portion of the excess funds can be channeled to stock market by banks, which will increase stock market return.

Even if capital inflows have a positive effect on stock market return at least in the short-run, capital inflow reversals are inevitable in the long-run in emerging markets and a negative impact on stock market return. A sudden capital outflow can be linked to stock market returns in several ways.

The financial sector is not highly developed in emerging economies; therefore capital inflows are generally short-term. Foreign investor's concern or fear about devaluation and expected stock market return can trigger capital inflow reversals and can lead to self-fulfilling stock market crashes.

If a sudden capital outflow is not sterilized, the central bank action to defend a fixed exchange rate tightens the money supply. As a result of tight money supply, interest rates increase, which lower the relative price of stock. Also, an increase in the interest rate increases the cost of capital and reduces investment, which may cause a recession in the economy. Also, a decrease in the money supply because of an unsterilized capital outflow may force people to sell stocks to meet their excess money demand.

If there is a capital inflow reversal, countries can choose to increase domestic interest rates to stop the capital outflows. An increase in the domestic interest rates lower the relative stock market returns and investors prefer other assets to equity.

If banks are heavily dependent on capital inflow, sudden capital inflow reversals can create solvency and liquidity problems in the banking sector, which can trigger a stock market crash as through banking stocks.

2.3.4. Stock market returns and Regional Stock Market Returns

The level of integration in emerging markets has increased since the 1990s. As a result, the contagion effect has been used as an explanatory variable in stock market returns models. The existence of contagion between stock markets is important to international investors for several reasons. First, if there is contagion between stock markets, investors cannot diversify their portfolios between different countries. Second, investors not only pay attention to domestic stock markets, but also to other stock markets in the region. Prior empirical studies used a world stock market index and regional stock market indexes as proxies for the contagion effect.

According to Roll (1988), 19 of 23 major stock markets declined more than 20 percent during the 1987 stock market crash. He concluded that the trade deficit, the fear of recession, the market response to world movement (decline in stock market return and increase in the U.S. interest rate) and institutional changes (margin rules and the absence of circuit breakers) caused the 1987 stock market crash. He found that the stock market crash began in the non-Japanese Asian markets, spread to a number of European stock markets, then to North American stock markets, and finally to Japan's stock market.

Malliaris and Urrutia (1992) claimed that the 1987 crash began simultaneously in all national stock markets. By using the Granger causality test, they examined the contemporaneous and the lead-lag relationship between six major stock markets for periods before, during, and after the 1987 market crash. Their results showed that the lead-lag relationship between national stock markets existed only during the crash period while the contemporaneous relationship between notional stock market existed periods before, during, and after.

Patel and Sarkar (1998) empirically examined the behavior of individual country stock prices and regional stock market prices when the regions are in crisis. They found strong evidence of contagion within regions, most individual stock market prices sharply declined when region was in crisis. However, they did not find significant evidence of contagion across regions (crises did not spill over across regions).

Bilson, Brailsford, and Hooper (2001) found contagion within regions, but not across regions. In their regression analysis, they the used return on regional stock market index and world stock market index as explanatory variables[3]. Their results show that return on regional market index is significant and positive in 12 of 20 markets while return on world market index is significant and positive in 3 of 20 markets.

In this study, we use Bilson, Brailsford, and Hooper (2001) definition for the regional stock market index.

[3] "The regional index (RI) is an equally weighed index formed excluding that particular market's returns computed for each of Latin America, Asia and Europe."
The world market index is the MSCI World Index.

2.3.5. Stock market returns and Global Variables

Our global variables include the world stock market index and world output. It is clear that an increase in world stock market index and world output is a sign of a healthy global economy which has a positive effect on emerging market economies and stock returns. Harvey (1995) found that world inflation, world GDP and world oil prices have limited explanatory power to determine stock market returns in emerging market economies.

In this study, different definitions for the world stock market index and world output are used to see how major developed economies' stock market and output affects emerging market stock returns. We constructed a world stock market index and world output for each emerging economies from three major developed countries, the U.S., Japan, Germany. For instance, the world stock market index (world output) for country A is a distance weighted average of the U.S., Japan and Germany's stock market index (output)[4].

2.5 Empirical Studies

Chen, Roll, and Ross (1986) attempted to develop a stock market return model as a function of macroeconomic variables. Their model included monthly (MP) and annual (YP) changes in industrial production, unanticipated inflation rates (UI), changes in expected inflation (DEI), a risk premium (UPR), the term structure (UTS), consumption (CG), and oil prices (OG).

[4] It is clear that a decrease in distance between emerging market economies and selected developed economies will increase weight. For example, the weight of Japanese economy on Asian economies will be higher than the weight of Japanese economy on Latin American economies.

Their model for stock returns can be written as:

$$R = a + b_{MP}\,MP + b_{DEI}\,DEI + b_{UI}\,UI + b_{UPR}\,UPR + b_{UTS}\,UTS + e$$

where a and e are constant and error terms, respectively. They estimated the model using monthly data for four different sample periods (1958-1984, 1958-1967, 1968-1977, and 1978-1984). MP and UPR are significant over the full sample periods and have positive coefficients, as expected. UTS is marginally significant over the full sample periods and has negative coefficients, as expected. UTS showed differences between long-term real interest rates (return on long-term government bonds) and short-term real interest rates (Treasury-bill rate). When long-term real interest rates decrease, real return on any form of capital decreases and the relative return on stock return increases. Therefore, investors change the composition of their portfolios in favor of stocks. DEI and UI are only significant in the period from 1968-1977 and have negative coefficients. Consumption and oil prices were separately added in their model to test their effects on stock returns. The results showed that they are insignificant and neither has an effect on stock market returns.

By using monthly data from January 1980 to December 1992, Kwon and Bacon (1997) tested whether macroeconomic variables have significant explanatory power for Korean stock market returns.

They derive 22 indexes for the Korean stock market, by section, size, and industry. They conducted three different time series regression models for each index. In the first model, they applied Chen, Roll, and Ross' (1986). Unexpected inflation (UI), expected inflation (DEI), and risk premium (URP) are insignificant for all 22 indexes while term structure (UTS) is significant for nine of the 22 indexes, and the production index (DPI) is only significant for two of the 22 indexes. Even if the results of the first regression model are consistent with the Chen, Roll, and Ross (1986) model, the results of the model can be improved by adding new variables. In the second model, they added the following explanatory variables: change in dividend yield (DDIV), monthly trade balance (TRB), change in the foreign exchange rate (DEXCH), change in oil price (DOIL), and change in money supply (DM1). Dividend yield (DDIV) is significant across all 22 indexes and has a negative coefficient. Change in foreign exchange rate (DEXCH) is significant for ten of 22 indexes and has a negative coefficient, as expected. The monthly trade balance (TRB), change in oil price (DOIL), and change in money supply (DM1) are insignificant for most of the 22 indexes. In the third model, they combined all variables from the first and second models. None of the variables (except term structure) show any significant difference from the previous models. Term structure (UTS) loses its explanatory power for most of the indexes.

Bilson, Brailsford and Hooper (2001) attempted to determine the macroeconomic indicators of the stock market index in emerging markets by assuming partial integration of the local and global markets. It is clear that high (low) integration will increase the explanatory power of global (local) variables. Stock market returns can be formulated as a function of both global and local variables. Their regression model can be written as:

$$R_{it} = \alpha_i + \beta_i R_{wt} + \delta_i MS_{it-1} + \theta_i GP_{it-1} + \gamma_i RA_{it-2} + \lambda_i ER_{it} + \epsilon_{it} \qquad \textbf{(1.1)}$$

,where R_{it} is the return for the country *i* at time *t*, and R_{wt} is the value-weighted world market index at time *t*. MS_{it-1} and GP_{it-1} denote the percentage change in the money supply variable and percentage change in the consumer price variable for country *i* at time t-1, respectively. RA_{it-2} is the percentage change in real activity variable for country i at time t-2 and ER_{it} is the percentage change in an exchange rate variable for country i at time t.

Bilson, Brailsford and Hooper separately tested Equation (1.1) for 20 emerging market using the OLS procedure and monthly data from January 1985 to December 1997. Results show that the exchange rate variable is the most powerful explanatory macroeconomic variable in the model in terms of significance (in twelve countries) and sign of coefficient (mostly negative as expected from theory). The value of the world market index is positive and significant in ten markets. Money supply is positive and significant in five markets, whereas goods prices and real activity variables are only significant in one market. Most importantly, R^2 values vary range from 0 to 38 percent.

Because of the poor results of the model, Equation (1.1) is extended by adding new macroeconomic (country risk, trade sector, interest rates and a regional index) and microeconomic (dividend yields and price-to-earning ratio) variables. The new model can be written as:

$$R_{it} = \alpha_i + \beta_i R_{wt} + \delta_i MS_{it} + \theta_i GP_{it} + \gamma_i RA_{it} + \lambda_i ER_{it} + X_i CR_{it} + \eta_i TS_{it} + \phi_i IR_{it} + \kappa_i RI_{it} + \mu_i PE_{it} + \nu_i DY_{it} + \epsilon_{it} \qquad \textbf{(1.2)}$$

where CR_{it}, TS_{it}, IR_{it}, RI_{it}, PE_{it}, and DY_{it} are political risk, trade sector, interest rates, regional index, price-to-earning ratio, and dividend yield, respectively.

Equation (1.2) is separately tested for 20 emerging markets using the OLS procedure and monthly data from February 1991 to December 1997. The results show that the price-to earnings-ratio is the best explanatory variable with positive significance in sixteen markets. The regional index variable is significant and positive in twelve markets. Dividend yield is significant and negative in ten markets. The significance of the macroeconomics variables disappears in the new model and even if the exchange rate variable is significant in fourteen markets, six of them have positive coefficients, an unexpected result. Political risk, interest rates and trade sector variables are only significant in a few markets.

CHAPTER III

LITERATURE REVIEW FOR CURRENCY CRISES

After liberalization of the capital account, international portfolio investors began to move funds among stock markets. There are two main risks for them; a decrease in the stock market and currency devaluation. When they expect a devaluation, they sell stock and buy foreign currency. These actions have two results. First, selling stocks decreases stock prices and secondly the demand for foreign reserves puts pressure on the authorities to devalue. The currency crisis variable is endogenous in our stock market crash model. Therefore, we need to specify the currency crisis model and use it to estimate unbiased and efficient estimates of the stock market crisis.

3.1 First Generation Model

Krugman (1979) developed a one-good, two asset, non-linear currency crisis model for a small open economy. Under a fixed exchange regime, the government has no control over budget deficit financing. The government budget deficit is financed by domestic credit creation; agents can trade domestic currency for foreign currency and reserves will decrease. The persistent loss of reserves initiate, speculative attacks against the currency and force the authorities to devalue. Because of the perfect foresight assumption, speculative attacks occur before international reserves are depleted to zero and the exchange rate jumps immediately.

Flood and Garber (1984) constructed a continuous-time, perfect foresight, linear currency crisis model for a small open economy. They developed the concept of a 'shadow floating exchange rate' to calculate the timing of a regime collapse. The shadow floating exchange rate adjusts for money market equilibrium allowing a speculative attack when reserves are exhausted. In this model, domestic credit grows at a constant rate, μ, and to maintain the money market equilibrium reserves decrease at a constant rate , μ. The government cannot support the fixed exchange rate forever with its finite reserves and when reserves reach a lower bound the exchange rate floats freely. The timing of the collapse depends on two market fundamentals: domestic credit growth and initial reserves. Increases in domestic credit growth accelerate the collapse, while an increase in initial reserves postpones it.

Flood and Garber's (1984) model has been extended in several ways. Flood, Garber and Kramer (1996) assume that the monetary authority sterilizes reserve losses by purchasing domestic government securities from the private sector so the monetary authority expands domestic credit and decreases domestic reserves. Therefore, speculative attacks do not change the money-market equilibrium but change the bond-market equilibrium. They extend the first generation model by adding an explicit bond market to the interest rate equation in the speculative attack model. In their model, an increase in domestic bond issues increases the interest rate differential and the probability of crisis will increase.

Calvo and Mendoza (1996) argued that the 1994 Mexican peso crisis could be explained by a new flow imbalance model rather than by the classical stock imbalance famework. They showed that the large expansion of M2, political instability, and short-term public debt with respect to reserves were the main reasons behind the 1994 Mexican peso crisis. In their explanation, huge capital inflows and increases in public expenditures caused the expansion of M2 and over expansion of central bank credit caused the public debt to increase. When capital flows out, expenditures decrease and agents refuse to roll over public debt, authorities do not have any choice but to devalue and to let the currency float freely.

3.2 Second Generation Model

Obstfeld (1994) showed in his two period models that If agents expect high inflation or their expectation about devaluation increase, they demand higher interest rates in the bond market and the cost of government debt (cost of fixed exchange rate) increases. Therefore, an increase in agents' expectation about devaluation or higher inflation can lead to higher interest rates and increase the cost of government debt. Also, an increase in interest rates lower investments and output. In period two, the government has an advantage over agents because it can choose exchange rates and tax rates to minimize the objective (loss) function after observing agents' expectation. The government's choice to devalue or not depends on the interest rate in period 1 and the currency composition of government debt. It is clear that higher interest rates and higher domestic currency debt increase the government's social cost function and the government prefers to devalue instead of defending exchange rates. It is certain that devaluation has political risk and loss of credibility costs too. The lack of information of the agents about the government's decision can lead to multiple equilibria.

Cole and Kehoe (1996) develope a self-fulfilling debt crisis model to explain better Mexico's 1994-1995 currency crisis, which occurred when Mexico had sound fundamentals before the crisis. In their model, the initial level of government debt is critical. If the initial level of government debt is too low, the government can rollover its debt without selling new debt and lenders are not demand a risk premium on government debt. In this scenario, a crisis is avoidable. In the opposite scenario, if initial level of government debt is too high, the government cannot rollover it's debt and lenders are not demand any of the government debt at any low risk premium so the crisis is inevitable. A self-fulfilling debt crisis can occur stochastically between these two extreme crisis zone. They conclude that increasing government debt, the shortening of maturity of the government debt, and political instability were the main causes of Mexico's 1994-1995 crisis.

Tornell (1999) argued that the sudden increase in interest rates could lead to a quick rise of banks' non-performing. The desire of the government to bail out these banks to prevent widespread banking problems increases fiscal deficits, therefore increasing the probability of a crisis.

Ozkan and Sutherland (1995) developed a model to explain the 1992-1993 European currency crises. In their model, given some degree of capital mobility and a fixed exchange rate, an increase in German interest rates may trigger a currency crisis in European currency markets by leading to higher domestic interest rates, a shortening of debts maturities, increasing costs of public debt, and decreasing output which raises the cost of fixed exchange rates and the probability of exchange rate regime changes.

Flood and Marion (2000) introduced an endogenous currency risk premium into the first-generation currency crisis model to show that self-fulfilling currency crises may occur because of agent's changing beliefs about currency risk. The model was used to explain the 1994 Mexican peso crisis by taking into account sterilization, debt-financed fiscal deficit and anticipatory price-setting behavior. They called their new model the "modified first-generation model" because their model is different from the first generation model in several aspects. First, the introduction of a risk premium in the interest parity condition makes the model nonlinear and multiple equilibria possible. Second, the fiscal deficit is financed by issuing bonds rather than by printing money. Third, forward indexation is assumed for goods price setting. In this model, when an agent's expectation for speculative attack increases, they demand a higher risk premium and sell domestic currency denominated securities for foreign currency denominated one. The demand for switching decreases reserves and forces exchange rate devaluation or the free float of the currency.

3.3 Currency Crises and Selected Explanatory Variables

Most of the explanatory variables in our model come from previous studies related to currency crises. In the empirical work, there is no clear distinction between the first and second-generation model. Most of the previous empirical work uses variables from both theoretical models.

3.3.1 Currency crises and M2 / Reserves

Foreign exchange reserves are an indicator of the government's ability to finance its current account deficit, when the country has a fixed exchange rate. Large foreign reserves relative to M2 show a governments' sustainability of the current account deficit and decrease the probability of a currency crises. To compare the international reserves among the countries, the ratio of money supply (M2) to international reserves is used as a scale variable and a low ratio of money supply (M2) to reserves may decrease the likelihood of a currency crisis.

3.3.2 Currency crises and Short Term External Debt to Reserves

As we saw in Flood and Marion's (2000) model, the uncovered interest parity condition no longer holds because of the introduction of a risk premium in the interest parity condition. We can use the short-term external debt to reserves ratio as a proxy for the risk premium. When the short-term external debt to reserves ratio increases, foreign creditors' doubts about the country's commitment to rollover its short-term liabilities increase. Countries can face difficulties finding new foreign debt to rollover their existing debt and the probability of currency crises may increase. Sachs and Radelet (1998) state that increases in the ratio of the short-term debt as a percentage of the international reserves may trigger panic for foreign investors and countries can face difficulties rolling over their short-tem debt obligations.

3.3.3 Currency crises and Real Exchange Rate Overvaluation

The real exchange rate overvaluation increases the risk of currency crisis by decreasing competitiveness of countries and worsening the current account. An increase in the current account deficit decreases a country's ability to generate external revenue to finance a balance of payments crisis. Therefore, overvalued exchange rates may lead to the expectation that a large devaluation will occur.

3.3.4 Currency crises and Political Stability

It is clear that increased political instability introduces uncertainty into markets and causes investors' to lose of confidence. First, investors want to make sure that governments will not change the existing peg after they have made a investment decision.

Second, investors want to make sure that governments will not change their economic plans for short-term political gains.

Block (2003) used a broad range of political variables (Election dummy, Right-wing government dummy, Democracy, Majority) and found that right-wing government, democracy and strong government (Majority) decrease the probability of currency crises in emerging markets[5]. He concluded that an unstable political situation may cause agents' loss of confidence and trigger a speculative currency attack. During elections, governments are more willing to increase fiscal expenses to win elections. Fiscal expenditures are primarily financed by monetary expansion and pressure on domestic currency increase. A stable government gives more confidence to the investor. Past experiences in developing countries show that coalition parties have different economic objectives, targets and problems between coalition parties are inevitable, which can give mixed signals to investors. In our study, a political risk variable is obtained from International Country Risk Guide (ICRG).

3.3.5 Currency crises and Current Account

The current account balance is a good proxy to measure competitive pressure on the exchange rate. Increase in the current account deficit is a sign that a country is losing its competitive position. A large current account deficit is sustainable if economic growth is higher and expected to remain high. Therefore, an increase in the current account deficit to GDP ratio shows that a country's ability to sustain its current account deficit decreases and pressure to devalue increases.

[5] Block (2003) provides an excellent literature review about political stability and currency crises.

3.3.6 Currency crises and Inflation

An increase in inflation rate can affect currency crisis through several channels. First, an increase in domestic inflation rate may be a sign of rapid growth in domestic credit (seignorage) to finance budget deficits and the domestic currency tends to depreciate. Under a fixed exchange rate regime, the central bank does not have any alternative but to back domestic currency to prevent it from depreciating. In this case, the central bank has several options. It can sell foreign assets or domestic bonds to buy domestic currency. A decrease in reserves and an increase in domestic debt increases the probability of a currency collapse. Second, if the inflation level is relatively high and the exchange rate is fixed, the competitiveness of a country decreases and the cost of defending a fixed exchange rate increases. Therefore, the government may find not defending the exchange rate less costly and the government's unwillingness to defend the fixed exchange rate may trigger a speculative attack. At the same time, an increase in inflation increases interest rates and then the increase the cost of domestic denominated currency debt and investment. Therefore, the government prefers to devalue instead of defending a fixed exchange rate.

3.3.7 Currency crises and Contagion Effect

A particular feature of the 1990s currency crises was the almost simultaneous depreciation of all exchange rates within a region. For instance, the devaluation of the Mexican peso in December 1994 was followed by devaluation in Argentina and other regional countries (the Latin American crises of 1994-1995) and the devaluation of the Thai baht in July 1997 was followed by devaluation in Malaysia, Indonesia, South Korea and other Asian countries (the Asian crises of 1997-1998). The spread of the December

1994 Mexican and July 1997 Asian currency crises has raised questions about how a currency crisis in one country affects other countries and how to measure those effects. Unfortunately, there is no consensus about how currency crises were transmitted from one country to another and previous studies have used several different definitions of contagion.

In their empirical study, Eichengreen, Rose and Wyplosz (1996) defined contagion as a dummy variable. If at least one other country in the same region has had a currency crisis in the current or previous year, the variable takes value of one, otherwise zero. In their probit model, they found a positive and significant relationship between currency crises and the contagion dummy variable. They explained the contagion effect with trade linkages and herd behavior[6].

Fratzscher (2002) focused on the role of contagion in currency crises in emerging markets during the 1990s. His study showed that currency crises in one country can spread to other countries trough three types of channels: trade linkages, bank lending competition and stock market integration. The bank lending competition theory says that if countries have common lenders, banks (common lenders) are not only withdrawing their funds from the country in crisis but also from other countries[7]. Stock market integration theory says that if the correlation of stock market returns across emerging markets is high, then losses in one equity market may cause a withdrawal from other equity markets. He defines three continuous contagion variables: trade contagion, bank

[6] Trade linkages theory say that if country A and B have a large degree bilateral trade or country A and B compete for third markets then a devaluation in country A will lower competitiveness of country B and increase pressure to devalue. Herd behavior theory says that if country A has a currency crisis, international investors are not only withdrawing their funds from country A, but also from other countries.
[7] Caramazza, Ricci and Salgado (2000)

contagion and stock market contagion[8]. His models with all three continuous contagion variables perform very well in predicting the crises.

We will use a new approach to identify contagion affects in the regions. In this approach, we will construct a regional market pressure index (RMPI). RMPI is an equally weighted average index formed by excluding a particular country's market pressure index (MPI) computed for each of Latin America, Asia and Europe[9]. For instance, RMPI for Argentina is an equally weighted average of MPIs in Latin American countries excluding Argentina. In this way, we can test empirically how an increase in RMPI will affect the other countries in the region. Our continuous contagion variable can explain trade linkages and herd behavior channels.

