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Money and Credit, Competitiveness, and Currency Crises in Asia and Latin America

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Abstract

This paper analyzes the role of money, credit, trade and competitiveness variables in signaling currency crises in a sample of East Asian and Latin American countries over the period 1972:01–1997:10. Bivariate tests suggest that money and credit, as well as trade and competitiveness variables, appear to behave differently around crisis episodes than they do during periods of tranquility, suggesting that they may help signal currency crises. In multivariate probit regressions, which allow for the identification of marginal contributions of individual variables, reductions in real domestic credit and in foreign reserves as well as appreciation in the real exchange rate imply increases in the probability of a crisis. Real exchange rate appreciation appears to play a greater role in predicting currency crises in East Asia, while foreign reserve losses play a greater role in Latin America.

I. Introduction

In the aftermath of the collapse of the Mexican peso peg in December 1994, many people asked who would be the next "Mexico" among emerging markets with fixed exchange rates. While the "tequila" crisis triggered speculative pressure against a number of East Asian currencies in early 1995 (notably the Hong Kong dollar, the Thai baht, and the Philippine peso), the effects were temporary, and it was generally believed that most Asian countries were less vulnerable to capital flow reversals and sharp currency depreciations compared to Latin America countries. The collapse of Asian currencies beginning in the summer of 1997 proved that Asian countries were vulnerable after all.

This development raises a number of interesting questions regarding the experience of Asia and Latin America with currency crises. First, how susceptible have these regions been to currency crises, and have currency crises in Asia been less prevalent compared to Latin America, as conventional wisdom suggests? To address this question we will review the incidence of episodes of sharp currency depreciation in the two regions over time, and assess their relative vulnerability to crises. Second, what indicators signaled the onset of currency crises in these economies? Were there differences in the performance of these indicators in signaling crises in Asia and Latin America?

To address these questions, this paper analyzes the incidence and determinants of currency crises using a multi-country panel dataset of six countries in Asia (Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand) and seven countries in Latin America (Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela), with monthly data spanning the period 1972:01–1997:10. Our objective is to compile stylized facts of the usefulness of various indicators in predicting the likelihood of exchange rate crises in each region.

The empirical literature suggests a large set of variables that may signal currency crises. However, given the experiences of emerging markets with currency crises, we focus on two groups of variables — domestic money/credit variables and international competitiveness variables.

There is a widespread perception that money and credit behavior and currency crises are closely linked, but the direction of these links is theoretically ambiguous. On the one hand, first generation models of balance-of-payments crises (Krugman, 1979), in which budget deficits are financed by central bank money creation, and more recent models of moral hazard in lending and "overborrowing" (McKinnon and Pill, 1996; Dooley, 1997; Krugman, 1998) suggest that currency crises are likely to be preceded by booms in some measures of money or credit.

On the other hand, currency crises may arise from deflationary pressures that tend to reduce money demand and induce capital flow reversals that deplete foreign reserves. Under these conditions, money and credit growth may tend to slow in the period immediately preceding currency crises (Calvo and Mendoza, 1996).

External competitiveness and trade also play a potential role in currency crises. For example, the 1994 collapse in the Mexican peso is believed to be in large part associated with an overvaluation in the real exchange rate (Dornbusch and Werner, 1994). The 1997 currency crises in Asia are also believed to have been preceded by losses in competitiveness associated with yen appreciation, and the entry of China into world markets (Huh and Kasa, 1997; Corsetti, Pesenti, and Roubini, 1998).[1]

[1] Monetary and competitiveness variables are not necessarily independent of each other. For example, nominal wage inflation in the presence of sticky prices can result in higher real wages and lower competitiveness.

A comparison of Asian and Latin American country experiences will allow us to clarify the relative roles of these variables in currency crises in the two regions. Latin America's greater historical macroeconomic instability and experience with hyperinflation suggests money and credit behavior may have played a greater role than in Asia. The greater openness of Asian economies and the dependence of their economic performance on export growth suggests international competitiveness and trade behavior may have played a greater role in currency crises in Asia than in Latin America.

The paper is organized as follows. Section II reviews the empirical literature on the determinants of currency crises. Section III presents the definition of crisis used in this paper, discusses the data and the explanatory variables, and describes our method of estimation. Section IV presents our main empirical results. A conclusion closes the paper.

II. Background Empirical Literature

Multi-country studies of exchange rate crises seek to exploit the power of cross-country datasets. A combined time series-cross section estimation where the experience of a large number of countries can be pooled together provides variation across countries as well as across time, thus increasing the sample number of crisis observations and the variability of the information set.

A substantial literature has now accumulated on the empirical modeling of exchange rate crises using multi-country datasets. This literature may be grouped into three broad categories: (i) stylized facts for event-studies obtained from comparing the behavior of variables in pre-crisis periods with their behavior during non-crisis periods (e.g., Eichengreen, Rose, and Wyplosz, 1995; Frankel and Rose 1996; Kaminsky and Reinhart, 1996; IMF, 1998), (ii) estimates of the probability and/or magnitude of devaluation for individual country time series or multi-country

panels (e.g., Eichengreen, Rose, and Wyplosz, 1995; Frankel and Rose, 1996; Kumar, Moorthy, and Perraudin, 1998; Esquivel and Larrain, 1998), and (iii) evaluations of variables signaling an impending crisis by measurement of deviations from "normal" levels beyond certain threshold values (e.g., Kaminsky and Reinhart, 1996; Kaminsky, Lizondo, and Reinhart, 1997; Goldstein and Reinhart, 1998).[2]

Selected papers using one or more of these methods with multi-country datasets involving emerging market economies are discussed below.[3] Table 1 summarizes the range of variables included in these studies.

Frankel and Rose (1996) use a panel for 105 developing countries from 1971 through 1992 to analyze the determinants of currency "crashes" defined as at least a 25 percent depreciation in the nominal bilateral dollar exchange rate and at least a 10 percent increase in the depreciation rate over the previous year. Requiring crashes to be at least three years apart, they identify 135 currency crashes and 1708 periods of tranquility. Using the event-study approach of Eichengreen, Rose, and Wyplosz (1995), they compare the behavior of sixteen macro variables during crisis periods with tranquil periods. Using probit regressions, they find that low levels of foreign direct investment, low international reserves (as a share of imports), high domestic credit growth, high foreign interest rates and overvaluation of the real exchange rate

[2] Some studies try to explain the timing of devaluation in a specific country (e.g., Blanco and Garber, 1986, for Mexico; Cumby and Wijnbergen, 1989, for Argentina). Another strand of the currency literature examines the issue of currency contagion. For example, Sachs, Tornell and Velasco (1996) analyze the spillover effects of the 1994-95 Mexican peso crash for a cross-section sample of 20 emerging market countries; Tornell (1998) extends the sample to include the 1997-98 Asia crisis; Radelet and Sachs (1998) use a cross-section panel of 22 emerging market countries during the period 1994-97. Glick and Rose (1998) analyze the links between trade competition and contagion for a large panel of emerging and industrial countries during five different currency crises episodes (1971, 1973, 1992-93, 1994-95, and 1997).

