

Predicting Currency Crises with a Nested Logit Model

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ABSTRACT. This paper finds strong evidence that external illiquidity and financial fragility are good predictors of currency crises. In this paper, a unique methodology – a multi-state nested logit model – is employed to measure the probabilities of speculative attacks and the probabilities of successful defenses by the central banks against speculative attacks. This model has two major virtues: (i) it allows us to predict both the probability of speculative attacks and the probability of successful defenses; (ii) it provides an empirical model to analyze the degree to which different economic factors affect the likelihood of speculative attacks and the abilities of central banks to defend, thereby sheds lights on what regulatory policies are appropriate to minimize the stampede of currency crises. (JEL F31, F32 and C53)

Introduction

During the past decade there have been numerous studies attempting to find reliable predictors of currency crises. The studies most widely cited include, Jeffrey J. Sachs, Aaron Tornell and Andres Velasco (1996), Jeffrey Frankel and Andrew Rose (1996), Graciela L. Kaminsky, Saul Lizondo and Carmen M. Reinhart (1997), Graciela L. Kaminsky (1998) and Edison J. Hali (2000). The methodologies used in the literature fall into two main categories: The signal extraction approach (indicator approach) developed by Kaminsky (1998) and the econometric analysis, three of which are particularly important – the multinomial logit approach of Eichengreen, Rose and Wyplosz(1995), the binary probit approach of Frankel and Rose (1996) and the ordinary least squares (OLS) regression model of Sachs, Tornell and Velasco(1996).

Each of these approaches has its strengths and limitations. First of all, the signal extraction approach is relatively simple to compute because fundamentally it

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only involves computing the number of indicators that have crossed their minimum thresholds within a given time window. However, there are a number of limitations to this model. First, it is a univariate approach which considers separately the signals from different indicators. As a result, it ignores the relationships among different indicators. Second, the signal extraction approach often uses composite indexes in order to summarize the signals of a number of different indicators. However, the weights used to construct the composite indexes are arbitrary. Moreover, the signal extraction approach is idiosyncratic, so it is difficult to apply to the standard statistical tests in order to evaluate the robustness of results.

The probit and OLS approaches, on the other hand, are multivariate approaches that consider multiple explanatory variables simultaneously in the prediction. In addition, standard test statistics can be used to test the significance of the empirical results. Sachs, Tornell and Velasco(1996) use an OLS method to regress a crisis index (which is a weighted average of the devaluation rate and the percentage decline in the foreign reserve) on a real exchange rate index, a lending boom variable (which is defined as the ratio of claims on private sector by deposit money banks and monetary authorities) and a "low-reserve" dummy. A recent paper by Manmohan Kumar , Moorthy Uma and William Perraudin (2002) tried to assess the probabilities of currency crashes using a simple logit model. However, these approaches are binomial approaches (two-states approaches) which can only predict the occurrence or non-occurrence of speculative attacks or currency crises. No distinction is made between successful and unsuccessful defenses by the central banks against speculative attacks. This distinction is important because the policy implications and economic consequences are very different for successful and unsuccessful defenses. The Eichengreen, Rose and Wyplosz study (1995) was a step forward in the study of currency crises not only because it was the first to use a multinomial logit study but also because it was the first to address instances of successful and unsuccessful defenses. However, this method treats the choice of speculative attacks and defenses in parallel and thus cannot be used to compute the conditional probabilities of successful defenses given speculative attacks. Moreover, Eichengreen et. al's paper focuses mainly on fiscal deficits, current account deficits, money and credit growth as well as inflation in the prediction of currency crises. The role of short term international liquidity is not considered even though it is found to be highly important by Lau and Park (1995) as well as Mckinnon and Pill (1996).

In this paper, a new empirical model – a nested logit model – is developed to estimate the probabilities of speculative attack and unsuccessful defenses. A major contribution of this paper is to develop a multivariate empirical model that can rectify the limitations of the models currently used in the literature. Firstly, unlike the univariate models, the nested logit model allows for the simultaneous analysis of multiple predictors and the examination of the relationship among these predictors. Secondly, the nested logit model subdivides the state of speculative attack into two states – the state of successful defense and unsuccessful defense. This allows us to evaluate both the probabilities of speculative attacks and the probabilities of successful defenses by the central banks given speculative attacks. In order to take into account the differences in nature of speculative attacks and defenses, the multi-state nested logit model was designed as a two-branch model. In the top branch, it analyses the odd of speculative attacks versus no speculative

attacks. Then, given a speculative attack, it evaluates the odd of successful defense versus unsuccessful defenses by the central banks.

Using this model, we find strong evidence that international illiquidity, fiscal deficits and financial fragility are important predictors of exchange rate crises. This finding provides strong support to the arguments of Ronald I. Mckinnon and Pill Huw(1996) as well as Robert Chang and Andres Velasco (1998a and 1998b) that financial weaknesses usually precedes currency crises. The empirical results of this paper demonstrates the importance of the “overborrowing syndrome” (which results from the moral hazard in the financial market) in triggering the speculative attacks in the foreign exchange market. In addition, this model is employed to perform out-of-sample predictions of the probabilities of speculative attacks and unsuccessful defenses shortly prior to the recent Argentinian and Brazilian crises. Also, three different statistical tests are used to evaluate the performance of our model relative the existing prediction models in the literature.

The predictors used in the empirical model are selected based on the insights of the three generations of theoretical models of currency crises. The “first generation model” (Paul Krugman, 1979; Robert Flood and Peter Garber, 1984a) suggests that exogenous government budget deficits lay at the root of balance of payment crises. The empirical implication of the first generation model is that excessively expansionary fiscal policy should be a reliable predictor of currency crises. The “second generation” model (Maurice Obstfeld ,1986) formulates the possibility of self-fulfilling speculative attacks. In their model, there can be multiple equilibria in the foreign exchange market. A high public debt with short maturity is a potential source of self-fulfilling currency crises. In their model, the threat of an attack generates expectations-driven increases in interest rates and thus there is a strong incentive for the central bank to abandon the peg since devaluation allows the government to roll over the short-term public debt at a lower interest rate. The empirical implication of the second generation model is that, prior to an attack, there is no reason to anticipate excessively expansionary monetary or fiscal policies but we should observe an drastic increase in domestic interest rate. Nevertheless, neither the first nor the second generation stories seem to be relevant in explaining the 1997 East Asian Crisis (Paul Krugman, 1999). For this reason, the third generation model was developed. The third generation model suggests that international illiquidity in a country’s financial system precipitates the collapse of the exchange rate. A financial system is internationally illiquid if its short-term obligations in foreign currency exceed the amount of foreign currency to which it can have access at short notice. When governments implicitly guarantee the debts of financial systems, the problem of moral hazard arises, thereby encouraging over-borrowing in short-term foreign currency. When authorities do not have adequate foreign reserves, the financial system is internationally illiquid and is highly vulnerable to speculative attack. The empirical implication of the third generation model is that external illiquidity is a crucial factor in financial crises and currency crises (Mckinnon and Pill, 1996; Chang and Velasco, 1998a and 1998b).

The paper is organized as follows: Section I provides a literature review on currency crises prediction; Section II discusses the predictors of speculative attacks and unsuccessful defenses of the central banks employed in this paper; Section III describes the nested logit model — the empirical model employed in this paper for

predicting speculative attacks and successful defenses; Section IV reports the estimation results of the nested logit model and analyses the effect of capital controls; Section V presents the in-sample and out-of-sample predictions of the model as well as evaluates the performance of the model by testing the predictive power of the nested logit model vis-a-vis the signal extraction model widely used in the literature; Section VI decomposes the increase in the probability of speculative attacks into various factors; Section VII discusses the policy implications of the empirical findings; Section VIII concludes by summarizing the model's empirical findings and by making policy recommendations about how central banks can reduce their vulnerabilities to speculative attacks and increase the probability of launching successful defenses. The data description is provided in Appendix A. The dates of successful and unsuccessful defended speculative attacks in the sample countries are reported in Appendix B.

I. Literature Review on the Prediction of Currency Crises

This section provides a comprehensive survey of the predictors used in the recent empirical studies of speculative attacks and currency crises. The most widely studied predictors fall primarily into the following categories:

- (1) predictors related to the current account problems (Kaminsky, 1998; Kaminsky and Reinhart, 1999):
 - overvaluation of real exchange rate (deviations of real exchange rate from trend)
 - declines in exports
 - increases in imports
 - deterioration in terms of trade
 - ratio of current account deficits to GDP
- (2) predictors related to the capital account problems (Kaminsky and Reinhart, 1999):
 - declines in foreign exchange reserves
 - differentials between domestic and foreign interest rates
- (3) predictors related to the compositions of capital inflows (Frankel and Rose, 1996):
 - FDI vs portfolio flows (as percentage of total debt)
 - long term vs. short-term portfolio capital
- (4) predictors related to the debt profile (as percentage of total debt) (Frankel and Rose, 1996):
 - fixed rate vs. floating rate borrowing
 - domestic currency vs. foreign currency denominated debt
 - amount of debt lent by commercial banks
 - amount of debt which is variable rate
 - amount of debt which is borrowed by public sector
 - amount of debt which is short-term
 - amount of debt lent by multilateral development banks
- (5) predictors related to the financial vulnerability and financial liberalization (Kaminsky, 1998; Kaminsky and Reinhart, 1999):

- growth in the M2 multiplier (growth in the ratio of M2 to base money)
 - ratio of domestic credit to GDP
 - lending boom — ratio of claims on the private sector by deposit money banks and monetary authorities to GDP (Sachs, Tornell and Velasco, 1996)
 - ratio of lending to deposit interest rates
 - dummy for domestic and external financial liberalization
- (6) predictors related to the overborrowing cycles and international liquidity:
- ratio of external debt to foreign exchange reserves (Frankel and Rose, 1996)
 - ratio of short-term foreign liabilities to foreign exchange reserves (Berg and Pattillo, 1998; Kaminsky, 1998 and Hali, 2000)
- (7) predictors related to the real sector and stock market (Eichengreen, Rose and Wyplosz, 1995; Frankel and Rose, 1996):
- CPI inflation and wage growth
 - real GDP growth
 - unemployment rate
 - changes in stock prices
- (8) predictors related to the fiscal and monetary policy (Kaminsky, 1998):
- ratio of fiscal deficits to GDP
 - excess M1 balances (the residuals from regressing real M1 on real GDP growth, inflation and a deterministic trend)
- (9) predictors related to the bank runs (Kaminsky, 1998):
- declines in bank deposits
- (10) predictors related to the foreign markets (Frankel and Rose, 1996):
- foreign real GDP growth
 - increases in foreign interest rates
- (11) predictors related to the political stability (Eichengreen, Rose and Wyplosz, 1995)
- government victory in election
 - government defeat in election
 - left-wing government
 - new finance minister

Before the Mexican debt crisis of 1994 and the Asian currency crises of 1997, the currency crises predictors used in the literature focus mainly on variables related to the fiscal and monetary policy as well as the real exchange rate. Among the predictors being examined, real exchange rate overvaluation is considered best in predicting currency crises. (John Bilson F.O., 1979; Susan Collins M., 1995; Sebastian Edwards; 1989; Kaminsky and Reinhart, 1996; Ramon Moreno, 1995; Inci Ötker and Ceyla Pazarbasioglu, 1994,1995). With the outbreak of the Mexican and Asian crises, it is alarming to realize that the traditional models fail to predict these crises as these models have omitted some important factors such as financial fragility and international illiquidity. Sachs, Tornell and Velasco (1995) shifts the focus of the literature from traditional indicators towards indicators related to the problem of financial vulnerability by presenting solid empirical evidence on the relationship between lending booms in the banking sector (measured as the ratio of claims on the private sector by deposit money banks and monetary authorities) and debt crises. Frankel and Rose (1996) further examine indicators related to

the overborrowing cycles and international liquidity such as the ratio of external debt to international reserves and the ratio of short-term foreign debt to international reserves. However, in Frankel and Rose's probit analysis, most of the debt variables do not have statistically significant coefficients. This somewhat weak result probably occurred because there was multicollinearity between their different debt variables and the low frequency data (annual data) lowered the power of the tests. Lau and Park (1995) was the first to provide strong evidence of the role of international illiquidity in triggering currency crises. They found that the ratio of short-term foreign liabilities to foreign exchange reserves together with the real exchange rate appreciation index sent out clear warning signals before the East Asian currency crisis.

II. Examining The Important Predictors of Speculative Attacks and Unsuccessful Defenses of the Central Banks Against Speculative Attacks

This section examines the key economic fundamentals important in determining the probability of speculative attacks and unsuccessful defenses of the central banks. They include variables related to the short-term international illiquidity (the ratio of short-term external liabilities to foreign exchange reserves), variables related to financial fragility (the lending rate differential and the ratio of quasi-money to international reserves), variables related to real exchange rate overvaluation (the real exchange rate appreciation index) and variables related to fiscal overspending (the ratio of fiscal deficits to GDP). These variables are considered important in predicting which countries are vulnerable to speculative attacks based on both the theoretical models of currency crises and the empirical findings of the literature. When these fundamentals are weak and when the potential costs of defense outweigh the potential benefits, the central banks are less likely to defend successfully, if they were to defend at all. In the empirical model, the one-quarter lag of these variables are used in the estimation to avoid the endogeneity problem.

A. Lending Rate Differentials

The lending rate differential between domestic-currency denominated loan and foreign-currency denominated loan is a predictor that has received much attention in the currency crises literature because all three generations of model predict that domestic interest rates should go up prior to currency crises. For the first generation model like the prospective deficits model of Craig Burnside, Martin Eichenbaum and Sergio Rebelo(2001), a basic prediction is that interest rates should have gone up prior to the crises because when the economic agents expect large prospective fiscal deficits, the expectation that these future deficits would be at least partially financed by seigniorage revenues or an inflation tax on outstanding nominal debt leads to an expectation of the collapse in the fixed exchange rate regimes, thereby raising $E_t \hat{e}_{t+1}^{regime-change}$ in the super-risk premium term of the uncovered interest parity described below and driving up the lending rate differentials. Empirically, they found that interest rates in Thailand and S.Korea did rise prior to the major movements in bath and the won. The second generation currency crises model argues that the expectations of speculative attacks generate expectations-driven

increases in interest rates and shift the economy from a "no-crisis" equilibrium to a "crisis" equilibrium. A large interest rate differential implies a market expectation of large exchange rate depreciation or currency risk and hence may precipitate a self-fulfilling crisis (Eichengreen, Rose and Wyplose, 1995). The third generation model maintains that lending rate differential contributed seriously to the unhedged overborrowing syndrome prior to the 1997 East Asian Crisis because a large interest rate differential makes it very costly for importers to hedge in incomplete markets (Mckinnon, 2000). Mckinnon's analysis is particularly insightful and 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 constrained 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 2). 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.”

Using the uncovered interest parity:

$$i_t - i_t^* = E_t \hat{e}_{t+1}^{regime-change} + E_t \hat{e}_{t+1}^{within-regime} + \rho_t^{currency} + \rho_t^{country}$$

where i_t and i_t^* are the domestic and foreign interest rate respectively, $E_t \hat{e}_{t+1}^{regime-change}$ is the expected exchange rate depreciation in the event of a regime change and $E_t \hat{e}_{t+1}^{within-regime}$ is the expected exchange rate depreciation if existing regime persists. $\rho_t^{currency}$ is the currency risk premium and $\rho_t^{country}$ is the country risk premium. According to the third generation currency crises model, the super-risk premium in the interest rate differentials, $\rho_t^{super-risk} \equiv E_t \hat{e}_{t+1}^{regime-change} + \rho_t^{currency}$, provides a temptation for the poorly behaved banks to borrow unhedged. When the decision making horizon is sufficiently short for banks with moral hazard, the bank managers ignore the unpredictable regime change in the exchange rate. They simply hope that any thing drastic will not happen in their watch (Mckinnon, 2001). This provides a temptation for the poorly behaved banks to borrow unhedged. Mckinnon finds that, before May 1997, the super risk

premium almost made up the whole of the interest rate differentials of S.Korea, Malaysia, Philippines and Thailand.

The predictive power of the interest rate differential is supported by empirical findings. Figure 1 and Figure 2 show the lending rate differential for various Asian and Latin American countries. However, even though all three generations of currency crises models predict the interest rate differential to rise prior to the crises, the different reasons for the rise suggested by the three models yield different implications on the estimation which allow us to test the validity of one model against the other. For the first generation model, the large fiscal deficits lays at the root of the currency crises and the high interest rate differential is only a consequence of such excessively expansionary fiscal policy. For this reason, the fiscal deficit variable should be a significant predictor of currency crises in the estimation and the interest rate differential will be less significant once the fiscal deficit variable is controlled for. Similarly, the third generation model argues that the overborrowing of short term foreign liabilities caused by the moral hazard problem is the immediate cause of the currency crises and the high interest rate differential is only an indirect cause of the overborrowing syndrome. In regard of this, the short-term international liquidity variable should be a strong predictor of currency crises in the estimation but the interest rate differential will be less significant once the short-term international liquidity variable is controlled for. In contrast to the first and third generation model, the second generation model suggests that the interest rate increases are expectations-driven and thus the high interest rate differential is itself a strong predictor as it reflects the market expectation of exchange rate depreciation or currency risk. For this reason, the interest rate differential variable should remain significant even when the fiscal deficit and short-term international liquidity variables are controlled for. In the empirical section, we will explore the validity of each generation model by examining the estimation result.

B. Ratio of Fiscal Deficits to GDP

According to the first generation model, high government deficit lies at the root of balance of payment crises. Nevertheless, the solid fiscal situation of most of the East Asian economies before the 1997-98 crisis suggests that speculative attacks did not arise solely because of fiscal deficits. Before the 1997-98 crisis, most of the East Asian economies had achieved such good fiscal balance that revenue from inflation taxes were unnecessary (See Figure 3). As Sachs, Tornell and Velasco(1996) argue, speculative attacks arose in Mexico not because of fiscal deficits, but because of Bank of Mexico's attempt to sterilize¹ capital inflows starting in 1990. 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 key in triggering the financial crisis of December 1994.

