Predicting Currency Crises
With a Nested Logit Model

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Predicting Currency Crises
With a Nested Logit Model*

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Abstract

This paper provides a unique methodology – a multi-state nested logit model – to evaluate the currency crisis probabilities and the probabilities of successful defense by the central bank given speculative attacks. This model provides better forecasts compared to the benchmark signal indicator approach and it provides important policy implications: it sheds light on the relative importance of international illiquidity, financial fragility and excessive fiscal deficits in triggering speculative attacks. The findings in this paper also provide empirical evidence on the importance of the “overborrowing syndrome” in triggering speculative attacks. Thus a policy advice to central banks is to strengthen the supervision in the banking sector to reduce the currency and maturity mismatch in the assets and liabilities side.

*Thanks to Professor Lawrence J. Lau and Ronald I. McKinnon for helpful comments. All remaining errors are my own.
1 Introduction

During the past decades there have been numerous studies in finding reliable indicators of currency crises. The studies that are most widely cited include, among others, Sach, Tornell and Velasco(1996), Frankel and Rose(1996), Kaminsky, Lizondo and Reinhart(1997), Kaminsky(1998) and Hali J.Edison(2000). The methodologies used in the literature can be classified into two main categories: The signal extraction approach (indicator approach) developed by Kaminsky(1998) and the regression approach — multinomial logit approach by Eichengreen, Rose and Wyplosz(1995), binary probit approach by Frankel and Rose(1996) and ordinary least squares approach by Sach, Tornell and Velasco(1996).

However, in my opinion, there are three limitations to these approaches. First of all, the signal extraction approach is a univariate approach. That is, signals from different indicators are considered separately and the interrelationship of different indicators is ignored. Moreover, the signal extraction approach often use composite index to summarize the signals by a number of indicators and the weights used in constructing the composite index are arbitrary. Secondly, in the signal extraction approach, the probit approach and the OLS approach, no distinction is made between successful and unsuccessful defense of speculative attacks, even though the dynamic of economic variables is very different around episodes of successful and unsuccessful attacks. Eichengreen, Rose and Wyplosz(1995) was the first to use a multinomial logit approach to study episodes of successful and unsuccessful attacks. However, this method is well known to have the problem of “Independence of irrelevant alternatives (IIA)”: the ratio of probabilities between any two choices is unaffected by the availability of a third choice. Thirdly, for the signal extraction approach, one cannot use standard statistical tests to evaluate the robustness of the results. For these reasons, the model developed in this paper is used to rectify these deficiencies. A major contribution of this paper is to develop an empirical model that allows economists to evaluate the probabilities of speculative attacks and the likelihood of the central bank successfully defending any speculative attack based on a multivariate optimization model.

The indicators included in this empirical model are inspired by the three generations of theoretical models of currency crises. The “first generation model” (Krugman, 1979 and Flood and Garber, 1984a) suggested that an exogenous government budget deficit lay at the root of the balance of payment crises. Excessively expansionary fiscal policy is financed by issuing domestic credit. The authorities announce that they are prepared to peg the exchange rate until reserves reach a specified lower bound, at which point they shift to floating. With the government pegging the relative value of return on domestic and foreign-currency-denominated assets(in Krugman’s model, the exchange rate), investors wish to hold domestic and foreign assets in fixed proportions. They rebalance their portfolios by exchanging some of the additional domestic assets for foreign exchange reserves of the central bank. Since they exchange only a portion of the increment supply (portfolio proportions remaining constant), the shadow exchange rate, which will prevail in the event that the pegging policy is abandoned, depreciates gradually over time. When it first equals the current exchange rate, investors attack the peg, depleting the authorities’ remaining reserves, for to do otherwise would make available arbitrage profits and imply market inefficiency. The empirical implication of the model, then, is that one should observe expansionary fiscal and monetary policies prior to speculative attacks.
and a widening of the differential between domestic and foreign interest rates due to domestic credit growth. Those policies should be accompanied by an increasingly overvalued exchange rate and a gradual decline in international reserves over an extended period.

The “second generation” model is developed by Flood and Garber (1984b) and Obstfeld (1986) who formulated the possibility of self-fulfilling speculative attacks. In their models, multiple equilibria exist in the foreign exchange market because of contingent nature of the authorities’ policy rule. In the absence of an attack, monetary policy and fiscal policies are in balance, and nothing prevents the indefinite maintenance of the currently prevailing currency peg. If and only if attacked, however, the authorities switch to more accommodating policies consistent with a lower level for the exchange rate. In this setting, speculative attacks can be self-fulfilling. But there is no reason to anticipate adverse trends in monetary and fiscal policies, wages and prices, reserves or the trade balance prior to the attack.

However, in the case of 1997 East Asian Crisis, neither of the first and second generation stories seem to be relevant (Krugman 1999). In regard of this, the third generation model is developed. The third generation model suggested that a country’s financial system is internationally illiquid if its potential short term obligations in foreign currency exceed the amount of foreign currency it can have access to in short notice. This condition may be crucial for the existence of financial crises and/or exchange rate collapses (Chang and Velasco, 1998a and 1998b). Chang and Velasco argue that the 1997-98 crises in Asia were in fact a consequence of international illiquidity. This follows from an analysis of empirical indicators of illiquidity and other macroeconomic statistics. They trace the emergence of illiquidity to financial liberalization, the shortening of the foreign debt structure, and the currency denomination of assets versus liabilities. They explain how financial crises became exchange rate collapses due to a government policy of both fixed exchange rates and acting as lending of last resort. Moderately weak fundamentals (especially real exchange rate overvaluation) and small changes in exogenous circumstances (term of trade, interest rates differential) can cause large changes in asset prices and economic activity. The magnifying mechanism is the financial system, whose collapse causes costly asset liquidation. The “over-borrowing syndrome” was modeled in advance of the 1997 East Asian Crisis by Mckinnon and Pill(1996).

The theoretical models of currency crises suggested that crises may be predictable with fully rational speculators. In this paper, a nested logit model is developed to generate insights about the relative vulnerability of different countries.

The paper is organized as follows: section 2 provides a literature review on the indicators of currency crises; section 3 discusses the variables of interest; section 4 describes the empirical model; section 5 gives a data description; section 6 reports the results of the nested logit model and gives a sensitive analysis; section 7 evaluates the performance of the model by testing the predictability power of the nested logit model and section 8 concludes.
2 Literature Review

This section summarizes the main findings in the speculative attacks and currency crises literature. The aim is to provide a comprehensive survey of the empirical literature on currency crises. While the papers written on or before 1997 are nicely summarized in Kaminsky, Lizondo and Reinhart(1997), this section provides an update on the recent empirical literature.

The traditional literature stressed that currency crises were caused by weak fundamentals such as excessively expansionary fiscal and monetary policy, which results in a persistent loss of international reserves that ultimately forced the central banks to abandon the exchange rate parity. The indicators used in these traditional models are ratio of fiscal deficit to GDP, ratio of M2 to international reserves, percentage losses of international reserves and real exchange rate appreciation (Bilson(1979), Collins(1995), Edwards(1989), Kaminsky and Reinhart(1996), Moreno(1995), Otker and Pazarbasiozlu(1994,1995) and Sachs, Tornell and Velasco(1995)).

More recent literature stresses the role played by currency mismatch and maturity mismatch in triggering currency crises. The key indicators studied by the recent papers are excessive short term external debts, variables related to lending boom and overborrowing cycles (Frankel and Rose(1996), Sachs,Tornell and Velasco(1995), Kaminsky(1998), Berg and Pattillo(1998) and Hali(2000)). Recent models suggested that currency crises may develop without any noticeable changes in economic fundamentals.

Table 1 provides a summary of recent empirical studies on currency crises. A similar summary for papers written before 1997 is in Kaminsky, Lizondo and Reinhart(1997). The first column lists the study, the second column describes the sample periods and the frequency of the data. The third column provides information on the countries covered. The fourth and fifth column list the indicators used in the papers and the preferred indicators. The sixth column sketches the methodology used and the last column provides some comments of the studies.
3 The Variables of Interest

In this section, the key variables relevant to the speculative attack literature are examined: interest rate differential, short international liquidity, real exchange rate appreciation, ratio of quasi-money to reserves and ratio of fiscal deficit to GDP.

3.1 Interest Rate Differential

It is critical to look at the interest rate differential because of two reasons: first, interest differential is an important contributor to the unhedged overborrowing syndrome before the 1997 East Asian Crisis. Mckinnon(2000)'s analysis is worth quoting at length:

"The incomplete markets make it difficult and expensive to hedge foreign exchange risk. Importers more than exporters find it difficult to cover forward commercial transactions, including ordinary trade credit, which must be continually repaid within a few days and weeks.

• Consider the case of a Thai importer who is not liquidity coonstrained but must repay dollar trade credit in 30 days. If foreign exchange regulations permit, the cheapest way to hedge would be to buy dollars today to hold on deposit for 30 days. But consider the opportunity cost of doing so. Before the crisis of 1997-98, interest rates in baht deposits averaged about 5 percentage points higher than interest rate on dollar deposits. Relative to going unhedged by holding higher-interest baht deposits for 30 days, this (annualized) 5 percent point margin is the importer’s cost of hedging.