3.4 Empirical Studies

Kaminsky, Lizondo and Reinhart (1997) divided previous studies into two groups. First, individual country studies used a few crisis indicators and focused on the one-step-ahead probability of regime change.[10] Second, a large number of country studies from a variety of economic and financial systems used a large number of crisis indicators. Some focused on an indicator of currency crises without conducting any formal test[11] and, some

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[8] Trade contagion variable between countries A and B are measured as: the degree of competition of country B for the home country A in the export market of commodity x in the third market D (the export market share of country B in region D multiplied by the share for country A of total exports of that commodity x to region D) plus the degree of bilateral trade between the countries A and B.

Bank contagion variable between countries A and B are measured as: the share of total bank loans that go from third country D to country B multiplied by the share of bank loans of country A received from country D.

Stock market contagion between countries A and B measured as: average correlation of stock returns between countries A and B.

[9] Construction of MPI for individual countries can be seen in section 4.1.

[10] Blanco and Garber (1986), Cumby and Van Wijenbergen (1989).

[11] Dornbusch, Goldfajn and Valdes (1995), Milesi-Feretti and Razin (1996).

focused on the one-step-ahead probability of regime change.[12] Also, we can classify previous studies as studies either including developing or developed countries and studies that include only specific regions such as East Asia, European Union or Latin American countries.[13]

Blanco and Garber (1986) developed a model to predict the timing of currency crises. In the first step, they estimated parameters from money demand and future exchange rate equations. In the second step, they substituted the estimated parameters in their model to predict one-step-ahead devaluation probabilities in Mexico between1973-1981. Their empirical result shows that probabilities of devaluation increased 20% before the August 1976 and February 1982 Mexican currency crises.

To determine the indicators of currency crises, Frankel and Rose (1996) pooled annual data with a large variety of variables for 105 developing countries from 1971 to 1992. In their results, the foreign direct investment to debt ratio, domestic credit growth, growth rate of GDP, and Northern interest rates are significant determinants of the probability of currency crises. Meanwhile, several debt variables, the current account, budget deficit, and the growth rate of northern GDP are not significant. Reserves to import ratio and overvaluation are marginally significant.

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[12] Frankel and Rose (1996), Kaminsky and Reinhart (1999), Klein and Marion (1994), Otker and Pazarbasioglu (1995).

[13] Flood and Marion (1996), Edin and Vredin (1993), Eichengreen, Rose and Wyplosz (1995), Goldstein (1998), Moreno (1995).

CHAPTER IV

METHODOLOGY

The data set in this study covers 20 Emerging Market Economies from different regions[14], including 7 from Asia, 7 from Latin America, 3 from Europe, 2 from Africa and 1 from the Middle East. The selection of the countries was primarily limited by the availability of the required data. The data consist of quarterly macroeconomic, financial, external and political variables from 1984 to 2001. The choice of variables and the sample size are dictated by theoretical studies and the availability of data.

Most of the data are from the International Financial Statistics CD-ROM database. International Financial Corporation's Emerging Market Dataset and Morgan Stanley Countries Index provide stock market indexes. Political stability data come from the International Country Risk Guide[15].

4.1 Definition of the Currency Crises and Stock Market Crises

First, we define currency crises and stock market crises, our dependent variables. There are several different definitions of currency crises in the existing literature. However, there is only one definition of stock market crises.

Frankel and Rose (1996) define a currency crisis as at least 25 percent depreciation of the nominal bilateral dollar exchange rate in one year and also at least 10

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[14] List of the countries : Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, Indonesia, Korea, Malaysia, Philippines, Thailand, India, Pakistan, Greece, Portugal, Turkey, South Africa, Nigeria, and Jordan.

[15] The data sources and construction are described in Appendix 1.

per cent higher depreciation than the previous year's depreciation. They also consider the fact that an exchange rate crisis may be continuous and fit a three-year lag to avoid double counting in highly inflationary economies.

Eichengren, Rose and Wyplosz (1996) used a broader definition of currency crises, "the market pressure index" (MPI), which can be formalized as:

$$\mathbf{MPI_{i,t}} = \frac{(\%\Delta\, e_{i,t})}{\sigma_{\Delta e,\, i}} + \frac{(\Delta \dot{I}_{i,t})}{\sigma_{\dot{I},i}} - \frac{(\%\Delta\, r_{i,t})}{\sigma_{\Delta r,\, i}} \qquad \mathbf{(4.1)}$$

where e, $\dot{I}$ and r are the bilateral exchange rate, interest rate and reserves of country "i" at time "t", respectively, Δ is first difference and σ is the standard deviation. An increase in market pressure index indicates increased pressure on the domestic currency. Equation (4.1) shows that government has three choices at the time of attack: to devalue the exchange rate, increase interest rates, or sell foreign reserves. Eichengren, Rose and Wyplosz (1996) constructed the dependent variable (exchange rate crisis) as:

$$\Pr(\text{Ccrisis})_{it} = 1 \text{ if } \text{MPI}_{it} > \mu_i + 1.5 * \sigma_i$$

$$\Pr(\text{Ccrisis})_{it} = 0, \text{ otherwise.}$$

Where μ, and σ are the mean and standard deviation of the MPI, respectively. To avoid double counting, they considered a quarter window.

Kaminsky and Reinhart (1999) point out that data for interest rates are not available for most of the countries. Therefore, they only included the weighted average of exchange rate changes and reserve changes to construct the MPI.

Their currency crises definition is:

$$Pr(Ccrisis)_{it} = 1 \text{ if } MPI_{it} > \mu_i + 3 * \sigma_i$$

$$Pr(Ccrisis)_{it} = 0, \text{ otherwise.}$$

In the empirical work, we will construct the MPI from the weighted average of exchange rate changes and reserve changes. We define a currency crisis as:

$$Pcc(crisis)_{it} = 1 \text{ if } MPI_{it} > \mu_i + 1.5 * \sigma_i$$

$$Pcc(crisis)_{it} = 0, \text{ otherwise.}$$

Patel and Sarkar (1998) defined the stock market crisis for developed and developing countries by constructing a variable, $CMAX_t$, which is the ratio of the dollar-denominated stock market index level at time t to the maximum value of the stock market index up to time t. $CMAX_t$ showed that the stock market index declines in emerging markets are larger than stock market index declines in developed markets. Therefore, they used different threshold levels for emerging and developed markets and defined a stock market crash as:

> We define a stock market crash as an event when the price index declines, relative to the historical maximum, more than 20 per cent for the developed markets, and more than 35 per cent for the emerging markets.[16] The beginning of the crash is the month when the price index falls below this threshold level. To avoid counting the same crisis twice, additional triggers occurring within a crisis are considered part of the existing crisis, instead of being an indicator of a new crisis (p. 6).

[16] For the developed markets and Asia, the trigger price represents a level about two standard deviations below the mean value of $CMAX_t$. For Latin American markets, the trigger price is about one standard deviation below the mean value of $CMAX_t$, reflecting the higher volatility of these markets. For the sake of consistency, we wanted to have one trigger level for all emerging markets.

Patel and Sarkar's definition has a few shortcomings. First, there is a probability that they will not consider a sharp decline[17] in the stock market index as a crisis if it does not meet their definition. Meanwhile, they may consider a modest decline[18] in the stock market index as a crisis if it fits in their definition. Second, Glen (2002) points out that using the dollar-denominated stock market index can mislead about stock market movements because some of the declines in the dollar-denominated stock market index may reflect a pure currency movement. Therefore, a sharp depreciation can decrease the dollar-denominated stock market index while leaving the local currency-denominated stock market index unchanged. Meanwhile, most of empirical studies related to stock market returns in emerging economies prefer to use dollar-denominated stock market index[19].

To overcome the above problems, I consider that a stock market crisis exists when there is a sharp decline in the stock market index. The decline in the index has to be "large" relative to what is considered standard from the viewpoint of each country. Also, we define a stock market crisis using both the dollar-denominated stock market index and the domestic currency-denominated stock market index.

In our empirical work, a stock market crisis is considered to occur during the quarter when one of the following conditions is met:

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[17] For example, 30 per cent decline in stock market index is not considered a crisis if stock market index declines, relative to the historical maximum, less than 35 per cent for the emerging markets.

[18] For example, 5 per cent decline in stock market index is considered a crisis if the stock market index declines, relative to the historical maximum, more than 35 per cent for the emerging markets.

[19] Bilson, Brailsford and Hooper (2001), Fifield, Power and Sinclair (2002).

Condition 1.

$$\Pr(\text{crisis})_{it} = 1 \quad \text{if } \%\Delta\, SMI_{it} < -1.5*\sigma_i - \mu_i$$

$$\Pr(\text{crisis})_{it} = 0, \quad \text{otherwise.}$$

Condition 2.

$\Pr(\text{crisis})_{it} = 1$ if $\%\Delta$ SMI $_{it} < -30$ for dollar-denominated stock market crises

$\Pr(\text{crisis})_{it} = 1$ if $\%\Delta$ SMI $_{it} < -25$ for local-currency denominated stock market crises

$\Pr(\text{crisis})_{it} = 0$, otherwise.

$\%\Delta$ SMI is percentage change of the dollar-denominated (the local currency-denominated) quarterly stock market index, μ and σ are the mean of the $\%\Delta$ SMI, and standard deviation of the $\%\Delta$ SMI, respectively. Condition 1 attempts to capture declines in the dollar-denominated (the local currency-dominated) stock market indexes that are sufficiently large relative to the historical country-specific decline of stock market indexes. It states that a percentage decline of the dollar-denominated (the local currency-denominated) quarterly stock market index has to be larger than the country specific mean of the $\%\Delta$ SMI plus one and half standard deviation of the country specific $\%\Delta$ SMI. Condition 2 states that a percentage decline of the dollar-denominated (the local currency-denominated) quarterly stock market index has to be larger than at least 30 percent for dollar-denominated stock market index and 25 percent for the local currency-denominated stock market index. Finally, I consider the continuity of the stock market and currency crises and impose a one-quarter window to avoid double counting of the stock market and currency crises. After we identify a crisis, we treat any crisis in the next quarter as a part of the same crisis and skip it before continuing to identify a new crisis.

4.2 Specification of the Empirical Model for Stock Market Crises and Currency Crises

We will use following specification for our empirical analysis.

$$PSMC_t = f(PCC_t, LCPI_{t-1}, LIP_{t-1}, RSMI_{t-1}, CI_{t-1}, WSMI_{t-1}, USIRP_{t-1}, WOG_{t-1}) \quad \textbf{(4.2.1)}$$

$$PCC_t = f(PSMC_t, LCPI_{t-1}, PS_{t-1}, OV_{t-1}, (STED/R)_{t-1}, (M2/R)_{t-1}, (CA/GDP)_{t-1}, RMPI_{t-1} \quad \textbf{(4.2.2)}$$

where $PSMC_t$ is the stock market crisis dummy, PCC_t is the currency crisis dummy, $LCPI_{t-1}$ is the inflation rate in t-1, LIP_{t-1} is the growth of industrial production in t-1, $RSMI_{t-1}$ is the return of regional stock market index in t-1, PCI_{t-1} is the portfolio capital inflow, $WSMI_{t-1}$ is the return of world stock market index in t-1, and WOG_{t-1} is the growth of world output in t-1 in equation 4.2.1.

OV_{t-1} is the real exchange rate overvaluation, $(STED/R)_{t-1}$ is the ratio of short term external debt to reserves, $(M2/R)_{t-1}$ is the ratio of money supply to reserves, $(CA/GDP)_{t-1}$ is the ratio of current account to real GDP, $RMPI_{t-1}$ is the regional market pressure index variable, and PS_{t-1} is the political stability index in equation 4.2.2.

Most of the specifications of macroeconomic variables in our model come from previous studies related to stock market returns and currency crises. In the empirical work, there is no clear distinction between the first and second-generation model. Most of the previous empirical work uses variables from both theoretical models. First, we will estimate separately equation (4.21) and (4.22) using a single equation probit model[20].

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[20] In single equation probit model I, we excluded contemporaneous stock market crises dummy and currency crises dummy variables to avoid endogenity bias and add lagged stock market return (Model II), lagged percentage change in exchange rate (Model II), lagged stock market crises dummy (Model III) and

Second, the existence of an empirical relationship between currency crises and stock market crises will be tested using a bivariate probit model. Finally, to directly see the correlation (causality) between currency crises and stock market crises, we estimate equations (4.21) and (4.22) using a simultaneous equation probit model.

4.3 Empirical Methodology

We utilize several statistical methods to investigate the relationship between stock market and currency crises. First, we will separately estimate equation (4.21) and (4.22) using single equation probit model where our binary measure of stock market crises is regressed against some explanatory variables (Model I), including the lagged change in the nominal exchange rate (Model II) and the lagged currency crises (Model III) and our binary measure of currency crises is regressed against some explanatory variables including the lagged stock market return and the lagged stock market crises. Single equation probit models assume that the random disturbances that affect the two crises are not correlated. However, it is possible that the random disturbances that affect the currency and stock market crises are correlated and need to be tested. Therefore, we estimate jointly both equations using bivariate probit models which allows for dependences in the correlation of the disturbances. The bivariate probit model can be expressed as follows:

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lagged currency crises dummym(Model III) variables to see if there is leading relationship between both crises.

$$Y^*_1 = \beta'_1 X_1 + u_1 \qquad \text{where } Y_1 = 1 \ \text{ if } Y^*_1 > 0, 0 \text{ otherwise} \qquad (4.3.1).$$

$$Y^*_2 = \beta'_2 X_2 + u_2 \qquad \text{where } Y_2 = 1 \ \text{ if } Y^*_2 > 0, 0 \text{ otherwise} \qquad (4.3.2).$$

$$E[u_1] = E[u_2] = 0$$

$$Var[u_1] = Var[u_2] = 1$$

$$Cov[u_1, u_2] = \rho$$

where Y^*_1 and Y^*_2 are the latent probabilities of stock market crises and currency crises, respectively; X_1, X_2, u_1, and u_2 are predetermined explanatory variables and error terms, respectively; β is corresponding parameters; and ρ is the correlation between the error terms[21]. All unobservable effects are captured by the error terms, u_1 and u_2, and ρ measures the correlation between the disturbances. Therefore, if currency crises and stock market crises are related, currency crises are an unobservable in the equation of stock market crises and stock market crises are an unobservable in the equation of currency crises and ρ measures (roughly) the correlation between currency crises and stock market crises after accounting for the effect of the included variables. Even though, the bivariate probit model provides a test of the existence of an empirical relationship between currency crises and stock market crises and generates an estimate of the strength of this relationship, bivariate probit models do not provide any information about casual direction between currency crises and stock market crises. Therefore, we employ a simultaneous equation probit model to see the direct effects of currency crises on stock market crises and vice versa. The single equation and bivariate probit model is well

[21] Bivariate probit models assume standard normal distribution. Therefore, $(u_1, u_2) \sim$ standard normal $(0,0,1,1,\rho)$.

known and documented in the literature,[22] while the simultaneous equation probit model is not as well known.

In order to obtain consistent estimates of the direct effects of currency crises on stock market crises and vice versa, we employ techniques that account for the simultaneous nature of the relationship. The simultaneous equation probit model is an appropriate model because stock market crises and currency crises are endogenous variables and should be estimated simultaneously to correct for possible endogeneity biases.

Mallar (1977) stated that existence of endogenous and dichotomous explanatory variable in the limited dependent model may cause feedback mechanism between limited dependent variables and limited independent variables. Therefore, a simultaneous equation probit model is appropriate. Simultaneous equation estimators are calculated as follows:

> (1) Obtain consistent estimates of the reduced form parameters by maximizing the maximum likelihood functions and use these to derive consistent estimates of endogenous indices, and (2) substitute the consistent estimates of endogenous indices for their unobserved counterparts and maximize the maximum likelihood functions with respect to the structural parameters (Mallar, 1977, pp. 1719).

Maddala (1983) showed that simultaneous equation estimation is the best estimator in existence for endogenous and dichotomous explanatory variables in the

[22] Greene (2000, ch. 19)

limited dependent model[23]. The simultaneous equation probit model can be expressed as

(4.3.3)

(4.3.4)

ɔf stock market crises and currency crises,

ned explanatory variables and error terms,

ıeters.

ɜrved. We can only observe whether there is

ɜr there is a crisis in the exchange market or

$Y_1 = 0$ otherwise

$Y_2 = 0$ otherwise

u_2, it causes a direct effect on currency

shes (Y^*_1) and vice versa. Therefore,

it models are inconsistent and biased.

reduced form of equation (4.3.3) and (4.3.4)

v_1 (4.3.5)

$$Y^*_2 = \pi_2 X + v_2 \qquad (4.3.6)$$

where X's, π's and v's are reduced form explanatory variables (X's include all the explanatory variables in Y_1 and Y_2), reduced form coefficients and reduced form error terms, respectively.

[23] Simultaneous equation estimation is the best estimator in the statistical sense.

In step one, the reduced form parameters (π_1, π_2) of equations (4.3.5) and (4.3.6) can be estimated with a probit model. The normality of the error terms v_1 and v_2 is assumed. The estimated reduced form parameters are used to predict the values of Y^*_1 and Y^*_2 in equations (4.3.5) and (4.3.6). Then,

$$\hat{Y}^*_1 = \hat{\pi}_1 X \qquad (4.3.7)$$

$$\hat{Y}^*_2 = \hat{\pi}_2 X \qquad (4.3.8)$$

In step two, the predicted values of $\hat{Y}^*_1$ and $\hat{Y}^*_2$ are be substituted in the right hand side of equations (4.3.3) and (4.3.4) as:

$$Y^*_1 = \tilde{\gamma}_1 \hat{Y}^*_2 + \tilde{\beta}'_1 X_1 + \acute{\upsilon}_1 \qquad (4.3.9)$$

$$Y^*_2 = \tilde{\gamma}_2 \hat{Y}^*_1 + \tilde{\beta}'_2 X_2 + \acute{\upsilon}_2 \qquad (4.3.10)$$

where $\tilde{\gamma}$'s and $\tilde{\beta}$'s are coefficients of structural equation.

Finally, the structural equations (4.3.9) and (4.3.10) will be estimated using the probit maximum likelihood method, assuming normality for the error terms. In general, we can write probabilities in the structural form of the probit model as follows:

$$P(Y_1 = 1) = \Phi(\tilde{\gamma}_1 \hat{Y}^*_2 + \tilde{\beta}'_1 X_1)$$

$$P(Y_2 = 1) = \Phi(\tilde{\gamma}_2 \hat{Y}^*_1 + \tilde{\beta}'_2 X_2)$$

where Φ is the cumulative distribution function (CDF) associated with a standard normal distribution.

Because of the two-stage estimation procedure, we cannot estimate the appropriate covariance matrix from the second stage structural model. Following Maddala (1983, 246-247), we can derive the correct covariance matrix.

The estimated parameters in the structural equations (4.3.9) and (4.3.10) can be defined by the two vectors as:

$$\tilde{\alpha}_1 = (\tilde{\gamma}_1, \tilde{\beta}'_1) = (\gamma_1\, \sigma_2/\sigma_1, \beta'_1/\sigma_1)$$

$$\tilde{\alpha}_2 = (\tilde{\gamma}_2, \tilde{\beta}'_2) = (\gamma_2\, \sigma_1/\sigma_2\,,\ \beta'_2/\sigma_2)$$

Then the corrected covariance matrix of $N^{1/2}(\tilde{\alpha}_1 - \alpha_{01})$ is

$$W_1^{-1}\,[W_1 - W_3W_2^{-1}W_4 - W_4'\,W_2^{-1}W_3' + W_3W_2^{-1}W_3']\,W_1^{-1}$$

where α_{01} is the true value of the two-stage estimates α_1 and $\tilde{\alpha}_1$ is the two-stage estimator.

The W matrices are defined as:

$$W_1 = 1/N \sum_1^N A_1\, ZZ'$$

$$W_2 = 1/N \sum_1^N A_2\, XX'$$

$$W_3 = 1/N \sum_1^N A_1\,(\tilde{\gamma}_1)\, ZX'$$

$$W_4 = 1/N \sum_1^N a_1a_2\, E\,[(Y_1 - \Phi_1)(Y_2 - \Phi_2)]$$

where $a_1 = \phi_1 / \Phi_1\,(1 - \Phi_1)$, $\quad a_2 = \phi_2 / \Phi_2\,(1 - \Phi_2)$,

$A_1 = a_1\phi_1$, $\quad A_2 = a_2\phi_2$, Z is a matrix which includes explanatory variables in structural models and N is the sample size. ϕ is the probability density function, Φ is the cumulative density function. To derive the covariance matrix of α_2, the subscripts 1 and 2 will be interchanged in the definitions of Z, W_1, W_2, W_3, and W4.

CHAPTER V

EMPIRICAL RESULTS

5.1. Descriptive Statistics

In this chapter, we first examine stock market crises and currency crises by providing some summary statistics. Descriptive statistics gives some information about time and regional distribution of crises and performance of crises as a predictor of each other.

5.1.1 Data Sample

The sample period includes 88 currency crisis episodes, 81 stock market crisis episodes based on the local currency-denominated stock market index and 81 stock market crisis episodes based on the dollar-denominated stock market index.