Burnside, Eichenbaum and Rebelo(2001) contributes to the reconciliation of the first generation model of Krugman(1979) with the third generation model of Mckinnon and Pill(1996) by articulating the view that it is the large *prospective* deficits associated with implicit bailout guarantees to the weak financial system that triggers the 1997 Asian currency crisis, notwithstanding the evidence that the crisis countries have either current surplus or small deficits. They argue that even

though the Asian countries did not have high current fiscal deficits in the period preceding the 1997 crisis, the expectation that the future deficits would be partially financed by seigniorage revenue or an inflation tax on outstanding nominal debt led to the collapse of the fixed exchange rate regimes in Asia due to the self-fulfilling prophecy.

C. Short-term International Liquefiable Liabilities

A high ratio of short-term international liquefiable liabilities to foreign exchange reserves is recognized by the third generation model as a crucial predictor of currency crises after the Mexican debt crisis of 1995 and the Asian currency crisis of 1997 (Lau and Park, 2000). This is because both of these two crises were preceded by soaring ratios of short-term external liabilities to foreign reserves as suggested by the third generation currency crisis model instead of being preceded by large fiscal deficits as suggested by the first generation currency crisis models.

The short-term international liquefiable liabilities of a country can be viewed largely as consisting of three components: the short-term external debt, the cumulative portfolio liabilities and the four-to-six months' imports. The sum of these three items provides an estimate of the amount of liquidity required in the event of crises. The **short-term external debt component** is closely associated with the "original sin" problem suggested by Mckinnon(2001) as well as Barry Eichengreen and Ricardo Hausmann(1999). "Original sin" is a situation in which the domestic currency cannot be used to borrow abroad or to borrow long term, even domestically. This incompleteness causes financial fragility 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). This makes the financial system externally illiquid and thus vulnerable to speculative attacks. When the speculative attacks occur, sufficient foreign exchange reserves are needed if the central banks want to bail out the troubled financial institutes. The second component of the short-term liquefiable external liabilities is the **cumulative portfolio liabilities component** which reflects the ins and outs of hot money. During the 1997 Asian currency crisis, the sudden switch from capital inflows to capital outflows left the central banks helpless to prevent their currencies from depreciating. Worse still, there is evidence that foreign portfolio investors were positive feedback traders (rushing to buy when the market is booming and rushing to sell when the market is declining). Rather than respond to information about the fundamentals, traders mimicked each other (Woochan Kim and Shang-Jin Wei, 2000). This herding behavior exacerbates the destabilizing effect of hot money outflow on foreign exchange rates. On top of the short-term external debt and portfolio liabilities components, **six months' imports** are included as another component of the short-term external liquefiable liabilities in view of the IMF's recommendation that central banks should keep a four to six months import equivalence of foreign exchange reserves as a cushion threshold to smooth import transactions.

The danger of having high short-term external liabilities are twofold: firstly, as pointed out in the third generation currency crises model, countries with high ratios of hard currency short-term liquefiable liabilities to hard currency liquid assets were extremely vulnerable to reversals of capital inflows. This capital out-flight occurred massively in East Asia during the second half of 1997. Secondly,

if banks and firms have high short-term external liquefiable liabilities relative to their short-term external assets, increases in short-term foreign interests adversely affect their ability to serve interest payments. Figure 6 clearly reveals the financial weaknesses of the crisis countries: all of the crisis countries in East Asia and Latin America (S.Korea, Indonesia, Thailand, Argentina, Brazil and Mexico) had high short-term external liquefiable liabilities prior to the currency crises. During the period of 1995-1997, S.Korea had a ratio of short-term external liabilities to foreign exchange reserves in excess of five and Thailand had a ratio of more than three. This was a financially fragile situation because international reserves would have been insufficient to repay short-term debt and portfolio liabilities had foreign banks and foreign investors decided not to roll them over. Figure 20 further examines the short-term and long term components of external debts. In 1996, more than half of the external debt in S.Korea was short-term. Figure 21 and Figure 22 report the total external debt and foreign exchange reserves in selected East Asian and Latin American countries in 1993-2000.

D. Ratio of Quasi-money to Foreign Exchange Reserves

Other variables related to financial fragility also receive much attention in the prediction of currency crises as a result of the third generation currency crisis model. As suggested by Robert Chang and Andres Velasco (1998c), one major cause of financial fragility is financial liberalization without prudent supervision of the international liquidity of the financial sector². Among the indicators being examined in this area, the ratio of M2 to foreign exchange reserves is the indicator most widely used to measure “financial deepening” and the vulnerability of financial systems to capital outflows. This indicator rises quickly before currency crises: in Chile the share of financial system loans to the private sector rose from 5 percent of the GDP in 1974 to over 82 percent in 1982; for Mexico this share went from 26 percent in 1991 to 41 percent in 1994. However, because M1 is used mostly for transaction purposes, quasi-money (the difference between M2 and M1) is a better measure of the quantity of domestic currency that may potentially be dumped and moved out of the country as capital outflow during speculative attacks. Figure 8 and Figure 9 show the evolution of the ratio of quasi money to foreign exchange reserves in the Asian and Latin American countries respectively. The high ratios for the crisis countries were consistent with the financial fragility hypothesis. For instance, the ratios were in excess of three in S.Korea, Thailand, Philippines and Malaysia at the end of 1996, so was Mexico before the 1994 debt crisis.

E. Ratio of Domestic Credit to GDP

Since the overborrowing cycle suggested by Mckinnon and Pill (1996) plays an important role in the third generation model, the ratio of domestic credit to GDP is used by Kaminsky(1998) and Kaminsky and Reinhart(1999) as indicators of the overborrowing cycle in the prediction of currency crises. It is argued that 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. As a result, the crises are preceded by an explosion of domestic credit which finally results in problems in the banking sector when the economy enters a recession. Figure 10 and Figure 11 show the ratio of domestic credit to

GDP of the Asian and Latin American countries in the last decade. The figure shows that the ratio of domestic credit to GDP grew steadily since 1990. Take the case of Thailand in Asia, the ratio grew from three in 1991 to nearly five prior to the 1997 Asian financial crisis. In Latin America, similar upward trend was observed in Mexico prior to the 1994 Mexican crisis and in Brazil prior to the 1999 Brazilian crisis. Nevertheless the growth was found to be quite steady.

F. Ratio of Public Debt to GDP

As suggested by the second generation model, a high public debt with short maturity is a potential source of self-fulfilling currency crises. In the second generation model, the threat of an attack generates expectations-driven increases in interest rates and thus there is a strong incentive for the central bank to abandon the peg since devaluation allows the government to roll over the short-term public debt at a lower interest rate. Thus, the ratio of public debt to foreign exchange reserves (the stock version of fiscal deficits) is an indicator implied by Paul Krugman's 1979 model. Benigno and Missale (2001)'s study identifies the importance of public debt in determining the probability of exchange rate devaluation. On the one hand, a high public debt with short maturity makes it more likely that the fixed peg will be abandoned because, in order to defend the peg, the government has to roll over its short-term debt at a higher-than-expected interest rate. This "debt-burden effect" reduces the central bank's incentive to defend when the government has a high public debt. On the other hand, resisting a crisis enhances the credibility of the central bank and allows the government to roll-over its debt at a lower interest rate. This "signaling effect" makes the central bank more likely to launch a defense when public debt is high. Thus, whether high short-term public debt strengthens or weakens the central bank's ability and incentive of defend depends on the relative strength of the signaling effect versus the debt burden effect. Figure 12 and Figure ?? show the ratio of public debt to GDP for various Southeast Asian and Latin American countries. The Southeast Asian countries in our sample have a ratio of around one (or below) prior to the 1997 Asian crisis, with the exception of Indonesia and Singapore. The Latin American countries also have a ratio of one or less preceding the 1994 Mexican crisis and the 1999 Brazilian crisis.

G. Real Exchange Rate Appreciation

Real exchange rate appreciation was considered one of the most reliable indicators in the currency crises literature, especially before the third generation currency crisis model was introduced. For instance, while estimates of the real appreciation of the Mexican Peso varies, common opinion put the accumulated real appreciation at 15-20 percentage points during 1988-1993. Similarly, before the Chilean currency crisis in 1982, the value of the Chilean Peso appreciated 30 percent between 1978 (the year an exchange rate stabilization was adopted) and the end of 1981. For Thailand, S.Korea and the Philippines, real exchange rates appreciated by at least 15-20 percentage points between 1986 and 1996. (see Figure 14 and 15). When a country's real exchange rate appreciates vis a vis its trade competitors, it becomes less competitive in exports. Therefore relative exchange rate appreciation has a negative impact on current account balances. The competitive devaluation of exchange rates – what is called the "beggar-thy-neighbor" phenomenon – proved to be important in generating speculative attack pressure for S.Korea and Thailand

during the last decade. The cause of the persistent real exchange rate appreciation can be explained by the Balassa-Samuelson theorem which states that the high productivity growth in the tradable sector relative to the non-tradable sector generates an upward pressure on the real exchange rate, which is exactly the case in the South-east Asian countries.

H. Unemployment Rate and Real GDP Growth

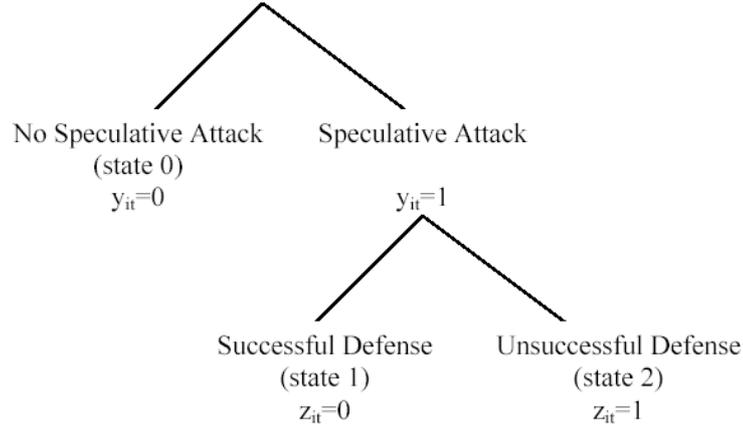
In addition to the aforementioned variables, unemployment rate and real GDP growth are two key variables that affect the willingness of the central banks to commit resources to defend against speculative attack. Imagine, for example, a situation in which GDP is weakening and the unemployment rate is rising. Authorities will hesitate to raise interest rates or to deplete international reserves to defend the currency. Knowing this, speculators will have a greater incentive to attack and a better likelihood of success (Olivier Jeanne, 1997). Using data for France, Francesco Caramazza (1993), Allan Drazen and Paul R. Masson (1994) find that ever since 1987 unemployment has positively affected realignment expectations. This result was confirmed by Thoman H. Alun (1994). Using the UK data, Paul R. Masson (1995) concludes similarly that persistent high unemployment increased the perception that the government would abandon the sterling parity. For this reason, our empirical model takes into account the effects of real GDP growth rates and unemployment rates on the likelihood that central banks will be successful in defending against speculative attacks.

Figure 16 and 17 plot the unemployment rate and the four-quarter moving average of real GDP growth for the selected East Asian and Latin American countries. The figures show that countries which have high unemployment rate relative to their historical mean are less likely to defend successfully. For instance, high unemployment rates in Colombia since 1990 jeopardize the central bank's ability and willingness to raise interest rates in order to defend against speculative attacks, thereby contributing to the outbreak of currency crises in the 1990s. A similar pattern is observed in Argentina, where rising unemployment rates since 1992 tied the hands of the central banks so that interest rates could not be used as a weapon of defend. In combination with rising unemployment rates, declining real GDP growth further weakens the central bank's willingness to defend because central banks may fear that raising the interest rate will contract the economy further and exacerbate the problem of high unemployment. In view of this, rising unemployment rates and slow growth in real GDP are important indicators of unsuccessful defenses against speculative attacks. These two variables proved to be highly relevant in predicting the ability of central banks to launch successful defenses. However, it should be emphasized that steadily low unemployment rate and satisfactory real GDP growth per se do not necessarily insulate a country from speculative attacks. A country can be growing fast but financially illiquid. Analogously, we can imagine it as a company that is profitable, but has no liquid assets with which to meet financial needs. This was the circumstance of the East Asian countries during the 1997 crisis. In Asia, crisis countries like Thailand and S.Korea had low steady unemployment rates (below 2 percent) before the outbreak of the 1997 crisis. These rates are below their ten-year historical average. However, high ratios of short-term external liabilities to international reserves clearly indicate a problem of external illiquidity. This gives speculators an incentive to attack. In

the face of vigorous attacks, Thailand was the first country to abandon its defense in July 1997, followed by Malaysia and the Philippines later in the same month, Indonesia in August 1997 and S.Korea in November 1997.

III. Nested Logit Model

The purpose of this section is to develop an empirical model (i) to predict the occurrence of speculative attacks and (ii) to evaluate the probability of unsuccessful defenses by central banks in the case of speculative attack. The empirical model is structured as a nested logit model, where the top branch represents the choice by speculators of whether or not to launch speculative attacks. The two choices result in two different outcomes: the “no speculative attack” state (state 0) and the speculative attack branch. The speculative attack branch initiates two states based on the outcomes of responses by central banks. The two states are the states of successful defenses (state 1) and unsuccessful defenses (state 2). This nested logit model has the virtue of considering the differences in the nature of speculative attacks and defenses. In the first stage, the speculators decide whether or not to attack. If the speculators choose to attack, we come to stage two where the central banks respond by launching successful or unsuccessful defenses³. The structure of the nested logit model is illustrated in the following diagram:



Based on this structure of the nested logit model, the following equations specify the probability of speculative attacks and the conditional probability of successful defenses in the case of speculative attacks:

Let X_{it} be the vector of predictive variables for country i at period t . (It consists of the joint sets of predictive variables for different states).

Let γ^{NA} and γ^A be the vectors of coefficients associated with the no speculative attack state (state 0) and the speculative attack branch (state 1 or 2) respectively.

Let β^{SD} and β^{UD} be the vectors of coefficients associated with the successful defense state (state 1) and the unsuccessful defense state (state 2) respectively.

$$\begin{aligned}
 P(\text{Speculative Attacks}) &\equiv P(A)_{it} = P(1, 2)_{it} \\
 (1) \qquad \qquad \qquad &= \frac{e^{\alpha_i^A + X_{it}' \gamma^A}}{e^{\alpha_i^A + X_{it}' \gamma^A} + e^{X_{it}' \gamma^{NA}}}
 \end{aligned}$$

$$P(\text{No Speculative Attacks}) \equiv 1 - P(A)_{it} = 1 - P(1, 2)_{it} = P(0)_{it}$$

$$(2) \quad = \frac{e^{\alpha_i^A + X_{it}' \gamma^A}}{e^{\alpha_i^A + X_{it}' \gamma^A} + e^{X_{it}' \gamma^{NA}}}$$

$$P(\text{Successful Defenses|Attacks}) \equiv P(SD|A)_{it} = P(1|1, 2)_{it}$$

$$(3) \quad = \frac{e^{X_{it}' \beta^{SD}}}{e^{X_{it}' \beta^{SD}} + e^{\alpha_i^{UD} + X_{it}' \beta^{UD}}}$$

$$P(\text{Unsuccessful Defenses|Attacks}) \equiv 1 - P(SD|A)_{it} = 1 - P(1|1, 2)_{it} = P(2|1, 2)_{it}$$

$$(4) \quad = \frac{e^{\alpha_i^{UD} + X_{it}' \beta^{UD}}}{e^{X_{it}' \beta^{SD}} + e^{\alpha_i^{UD} + X_{it}' \beta^{UD}}}$$

In the estimation of the coefficients, two normalizations are necessary for identification purposes: In the top branch of the model, the probabilities of speculative attack and no speculative attack always sum up to 1. As a result, only the odd of attack and no attack ($\frac{e^{X_{it}' \gamma^A}}{e^{X_{it}' \gamma^A} + e^{X_{it}' \gamma^{NA}}}$) can be identified. This implies that only $e^{X_{it}' (\gamma^A - \gamma^{NA})}$ can be identified. In view of this, γ^{NA} is normalized to 0 in the estimation. Similarly, only the odd of successful and unsuccessful defenses can be identified in the lower branch of the model. Hence, β^{SD} is normalized to 0. After normalization, γ^A measures the effect of changes in X_{it} on the odd of attack versus no attack. β^{UD} measures the effect of changes in X_{it} on the odd of unsuccessful defenses versus successful defenses.

The vector of predictive variables in the basic specification of the nested logit model includes the one-quarter lag of all of the variables discussed in Section II⁴.