• Now consider the case of an illiquid Thai importer, one who does not yet have ready liquid assets for repaying the debt. To fashion the same kind hedge, he must first borrow baht from the bank, and in 1995-96 the prime loan rate in Thailand was 13.5 percent (see figure 1(a)). By investing in a dollar deposit at 5 percent, he is hedged, but the opportunity cost of doing so has risen to 8.5 percentage points.

True, the illiquid Thai importer is more likely to resort to the futures market to buy dollars forward on an organized exchange if it exists. However, the cost of the forward premium on dollars over baht, which will be somewhere between the opportunity cost of the liquid importer and the illiquid, for example, between 5 and 8.5 percentage points in the example. With large interest differentials between the center country and the periphery, merchants and manufacturers find the opportunity cost of hedging to be correspondingly high. ... In East Asian emerging markets, the margin of temptation to borrow unhedged in foreign exchange can be overwhelming when interet rate differentials are large."

Second, the interest differential is a good measure of the expected exchange rate depreciation and risk premium:
\[ i - i^* = E\hat{e} + \rho_{\text{currency}} \]

where \( i \) and \( i^* \) is the domestic and foreign interest rate respectively, \( E\hat{e} \) is the expected exchange rate depreciation and \( \rho_{\text{currency}} \) is the currency risk premium. A large interest differential implies a market expectation of large exchange rate depreciation or currency risk, and hence is an evidence of self-fulfilling crises (Eichengreen, Rose and Wyplosz 1995).

### 3.2 Short Term International Liquidity

Short term liquidity variable is critical to our analysis. The ratio of sum of short term external debt, cumulative portfolio liabilities and 6 month’s import to foreign exchange reserves is used as the measure for short term international liquidity.

First of all, the increases in short-term interest threaten bankruptcy much more if banks and firms have short-term liquid liabilities relative to their longer-term, less liquid assets. One reason is the “original sin” situaton as suggested by Mckinnon (2001). “Original sin” is a situation in which the domestic currency cannot be used to borrow abroad or to borrow long term, even domestically. In the presence of this incompleteness, financial fragility is unavoidable because all domestic investments will have either a currency mismatch (projects that guarantee pesos will be financed with dollars) or a maturity mismatch (long term projects will be financed by short term loans). As pointed out in the third generation currency crises model, countries with high ratios of hard currency short term liabilities to liquid assets were extremely vulnerable to a reversal of capital inflows, which occurred massively in the second half of 1997 in east Asia.

Secondly, the cumulative portfolio liabilities are likely to reflect the ins and outs of hot money. The sudden switch from capital inflows to capital outflows left the central banks helpless to prevent their currencies from depreciating. In the context of the recent Asian currency crisis, it has been found that foreign portfolio investors have been positive feedback traders (rushing to buy when the market is booming and rushing to sell when the market is declining), and eager to mimic each other’s behavior ignoring information about the fundamentals (Kim and Wei, 2000). There are theoretical models in which herding behaviors destabilize the prices.

Thirdly, four to six month’s import equivalence of foreign exchange reserves is a cushion threshold set by IMF to smooth import transactions in the episodes when exporters expect a currency depreciation and hence unwilling to convert foreign currency export earnings to domestic currency at the current exchange rate.

Figure 1(b) reveals that the ratio exceeds two in all the East Asian Crisis Countries in 1995 to 1997. This suggests a financially fragile situation in the sense that international reserves would not have been sufficient to repay the short term debt and portfolio liabilities had foreign banks and foreign investors decided not to roll them over. Figure 2(a) reveals the short term and long term components of external debts and Figure 2(b) shows the total external debt and foreign exchange reserves in selected East Asian and Latin American countries in 1993 – 2000.
Chang and Velasco (1998c) suggested that financial liberalization plays a key role in the Asian financial vulnerability. The trend included the deregulation of interest rates and the easing of reserve requirements on banks; in Korea, for instance, lending interest rates were liberalized between 1991 and 1993, and the marginal reserve requirements, which had been as high as 30 percent around 1990, were reduced to seven percent in 1996. In addition, policies oriented towards the promotion of competition and entry of financial institutions were enacted: requirements on the opening and branching of banks were relaxed in Indonesia and Malaysia in 1988-89; restrictions on activities of foreign banks were eased in Korea and Thailand in 1991 and 1993 respectively.

3.3 Real Exchange Rate Appreciation

The real exchange rate appreciation has received much attention in the speculative attack literature. It is quite striking that almost all econometric studies that were taken concluded that real exchange rate appreciation was a major indicator.

In 1990-1994, capital inflows to Mexico are massive, averaging more than 6.7 percent of Mexican GDP. The large inflows pushed the real exchange rate up. Chile’s appreciation was 30 percent between 1978 (the year an exchange rate stabilization was adopted) and year-end 1981. Estimates for Mexico’s varied, but common opinion put the real appreciation accumulated in 1988-1993 at 15-20 percentage points. For East Asian countries, real exchange rate appreciation also amounts to 15-20 percentage points between 1986 and 1996 (see figure 1(c)).

3.4 Ratio of Quasi Money to Foreign Exchange Reserves

Ratio of M2 to Foreign Exchange Reserves is widely used in the speculative attack literature as an indicator of “financial deepening” and the vulnerability of the financial system to capital outflows. This indicator rose quickly, so did lending by both banks and non-banks before currency crises: in Chile the share of financial system loans to private sector in GDP rose from 5 percent in 1974 to over 82 percent in 1982; for Mexico this share went from 26 percent in 1991 to 41 percent in 1994. However, since M1 is used mostly for transaction purpose, quasi money (the difference between M2 and M1) is a better measure of the potential dumping of domestic currency in the case of capital outflows during speculative attacks.

As discussed in Chang and Velasco (1998c), there are several factors that conspired to transform the financial boom into a particularly dangerous phenomenon:

- The first was the currency denomination of assets and liabilities. Domestic banks borrowed abroad and in foreign currency, and also took an increasing stock of dollar denominated deposits at home. In turn, they lent at home, mostly in domestic currency. This means that bank were very exposed to exchange risk — not a concern early on when promises to sustain fixed exchange rate indefinitely enjoyed some credibility, but troublesome later when devaluations became a fact. It also meant that central banks were
hindered in their ability to serve as lenders of last resort vis a vis the domestic financial system.

- A second factor was the large share of short term loan abroad.

Figure 1(d) shows the evolution of the ratio of quasi money to foreign reserves. The high level of the ratio seems consistent with the hypothesis of international illiquidity. At the end of 1996, the ratio was almost 5 in Korea, 4 in Thailand and the Philippines, and 3 in Malaysia. It is notable that the ratio had been nearly 5 in Mexico in 1994, just before its own crisis.

3.5 Ratio of Fiscal Deficit to GDP

In Krugman's first generation model, government budget deficits lay at the root of the balance of payment crises because expansionary fiscal and monetary policy together with pegged exchange rate regime will result in an increasingly overvalued exchange rate and a gradual decline in international reserves over an extended period. However, before the 1997-98 crisis, most of the East Asian economies had good fiscal balance so that revenue from the inflation tax is unnecessary. In my opinion, speculative attacks arose not because of fiscal deficits, but because of large short term external borrowings. As Sachs, Tornell and Velasco(1996) discuss in some detail, speculative attacks arose not because of fiscal deficits, but because of Bank of Mexico's attempt to sterilize capital inflows starting in 1990. Then when interest rates rose in 1994, the authorities attempted to play on a very steep yield curve, borrowing short on the expectation that the international rate hike would be temporary. The Mexican government's inability to roll over its large stock of short term debt (in particular, the infamous Tesobonos) was to prove key in triggering the financial crisis in December 1994.

3.6 Additional Variables Affecting Successful and Failed Defense Against Speculative Attacks

There are several variables in the pre-crisis characteristics of economies that affect the abilities of the central banks to rebuff a speculative attack. Imagine, for example, that GDP is weakening, unemployment rate is rising and foreign exchange reserve is declining. The authorities will be less ready to employ higher interest rates or to deplete international reserves to defend the currency. Knowing this, speculators will have more incentive to attack and a greater likelihood of success (Jeanne, 1997). Caramazza(1993) and Drazen and Masson(1994), by using data for France, find that unemployment positively affected realignement expectations ever since 1987, a result confirmed by Thomas(1994). Masson(1995) studies the UK and similarly conclude that persistent high unemployment increased the perceived probability that the government would abandon the sterling parity. In view of this, we also examine in the empirical model the effects of GDP growth rate, international reserve growth rate and unemployment rate on the likelihood of successful defense in the empirical model.
Figure 1(a): Interest Rate Differential

Lending Rate Differential (China)

Lending Rate Differential (Hong Kong)

Lending Rate Differential (Indonesia)

Lending Rate Differential (Nigeria)

Lending Rate Differential (Malaysia)

Lending Rate Differential (The Philippines)

Lending Rate Differential (Singapore)

Lending Rate Differential (Taiwan)

Lending Rate Differential (Thailand)

Lending Rate Differential (India)

Lending Rate Differential (Argentina)

Lending Rate Differential (Bolivia)

Lending Rate Differential (Brazil)

Lending Rate Differential (Chile)

Lending Rate Differential (Colombia)

Lending Rate Differential (Mexico)

Lending Rate Differential (Uruguay)

Lending Rate Differential (Venezuela)
Figure 1(b): Short Term International Liquidity