[3] Kaminsky, Lizondo, and Reinhart (1998) summarize the main theoretical explanations for speculative attacks and balance of payments crises, including both 1st and 2nd generation speculative attack models. They also provide a

increase the probability of a currency crash. They find that neither the current account nor the fiscal balance has a significant effect on the likelihood of a currency crash.[4]

Kaminsky and Reinhart (1996) study the behavior of 9 macroeconomic and financial indicators around the time of 76 currency-crisis episodes in 15 developing and 5 industrial countries over the 1970-95 period. They define currency crises in terms of three standard deviations from the mean of a weighted average of nominal exchange rate depreciations and reserve losses. (They also study banking crises.) Using the event-study methodology, they observe that in the months prior to currency crises the real exchange rate appreciates and the ratio of M2 to foreign reserves rises, M1 growth is high, exports and the terms of trade weaken, output declines, and foreign exchange reserves fall; the behavior of imports appears to fall.[5]

Kaminsky, Lizondo, and Reinhart (1998), using basically the same dataset as Kaminsky and Reinhart (1996), present nonparametric evaluations of 17 different variables in signaling an impending crisis by measuring the deviations of each variable from certain threshold values. The threshold values are calculated so as to balance the number good signals issued against the risk of false signals. They establish a ranking for each indicator in terms of the number of good signals issued and the fewest number of false signals issued, the average lead time prior to a crisis in which a signal is first issued, and the persistence of signals ahead of crises. They

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detailed discussion of the empirical literature, describing the various methodologies and variables that have been identified as the most useful indicators.

[4] Apart from their manner of defining exchange rate crises, the methodology of Frankel and Rose largely follows that of Eichengreen, Rose, and Wyplosz (1995), who focus exclusively on industrial countries and define exchange rate crises in terms of a weighted average of nominal exchange rate depreciation, reserve losses, and interest rate increases.

[5] They do present statistical evidence of the extent to which currency crises are associated with financial liberalization and banking crises.

conclude that the signals that have the best track record in anticipating crises include: exports, deviations of the real exchange rate from trend, the ratio of M2 to foreign reserves, output, and equity prices. Other indicators considered, such as imports, interest differentials, the ratio of lending to deposit interest rates, and bank deposits are found to be much less useful.

The IMF *World Economic Outlook* (1998) analyzes the behavior of 12 macrovariables around the time of currency crises in 53 countries (22 industrial countries, 31 developing countries) over the 1975-97 period; 158 episodes are identified in which countries experienced substantial exchange market pressures, defined as in Kaminsky and Reinhart (1996). Using an event-study methodology, this study finds that in the months prior to exchange rate crises, the real effective exchange rate is higher, export performance is worse, international reserves decline sharply, the terms of trade declines somewhat, inflation is significantly higher, nominal private credit growth rises, M2/foreign reserves rises (and falls sharply in the months following a crisis), nominal and real M2 growth rise sharply (peaking at 18 months prior to crises), and financial asset prices boom and bust (relative to U.S. or German stock prices), while there is no clear pattern in real economic activity (as measured by growth in industrial output or manufacturing output) or in the trade balance.

Kumar, Moorthy, and Perraudin (1998) use a panel of monthly data for 32 emerging countries from January 1985 to March 1998. They consider a kitchen's sink worth of potential explanatory variables. Using a multivariate probit analysis they find export growth, real GDP deviations from trend, foreign reserve losses, and inflation are helpful variables; they also find that the fiscal balance, nonfuel commodity prices, as well as a regional contagion measure provide some explanatory power.

Esquivel and Larrain (1998) examine the determinants of currency crises with an annual panel dataset for 30 industrial and emerging market countries between 1975 and 1996. They estimate a probit model, and find that high rates of seigniorage (defined as the annual change in the monetary base as a percent of GDP) current account imbalances, real exchange rate misalignment (defined as the negative of the percentage deviation of the real exchange rate from its average over the previous 60 months), low foreign exchange reserves, negative terms of trade shocks, poor growth performance, and a measure of regional contagion all have significant power in explaining the presence of currency crises in their sample.

These studies suggest that a number of variables have been effective in indicating the onset of many crises.

III. Data and Methodology

Identification of Currency Crisis Episodes

Several alternative definitions of currency crises have been employed in the literature: (i) some rate of depreciation above a certain exogenous threshold (e.g., Frankel and Rose, 1996; Kumar, Moorthy, and Penaudin, 1998); (ii) some weighted average of devaluation and reserve losses (and possibly interest rate changes) above a certain threshold (e.g. Eichengreen et al, 1995; Moreno, 1995); and (iii) nominal devaluations larger than some threshold defined in terms of moments of the sample (e.g., Kaminsky and Reinhart, 1996; Kaminsky, Lizondo, and Reinhart, 1998; IMF, 1998; Esquivel and Larrain, 1998; Moreno, 1999).

In this study, episodes of sharp currency depreciation for each country are defined as those in which the percentage change in the exchange rate exceeds the mean plus two standard deviation, computed over the full sample period. To reduce the chances of capturing the

continuation of the same episode, 12 months of data were skipped after each episode before continuing the search for the next episode. (Some episodes and the data around them were dropped when there were no monetary data reported, specifically the Philippines in the mid-1980s.) For episodes of hyperinflation, we follow Kaminsky and Reinhart (1996) and separate the nominal exchange rate depreciation observations for each country according to whether or not inflation in the previous 6 months was greater than 150 percent; for each subsample we calculated separate standard deviation and mean estimates with which to define exchange rate crisis episodes. This approach avoids screening out sizable depreciation events in more moderate inflation periods for countries that have occasionally experienced periods of hyperinflation and extreme devaluations.

Two points are worth making with regard to our choice of episodes. First, the cut-off point of two standard deviations is entirely arbitrary. However, Frankel and Rose (1996) and Kumar, Moorthy, and Penaudin (1998) suggest that the results are not very sensitive to the precise cut-off chosen in selecting depreciation episodes.

Second, in contrast to some previous research, which includes episodes of speculative pressure in which the exchange rate did not always adjust, the present paper focuses on episodes of sharp depreciation alone, and does not consider the behavior of foreign exchange reserves and interest rate differentials. This criterion excludes instances where a currency came under severe pressure but the authorities successfully defended it by intervening heavily in the foreign exchange market, by raising interest rates sharply, or by other means.

As argued by Frankel and Rose (1996), the lack of market-determined short-term interest rates for much of the sample period in many emerging countries implies that interest rate changes are less useful indicators of exchange rate pressures (over the sample) than other very difficult to

measure factors, such as tightening of reserve requirements. In addition, foreign currency reserve movements are notoriously noisy measures of exchange market intervention. (This was dramatically exemplified by the experience of Thailand in 1997, where much of the intervention that depleted foreign currency reserves occurred in the forward market and off the central bank's balance sheet). With this in mind, in this paper we instead try to assess whether foreign exchange reserves contain any information that may be useful in signaling episodes of sharp currency depreciation.