Let Y_{it} be a zero-one dummy denoting the state of speculative attack is realized and Z_{it} be a zero-one dummy denoting the state of unsuccessful defense given a speculative attack is realized. That is,

$$Y_{it} = \begin{cases} = 1 & \text{if there is speculative attack in country } i \text{ at time } t \\ = 0 & \text{otherwise} \end{cases}$$

$$Z_{it} = \begin{cases} = 1 & \text{if there is unsuccessful defence in country } i \text{ at time } t \\ = 0 & \text{otherwise} \end{cases}$$

The likelihood function is:

$$L = \prod_{i=1}^N f_i(\{y_{it}\}_{t=1}^T, \{z_{it}\}_{t=1}^T)$$

where N is the number of countries in our sample (see Appendix B for the list of countries included in the sample) and T is the number of periods for each country. Using a fixed effect logit model which assumes that $y_{it} \sim \text{Bernoulli}(\Lambda(\alpha_i^A + \mathbf{X}_{it}' \gamma^A))$ and $z_{it}|y_{it} = 1 \sim \text{Bernoulli}(\Lambda(\alpha_i^{UD} + \mathbf{X}_{it}' \beta^{UD}))$ where $\Lambda(\alpha_i^A + \mathbf{X}_{it}' \gamma^A) = \frac{e^{\alpha_i^A + \mathbf{X}_{it}' \gamma^A}}{1 + e^{\alpha_i^A + \mathbf{X}_{it}' \gamma^A}}$ and $\Lambda(\alpha_i^{UD} + \mathbf{X}_{it}' \beta^{UD}) = \frac{e^{\alpha_i^{UD} + \mathbf{X}_{it}' \beta^{UD}}}{1 + e^{\alpha_i^{UD} + \mathbf{X}_{it}' \beta^{UD}}}$. The density function $f_i(\{y_{it}\}_{t=1}^T, \{z_{it}\}_{t=1}^T)$

is defined as follows:

$$\begin{aligned}
f_i(\{y_{it}\}_{t=1}^T, \{z_{it}\}_{t=1}^T) &= \prod_{t=1}^T [1 - \Lambda(\alpha_i^A + \mathbf{X}'_{it}\boldsymbol{\gamma}^A)]^{1-y_{it}} & (5) \\
&\quad [\Lambda(\alpha_i^A + \mathbf{X}'_{it}\boldsymbol{\gamma}^A)\Lambda(\alpha_i^{UD} + \mathbf{X}'_{it}\boldsymbol{\beta}^{UD})]^{y_{it}z_{it}} \\
&\quad [\Lambda(\alpha_i^A + \mathbf{X}'_{it}\boldsymbol{\gamma}^A)(1 - \Lambda(\alpha_i^{UD} + \mathbf{X}'_{it}\boldsymbol{\beta}^{UD}))]^{y_{it}(1-z_{it})} \\
&= \prod_{t=1}^T [1 - \Lambda(\alpha_i^A + \mathbf{X}'_{it}\boldsymbol{\gamma}^A)]^{1-y_{it}} \\
&\quad [\Lambda(\alpha_i^A + \mathbf{X}'_{it}\boldsymbol{\gamma}^A)]^{y_{it}} [\Lambda(\alpha_i^{UD} + \mathbf{X}'_{it}\boldsymbol{\beta}^{UD})]^{y_{it}z_{it}} \\
&\quad [1 - \Lambda(\alpha_i^{UD} + \mathbf{X}'_{it}\boldsymbol{\beta}^{UD})]^{y_{it}(1-z_{it})}
\end{aligned}$$

However, since the number of fixed effect parameters α_i^A and α_i^{UD} increase with N, α_i^A and α_i^{UD} cannot be consistently estimated for a fixed T. As the estimate of $\boldsymbol{\gamma}^A$ and $\boldsymbol{\beta}^{UD}$ are functions of the estimators for α_i^A and α_i^{UD} , the MLE of $\boldsymbol{\gamma}^A$ and $\boldsymbol{\beta}^{UD}$ are not consistent either. This problem is known as the incidental parameter problem (Neyman and Scott(1948), Lancaster(2000)). The solution to get around this incidental parameter problem is to find the sufficient statistics for α_i^A and α_i^{UD} and estimate the conditional likelihood function conditional on the sufficient statistics for α_i^A and α_i^{UD} . By definition of a sufficient statistic, the conditional distribution given the sufficient statistic will not depend on α_i^A and α_i^{UD} . Chamberlain(1980) finds that $\sum_{t=1}^T y_{it}$ is the a minimum sufficient statistic for α_i^A . Therefore, Chamberlain suggests maximizing the *conditional* likelihood function to obtain the consistent logit estimates for $\boldsymbol{\gamma}^A$:

$$(6) \quad f c_i^A = f_i^A(y_{i1}, y_{i2}, \dots, y_{iT} | \sum_{t=1}^T y_{it})$$

The conditional likelihood for the T observations of y_{it} conditional on the number of ones in the set $\{y_{it}\}_{t=1}^T$ as derived in Greene(2000) is:

$$(7) \quad f c_i^A = \frac{\exp(\sum_{t=1}^T y_{it} \mathbf{X}'_{it} \boldsymbol{\beta}^A)}{\sum_{\sum_t d_{it}^A = S_i^A} \exp(\sum_{t=1}^T d_{it}^A \mathbf{X}'_{it} \boldsymbol{\beta}^A)}$$

where the function in the denominator is summed over the set of all $\binom{T}{S_i^A}$ different sequences of T zeros and ones that have the same sum as $S_i^A = \sum_{t=1}^T y_{it}$. As the denominator of eqt.9 requires a large amount of computing time when the number of possible sequences of T zeros and ones that have the same sum as $S_i^A = \sum_{t=1}^T y_{it}$ is large, the recursive computational method given by Howard (1972) as well as Krailo and Pike (1984) is employed.

Since we know that the distribution of z_{it} is the same as that of y_{it} given $y_{it} = 1$, a set of sufficient statistics for α_i^{UD} is the sum of z_{it} and the set of y_{it} which equals to 1 ($\sum_{t=1}^T z_{it}, \{y_{it} = 1\}_{t=1}^T$). That means, we can obtain consistent estimates for $\boldsymbol{\beta}^{UD}$ by estimating the following conditional density function:

$$(8) \quad f c_i^{UD} = f_i^{UD}(z_{i1}, z_{i2}, \dots, z_{iT} | \sum_{t=1}^T z_{it}, \{y_{it} = 1\}_{t=1}^T)$$

$$(9) \quad f c_i^{UD} = \frac{\exp(\sum_{t=1}^T y_{it} z_{it} \mathbf{X}'_{it} \boldsymbol{\beta}^{UD})}{\sum_{\sum_t d_{it}^{UD} = S_i^{UD}} \exp(\sum_{t=1}^T y_{it} d_{it}^{UD} \mathbf{X}'_{it} \boldsymbol{\beta}^{UD})}$$

Given this, a procedure to obtain consistent estimates of β^A and β^{UD} is described as follows:

- (i). Apply MLE to eqt.7 to get consistent estimate of β^A .
- (ii). Restrict to the set of data where $y_{it} = 1$, estimate eqt.9 to get consistent estimate of β^{UD} .

It is widely known that in a logit or probit model, the *magnitude* of the marginal impact of a unit change in a predictor X_j on the predicted probability $\left(\frac{\partial P}{\partial X_j}\right)$ is not directly measured by the coefficient associated with X_j but is measured by a function of both the predictors (which are time varying) and the coefficients associated with the predictors (see equation 10 and 11 below). Nevertheless, the *direction* of relationship between a predictor and the predicted probability is uniquely determined by the sign of the estimation coefficient associated with the predictor. The relative importance of various predictors in predicting the occurrences of recent crises are examined in greater details in Section VI. Below is an analysis of the relationship between a unit change in a predictor X_j and the predicted probability $\left(\frac{\partial P}{\partial X_j}\right)$:

Let γ_j^A be the estimation coefficient associated with the predictor X_j in the prediction of speculative attacks. That is, it is the j^{th} component of the coefficient vector γ_A . The marginal impact of a unit change in a predictor X_j on the predicted probability of speculative attack $\left(\frac{\partial P(A)}{\partial X_j}\right)$ is measured by:

$$(10) \quad \frac{dP(A)}{dX_j} = \frac{d\left(\frac{e^{X'\gamma^A}}{1+e^{X'\gamma^A}}\right)}{dX_j} = \gamma_{A,j} \left[\frac{e^{X'\gamma^A}}{(1+e^{X'\gamma^A})}\right]^2$$

Since the second component $\left[\frac{e^{X'\gamma^A}}{(1+e^{X'\gamma^A})}\right]^2$ is always positive, the marginal impact of a unit change in a predictor X_j on the predicted probability of speculative attacks is of the same sign as the estimation coefficient associated with this predictor (γ_j^A).

Similarly, let β_j^{UD} be the estimation coefficient associated with the predictor X_j in the prediction of unsuccessful defenses given speculative attacks. That is, it is the j^{th} component of the coefficient vector β^{UD} . The marginal impact of a unit change in a predictor X_j on the predicted probability of speculative attack $\left(\frac{\partial P(UD|A)}{\partial X_j}\right)$ is measured by:

$$(11) \quad \frac{dP(UD|A)}{dX_j} = \frac{d\left(\frac{e^{X'\beta^{UD}}}{1+e^{X'\beta^{UD}}}\right)}{dX_j} = \beta_{UD,j} \left[\frac{e^{X'\beta^{UD}}}{(1+e^{X'\beta^{UD}})}\right]^2$$

Again, since the second component $\left[\frac{e^{X'\beta^{UD}}}{(1+e^{X'\beta^{UD}})}\right]^2$ is always positive, the marginal impact of a unit change in a predictor X_j on the predicted probability of unsuccessful defenses given speculative attacks is of the same sign as the estimation coefficient associated with this predictor (β_j^{UD}).

A. Indexes of Speculative Attacks, Successful Defenses and Unsuccessful Defenses

The next step is to identify the episodes of speculative attacks, successful defenses and unsuccessful defenses in the data. As we mention earlier, the instruments most widely used by the central banks to defend against speculative attacks are foreign exchange reserves and discount rates (the interest rate at which banks borrow from the central banks)⁵. For this reason, our model uses the following measures to define instances of speculative attacks with successful and unsuccessful defenses:

A successful defense of a speculative attack $Y_{it}(1 - Z_{it})$ is defined as an event in which either the decline in reserves ($-\Delta \text{Res}_{it}$) or the increase in discount rate ($\Delta \text{DisRate}_{it}$) exceeds the corresponding thresholds and there is no currency crisis in the current quarter ($Z_{it} = 0$):

$$Y_{it}(1 - Z_{it}) \begin{cases} = 1 & \text{if } (\Delta \text{Res}_{it} < -\overline{\text{Res}}_i \text{ or } \Delta \text{DisRate}_{it} > \overline{\text{DisRate}}_i) \\ & \text{and } Z_{it} = 0 \\ = 0 & \text{otherwise} \end{cases}$$

The threshold for quarterly reserves loss ($\overline{\text{Res}}_i$) and the threshold for percentage increase in the discount rate ($\overline{\text{DisRate}}_i$) is two standard deviations from the mean of the country. An unsuccessful defense of a speculative attack ($Z_{it} = 1$) (that is, a currency crisis) is defined as an event in which the exchange rate depreciates by more than two standard deviations in a quarter compared to the mean in the preceding five years of the country:

$$Z_{it} \begin{cases} = 1 & \text{if } (\Delta EX_{it} > \overline{EX}_i) \\ = 0 & \text{otherwise} \end{cases}$$

The threshold for the depreciation rate of domestic currency (\overline{EX}_i) is two standard deviations in a quarter compared to the mean quarterly depreciation in the country in the preceding five years.

A state in which there is no speculative attack ($Y_{it} = 0$) is a state in which both $Y_{it}(1 - Z_{it})$ and Z_{it} equal 0. In addition, in order to avoid measuring the same crises twice (or more), in cases in which there are a number of crisis observations in close succession, we accept only the first observation. The window we use in this paper is four quarters.

IV. Estimation Results and Sensitivity Analysis

A. Estimation Results

Estimate (a) of Table 1 shows the nested logit estimates of the benchmark model and the corresponding t-statistics. The predictors used in the benchmark model include the one period lag of the lending rate differential, the ratio of fiscal deficits to GDP, the ratio of short-term external liquefiable liabilities to foreign exchange reserves, the ratio of quasi-money to foreign exchange reserves, the ratio of domestic credit to GDP, the ratio of public debt to GDP, the real exchange rate appreciation index, the deviations of unemployment rates from historical means and the real GDP growth.

The significant predictors of speculative attacks are: (i) the ratio of short-term external liquidity to foreign exchange reserves and (ii) the ratio of fiscal deficits to GDP. This suggests that countries that have low external liquidity and excessive budget deficits are more vulnerable to speculative attacks. The lending rate differential does not show up as a significant predictor of speculative attacks once the short-term external liquidity variable and fiscal deficit variable are controlled for. This finding provides evidence to support the first and third generation models of currency crises but not the second generation model.

The significant predictors of unsuccessful defenses are: (i) the ratio of short-term external liquidity to foreign exchange reserves; (ii) the ratio of quasi-money to international reserves; (iii) high unemployment rate relative to the historical mean and (iv) low real GDP growth. The significance of the quasi-money ratio indicates that financial deepening without prudent regulatory policies can weaken the ability of the central bank to control capital outflow and hence reduces its ability to defend against speculative attack. High domestic unemployment and weak real GDP growth reduces the incentive of the central banks to employ their two key weapons (namely, the discount rate and the foreign reserves) to defend against speculative attacks. A discussion of the contagion of currency crises are provided in Kaminaky and Reinhart(1998) as well as Lau and Yan(2002) respectively.

B. An Analysis of the effects of Capital Controls

In Estimates (b) of Table 1, we examine the effectiveness of capital controls in reducing the vulnerability of a country to speculative attacks and in increasing the probability of mounting a successful defense. This analysis is interesting because there has been a hot debate among scholars of whether capital controls are effective in lowering the risk of currency crises: whilst some economists like Padma Desai (2000) argued that timely capital controls would have prevented the East Asian countries from the balance of payment crises of 1997 and Russia from the balance of payment crisis of 1998, the IMF and the U.S. Treasury could not accept this option. The capital control adopted by Malaysia in the aftermath of the 1997 Asian financial crisis also aroused lots of controversy.

Estimate (b) examines the effectiveness of capital controls in stemming speculative attacks for countries that are externally illiquid (as measured by a high ratio of short-term external liabilities to foreign exchange reserves) and countries that have fragile financial markets (as measured by a high ratio of quasi-money to foreign exchange reserves). A capital control index is defined based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)*. The capital control index is constructed by taking the average of the 0/1 dummies of restrictions on 13 items in the capital account⁶. This capital control index is multiplied by the ratio of short-term international liabilities to international reserves as well as the ratio of quasi-money to international reserves.

The results of Estimates (b) the cross product of the capital control index and the ratio of short-term international liabilities to international reserves is significant in lowering the probability of speculative attack. This indicates that effective capital controls can reduce the probability of speculative attack that involves the massive withdrawal of quasi-money. According to the estimation result, the cross product of the capital control index and the ratio of quasi-money to international reserves is significant in raising the probability of successful defense given an attack. This

indicates that capital controls are effective in rescuing countries with fragile financial systems, *ceteris paribus*. Nevertheless, all these conclusions rely on the assumption that capital controls are not endogenous and do not affect the underlying strength of the financial system and international liquidity. If this assumption does not hold (that is, if the Lucas critique applies), then the above conclusion on capital controls needs to be taken with caution.

Predictors (X)	Estimate (a)		Estimate (b)	
	γ^A	β^{UD}	γ^A	β^{UD}
Lending Rate Differentials	0.1207 (1.8295)	0.7754 (1.7465)	0.1196 (1.8247)	0.0652 (0.2089)
Ratio of short external liabilities to FX reserves	0.3775 (3.0107)**	0.9745 (3.1838)**	0.2317 (2.7097)**	0.9264 (2.3845)*
Real Exchange Rate Appreciation Index (86Q1=1)	0.1622 (2.0667)*	0.4396 (1.3330)	0.2079 (2.3544)*	1.2618 (2.7482)**
Ratio of Quasi-money to FX reserves	0.0737 (0.5135)	0.9242 (2.5753)*	0.5440 (3.5467)**	1.5785 (3.6873)**
Ratio of fiscal deficits to GDP	0.4391 (2.5575)*	0.5047 (0.8937)	0.4496 (2.6131)**	0.3037 (0.4675)
Ratio of domestic credit to GDP	0.2070 (1.1579)	0.7429 (1.9141)	0.2526 (1.3964)	0.7570 (1.6883)
Unemployment rate (deviations from historical historical mean)	0.0623 (0.5862)	0.1556 (2.0947)*	0.0395 (0.3698)	0.2750 (2.9051)**
Real GDP growth	-0.0782 (-0.5847)	-0.4195 (-2.1100)*	-0.0580 (-0.4328)	-0.0247 (0.0574)
Ratio of public debts to GDP	0.0740 (0.6639)	0.1672 (1.4672)	0.0077 (0.0680)	0.2243 (0.6065)
Capital controls index \times ratio of short term foreign liabilities to FX reserves	-	-	-0.2463 (-1.6602)	-2.0378 (-4.1002)**
Capital controls index \times ratio of quasi-money to FX reserves	-	-	-0.8703 (-3.9349)**	-0.7831 (-1.3061)

Note: 1. The numbers in parentheses are the t-statistics

2. * indicates the t-statistic is significant at 5% level of significance and

** indicates the t-statistic is significant at 1% level of significance.

TABLE 1. Nested Logit Estimates with and without Capital Control Indexes – Estimate (a) and Estimate (b)

V. Evaluation of the In-sample and Out-of-sample Predictive Abilities of Successful and Unsuccessful Defenses

The model's in-sample predictive power of currency crises and unsuccessful defenses are evaluated using three statistical scores: the quadratic probability score (QPS), the log probability score (LPS) and the global squared bias (GSB) suggested by Kaminsky (1998). The time period used in performing in-sample predictions is 1982Q1 to 1999Q4, and the time period used in performing out-of-sample predictions is 2000Q1 to 2000Q4.

The quadratic probability score (QPS) is

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

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

The log probability score (LPS) is:

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

LPS ranges from 0 to ∞ , 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 (GSB):

$$GSB = \frac{1}{I} \sum_{i=1}^I 2(\bar{P}_i - \bar{R}_i)^2$$

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

Table 2 part (a) reports the results of the goodness of fit tests for currency crises. The nested logit model outperforms the signal indicator approach in predicting currency crises under all three testing scores. The performance of the nested logit model matches that of the signal indicator approach in tranquil time using the QPS and LPS measurement and performs better using the GSB measurement. In the prediction during crisis period, the nested logit model performs consistently better than the signal indicator approach under all three measurements. Table 1 part (b) reports the results of the goodness of fit tests for successful defenses. Figure 25 - 40 plot the predicted unconditional probabilities of successful speculative attacks and the predicted conditional probabilities of successful defenses given speculative attacks for selected Latin American and East Asian countries. The predicted probabilities assuming full capital controls (with capital control index set to one) are also reported for comparison. Notice that the nested logit model performs well in predicting which countries are more vulnerable to speculative attacks and which

Part (a): Goodness of Fit for Crisis Periods (State 2) and Non-crisis Periods (State 0 and 1)						
Model	QPS		LPS		GSB	
	Non-Crisis Periods	Crisis Periods	Non-Crisis Periods	Crisis Periods	Non-Crisis Periods	Crisis Periods
Kaminsky's Composite Indicator	0.110	0.862	0.240	1.161	0.071	0.735
Nested Logit (Estimate (a))	0.1083	0.4504	0.2430	0.6446	0.041	0.1861
Part (b): Goodness of Fit for Periods with Successful Defenses given Speculative Attacks						
Model	QPS		LPS		GSB	
Nested Logit (Estimate (a))	0.5156		0.7279		0.2934	

TABLE 2. Goodness of Fit of the Nested Logit Model Compared with the Signal Indicator Approach

countries are likely to fail to defend against speculative attacks. For example, the model performs well in predicting the currency crisis in China during 1994Q1, in S.Korea and Thailand during 1997Q3, the Brazilian crisis during 1999 Q1, the Mexican crisis of 1994Q4 etc.