- China
- Hong Kong
- Indonesia
- Korea
- Malaysia
- The Philippines
- Singapore
- Taiwan
- Thailand
- India
- Mexico
- Uruguay
- Venezuela

(Short Debt + Portfolio Liabilities + 6 Months of Imports) / Reserves
Figure 1(c): Real Exchange Rate Index
Figure 1(d): Ratio of Quasi-Money to International Reserves

(M2-M1)/Reserves

China

Hong Kong

Indonesia

Korea

Malaysia

The Philippines

Singapore

Taiwan

Thailand

India

Argentina

Bolivia

Brazil

Chile

Colombia

Mexico

Uruguay

Venezuela
Figure 1(e): Ratio of Fiscal Deficit to GDP

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</table>
Figure 2(a): Short Term and Long Term External Debt

External Debt -- China

External Debt -- HK

External Debt -- Indonesia

External Debt -- Korea

External Debt -- Malaysia

External Debt -- Philippines

External Debt -- Singapore

External Debt -- Taiwan

External Debt -- Thailand

External Debt -- India

External Debt -- Argentina

External Debt -- Bolivia

External Debt -- Brazil

External Debt -- Chile

External Debt -- Colombia

External Debt -- Mexico

External Debt -- Uruguay

External Debt -- Venezuela

Millions US Dollars

Long Debt

Short Debt
Figure 2(b): External Debt and International Reserves

External Debt and Reserves -- Asian Countries

Asian Countries:
- CH: China
- ID: Indonesia
- IN: India
- KR: Korea
- MY: Malaysia
- PH: Philippines
- SG: Singapore
- TW: Taiwan
- TH: Thailand

External Debt and Reserves -- Latin American Countries

Latin American Countries:
- AR: Argentina
- BO: Bolivia
- BR: Brazil
- CL: Chile
- CB: Colombia
- MX: Mexico
- PU: Peru
- UG: Uruguay
- VZ: Venezuela

Graphs showing external debt and reserves for Asian and Latin American countries from 1996 to 2000 in millions of US dollars.
4 Model

The purpose of the empirical model is to evaluate the probabilities of no speculative attack and speculative attack and, given any speculative attack, compares the probabilities of successful defense and unsuccessful defense.

The model used is a nested logit model, where the top branch is a choice between state 0 (the “no speculative attack” state) and the lower branch (the “speculative attack” branch). The lower branch is a choice between state 1 (successful defense) and state 2 (unsuccessful defense). State 1 and 2 are correlated. The correlation parameter is denoted as $\lambda$.

![Diagram of the model](attachment:diagram.png)

where $\{\Omega \text{ it}\}$ is the universal set at time $t$ for country $i$.

The likelihood for an individual observation is:

$$LOGL = D(0|X)L(0|X) + D(1|X)L(1|X) + D(2|X)L(2|X)$$

where $D(.|X)$ is zero-one dummy denoting which state is realized, and $L(.|X)$ is the likelihood of different states conditional on explanatory variables $X$.

Let $\mu_s = \beta_s X_s$ where $X_s$ is the vector of explanatory variables for state $s$ and $\beta_s$ is the vector of estimated coefficients.

$$LOGL = -log(e^{\mu_0} + [e^{\mu_1} + e^{\mu_2}]^3) + D(0|X)\mu_0 + D(1|X)((\lambda - 1)LOG(e^{\mu_1} + e^{\mu_2}) + \frac{\mu_1}{\lambda}) + D(2|X)((\lambda - 1)LOG(e^{\mu_1} + e^{\mu_2}) + \frac{\mu_2}{\lambda})$$

In the basic nested logit model, the explanatory variables in $\mu_2$ include the lag values of lending rate differential, growth of lending rate differential, short term international liquidity ratio, real exchange rate appreciation, ratio of quasi money to foreign exchange reserves and ratio of fiscal deficit to GDP; the explanatory variables in $\mu_1$ include the lag values of foreign exchange reserves growth, unemployment rate and real GDP growth.
Based on this model, the unconditional probabilities of each state and the conditional probabilities of successful and unsuccessful defense are measured as follows:

\[
P(\text{no speculative attack}) = P(0) = \frac{e^{\mu_0}}{e^{\mu_0} + (e^{\mu_1} + e^{\mu_2})} \lambda \\
P(\text{successful defence | attack}) = P(1 | 1, 2) = \frac{e^{\mu_1}}{e^{\mu_1} + e^{\mu_2}} \\
P(\text{unsuccessful defence | attack}) = P(2 | 1, 2) = \frac{e^{\mu_2}}{e^{\mu_1} + e^{\mu_2}} \\
P(\text{successful defense}) = P(1) = (1 - P(0)) P(1 | 1, 2) \\
P(\text{unsuccessful defense}) = P(2) = (1 - P(0)) P(2 | 1, 2) \\
P(\text{speculative attack}) = P(1, 2) = \frac{(e^{\mu_1} + e^{\mu_2})^\lambda}{e^{\mu_0} + (e^{\mu_1} + e^{\mu_2})^\lambda}
\]

Now let’s examine the relationship between the coefficient estimates and the conditional and unconditional probabilities:

- The marginal effect of each variable in \( \mu_2 \) on the probability of speculative attack is measured as follows:
  \[
  \frac{dP(1, 2)}{d\mu_2} = \frac{\frac{\partial}{\partial \mu_2} \left( \frac{e^{\mu_1}}{e^{\mu_1} + e^{\mu_2}} \right) \lambda}{\left(1 + (e^{\mu_1} + e^{\mu_2})\lambda\right)^2} > 0
  \]
  Hence,
  \[
  \frac{dP(1, 2)}{dX_{2j}} = \frac{dP(1, 2)}{d\mu_2} \frac{d\mu_2}{dX_{2j}} = \frac{dP(1, 2)}{d\mu_2} \beta_{2j} \text{ has same sign as } \beta_{2j}
  \]
  This shows that the marginal effect of variable \( X_{2j} \) in vector \( \mu_2 \) on the probability of speculative attack has the same sign as the estimation coefficient \( \beta_{2j} \) based on the nested logit model.

- The marginal effect of each variable in \( \mu_1 \) on the conditional probability of successful defense is measured as follows:
  \[
  \frac{dP(1 | 2)}{d\mu_1} = \frac{\lambda (e^{\mu_1} + e^{\mu_2})}{\lambda (e^{\mu_1} + e^{\mu_2})^2} \text{ has same sign as the correlation coefficient } \lambda
  \]
  Hence,
  \[
  \frac{dP(1 | 2)}{dX_{1j}} = \frac{dP(1 | 2)}{d\mu_1} \frac{d\mu_1}{dX_{1j}} = \frac{dP(1 | 2)}{d\mu_1} \beta_{1j} \text{ has same sign as the product of } \lambda \text{ and } \beta_{1j}
  \]
  This indicates that the marginal effect of variable \( X_{1j} \) in vector \( \mu_1 \) on the conditional probability of successful defense has the same sign as the product of \( \lambda \) and the estimation coefficient. If the estimate of \( \lambda \) is positive, then the marginal effect will have the same sign as the estimation coefficient.

- The marginal effect of each variable in \( \mu_2 \) on the conditional probability of successful defense is measured as follows:
  \[
  \frac{dP(1 | 2)}{d\mu_2} = -\frac{\lambda (e^{\mu_1} + e^{\mu_2})}{\lambda (e^{\mu_1} + e^{\mu_2})^2} \text{ has opposite sign as the correlation coefficient } \lambda
  \]
  Hence,
  \[
  \frac{dP(1 | 2)}{dX_{2j}} = \frac{dP(1 | 2)}{d\mu_2} \frac{d\mu_2}{dX_{2j}} = \frac{dP(1 | 2)}{d\mu_2} \beta_{2j} \text{ has opposite sign as the product of } \lambda \text{ and } \beta_{2j}
  \]
This indicates that the marginal effect of variable $X_{2j}$ in vector $\mu_2$ on the conditional probability of successful defense has the opposite sign as the product of $\lambda$ and the estimation coefficient. If the estimate of $\lambda$ is positive, then the marginal effect will have opposite sign as the estimation coefficient. The estimated $\lambda$ is 0.8.

4.1 Index of Speculative Attacks, Successful Defense and Unsuccessful Defense

The next step is to identify speculative attacks with successful defense and unsuccessful defense. The most widely used instruments by the central banks to defend speculative attacks are foreign exchange reserves and discount rate (the interest rate at which banks borrow from the central bank). For example, the central bank of Chile and the Bank of Mexico spent large quantities of reserves defending the peg and held on to the bitter end. Mexico, for instance, allowed international reserves to fall from nearly US $30 billion in early 1994 to US $6 billion at the end of the year. However, the increased importance and flexibility of the price mechanism in the new market environment have induced many central banks to focus more on discount rate in trying to influence liquidity. In view of this, the measures used in defining episodes of speculative attacks with successful and unsuccessful defense are as follows:

The event of speculative attack being successfully defended ($D(1|X)_{it}$) is an event where either the decline in reserves ($-\Delta \text{Res}_t$) or the increase in discount rate ($\Delta \text{DisRate}_t$) exceed the corresponding thresholds and there is no currency crisis in the following quarter:

$$D(1|X)_{it} = \begin{cases} 
1 & \text{if } (\Delta \text{Res}_{it} < -20\% \text{ or } \Delta \text{DisRate}_{it} > \mu^\text{Dis}_i + 1.5\sigma^\text{Dis}_i) \text{ and } \\
D(2|X)_{i,t+1} = 0 & \text{otherwise} 
\end{cases}$$

The event of speculative attack being unsuccessfully defended ($D(2|X)_{it}$), that is, a currency crisis, is an event where the exchange rate depreciates by more than two standard deviations in a quarter compared to the mean depreciation in country $i$:

$$D(2|X)_{it} = \begin{cases} 
1 & \text{if } \Delta \text{EX}_{it} > \mu^\text{EX}_i + 2\sigma^\text{EX}_i \\
0 & \text{otherwise} 
\end{cases}$$

where subscript $i$ is the country index and the subscript $t$ is the time index.

