Currency and Banking Crises: The Early Warnings of Distress

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Abstract

The abruptness and virulence of the 1997 Asian crises have led many to claim that these crises are of a new breed and thus they were unforecastable. This paper examines 102 financial crises in 20 countries and concludes that the Asian crises are not of a new variety. Overall, the 1997 Asian crises, as well as previous crises in other regions, occur when the economies are in distress, making the degree of fragility of the economy a useful indicator of future crises. Based on this idea, the paper proposes different composite leading indicators of crises, which are evaluated in terms of accuracy both in-sample and out-of-sample.

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I. Introduction

The spectacular collapse of some of the currencies in the crises of the 1990s pales in comparison to the dramatic swings in the public opinion about the affected countries. Overall, the assessment of the financial press and even the economics profession on the affected countries has been on a roller coaster ride, from hailing the status quo in the months preceding the crises to despair about the economic prospects for the countries after the speculative attacks. For example, in January 1992, after five years without realignments, politicians and the financial press were still hailing the monetary and fiscal convergence across countries in the Exchange Rate Mechanism (ERM). According to this view, the ten ERM countries were marching happily toward "El Dorado"—the European Monetary Union.[1] Eight months later, the ten little indians were down to six, with the Italian lira and the British pound floating freely against the other currencies and the Spanish peseta and the Portuguese escudo with a new central parity. By early 1993, there were only five.[2] In fact, in 1993, the peg was de facto abandoned with the enlargement of the bands to 15 percent. Economic analysts, who had been surprised by the force of the attack, were quickly abandoning the prospects of fixed exchange rates for Europe. And history repeated itself. In 1993, after years of struggling against inflation, government deficits, and a regulated economy, Mexico was finally advertised as being in the footsteps of a new era. Indeed, the "new" Mexico was even enshrined by joining the OECD. All those dreams evaporated in 1994 when Mexico faced default, systemic banking failure, and was treated as an outcast in international capital markets. In the late 1990s, it was Asia's turn. According to the financial press, in 1996, Indonesia, Korea, Malaysia, and Thailand were still the "tigers." In 1997, they were at the brink of bankruptcy, with public opinion, once again, surprised at the degree of distress in these economies.

This "sudden" (at least in the opinion of the financial press and economic analysts) change in the state of affairs has led many to argue in favor of irrational behavior of investors and self-fulfilling crises in which even sustainable pegs are attacked and frequently broken. Evidently, these hypotheses leave no role for policy makers to prevent a crash but to "throw sand in the wheels" of international capital markets. In contrast, this paper shows that currency crises mostly erupt in fragile economies, with signs of distress emanating from various sectors of the economy. Naturally, this makes the degree of vulnerability of the economy a useful leading indicator of currency crises.

Since the mid-1980s, banking crises have come to the forefront of international economics. Situations of banking distress have quickly multiplied, becoming one of the main obstacles to exchange rate stability and magnifying the severity of currency crashes (see, Kaminsky and Reinhart (1996)). While financial frailty has been more common and severe in emerging markets (Mexico,1992-96, Thailand, 1996-, Indonesia 1997-), industrialized economies have not been spared, with Japan being the most recent example. Moreover, banking and currency crises have tended to cluster and have come to be known as the "twin crises." The temporal connections between currency and banking

[1] In this counting, Belgium and Luxembourg are included together since the Luxembourg franc was set at par to Belgium's franc.

[2] The Irish punt joined the list in January 1993.

crises as well as their similar roots indicate that it is important to gauge banking sector vulnerability to assess the dangers of a currency crash. Thus, this paper also deals with banking crises. Again, the paper examines the degree of vulnerability of the economy at the onset of banking crises and uses that information to forecast crises.