To evaluate how well the model predicts episodes of successful and unsuccessful defenses outside the sample periods, out-of-sample predictions are performed using data between 2000Q1 and 2001Q4, subject to the availability of data. The out-of sample forecasts are shown in Figure 25 - 40 together with the in-sample forecasts.

VI. Exploring the Importance of Various Factors in Attributing to the Speculative Attack Pressure

Table 3 explores further the factors that attribute to the increase in the speculative attack pressure in various countries by disaggregating the increase in the predicted probability of speculative attack into different causality factors. The first degree Taylor series expansion is used in the decomposition. Let $P(A)_{it}$ and $P(A)_{it_0}$ be the probability of speculative attack in country i during period t and the base period t_0 respectively, and $t' = \frac{t+t_0}{2}$ be the period half way between period t and the base period t_0 . In this exercise, period t is taken to be the period when our predicted probability of speculative attacks peaks, and the base period is the period five years ahead of the peak period ⁷ or a period with a relatively low predicted probability. This exercise allows us to examine the factors that give rise to the increase in the speculative attack pressure during the years preceding the period with peak predicted speculative attack pressure. The first degree Taylor series expansion of the increase in the probability of speculative attacks, $P(A)_{it} - P(A)_{it_0}$, with respect to the predictive variables X_1, X_2, \dots, X_j is written as follows:

$$\begin{aligned} P(A)_{it} - P(A)_{it_0} &= \frac{\partial P(A)_{it'}}{\partial X_{1,it'}}(X_{1,it} - X_{1,it_0}) + \frac{\partial P(A)_{it'}}{\partial X_{2,it'}}(X_{2,it} - X_{2,it_0}) \\ &\quad + \dots + \frac{\partial P(A)_{it'}}{\partial X_{j,it'}}(X_{j,it} - X_{j,it_0}) + \varepsilon_{it} \\ &= [P(A)_{it'}]^2 [\gamma_{A1}(X_{1,it} - X_{1,it_0}) + \gamma_{A2}(X_{2,it} - X_{2,it_0}) \\ &\quad + \dots + \gamma_{Aj}(X_{j,it} - X_{j,it_0})] + \varepsilon_{it} \end{aligned}$$

Each term $\gamma_{A1}(X_{1,it} - X_{1,it_0}), \gamma_{A2}(X_{2,it} - X_{2,it_0}), \dots, \gamma_{Aj}(X_{j,it} - X_{j,it_0})$ on the right hand side measures how much the increase in the predicted probability of speculative attacks can be attributable to each predictive variable, with $\gamma_{A1}, \gamma_{A2}, \dots, \gamma_{Aj}$ denote the estimated coefficients of the predictive variables X_1, X_2, \dots, X_j respectively in the speculative attack state. Table 3 shows that most important culprit of the rise in the speculative attack pressure of Thailand, S.Korea, Indonesia and Philippines in 1997 was the increase in the ratio of short-term external liabilities to foreign exchange reserves. The increase in the speculative attack pressure of Brazil in 1999 was mainly attributed to the large ratio of fiscal deficits to GDP. In the cases of Hong Kong in 1998, the major contributing factor was the high ratio of domestic credit to GDP pressure.

	(t_0, t)	$P(A)_{it} - P(A)_{it_0}$	lending rate differential	ratio of short term external liabilities to reserves	real exchange rate appre. index	ratio of quasi money to reserves
Argentina	(94Q1,95Q1)	0.126	0.032	0.029	0.0001	<i>0.065</i>
Brazil	(98Q1,99Q1)	0.248	-0.002	0.030	-0.022	<i>0.028</i>
Chile	(92Q4,97Q4)	0.359	-0.057	<i>0.318</i>	0.001	0.037
China	(91Q4,98Q1)	0.106	-0.0006	0.008	0.003	<i>0.102</i>
HK(SAR)	(96Q4,97Q4)	0.068	0.072	-0.034	0.081	-0.109
Colombia	(93Q1,98Q1)	0.098	-0.0006	0.0450	0.006	<i>0.068</i>
Indonesia	(92Q3,97Q3)	0.149	0.069	<i>0.071</i>	-0.030	0.006
S.Korea	(92Q3,97Q3)	0.194	-0.010	<i>0.398</i>	-0.013	0.049
Malaysia	(92Q3,97Q3)	0.203	-0.0104	0.187	-0.068	<i>0.356</i>
Mexico	(93Q4,94Q4)	0.248	0.005	0.104	-0.059	<i>0.177</i>
Philippines	(94Q2,97Q3)	0.213	-0.0004	<i>0.410</i>	-0.063	0.143
Singapore	(95Q4,97Q4)	0.266	0.002	<i>0.168</i>	-0.029	0.005
Taiwan	(96Q4,97Q4)	0.076	-0.003	0.032	-0.033	-0.015
Thailand	(92Q3,97Q3)	0.114	-0.0007	<i>0.042</i>	-0.016	0.002
Uruguay	(86Q2,96Q2)	0.190	-0.011	-0.039	0.032	-0.340
Venezuela	(93Q2,94Q2)	0.099	-0.0006	0.014	0.017	0.008

	ratio of govt. deficits to GDP	ratio of domestic credit to GDP	deviation of unemploy. rate from mean	decline of real GDP	ratio of public debt to GDP
Argentina	0.002	0.003	0.027	-0.038	0.002
Brazil	<i>0.133</i>	0.005	-0.008	0.007	0.076
Chile	0.004	0.007	0.173	0.046	-0.174
China	-0.003	0.003	0.030	-0.007	-0.030
HK(SAR)	-0.051	<i>0.432</i>	-0.123	-0.200	0
Colombia	0.011	0.014	0.037	-0.027	-0.055
Indonesia	0.049	0.025	-0.007	-0.031	-0.003
S.Korea	-0.016	0.044	-0.026	0.002	-0.233
Malaysia	-0.043	0.047	-0.135	-0.078	-0.052
Mexico	0.002	-0.026	0.011	0.032	0.001
Philippines	-0.0005	0.094	-0.185	-0.065	-0.119
Singapore	0.016	0.006	0	0.111	-0.014
Taiwan	-0.029	0.034	-0.028	0.003	<i>0.115</i>
Thailand	0.023	0.013	0.042	-0.020	0.027
Uruguay	0.347	-0.155	<i>0.557</i>	-0.143	-0.056
Venezuela	-0.002	0.011	<i>0.042</i>	-0.020	0.027

TABLE 3. Percentage of the Increase in the Predicted Probabilities of Speculative Attacks Attributable to Various Factors

VII. Policy Implications

From the estimation results of the nested logit model, we find that the significant predictors of speculative attacks are: (i) the ratio of short-term external liquidity to foreign exchange reserves and (ii) the ratio of fiscal deficits to GDP and the significant predictors of unsuccessful defenses are: (i) the ratio of short-term external liquidity to foreign exchange reserves; (ii) the ratio of quasi-money to international reserves; (iii) high unemployment rate relative to the historical mean and (iv) low real GDP growth.

Based on these findings, the policy recommendations are:

- Financial liberalization should be accompanied by prudent supervision of short-term foreign borrowings in the banking sector. Pre-matured capital liberalization is one of the major factors leading to financial crises in many countries, such as Indonesia, S.Korea, Malaysia, Philippines, Thailand and Mexico. Mckinnon(1993) stressed that capital controls should be liberalized only after everything else, including macroeconomic stabilization and prudent bank regulation and control, are securely in place.
- Maintain adequate foreign exchange reserves relative to the short-term external liabilities as a caution against the out-flight of hot money. It would be very risky for the central bank to implicitly guarantee private debts if the central bank is financially insolvent or illiquid in terms of hard currencies. Sufficient international reserves are necessary if the central bank is to effectively play the role of lender of last resort. Also, debt-maturity lengthening is recommended, as suggested by Guillermo A. Calvo and Enrique G. Mendoza (2000). However, the trade-off is that lengthening debt maturity generally increases debt-serving costs and hence this is an important topic that requires future research.
- A good discipline policy over the fiscal deficits should be maintained by the government. Excessively expansionary fiscal policy significantly increase the country's vulnerability to speculative attack.

The empirical results of this paper also provide insights on whether capital controls can insulate an economy from crises. This policy implication is especially important for China because with China's accession to the WTO on November 11 2001, it is important to examine whether China should continue to maintain capital controls in the medium run and whether China's capital controls are effective in reducing its currency risks. The empirical results of this paper show that capital controls to some extent is effective in reducing massive withdrawal of loans or hot money. Nevertheless, all these conclusions rely on the assumption that capital controls are not endogenous and do not affect the underlying strength of the financial system and international liquidity. If this assumption does not hold, the above conclusion on capital controls needs to be interpreted with extreme caution.

VIII. Conclusions

In this paper, a multi-state nested logit model is employed in order to (i) predict the probabilities of speculative attacks and the conditional probabilities of successful defenses and (ii) analyze the relative importance of various internal and external economic factors in triggering speculative attacks and in affecting the likelihood of successful defenses by central banks. The external economic factors

include external illiquidity (as measured by a high ratio of short-term external liabilities to foreign exchange reserves), low trade competitiveness (as measured by a high real exchange rate appreciation) and high cost of hedging in the foreign exchange market (as measured by a high lending rate differentials). The internal economic factors include financial deepening (as measured by a high ratio of quasi-money to foreign exchange reserves), high fiscal deficits (as measured a high ratio of fiscal deficits to GDP, weak domestic labor employment (as measured by a high unemployment rate relative to the historical mean) and slow real sector growth (as measured by a low real GDP growth). The nested logit estimates suggest that high ratio of short-term external liabilities to foreign exchange reserves and large fiscal deficits are significant predictors of speculative attacks. Also, high ratio of short-term external liabilities to foreign exchange reserves, high ratio of quasi-money to foreign reserves, high unemployment rate and low real GDP growth are significant predictors of unsuccessful defense. This conclusion is robust to the inclusion of the capital control variables.

The predictive abilities of the nested logit model are evaluated using three statistical scores: the quadratic probability score (QPS), the log probability score (LPS) and the global squared bias (GSB). All scores indicate that, the nested logit model outperforms the signal indicator approach in predicting currency crises and unsuccessful defenses. To evaluate how well the model is able to forecast currency crises, out-of-sample forecasts are performed for all countries in the sample. It is observed that, even as early as 2000, Argentina was highly vulnerable to speculative attacks and was unlikely to be able to mount a successful defense. The high ratio of short-term external liabilities to international reserves (around 500 percent) and the rising unemployment rate (it reached 18 percent in 2001Q3) all indicate that Argentina is highly vulnerable to currency crises and has weak defense ability.

The empirical findings of the nested logit model have several important policy implications: (i) financial liberalization should be accompanied by prudent supervision of short-term foreign borrowings in the financial sector and (ii) it is necessary to maintain adequate foreign exchange reserves relative to the short-term external liabilities as a caution against the sudden out-flight of hot money; and (iii) it is necessary for the government to have a good discipline policy over the fiscal deficits to reduce the vulnerability to speculative attacks. .

Appendix A: Data Description

The sample data consists of quarterly data from 1982 Q1 through 2001 Q4 for the following countries: Argentina, Brazil, Chile, China, Colombia, Hong Kong, S.Korea, Malaysia, Mexico, the Philippines, Singapore, Taiwan, Thailand, Uruguay and Venezuela. The primary data source is International Financial Statistics (IFS), supplemented by the World Development Indicator CD-ROM. The following table shows the sources and definitions of the variables:

Predictors	Sources and Definitions
1. Lending rate differential	The lending rate differential is constructed as the difference between 3-month lending interest rate in domestic country and US. The lending interest rate is taken from IFS line 60P.
2. Ratio of short-term international liquefiable liabilities to foreign exchange reserves	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 cumulative sum of the portfolio liabilities flow data obtained from IFS line 78BGD. The import data is from IFS line 98C. The foreign exchange reserves data is from IFS line 1L.
3. Real exchange rate appreciation index	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.
4. Ratio of quasi-money (M2-M1) to foreign exchange reserves	M2 is IFS line 34 plus 35. M1 is line 34. The foreign exchange reserves data is from IFS line 1L.
5. Ratio of fiscal deficits to GDP	Fiscal deficit is IFS line 80 and GDP is IFS line 99B.
6. Ratio of M2 to foreign exchange reserves	M2 is IFS line 34 plus 35. The foreign exchange reserves data is from IFS line 1L.
7. Deviation of real exchange rate from trend	Defined as the residuals of regressing the real exchange rate on a time trend.
8. Export growth	Export data is from IFS line 90C.
9. Reserves growth	Foreign exchange reserves data is from IFS line 1L.
10. Excess real M1 balances	Defined as M1 (IFS line 34) deflated by CPI (IFS line 64) less an estimated demand for money. Hence, excess real M1 balances are the residuals from the regression of real M1 on real GDP (IFS line 99B.P), consumer price inflation and a deterministic trend.

Predictors	Sources and Definitions
11. Growth in the ratio of domestic credit to GDP	Total domestic credit is IFS line 52. Nominal GDP is IFS line 99B.
12. Growth of M2 multiplier	Defined as the ratio of M2 (IFS line 34 plus 35) relative to base money (IFS line 14).
13. Real lending interest rate	Defined as lending interest rate (IFS line 60P) deflated by CPI (IFS line 64).
14. Imports growth	Import data is from IFS line 98C.
15. Industrial production growth	Industrial production data is from IFS line 66 and Global Development Finance 2000 CD-ROM.
16. Terms of Trade growth	Terms of trade data is constructed as IFS line 74D divided by IFS line 75D.
17. Ratio of 3m lending rate to deposit rate	Lending rate is IFS line 60P, deposit rate is IFS line 60L.
18. Bank deposits	Bank deposit and its growth are based on IFS line 24 and 25.
19. Stock price index growth	Stock price index is from IFS line 62, supplemented by Global Financial Data database.
20. Real lending rate differential	The difference between the lending rate of domestic country and US (IFS line 60P), deflated by the inflation in CPI (IFS line 64).
21. Real lending rate differential growth	Take the growth rate of the real lending rate differential.
22. Ratio of current account balance to GDP	Current account balance is taken from IFS line 78ALD. Nominal GDP is taken from IFS line 99B.
23. Ratio of claims on the private sector by deposit money banks and monetary authorities to GDP (Sachs, Tornell and Velasco (1996) call it the lending boom)	Claims on the private sector by deposit money banks and monetary authorities is from IFS line 32D. Nominal GDP is from IFS line 99B.
24. Unemployment rate	Historical unemployment rate is from World Development Indicator CD-ROM. Recent data are from the official webpages of various countries.
25. Public Debt	The total public debt is from IFS line 88ZF. The public debt in domestic currency is from IFS line 88AZF. The public debt in foreign currency is from IFS line 89AZF.

Appendix B: Dates of Speculative Attacks that were
Successfully and Unsuccessfully Defended
(In-sample period:1982-99, Out-of-sample period:2000-01)

Countries	Successful Defense Dates	Unsuccessful Defense Dates
1. Argentina	1992Q4, 1995Q1	1982Q3, 1987Q3, 1989Q2, 2001Q3
2. Brazil	None between 1982Q1-2001Q4	1983Q1, 1987Q2, 1989Q3, 1999Q1
3. Chile	1997Q4	1982Q2, 1985Q3
4. China, PRC	1992Q3, 1998Q1	1989Q4, 1994Q1
5. Colombia	1986Q3, 1993Q4, 1995Q2, 1998Q1	1982Q4, 1985Q1, 1990Q1Q2
6. Hong Kong, SAR	1993Q1, 1997Q4	None between 1982Q1-2001Q4
7. Indonesia	1994Q2, 2000Q4	1997Q3
8. S.Korea	1986Q3	1997Q3
9. Malaysia	None between 1982Q1-2001Q4	1997Q3
10. Mexico	1992Q3	1985Q3, 1987Q4, 1994Q4
11. Philippines	1982Q4, 1989Q2, 1993Q2, 1995Q2	1982Q4, 1990Q3, 1997Q3
12. Singapore	1995Q1	1997Q4
13. Taiwan	1983Q4, 1988Q1, 1990Q2	1995Q3, 1997Q4
14. Thailand	1988Q1, 1994Q1	1984Q4, 1997Q3
15. Uruguay	1996Q2	1982Q4, 1989Q2, 1994Q3
16. Venezuela	None between 1982Q1-2001Q4	1983Q2, 1986Q4, 1989Q1, 1992Q4, 1994Q2