The event of no speculative attack is the event where both $D(1|X)_{it}$ and $D(2|X)_{it}$ equal 0.

To avoid measuring the same crises twice (or more), we exclude second (and subsequent) observations which occur within given proximity to the first crisis (the window is typically 1 quarter).
5 Data Description

The quarterly data from 1982 Q1 through 2000 Q4 for the following countries are assembled: Chile, China, Colombia, Israel, Korea, Malaysia, Mexico, the Philippines, Taiwan, Thailand, Turkey, Uruguay and Venezuela. The sample included in the estimation is based on data availability.
Table 2 shows the sources and definitions of the variables and Table 3 shows the date of speculative attacks successfully defended and unsuccessfully defended.

Table 2: Data Sources

<table>
<thead>
<tr>
<th>The Indicator</th>
<th>Source and Definition</th>
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<tbody>
<tr>
<td>1. Lending interest rate differential</td>
<td>The interest rate differential is constructed as the difference between lending interest rate of domestic country and US. The lending interest rate is taken from IFS line 60P.</td>
</tr>
<tr>
<td>2. Ratio of Short term international liquidity to foreign exchange reserves</td>
<td>The short-term external debt data is obtained from the Asian Development Bank (ADB) web page and Bank of International Settlements (BIS) web page. The cumulative portfolio liabilities data is constructed as the cumulated sum of the flow portfolio liabilities data obtained from IFS line 78BGD. The import data is from IFS line 98C. The foreign exchange reserves data is from IFS line 1L.</td>
</tr>
<tr>
<td>3. Real exchange rate appreciation index</td>
<td>The exchange rate data is obtained from IFS line .AE..ZF. The exchange rate for China before 1994 Q1 is the swap rate obtained from Global Financial Data. The exchange rate is deflated by WPI (IFS line 63..ZF) and then the real exchange rate is normalized to 1969 Q4 = 1.</td>
</tr>
</tbody>
</table>
(Continue) Table 2: Data Sources

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4. ((M^2 - M^1))/ Foreign exchange reserves</td>
<td>M2 is IFS lines 34 plus 35. M1 is line 34. The foreign exchange reserves data is from IFS line 1L.</td>
</tr>
<tr>
<td>5. Fiscal deficit/ GDP</td>
<td>Fiscal deficit is IFS line 80 and GDP is IFS line 99B.</td>
</tr>
<tr>
<td>6. (M^2)/ Foreign exchange reserves</td>
<td>M2 is IFS lines 34 plus 35. The foreign exchange reserves data is from IFS line 1L.</td>
</tr>
<tr>
<td>7. Deviation of real exchange rate from trend</td>
<td>Defined as the residuals of regressing real exchange rate on a time trend.</td>
</tr>
<tr>
<td>8. Exports growth</td>
<td>Exports data is from IFS line 90C.</td>
</tr>
<tr>
<td>9. Reserves growth</td>
<td>The foreign exchange reserves data is from IFS line 1L.</td>
</tr>
<tr>
<td>10. Excess real M1 balances</td>
<td>Defined as M1 (IFS line 34) deflated by CPI (IFS line 64) less an estimated demand for money. Excess real M1 balances are the residual from regression of real M1 on real GDP (IFS line 99B.P), consumer price inflation and a deterministic trend.</td>
</tr>
<tr>
<td>11. Growth of Domestic credit/ GDP</td>
<td>Total domestic credit is IFS line 52. Nominal GDP is IFS line 99B.</td>
</tr>
<tr>
<td>12. Growth of M2 multiplier</td>
<td>The ratio of M2 (IFS line 34 plus 35) relative to base money (IFS line 14).</td>
</tr>
<tr>
<td>13. Real lending interest rate</td>
<td>Lending interest rate (IFS line 60P) deflated by CPI (IFS line 64).</td>
</tr>
<tr>
<td>14. Imports growth</td>
<td>Imports data is from IFS line 98C.</td>
</tr>
<tr>
<td>15. Industrial production growth</td>
<td>Industrial production data is from IFS line 66 and Global Development Finance 2000 CD-ROM.</td>
</tr>
<tr>
<td>16. Terms of trade growth</td>
<td>Terms of trade is constructed as IFS line 74D divided by IFS line 75D.</td>
</tr>
<tr>
<td>17. Ratio of 3-month lending rate to deposit rate</td>
<td>Lending rate is IFS line 60P, deposit rate is IFS line 60L.</td>
</tr>
<tr>
<td>18. Bank deposit growth</td>
<td>Bank deposit is IFS line 78D.</td>
</tr>
<tr>
<td>19. Stock price index growth</td>
<td>Stock price index is IFS line 62, supplemented by Global Financial Data database.</td>
</tr>
<tr>
<td>20. Real lending rate differential</td>
<td>Difference of lending interest rate (IFS line 60P) of domestic country and US, deflated by CPI (IFS line 64).</td>
</tr>
</tbody>
</table>
(Continue) Table 2: Data Sources

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Real lending rate differential growth</td>
<td>Same as real lending rate differential.</td>
<td></td>
</tr>
<tr>
<td>22. Ratio of current account balance to GDP</td>
<td>Current account balance is from IFS line 78ALD. Nominal GDP is IFS line 99B.</td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Dates of Speculative Attacks Successfully Defended and Unsuccessfully Defended (1982-2000)

<table>
<thead>
<tr>
<th>Country</th>
<th>Successful Defense Date</th>
<th>Unsuccessful Defense Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chile</td>
<td>None between 1982Q1-1998Q4</td>
<td>None between 1982Q1-1998Q4</td>
</tr>
<tr>
<td>2. China</td>
<td>1993Q4</td>
<td>1993Q2</td>
</tr>
<tr>
<td>4. Israel</td>
<td>None between 1982Q1-2000Q1</td>
<td>1983Q4, 1985Q2</td>
</tr>
<tr>
<td>5. Korea</td>
<td>None between 1982Q1-1999Q4</td>
<td>1997Q4</td>
</tr>
<tr>
<td>7. Mexico</td>
<td>1995Q2, 1995Q4</td>
<td>1994Q4</td>
</tr>
<tr>
<td>11. Turkey</td>
<td>1991Q1</td>
<td>1994Q1, 2001Q1</td>
</tr>
<tr>
<td>12. Uruguay</td>
<td>1983Q1, 1990Q2</td>
<td>1982Q4</td>
</tr>
</tbody>
</table>
6 Interpretation of Results and Sensitivity Analysis

Nine variables are included in the basic nested logit estimates (column 1(e) in Table 4). This includes six explanatory variables in \( \mu_2 \), which are the lag values of: lending rate differential, growth of lending rate differential, short term international liquidity ratio, real exchange rate appreciation, ratio of quasi money to foreign exchange reserves and ratio of fiscal deficit to GDP; and three variables in \( \mu_1 \), which include the lag values of: foreign exchange reserves growth, unemployment rate and real GDP growth.

Column 1(e) in Table 4 shows the nested logit estimates of the basic model and the corresponding t-statistics. The short-term liquidity ratio, the real exchange rate appreciation index, the ratio of difference of quasi money to foreign exchange reserves all show up to be significant at 5 percent level of significance. This provides a strong empirical support to the third generation model of currency crises: financial fragility and international illiquidity are key triggering of speculative attacks.

The ratio of fiscal deficit to GDP does not have significant coefficient, this is because, in my opinion, speculative attacks arose not because of fiscal deficits, but because of large short term external borrowings. Similar argument is put forward by Sachs, Tornell and Velasco(1996). As a result, once the factor of international illiquidity is controlled for, the ratio of fiscal deficit to GDP per se does not have strong predictive power of speculative attacks.

Interestingly, though the lending rate differential variable and its growth have the correct sign, they do not have statistically significant coefficients. This somewhat weak results are probably the result of multicollinearity between the lending rate differential and the other variables that measure financial fragility and international fragility. On the other hand, the growth of real lending rate differential (as shown in column (1b) of Table 4) does show up to be statistically significant.

The variables that measure the pre-crisis characteristics of economies and affect the abilities of the central banks to defend a speculative attack (the lagged GDP growth, lagged unemployment rate and lagged foreign exchange reserves growth) are all statistically significant at the 5 percent significance level and have the correct sign. This is consistent with Masson(1995)’s finding that high unemployment and low GDP growth increased the probability that the government would abandon the currency parity.