While forecasting the exact timing of crises is likely to continue to remain an elusive goal, this paper argues that we can construct a warning system that helps to monitor whether a country may be slipping into a situation that is bound to end up in a crisis. The construction of the system of early warnings is based on the empirical regularities observed in a sample of 20 countries from 1970 to 1995. The countries studied are: Argentina, Bolivia, Brazil, Colombia, Chile, Denmark, Finland, Indonesia, Israel, Malaysia, Mexico, Philippines, Norway, Peru, Spain, Sweden, Thailand, Turkey, Uruguay, and Venezuela. This sample allows us to study the onset of 76 currency crises and 26 banking crises.[3] This paper proposes four different composite leading indicators and evaluates them in terms of forecasting accuracy and calibration. The core of the different early-warning indicators is the degree of distress of the economy, which is captured by examining what sectors of the economy and how many have been affected by "anomalous" bad shocks and also by examining the severity of the bad shocks. The main results can be summarized as follows:

First, with regard to the distress of the economies at the onset of crises, the analysis shows that overall, crises have developed in the midst of multiple economic problems, with basically no crisis occurring following a unique bad shock.

Second, the best composite leading indicator is the one that accounts for the forecasting track record of the individual leading indicators.

Third, the ability of the distress warning system is tested out-of-sample for the Asian crisis. In contrast to the view that the Asian crisis could not have been anticipated, the results show that, overall, these economies were far from healthy, with clear signs of distress surfacing as early as eighteen months before the currency collapse.

The rest of the paper is organized as follows. Section II reviews in some detail the theoretical literature on banking and currency crises to motivate the selection of the individual leading indicators. Section III examines briefly the events preceding some of the most well known financial crises and points to the many sources of fragilities on the eve of both speculative attacks against the domestic currency and on the midst of banking problems. Section IV starts to describe the technique to capture the degree of distress of the economy by using the methodology of leading indicators. This section only examines the signals of crises issued by individual indicators. Section V provides evidence that economies during "crisis times" are more fragile than in "tranquil times," with signs of distress widespread over the external, financial, and domestic sectors of the economy. Section VI uses the information on the degree of vulnerability of the economy to construct different composite indicators of crises. The forecasts of the different composite indicators are then evaluated in-sample in terms of forecasting accuracy and calibration. This section also reports out-of-sample forecasts of crises for Indonesia, Malaysia, Philippines, and Thailand. Section VII concludes.

II. On the Symptoms of Crisis: Literature Review

The currency crises of the 1970s, 1980s, and the 1990s and the banking crises of the pre-WWI period as well as the banking crises of late in Latin America, Europe, and Asia have generated a prolific and still-growing literature on crises. This section briefly reviews this literature to pinpoint the different possible sources of economic distress at the onset of crises.

The earlier models of balance of payments problems were inspired by the Latin American style of currency crises of the late 1970s. In these models unsustainable money-financed fiscal deficits lead to a persistent loss of international reserves and ultimately ignite a currency crash (See, for example, Krugman (1979)). Stimulated by the EMS collapses in 1992 and 1993, more recent models of currency crises have stressed that the depletion of international reserves might not be at the root of currency crises.[4] Instead, these models focus on government officials' concern on, for example, unemployment. Governments are modeled facing two, often conflicting, targets: reducing inflation and keeping economic activity close to a given target. Fixed exchange rates may help in achieving the first goal but at the cost of a loss of competitiveness and a recession. With sticky prices, a devaluation may restore competitiveness and help in the elimination of unemployment, thus prompting the authorities to abandon the peg during recessions.[5] The crises in Latin America in the 1980s, the Nordic countries in 1992, and in Mexico in 1994 have prompted the economics profession to model the effects of banking problems on balance-of-payments difficulties. For example, Diaz Alejandro (1985) and Velasco (1987) model difficulties in the banking sector as giving rise to a balance-of-payments crisis arguing that if central banks finance the bail-out of troubled financial institutions by printing money we have the classical story of a currency crash prompted by excessive money creation.