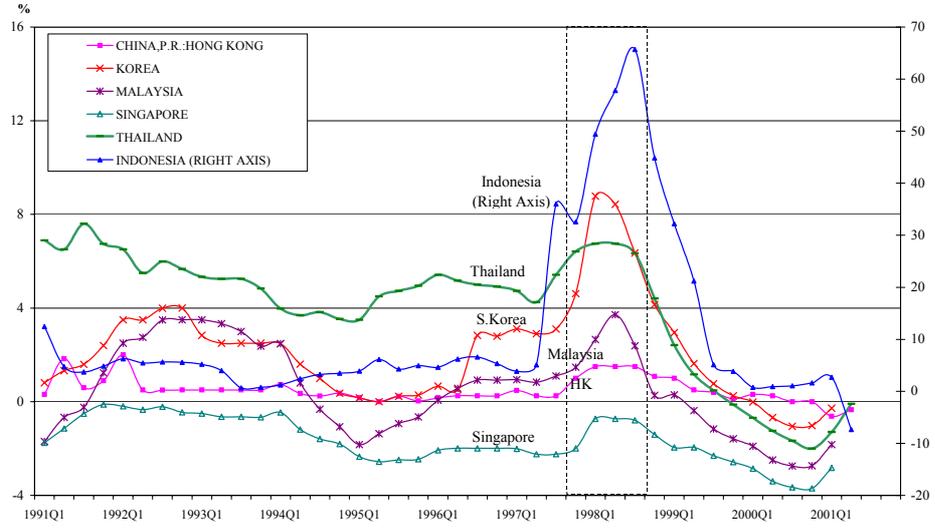


FIGURE 1. Lending Rate Differentials – Selected Asian Countries

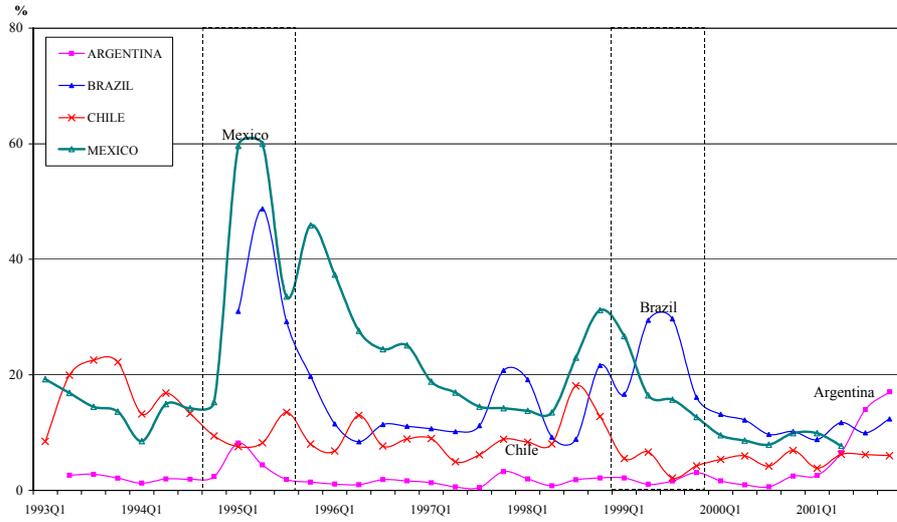


FIGURE 2. Lending Rate Differentials – Selected Latin American Countries

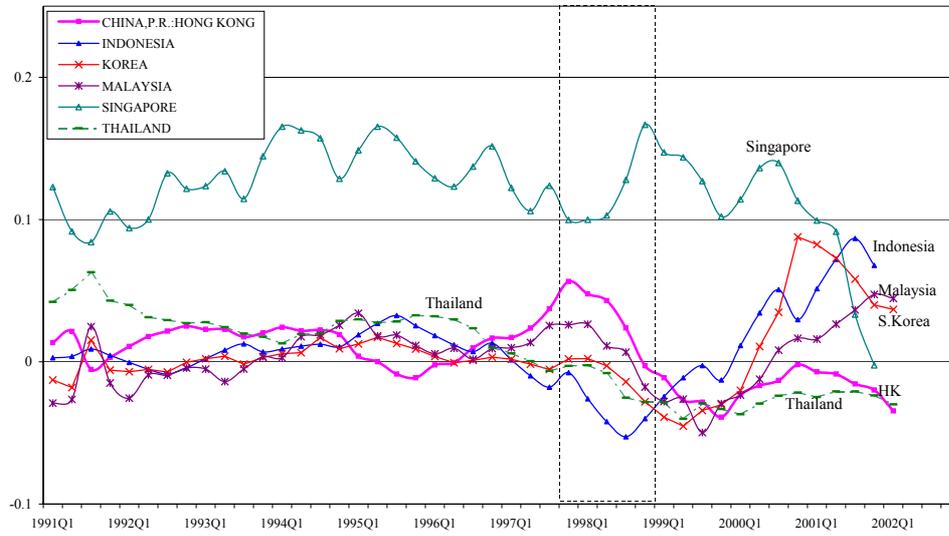


FIGURE 3. Ratio of Fiscal Balance to GDP – Asian Countries

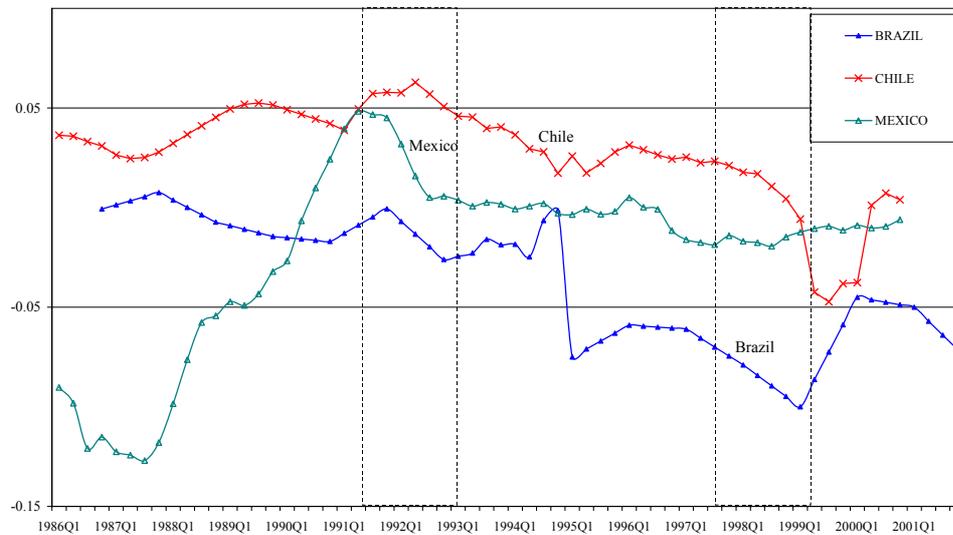


FIGURE 4. Ratio of Fiscal Balance to GDP – Latin American Countries (Part 1)

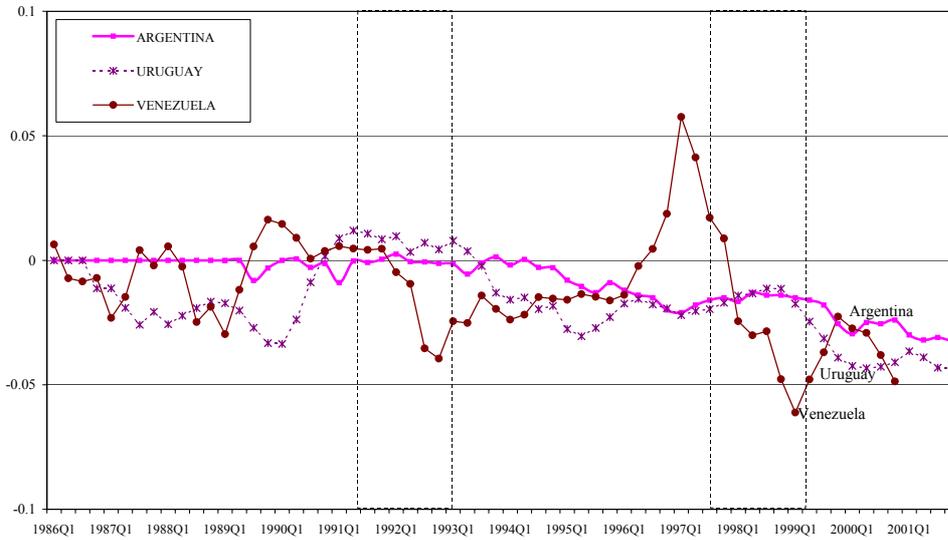


FIGURE 5. Ratio of Fiscal Balance to GDP – Latin American Countries (Part 2)

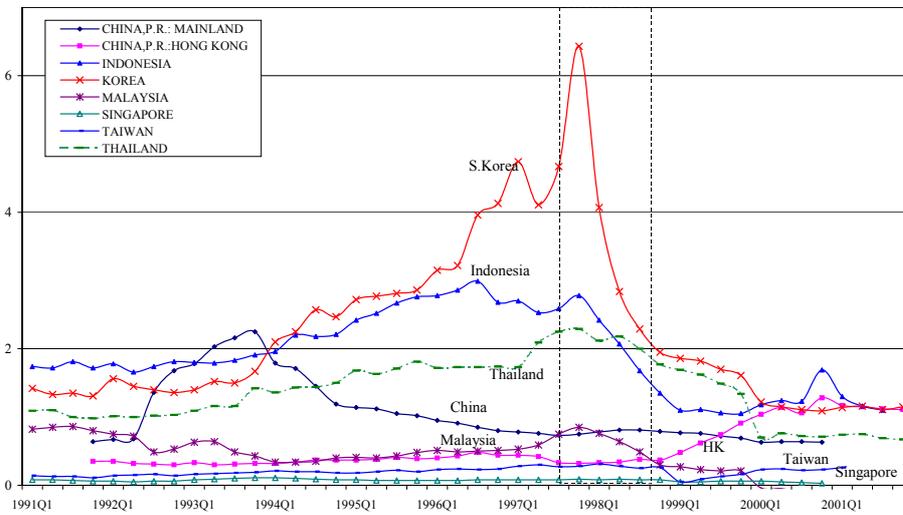


FIGURE 6. Ratio of Short-Term External Liabilities to Foreign Exchange Reserves – Asian Countries

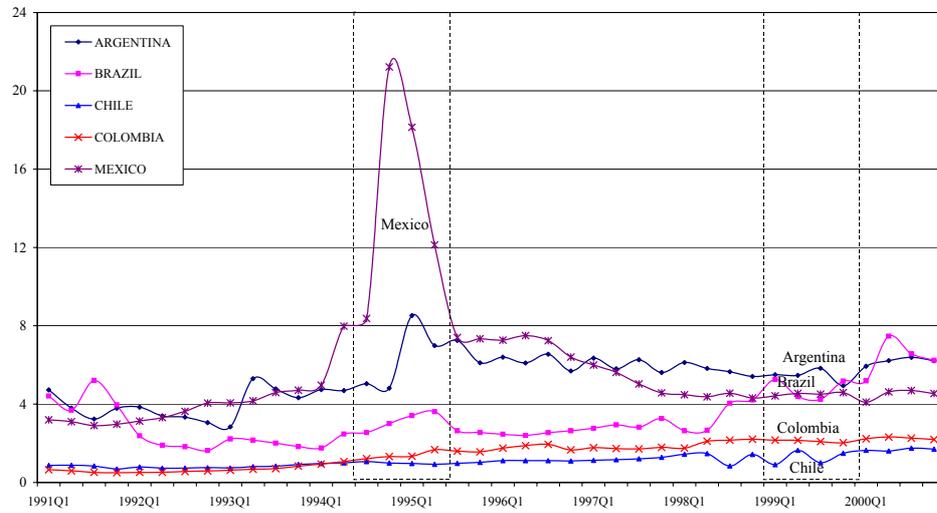


FIGURE 7. Ratio of Short-Term External Liabilities to Foreign Exchange Reserves – Selected Latin American Countries