6.1 Sensitivity Analysis

Column (1a), (1c), (1d), (2), (3) and (4) of Table 4 performs a variety of robustness checks. The first perturbations (column (1a)) include replacing the lending rate differential by the real lending rate differential and dropping the growth of lending rate differential. The second perturbations (column (1c)) include replacing the lending rate differential and its growth by the real lending rate differential and its growth. The third perturbation include replacing the ratio
of quasi money to foreign exchange reserves by the ratio of base money to foreign exchange reserves and its growth. In all these perturbations, the coefficients of short term international liquidity ratio, real exchange rate appreciation and the ratio of quasi money to foreign exchange reserves are all robust: they are all statistically significant and have the correct sign.

In column (2) and (3) of Table 4, the six variables included in $\mu_2$ are replaced by the five variables that have the lowest noise-to-signal ratios based on my calculations and Berg and Pattillo(1998)’s calculations respectively. The calculation of the noise-to-signal ratios is discussed in greater details in appendix A. However, the basic model (column 1(e) in Table 4) which explicitly includes variables that measure international illiquidity and financial fragility perform better in terms of prediction abilities and its estimates seem more sensible.

In column (4) of Table 4, an index that measures the intensity of capital controls is added to the estimation. Since restricting the international flow of capital essentially means limiting and restricting the purchases and sales of foreign assets by domestic residents and/or domestic assets by foreign residents, capital controls have an effect of reducing massive shifts from domestic assets to foreign assets. To capture the effect of capital controls, a foreign ownership restrictions index is constructed based on a method proposed by Miniane (2000). This measure is derived from the IMF’s Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) and is the average of 0/1 dummies of restrictions on 13 items in the capital account\(^1\). In the estimation, the restrictions-based measure constructed based on IMF is interacted with the ratio of quasi-money to international reserves and added to the estimation. The estimation result is in column (4) of Table 4.

However, the link between capital flow restrictions and exchange rate stability is not conclusive in the literature. On the one hand, restrictions on capital inflows and/or outflows are long believed to reduce exchange rate instability and a large literature on the appropriate sequencing of financial liberalization in developing countries suggests that lifting controls on the capital account too soon may destabilize the economy. In the early 1970s, James Tobin argued that a global tax (“Tobin tax”) on foreign exchange transactions would reduce destabilizing speculation in international financial markets. In the aftermath of the European (1992-1993) and Asian (1997-1998) currency crises, some have renewed calls for some form of capital controls. On the other hand, as suggested by Glick and Hutchison (2001), capital controls themselves may have a destabilizing effect on exchange rates for several reasons. First, restrictions on the international capital account may in fact lead to a net capital outflow and precipitate increased instability.

\(^1\)An alternative measure is proposed by Edison and Warmock (2001). That measure captures both the intensity of foreign ownership restrictions and is available at a higher frequency than annual for a wide range of countries. However, this measure is only a narrow measure of capital controls, focusing only on restrictions on foreign ownership of domestic equities. The measure they propose is the ratio of the market capitalizations underlying a country’s Investable and Global Indices as computed by the International Finance Corporation (IFC). For each emerging market country, the IFC computes a Global Index (IFCG) that is designed to represent the market. The IFC also computes an Investable index (IFCI), designed to represent that portion of the market available to foreign investors. Hence, the ratio of the market capitalizations of a country’s IFCI and IFCG is a quantitative measure of the availability of the country’s equities to foreigners, and one minus the ratio is a measure of the intensity of capital controls. Figure 4(a) and 4(b) shows the capital controls index of selected East Asian and Latin American countries.
financial instability. Second, the imposition of controls is typically correlated with other restrictions on economic activity that investors regard as inimical to the economic environment. Finally, capital controls may be ineffective and distortionary, leading to economic misallocation and corruption that, in turn, contribute to economic instability. From the data, the incidence of capital controls is high throughout the sample period - it rose noticeably from 1975 through 1989 and then declined in the 1990s, as many countries pushed for greater liberalization in the movement of financial capital.

The findings in column (4) of Table 4 indicate that capital controls have a slight stabilization effect on foreign exchange market, though the effect is insignificant. This is consistent with the arguments that capital controls have both positive effects (Tobin, 1970s) and negative effects (Glick and Hutchison, 2001) on foreign exchange market stability.
Table 4: Nested Logit Estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimates (1a)</th>
<th>Estimates (1b)</th>
<th>Estimates (1c)</th>
<th>Estimates (1d)</th>
<th>Estimates (1e)</th>
<th>Estimates (2)</th>
<th>Estimates (3)</th>
<th>Estimates (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Lending Rate Differential</td>
<td>1.3518 (0.4388)</td>
<td>1.3367 (0.4293)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.1471 (7.6894)</td>
<td>--</td>
</tr>
<tr>
<td>Real Lending Rate Differential</td>
<td>--</td>
<td>0.0108 (0.0012)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Lending Rate Differential (%)</td>
<td>--</td>
<td>--</td>
<td>0.9408 (0.3936)</td>
<td>0.8405 (0.4301)</td>
<td>0.9445 (0.3857)</td>
<td>--</td>
<td>--</td>
<td>1.8805 (0.7561)</td>
</tr>
<tr>
<td>Lending Rate Differential (%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.0275 (0.0378)</td>
<td>--</td>
<td>--</td>
<td>0.0313 (0.0449)</td>
</tr>
<tr>
<td>(Short External Debt + Portfolio Liabilities + 6 Months of Imports)/ Reserves</td>
<td>0.2580 (4.0468)</td>
<td>0.2575 (4.0073)</td>
<td>0.2570 (4.0543)</td>
<td>0.1740 (1.5139)</td>
<td>0.2555 (4.0230)</td>
<td>--</td>
<td>--</td>
<td>0.2750 (3.6583)</td>
</tr>
<tr>
<td>Real Exchange Rate Index Appreciation (1986=1)</td>
<td>3.0947 (4.1935)</td>
<td>3.0902 (4.0666)</td>
<td>3.1033 (3.9659)</td>
<td>3.4920 (5.1838)</td>
<td>3.0901 (3.9445)</td>
<td>--</td>
<td>0.0046 (3.9796)</td>
<td>2.9723 (3.8566)</td>
</tr>
<tr>
<td>Real Exchange Rate Deviations from Trend</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.1522 (0.6277)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>(M2-M1)/ Reserves</td>
<td>0.3792 (2.8099)</td>
<td>0.3787 (2.8065)</td>
<td>0.3816 (2.7498)</td>
<td>--</td>
<td>0.3796 (2.7157)</td>
<td>--</td>
<td>--</td>
<td>0.1504 (1.3338)</td>
</tr>
<tr>
<td>M2/ Reserves</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>M2/ Reserves Growth (%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.3575 (2.7037)</td>
<td>0.2660 (2.9933)</td>
<td>--</td>
</tr>
<tr>
<td>Excess M1 Balances</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.4565 (0.5778)</td>
<td>0.9249 (1.0730)</td>
<td>--</td>
</tr>
<tr>
<td>Base Money/ Reserves</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.7022 (2.6938)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Base Money Growth</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.6147 (0.7944)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fiscal Deficit/ GDP</td>
<td>9.2833 (0.5652)</td>
<td>9.2029 (0.5602)</td>
<td>9.1962 (0.5770)</td>
<td>9.4783 (0.6148)</td>
<td>9.0762 (0.5424)</td>
<td>--</td>
<td>--</td>
<td>10.6919 (0.6463)</td>
</tr>
<tr>
<td>Capital Controls Index * (M2-M1)/ Reserves</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-0.3028 (-0.5339)</td>
</tr>
<tr>
<td>Bank Deposit Growth (%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2.7368 (4.2852)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Domestic Credit/ GDP Growth</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.2589 (1.7434)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Exports Growth (%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-1.0090 (-2.0838)</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: The numbers in parentheses are t-statistics.
7 Probabilities of Speculative Attacks: Prediction Abilities

Prediction abilities of the model can be evaluated using three statistical scores: the quadratic probability score (QPS), log probability score (LPS) and global squared bias (GBS).

The quadratic probability score (QPS) is:

\[ QPS = \frac{1}{IT} \sum_{t=1}^{T} \sum_{i=1}^{I} 2(P_{it} - R_{it})^2 \]

where \( P_{it} \) is the predicted probability of speculative attack in country \( i \) at time \( t \) and \( R_{it} \) is realizations of speculative attack. QPS ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy.

The log probability score (LPS) is:

\[ LPS = -\frac{1}{IT} \sum_{t=1}^{T} \sum_{i=1}^{I} [(1 - R_{it})\ln(1 - P_{it}) + R_{it}\ln(P_{it})] \]

LPS ranges from 0 to \( \infty \), with a score of 0 corresponding to perfect accuracy. The loss function associated with LPS differs from that corresponding to QPS, as large mistakes are penalized more heavily under LPS.

The average forecast calibration is measured by the global squared bias (GBS):

\[ GSB = \frac{1}{I} \sum_{i=1}^{I} 2(\tilde{P}_i - \tilde{R}_i)^2 \]

where \( \tilde{P}_i = 1/T \sum_{t=1}^{T} P_{it} \) and \( \tilde{R}_i = 1/T \sum_{t=1}^{T} R_{it} \). GSB \( \in [0, 2] \), with GSB = 0 corresponding to perfect global calibration, which occurs when the average probability forecast equals the average realization.