Data for the end-of-period exchange rate against the U.S. dollar were collected from the International Financial Statistics CD-ROM issued by the International Monetary Fund. The sample includes Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand in Asia and Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela in Latin America. Hong Kong was excluded because of the lack of monthly data. Cases in which more than one country was affected by a crisis, either because of a common shock or because of contagion effects, were counted as more than one crisis. The full sample period spans 1972:01-1997:10 for all countries.

Figure 1 shows the year-by-year number of crises according to our definition. For the full period we identify 59 crises, 31 in Asia and 28 in Latin America. Currency crises in Asia were relatively more prevalent in the period 1972-80 and, of course, in 1997. In Latin America, crises were more prevalent in the 1980s and early 1990s. Table 2 presents summary statistics for the number of crises for each region for the full sample period, and also for the subperiods 1972-1987 and 1988-1997.

One interesting thing to note from the figure is that there is no evident pattern of increase in the number of episodes of sharp depreciation. In fact, if you cut the sample, the frequency of crises (average/year) in the period 1988-1997 was slightly slower than in the 1972-1987 period.

However, what is very different in 1997, compared to past episodes, is the high concentration of crises in one year.

Indicator Variables

As noted in Section II, the theoretical and empirical literature has identified a vast array of variables potentially associated with currency crises (see Kaminsky, Lizondo, and Reinhart, 1998). The choice of explanatory variables in our analysis was determined by the questions we posed earlier, as well as by the availability of data on a monthly basis. The data series and sources are described in the Data Appendix.

The explanatory variables used in our analysis can be divided into two broad groups:[6]

- *Money and credit variables*, comprising nominal and real M2, M2/reserve money multiplier, M2/foreign reserves, foreign reserves, and nominal and real domestic credit (net of claims on the public sector), all in growth rates.
- *Competitiveness and trade variables*, comprising the deviations in trend in the real trade weighted exchange rate (defined so that a positive deviation is a real depreciation of the domestic currency), export revenue growth (in U.S. dollars), and the trade balance (as a percentage of exports).

The behavior of money or domestic credit prior to episodes of depreciation is theoretically ambiguous. On the one hand, broadly interpreted first-generation models of currency attack (Krugman, 1979), and models of money and credit booms with moral hazard (McKinnon and Pill,

[6] We also experimented with two global variables: trade-weighted foreign industrial production and GDP-weighted foreign interest rates, where the foreign countries were the U.S., Japan, and Germany. These variables were not significant in the probit regressions reported below and were dropped to simplify the exposition.

1997; Dooley, 1997; Krugman, 1998; Sachs, Tornell, and Velasco, 1996) suggest that the growth in these variables should be faster than during periods of tranquility. On the other hand, if episodes of sharp depreciation are associated with slowing economic activity and corresponding declines in the demand for money and credit prior to a crisis, the growth in these variables may tend to be slower than during periods of tranquility.

We also expect the growth rate of M2/foreign reserves to be higher prior to episodes of depreciation. The reason is that a higher ratio (exceeding unity) implies a decline in the foreign currency backing of the short-term domestic currency liabilities of the banking system. This would make it difficult to stabilize the currency if sentiment shifts against it.

The growth rate of foreign reserves is expected to slow or turn negative prior to episodes of sharp depreciation. However, this variable is quite noisy (Frankel and Rose, 1996). For example, official statistics understated the extent of depletion in foreign reserves prior to the collapse of the Thai baht peg in 1997, due to off-balance sheet transactions by the Bank of Thailand in the forward market. For this reason, we test directly for the existence of a statistical relationship between foreign reserves and episodes of sharp depreciation to determine how much information is contained in this variable.

The M2 multiplier, defined as the ratio of M2 to the monetary base, is often used as an indicator of the effects of financial liberalization (Calvo and Mendoza, 1996). Such liberalization may lead to monetary booms reflected in increases in the multiplier that in turn lead to currency crises. Kaminsky and Reinhart (1996) observe that the financial sector had been liberalized during the five years prior to 18 of the 26 banking crises they study, and their index of financial liberalization signals 71 percent of balance of payments crises (and 67 percent of banking crises,

which in turn signal balance of payments crises). We would therefore expect a positive relationship between M2 multiplier growth and crisis episodes.

As for the competitiveness and trade variables, prior to episodes of sharp depreciation we would expect the real trade-weighted exchange rate to *appreciate more* relative to periods of tranquility, export growth to be more sluggish, and the trade balance to be smaller.

Methodology

We present two types of analysis of the data. First, we present event-study graphs describing the average behavior of variables during a 25-month window centered around crises in each region. We also report t-statistics for the difference between the mean of each variable in the 12-month period prior to crises and its mean in non-crisis, "tranquil" periods.

Secondly, we present probit estimates. Our use of probit models allows us to go beyond the bivariate t-tests to focus on the joint contribution of money or competitiveness variables to currency crises. It also enables us to assess the extent to which the variables we focus on in this study helped predict the 1997 crisis.

IV. Empirical Results

Crisis event studies

To describe the behavior of economic variables during each depreciation crisis, a window of 25 months was constructed, including the 12 months before the crisis, the month of the crisis, and 12 months after the crisis. For each region, averages were then computed across all crises for each month in the windows. (For variables expressed in growth rate terms, averages of 12-month growth rates were computed in order to smooth the data.) Months outside the 25-month crisis

windows were designated tranquil periods, and the average was computed for these tranquil periods.

Figure 2 plots the difference between the average value of a variable during each month of the 25-month window less the average value for the entire tranquil period. Standard error bands were calculated as two times the sum of the standard errors for the mean of the crisis windows (spanning the 25-month period illustrated in the panels) and for the mean of tranquil periods.[7] The following results are apparent:

- *In both regions, real money and real domestic credit growth is lower during the leadup to crises compared to tranquil periods.* Recalling the preceding discussion, this result suggests that rather than being preceded immediately by credit booms, episodes of sharp depreciation may be associated with slowing economic activity and corresponding declines in the demand for money and credit prior to a crisis. This does not rule out that there may have been a credit boom in the more distant past, but if there has, it is not obvious in real money or credit growth rates in the eve of a crisis.
- *The M2/reserve money ratio is greater during the onset of crises in Asia, though not in Latin America.* This result is somewhat surprising. The M2 multiplier is often used as an indicator of the effects of financial liberalization. Such liberalization may lead to monetary booms reflected in increases in the multiplier, that in turn lead to currency crises. We would therefore have expected a positive relationship between money multiplier growth and crisis episodes. However, financial liberalization may involve a level shift or a trend in

[7] In estimating the standard error band, we could either compute the standard error for the mean around each of the months inside the window (averaging over the number of crisis episodes only) or compute the standard error for the mean of all of the months inside the window (averaging over the 25 months inside the window as well as over the number of crisis episodes). We use the latter procedure, which is more consistent with the t-tests reported below. This produces a tighter standard error band.

the money multiplier over a long period. For this reason, money multiplier growth may not give a clear signal of impending crises.