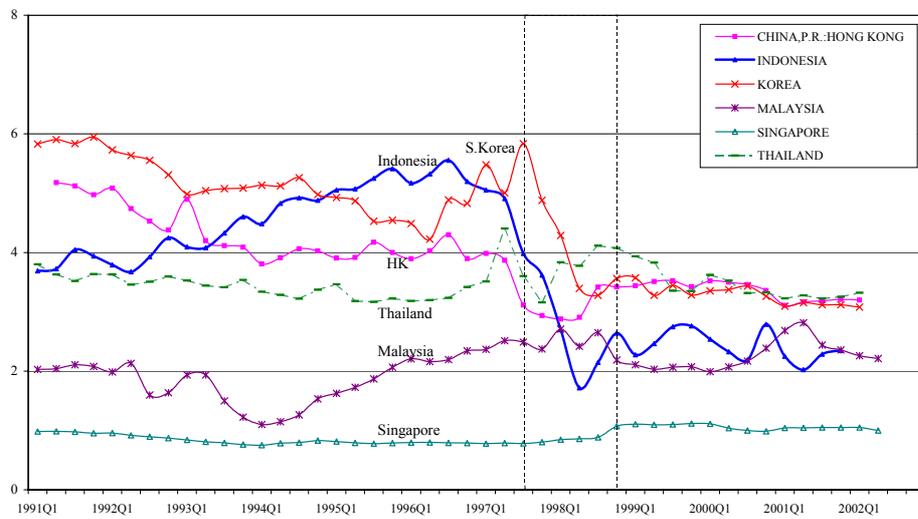


FIGURE 8. Ratio of Quasi-money to Foreign Reserves

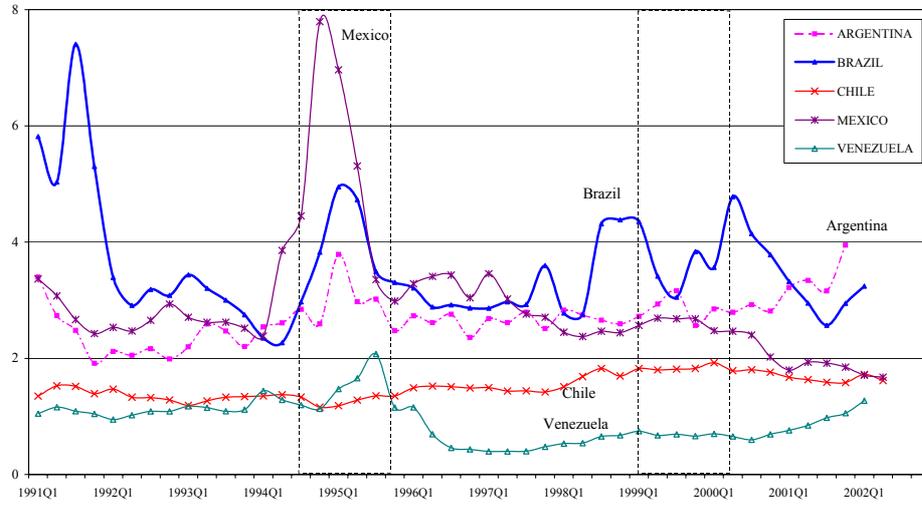


FIGURE 9. Ratio of Quasi-money to Foreign Reserves

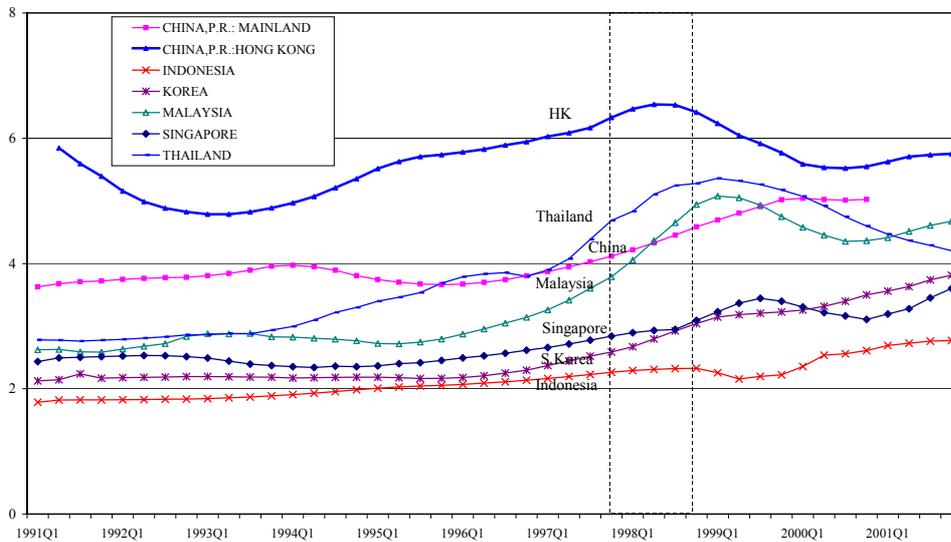


FIGURE 10. Ratio of Domestic Credit to GDP – Asian Countries

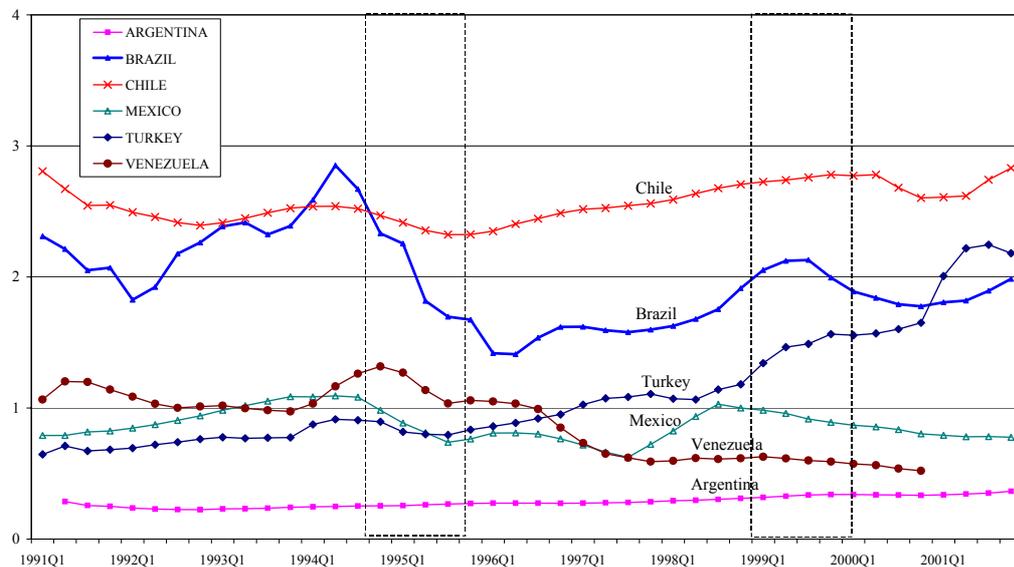


FIGURE 11. Ratio of Domestic Credit to GDP – Latin American Countries

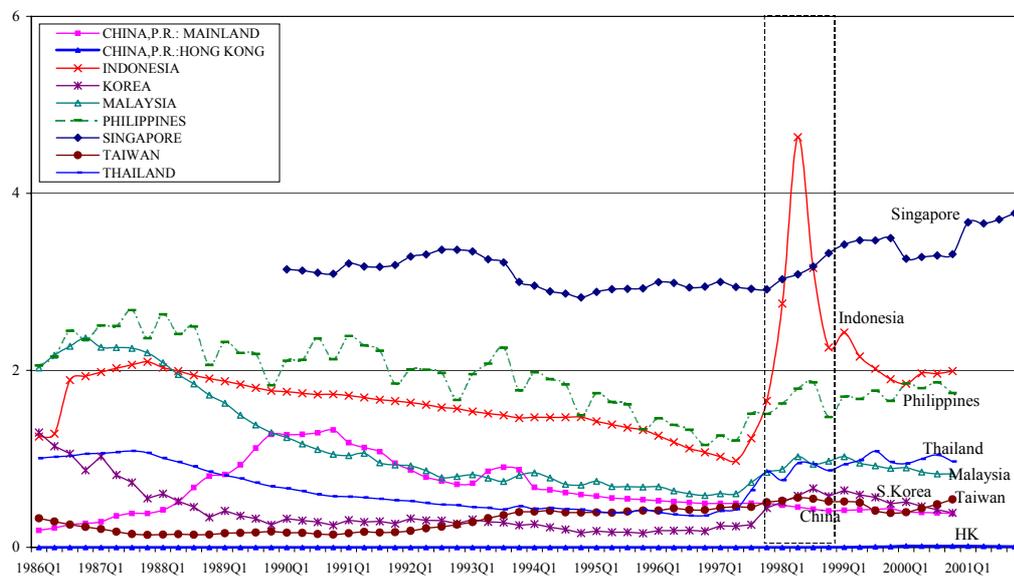


FIGURE 12. Ratio of Public Debt to GDP – Asian Countries

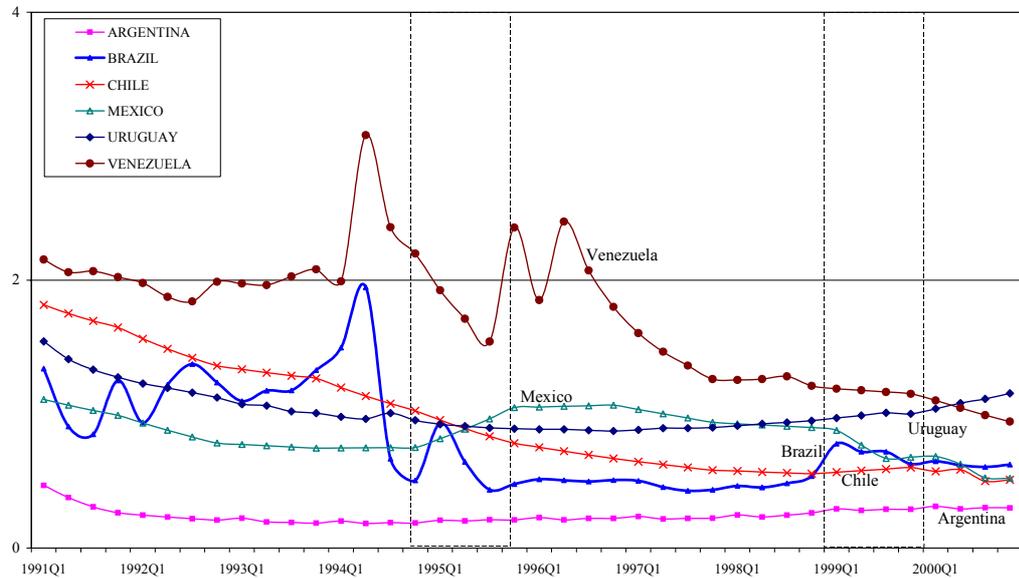


FIGURE 13. Ratio of Public Debt to GDP – Latin American Countries

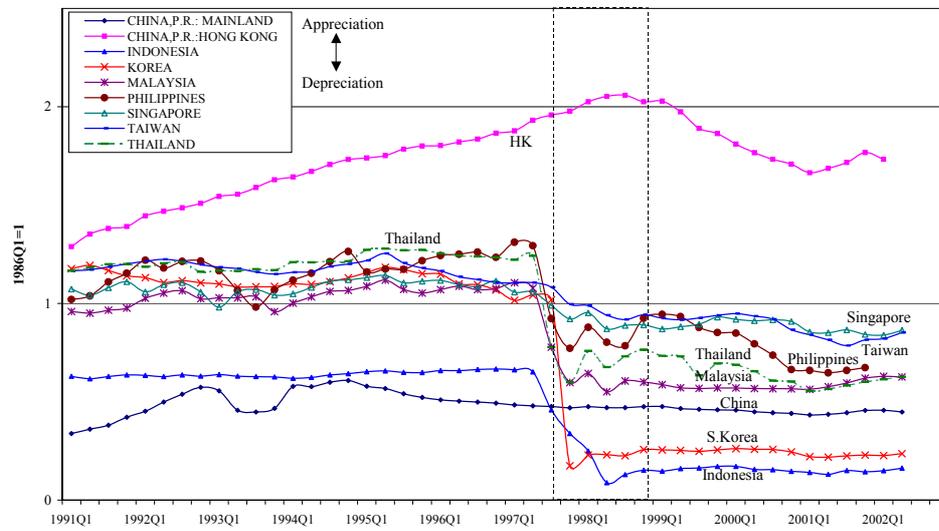


FIGURE 14. Real Exchange Rate Index – Asian Countries

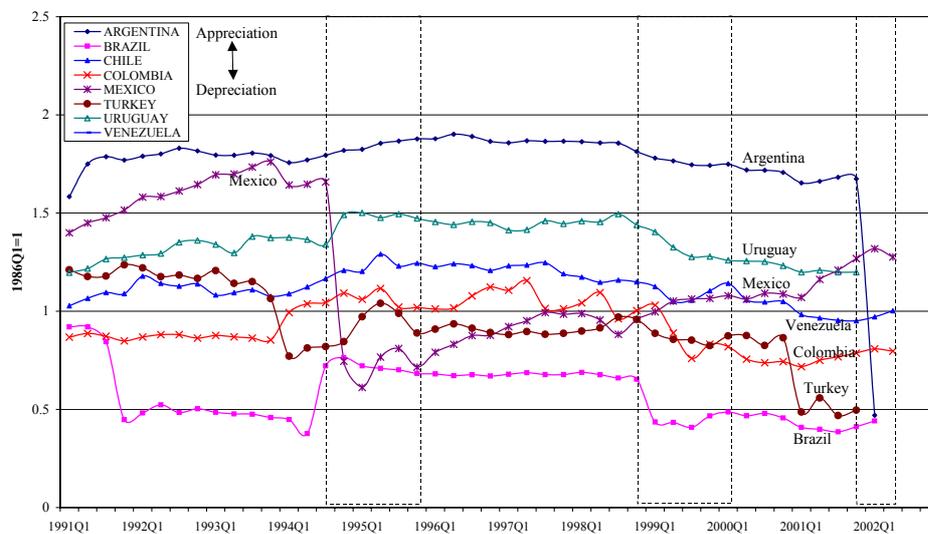


FIGURE 15. Real Exchange Rate Index – Latin American Countries

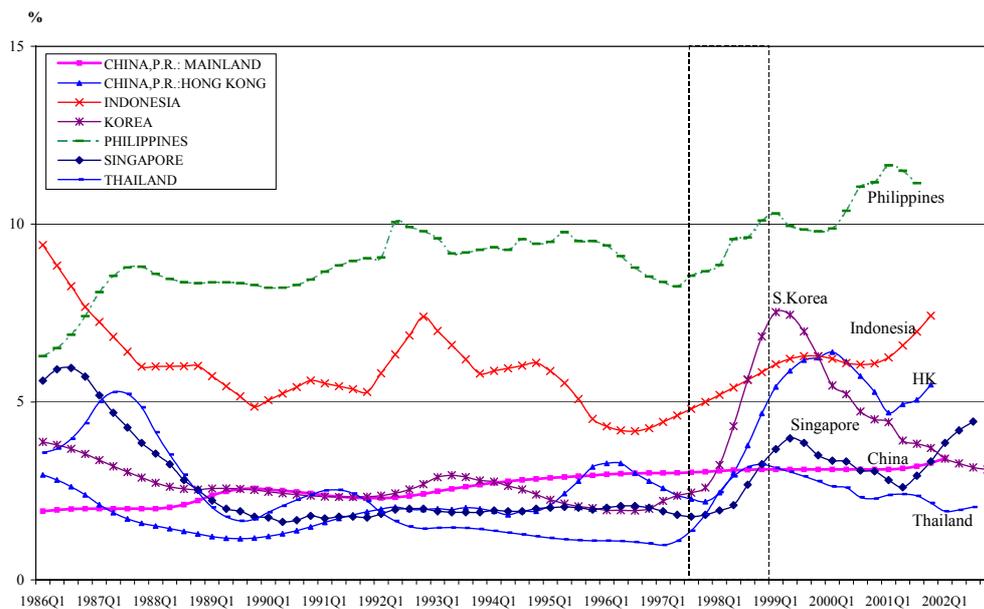


FIGURE 16. Unemployment Rate – Asian Countries

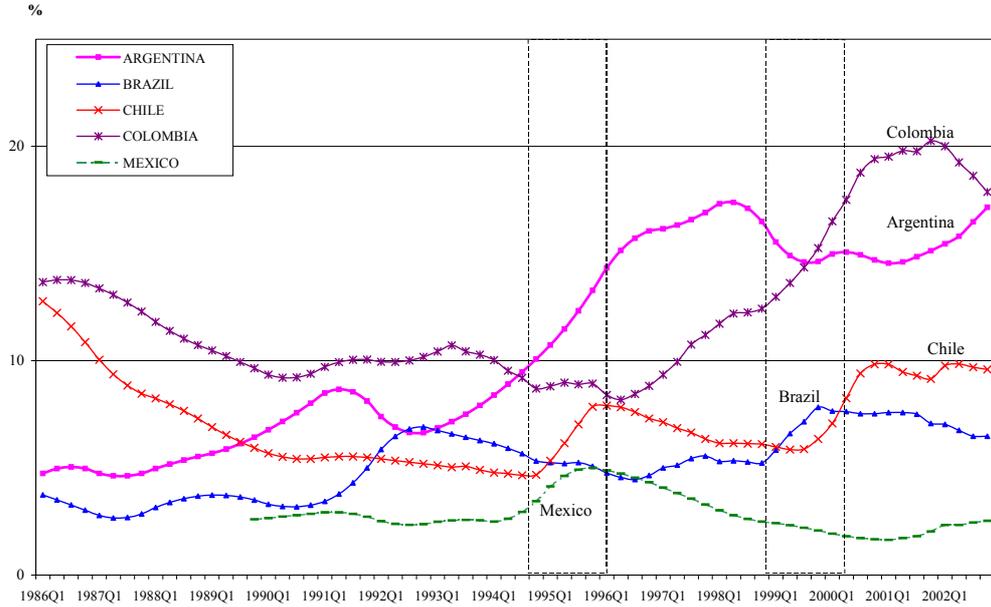


FIGURE 17. Unemployment Rate – Latin American Countries

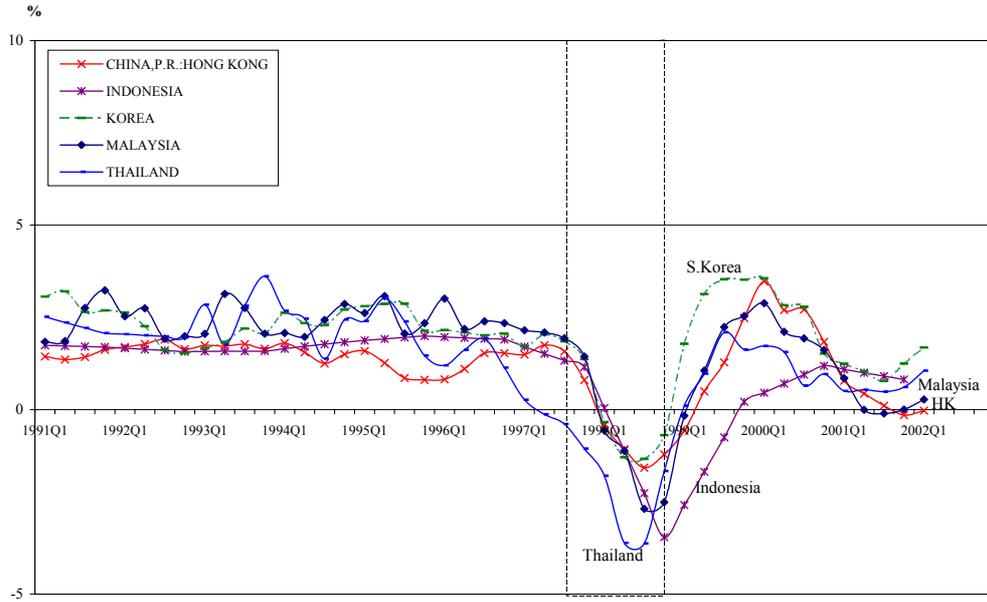


FIGURE 18. Growth of Real GDP – Asian Countries

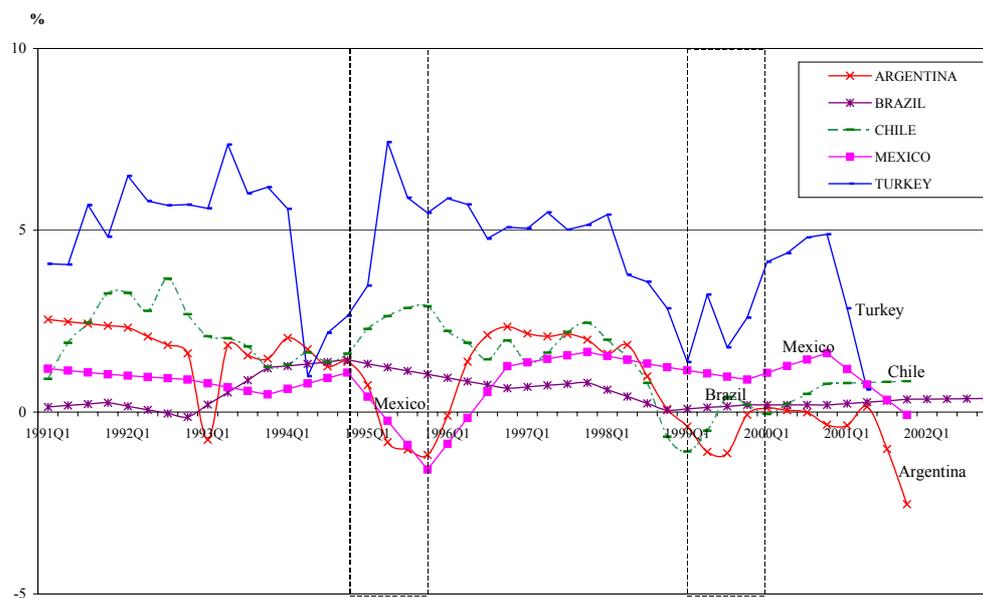


FIGURE 19. Growth of Real GDP – Latin American Countries

Asian Countries:		Latin American Countries:	
CH:	China	PH:	Philippines
ID:	India	AR:	Argentina
IN:	Indonesia	MX:	Mexico
KR:	S.Korea	BO:	Bolivia
MY:	Malaysia	BZ:	Brazil
		SG:	Singapore
		TH:	Thailand
		CL:	Chile
		PU:	Peru
		UG:	Uruguay
		VZ:	Venezuela
		CB:	Colombia