Table 5 reports the results for the goodness of fit tests. The nested logit model outperforms the benchmark signal indicator approach by Kaminsky, Saul and Reinhart (1998) (KSR) in crisis time under all three testing scores. During tranquil time, the KSR model has a slightly better fit as measured by QPS and LPS, though still underperform the nested logit model when measured by GSB. Figure 3 plots the predicted unconditional probabilities of successful speculative attacks and the conditional probabilities of successful defense given speculative attacks for selected Latin American and East Asian countries in 1986Q1-2000Q4. Notice that the nested logit model perform well in predicting which countries are more vulnerable to speculative attack and fail to defend given any speculative attack. Note that the case of Colombia in 1998 provides an evidence for the honeymoon effect in which the probability for a country to have a currency crisis right after another currency crisis is minimal (Mckinnon 2001).
Table 5: Goodness of Fit

<table>
<thead>
<tr>
<th>Model</th>
<th>QPS</th>
<th></th>
<th>LPS</th>
<th></th>
<th>GSB</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tranquil Time</td>
<td>Crisis Time</td>
<td>Tranquil Time</td>
<td>Crisis Time</td>
<td>Tranquil Time</td>
<td>Crisis Time</td>
</tr>
<tr>
<td>Kaminsky’s Composite Indicator</td>
<td>0.110</td>
<td>0.862</td>
<td>0.240</td>
<td>1.161</td>
<td>0.071</td>
<td>0.735</td>
</tr>
<tr>
<td>Nested Logit Model (Column (4) of Table 4)</td>
<td>0.0430</td>
<td>0.5929</td>
<td>0.1193</td>
<td>1.0689</td>
<td>0.00076</td>
<td>0.1858</td>
</tr>
</tbody>
</table>

Note:
- Kaminsky’s composite indicator is an indicator that weights the signals of different variables by the inverse of their noise-to-signal ratios. It performs the best in Kaminsky’s 1998 paper when predicting both currency and banking crises.
Figure 3(a): Predicted Probabilities for Selected East Asian Countries
Predicted Probabilities -- Malaysia

Liberalization date: Dec 1988
Capital controls imposed: September 1998
Capital controls gradually lifted during 1999

Predicted Probabilities -- Philippines

Liberalization date: June 1991
Predicted Probabilities -- Taiwan

Liberalization date: Jan 1991

Predicted Probabilities -- Thailand

Liberalization date: September 1987

β
Figure 3(b): Predicted Probabilities for Selected Latin American Countries
8 Conclusions

This paper provides a unique methodology – a multi-state nested logit model – to (i) analyses the relative importance of international illiquidity, financial fragility and fiscal deficit in triggering speculative attacks and (ii) predicts the probabilities of speculative attacks and the conditional probabilities of successful defense given speculative attacks. The nested logit estimates suggested that international illiquidity (as measured by ratio of short term international liquidity to foreign exchange reserves), financial fragility (as measured by the ratio of quasi money to foreign exchange reserves), and real exchange rate appreciation are important factors that trigger speculative attacks. This provides empirical support to the third generation model in the literature of currency crises. Fiscal deficits does not show up to be significant once international liquidity and financial fragility factors are controlled for. This conclusion is robust to a number of variations of the model.

The predictive abilities of the nested logit model are evaluated using three statistical scores: the quadratic probability score (QPS), log probability score (LPS) and global squared bias (GSB). All scores indicate that the nested logit model outperform the benchmark signal indicator approach by Kaminsky, Saul and Reinhart(1998) in crisis time and in both tranquil and crisis time when measured by GSB.

In terms of policy implications, the findings in this paper provide an empirical evidence on the importance of the “overborrowing syndrome” in triggering speculative attacks. Thus a policy advice to central banks is to strengthen the supervision in the banking sector to reduce the currency and maturity mismatch in the assets and liabilities side. On the other hand, while there is a policy debate in the literature on whether capital controls work in fending off speculative attacks, there is evidence from this paper that effective capital controls work in reducing massive capital outflights and lowering the probabilities of successful attacks.
### Table 1: Indicators of Currency Crises: A Review of the Literature

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample period and frequency</th>
<th>Country coverage</th>
<th>Indicators</th>
<th>“Preferred” Indicators</th>
<th>Methodology</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eichengreen, Rose and Wyplosz (ERW) (1994a)</td>
<td>1967-1992, monthly data</td>
<td>22 countries (mostly OECD): US, UK, Austria, Belgium, Denmark, France, Italy, Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Finland, Greece, Ireland, Portugal, Spain, Australia, South Africa, India, Korea and Germany</td>
<td>(1) exports/imports (2) fiscal ratio (3) reserve growth (4) inflation (5) credit growth (6) money growth (7) interest rate (8) real interest rate</td>
<td>Indicators that are significant at 10 percent significance level: (1) exports/imports (2) fiscal ratio (3) reserve growth (4) inflation</td>
<td>The extent of financial crisis is measured by a “crisis index” which is a weighted average of devaluation rate with respect to DM, the percentage change in foreign exchange reserves and percentage changes in short interest rate. They report two non-parametric tests: the two-sample Kolmogorov-Smirnov test for equality of distribution functions between crisis and non-crisis period (this examines the entire distribution), and the Kruskal-Wallis test for the equality of populations (this focuses more on sample medians). They also report the traditional t test for equality of first moments (without assuming equal variances).</td>
<td></td>
</tr>
<tr>
<td>Eichengreen, Rose and Wyplosz (ERW) (1995)</td>
<td>1959-1993, quarterly data</td>
<td>20 OECD countries</td>
<td>(1) change in international reserves (2) real effective exchange rate (3) credit growth (4) M1 growth (5) bond yield (6) interest rates (7) stock prices (8) inflation (9) wage growth (10) GDP growth</td>
<td>(1) High money growth (2) High credit growth (3) High wages (4) High price inflation (5) government deficit (6) current account deficit</td>
<td>Speculative pressure is measured as a weighted average of exchange rate changes, interest rate changes, and reserve changes. Speculative attacks – crises – are defined as periods when this speculative</td>
<td></td>
</tr>
<tr>
<td>Sachs, Tornell and Velasco (STV) (1996)</td>
<td>1989-1994, annual data</td>
<td>20 countries: Turkey, South Africa, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, Jordan, Sri Lanka, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Thailand, Zimbabwe and Taiwan.</td>
<td>(1) depreciation of trade weighted real exchange rate index (RER) (2) lending boom (LB) (ratio of claims on the private sector by deposit money banks and monetary authorities) (3) dummy for countries with low reserves, measured as having a reserves/M2 ratio in the lowest quartile. (4) dummy for weak fundamentals which means</td>
<td>(1) high exchange rate appreciation (2) lending boom (3) low reserves relative to M2</td>
<td>The extent of financial crisis is measured by a “crisis index” (IND) which is a weighted average of devaluation rate with respect to the U.S. dollar and the percentage change in foreign exchange reserves. The basic equation regresses the crisis index IND on the levels of RER and LB and on the product of the dummies</td>
<td>RER measures the real exchange rate misalignment and the lending boom measures the financial system vulnerability. A country has strong fundamentals if its real depreciation is in the highest quartile of the sample and banking boom is in the lowest quartile. A country has low reserve if its money-to-reserves ratio is below the first quartile.</td>
</tr>
</tbody>
</table>
having RER in the lowest three quartiles or LB in the highest three quartiles with RER and LB respectively. quartile. The weak fundamental dummy and reserve inadequacy dummy measures the vulnerability of a country to a self-fulfilling reversal of capital inflow.

The regression results support the idea that the level of Central Bank reserves relative to short term liabilities is important in determining whether a country is vulnerable to a self-fulfilling panic.
### Table: Capital Inflows and Currency Crashes

<table>
<thead>
<tr>
<th>Source</th>
<th>Sample</th>
<th>Capital Inflow Variables</th>
<th>Indicators of a Currency Crisis</th>
<th>Explanations for the Capital Inflows Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frankel and Rose (FR) (1996)</td>
<td>105 countries, including 105 countries, Argentina, Benin, Burundi, Burkina Faso, Bangladesh, Bolivia, Brazil, Bhutan, Botswana, Central African Republic, Chile, Cote d’Ivoire, Cameroon, Congo, Comoros, Costa Rica, Dominican Republic, Algeria, Ecuador, Egypt, Ethiopia, Gabon, Ghana, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Guatemala, Guyana, Honduras, Indonesia, India, Jamaica, Jordan, Laos, Madagascar, Maldives, Mexico, Mali, Myanmar, Malawi, Niger, Nigeria, Nicaragua, Peru, Philippines, Paraguay, Romania, Rwanda, Sudan, Senegal, Sierra Leone, El Salvador, Somalia, Sao Tome and Principe, Swaziland, Syrian Arab Republic, Chad, Togo, Trinidad &amp; Tobago, Turkey, Tanzania, Uganda, Uruguay, Venezuela, Vanuatu, Zaire, Zambia, Zimbabwe.</td>
<td>1971-1992, annual data</td>
<td></td>
<td>- The hypothesis regarding FDI is that FDI is a safer way to finance investment than domestic debt. One argument is that FDI is directly tied to real investment in plant, equipment and infrastructure; whereas borrowing can go to finance consumption which does not help add to the productive capacity necessary to generate export earnings to serve the debt in the future. The stronger argument in favor of FDI is that of stability. In the event of a crash, investors can suddenly dump securities and banks can refuse to roll over loans, but multinational corporations cannot quickly pack up their factories and go home. However, Dooley et al. (1995), have found that a high level of FDI seems to be associated with higher variability of capital inflows. Not lower.</td>
</tr>
</tbody>
</table>