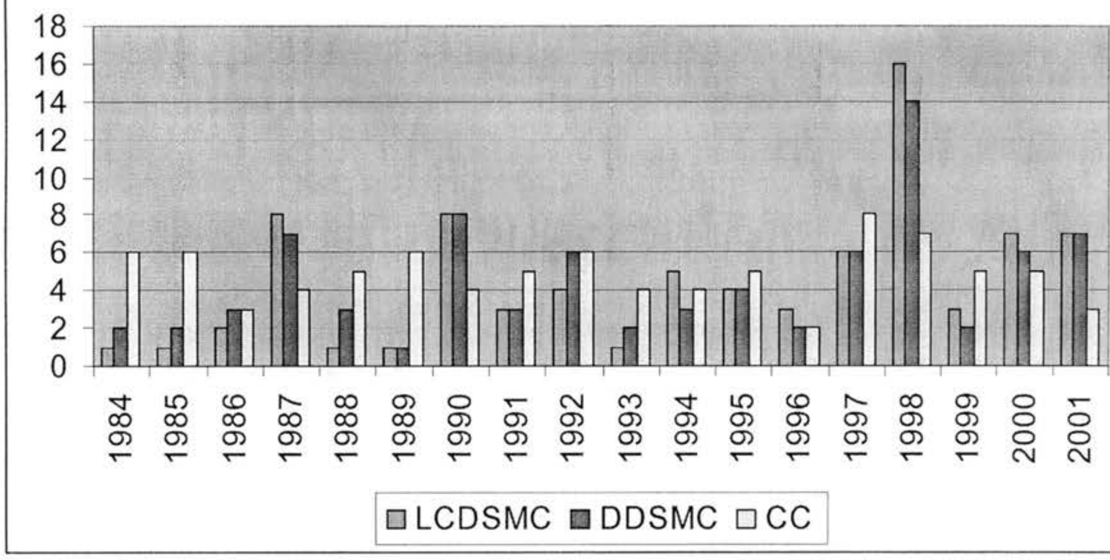
Figure 1 shows the number of currency and stock market crises per year during the sample period 1984-2001. LCDSMC and DDSMC are stock market crises based on the local currency-denominated stock market index and the dollar-denominated stock market index, respectively and CC is currency crises.

Stock market crises are relatively more frequent in 1987, 1990-1992, 1994-1995, 1997-1998 and 2000-2001. The first peak is observed in 1987, when the Latin American stock markets declined sharply after the United States stock market crashed. The second peak is observed in 1990-1992, when Portugal, Greece, Turkey and some Asian countries stock markets declined sharply. A third peak is observed in 1994-1995, when the Latin

American stock markets crashed, again related to Mexican financial crisis of December 1994. The fourth peak is observed in 1997-1998, when Asian stock markets crashed. The fifth peak observed in 2000-2001 reflects a crisis around the world[24].

Currency crises were relatively more frequent in 1992, 1997-98 and 1999-2000. In 1992, financial instability in Europe caused currency crises in Portugal, Greece and Turkey. The currency crisis in 1997-1998 reflected the Asian crises' effects on other countries. Finally, the peak observed in 1999-2000 was due to the Brazilian currency crisis and a global crisis.

Figure 1. Number of Crise Per Year



[24] Stock market and currency crises around 2000 were different from the other major crises. Crises were wide speared around the world instead of a specific region.

5.1.2 The time and regional distribution of the local currency-denominated stock market crises, currency crises and "twin" crises

Tables 1a and 1b provide a quick overview of the time distribution and regional distribution of the local currency-denominated stock market crises, currency crises and "twin" crises[25]. A total of 81 stock market crises (5.9 percent of observations), 88 currency crises (6.4 percent of observations) and 35 "twin" crises (2.3 percent observations) are identified in the sample period 1984-2001. We can reach the following conclusions from Tables 1a and 1b: First, the number and average per year[26] (frequency)[27] of stock market and "twin" crises has increased (decreased) over time while the number, average per year and frequency of currency crises tend to be stable. As can be seen from Table 1a, the number of stock market crises tripled and "twin" crises doubled over time in our sample period while the number of currency crises was constant. Also, the average stock market crises per year tripled and "twin" crises per year doubled over time. However, average currency crises per year decreased slightly. Finally, the frequency of crises shows that in 1996-2001 there was a stock market crisis on average every 2.9 years and "twin" crisis every 7.5 years while in 1984-1989 we had a stock market crisis an average, every 7.5 years and "twin" crises every 15 years.

[25] "Twin" crises are defined as a stock market crisis accompanied by a currency crisis in either the previous, current, or following quarter.
[26] Average crises per year is calculated as the number of crises multiplied by number of countries in sample and the result divided by total sum of country-years.
[27] Frequency of crises is calculated as the total sum of country-years divided by number of crises.

Table 1b shows the distribution of crises by regions. Asia has the highest number of stock market, currency, and "twin" crises[28]. Also, Asia has the highest average stock market and "twin" crises per year, followed by the Latin America. Finally, currency crises are equally distributed among all the regions.

[28] The Latin American countries included are Argentina, Brazil., Chile, Columbia, Mexico, Peru, and Venezuela. Asian countries included are Indonesia, Korea, Malaysia, Philippines, Thailand, India, and Pakistan. Other countries included are Greece, Portugal, Turkey, Nigeria, South Africa and Jordan.

Table 1a. Local Currency Denominated Stock Market Crises and Currency Crises

Time distribution of local currency-denominated stock market crises and currency crises				
	1984-2001	1984-1989	1990-1995	1996-2001
Stock Market Crises				
Number of Crises	81	14	25	42
Average Crises Per Year	4.7	2.7	4.3	7.0
Frequency of Crises	4.2	7.5	4.8	2.9
Currency Crises				
Number of Crises	88	28	29	31
Average Crises Per Year	5.1	5.3	4.8	5.1
Frequency of Crises	3.9	3.8	4.1	3.9
Twin Crises				
Number of Crises	32	7	9	16
Average Crises Per Year	1.9	1.3	1.5	2.7
Frequency of Crises	10.8	15.0	13.0	7.5

Table 1b.

Regional distribution of local currency-denominated stock market crises and currency crises			
	Asia	**Latin America**	**Others**
Stock Market Crises			
Number of Crises	38	23	20
Average Crises Per Year	2.2	1.4	1.2
Frequency of Crises	3.2	5.2	5.1
Currency Crises			
Number of Crises	31	29	28
Average Crises Per Year	1.8	1.7	1.6
Frequency of Crises	4.0	4.0	3.6
Twin Crises			
Number of Crises	16	10	6
Average Crises Per Year	0.91	0.58	0.35
Frequency of Crises	6.4	12.0	17.0

5.1.3 The time and regional distribution of the dollar-denominated stock market crises, currency crises and "twin" crises

Tables 2a and 2b show the time distribution and regional distribution of the dollar-denominated stock market crises, currency crises and "twin" crises. A total of 81 stock market crises (5.9 percent of observations), 88 currency crises (6.4 percent of observations), and 40 "twin" crises (2.9 percent of observations) are identified in the sample period 1984-2001.

As can be seen from Tables 1a, 1b, 2a, and 2b, the time distribution and regional distribution of the dollar-denominated stock market crises is not much different than the local currency-denominated stock market crises. However, the number and the regional distribution of "twin" crises show significant differences. First, the number of "twin" crises increased from 32 to 40 in our sample periods 1984-2001. Others have the highest increase with 50 percent, followed by the Latin America with 20 percent. It is obvious that using the dollar-denominated stock market index to define stock market crises will increase "twin" crises because a huge depreciation decreases the dollar-denominated stock market index[29] while it leaves the local currency-denominated stock market index unchanged. In this scenario, we identify a dollar-denominated stock market crisis and a "twin" crisis but we could not identify a local currency-denominated stock market crisis and a "twin" crisis. Second, "twin" crises are equally distributed among all the regions.

[29] In this scenario, it is assumed that local currency-denominated stock market index unchanged. Therefore, decrease in the dollar-dominated stock market reflects pure currency depreciation.

Table 2a. Dollar-Denominated Stock Market Crises and Currency Crises

Time distribution of dollar-denominated stock market crises and currency crises				
	1984-2001	**1984-1989**	**1990-1995**	**1996-2001**
Stock Market Crises				
Number of Crises	81	18	26	37
Average Crises Per Year	4.7	3.4	4.3	6.2
Frequency of Crises	4.2	5.8	4.6	3.2
Currency Crises				
Number of Crises	88	28	29	31
Average Crises Per Year	5.1	5.3	4.8	5.1
Frequency of Crises	3.9	3.8	4.1	3.9
Twin Crises				
Number of Crises	40	7	13	20
Average Crises Per Year	2.3	1.4	2.1	3.4
Frequency of Crises	8.6	15.0	9.2	6.0

Table 2b.

Regional distribution of dollar-denominated stock market crises and currency crises			
	Asia	**Latin America**	**Others**
Stock Market Crises			
Number of Crises	32	28	21
Average Crises Per Year	1.8	1.6	1.2
Frequency of Crises	3.8	4.3	4.9
Currency Crises			
Number of Crises	31	29	28
Average Crises Per Year	1.8	1.7	1.6
Frequency of Crises	4.0	4.0	3.6
Twin Crises			
Number of Crises	16	12	12
Average Crises Per Year	0.9	0.7	0.7
Frequency of Crises	7.7	10.0	8.5

5.1.4. Performance of crises as a predictor of each other

Kaminsky and Reinhart (1999) and Glick and Hutckinson (2001) used the signal approach to link banking crises and currency crises. In this section, the same procedure is adopted to discuss the link between stock market and currency crises, the method of Kaminsky and Reinhart (1999) is followed.

The following matrix is used to measure the performance of stock market crises and currency crises as predictors of each other.

	Currency Crisis (t)	No Currency Crisis (t)
Stock Market Crisis (t)	A (t)	B (t)
No Stock Market Crisis (t)	C (t)	D (t)

A(t) is the number of instances in which a stock market crisis issues a signal in a particular quarter t and a currency crisis occurred in quarter t (i.e. A(t) is the number of quarters the stock market crisis provides "good signal" about the occurrence of currency crisis). B(t) is the number of instances in which a stock market crisis issues a signal in a particular quarter t and a currency crisis did not occur in quarter t (i.e. B(t) is the number of quarters the stock market crisis provide "bad signal" or "noise" about the occurrence of currency crises). C(t) is the number of instances in which a stock market crisis did not issue a signal in a particular quarter t when there was a currency crisis in quarter t (i.e. C(t) is the number of quarters the stock market crisis did not provide a good signal about the occurrence of currency crises). D(t) is the number of instances in which a stock market crisis did not issue a signal in a particular quarter t when there was no currency crisis in quarter t (i.e. D(t) is the number of quarters in which neither a stock market crisis or currency crises occurred). It is obvious from the above matrix that the perfect predictor will produce only observations A and D.

Table 3a shows the local currency-denominated stock market crises in quarter t, which followed by currency crises in quarter (t-1), t and (t+1). The first column shows the number of the local currency –denominated stock market crises. The second, third and fourth columns show whether the local currency-denominated stock market crises in quarter t was accompanied by a currency crisis one period before, contemporaneously and one period ahead, respectively. The last column shows the predictive power of stock market crises[30]. Table 3b shows whether currency crises in quarter t are accompanied by local currency-denominated stock market crises quarter in (t-1), t and (t+1).

Based on the comparison of tables 3a and 3b, we can reach several conclusions.

The percentage of local currency-denominated stock market crises associated with currency crises at time t-1, t and t+1 is 7 percent, 22 percent and 10 percent, respectively. The percentage of currency crises associated with local currency-denominated stock market crises at time t-1, t and t+1 is 9 percent, 20 percent and 7 percent, respectively. Based on Tables 3a and 3b, we can conclude that both crises appear to occur at the same time and the local currency-denominated stock market crises slightly lead currency crises rather than vice-versa[31]. The last columns show that the predictive power of local currency-denominated stock market crises about the onset of currency crises (32 percent) is higher than the predictive power of currency crises (28 percent). In Asia, the

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[30] Number of stock market crises was accompanied by currency crises at time t and (t+1).

[31] Tables 3a and 3b show that the percentage of local currency-denominated stock market crises preceding a currency crisis (9 percent) is higher than the percentage of currency crises preceding a local currency-dominated stock market crisis (7 percent).

predictive power of local currency-denominated stock market crises (34 percent) is lower than the predictive power of currency crises (40 percent). In Latin America, the predictive power of local currency-denominated stock market crises (34 percent) is higher than the predictive power of currency crises (30 percent).

Table 3a. Local Currency-Denominated Stock Market Crises as a Predictor of Currency Crises

	Number of Stock Market Crises	Number (**Percentage**) of Stock Market Crises Accompanied by Currency Crises			Stock Market Crises Predicting Currency Crises
		A (t-1)	A (t)	A (t+1)	A (t,t+1))
All Countries	81	6 (**7**)	18 (**22**)	8 (**10**)	26 (**32**)
Asia	38	2 (**5**)	10 (**26**)	4 (**8**)	14 (**34**)
Latin America	23	2 (**8**)	7 (**30**)	1 (**4**)	8 (**34**)
Others	20	2 (**10**)	1 (**5**)	3 (**15**)	4 (**20**)

Table 3b. Currency Crises as a Predictor of Local Currency-Denominated Stock Market Crises

	Number of Currency Crises	Number (**Percentage**) of Currency Crises Accompanied by Stock Market Crises			Currency Crises Predicting Stock Market Crises
		A (t-1)	A (t)	A (t+1)	A (t,t+1))
All Countries	88	8 (**9**)	18 (**21**)	6 (**7**)	24 (**28**)
Asia	30	4 (**13**)	10 (**33**)	2 (**7**)	12 (**40**)
Latin America	30	1 (**3**)	7 (**23**)	2 (**7**)	9 (**30**)
Others	28	3 (**11**)	1 (**4**)	2 (**8**)	3 (**12**)

Tables 4a and 4b show the performance of the dollar-denominated stock market crises and currency crises as predictors of each other. The percentage of the dollar-dominated stock market crises associated with currency crises at time t-1, t and t+1 are 6 percent, 33 percent and 9 percent, respectively. The percentage of currency crises associated with dollar-denominated stock market crises at time t-1, t and t+1 are 9 percent, 30 percent and 6 percent, respectively. Based on Tables 4a and 4b, one conclude that both crises appear to occur at the same time and the dollar-denominated stock market crises lead currency crises rather than vice-versa. The last columns show that the predictive power of the dollar-denominated stock market crises (42 percent) is higher than the predictive power of currency crises (36 percent).

It can be seen from the last columns of the Tables 3a and 4a that the predictive power of dollar-denominated stock market crises (42 percent) is higher than the predictive power of local currency-dominated stock market crises (32 percent). Also, the predictive power of currency crises (36 percent)) is higher than the predictive power of currency crises (28 percent) as can be seen from the last columns of Tables 3b and 4b. It is clear that a sharp currency depreciation can decrease the dollar-denominated stock market index while leaving local currency-denominated stock market index unchanged. Therefore, we can identify more "twin" crises when we use dollar-denominated stock market index.

Table 4a. Dollar-Denominated Stock Market Crises as a Predictor of Currency Crises

	Number of Stock Market Crises	Number (**Percentage**) of Stock Market Crises Accompanied by Currency Crises			Stock Market Crises Predicting Currency Crises
		A (t-1)	A (t)	A (t+1)	A (t,t+1))
All Countries	81	5 (**6**)	27 (**33**)	8 (**9**)	35 (**42**)
Asia	32	1 (**3**)	12 (**38**)	3 (**9**)	15 (**47**)
Latin America	28	2 (**7**)	9 (**32**)	1 (**4**)	10 (**36**)
Others	21	2 (**10**)	6 (**30**)	4 (**20**)	10 (**50**)

Table 4b. Currency Crises as a Predictor of Dollar-Denominated Stock Market Crises

	Number of Currency Crises	Number (**Percentage**) of Currency Crises Accompanied by Stock Market Crises			Currency Crises Predicting Stock Market Crises
		A (t-1)	A (t)	A (t+1)	A (t,t+1))
All Countries	88	8 (**9**)	27 (**30**)	5 (**6**)	32 (**36**)
Asia	30	3 (**10**)	12 (**40**)	1 (**3**)	13 (**43**)
Latin America	30	1 (**3**)	9 (**30**)	2 (**6**)	11 (**36**)
Others	28	4 (**14**)	6 (**21**)	2 (**7**)	8 (**28**)

5.1.5 Performance of crises as a signal of each other

Tables 5a and 5b are constructed from the previous matrix. Tables 5a and 5b report calculations of the noise-to-signal ratio associated with the local currency-dominated stock market crises and currency crises. The noise-to-signal ratio for currency crises (the local currency-denominated stock market crises) is calculated by dividing number of bad signals issued by the local currency-denominated stock market crises (currency crises) as a percentage of number of quarters where bad signals could have been issued, by the number of good signals issued by the local currency-denominated stock market crises (currency crises) as a percentage of the number of quarters where a good signal could have been issued[32]. An increase in good signals and decrease in bad signals (noise) lowers the above ratio therefore we prefer lower noise-to-signal ratio.

Tables 5a and 5b show that the contemporaneous (t) noise-to-signal ratios are lower than the leading (t+1) noise-to-signal ratios. Also, the contemporaneous noise-to-signal ratio of currency crises and the local currency-denominated stock market crises are not much different from each other both for the full sample and regional. However, for Asia (Latin America) the leading (t+1) noise-to-signal ratio of stock market crises is higher (lower) than currency crises. The overall performance of the local currency-denominated stock market crises (currency crises) as a signal of currency crises (the local currency-denominated stock market crises) can be seen from the last column of Tables 5a and 5b. All numbers are less than 1 implying that when local currency-denominated stock market crises occur currency crises are more likely than not and vice-versa.

[32] Noise-to-Signal Ratio is [B/ (B+D)/ (A/A+C)], where B is the number of the local currency-denominated stock market crises not accompanied by a currency crises, (B+D) is the total number of quarters without a currency crises, A is the number of the local currency-dominated stock market crises accompanied by a currency crises and (A+C) is the total number of currency crises.

Table 5a. Performance of Local Currency-Denominated Stock Market Crises as a Signal of Currency Crises

	Noise-to-Signal Ratio of Currency Crises		
	t	t+1	(t) + (t+1)
All Countries	0.24	0.85	0.16
Asia	0.18	0.56	0.10
Latin America	0.15	1.46	0.12
Others	1.11	0.33	0.23

Table 5b. Performance of Currency Crises as a Signal of Local Currency-Denominated Stock Market Crises

	Noise-to-Signal Ratio of Stock Market Crises		
	t	t+1	(t) + (t+1)
All Countries	0.24	0.86	0.16
Asia	0.17	1.20	0.13
Latin America	0.17	0.70	0.12
Others	1.40	0.67	0.43

Tables 6a and 6b report calculation of the noise-to-signal ratio associated with dollar-denominated stock market crises and currency crises. The results are similar to Tables 5a and 5b.

Table 6a. Performance of Dollar-Denominated Stock Market Crises as a Signal of Currency Crises

	Noise-to-Signal Ratio of Currency Crises		
	t	**t+1**	**(t) + (t+1)**
All Countries	0.14	0.63	0.09
Asia	0.11	0.62	0.08
Latin America	0.14	1.80	0.13
Others	0.14	0.25	0.07

Table 6b. Performance of Currency Crises as a Signal of Dollar-Denominated Stock Market Crises

	Noise-to-Signal Ratio of Stock Market Crises		
	t	**t+1**	**(t) + (t+1)**
All Countries	0.14	1.04	0.11
Asia	0.10	0.74	0.07
Latin America	0.14	0.87	0.12
Others	0.16	0.56	0.11

5.2. Estimates of Currency and Stock Market Crises using Single Equation Probit Model

Descriptive statistics analysis shows that there is a link between stock market crises and currency crises; however, it has a few shortcomings. First, it deals with each variable separately and therefore ignores correlations between variables. Second, it ignores the joint contribution of variables to stock market crises and currency crises. Finally, there is no test to assess the statistical significance of the results based on the descriptive statistics. Therefore, we further investigation using more sophisticated econometric tools is required.

In this section, we examine potential linkages between stock market crises and currency crises and estimate variety of single equation probit models. In Model I, our binary measure of stock market crises is regressed against explanatory variables (Inflation Rate, Industrial Production Growth, Regional Stock Market Return, Portfolio Capital Inflows, World Stock Market Return and World Output Growth). Model II is including Model I and a lagged percentage changes in nominal exchange rates. Model III is including Model I and a lagged currency crises dummy variable. Also, our binary measure of currency crises is regressed against explanatory variables (Inflation Rate, Overvaluation, Current Account/ GDP, Political Stability, Short Term External Debt/ Reserves, M2/ Reserves and Regional Market Pressure Index) in Model I. Model II is including Model I and a lagged stock market returns. Model III is including Model I and a lagged stock market crises dummy variable.

In order to test for the link between stock market crises and currency crises, we introduce the lagged percentage change in the exchange rate and lagged currency crisis dummy variables in to the stock market crisis equation and, similarly, the lagged stock market return and lagged stock market crisis dummy variables in to the currency crisis equation. If the coefficients associated with the lagged dummy variables are significant, we conclude that stock market crises are a good leading indicator of currency crises and currency crises are a good leading indicator of stock market crises in emerging market economies or vice-versa.

5.2.1. Single Equation Probit Model Results for Dollar-Denominated Stock Market Crises

In this and the next sections, we use quarterly observations for twenty countries over the entire sample period, 1984.Q1-2001.Q4. Table 7a reports the regression results of the probit model of the probability of stock market crisis with currency crises and a set of local and global control variables. Three different versions of the dollar-denominated stock market crises model are estimated: one without lagged change in the exchange rate and lagged currency crises, one with lagged change in the exchange rate and the other with lagged currency crises.

The second, fourth and sixth columns show coefficient estimates of the dollar-denominated stock market crises. I also include the associated z-statistics in parentheses, which test (individual independent variables) the null hypothesis of no effect. The magnitude of the probit model coefficients does not have a straightforward interpretation. They indicate whether the coefficients are statistically significant and indicate whether the impact of explanatory variables is positive or negative.

Since the probit model coefficients cannot give any information about magnitude of explanatory variables on the dependent variable, I report the marginal effects in the third, fifth and seventh columns. The marginal effect is the effect of a one-unit change in the reqressor on the probability of crises, evaluated at the mean of the data.

Several diagnostic tests also are reported at the foot of the tables, including the McFadden-R^2 and log-likelihood test. The McFadden-R^2 shows how well our model can explain crises and it increases as the fit of model improves[33]. Log-likelihood tests the joint significance of all the coefficients. P-values show the significance level of the log-likelihood tests.

All variables in the dollar-denominated stock crises models have the expected sign and are statistically significant, except for world output growth in all models, lagged change of the exchange rate in Model II, and the lagged currency crises dummy variables in Model III. The coefficient of inflation rate shows that one percentage point increase in inflation rate raises the probability of a dollar-denominated stock market crisis by 0.22 percentage points. The finding supports the "proxy effect theory", which states, an increase in the inflation rate, decreases output growth, which in turn causes the stock market to decline.