- *The M2/foreign reserve ratio is greater in both regions prior to crises, peaking in the month before crises.* This is to be expected. A higher ratio implies a decline in the foreign currency backing of the short-term domestic currency liabilities of the banking system. This would make it difficult to stabilize the currency if sentiment shifts against it.
- *Foreign reserve growth is generally lower in Latin America during the entire 12-month leadup to crises; in Asia, foreign reserve growth falls roughly three months prior to crises.* Sluggish or negative growth in foreign reserves prior to a crisis is consistent with our expectations.
- *In Latin America, nominal money and credit growth is greater during the pre-crisis period than in tranquil periods; in Asia, it is lower.* This is consistent with Latin America's past history of rapid money growth and inflation compared to Asia.
- *The real exchange rate is lower (more overvalued), exports are lower, and the trade balance is lower in the pre-crisis periods in both regions.* These results are broadly in line with what we would expect. A real appreciation generates pressures for devaluation, sluggish export growth makes the defense of a peg more costly (as suggested by second generation models of currency crises) and a trade balance deterioration may make the currency more vulnerable to interruptions in credit.

One remarkable feature of these figures is the qualitative similarities in Asia and Latin America (with the exception of nominal M2 and domestic credit), which indicates that the two regions share more characteristics than casual observation might suggest.

Table 3 reports the t-test statistics for the difference in the mean value of each variable in the 12-month period prior to crises and its mean value during periods of tranquility, for each region individually and pooled together. (These calculations drop the observations for the month in which crises occur and for the 12 months after crises, which by construction are excluded from the non-crisis sample.) The corresponding p-values are reported in parentheses.[8] As might be expected, the t-test results are consistent with the impressions created by the figures.

For the full sample of countries (column 1), the t-tests confirm that growth in real M2, real domestic credit, as well as foreign reserves, tends to be significantly *slower* prior to episodes of sharp depreciation than during periods of tranquility. In addition, the ratio of M2/foreign reserves tends to grow *faster* prior to episodes of sharp depreciation than during periods of tranquility. The difference in means for nominal M2 is positive and significant at 10 percent, whereas the measure of nominal domestic credit used here is not statistically significant at conventional levels. The differences in means in the real trade-weighted exchange rate, exports, and the trade balance are all statistically significant, with the expected negative sign.

Inspection of the t-statistics by region, which are reported in columns 2 and 3, allows us to ascertain more precisely the extent to which the impression conveyed by the plots on similarities and differences in Asia and Latin America is confirmed by the statistical tests. The results for most money and credit and competitiveness variables in each region are generally the same as in the full sample, and as indicated earlier by the figures, the number of qualitative similarities suggests that the two regions share more characteristics than casual observation might suggest.

[8] The standard errors used in these tests were calculated as the sum of standard errors for the mean of the 12-month period prior to crises and for the mean of the tranquility period.

Probit Regressions

Our crisis event-study analysis describes the behavior of each of our macroeconomic variables taken in isolation. However, policymakers are typically interested in the marginal contribution of individual variables to the probability of a crisis, while taking into account the impact of other variables. To the extent that the information of particular variables overlaps, some variables may provide little explanatory power for currency crises in the presence of other variables. For example, recall that we found that prior to crises the real exchange rate appears to appreciate more, and the trade balance appeared to be smaller, than during periods of tranquility. However, if the real exchange rate variable is a good measure of international competitiveness, the trade balance may not add any extra information to that contained in the real exchange rate. To assess the marginal information value of our indicator variables we use a multivariate probit model where selected variables are employed simultaneously.

We implement the probit regressions with a bivariate index of exchange rate crises on the left-hand side (with a value of 1 for months in which currency crises occurred by our definition and 0 otherwise) and lagged values of selected macroeconomic variables on the right-hand side. (To prevent overlapping observations for those variables expressed in growth rates, one-month, rather than 12-month growth rates, are used.) To allow sufficient lags of our indicator variables and to economize on degrees of freedom, the data was averaged over 1–6 month lags and over 7–12 month lags. Both of these six-month averages of lagged data were included simultaneously in the estimations.

Table 4 reports results of probit estimation over the full period for our set of 13 countries using maximum likelihood. Three alternative models are estimated, involving different combinations of money or credit variables on the right-hand side. Model I uses real M2 and

foreign reserves, Model II uses the money multiplier and the ratio of M2/foreign reserves, and Model III uses total domestic credit (less claims on the government). In all three cases, the trade or competitiveness variables included on the right-hand side are the real exchange rate, exports, and the trade balance. The table reports the cumulative effects of one percent increases in the two lagged averages of each regressor on the monthly probability of a crisis (expressed in percentage points).[9] The p-values for z-test of the null that the sum of coefficients is zero and the chi-squared (Wald) test of the null that the block of coefficients has an effect of zero are presented in parentheses. The performance of the three alternative models is roughly comparable, with Model III, which uses the domestic credit variable, having a slight edge (a higher Pseudo-R^2).

The results are broadly consistent with the t-tests reported in Table 3, except that it is now possible to evaluate marginal contributions. The following results are apparent:

- *Episodes of sharp depreciation are more likely when financial vulnerability to the external sector rises,* as measured by a contraction in foreign reserves or increases in the ratio of M2 to foreign reserves.
- *Depreciation episodes are more likely when real domestic credit falls.* The insignificance of real M2 may be caused by foreign reserves capturing part of the observed behavior of money and credit, robbing real M2 of explanatory power.
- *The growth in the money multiplier is not a good predictor of episodes of sharp depreciation even when controlling for other variables.* As the money multiplier is often used as a proxy for financial liberalization (Calvo and Mendoza, 1996), this suggests that to the extent that liberalization is measured by this variable, it contains no information that helps predict currency crises.

[9] The probability of a crisis occurring in the following 12-month period is much higher. See footnote 10.

- *The appreciation of the real exchange rate (relative to trend) is associated with a higher probability of sharp depreciation.* (Our definition of the real exchange rate implies that negative deviations correspond to appreciations.)
- *Neither exports nor the trade balance are significant,* in contrast to the results in Table 3. This suggests that the real exchange rate captures the competitiveness effects that may be reflected in these variables.

We now use the probit models to address two questions posed earlier. First, have changes in the global environment since the late 1980s affected the vulnerability of the countries in our samples to crises (Table 5)? Second, are there differences in the vulnerability of Asian and Latin American countries to currency crises (Table 6)? In performing the estimation, we will focus on Model III, which appears to have the best fit. We also drop exports and the trade balance from the right-hand side, as these are consistently not significant.

Table 5 reveals that the predictive ability of the model appears to have improved since 1988, as there is a distinct rise in the pseudo-R2, and competitiveness factors seem to have become more important. In particular, real domestic credit, previously significant, becomes insignificant at conventional levels. The foreign reserves coefficients becomes larger and more significant, suggesting that the importance of this measure of external vulnerability in predicting currency crises has increased. We also find that the real exchange rate becomes significant after the late 1980s, suggesting that competitiveness effects have become more important.