---

**Macroeconomic variables:**
- Growth of domestic credit (a proxy measure of monetary policy)
- Components of capital inflows: (1) Foreign direct investment (FDI) vs. portfolio flows (2) long term vs. short term portfolio capital flows (3) fixed rate vs. floating rate borrowing (4) domestic currency vs. foreign currency denominated debt
- Compositions of debt: (1) amount lent by commercial banks (2) amount which is variable rate (3) amount which is public sector (4) amount which is short term (5) amount lent by multilateral development banks

**Indicators that are significant:**
- Low ratio of FDI to debt
- Low international reserves
- High domestic credit growth
- High foreign interest rates
- Overvaluation of the real exchange rate

**Variables regarding FDI:**
- The definition of a currency crisis differs from ERW in that they focus only on large exchange rate movements (a nominal depreciation of the currency of at least 25 percent and that this depreciation exceeds the previous year's change by a margin of at least 10 percent). In other words, FR's definition of currency crises does not include speculative attacks successfully defended through reserves sales or interest rate increases. FR argue that it is difficult to identify successful defenses since reserve movements are noisy measures of exchange market intervention and interest rates were controlled for long periods in most of the countries in the sample. FR shift the focus of the literature towards modeling currency crashes for developing countries using probit analysis. FR estimate probit models and they have seven debt-composition regressors, each expressed as percentage of total debt: Most...
of the debt composition variables do not have significant coefficients, though some (like the concessional variable) are close to significant. The somewhat weak results are probably the result of multicollinearity between their different debt characteristics. Also, neither the current account nor the budget deficit has the predicted sign, though neither effect is statistically significant at conventional levels. High debt, lower reserves, and a more overvalued real exchange rate all seem to raise the odds of crash incidence.

### Kaminsky (1998)

**January 1970 to June 1995**

20 countries from three regional groups: Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, Peru, Uruguay and Venezuela), Asia (Indonesia, Malaysia, Philippines and Thailand) and other (Denmark, Finland, Israel, Norway, Spain, Sweden, Turkey)

### Variables related to overborrowing cycles:

1. M2 multiplier
2. Domestic credit/GDP
3. Dummy for domestic and external financial liberalization

### Variables related to bank runs:

1. Bank deposits
2. M2 Multiplier, Bank Deposits, Terms of trade

### Indicators in order of increasing noise-to-signal ratios in indicating currency crises:

1. Real Exchange Rate
2. Exports, World Real Interest rate, Stock Prices
3. M2:Reserves, Foreign Debt, Output
4. Domestic Credit/GDP, Excess M1 Balances, Reserves
5. M2 Multiplier, Bank Deposits, Terms of trade
6. Domestic Real Interest Rate

### Four composite indicators and their empirical joint distribution are constructed. The simplest composite indicator include a number of variables that cross the threshold at any given time. A weighted variant of the composite indicator weighs each variable by its noise-to-signal ratios. The quadratic probability score (QPS), log probability score (LPS) and global squared bias (GSB) are computed to explain the indicators:

- **Overborrowing cycles variables**: Both banking and currency crises have been linked to rapid growth in credit fueled by liberalization of the domestic financial system and by the elimination of capital account restrictions
- **Bank runs variables**: Banking crises and currency can be preceded by bank runs.
- **Monetary policy**: High debt, lower reserves, and a more overvalued real exchange rate all seem to raise the odds of crash incidence.

### Explanations for the indicators:

- **Overborrowing cycles variables**: Both banking and currency crises have been linked to rapid growth in credit fueled by liberalization of the domestic financial system and by the elimination of capital account restrictions.
- **Bank runs variables**: Banking crises and currency can be preceded by bank runs.
- **Monetary policy**: High debt, lower reserves, and a more overvalued real exchange rate all seem to raise the odds of crash incidence.
Variables related to current account:
(1) Exports
(2) Imports
(3) Term of Trade
(4) Real Exchange Rate

Variables related to capital account:
(1) Reserves
(2) M2/reserves
(3) Real Interest Rate Differential
(4) World Real Interest Rate
(5) Foreign Debt
(6) Capital Flight
(7) Short-term Foreign Debt

Variables related to growth slowdown:
(1) Output
(2) Domestic Real Interest Rate
(3) Lending/Deposit Rate
(4) Stock Prices

(7) Real Interest Rate Differential, Capital Flight, Short-term Foreign Debt, External Financial Liberalization

The variables with the lowest noise-to-signal ratio and the highest probability of crisis conditional on the signal are:
(1) real exchange rate, (2) equity prices and the money multiplier.

Presumably, the likelihood of a crisis is greater when several variables signal simultaneously. To that ends, Kaminsky (1998) develops composite indexes. The best composite indicator outperforms the real exchange rate in predicting crises in the sample, but it is worse at predicting observations of no crisis.

Compare the performance of the four composite indicators. Also, the noise-to-signal ratios of the variables in indicating currency crises and banking crises are compared.

Variables: Loose monetary policy can fuel a currency crisis. To the extent that a devaluation worsens the health of a banking sector it can also trigger a banking crisis.

Current account variables: Real exchange rate overvaluations and a weak external sector are a part of a currency crisis. They add to the vulnerability of the banking sector since a loss of the competitiveness and external markets could lead to a recession, business failures, and a decline in the quality of loans. Thus, large negative shocks to exports, the terms of trade, and the real exchange rate and positive shocks to imports are interpreted as symptoms of financial crises.

Capital account variables: High world interest rates may lead to currency crises as they result in capital outflows. Capital account problems become more severe when the country’s foreign debt is large and capital flight increases since it may raise issues of debt unsustainability.

Debt concentrated at
short maturities will increase the vulnerability of a country to external shocks.

**Growth variables:**
Recessions and the burst of asset price bubbles precede financial crises. High real interest rates could be a sign of liquidity crunch leading to a slowdown and banking fragility. An increase in the lending/deposit ratio in the domestic economy can capture a decline in loan quality.

<table>
<thead>
<tr>
<th><strong>Kaminsky, Lizondo and Reinhart (KLR) (1998)</strong></th>
<th><strong>1970-1995, annual data</strong></th>
<th><strong>Same as Kaminsky(1998)</strong></th>
<th><strong>This paper provides a comprehensive review of the literature published before 1998 on indicators of crises.</strong></th>
<th><strong>Based on a comprehensive survey of literature, they found that the variables that have the best track record within the signal extraction approach include: (1) deviations of the real exchange rate from trend (2) exports growth (3) M2/reserves (4) output growth (5) equity prices growth</strong></th>
<th><strong>Use signal extraction approach to assess the evolution of many macroeconomic and financial variables around the time of currency crises.</strong></th>
</tr>
</thead>
</table>

| **Kaminsky and Reinhart (1999)** | **Focus on the periods when the latest twin crisis happened in each country, so sample period vary for different countries. The periods range from 1971 to 1997. Frequency is monthly.** | **Same as Kaminsky(1998)** | **Indicators associated with financial liberalization: (1) M2 multiplier (2) growth in domestic credit/GDP (3) real deposit interest rate (4) ratio of lending-to-deposit interest rates** | **Indicators in order of decreasing accuracy in signaling balance of payments crises: (1) Real interest rate (2) Real interest rate differential (3) exports (4) M2/reserves (5) M2 multiplier (6) terms of trade (7) reserves** | **The extent of currency market turbulence is measured by a weighted average of the rate of change of exchange rate and of reserves. The basic approach is to compute the conditional probability of balance of payment crises conditioning on a banking crisis.** |

| **Explanations for the indicators:** | **M2 multiplier:** the reductions in reserve requirement that often accompany financial liberalization play a role in explaining the large increase in the M2 multiplier. |
Other financial variables:
(1) excess real M1 balances
(2) real commercial bank deposits
(3) M2/reserves

Variables related to current account:
(1) percent deviation of the real exchange rate from trend
(2) value of exports and imports (in US$)
(3) term of trade

Variables related to capital account:
(1) foreign exchange reserves (in US$)
(2) domestic-foreign real deposit interest rate differential

Variables related to real sector:
(1) industrial production
(2) index of equity prices (in US$)

Fiscal variable:
(1) budget deficits/GDP

(8) output
growth can be because the central bank increases domestic credit to finance government deficits (Krugman (1979)) or the Central Bank pumping money to the banks

Real deposit interest rate, real interest rate differentials: it reflects lax monetary policy ahead of currency crisis.

Ratio of lending-to-deposit interest rates: it reflects the high risk premia due to the deterioration in credit risk

Excess real M1 balances: this is a loose monetary policy story (Krugman (1979))

Bank deposits: capital flight and a run against a domestic bank may precede both currency and banking crises.

M2/reserves: it measures the vulnerability of the financial system to capital outflows.

Exports, Term of Trade, Real Exchange Rate: real exchange rate overvaluations and a weak external sector are a part of a currency crises. It adds vulnerability to the banking
sector, since the loss of competitiveness and external markets could lead to a recession, business failures, and a decline in the quality of loans. Thus large negative shocks to exports, the terms of trade, and the real exchange rate are associated with signals

**Imports:** Theory is ambiguous. Rapid import growth can be the sign of a buoyant economy (a negative shock to imports), or it could be the sign of overvaluation, hence a positive shock could be a signal.