The coefficient for industrial production growth shows that a one percentage point decrease in industrial production growth raises the probability of dollar-denominated stock market crises by 0.25 percentage points. Robust economic growth is viewed as a sign of strong economic fundamentals by investors. Therefore, an increase in industrial

[33] The McFadden-R^2 $= 1 - \ln L / \ln Lo$ where lnL and lnLo are the maximized value of the log-likelihood function and the log-likelihood computed with only a constant term.

production will increase investors' confidence in the stock market and decrease the probability of crises.

Regional stock market return and world stock market return are negative and statistically significant, as expected. The coefficient for the regional stock market return (world stock market return) shows that a one percentage point decrease in the regional stock market return (world stock market return) increases the probability of a dollar-denominated stock market crises by 0.15 (0.01) percentage points. The finding suggests that a decline in regional and in world stock market return is expected to increase the probability of stock market crises. This can be seen as evidence in favor of the existence of a contagion effect.

The coefficient of the ratio of portfolio capital inflows to market capitalization variable is negative and statistically significant, as expected. One percentage point increases in the portfolio capital inflows decreases the probability of a dollar-denominated stock market crises by 0.066 percentage points. Increases in portfolio capital inflows show inflows of foreign funds at least in the short-run, will tend to reduce the probability of a crisis.

Finally, the coefficients associated with the lagged change in exchange rate and lagged currency crises dummy variables are insignificant in our model, suggesting that currency crises are not a leading indicator of dollar-denominated stock market crises.

Table 7a. Probit Results and Marginal Effects for Dollar-Denominated Stock Market Crises

Variables	Model I		Model II		Model III	
	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects
Inflation Rate (t-1)	2.301 (1.84)*	0.2222	1.494 (0.94)	0.1435	2.515 (1.82)*	0.2412
Industrial Prod. Growth(t-1)	-2.609 (-1.82)*	-0.2519	-2.612 (-1.83)*	-0.2508	-2.615 (-1.79)*	-0.2507
Regional Stock Market Return (t-1)	-1.585 (-2.9)***	-0.1530	-1.574 (-2.8)***	-0.1511	-1.505 (-2.7)***	-0.1445
Portfolio Capital Inflows (t-1)	-0.686 (-3.1)***	-0.0662	-0.672 (-3.1)***	-0.0646	-0.693 (-3.1)***	-0.0665
World Stock Market Return (t-1)	-0.109 (-5.2)***	-0.0105	-0.110 (-5.3)***	-0.0105	-0.111 (-5.3)***	0.0105
World Output Growth (t-1)	-0.274 (-1.22)	-0.0264	-0.278 (-1.23)	-0.0333	-0.252 (-1.12)	-0.0242
% Change of Nominal Exchange Rate (t-1)			0.002 (0.82)	0.0002		
Currency Crises Dummy (t-1)					-0.159 (-0.60)	-0.0135
Log-Likelihood p-value	-235.225 0.000		-234.900 0.000		-232.098 0.000	
McFadden-R^2	0.12		0.12		0.12	
Number of Obs.	1120		1120		1111	
Number of Crises	72		72		71	

*, ** and *** correspond to the 10%, 5% and 1% significance level, respectively.

A useful summary of the prediction ability of the probit model is a table of the hits and misses of a prediction rule as follows: predict a crisis period when the predictive choice probability is greater than a selective cutoff-point, otherwise a zero. Since the predictive ability of the estimated probit model is sensitive to the cutoff-point (the probability value) used in the prediction rule, I report the results using a number of cutoff-points. The left side (the right side) of table 7b shows the prediction ability of the Model I (Model II) for dollar-denominated stock market crises using different cutoff-point. A is the number of stock market crises correctly predicted; B is the number of stock market crises not correctly predicted (Type I error); C is the number of crises predicted when there were no crises (Type II error); D is the number of crises not predicted when there were no crises

The bottom of the table 7b shows goodness-of –fit statistics for our model. Those statistics are calculated as follows:

% of observation called correctly: (D+A)/number of total observations.

% of Type I and Type II errors: (B+C)/ number of total observations.

% of crises called correctly (conditional probability): A/ (A+B).

% of false alarms to total alarms: C/(C+A).

% of probability of crises given an alarm (good signals): A/ (A+C).

% of probability of crises given no alarm (noise): B/ (B+D).

Noise-to-Signal ratio: [B/ (B+D)/A/ (A+C)]

As expected, the predictive ability of the estimated probit model is sensitive to the cutoff-point used in the prediction rule. For instance, the percentage of crises predicted correctly ranges from 31 percent (for the cutoff-point of 0.20) to 3 percent (for the cutoff-point of 0.50) in Model I. If a 0.50 cutoff-point is chosen, we will predict relatively few crises and as a result the ability of the model to predict crises will be underestimated. Greene (2000) states that increasing the cutoff-point will always reduce the probability of Type II errors while increasing the probability of Type I errors and there is no clear answer as to the best cutoff-point to choose. The lowest total error rate is generated by Model I with the cutoff-point 0.40 and only 8 percent of crises is correctly predicted at this the cutoff level. In applications, the choice of the cutoff-point level will depend on the relative cost associated with Type I and Type II errors but in practice, it is not easy to measure the cost of Type I and Type II errors.

Table 7b. Prediction (Goodness-of -Fit) Ability of the Probit Model

	The dollar-denominated stock market crises							
Predicted Probabilities (Cutoff-Points)	Model I				Model II			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	22	50	34	1014	20	52	35	1013
30 % cutoff	10	62	12	1036	9	63	12	1036
40 % cutoff	6	66	5	1043	5	67	5	1043
50 % cutoff	2	70	4	1044	2	70	4	1044
60 % cutoff	0	72	1	1047	0	72	1	1047

	Model I					**Model II**				
Cutoff Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%
% of observations correctly called	93	93	93	93	93	92	93	93	93	93
% of Type I and Type II errors	7.50	6.61	6.34	6.61	6.52	7.77	6.70	6.43	6.61	6.52
% of crises correctly called	31	15	8	3	0	28	13	7	3	0
% of false alarms of total alarm	61	55	45	67	100	64	57	50	67	100
% probabilities of crisis given an alarm	39	45	55	33	0	36	43	50	33	0
% probabilities of crisis given no alarm	4.7	5.6	6.0	6.3	6.4	4.9	5.7	6.0	6.3	6.4
Noise-to-signal ratio	0.12	0.13	0.11	0.19		0.14	0.13	0.12	0.19	

5.2.2. Single Equation Probit Model Results for Local Currency-Denominated Stock Market Crises

Table 8a reports the regression results of the probit model of the probability of local currency-denominated stock market crisis with a set of local and global control variables. Three different versions of the local currency-denominated stock market crises model are estimated.

The regional stock market return, portfolio capital inflows and world stock market return variables are significant and negative in all three models, as expected. The coefficient for regional stock market return (world stock market return) shows that a one percentage point decrease in the regional stock market return (world stock market return) raises the probability of a local currency-denominated stock market crisis by 0.19 (0.012) percentage point. The finding suggests that a decline in regional and in world stock market returns will increase the probability of a stock market crisis. This can be seen as evidence in favor of the existence of the contagion effect.

The inflation rate is significant in Model I and III while industrial production growth and world output growth are insignificant in all three models. On the other hand, the coefficient associated with lagged change in exchange rate and lagged currency crises dummy variables are insignificant in our model, suggesting that currency crises are not a leading indicator of local currency-denominated stock market crises.

The left side (the right side) of Table 8b shows the prediction ability of the Model I (Model II) for local currency-denominated stock market crises using different cutoff-points.

Based on comparison of the dollar-denominated and local currency-denominated stock market crises, we can reach following conclusions: The predictive ability of the dollar-denominated stock market crisis model is higher than the predictive ability of the local currency-denominated stock market crisis model. For instance, moving from dollar-denominated stock market crises to local currency-denominated stock market crises decreases the percentage of correctly called crises and increases the percentage of false alarm in all cutoff-point level. Also, dollar denominated stock market crises have lower wrong predictions (Type I plus Type II errors) and noise-to-signal ratios than local currency-denominated stock market crises at all cutoff-point levels.

Table 8a. Probit Results and Marginal Effects for Local Currency-Denominated Stock Market Crises

Variables	Model I		Model II		Model III	
	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Margina Effects
Inflation Rate (t-1)	2.092 (1.67)*	0.2012	2.204 (1.52)	0.2119	2.256 (1.65)*	0.2148
Industrial Produ. Growth (t-1)	-1.896 (-1.37)	-0.1823	-1.902 (-1.37)	-0.1828	-1.894 (-1.33)	-0.1802
Regional Stock Market Return (t-1)	-2.037 (-3.8)***	-0.1959	-2.040 (-3.8)***	-0.1961	-1.969 (-3.7)***	-0.1773
Portfolio Capital Inflows (t-1)	-0.502 (-2.25)**	-0.0482	-0.504 (-2.30)**	-0.0484	-0.513 (-2.27)**	-0.0488
World Stock Market Return (t-1)	-0.127 (-6.1)***	-0.0122	-0.127 (-6.1)***	-0.0122	-0.129 (-6.2)***	-0.0123
World Output Growth (t-1)	-0.116 (-0.53)	-0.0111	-0.116 (-0.53)	-0.0111	-0.097 (-0.44)	-0.0092
% Change of Nominal Exchange Rate (t-1)			0.0003 (0.2)	0.00003		
Currency Crises Dummy (t-1)					-0.198 (-0.72)	-0.0163
Log-Likelihood p-value	-235.901 0.000		-235.890 0.000		-232.629 0.000	
McFadden-R^2	0.13		0.13		0.13	
Number of Obs.	1122		1122		1113	
Number of Crises	74		74		73	

Table 8b. Prediction (Goodness-of -Fit) Ability of the Probit Model

	The local currency-denominated stock market crises							
	Model I				Model II			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	17	57	41	1007	16	58	36	1012
30 % cutoff	7	67	13	1035	7	67	12	1036
40 % cutoff	5	69	7	1041	5	69	8	1040
50 % cutoff	2	72	5	1043	2	72	5	1043
60 % cutoff	0	74	4	1044	0	74	4	1044

	Model I					Model II				
Cutoff Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%
% of observations correctly called	91	93	93	93	93	92	93	93	93	93
% of Type I and Type II errors	8.73	7.13	6.77	6.86	6.96	8.39	7.05	6.88	6.88	6.96
% of crises correctly called	23	10	7	3	0	22	9	7	3	0
% of false alarms of total alarm	71	65	58	71	100	69	63	61	71	100
% probabilities of crisis given an alarm	29	35	42	29	0	31	37	39	29	0
% probabilities of crisis given no alarm	5.4	6.1	6.2	6.5	6.6	5.4	6.1	6.2	6.4	6.6
Noise-to-signal ratio	0.18	0.17	0.15	0.22		0.17	0.16	0.16	0.22	

5.2.3. Single Equation Probit Model for Currency Crises with Dollar-Denominated Stock Market Crises

Table 9a reports the regression results of the probit model of currency crises with lagged dollar-denominated stock market return and lagged dollar-denominated stock market crises and a set of internal and global control variables. There are three currency crises models. The first model uses only a set of internal and global control variables as explanatory variables, the second model uses lagged dollar-denominated stock market return as an explanatory variable and the third model uses lagged dollar-denominated stock market crises dummy as an explanatory variable.

All variables in the currency crises models are statistically significant except short term external debt in all three models, the lagged dollar denominated stock market return in Model II, and the lagged dollar denominated stock market crises dummy variable in Model III. Inflation rate, overvaluation, the ratio of money supply to reserves and the regional market pressure index have positive signs as expected and are statistically significant in all three models. An increase in those variables increases the probability of currency crises. The coefficient of the regional market pressure index shows that a one percentage point increase in the regional market pressure index raises the probability of currency crises by 0.055 percent. This can be seen as evidence in favor of the existence of the contagion effect.

Political stability and the current account to GDP variable both are negative, as expected, and statistically significant. A decrease in these variables increases the probability of currency crises.

The coefficients associated with the lagged dollar-denominated stock market return and lagged dollar-denominated stock market crises dummy variables are not statistically significant, suggesting that the lagged dollar-denominates stock market return and crises are not leading indicators of currency crises in emerging market economies. This results from single equation probit model do not support Kaminksy, Lizondo and Reinhart (1997) and Kaminksy and Reinhart (1999). Using the "signal approach model", they found that stock prices are a good leading indicator of currency crises.

Table 9a. Probit Results and Marginal Effects for Currency Crises with the Dollar-Denominated Stock Market Crises

Variables	Model I		Model II		Model III	
	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects
Inflation Rate (t-1)	2.889 (2.59)***	0.2043	3.062 (2.66)***	0.2165	2.854 (2.57)***	0.2037
Political Stability (t-1)	-0.021 (-3.6)***	-0.0020	-0.020 (-3.7)***	-0.0014	-0.021 (-3.6)***	-0.0014
Overvaluation (t-1)	0.00005 (2.49)**	0.000004	0.00005 (2.46)**	0.000004	0.00005 (2.49)**	0.000004
Short Term External Debt (t-1)	0.014 (0.95)	0.0010	0.014 (0.92)	0.0010	0.014 (0.93)	0.0010
Money Supply/ Reserves (t-1)	0.017 (3.10)***	0.0011	0.017 (3.03)***	0.0012	0.017 (3.04)***	0.0012
Current Account/ GDP (t-1)	-6.655 (-1.96)**	-0.4707	-6.444 (-1.90)**	-0.4557	-6.846 (-2.01)**	-0.4886
Regional Market Pressure Index (t-1)	0.777 (9.44)***	0.0549	0.7356 (8.61)***	0.0454	0.7334 (8.70)***	0.0453
Stock Market Return (t-1)			-0.030 (-1.09)	-0.002		
Stock market Crises (t-1)					0.221 (0.84)	0.0189
Log-Likelihood p-value	-205.508 0.000		-204.956 0.000		-205.128 0.000	
McFadden-R^2	0.26		0.26		0.26	
Number of Obs.	1117		1117		1112	
Number of Crises	77		77		77	

The left side (the right side) of Table 9b shows the prediction ability of Model I (Model II) for currency crises using different cutoff-points. The percentage of crises predicted correctly ranges from 40 percent (for the cutoff-point of 0.20) to 13 percent (for the cutoff-point of 0.70) in Model I. The lowest total error rate is generated by the Model I with cutoff-point 0.60 and only 16 percent of crises are correctly predicted at this the cutoff level.

Table 9b. Prediction (Goodness-of -Fit) Ability of the Probit Model

	Currency crises with dollar-denominated stock market crises							
	Model I				**Model II**			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	31	46	52	988	31	46	51	989
30 % cutoff	23	54	25	1015	24	53	21	1019
40 % cutoff	16	61	13	1027	16	61	11	1029
50 % cutoff	13	64	6	1034	13	64	6	1034
60 % cutoff	12	65	2	1038	12	65	2	1038
70 % cutoff	10	67	2	1038	10	67	2	1038

	Model I						**Model II**					
Cutoff Percentages	20%	30%	40%	50%	60%	70%	20%	30%	40%	50%	60%	70%
% of obs. correctly called	91	93	93	94	94	94	91	93	93	94	94	94
% of Type I and Type II errors	8.77	7.07	6.62	6.27	6.00	6.18	8.68	6.62	6.44	6.27	6.00	6.18
% of crises correctly called	40	30	21	17	16	13	40	31	21	17	16	13
% of false alarms of total alarm	63	52	33	32	14	17	62	47	41	32	14	17
% prob. of crisis given an alarm	37	48	67	68	86	83	38	53	59	68	86	83
% prob. of crisis given no alarm	4.5	5.1	5.6	5.8	5.9	6.1	4.4	4.9	5.6	5.8	5.9	6.1
Noise-to-signal ratio	0.12	0.11	0.08	0.09	0.07	0.07	0.12	0.09	0.10	0.09	0.07	0.07

5.2.4. Single Equation Probit Model for Currency Crises with Local Currency-Denominated Stock Market Crises

Table 10a reports the regression results of the probit model of the probabilities of currency crisis with the lagged local currency-denominated stock market return, lagged local currency-denominated stock market crises and a set of local and global control variables. There are three currency crises models. The first model uses only a set of internal and global control variables as explanatory variables; the second model uses the lagged local currency-denominated stock market return as an explanatory variable; the third model uses the lagged local currency-denominated stock market crises dummy as an explanatory variable.

The results are similar to the previous currency crises model. All variables in the currency crises models are statistically significant, except short-term external debt (in all three models), the lagged local currency-denominated stock market return in Model II and the lagged local currency-denominated stock market crises dummy in Model III. The inflation rate, overvaluation, the ratio of money supply to reserves and the regional market pressure index have positive signs, as expected, and are statistically significant in all three models. An increase in those variables increases the probability of currency crises. Political stability and the current account to GDP variable both are negative, as expected, and statistically significant. A decrease in these variables increases the probability of a currency crisis.

The coefficients associated with the lagged local currency-denominated stock market return and the lagged local currency-denominated stock market crises dummy variables are not statistically significant, suggesting that the lagged local currencydenominates stock market return and crises are not leading indicators of currency crises in emerging market economies.

Table 10b shows the prediction ability of the probit model for currency crises with Model I (left side of table) and with Model II (right side of table). We can reach the following conclusions from our probit model results: In general, our local and global explanatory variables have good explanatory power on dollar denominated stock market crises and currency crises. Therefore, both local and global variables appear to be at the root of stock market and currency crises. The lagged currency crises are not a leading indicator of local currency-denominated and dollar-denominated stock market crises. Also, lagged local currency-denominated stock market crises and lagged dollar-denominated stock market crises are not a good leading indicator of currency crises.

Table 10a. Probit Results and Marginal Effects for Currency Crises with the Local Currency-Denominated Stock Market Crises

Variables	Model I		Model II		Model III	
	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects
Inflation Rate (t-1)	2.889 (2.59)***	0.2043	3.169 (2.40)**	0.2248	2.872 (2.57)***	0.2031
Political Stability (t-1)	-0.021 (-3.6)***	-0.0020	-0.021 (-3.7)***	-0.0015	-0.021 (-3.7)***	-0.0015
Overvaluation (t-1)	0.00005 (2.49)**	0.000004	0.00005 (2.49)**	0.000004	0.00006 (2.51)**	0.000004
Short Term External Debt (t-1)	0.014 (0.95)	-0.0010	0.015 (0.98)	0.0010	0.015 (0.96)	0.0010
Money Supply/ Reserves (t-1)	0.017 (3.10)***	0.0012	0.017 (3.05)***	0.0012	0.017 (2.97)***	0.0012
Current Account/ GDP (t-1)	-6.655 (-1.96)**	-0.4707	-6.584 (-1.94)**	-0.4670	-6.527 (-1.92)**	-0.4614
Regional Market Pressure Index (t-1)	0.777 (9.44)***	0.0549	0.775 (9.39)***	0.0550	0.781 (9.43)***	0.0552
Stock Market Return (t-1)			-0.0008 (-0.40)	-0.00006		
Stock Market Crises (t-1)					0.388 (1.52)	0.0375
Log-Likelihood p-value	-205.508 0.000		-205.498 0.000		-204.342 0.000	
McFadden-R^2	0.26		0.26		0.27	
Number of Obs.	1117		1117		1114	
Number of Crises	77		77		77	

Table 10b. Prediction (Goodness-of -Fit) Ability of the Probit Model

	Currency crises with local currency-denominated stock market crises							
	Model I				**Model II**			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	31	46	52	988	32	45	53	987
30 % cutoff	23	54	25	1015	24	53	20	1020
40 % cutoff	16	61	13	1027	16	61	11	1029
50 % cutoff	13	64	6	1034	13	64	6	1034
60 % cutoff	12	65	2	1038	11	66	3	1037
70 % cutoff	10	67	2	1038	9	68	2	1038

	Model I						**Model II**					
Cutoff Percentages	20%	30%	40%	50%	60%	70%	20%	30%	40%	50%	60%	70%
% of obs. correctly called	91	93	93	94	94	94	91	93	94	94	94	94
% of Type I and Type II errors	8.77	7.07	6.62	6.27	6.00	6.18	8.77	6.53	6.53	6.27	6.18	6.27
% of crises correctly called	40	30	21	17	16	13	41	31	21	17	14	12
% of false alarms of total alarm	63	52	33	32	14	17	62	45	41	32	21	18
% prob. of crisis given an alarm	37	48	67	68	86	83	38	55	59	68	79	82
% prob. of crisis given no alarm	4.5	5.1	5.6	5.8	5.9	6.1	4.4	4.9	5.6	5.8	6.0	6.1
Noise-to-signal ratio	0.12	0.11	0.10	0.09	0.07	0.07	0.11	0.09	0.09	0.09	0.08	0.08

5.3. Bivariate Probit Model Estimation

We found significant contemporaneous correlation between the stock market and currency crises using descriptive statistics. The probability of a stock market crisis is dependent upon currency crisis and vice versa. Therefore, it is possible that the random disturbances that affect the currency and stock market crises are correlated and this is a violation of the assumptions on which the single equation probit analysis is based. We estimate a bivariate probit model which allows for correlation of the disturbance of currency and stock market crises equations and provides an estimate of the strength of this correlation. The bivariate probit model estimates an extra parameter, ρ, to measure the error correlation between currency crises and stock market crises in the same sense as a seemingly unrelated regression model.

Tables 11a and 12a provide estimates of the coefficients of bivariate probit models parameters including an estimate of ρ and their statistical significances. The bivariate probit model results for currency crises models are very similar to the single equation probit model results[34]. All variables in the currency crises model are statistically significant except short-term external debt, percentage change of nominal exchange rate and stock market return. However, the bivariate probit model results for stock market crises show some differences. For instance, industrial production growth becomes significant in the local currency-denominated stock market crises model while portfolio capital inflows become insignificant.

The estimate of ρ in both models indicates highly significant and positive relationship between currency crises and stock market crises through disturbance terms.

[34] We compare the bivariate probit model 11a (12a) with the single equation model in Table 7a (8a) and 9a (10a).