Table 6 reveals that real domestic credit and foreign reserves help predict crises in Latin America better than in Asia, while the real exchange rate plays a more important role in Asia. The coefficient values on the real exchange rate tend to be larger in Asia than in Latin America. This

is broadly consistent with the greater role trade appears to have played in Asia in the past decades.

Predicting the 1997 crises

We now use the model to ask two additional questions. First, did these indicators help predict the 1997 crises? Second, were the predicted probabilities different in Asia and Latin America? To address these questions, we re-estimate the model of real domestic credit, foreign reserves, and the real exchange rate to 1995:06 for the full set of countries. Using the estimated coefficients, the actual values of the right-hand side variables and the assumed normal distribution, we estimate the total predicted probability and contribution of each variable over the period 1995:07-1997:10. (We drop Colombia in the prediction — but not in the estimation — because of missing values over the prediction interval.)

The panels in Figure 3 illustrate total predicted probabilities (hatched lines), the contribution of individual right-hand side variables to the total (bubble lines), and the average in-sample predicted probabilities (solid flat lines).

Several observations emerge from these charts. First, the average in-sample *monthly* predicted probability of a crisis in our probit models ranges from a low of 1.4 percent (under certain assumptions, this implies approximately a 16 percent probability that a crisis will occur at least once in the following 12 months)[10], in Thailand or Malaysia, to a high of 3.5 percent (35 percent over a 12-month period) in Argentina. Bearing this in mind, we focus on whether there

[10] If each month is an independent "trial" in which a crisis event may or may not occur, p(M) denotes the monthly probability of a crisis, and p(A) denotes the probability that a crisis will occur once in a 12-month period, p(A) can be calculated as follows:

$$p(A) = (1-(1-p(M))^{12})*100.$$

appear to be large proportionate changes in predicted probabilities as we approach July 1997, when the crisis broke out in Thailand.

Turning first to the Asian countries, predicted probabilities in 1995:07 tended to be below the average in-sample predicted probabilities for each country (an exception is Malaysia). There are subsequent distinct upturns in predicted probabilities, notably in Thailand, but also in Indonesia, Malaysia (reversing an earlier decline), the Philippines, and Singapore. In Thailand, the monthly predicted probability increases by factor of about 10 between July 1995 and July 1997, to peak at about 4.2 percent (roughly 40 percent probability of a crisis in a 12-month period). The increase is gradual, and then steepens towards the middle of 1997. In Indonesia, Malaysia and the Philippines, most of the increase occurs in 1997, while in Singapore the increase is quite gradual and is not as pronounced as in Thailand.

In contrast to the tendency for predicted probabilities to rise in East Asia, the trend in our sample of Latin American countries is flat (Brazil, Chile, Mexico, Peru) or even declining (Venezuela and Argentina), and predicted probabilities tend to fall or remain below their in-sample averages. From this point of view, the signals given out by Asia on the eve of the 1997 crisis were qualitatively quite different from the signals given out by Latin America.

The regional differences in the observed trends in predicted probabilities reflect differences in the behavior of the three explanatory variables. In Asia, the increase in predicted probabilities is the result of reductions in foreign exchange reserves, and a tendency for real trade-weighted exchange rate appreciation. Real domestic credit growth made essentially no contributions to changes in predicted probabilities. These effects are particularly apparent in Thailand.

The contribution of real trade-weighted exchange rate appreciation — associated largely with the appreciation of the yen from 1995 to 1997 — conforms to intuition and suggests that competitiveness effects played some role (albeit small) in the East Asian crisis.

As might be expected, in Latin America, there was generally no distinct trend in the explanatory variables, with the exception of Venezuela, where the decline in predicted probabilities reflects increases in domestic credit growth.

The relatively important contribution of foreign reserve depletion to the rise in predicted probabilities in Asia is of interest for at least two reasons. First, prior to July 1997, analysts focused on the high levels of foreign reserves to conclude that East Asian economies were not vulnerable to currency crisis. Our analysis suggests that the rate of *depletion* of such reserves is also important.

Second, as noted earlier, this variable is very noisy, and in the case of Thailand official statistics understated the extent of depletion prior to the crisis of July 1997 because they ignored off-balance-sheet transactions of the central bank. Nevertheless, the variable did signal an increasing likelihood of a sharp depreciation. This highlights the importance of ensuring that the reporting of this statistic is timely and transparent.

It may also be noted that in generating predicted probabilities we have assumed that the same model applies to Asia and Latin America. If we instead assumed that a different model applies to each region, based on Table 6, in generating predicted probabilities in Asia a smaller weight would be assigned to changes in foreign reserves, and a larger weight to the real exchange rate (the reverse would be true in Latin America). The apparent importance of foreign reserve depletion in Asia in the 1997 episodes might suggest that Asia in the 1990s has become "more like

Latin America." Of course, more currency crises observations would be needed to confirm such an interpretation.

V. Conclusions

This paper has analyzed the role of the money, credit, trade, and competitiveness variables in signaling currency crises (defined as episodes of sharp depreciation) in a sample of East Asian and Latin American countries over the period 1972:01-1997:10. Using bivariate tests, we find that money and credit, as well as trade and competitiveness variables appear to behave differently around crisis episodes than they do during periods of tranquility, suggesting that they may help signal such crises. In multivariate probit regressions, which allow identification of the marginal contribution of individual variables, reductions in real domestic credit and in foreign reserves and appreciation in the real exchange rate imply increases in the probability of a crisis.

When splitting the sample into two time periods we find that the fit of our preferred model appears to have improved since the late 1980s, and that external factors appear to be more significant. When splitting our sample by region, we find that our preferred model appears to fit Latin America better. The real exchange rate appears to play a greater role in predicting currency crises in East Asia. Foreign reserves play a greater role in Latin America.

Finally, we estimate our model up to 1995:06 and compute out-of-sample predicted crisis probabilities up to 1997:10. There is a distinct rise in these probabilities in East Asian economies above their in-sample means. In Thailand, the probability of a crisis within a 12-month period peaked at about 40 percent in 1997, well above the average in-sample probability of 16 percent. This rise is attributable to foreign reserve depletion (somewhat in contrast to the implications of estimates with the sample split by regions), and to a lesser extent, to real trade-weighted

appreciation. In Latin America, total predicted probabilities are flat or declining, and tend to remain below their in-sample averages.

We conclude with some comments these results may suggest.

First, the sources of currency crises may have changed over time in Asia, from being driven largely by competitiveness to being driven by external vulnerability of the kind measured by foreign reserve depletion. The issue of external vulnerability and its role in triggering crises even in rapidly-growing economies is worth exploring further.

Second, our specification alerts policy makers that they would do well to watch out for sluggish growth in real money growth or credit. These, rather than money and credit booms, may occur just before a currency crisis. This is not to say that money and credit booms may not have occurred in earlier periods, but the specification used in this paper does not capture these effects.

Third, exchange rate appreciation appears to have played some role in the recent crises in East Asia. In Latin America, such real appreciation traditionally reflected high domestic inflation with a nominal peg. In Asia, however, such real appreciation to a significant degree reflected the weakness in the yen against the U.S. dollar. This highlights the importance of a careful assessment of how exchange rate policy affects vulnerability to a currency crisis.