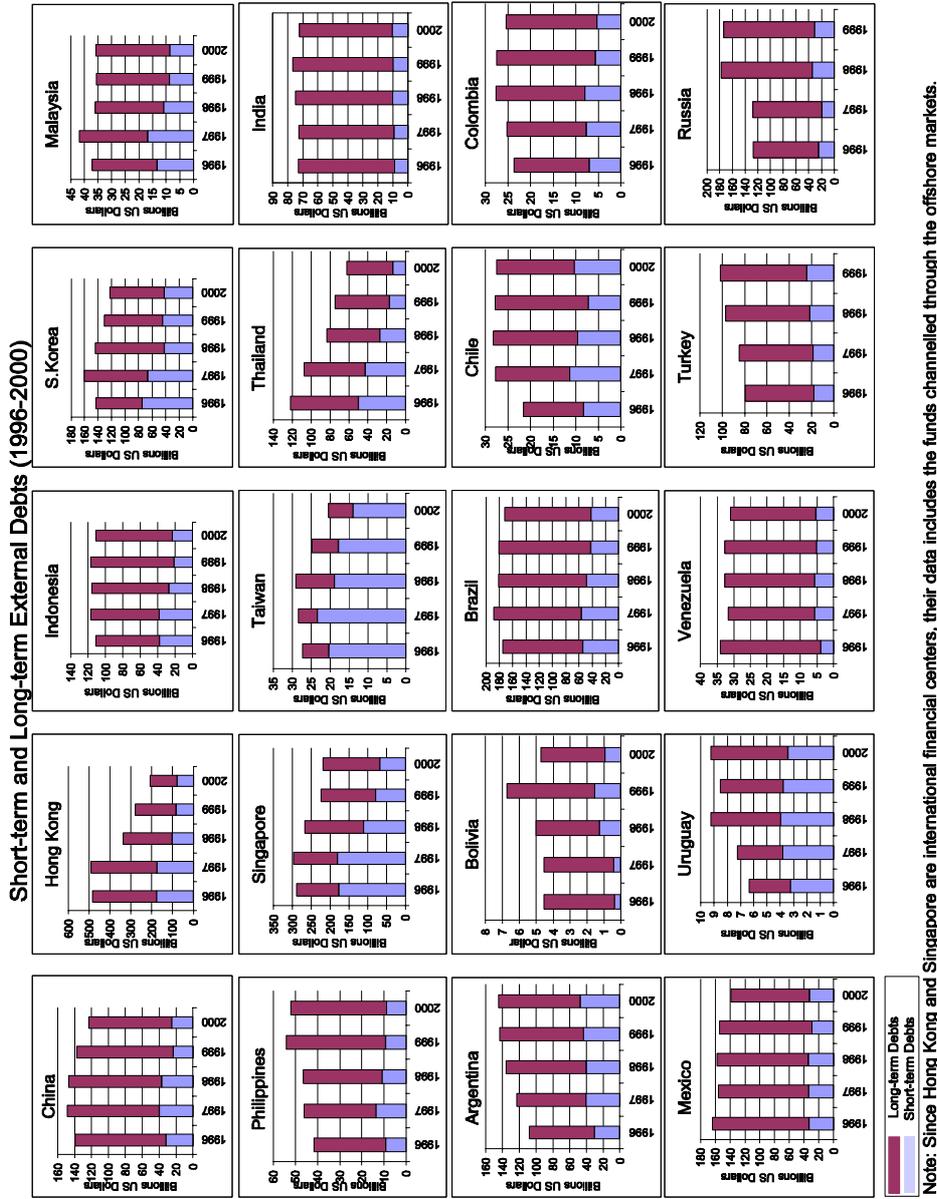


FIGURE 20. Short-term and Long-term External Debts

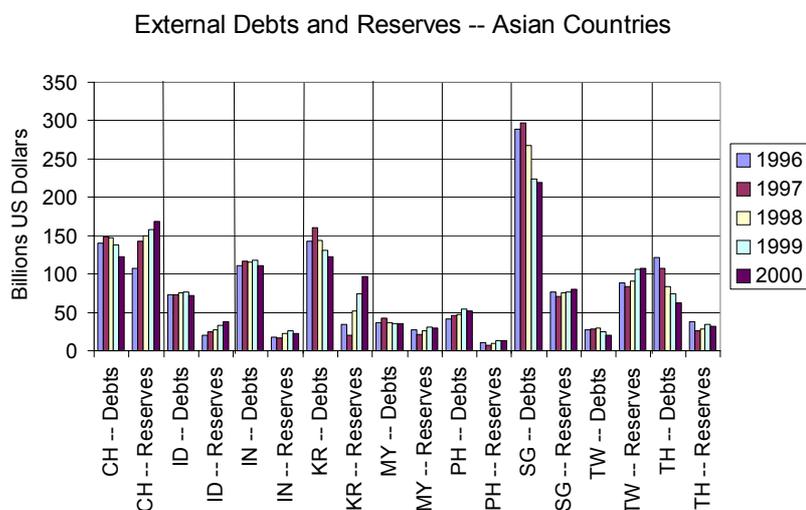


FIGURE 21. External Debts and Reserves – Asian Countries

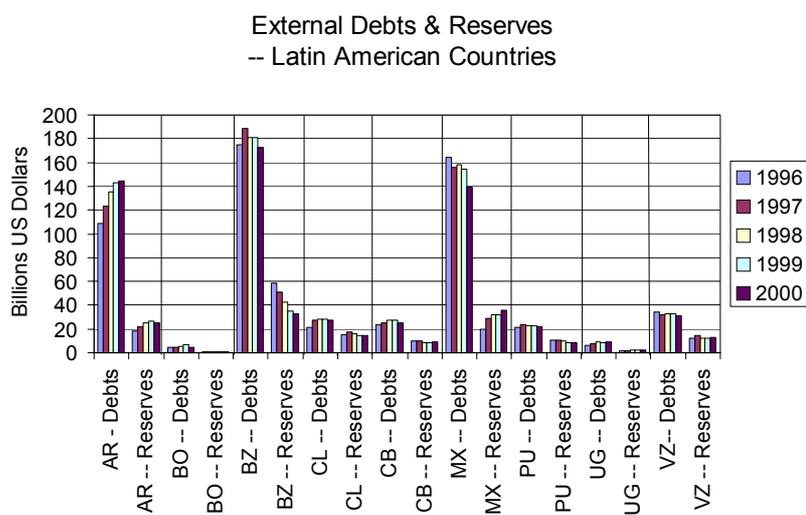


FIGURE 22. External Debts and Reserves – Latin American Countries

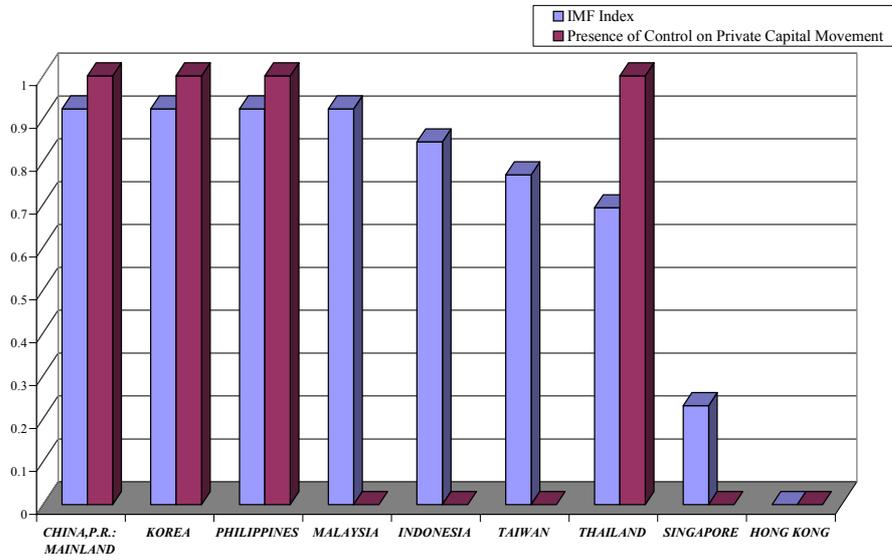


FIGURE 23. Capital Control Index of Asian Countries as at March 1997

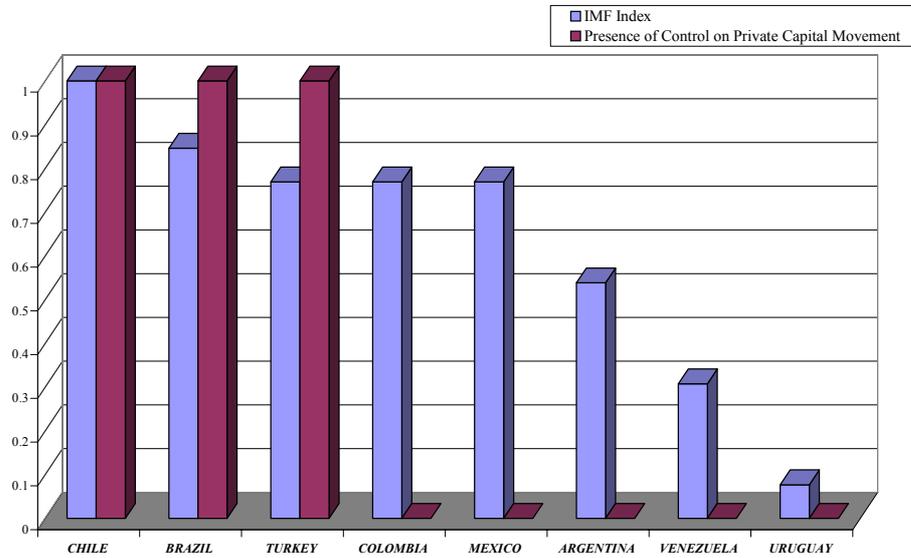


FIGURE 24. Capital Control Index of Latin American Countries as at March 1995

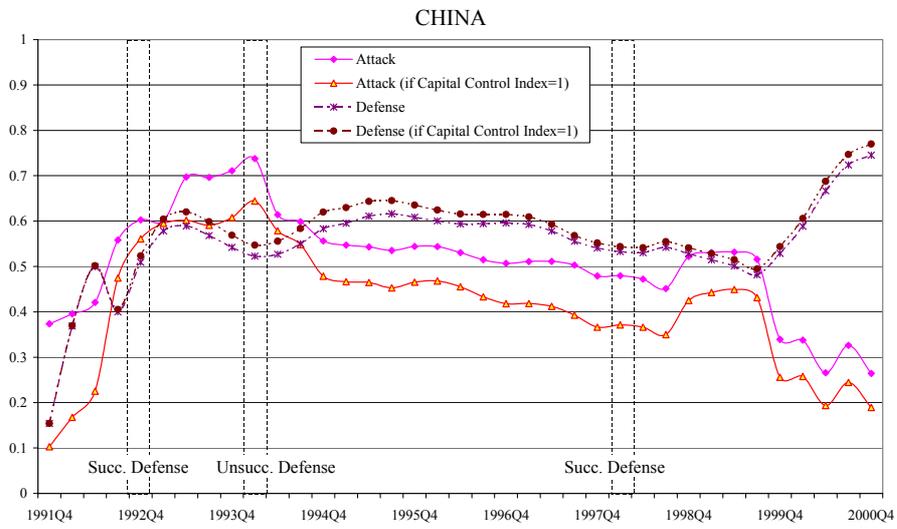


FIGURE 25. Predicted Probabilities – China

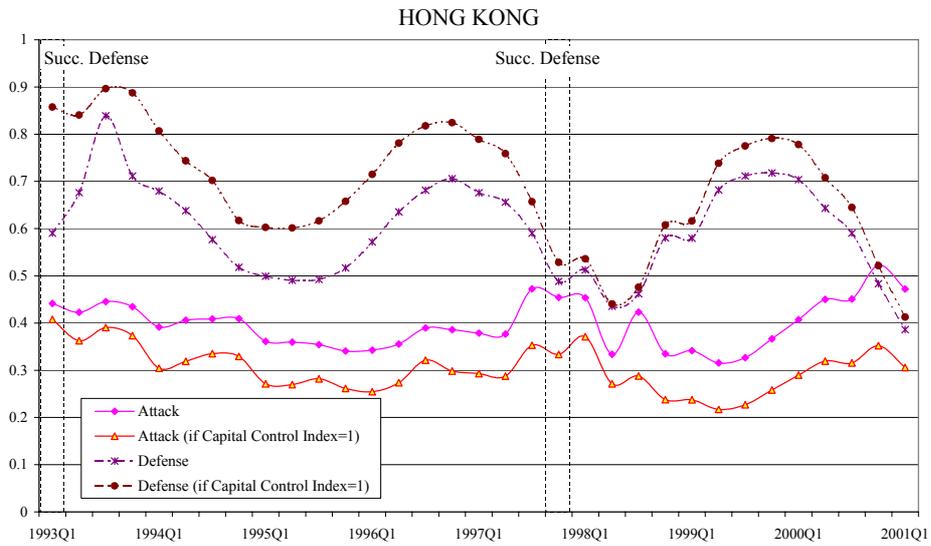


FIGURE 26. Predicted Probabilities – Hong Kong

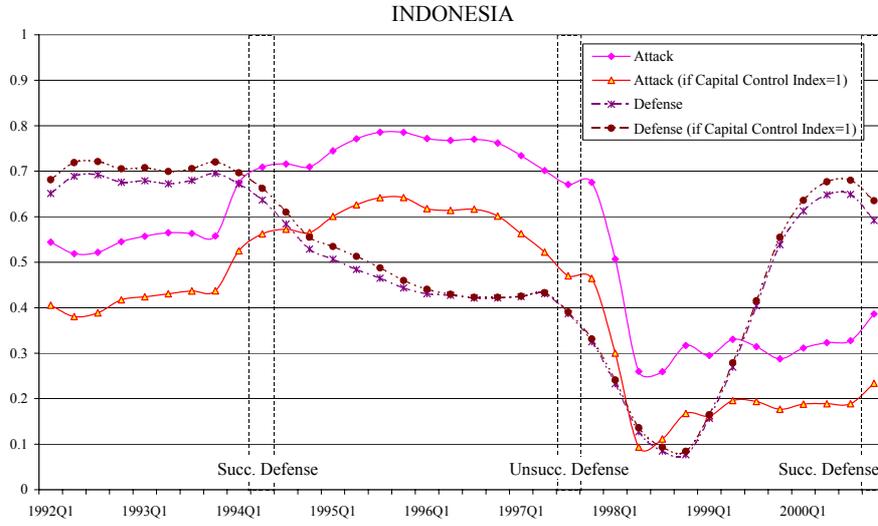


FIGURE 27. Predicted Probabilities – Indonesia

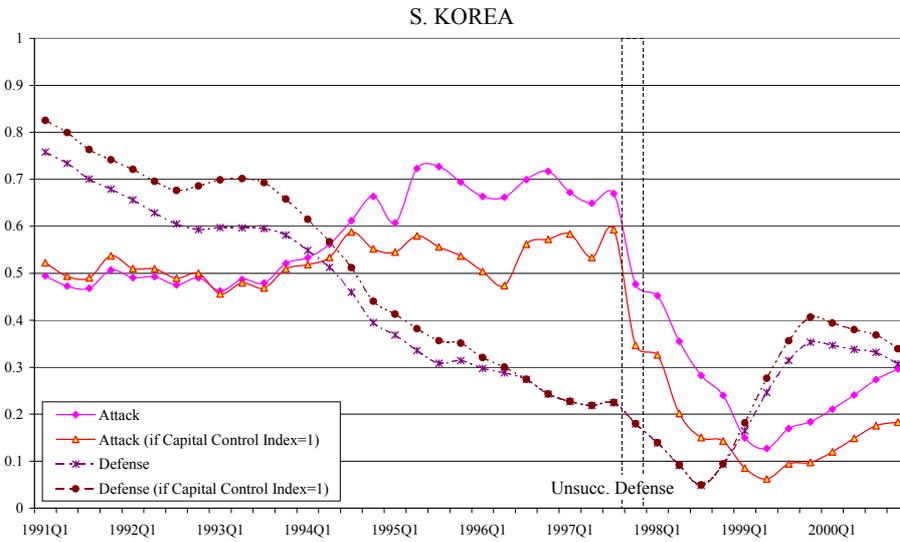


FIGURE 28. Predicted Probabilities – S.Korea

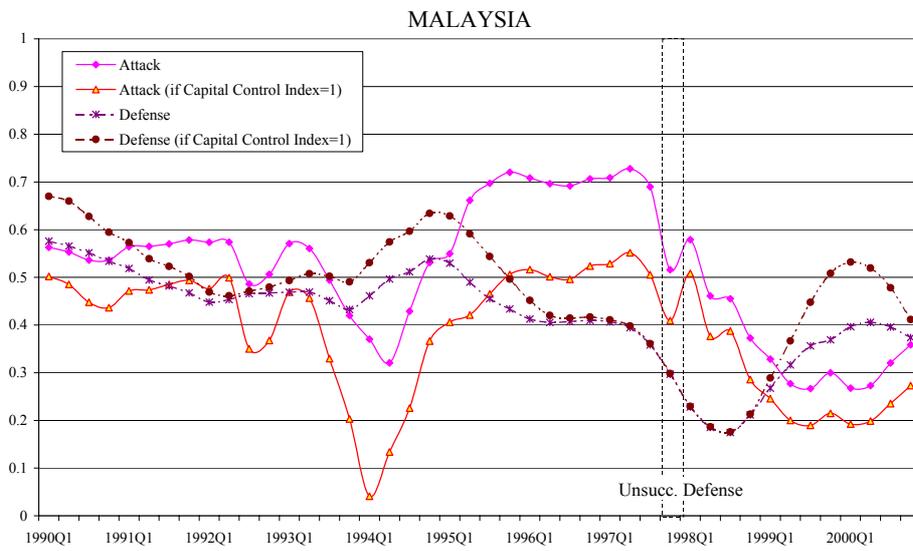


FIGURE 29. Predicted Probabilities – Malaysia

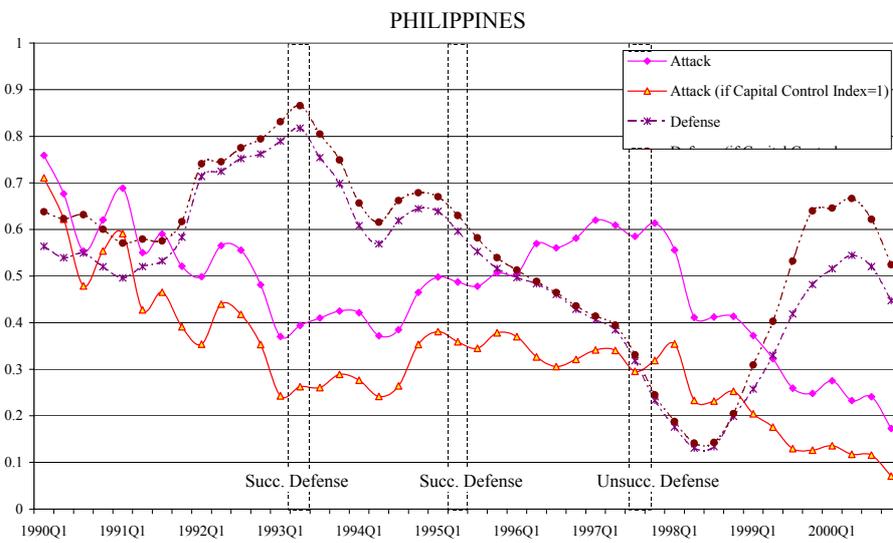


FIGURE 30. Predicted Probabilities – Philippines

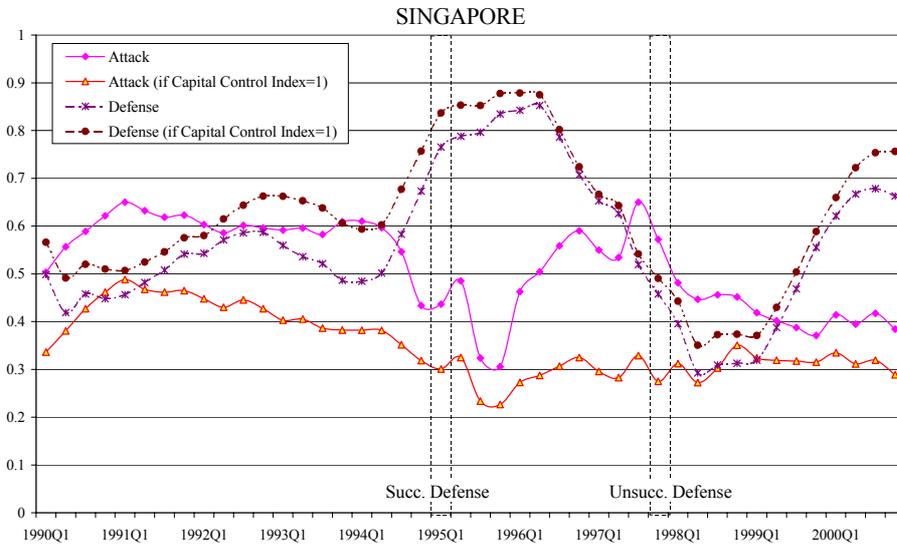


FIGURE 31. Predicted Probabilities – Singapore

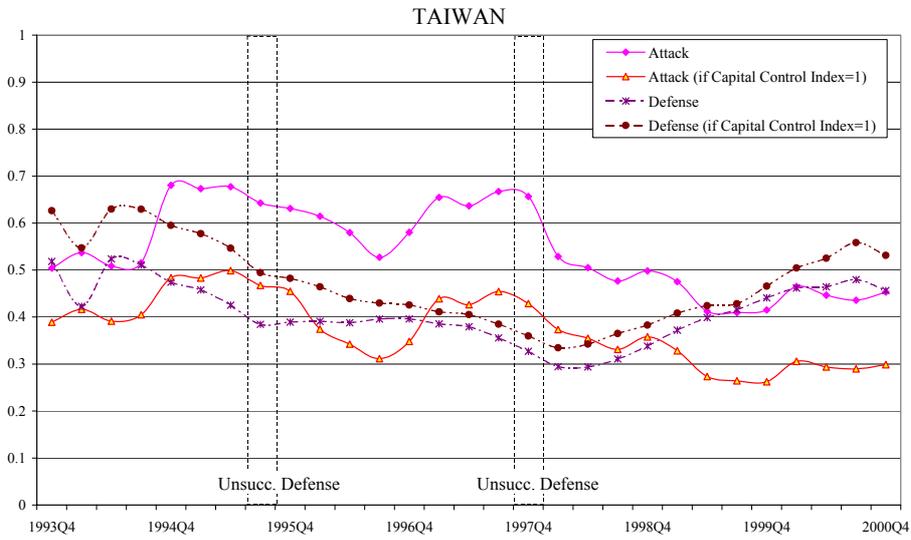


FIGURE 32. Predicted Probabilities – Taiwan

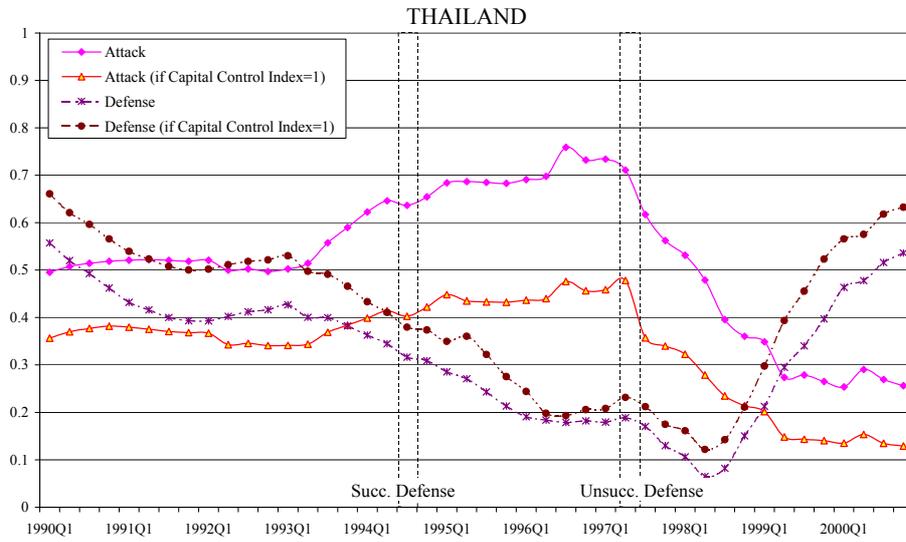


FIGURE 33. Predicted Probabilities – Thailand

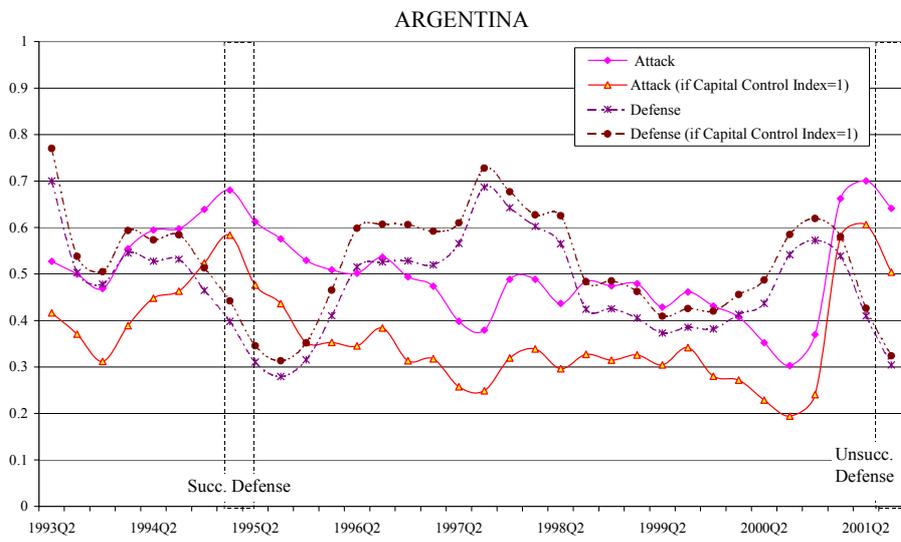


FIGURE 34. Predicted Probabilities – Argentina

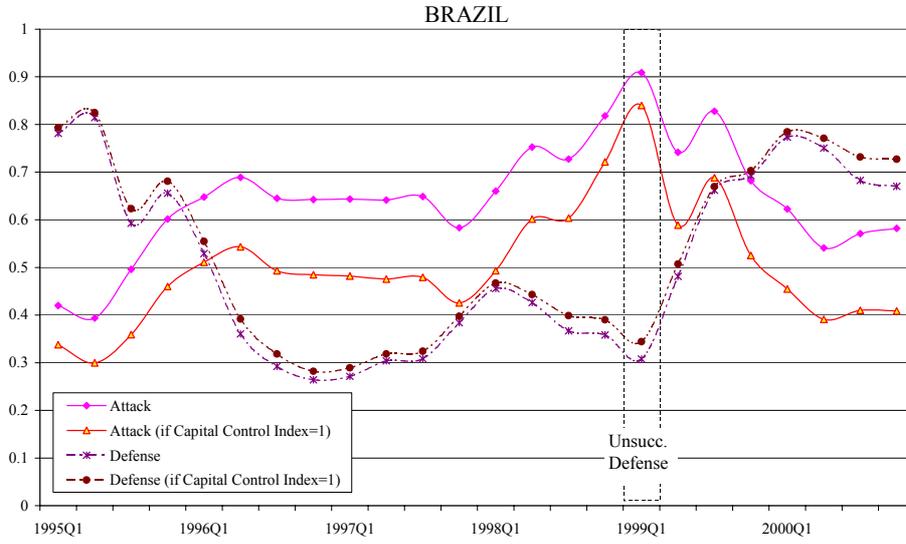


FIGURE 35. Predicted Probabilities – Brazil

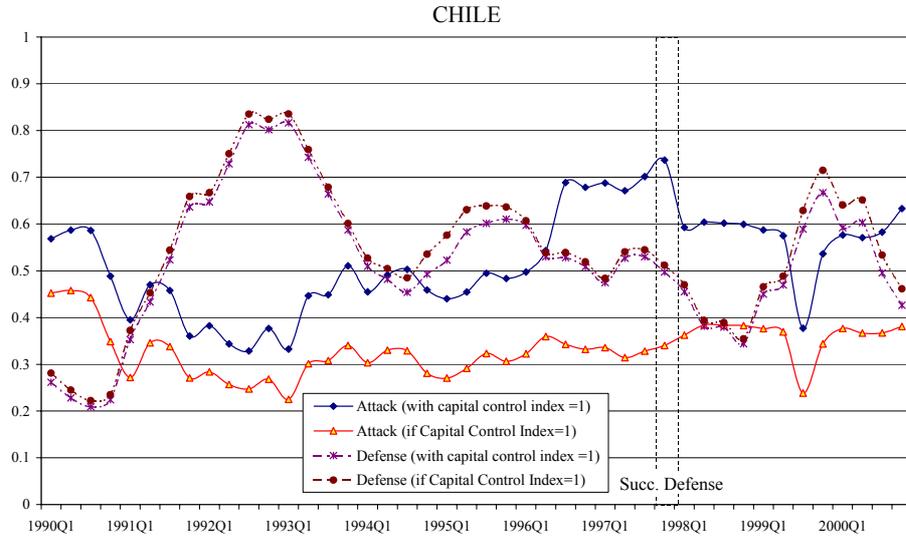


FIGURE 36. Predicted Probabilities – Chile

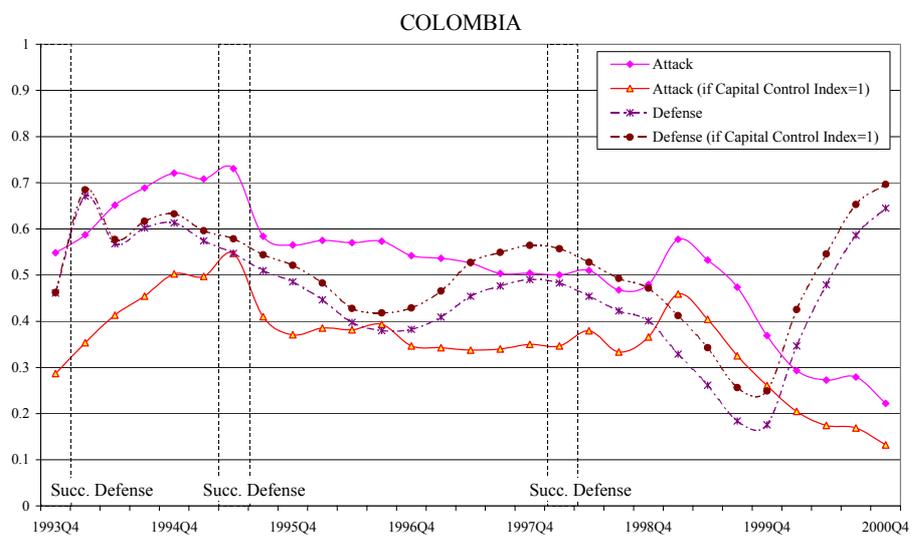


FIGURE 37. Predicted Probabilities – Colombia

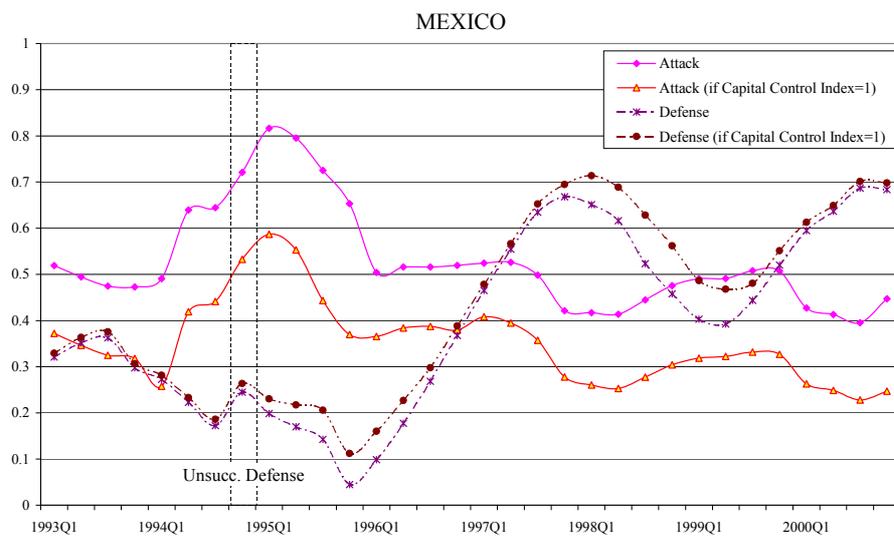


FIGURE 38. Predicted Probabilities – Mexico

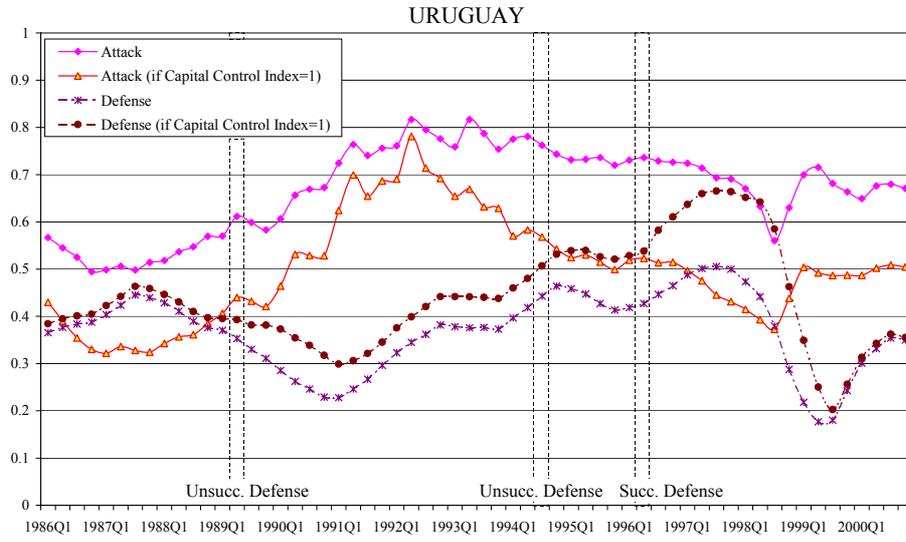


FIGURE 39. Predicted Probabilities – Uruguay

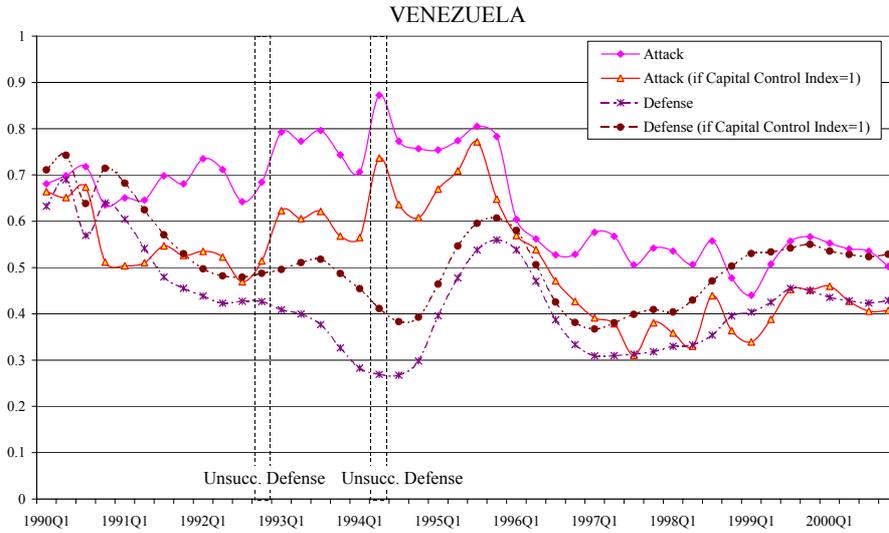


FIGURE 40. Predicted Probabilities – Venezuela

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Notes

¹Sterilization is to use offsetting open market operations to prevent an act of exchange market intervention by the central bank from changing the monetary base. With sterilization, any purchase of foreign exchange is accompanied by an equal-value sale of domestic bonds, and vice versa.

²Robert Chang and Andres Velasco (1998c) suggest that financial liberalization played a key role in the Asian financial vulnerability. In Asia, the trend of financial liberalization included the deregulation of interest rates and the easing of reserve requirements on banks. For instance, in S.Korea, 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, governments enacted policies designed to promote competition and to encourage the entry of financial institutions into the domestic market. In 1988 and 1989, restrictions on the opening and branching of banks were relaxed in both Indonesia and Malaysia respectively. In 1991 and 1993 restrictions on the activities of foreign banks were eased in both S.Korea and Thailand respectively.