Therefore, we reject the single equation model in favor of bivariate probit model. The estimated correlation between the disturbance terms for currency crises and local currency-denominated (dollar denominated) stock market crises is 0.40 (0.54); this suggests a higher correlation between currency crises and dollar denominated stock market crises than local currency-denominated stock market crises. Tables 11b, 11c, 12b and 12c show the predictive ability of bivariate probit models.

Based on the comparison of the single equation probit, Model I, and the bivariate probit model I, we can reach the following conclusions[35]:

The bivariate probit model I based on dollar-denominated stock market crises has a lower percentage of Type I and Type II errors than single equation probit model (Model I) at all cutoff-point levels. Percentage of crises called correctly (noise-to-signal ratios) is higher (lower) in the bivariate probit model I than the single equation probit model (Model I) at all cutoff-point levels. The lowest total errors in the bivariate probit model is 6.21 percent (at the cutoff-point of 0.40) for dollar-denominated stock market crises and 5.94 percent (at the cutoff-point of 0.60) for domestic currency crises, which is lower than the single equation probit model.

The bivariate probit model I based on local currency-denominated stock market crises has a lower percentage of Type I and Type II errors than the single equation probit model (Model I) at all cutoff-point levels except currency crises at the 50 percent level. The percentage of crises called correctly (noise-to-signal ratios) is higher (lower) in the bivariate probit model I than the single equation probit model (Model I) at all cutoff-point levels except currency crises at the 50 percent level. The lowest total errors in the

[35] We compare the left side (model I) of Tables 7b and 9b with table 11b and left side (model I) of Tables 8b and 10b with table 12b.

bivariate probit model is 6.74 percent (at the cutoff-point of 0.40) for local currency-denominated stock market crises and 5.93 percent (at the cutoff-point of 0.60) for currency crises, which is lower than the single equation probit model. We can conclude that the bivariate probit model I have better in sample forecasting ability than single equation probit model (Model I). Also, we can reach similar conclusion for the bivariate probit model II and single equation probit model (Model II).

Table 11a. Bivariate Probit Model Results and Marginal Effects: Dollar Denominated Stock Market Crises

	Stock Market Crises	Currency Crises	Stock Market Crises	Currency Crises
	Model I	**Model I**	**Model II**	**Model II**
Variables	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	3.031 (2.05)**		3.215 (1.79)*	
Ind. Prod. Growth (t-1)	-2.907 (-2.33)**		-2.914 (-2.35)**	
Regional Stock Market Index (t-1)	-1.717 (-3.0)***		-1.725 (-3.0)***	
Portfolio Capital Inflow (t-1)	-0.566 (-2.24)**		-0.565 (-2.21)**	
World Stock Market Index (t-1)	-0.106 (-5.2)***		-0.106 (-5.2)***	
World Output Growth (t-1)	-0.336 (-1.35)		-0.340 (-1.37)	
% Change of Exchange Rate (t-1)			-0.0004 (-0.14)	
Inflation Rate (t-1)		2.968 (2.61)***		3.661 (2.90)***
Political Stability (t-1)		-0.019 (-3.10)***		-0.019 (-3.0)***
Overvaluation (t-1)		0.00006 (3.05)***		0.00006 (3.06)***
Short Term External Debt (t-1)		0.017 (1.11)		0.018 (1.17)
Money Supply/ Reserves (t-1)		0.016 (3.34)***		0.016 (3.14)***
Current Account/ GDP (t-1)		-6.771 (-2.05)**		-6.476 (-1.95)**
Regional Market Pressure Index(t-1)		0.697 (7.93)***		0.687 (7.69)***
Stock Market Return (t-1)				-0.002 (-1.09)
ρ	0.542 (6.06)***		0.554 (6.20)***	

Continues from Table 11a.

Log-Likelihood	-420.319		-419.756	
Number of Observation	1111	1111	1111	1111
McFadden-R^2	20		20	
Number of Crises	70	76	70	76

Table 11b. Prediction (Goodness-of -Fit) Ability of Bivariate Probit Model I

	The dollar-denominated stock market crises				Currency crises			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	24	46	32	1009	32	44	51	984
30 % cutoff	11	59	11	1030	24	52	19	1016
40 % cutoff	5	65	4	1037	16	60	9	1026
50 % cutoff	2	68	3	1038	13	63	4	1031
60 % cutoff	0	70	0	1041	12	64	2	1033
70 % cutoff					10	66	2	1033

	The dollar-denominated stock market crises					Currency crises					
Cut off Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	93	94	94	94	94	91	94	94	94	94	94
% of Type I and Type II errors	7.02	6.30	6.21	6.39	6.30	8.56	6.39	6.21	6.03	5.94	6.12
% of crises correctly called	34	16	7	3	0	42	32	21	17	16	13
% of false alarms of total alarm	57	50	44	60		61	44	36	24	14	17
% probabilities of crisis given an alarm	43	50	56	40		39	56	64	76	86	83
% probabilities of crisis given no alarm	4.4	5.4	5.9	6.1		4.3	4.9	5.4	5.8	5.8	6.0
Noise-to-signal ratio	0.10	0.11	0.11	0.15		0.11	0.09	0.08	0.08	0.07	0.07

Table 11c. Prediction (Goodness-of -Fit) Ability of Bivariate Probit Model II

	The dollar-denominated stock market crises				Currency crises			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	23	47	33	1008	32	44	52	983
30 % cutoff	9	61	11	1030	24	52	19	1016
40 % cutoff	5	65	5	1036	16	60	9	1026
50 % cutoff	2	68	3	1038	12	64	5	1030
60 % cutoff	0	70	0	1041	12	64	3	1032
70 % cutoff					10	66	3	1032

	The dollar-denominated stock market crises					Currency crises					
Cut off Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	93	94	94	94	94	91	94	94	94	94	94
% of Type I and Type II errors	7.20	6.48	6.30	6.39	6.30	8.64	6.39	6.21	6.03	5.94	6.12
% of crises correctly called	33	13	7	3	0	42	32	21	16	16	13
% of false alarms of total alarm	59	55	50	60		61	44	36	29	20	23
% probabilities of crisis given an alarm	41	45	50	40		39	56	64	71	80	77
% probabilities of crisis given no alarm	4.5	5.6	5.9	6.1		4.3	4.9	5.4	5.9	5.8	6.0
Noise-to-signal ratio	0.10	0.12	0.12	0.15		0.11	0.09	0.08	0.08	0.07	0.08

Table 12a. Bivariate Probit Model Results and Marginal Effects: Local Currency Denominated Stock Market Crises

	Stock Market Crises	Currency Crises	Stock Market Crises	Currency Crises
	Model I	**Model I**	**Model II**	**Model II**
Variables	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	2.456 (1.65)*		2.594 (1.28)	
Ind. Prod. Growth (t-1)	-2.263 (-1.74)*		-2.298 (-1.74)*	
Regional Stock Market Index (t-1)	-2.106 (-4.0)***		-2.113 (-4.1)***	
Portfolio Capital Inflow (t-1)	-0.418 (-1.32)		-0.418 (-1.32)	
World Stock Market Index (t-1)	-0.124 (-6.3)***		-0.124 (-6.3)***	
World Output Growth (t-1)	-0.117 (-0.47)		-0.119 (-0.48)	
% Change of Exchange Rate (t-1)			-0.0003 (-0.08)	
Inflation Rate (t-1)		2.681 (1.83)*		3.227 (2.08)**
Political Stability (t-1)		-0.020 (-3.15)***		-0.019 (-3.0)***
Overvaluation (t-1)		0.00006 (3.13)***		0.00006 (3.16)***
Short Term External Debt (t-1)		0.017 (1.10)		0.018 (1.14)
Money Supply/ Reserves (t-1)		0.016 (3.13)***		0.016 (2.96)***
Current Account/ GDP (t-1)		-6.069 (-1.82)*		-5.865 (-1.76)*
Regional Market Pressure Index (t-1)		0.742 (8.66)***		0.736 (8.48)***
Stock Market Return (t-1)				-0.002 (-0.86)
ρ	0.407 (3.46)***		0.420 (3.48)***	

Continues from Table 12a.

Log-Likelihood	-432.590		-432.229	
Number of Observation	1113	1113	1113	1113
McFadden-R^2	20		20	
Number of Crises	73	76	73	76

Table 12b. Prediction (Goodness-of -Fit) Ability of Bivariate Probit Model I

	The local currency-denominated stock market crises				Currency crises			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	18	55	34	1006	33	43	51	986
30 % cutoff	8	65	12	1028	23	53	18	1019
40 % cutoff	5	68	7	1033	16	60	10	1027
50 % cutoff	2	71	5	1035	12	64	6	1031
60 % cutoff	0	73	4	1036	12	64	2	1035
70 % cutoff					10	66	2	1035

	The local currency-denominated stock market crises					Currency crises					
Cut off Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	92	93	93	93	93	92	94	94	94	94	94
% of Type I and Type II errors	8.00	6.92	6.74	6.83	6.92	8.45	6.38	6.29	6.29	5.93	6.11
% of crises correctly called	25	11	7	3	0	43	30	21	16	16	13
% of false alarms of total alarm	65	60	58	71	100	61	44	38	33	14	17
% probabilities of crisis given an alarm	35	40	42	29	0	39	56	62	67	86	83
% probabilities of crisis given no alarm	5.2	6.1	6.2	6.4		4.2	4.9	5.5	5.8	5.8	6.0
Noise-to-signal ratio	0.15	0.15	0.15	0.22		0.11	0.09	0.09	0.09	0.07	0.07

Table 12c. Prediction (Goodness-of -Fit) Ability of Bivariate Probit Model II

Predicted Probabilities (Cutoff-Points)	The local currency-denominated stock market crises				Currency crises			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	18	55	33	1007	32	44	52	985
30 % cutoff	7	66	13	1027	24	52	18	1019
40 % cutoff	5	68	7	1033	16	60	10	1027
50 % cutoff	2	71	5	1035	12	64	6	1031
60 % cutoff	0	73	4	1036	12	64	3	1034
70 % cutoff					10	66	3	1034

	The local currency-denominated stock market crises					Currency crises					
Cut off Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	92	93	93	93	93	91	94	94	94	94	94
% of Type I and Type II errors	7.90	7.09	6.74	6.83	6.92	8.62	6.29	6.29	6.29	6.01	6.20
% of crises correctly called	25	10	7	3	0	42	32	21	16	16	13
% of false alarms of total alarm	65	65	58	71	100	62	43	38	33	20	23
% probabilities of crisis given an alarm	35	35	42	29	0	38	57	62	67	80	77
% probabilities of crisis given no alarm	5.2	6.1	6.2	6.4		4.3	4.9	5.5	5.8	5.8	6.0
Noise-to-signal ratio	0.15	0.17	0.15	0.22		0.11	0.09	0.09	0.09	0.07	0.08

5.4. Simultaneous Equation Probit Model Estimations

Results from bivariate probit models indicate that currency crises and stock market crises are linked through their correlated errors. Even if the bivariate probit models provide a clear indication of the degree to which currency crises and stock market crises are related, these models do not provide guidance in determining causal direction. Therefore, single equation and bivariate probit models serve as a preliminary tool in an investigation of the currency and stock market crises relationship. In order to correct for possible endogeneity bias and obtain consistent estimates of the direct effects of currency crises on stock market crises and of stock market crises on currency crises, we need to employ techniques that account for the simultaneous nature of the relationship. To overcome the above problems, we employ a simultaneous equation probit model where stock market and currency crises are treated as endogenous variables.

5.4.1. Simultaneous Equation Probit Model Estimation for Dollar Denominated Stock Market Crises and Currency Crises

Table 13a reports the regression results of the dollar-denominated stock market crises and currency crises based on simultaneous equation probit model with the onset of a set of local and global control variables.

The results from the simultaneous equation model are similar to the single equation probit model II and the bivariate model II except that the world output growth becomes significant while the inflation rate insignificant in the stock crises model. All variables are statistically significant in the dollar-denominated stock market crisis equation, except for inflation rate. Also, all variables have the expected signs.

Industrial production growth is significant and positive, as expected, in the dollar-denominated stock market crises equation. A one percentage point decrease in industrial production growth raises the probability of a dollar-denominated stock market crisis by 0.19 percentage point. A decrease in the world output growth, regional stock market returns, world stock market return and portfolio capital inflow increases the probability of dollar-denominated stock market crises.

All variables are statistically significant and have the expected signs in the currency crisis equation except short-term external debt variable. An increase in the inflation rate, overvaluation of the real exchange rate, money supply to reserve ratio and the regional market pressure index increase the probability of a currency crisis. While an increase in political stability and current account to the GDP ratio will decrease the probability of a currency crisis.

Finally, the coefficient for the contemporaneous currency crisis and dollar-denominated stock market crisis variables show that a one percentage point increase in the contemporaneous probability of currency crises raises the probability of a dollar-denominated stock market crisis by 0.037 percentage point (significant at the 1 percent level) and a one percentage point increase in the contemporaneous probability of dollar-denominated stock market crises, raises the probability of a currency crises by 0.020 percentage point (significant at the 5 percent level). This is evidence that stock market crises should be treated as an endogenous in currency crises model and currency crises should be treated as an endogenous variable in the stock market crises model. Therefore, a simultaneous equation probit model is an appropriate model.

Table 13b shows the prediction ability of simultaneous equation probit model for dollar-denominated stock market crises and currency crises. Based on a comparison of the predictive ability of the single equation probit model II and the simultaneous equation probit model, we reach following conclusions[36]:

The simultaneous equation probit model, based on dollar-denominated stock market crisis, have a lower percentage of Type I and Type II errors than the single equation probit model (Model II) at all cutoff-point levels. The percentage of crises correctly predicted (noise-to-signal ratios) is higher (lower) in the simultaneous equation probit model than in the single equation probit model (Model II) at all cutoff-point levels. The lowest total error rate in the simultaneous equation probit model is 6.12 percent (at the cutoff-point of 0.40) for dollar-denominated stock market crises and 6.03 percent (at the cutoff-point of 0.40) for domestic currency crises, which is lower than the single equation probit model.

Also, the simultaneous equation probit model has a lower percentage of Type I and Type II errors than the bivariate probit model II at all cutoff-point levels except the 50 and 60 percent levels in currency crises[37]. The percentage of crises correctly predicted (noise-to-signal ratios) is higher (lower) in the simultaneous equation probit model than the bivariate probit model in all cutoff-point levels except the 60 percent level in currency crises.

We can conclude that the simultaneous equation model based on dollar-denominated stock market crises has better forecasting ability than single equation probit model II and bivariate probit model II.

[36] We compare the right side of tables 7b and 9b with Table 13b.
[37] We compare the table 11c with table 13b.

Table 13a. Simultaneous Equation Probit Results and Marginal Effects

Variables	Dollar-denominated stock market crises		Currency Crises	
	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects
Inflation Rate (t-1)	1.793 (1.20))	0.1334		
Ind. Prod. Growth (t-1)	-2.639 (-1.73)*	-0.1964		
Regional Stock Market Index (t-1)	-1.189 (-1.94)**	-0.0884		
Portfolio Capital Inflow (t-1)	-0.376 (-1.87)*	-0.0280		
World Stock Market Index (t-1)	-0.130 (-5.4)***	-0.0097		
World Output Growth (t-1)	-0.554 (-2.28)**	-0.0412		
Currency Crises (t)	0.501 (6.03)***	0.0372		
Inflation (t-1)			2.345 (1.67)*	0.1598
Political Stability (t-1)			-0.018 (-3.08)***	-0.0012
Overvaluation (t-1)			0.00004 (2.20)**	0.000004
Short Term External Debt (t-1)			0.020 (0.95)	0.0013
Money Supply/ Reserves (t-1)			0.017 (2.34)**	0.0011
Current Account/ GDP (t-1)			-6.186 (-1.99)**	-0.4216
Regional Market Pressure Index (t-1)			0.657 (7.85)***	0.0447
Stock Market Crises (t)			0.292 (2.15)**	0.0199

Continues from Table 13a

Log-Likelihood	-209.183		-202.672	
p-value for overall significance	0.0000		0.0000	
McFadden-R^2	0.20		0.26	
Number of Observation	1111		1111	
Number of Crises	70		76	

Table 13b. Prediction (Goodness-of -Fit) Ability of Simultaneous Equation Probit Model

	Dollar-denominated stock market crises				Currency crises			
Predicted Probabilities (Cutoff-Points)	A	B	C	D	A	B	C	D
20 % cutoff	29	41	37	1004	38	38	52	983
30 % cutoff	13	57	12	1029	26	50	20	1015
40 % cutoff	10	60	8	1033	19	57	10	1025
50 % cutoff	3	67	5	1036	13	63	5	1030
60 % cutoff	2	68	2	1039	12	64	4	1031
70 % cutoff					10	66	2	1033

	Dollar-denominated stock market crises					Currency crises					
Cutoff Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	93	94	94	94	94	92	93	94	94	94	94
% of Type I and Type II errors	7.02	6.21	6.12	6.39	6.30	8.10	6.30	6.03	6.12	6.12	6.12
% of crises correctly called	41	19	14	4	3	50	34	25	17	16	13
% of false alarms of total alarm	56	48	44	57	50	58	43	34	28	25	17
% probabilities of crisis given an alarm	44	52	56	43	50	42	57	66	72	75	83
% probabilities of crisis given no alarm	3.9	5.2	5.5	6.1	6.1	3.7	4.7	5.3	5.8	5.8	6.0
Noise-to-signal ratio	0.09	0.10	0.10	0.14	.12	0.09	0.08	0.08	0.08	0.08	0.07

5.4.2. Simultaneous Equation Probit Model Estimation for Local Currency Denominated Stock Market Crises and Currency Crises

Table 14a reports the results of the local currency-denominated stock market crises and currency crises based on the simultaneous equation probit model with the set of local and global control variables.

The simultaneous equation probit model results for currency crises are similar to the single equation (Model II) and the bivariate probit model II results. However, the simultaneous equation probit model results for stock market crises show some differences. All variables have the expected signs and the regional stock market return, world stock market return and portfolio capital inflow are statistically significant in the local currency-denominated stock market crises model. The inflation rate, political stability, overvaluation, ratio of money supply to reserves, ratio of the current account to GDP and the regional market pressure index are statistically significant in the currency crises model.

Decreases in the regional stock market return, world stock market return and portfolio capital inflows increase the probability of a local currency-dominated stock market crisis. An increase in the inflation rate, overvaluation, money supply to reserve ratio and the regional market pressure index, increases the probability of a currency crisis. An increase in political stability and the current account to GDP ratio, decrease the probability of a currency crisis.

Finally, the coefficient of currency crisis and local currency-dominated stock market crisis variables show that a one percentage point increase in the contemporaneous probability of currency crises raises the probability of a local currency-dominated stock market crises by 0.018 percentage point (significant at the 1 percent level) and a one percentage point increase in the contemporaneous probability of a local currency-dominated stock market crises raises the probability of a currency crises by 0.014 percentage point (significant at the 10 percent level). This result suggests that there is contemporaneous correlation between stock market and currency crises in emerging market economies, even when controlling for an endogeneity bias and other explanatory variables.

Table 14b shows the predictive ability of simultaneous equation probit model for the local currency-denominated stock market crises and currency crises.

Based on the comparison of the prediction ability of single equation probit model II and simultaneous equation probit model, we reach following conclusions[38]: Simultaneous equation probit model based on local currency-denominated stock market crises have a lower percentage of Type I and Type II errors than the single equation probit model (Model II) at all cutoff-point levels. The percentage of crises correctly predicted (noise-to-signal ratios) is higher (lower) in the simultaneous equation probit model than the single equation probit model (Model II) at all cutoff-point levels except the 50 percent level. The lowest total errors in the simultaneous equation probit model is 6.56 percent (at the cutoff-point of 0.50) for dollar-denominated stock market crises and 6.02 percent (at the cutoff-point of 0.60) for currency crises, which is lower than the single equation probit model.

The simultaneous equation probit model has a lower percentage of Type I and Type II errors than the bivariate probit model II at all cutoff-point levels, except the 20

[38] We compare the right side of tables 8b and 10b with table 14b.

percent level in stock market crises and 60 percent level in currency crises[39]. The percentage of crises correctly predicted (noise-to-signal ratios) is higher (lower) in the simultaneous equation probit model than the bivariate probit model in all cutoff-point levels.

We conclude that the simultaneous equation model based on local currency-denominated stock market crises has better forecasting ability than the single equation probit model and bivariate probit model.

Based on our results in this section, we reach following conclusions: First, there is a significant simultaneous causality between stock market and currency crises in emerging market economies. Second, the effect of the currency crises on the stock market crises is larger (in terms of probability) than the effect of stock market crises currency crises. Third, the predictive ability of currency crisis is higher than the predictive ability of stock market crisis. Finally, the explanatory power and the predictive ability of the dollar-denominated stock market crisis model are higher than the predictive ability of the local currency-denominated stock market crisis model.

[39] We compare table 12c with table 14b.