Data Appendix

The countries included in the analysis are for Asia: Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand, and for Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela. The data span is 1972:01-1997:10. IFS codes for each data series are indicated in parentheses below.

Exchange rate: end-of-period nominal exchange rates (ae) were used in defining currency crisis episodes and in constructing real exchange rates.

Money and credit variables: reserve money (14), M2 (34+35), foreign reserves in U.S. dollars (1ld), domestic credit (32) less claims on government (32an). The money multiplier is defined as M2/reserve money. Real variables were obtained by scaling by the CPI (64).

Competitiveness and trade variables: Trade-weighted real exchange rate was created by taking the trade-weighted sum of logs of the bilateral real exchange rates (defined in terms of CPI indices) against the U.S. dollar, the deutschemark, and the yen, where the trade-weights are based on the average bilateral trade with the U.S., Europe, and Japan in 1980 and 1990. An increase in this index is a *real* depreciation of the domestic currency. The deviation from trend was computed by taking the residuals of a regression of the above series from a constant and a trend for each country. Exports are from line 70d; imports from 71d. The trade balance is defined as (exports – imports)/exports.

Table 1. Macroeconomic Indicators in Selected Currency Crisis Studies						
Study	Frankel and Rose (1996)	Kaminsky and Reinhart, (1996)	Kaminsky, Lizondo, and Reinhart (1998)	IMF (1998)	Kumar, Moorthy, and Peraudin (1998)	Esquivel and Larrain (1998)
Sample Period	1971-92 annual	1970-1995 monthly	1970-1995 monthly	1975-97 monthly	1/85-3/98 monthly	1975-96 annual
Countries	105 developing	20 (15 emerging)	20 (15 emerging)	53 (31 emerging)	32 emerging	30 (15 emerging)
Technique	mn . diff., probit	mn. Difference	signal	mn. diff., probit	logit	probit, signal
real exchange rate	*✚	*	*✚	*✚	*	*✚
export growth		*	*✚	*	*✚	
import growth		*	*		*	
trade balance	*		*	*	*	*✚
output growth	*	*	*✚	*	*	*✚
stock price change		*	*✚	*	*	
inflation				*	*	
money growth		*		*		*
domestic credit growth	*✚	*	*	*✚	*	*
foreign reserve growth	*	*	*	*	*✚	
M2/foreign reserves	(for. res./imp.) *✚	*	*✚	*✚	(for. res./imp.) *✚	*✚
money multiplier			*	*	*	
fiscal balance	*				*✚	*
capital flows; for. debt	*✚				*	
liberalization		*✚			*	
banking crisis		*✚	*			
real interest rate			*	*	*	
lending rate/deposit rate			*		*	
real int. differential			*		*	
bank deposits			*			
liberalization		*✚			*	
banking crisis		*✚	*			
contagion					*✚	*✚
foreign output	*					
foreign interest rate	*✚			*✚	*	
nonfuel commodity price					*	
terms of trade		*	*	*✚	*	*✚

Note: "significant" variables indicated by ✚

Table 2. Number of Crisis Episodes						
Periods	All countries		Asia		Latin America	
	Total	Avg./year	Total	Avg./year	Total	Avg./year
Full Sample	59	2.3	31	1.2	28	1.1
1972:01–1987:12	39	2.4	21	1.3	18	1.1
1988:01–1997:10	20	2.0	10	1.0	10	1.0

Table 3. T-test Statistic for Differences in Means between Crisis and Tranquil Periods (p-value in parentheses)			
	All countries (1)	Asia (2)	Latin America (3)
Money and Credit Variables			
Nominal M2 growth	1.84 (0.07)	-4.14 (0.00)	2.63 (0.01)
Real M2 growth	-8.31 (0.00)	-4.25 (0.00)	-7.66 (0.00)
M2/reserve money	0.32 (0.75)	0.62 (0.54)	0.31 (0.54)
M2/foreign reserves	5.17 (0.00)	2.79 (0.01)	4.61 (0.00)
Foreign reserves growth	-6.49 (0.00)	-1.99 (0.05)	-6.19 (0.00)
Nominal domestic credit growth	1.39 (0.16)	-1.47 (0.14)	2.21 (0.03)
Real domestic credit growth	-7.39 (0.00)	-1.71 (0.07)	-7.78 (0.00)
Competitiveness and Trade Variables			
Real exchange rate (deviation from trend)	-11.27 (0.00)	-11.87 (0.00)	-6.89 (0.00)
Export growth	-6.01 (0.00)	-5.03 (0.00)	-4.16 (0.00)
Trade balance/exports	-3.72 (0.00)	-3.64 (0.00)	-1.62 (0.11)

Table 4. Probit Regressions, 1972:01–1997:10, all countries			
	Model I	Model II	Model III
Real M2 growth	-.013 (0.36/0.53)		
Real domestic credit growth			-.032 (0.00/0.01)
Foreign reserves growth	-.017 (0.00/0.00)		-.018 (0.00/0.00)
Money multiplier		-.008 (0.45/0.71)	
M2/foreign reserves		.009 (0.04/0.01)	
Real exchange rate (deviation from trend)	-.023 (0.04/0.10)	-.032 (0.01/0.02)	-.029 (0.01/0.03)
Export growth	-.008 (0.37/0.50)	-.013 (0.18/0.29)	-.006 (0.44/0.45)
Trade balance/exports	-.000 (0.99/0.30)	-.001 (0.85/0.39)	-.004 (0.48/0.40)
Chi2(16) (p-value)	30.91 (0.00)	22.66 (0.01)	38.99 (0.00)
Log Likelihood/Pseudo R2	-249.39 (0.06)	-253.53 (0.04)	-235.89 (0.08)
No. obs.	2912	2913	2831

Note: Probit slope derivatives multiplied by 100 to convert into percentages, report the effects of one-percent changes in regressors on the monthly probability of a crisis (expressed in percentage points). p values for z-tests of null that sum of coefficients and for Wald test of null that block of coefficients is zero are in parentheses. Models are estimated with a constant, not reported.

Table 5. Probit Regressions, Split periods, all countries, Model III		
	1972:01–1987:12	1988:01–1997:10
Real domestic credit growth	-.041 (0.04/0.07)	-.013 (0.31/0.17)
Foreign reserves growth	-.017 (0.02/0.02)	-.022 (0.00/0.01)
Real exchange rate	-0.025 (0.09/0.17)	-0.043 (0.00/0.00)
Chi2(6) (p-value)	19.11 (0.00)	25.24 (0.00)
Log Likelihood (Pseudo R2)	-151.3 (0.06)	-81.40 (0.13)
No. obs.	1608	1238

Note: See Table 4.

Table 6. Probit Regressions, 1972:01–1997:12, Asia and Latin America, Model III		
	Asia	Latin America
Real domestic credit growth	-.012 (0.76/0.68)	-.029 (0.00/0.00)
Foreign reserves growth	-.018 (0.06/0.17)	-.014 (0.00/0.00)
Real exchange rate	-.073 (0.00/0.01)	-.017 (0.04/0.12)
Chi2(6) (p-value)	17.15 (0.00)	28.53 (0.00)
Log Likelihood (Pseudo R2)	-133.70 (0.06)	-98.77 (0.13)
No. obs.	1456	1390

Note: See Table 4.