**Output, Stock Prices:** Recessions and the burst of asset price bubbles precede financial crises

**Deficit/GDP:** Loose fiscal policy financed by credit from the central bank (Krugman (1979))

| Berg and Pattillo (BP) (1998) | Four sets of sample: (1) KLR sample (2) update FR’s sample to 1996 (3) STV sample (4) 23 country sample, 1970 – 1995:4 | 23 country sample: They added the following countries to the 15 KLR emerging market economies: India, Jordan, Korea, Pakistan, South Africa, Sri Lanka, Taiwan Province of China, and Zimbabwe | Same indicators as in KLR, FR and STV. In the probit analysis, BP augment the KLR model by adding the ratio of short term debt to reserves as one of the explanatory variables. | The paper evaluates the three models by posing the question: If the IMF had been using these models in 1996, how well would they have been able to predict the Asian crisis. Among the three models (KLR, FR, STV), the most successful pure pre-1997 forecasts are the KLR-based | They rerun the three models (KLR, FR and STV) using data up to 1996 and then using data after 1996 to generate out-of-sample predictions. The compare the performance of the three models in predicting the 1997 currency crisis. |
probabilities of crisis derived from the weighted sum of signaling indicators. When the model issued an alarm during 1995:5 to 1996:12 period, a crisis would actually have followed in 1997 37 percent of the time.

(1) US output
(2) G-7 output
(3) US interest rates
(4) Oil prices
(5) change in short-term debt/foreign reserves
(6) level of short-term debt/foreign reserves |
| --- | --- | --- | --- |
| Performance of indicators in order of increasing noise-to-signal ratios: 
(1) changes in real exchange rate 
(2) 12 month percentage changes in short-term debt/reserves 
(3) level of M2/reserves 
(4) level of short term debt/reserves 
(5) changes in M2/reserves 
(6) changes in reserves 
(7) excess M1 balances 
(8) changes in equity index 
(9) changes in G-7 output 
(10) changes in US output 
(11) changes in industrial production 
(12) changes in exports 
(13) changes in real interest rate 
(14) changes in domestic credit/GDP 
(15) changes in M2 multiplier 
(16) changes in imports 
(17) changes in commercial bank deposits 
(18) changes in US interest rate 
(19) changes in oil prices 
(20) changes in real interest rate differential |
| The crisis indices are the average of percent changes in the bilateral nominal exchange rate and the percent change in foreign reserves. |
| Explanations for the new indicators: 
US output, G-7 output: the foreign recessions and US recession often precede crises 
US interest rate: US rate increases often associated with capital outflows 
Oil Prices: High oil prices are associated with recessions |
<table>
<thead>
<tr>
<th>(21) changes in lending/ deposit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>
Appendix A: Noise-to-signal Ratios

The noise-to-signal ratio of each variable can be measured in terms of the matrix below:

<table>
<thead>
<tr>
<th></th>
<th>Crisis within the window period</th>
<th>No crisis within the window period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal was issued</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>No signal was issued</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Variable X is said to “signal” a crisis in period t if in that period the variable crosses the critical threshold. Cell A represents the number of periods in which the variable issued a good signal, B is the number of periods in which the variable issued a bad signal or “noise”, C is the number of periods in which the variable failed to issue a signal which would have been a good signal, and D is the number of periods in which the variable does not issue a signal that would have been a bad signal. The noise-to-signal ratio is defined as the number of bad signals as a share of possible bad signals (\( \frac{B}{B+D} \)) divided by the number of good signals as a share of possible good signals (\( \frac{A}{A+C} \)). The optimal threshold is defined as the threshold that minimize the noise-to-signal ratio.

The signaling horizon or crisis period is the period within which the variable would be expected to have an ability for anticipating crises. Kaminsky, Lizondo and Reinhart(1998) define the period to be 24 months and it is defined to be 4 quarters in my calculations.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lending rate differential</td>
<td>-</td>
<td>0.72</td>
<td>2</td>
<td>---</td>
</tr>
<tr>
<td>(Short debt+cum. portfolio liab.+ 6 month’s imports)/reserves</td>
<td>-</td>
<td>0.79</td>
<td>2.2</td>
<td>---</td>
</tr>
<tr>
<td>Real exchange rate index (1969=1)</td>
<td>-</td>
<td>0.20</td>
<td>2.1</td>
<td>---</td>
</tr>
<tr>
<td>(M2-M1)/reserves</td>
<td>-</td>
<td>0.63</td>
<td>2.4</td>
<td>---</td>
</tr>
<tr>
<td>Govt. deficit/GDP</td>
<td>-</td>
<td>0.62</td>
<td>2.4</td>
<td>---</td>
</tr>
<tr>
<td>Real exchange rate differential</td>
<td>+</td>
<td>0.45</td>
<td>2.2</td>
<td>---</td>
</tr>
<tr>
<td>Real exchange rate appreciation rate</td>
<td>-</td>
<td>0.79</td>
<td>2.5</td>
<td>---</td>
</tr>
<tr>
<td>M2/reserves</td>
<td>-</td>
<td>0.76</td>
<td>2.4</td>
<td>---</td>
</tr>
<tr>
<td>Deviation of real exchange rate from trend</td>
<td></td>
<td>0.20</td>
<td>2.4</td>
<td>0.24</td>
</tr>
<tr>
<td>Exports growth</td>
<td>-</td>
<td>0.41</td>
<td>2.5</td>
<td>0.46</td>
</tr>
<tr>
<td>Reserves growth</td>
<td>-</td>
<td>0.79</td>
<td>2.3</td>
<td>0.49</td>
</tr>
<tr>
<td>Excess real M1 balances</td>
<td>-</td>
<td>0.56</td>
<td>1.9</td>
<td>0.53</td>
</tr>
<tr>
<td>Domestic credit/GDP growth</td>
<td>-</td>
<td>0.56</td>
<td>2.5</td>
<td>0.69</td>
</tr>
<tr>
<td>M2 multiplier growth</td>
<td>-</td>
<td>0.72</td>
<td>2</td>
<td>0.74</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>+</td>
<td>0.73</td>
<td>2.3</td>
<td>0.80</td>
</tr>
<tr>
<td>Imports growth</td>
<td>-</td>
<td>0.58</td>
<td>2.2</td>
<td>1.19</td>
</tr>
<tr>
<td>Industrial production growth</td>
<td></td>
<td>0.69</td>
<td>1.5</td>
<td>1.23</td>
</tr>
<tr>
<td>Terms of trade growth</td>
<td>-</td>
<td>0.70</td>
<td>2.5</td>
<td>1.42</td>
</tr>
<tr>
<td>Lending rate/deposit rate</td>
<td>-</td>
<td>0.56</td>
<td>2.4</td>
<td>1.44</td>
</tr>
<tr>
<td>Bank deposit growth</td>
<td>-</td>
<td>0.54</td>
<td>2.4</td>
<td>1.53</td>
</tr>
<tr>
<td>Stock price index growth</td>
<td></td>
<td>1.28</td>
<td>1.8</td>
<td>1.81</td>
</tr>
<tr>
<td>Real Lending Rate Differential</td>
<td>-</td>
<td>0.45</td>
<td>2.3</td>
<td>1.97</td>
</tr>
<tr>
<td>Real Lending Rate Growth</td>
<td>-</td>
<td>0.52</td>
<td>2.2</td>
<td>---</td>
</tr>
<tr>
<td>Current account/GDP</td>
<td>-</td>
<td>0.68</td>
<td>2.4</td>
<td>---</td>
</tr>
<tr>
<td>Base Money/Reserve</td>
<td>-</td>
<td>0.46</td>
<td>2.4</td>
<td>---</td>
</tr>
</tbody>
</table>

Note:
2. Excess real M1 balances is the residual from regression of real M1 on real GDP, inflation, and a deterministic trend.
Appendix B: Capital Controls Index

Figure 4(a): Capital Controls Index -- East Asian Countries

- **Foreign Ownership Restrictions Index -- China**: Liberalization date: November 1992
- **Foreign Ownership Restrictions Index -- Indonesia**: Liberalization date: September 1989
- **Foreign Ownership Restrictions Index -- Korea**: Liberalization date: January 1992
- **Foreign Ownership Restrictions Index -- Malaysia**: Liberalization date: December 1988
- **Foreign Ownership Restrictions Index -- Philippines**: Liberalization date: June 1991
- **Foreign Ownership Restrictions Index -- Taiwan**: Liberalization date: January 1991
- **Foreign Ownership Restrictions Index -- Thailand**: Liberalization date: September 1987

Source: Edison and Warnock (2001)
Figure 4(b): Capital Controls Index — Latin American Countries

Foreign Ownership Restrictions Index — Argentina

Liberalization date: November 1989

Foreign Ownership Restrictions Index — Brazil

Liberalization date: May 1991

Foreign Ownership Restrictions Index — Chile

Liberalization date: January 1992

Foreign Ownership Restrictions Index — Colombia

Liberalization date: February 1991

Foreign Ownership Restrictions Index — Mexico

Liberalization date: May 1989

Foreign Ownership Restrictions Index — Turkey

Liberalization date: July 1989

Foreign Ownership Restrictions Index — Venezuela

Liberalization date: January 1990

Source: Edison and Warnock (2001)
References


Kim, Woochan and Wei, Shang-Jin , 2000, “Foreign Portfolio Investors Before and During a Crisis”, working paper, Brookings Institution, Harvard University and NBER.