Table 14a. Simultaneous Equation Probit Results and Marginal Effects

	The local currency-denominated stock market crises		Currency Crises	
Variables	Estimates (z-stat.)	Marginal Effects	Estimates (z-stat.)	Marginal Effects
Inflation Rate (t-1)	1.715 (1.35)	0.1586		
Ind. Prod. Growth (t-1)	-1.861 (-1.35)	-0.1722		
Regional Stock Market Index (t-1)	-1.860 (-3.5)***	-0.1720		
Portfolio Capital Inflow (t-1)	-0.340 (-1.61)*	-0.0314		
World Stock Market Index (t-1)	-0.133 (-6.3)***	-0.0120		
World Output Growth (t-1)	-0.202 (-0.92)	-0.0186		
Currency Crises (t)	0.202 (2.72)***	0.0180		
Inflation (t-1)			2.527 (2.55)***	0.1756
Political Stability (t-1)			-0.021 (-3.99)***	-0.0014
Overvaluation (t-1)			0.00006 (2.17)**	0.000004
Short Term External Debt (t-1)			0.019 (0.93)	0.0013
Money Supply/ Reserves (t-1)			0.017 (2.33)**	0.0011
Current Account/ GDP (t-1)			-5.957 (-2.02)**	-0.4140
Regional Market Pressure Index (t-1)			0.739 (10.8)***	0.0513
Stock Market Crises (t)			0.209 (1.74)*	0.0145

Continues from Table 14a

Log-Likelihood	-229.934		-205.80	
p-value for overall significance	0.0000		0.0000	
McFadden-R^2	0.14		0.26	
Number of Observation	1113		1113	
Number of Crises	73		76	

Table 14b. Prediction (Goodness-of -Fit) Ability of Simultaneous Equation Probit Model

	The local currency-denominated stock market crises				Currency crises			
Predicted Probabilities (Cutoff-Points)	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
20 % cutoff	20	53	38	1002	35	41	52	985
30 % cutoff	8	65	12	1028	24	52	17	1020
40 % cutoff	7	66	8	1032	16	60	9	1028
50 % cutoff	4	69	5	1035	12	64	5	1032
60 % cutoff	2	71	3	1037	12	64	3	1034
70 % cutoff					10	66	2	1035

	The local currency-denominated stock market crises					Currency crises					
Cutoff Percentages	20%	30%	40%	50%	60%	20%	30%	40%	50%	60%	70%
% of observations correctly called	92	93	93	93	93	92	94	94	94	94	94
% of Type I and Type II errors	8.17	6.92	6.65	6.56	6.64	8.35	6.20	6.20	6.20	6.02	6.11
% of crises correctly called	27	11	10	6	3	46	32	21	16	16	13
% of false alarms of total alarm	66	60	53	55	60	60	41	36	29	20	17
% probabilities of crisis given an alarm	34	40	47	45	40	40	59	64	71	80	83
% probabilities of crisis given no alarm	5.0	6.1	6.0	6.3	6.4	4.0	4.9	5.5	5.8	5.8	6.0
Noise-to-signal ratio	0.15	0.15	0.13	0.14	0.16	0.10	0.08	0.09	0.08	0.7	0.7

5.5. Predicted Probabilities of Crises

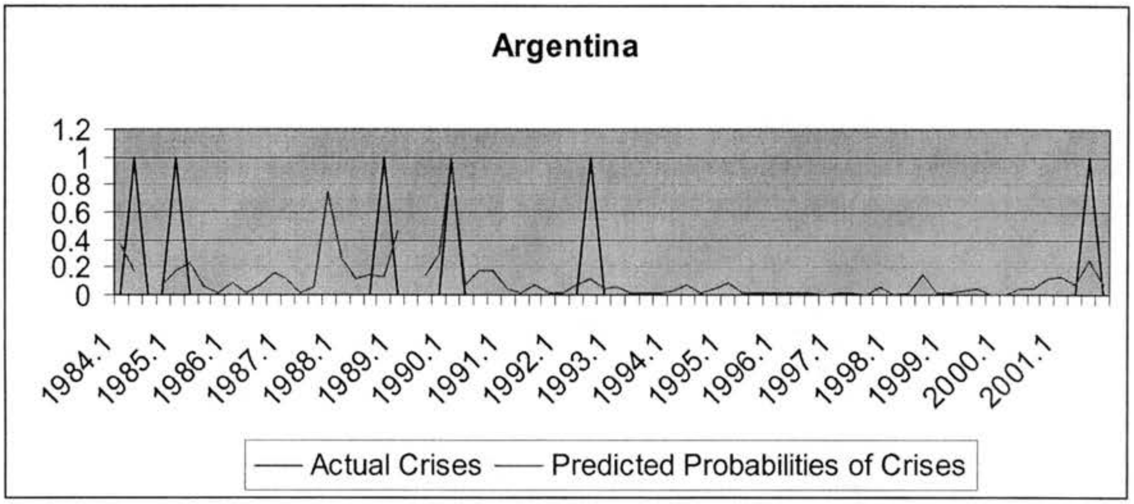
In figures 2 and 3, the solid line shows the predicted probabilities of dollar-denominated stock market crises and currency crises based on the simultaneous equation probit model and the line show the date of the crises according to our definitions. We selected 9 countries from Latin America, Asia and Europe.

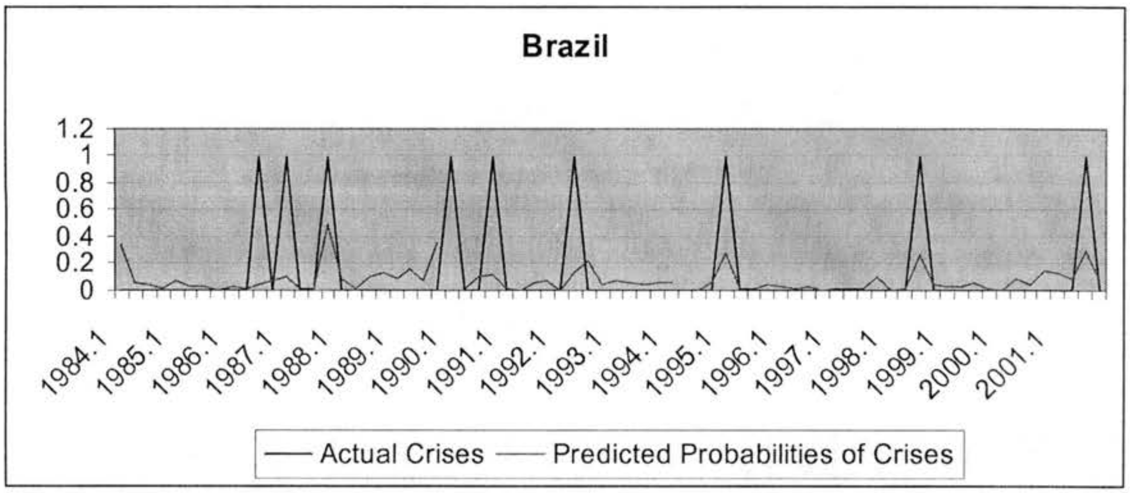
Based on the figures, we can conclude that the stock market and currency crises model does fit for the Asian crises in 1997-1998 fairly well. The predicted probabilities of the stock market crises range from 45 to 80 percent and the predicted probabilities of currency crises range from 80 to 100 percent during the 1997-1998 periods in Asia.

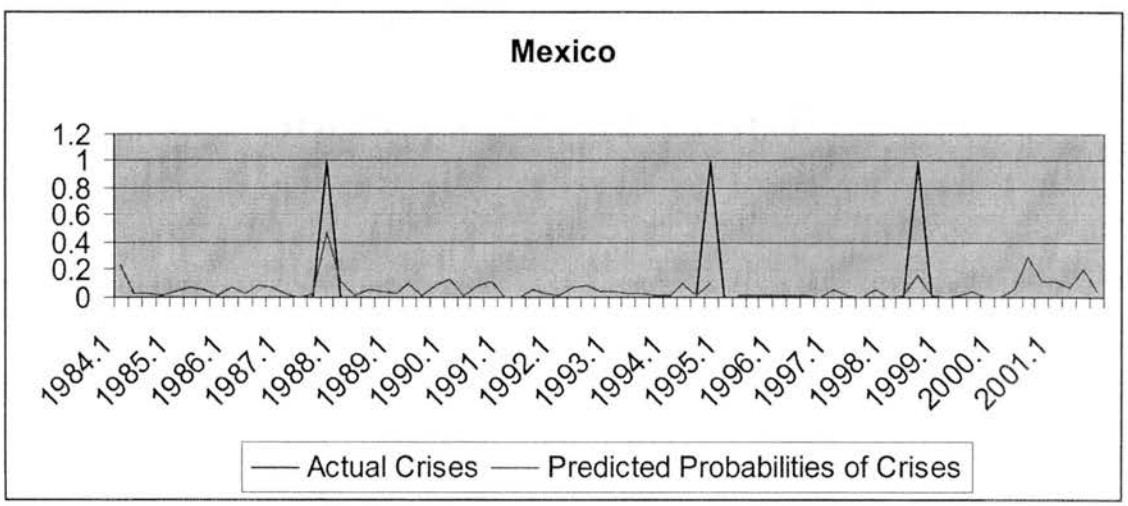
With regard to currency crises in 1990-1992, the corresponding probabilities are high in Europe. Also, the probabilities of stock market crises are high in 1990-1992 in Latin America, as seen in Figure 2.

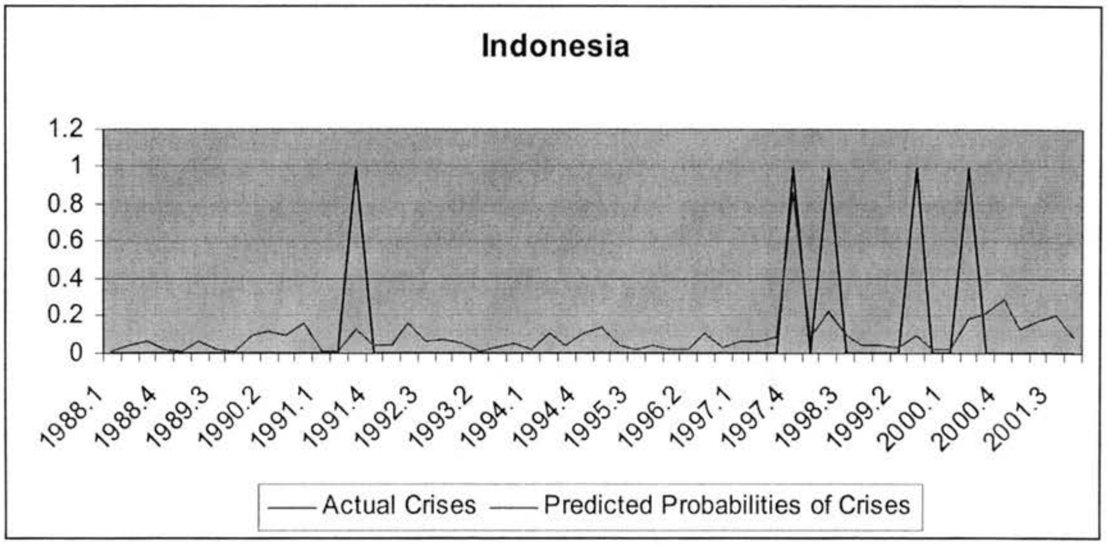
With regard to the Latin American crises in 1994-95, corresponding probabilities are not very high. Finally, the 2000-2001 crises best fit for Turkey and Greece.

Figure 2. Predicted Probabilities of Dollar-Denominated Stock Market Crises





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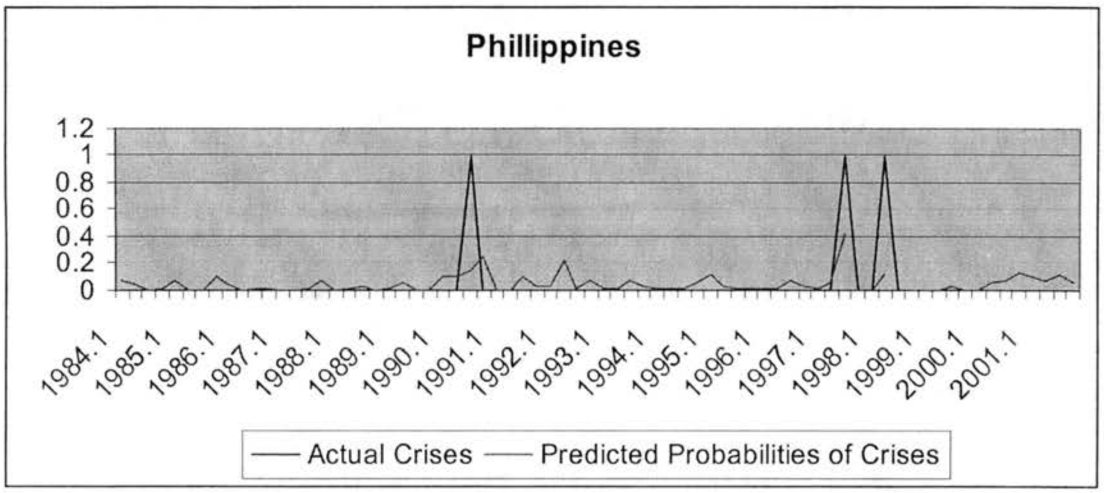
2001.3
Actual Crises
Predicted Probabilities of Crises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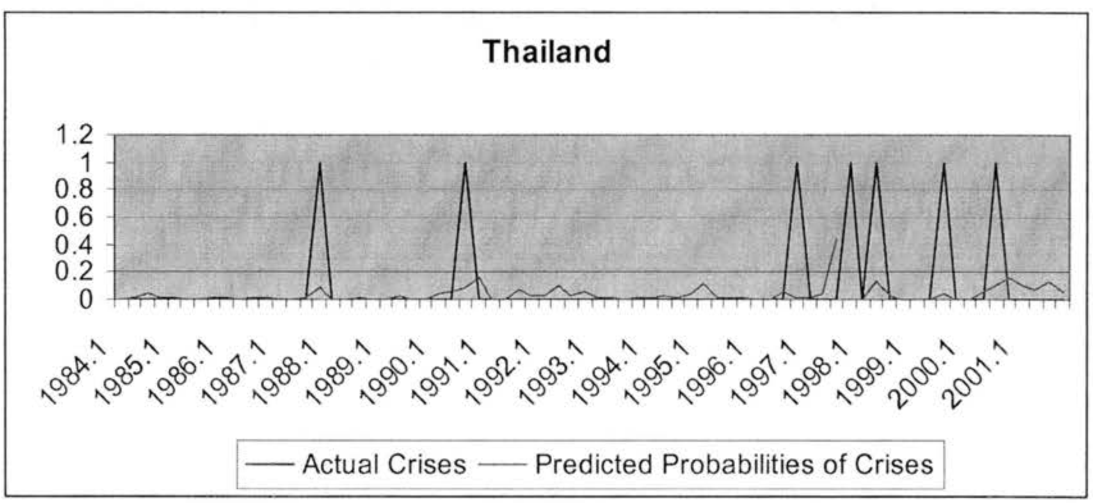
Actual Crises
Predicted Probabilities of Crises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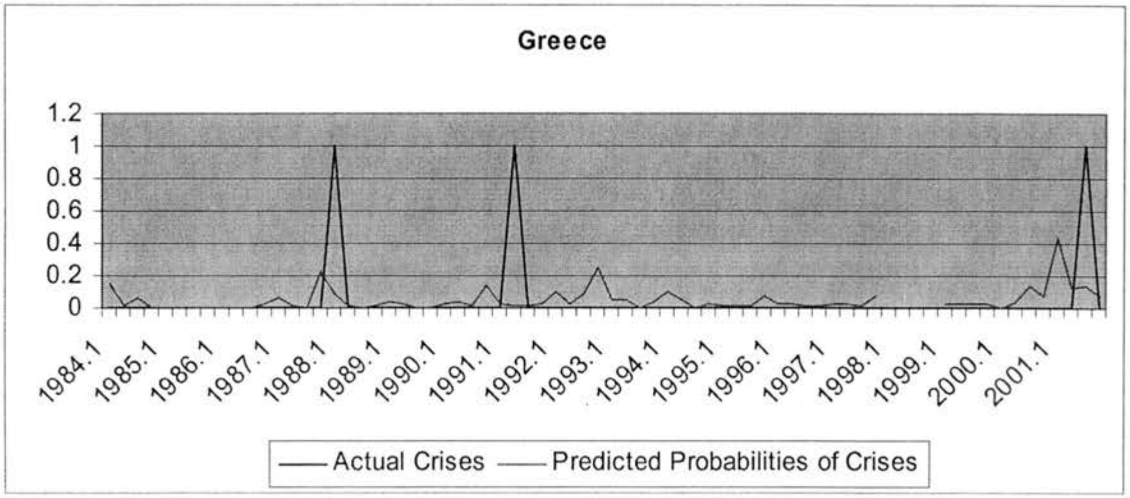
Actual Crises
Predicted Probabilities of Crises



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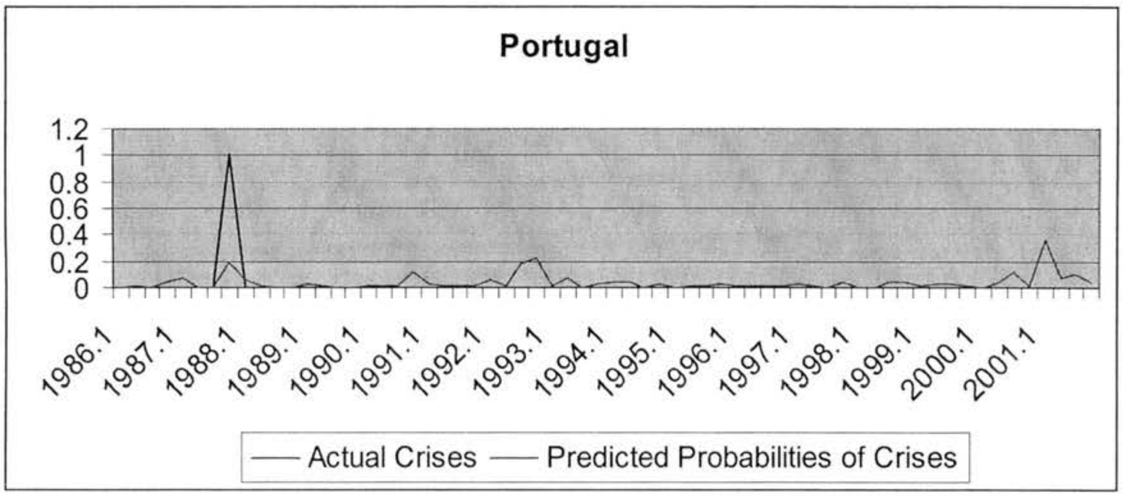
Actual Crises
Predicted Probabilities of Crises



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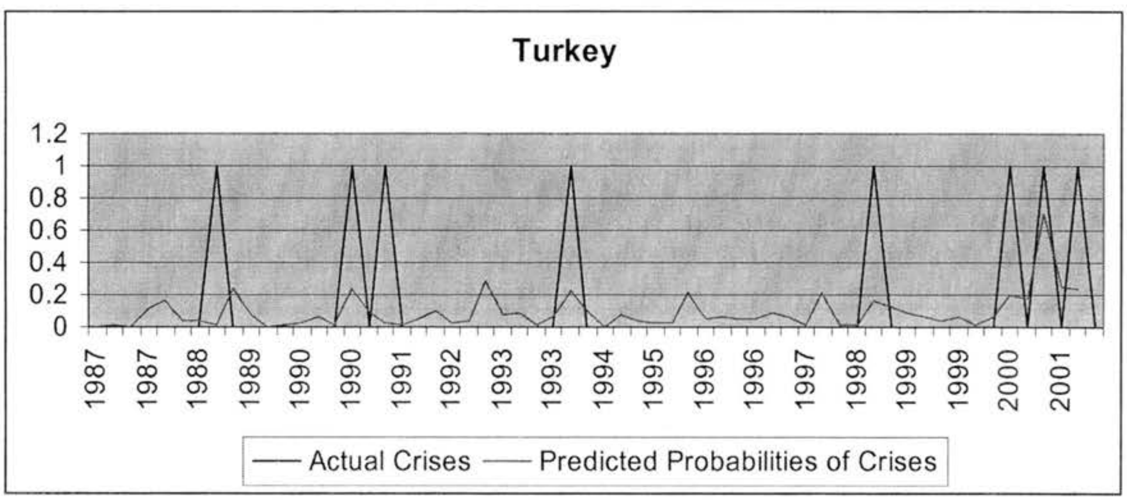
Actual Crises
Predicted Probabilities of Crises