Figure 1.

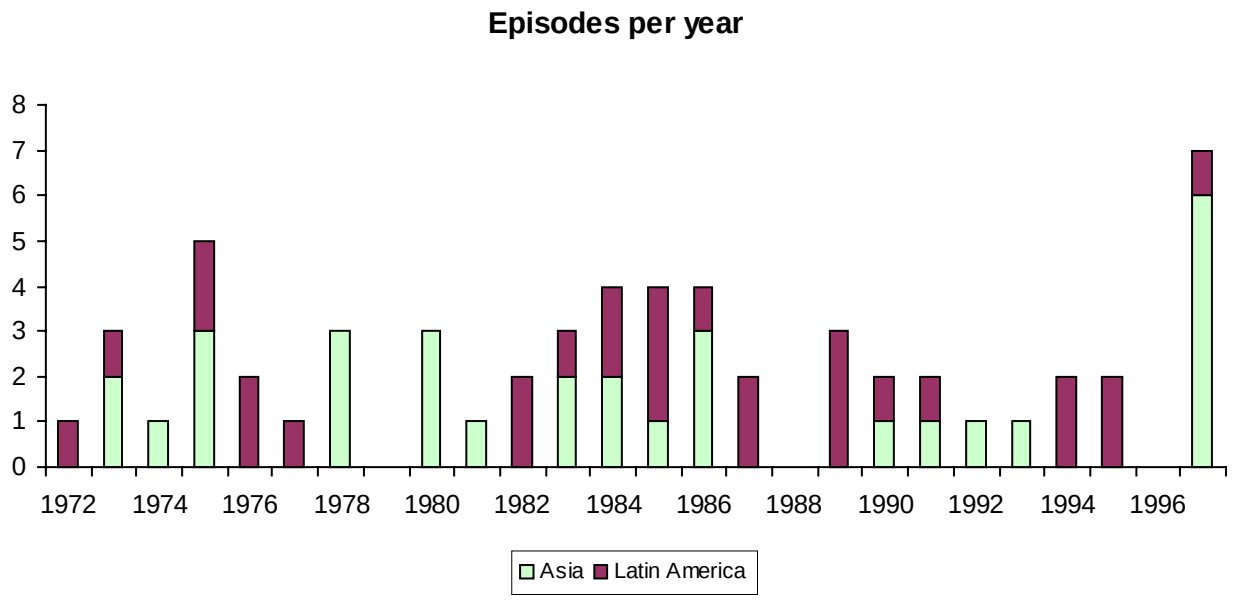

Episodes per year
8
7
6
5
4
3
2
1
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
Asia
Latin America