³In this paper, the definition of the unsuccessful defense state (state 2) includes cases of "unsuccessful defenses" and "nondefenses". The latter are cases in which central banks simply abandon the exchange rate peg without attempting to defend it at all. This scenario occurs when the central banks are reluctant to employ their two major weapons — foreign exchange reserves and discount rates — to defend the exchange rate and when central banks feel that devaluing the domestic currency may have great potential benefits. In both the cases of unsuccessful defenses and successful **non**defenses, currency crises occur. Instances of "successful nondefenses" include those of Taiwan and Singapore in 1997Q4.

⁴A number of alternative specification have also been tried. In the short spectrum, we tried to examine the contemporary influences of the indicators on the probability of currency crises. However, this specification is not chosen as the final specification because it may be subject to the endogeneity problem. We have also allowed for predictive variables lagged up to two, three, four quarters. In addition, to conserve degrees of freedom, we have tried to model the lags using moving averages instead of including different lags into the estimation separately. The results reported in this paper correspond to one-quarter lag of the predictive variables.

⁵For example, the central bank of Chile and the Bank of Mexico spent large quantities of reserves defending pegged currencies and held on to the bitter end. Mexico 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 has caused many central banks to focus more heavily on discount rates in the defenses.

⁶The 13 items include capital controls on (i) capital market securities, (ii) money market instruments, (iii) collective investment securities, (iv) derivatives and other instruments, (v) commercial credits, (vi) financial credits, (vii) guarantees, sureties and financial backup facilities, (viii) direct investment, (ix) liquidation of direct investment, (x) real estate transactions, (xi) personal capital movements and, finally, provisions specific to (xii) commercial banks and (xiii) other credit institutions institutional investors. An alternative measure is proposed by Edison and Warnock (2001). This measure captures 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 capitalization 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) 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 capitalization 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.

⁷We use the earliest period subject to the availability of data for the country if the data five years ahead of the peak period is not available.