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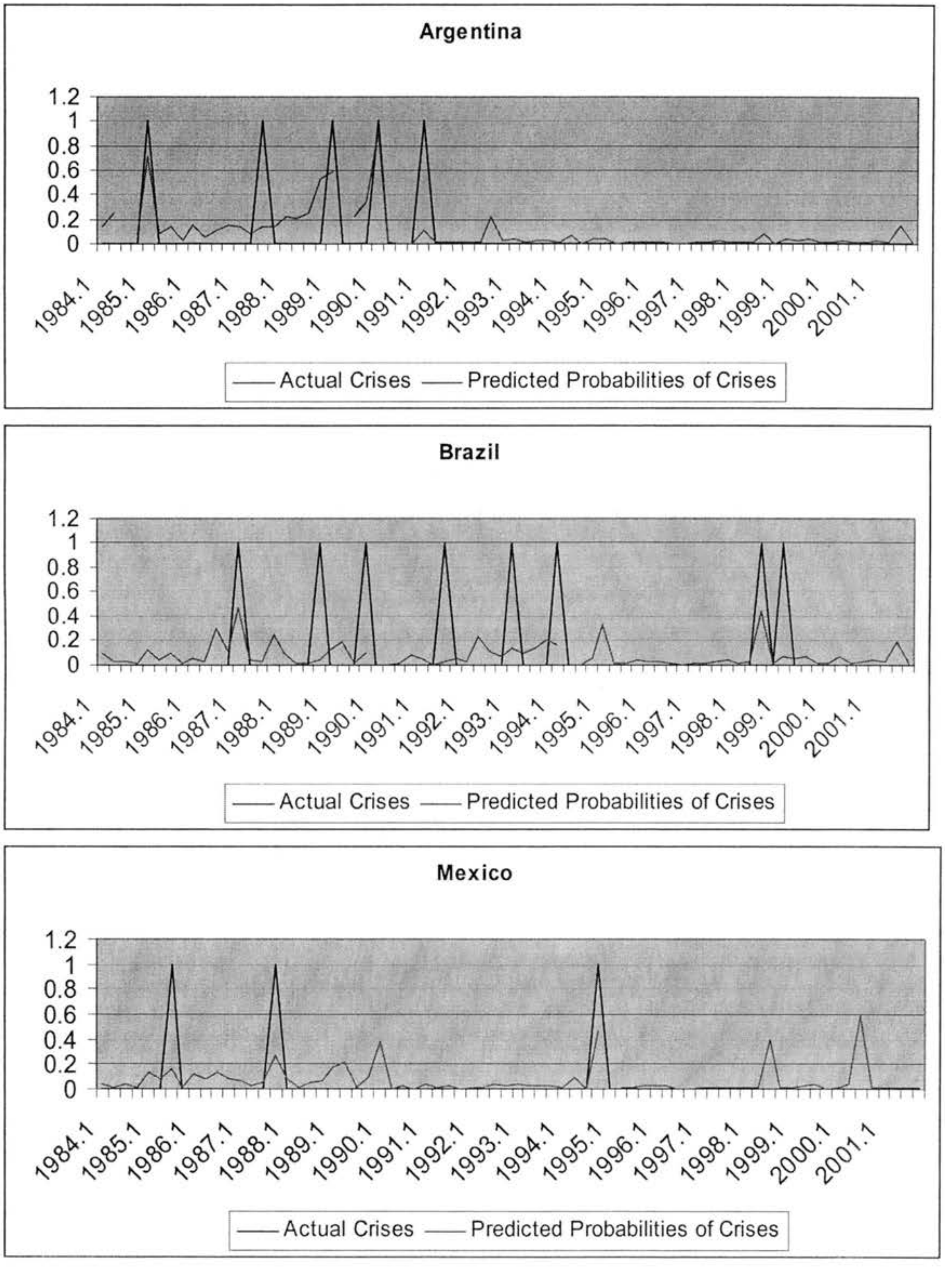
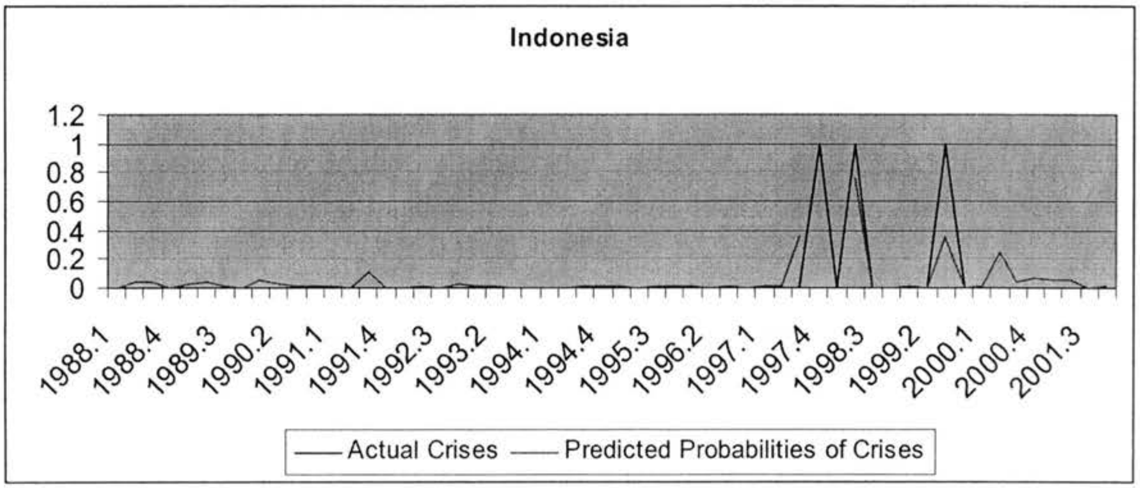
Actual Crises
Predicted Probabilities of Crises

Figure 3. Predicted Probabilities of Currency Crises

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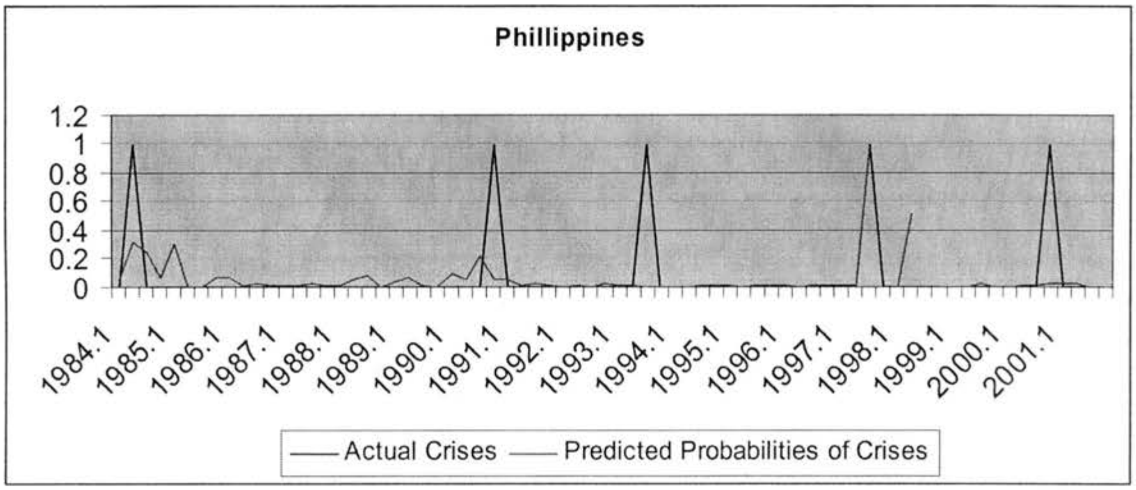
Actual Crises
Predicted Probabilities of Crises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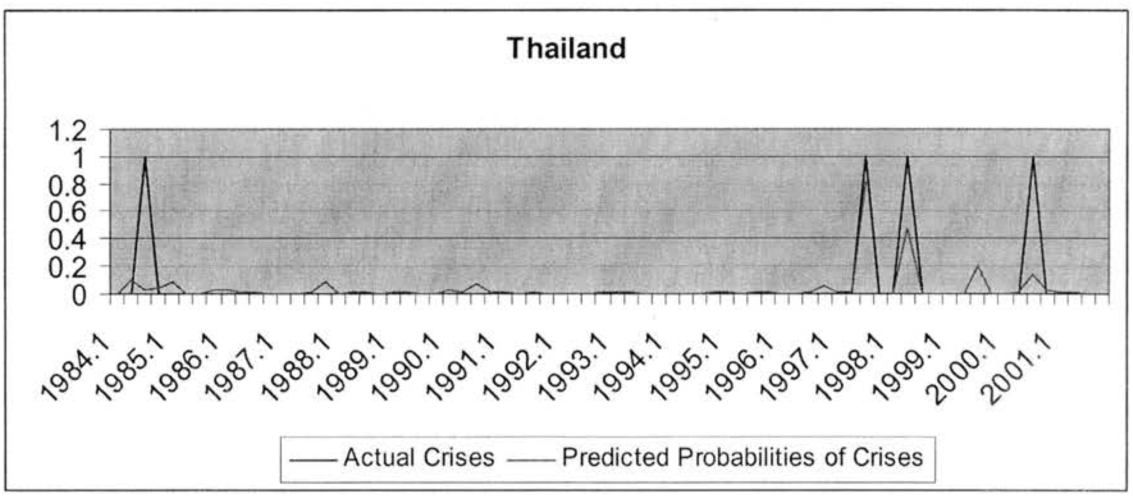
Actual Crises
Predicted Probabilities of Crises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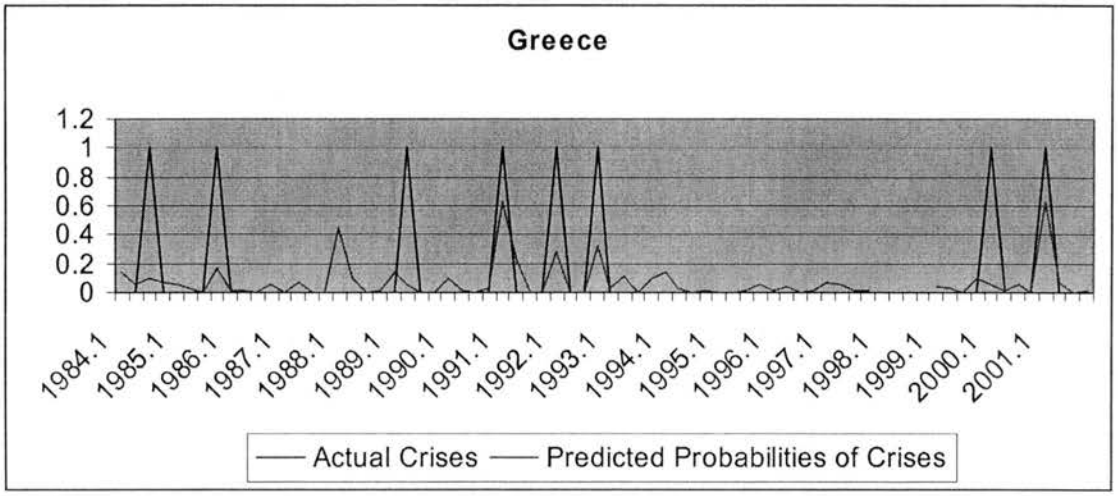
Actual Crises
Predicted Probabilities of Crises


Greece
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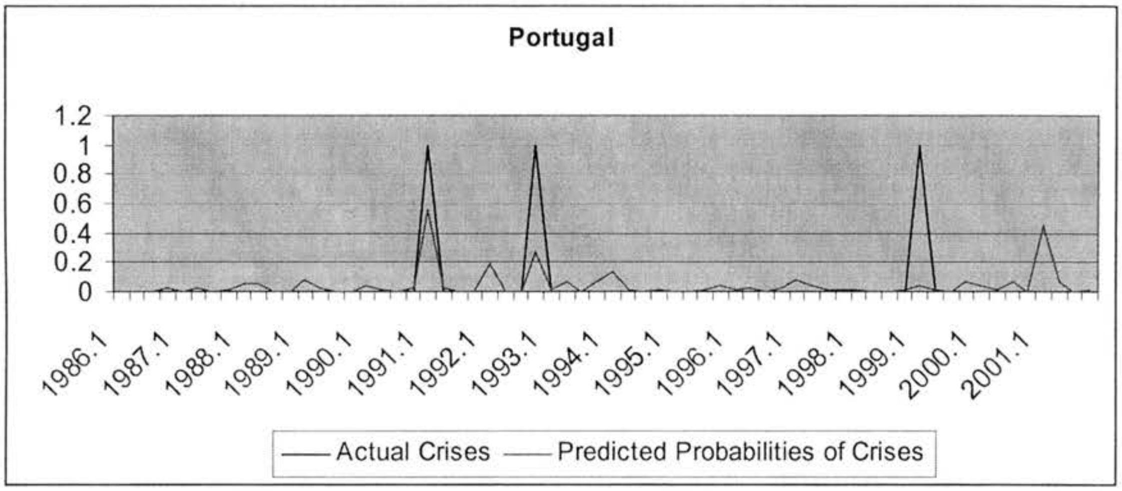
Actual Crises
Predicted Probabilities of Crises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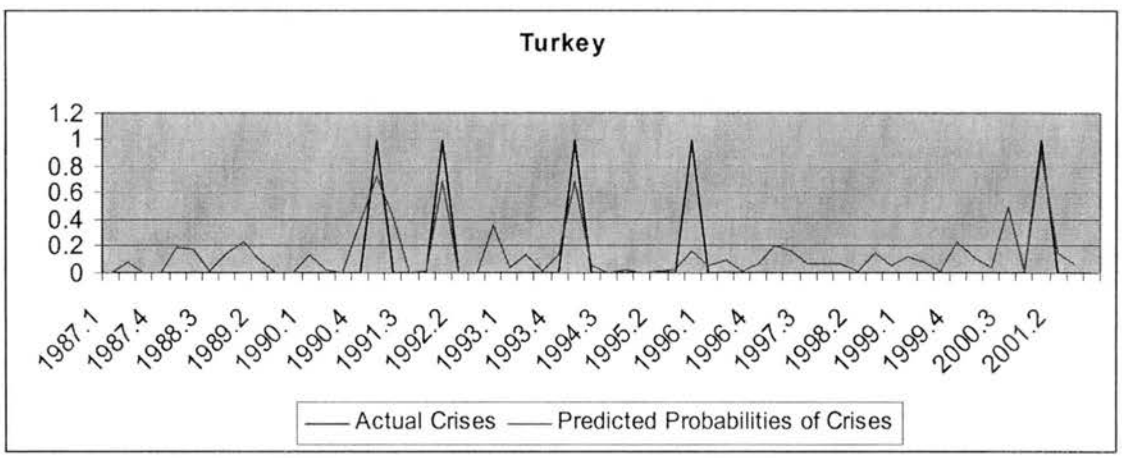
Actual Crises
Predicted Probabilities of Crises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1999.1
1999.4
2000.3
2001.2
Actual Crises
Predicted Probabilities of Crises

5.6. Results Based on Out-Of-Sample Forecasts

In this section, we test the predictive ability of our models by estimating the model on a restricted period 1984:1-1999:4 and computing an out-of-sample forecast for the remaining eight quarters. As a first step, the coefficients were estimated after the last eight quarters (2000:1 and 2001:4) in the sample are excluded. The results of these out of sample estimates are shown in Tables 15a, 16a 17a, 18a and 19a. For the most part, the results do not differ from the full sample estimates. In the second step, fitted probabilities for the excluded quarters are computed based on the estimated coefficients of the out of sample model[40]. Finally, these probabilities are used to predict crises for the excluded quarters. Table 15b and 16b shows the goodness-of-fit statistics obtained using these steps. The model has some success in forecasting stock market crises and limited success in forecasting currency crises. Table 15b compares the forecasting ability of single equation probit model II (SEM II), bivariate probit model II (BVM II), and simultaneous equation probit model (SEM) for dollar-denomidated stock market crises and currency crises. Based on our results from Table 15b, we can conclude that the simultaneous equation probit model has better forecasting ability than single equation probit model II and bivariate probit model II. For instance, the percentage of stock market crises correctly forecasted (Type I and Type II errors) is higher (lower) in

[40] Only significant coefficients are used.

simultaneous equation model than the single equation probit model II at all cutoff-point levels and than bivariate brobit model II at all cutoff-point levels except 20 percent level. Table 16b compares the forecasting ability of single equation probit model II (SEM II), bivariate probit model II (BVM II), and simultaneous equation probit model (SEM) for local currency-denominated stock market crises and currency crises.

Table 15a. Out of Sample Single Equation Probit Model Results for Stock Market Crises

Variables	Dollar-Denominated Stock Market Crises		Local Currency-Denominated Stock Market Crises	
	Model I	**Model II**	**Model I**	**Model II**
	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	1.994 (1.58)	1.114 (0.71)	2.028 (1.59)	2.219 (1.27)
Industrial Production Growth (t-1)	-2.156 (-1.49)	-2.173 (-1.51)	-1.896 (-1.34)	-1.900 (-1.34)
Regional Stock Market Return (t-1)	-1.443 (-2.58)***	-1.433 (-2.56)***	-1.832 (-3.37)***	-1.835 (-3.37)***
Portfolio Capital Inflows (t-1)	-0.628 (-2.8)***	-0.612 (-2.77)***	-0.479 (-2.11)**	-0.482 (-2.11)**
World Stock Market Return (t-1)	-0.109 (-4.80)***	-0.110 (-4.82)***	-0.138 (-6.07)***	-0.138 (-6.05)***
World Output Growth (t-1)	-0.252 (-1.02)	-0.261 (-1.04)	-0.226 (-0.90)	-0.225 (-0.89)
% Change of Nominal Exchange Rate (t-1)		0.002 (0.92)		
Currency Crises Dummy (t-1)				-0.0005 (-0.16)
Log-Likelihood p-value	-198.949 0.000	-198.543 0.000	-196.472 0.000	-196.459 0.000
McFadden-R^2	0.11	0.11	0.14	0.14
Number of Obs.	987	987	989	989
Number of Crises	59	59	61	61

Table 16a. Out of Sample Single Eguation Probit Model Results for Currency Crises

Variables	Currency Crises with Dollar-Denominated Stock Market Crises		Currency Crises with Local Currency-Denominated Stock Market Crises	
	Model I	**Model II**	**Model I**	**Model II**
	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	3.022 (2.68)***	3.136 (2.72)***	3.022 (2.68)***	3.189 (2.40)**
Political Stability (t-1)	-0.021 (-3.42)***	-0.021 (-3.42)***	-0.021 (-3.42)***	-0.021 (-3.40)***
Overvaluation (t-1)	0.0002 (1.92)*	0.0002 (1.96)**	0.0002 (1.92)*	0.0002 (1.93)*
Short Term External Debt (t-1)	0.015 (0.97)	0.014 (0.93)	0.015 (0.97)	0.015 (0.99)
Money Supply/ Reserves (t-1)	0.017 (3.03)***	0.016 (2.96)***	0.017 (3.03)***	0.017 (2.99)***
Current Account/ GDP (t-1)	-6.914 (-1.93)*	-6.657 (-1.85)*	-6.914 (-1.93)*	-6.850 (-1.91)*
Regional Market Pressure Index (t-1)	0.774 (8.88)***	0.770 (8.08)***	0.774 (8.88)***	0.773 (8.85)***
Stock Market Return (t-1)		-0.002 (-0.76)		-0.0004 (-0.23)
Log-Likelihood	-181.439	-181.137	-181.439	-181.410
p-value	0.000	0.000	0.000	0.000
McFadden-R^2	0.27	0.27	0.27	0.27
Number of Obs.	983	983	983	983
Number of Crises	69	69	69	69

Table 17a. Bivariate Probit Model Results : Dollar Denominated Stock Market Crises

	Stock Market Crises	Currency Crises	Stock Market Crises	Currency Crises
	Model I	**Model I**	**Model II**	**Model II**
Variables	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	2.717 (1.81)*		3.012 (1.65)*	
Ind. Prod. Growth (t-1)	-2.459 (-1.87)*		-2.509 (-1.86)*	
Regional Stock Market Index (t-1)	-1.576 (-2.6)***		-1.575 (-2.59)***	
Portfolio Capital Inflow (t-1)	-0.508 (-1.88)*		-0.508 (-1.87)*	
World Stock Market Index (t-1)	-0.105 (-4.6)***		-0.104 (-4.57)***	
World Output Growth (t-1)	-0.313 (-1.09)		-0.316 (-1.10)	
% Change of Exchange Rate (t-1)			-0.0006 (-0.22)	
Inflation Rate (t-1)		3.080 (2.65)***		3.224 (2.59)***
Political Stability (t-1)		-0.019 (-2.89)***		-0.019 (-2.8)***
Overvaluation (t-1)		0.0001 (1.00)		0.0001 (1.01)
Short Term External Debt (t-1)		0.016 (1.05)		0.015 (0.98)
Money Supply/ Reserves (t-1)		0.017 (3.32)***		0.016 (3.11)***
Current Account/ GDP (t-1)		-7.307 (-2.04)**		-6.647 (-1.86)*
Regional Market Pressure Index (t-1)		0.698 (7.59)***		0.687 (7.26)***
Stock Market Return (t-1)				-0.004 (-1.28)
ρ	0.542 (5.57)***		0.561 (5.58)***	

Continues from Table 17a.

Log-Likelihood	-362.131		-361.003	
Number of Observation	978	978	978	978
McFadden-R^2	21		21	
Number of Crises	57	68	57	68

Table 18a. Bivariate Probit Model Results: Local Currency Denominated Stock Market Crises

	Stock Market Crises	Currency Crises	Stock Market Crises	Currency Crises
	Model I	**Model I**	**Model II**	**Model II**
Variables	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)	Estimates (z-stat.)
Inflation Rate (t-1)	2.424 (1.64)*		2.552 (1.20)	
Ind. Prod. Growth (t-1)	-2.302 (-1.71)*		-2.329 (-1.71)*	
Regional Stock Market Index (t-1)	-1.912 (-3.4)***		-1.918 (-3.4)***	
Portfolio Capital Inflow (t-1)	-0.392 (-1.19)		-0.392 (-1.18)	
World Stock Market Index (t-1)	-0.134 (-5.9)***		-0.134 (-5.9)***	
World Output Growth (t-1)	-0.214 (-0.69)		-0.215 (-0.68)	
% Change of Exchange Rate (t-1)			-0.0003 (-0.07)	
Inflation Rate (t-1)		2.798 (1.88)*		3.212 (2.06)**
Political Stability (t-1)		-0.020 (-2.93)***		-0.020 (-2.8)***
Overvaluation (t-1)		0.0002 (1.74)*		0.0002 (1.76)*
Short Term External Debt (t-1)		0.017 (1.09)		0.018 (1.10)
Money Supply/ Reserves (t-1)		0.016 (3.06)***		0.016 (2.85)***
Current Account/ GDP (t-1)		-6.314 (-1.76)*		-6.101 (-1.69)*
Regional Market Pressure Index (t-1)		0.734 (8.17)***		0.730 (8.02)***
Stock Market Return (t-1)				-0.001 (-0.62)
ρ	0.447 (3.84)***		0.457 (3.48)***	

Continues from Table 18a.