Figure 2. Behavior of variables around crisis episodes

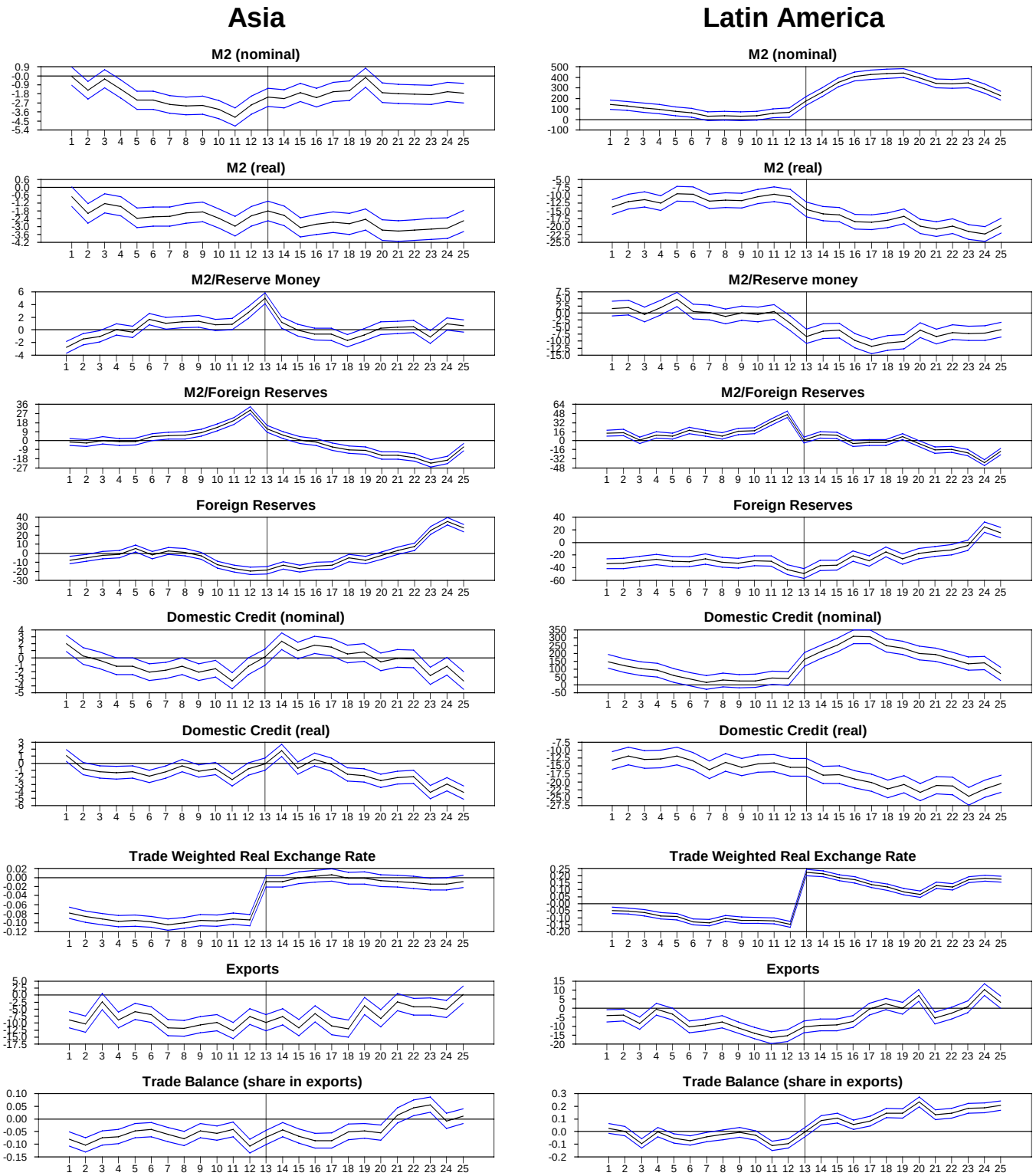
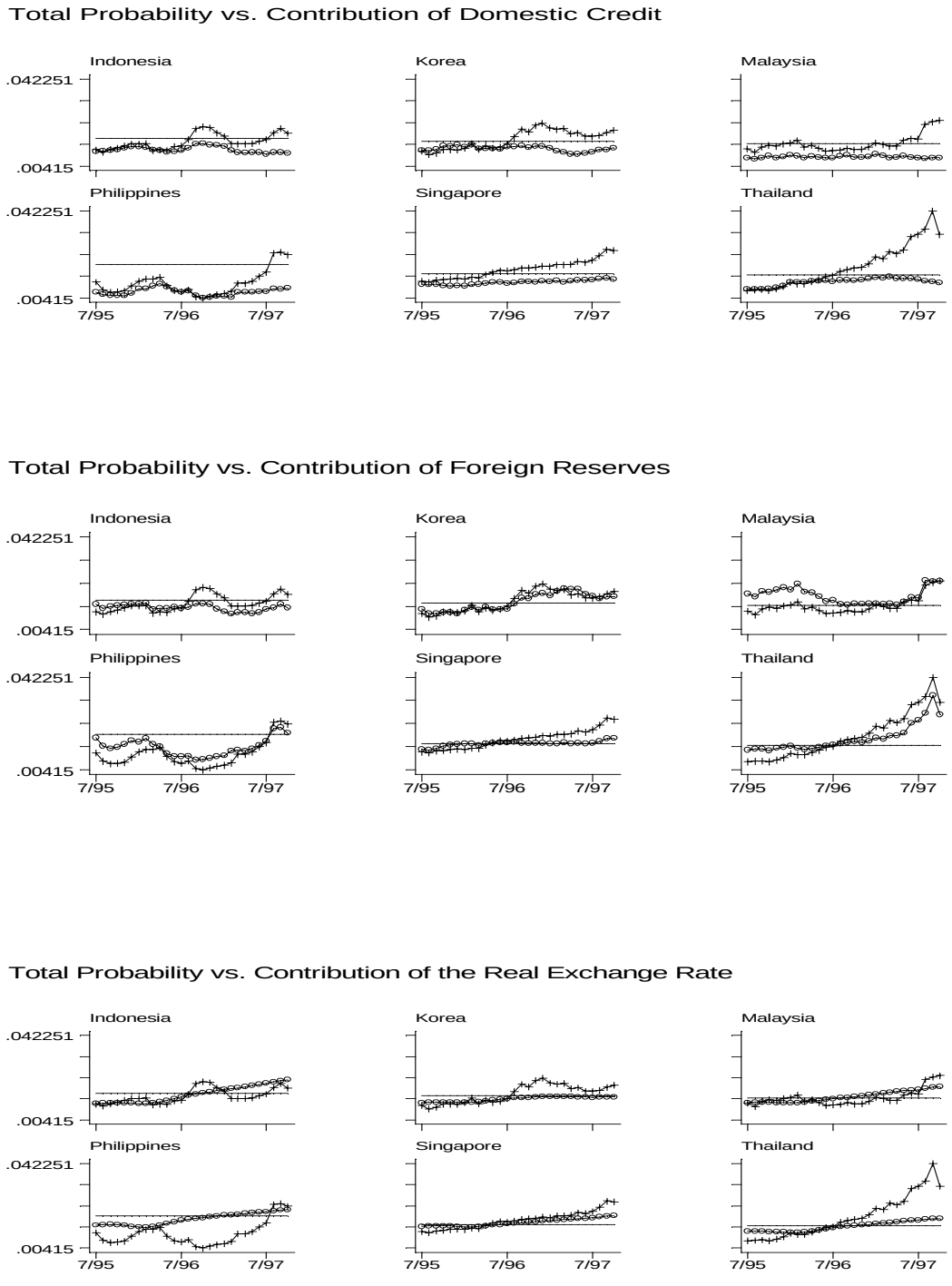
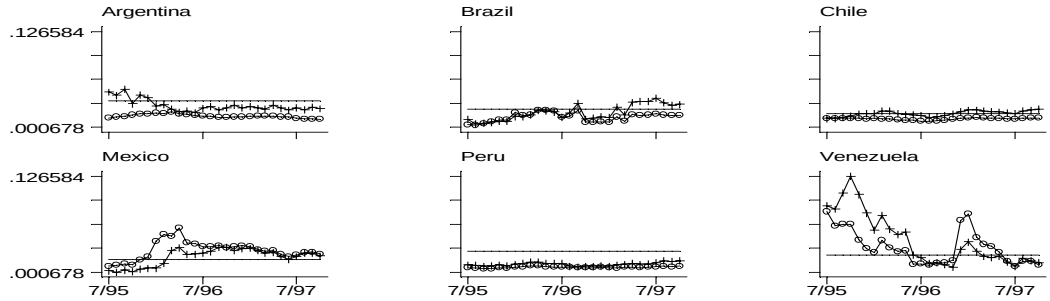


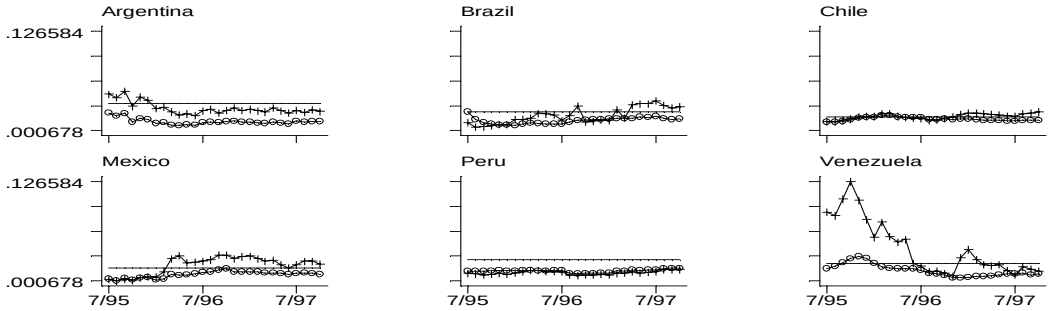
Figure 3. Predicted crisis probabilities



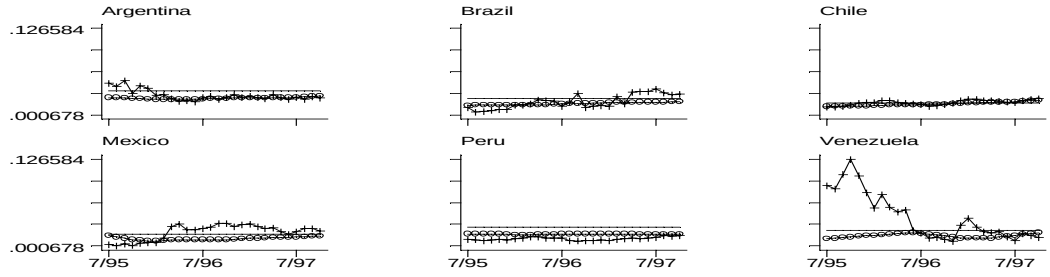
Total Probability vs. Contribution of Domestic Credit



Total Probability vs. Contribution of Foreign Reserves



Total Probability vs. Contribution of the Real Exchange Rate



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