Log-Likelihood	-368.687		-368.484	
Number of Observation	980	980	980	980
McFadden-R^2	21		21	
Number of Crises	60	68	60	68

Table 19a. Simultaneous Equation Probit Results

Variables	Dollar-denominated stock market crises Estimates (z-stat.)	Currency Crises Estimates (z-stat.)	Local Currency-denominated stock market crises Estimates (z-stat.)	Currency Crises Estimates (z-stat.)
Inflation Rate (t-1)	1.477 (1.04)		1.754 (1.35)	
Industrial Production Growth (t-1)	-2.0882 (-1.40)		-1.851 (-1.30)	
Regional Stock Market Index (t-1)	-1.347 (-2.33)**		-1.762 (-3.2)***	
Portfolio Capital Inflow (t-1)	-0.391 (-1.89)*		-0.353 (-1.65)*	
World Stock Market Index (t-1)	-0.114 (-4.8)***		-0.13 (-6.1)***	
World Output Growth (t-1)	-0.455 (-1.80)*		-0.295 (-1.20)**	
Currency Crises (t)	0.346 (4.55)***		0.149 (2.04)**	
Inflation (t-1)		2.357 (1.62)*		2.545 (2.69)***
Political Stability (t-1)		-0.017 (-2.67)***		-0.021 (-3.6)***
Overvaluation (t-1)		0.0002 (2.66)***		0.0002 (2.93)***
Short Term External Debt (t-1)		0.020 (0.90)		0.020 (0.94)
Money Supply/ Reserves (t-1)		0.016 (2.15)**		0.016 (2.18)**
Current Account/ GDP (t-1)		-5.990 (-1.81)*		-5.571 (-1.76)*
Regional Market Pressure Index (t-1)		0.6171 (6.66)***		0.723 (9.85)***
Stock Market Crises (t)		0.3737 (2.54)**		0.242 (1.95)**

Log-Likelihood	-181.316	-177.909	-191.967	-179.759
p-value for overall significance	0.0000	0.0000	0.0000	0.0000
McFadden-R^2	0.16	0.28	0.14	0.27
Number of Observation	978	978	980	980
Number of Crises	57	68	60	68

Table 15b. Prediction (Goodness-of -Fit) Ability of Out of Sample Model

	Dollar-denominated stock market crises			Currency crises				
Cutoff Percentages	10%	20%	30%	10%	20%	30%	40%	50%
% of observations correctly called (SEM II)	78	90	92	91	92	93	93	93
% of observations correctly called(BVM II)	78	92	93	93	94	95	95	95
% of observations correctly called (SEM)	80	90	93	95	95	95	95	95
% of crises correctly called (SEM II)	83	17	8	25	25	25	25	25
% of crises correctly called (BVM II)	83	67	17	25	25	25	25	25
% of crises correctly called (SEM)	92	64	27	37	25	25	25	25
% of Type I and Type II errors (SEM II)	0.22	0.10	0.080	0.083	0.069	0.061	0.061	0.061
% of Type I and Type II errors (BVM II)	0.21	0.09	0.075	0.069	0.061	0.053	0.053	0.053
% of Type I and Type II errors (SEM)	0.20	0.10	0.075	0.054	0.061	0.053	0.053	0.053

Table 16b. Prediction (Goodness-of -Fit) Ability of Out of Sample Model

	Local Currency-denominated stock market crises			Currency crises				
Cutoff Percentages	10%	20%	30%	10%	20%	30%	40%	50%
% of observations correctly called (SEM II)	76	88	92	92	94	94	94	94
% of observations correctly called(BVM II)	76	88	93	95	95	95	95	95
% of observations correctly called (SEM)	78	90	93	95	95	95	95	95
% of crises correctly called (SEM II)	82	27	9	38	25	25	25	25
% of crises correctly called (BVM II)	82	27	9	38	25	25	25	25
% of crises correctly called (SEM)	91	36	9	38	25	25	25	25
% of Type I and Type II errors (SEM II)	0.24	0.11	0.074	0.068	0.061	0.061	0.061	0.061
% of Type I and Type II errors (BVM II)	0.23	0.11	0.074	0.046	0.054	0.054	0.054	0.054
% of Type I and Type II errors (SEM)	0.25	0.13	0.074	0.046	0.054	0.054	0.054	0.054

CHAPTER VI

SUMMARY AND CONCLUSION

The main purpose of this dissertation is to identify the determinants of stock market and currency crises, and to investigate the direction of causality between the two crises in emerging markets over the 1984-2001 periods. In order to do that, we use descriptive statistics, three versions of a single equation probit model, a bivariate probit model, and a simultaneous equations probit model.

First, the descriptive statistic analysis shows that the number and annual average (frequency) of stock market and "twin" crises have increased (decreased) over time while the number, average per year and frequency of currency crises tends to be stable. Over time increases in stock market crises can be explained by increases in stock market capitalization, trading and integration. Increases in "twin" crises are a result of increases in stock market crises. Also, descriptive statistic analysis indicates that most stock market and currency crises tend to occur simultaneously rather than one leading the other. This can be seen as evidence in favor of the existence of contemporaneous relationship between stock market and currency crises.

To identify the determinants of stock market and currency crises and to test the results from descriptive statistics, we estimate stock market and currency crises using a single equation probit model. The results from the estimated stock market crisis models show that the inflation rate, industrial production growth, portfolio capital inflow, regional stock market index and world stock market index are significant factors explaining stock market crises. Of importance, the coefficient associated with the lagged currency crisis is insignificant, indicating that currency crises are not a leading indicator of stock market crises.

The results from the estimated currency crisis model show that the inflation rate, political stability, real exchange rate overvaluation, the short term external debt to reserves ratio, money supply to reserves ratio, current account to GDP ratio and the regional market pressure are significant factors explaining stock market crises. In addition, the coefficient associated with the lagged stock market crises variable is insignificant, suggesting that a stock market crisis is not a leading indicator of a currency crisis. Also, goodness-of-fit statistics shows that the predictive ability of the dollar-denominated stock market crisis model is higher than the predictive ability of the local currency-denominated stock market crisis model.

To investigate the correlation of error terms between stock market and currency crises, a bivariate probit model is estimated. The results show a highly significant, positive error term correlation between the two. The estimated correlation between currency crises and local currency-denominated (dollar denominated) stock market crises is 0.40 (0.54); this suggests a higher correlation between currency crises and dollar denominated stock market crises than local currency-denominated stock market crises. Also, goodness-of-fit statistics showed that the predictive ability of the bivariate probit model is higher than the predictive ability of the single equation probit model.

In order to correct for possible endogeneity bias and to obtain consistent estimates of the direct effects between the two crises, we employ a simultaneous equations probit model where stock market and currency crises are treated as endogenous variables and account for the simultaneous nature of the relationship.

The results show that a one percentage point increase in the contemporaneous probability of a currency crisis raises the probability of a dollar-denominated stock market (local currency-dominated stock market) crisis by 0.037 (0.018) percentage points (significant at the 1 percent level) and a one percentage point increase in the contemporaneous probability of a dollar-denominated stock market (local currency-dominated stock market) crisis raises the probability of currency crisis by 0.020 (0.014) percentage points (significant at the 5 (10) percent level). This is evidence that stock market crises should be treated as endogenous in currency crises models and currency crises should be treated as endogenous in the stock market crises models and a simultaneous equation probit model is the appropriate model.

Therefore, we conclude that there is contemporaneous relationship between stock market and currency crises in emerging market economies, even when controlling for endogeneity bias and other explanatory variables. Also, the probability of a currency crisis on stock market crisis (0.037) is greater than the probability of a stock market crisis on currency crises (0.020). Finally, goodness-of-fit statistics showed that the simultaneous equation probit models have more satisfactory forecasting ability than single equation and bivariate probit models.

REFERENCES

Abdalla, I. S. A., V. Murinde (1997), " Exchange Rate and Stock Price Interactions in Emerging Financial Markets: Evidence on India, Korea, Pakistan, and the Philippines." *Applied Financial Economics*, Vol.7, pp. 25-35.

Aggarwal, R. (1981), " Exchange Rates and Stock Prices: A Study of the US Capital Markets under Floating Exchange Rates." *Akron Business and Economic Review* (Fall), Vol.12, pp. 7-12.

Bahmani-Oskooee, M., and Sohrabian, A., (1992), "Stock Prices and the Effective Exchange Rate of the Dollar." *Applied Economics*, Vol. 24, No.4, pp.459-464.

Bilson, C. M., Brailsford, T. J., and Hooper, V. J. (2001), "Selecting Macroeconomic Variables as Explanatory Factors of Emerging Stock Market Returns." *Pasific-Basin Finance Journal*, Vol.9, pp.401-426.

Blanco, Herminio and Garber, Peter M. (1986), " Recurrent Devaluation and Speculative Attacks on the Mexican Peso." *Journal of Political Economy*, Vol.94, No.1, pp. 148-166.

Block, A. S., (2003), "Political Conditions and Currency Crises in Emerging Markets." *Emerging Markets Review*, Vol.4, pp.287-309.

Bond, T. J. (1999), "Capital Inflows to Asia: The Role of Monetary Policy." *Transition Economies in Comparative Countries*, pp.61-70.

Calvo, Guillermo A. and Mendoza, Enrique G. (1996), "Mexico's Balance of Payments Crisis: A Chronicle of A Death Foretold." *Journal of International Economics*, Vol. 41, (November), pp. 235-264.

Caramazza, F., Ricci, L., and Salgoda, R. (2000), "Trade and Financial Contagion in Currency Crises." *International Monetary Fund Working Paper*, no.55.

Chen, N. F., Roll, R., and Ross, S. A. (1986), "Economic Forces and the Stock Market." *Journal of Business*, Vol.59, pp. 383-403.

Cole, Harold L. and Kehoe, Timothy J. (1996), " A Self-Fulfilling Model of Mexico's 1994-1995 Debt Crisis." *Journal of International Economics*, Vol. 41, pp. 309-330.

Cumby, R. E., and Van Wijenbergen, S. (1989), "Financial Policy and Speculative Runs with a Crawling Peg: Argentina1979-1981." *Journal of International Economics*, Vol.27, pp.111-127.

Dornbusch, R., Goldfajn, I., and Valdes, R. (1995), "Currency Crises and Collapses." *Brooking Papers on Economics Activity*, Vol.2, pp. 219-270.

Dumas, B., and B. Solnik (1995), "The World Price of Foreign Exchange Risk." *The Journal of Finance*, Vol.50, no.2 (June), pp. 445-479.

Edin, P., A., and Vredin, A. (1993), "Devaluation Risks in Target Zones: Evidence from The Nordic Countries." *The Economic Journal*, Vol.103, (January), pp. 161-175.

Eichengren, Barry, Rose, Andrew K. and Wyplosz, Charles (1995), " Exchange Rate Mayhem: The Antecedents and Aftermath of Speculative Attacks." *Economic Policy*, October.

Eichengren, B., Rose, A. K. and Wyplosz, C. (1996), "Contagious Currency Crises." *NBER Working Paper*, No.5681.

Fama, Eugene F. (1981), " Stock Returns, Real Activity, Inflation, and Money." *The American Economic Review*, Vol.71 (September), pp. 454-565.

Ferson, W. E., Harvey C. R. (1994), "Sources of Risk and Expected Return in Global Equity Markets." *Journal of Banking and Finance*, Vol.18, pp. 775-803.

Fifield, S. G. M., Power, D. M. and Sinclair, C. D. (2002), "Macroeconomic Factors and Share Return: An Analysis Using Emerging Market Data." *International Journal of Finance and Economics*, Vol. 7, pp51-62.

Flood, Robert P., Garber, Peter M. and Kramer, Charles (1996), "Collapsing Exchange Rate Regime: Another Linear Example." *Journal of International Economics*, Vol. 41, November, pp. 223-234.

Flood, Robert P. and Garber, Peter M. (1984), "Collapsing Exchange Rate Regime: Same Linear Example." *Journal of International Economics*, Vol.17, pp. 1-13.

Flood, Robert P. and Marion, Nancy P. (1996), "Speculative Attacks: Fundamentals and Self-Fulfilling Prophecies." *NBER Working Paper*, No.5789, October.

Flood, Robert P. and Marion, Nancy P. (1998), "Perspectives on The Recent Currency Crises Literature." *NBER Working Paper*, No. 6380, January.

Flood, Robert P. and Marion, Nancy P. (2000), "Self-Fulfilling Risk Predictions: An Application to Speculative Attacks." *Journal of International Economics*, Vol. 50, pp. 245-268.

Frankel, Jeffrey A. and Rose, Andrew K. (1996), "Currency Crashes in Emerging Markets: An Empirical Treatment." *Journal of International Economics*, Vol.41, pp.351-366.

Fratzscher, M. (2002), "On Currency Crises and Contagion." *European Central Bank Working Paper*, No.139.

Geske, Robert, and Roll, Richard (1983), "The Fiscal and Monetary Linkage between Stock Returns and Inflation." *The Journal of Finance*, Vol.38 (March), pp. 1-33.

Glen, J. (2002), "Devaluation and Emerging Stock Markets." *Emerging Markets Review*, Vol.3, pp. 409-428.

Glick, R., Moreno, R. and Spiegel, M., M.(2001), "Financial Crises in Emerging Markets" *Cambridge University Press.*

Goldfajn, Ilan and Valdes, Rodrigo O. (1997), "Are Currency Crises Predictable?" *IMF Working Paper*, No. 159, December.

Goldstein, M. (1998), "The Financial Crises: Causes, Cures, and Systemic Implications." Policy Analyses in International Economics, Vol.55, *Institute for International Economics.*

Greene, William H. (2000), Econometric Analysis, *Practice Hall.*

Habibullah, M. S., and Baharumshah, A. Z. (1996), "Money, Output and Stock Prices in Malaysia; An Application of The Cointegration Tests." *International Economic Journal*, Vol.10, No.2, Summer, pp.121-130.

Harvey, C., R. (1995), "Predictable Risk and Return in Emerging Markets." *Review of Financial Studies*, Vol.8, pp.773-816.

Jorion, Philippe (1991), "The Pricing of Exchange Rate Risk in the Stock Market." *Journal of Financial and Quantitative Analysis*, Vol. 26, no. 3 (September), pp. 363-376.

Kaminsky, Graciela L., and Reinhart, Carmen M. (1999), " The Twin Crises: The Cause of Banking and Balance-of-Payment Problems." *American Economic Review*, June, pp. 473-500.

Kaminsky, Graciela L., Lizondo, Saul and Reinhart, Carmen M. (1997), "Leading Indicator Of Currency Crises." *Policy Research Working Paper*, No. 1852, December.

Klein, Michael W. and Marion, Nancy P. (1994), "Explaining The Duration of Exchange-Rate Pegs." *NBER Working Paper*, No. 4651, February.

Krugman, Paul R. (1979), "A Model of Balance-of –Payments Crises." *Journal of Money, Credit, and Banking*, Vol. 11, No. 25, pp. 311-325.

Kwon, C. S., and Bacon, F. W. (1997), "The Effect of Macroeconomic Variables on Stock Market Returns in Developing Markets." *Multinational Business Review*, Fall, pp.63-70.

Ma, C. K., G. W. Kao (1990), "On Exchange Rate Changes and Stock Price Reactions." *Journal of Business, Finance, and Accounting*, Vol.7, no.3 (Summer), pp. 441-449.

Maddala, G.S. (1983), Limited-Dependent and Qualitative Variables in Econometrics, NewYork: *Cambridge University Press*.

Mallar, Charles D. (1977), "The Estimation of Simultaneous Probability Models." *Econometrica*, Vol.45, no.7, pp.1717-1722.

Malliaris, A. G., and Urritia, Jorge L. (1992), "The International Crash of October 1987: Causality Test." *Journal of Financial and Quantitative Analysis*, Vol.27 (September), pp. 353-363.

McCarthy, Joseph. Najand, Mohammad. Seifert, Bruce (1990), " Empirical Test of the Proxy Hypothesis." *The Financial Review*, Vol.25 (May), pp. 251-263.

Milessi, F., and Ranzi, G. A. (1996), "Current Account Sustainability: Selected East Asian and Latin American Experiences." *NBER Working Paper*, No.5791, October.

Moreno, R. (1995), "Macroeconomics Behavior During Periods of Speculative Pressure or Realignment: Evidence from Pacific Basin Economies." *Economic Review*, Vol.3, pp. 1-17.

Nieh, C. C., and Lee, C. H. (2001), "Dynamic Relationship Between Stock Prices and Exchange Rates for G-7 Countries." *The Quarterly Review of Economics and Finance*, Vol.41, pp.477-490.

Obstfeld, Maurice (1984), " Balance of Payment Crises and Devaluation." *Journal of Money, Credit, and Banking*, Vol. 16, No. 2, May, pp. 208-217.

Obstfeld, Maurice (1986), " Rational And Self-Fulfilling Balance of Payment Crises." *American Economic Review*, Vol. 76, No.1, March, pp. 72-81.

Obstfeld, Maurice (1994), " The Logic of Currency Crises." *NBER Working Paper*, No. 4640, February.

Obstfeld, Maurice (1996), "Models of Currency Crises With Self-Fulfilling Features." *European Economic Review*, Vol. 40, pp. 1037-1047.

Otker, Inci and Ceyla, Pazarbasioglu (1995), "Speculative Attacks and Currency Crises: The Mexican Experience." *IMF Working Paper*, November.

Ozkan, F. Gulcin and Alan Sutherland (1995), "Policy Measures to Avoid A Currency Crisis." *The Economic Journal*, Vol. 105, March, pp. 510-519.

Patel, S., and Sarkar, A. (1998), "Stock Market Crises in Developed and Emerging Markets." *Financial Analysts Journal*, Vol.54, No.6, Nov/Dec, pp. 50-61.

Patnaik, P. (1994), "Macro-economic Policy in Time of Globalization." *Economic and Political Weekly*, Vol. 29, April, pp. 917-921.

Perotti, E. C., and Oijen, P. (2001), "Privatization, Political Risk and Stock Market Development in Emerging Economies." *Journal of International Money and Finance*, Vol.20, pp. 43-69.

Roll, Richard (1988), "The International Crash of October 1987." *Financial Analysts Journal*, (September/October), pp. 19-35.

Sachs, Jeffrey and Radelet, Steven (1998)," The Onset of the East Asian Financial Crisis." *NBER Working Paper*, No. 6680.

Smith, C. E. (1992), "Stock Market and the Exchange Rate: A Multi Country Approach." *Journal of Macroeconomics*, Vol.14, no.4 (Fall), pp607-629.

Solnik, B. H. (1974), " An Equilibrium Model of the International Capital Market." *Journal of Financial Economy*, Vol.8, pp. 500-524.

Solnik, B. H. (1987), "Using Financial Prices to Test Exchange Rate Models: A Note." *The Journal of Finance*, Vol.24, no.1 (March), pp. 141-149.

Stulz, R., M. (1986), "Asset Pricing and Expected Inflation." The Journal of Finance, Vol.41, March, pp. 209-223.

Thorbecke, Willem (1994), " Trade Deficit News, Systematic Risk and the Crash of 1987." *Eastern Economic Journal*, Vol.20 (Winter), pp. 97-114.

Tornell, Aaron (1999), " Common Fundamentals In The Tequlia and Asian Crises." *NBER Working Paper*, No. 7139, may.

Appendix 1. Data Sources

Most of our data come from the International Financial Statistic CD-ROM database. International Financial Corporation's Emerging Market Dataset and Morgan Stanley Countries Index provide stock market indexes. Political risk variable data come from the International Country Risk Guide.

Data Construction:

Inflation rate: Log difference of Consumer Price Index (IFS line 64).

Inflation rate (t-1) = Log CPI (t-1) – Log (t-2)

Industrial Production Growth: Log difference of Industrial Production (IFS line 66). Industrial Production Growth (t-1) = Log IP (t-1) – Log IP (t-2)

Portfolio Capital Inflow: Portfolio capital inflow (IFS line 78 bgd) divided by market capitalization (IFC).

Short Term External Debt to Reserves: Liabilities of monetary authorities (IFS line 4d) + liabilities of banks (IFS line7bd) + liabilities of other banking institutions (IFS line 7fd) divided by non-gold reserves (IFS line1Ld).

Money Supply to Reserves: Money supply (IFS line 34+35) converted to dollars (divided by average-period nominal exchange rate IFS line rf) divided by IFS line 1Ld.

Current Account to GDP: Current Account (IFS line 76ald) divided by GDP (IFS line 99b).

Political Stability: the measure on political stability variable data comes from the International Country Risk Guide. This variable constructed from several components and weighted as:

a. Government Stability (12)
b. Socio-Economic Conditions (12)
c. Investment Profile (12)
d. Internal Conflict (12)
e. External Conflict (12)
f. Corruption (6)
g. Military in Politics (6)
h. Religion in Politics (6)
i. Law and Order (6)
j. Ethnic Tension (6)
k. Democratic Accountability (6)
l. Bureaucracy Quality (4)

Number in parentheses show maximum weight these component can contribute political risk variable. Increase in these components is a sign that political risk decreases.

Real Exchange Rate Overvaluation: End of period nominal exchange rate (IFS line rf) deflated by consumer price index (IFS line 64) to compute real exchange rates. To construct the overvaluation measure we use deviations of real exchange rates from previous 4-quarter moving averages. (The results multiplied by -1). Therefore, a positive numbers show overvaluations.

Regional Stock Market Return: International Financial Corporation's Emerging Market Dataset and Morgan Stanley Countries Index. In the first step, we constructed dollar denominated regional stock market index for each countries. For instance, the regional stock market index for Argentina is computed as: Sum of the stock market index of Brazil, Chile, Columbia, Peru, Venezuela and Mexico divided by 6 then we take log differences of regional stock market indexes to construct regional stock market returns.

Regional Market Pressure Index: Constructed from individual countries market pressure index. For instance, the regional market pressure index for Argentina is the average of Brazil, Chile, Columbia, Peru, Venezuela and Mexico's market pressure indexes.

World Output Growth: Weighted average of the U.S., Japan and Germany's GDP. IFS line 99b. Physical distance is used as a weight. In first step, we constructed a world output for each country. For instance, world output for Argentina constructed as: (GDPus / Dus) + (GDPj / Dj) + (GDPgr / Dgr). US, J and GR are the United States, Japan and Germany, respectively and Dus is physical distance between the U.S. and Argentina. We take log differences of world output to construct world output returns.

World Stock Market Return: Weighted average of the U.S., Japan and Germany's stocks market index. IFS line 62. Physical distance used as a weight. In first step, we constructed a world stock market index for each country. For instance, world stock market index for Argentina constructed as: (SMIus / Dus) + (SMIj / Dj) + (SMIgr / Dgr). US, J and GR are the United States, Japan and Germany, respectively and Dus is physical distance between the U.S. and Argentina. We take log differences of world stock market index to construct world output returns.

2

VITA

Sakir Gormus

Thesis: STOCK MARKET AND CURRENCY CRISES IN EMERGING ECONOMIES: A SIMULTANEOUS APPROACH

Major Field: Economics

Biographical:

Personal Data: Born in Giresun, Turkey, On January 1, 1969, the son of Ali and Ayse Gormus.

Education: Received Bachelor of Science degree in Economics from University of Istanbul, Istanbul in August 1993. Received Master of Science degree in Economics from University of Illinois at Urbana-Champaign, Illinois in May 1997. Completed the requirements for the Ph.D. degree with a major in Economy at Oklahoma State University in July 2004.