More recently, the literature on capital inflows and capital inflow problems has suggested another potential source of instability (see, for example, Montiel and Reinhart (1997) for a comprehensive review of the literature), that of liquidity crises due to sudden reversals in capital flows. For example, the debt crisis in 1982, the Mexican crisis in 1994 and the so-called Tequila effect, and the Asian crises in 1997-1998 show that capital inflows can come to a sudden stop and even can sharply reverse their course and become capital outflows. The sudden reversal, prompted, in large part, by fluctuations in interest rates in industrialized countries, is more abrupt when capital inflows are in the form of portfolio flows or short-term capital movements rather than direct foreign investment. The liberalization of capital account transactions, by allowing this type of short-term capital flows, may contribute to the instability of the flow of reserves and the ability of the country to peg the domestic currency.

While the literature on capital flow problems focuses on the sudden reversal of net capital inflows on the eve of financial crises, some authors have emphasized the need to examine the evolution of gross capital flows, citing that a salient feature at the onset of many financial crises in several Latin American countries has been of coexistence of

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[3] The dates of those crises are reported in Table 1. The 102 financial crises were originally identified in Kaminsky and Reinhart (1996). See that paper for a detailed discussion on the identification of the dates of the crises.

[4] See, for example, Obstfeld (1996).

[5] Other factors may also affect the government decision to keep or abandon the peg. To the extent that the authorities are concerned about the fiscal accounts, the decision to defend the peg with high interest rates may worsen the fiscal sector, prompting the government to abandon the peg.

inverse and offsetting capital flows, with domestic residents often choosing to invest their savings in international capital markets at the same time that they are seeking external finance. This gross capital outflow, which is often measured by variations in assets held abroad by domestic residents and has been dubbed "capital flight," was, for example, at the center of the Mexican crisis of 1982.[6] In the eve of that crisis, the exploding government deficit was being financed by foreign borrowing at the same time that Mexican residents, doubtful about the public sector's ability to honor its debt, were sharply increasing their investments overseas.[7]

The literature on banking crises and panics is also quite abundant. Most of the work (see, for example, Calomiris and Gorton (1991)) has pointed that crises and panics are preceded by recessions and are most likely to occur when the recessions follow a period of substantial increase in credit, which fuels a prolonged expansion in economic activity. As the recession unfolds, depositors try to re-assess the risk of the bank debt. Since they are uninformed about the quality and value of the assets of each individual bank, the bad shock may result in depositors withdrawing large amounts from all banks. Another line of inquiry has also suggested that large unexpected liquidity shocks, such as a large withdrawal of deposits, may lead to a bank panic with depositors withdrawing from all banks. More recently, the literature has focused on the effects of currency crises on the vulnerability of the banking sector. For example, in Stocker (1995), an initial external shock, such as an increase in foreign interest rates, coupled with a commitment to a fixed parity results in the loss of reserves. If not sterilized, this may lead to a credit crunch, increased bankruptcies, and a financial crisis. Moreover, if a devaluation occurs, the position of banks could be weakened further if many of their liabilities are denominated in foreign currency. Also, if central banks fight the speculative attacks with steep increases in interest rates, the fragility of the banking sector will deepen further (see also Mishkin (1996)).

Another possibility is that currency and banking crises are caused by common factors or events. For example, McKinnon and Pill (1994) examine the role of capital flows in an economy with an unregulated banking sector with deposit insurance and moral hazard problems of the banks. Capital inflows in such an environment can lead to overlending cycles with consumption booms and exaggerated current account deficits. Most of the times these overlending cycles are also accompanied by booms in the stock and real estate markets. In turn, this overborrowing cycle leads to a real exchange rate appreciation, a loss of competitiveness, and a slowdown in growth. As the economy enters a recession, the excess lending during the boom makes banks more prone to a crisis when a recession unfolds. This state of business becomes even more complicated by the pervasive over-exposure of financial institutions to the stock and real estate markets, which makes banks even more vulnerable when asset bubbles burst as the recession

[6] Capital flight can cause serious economic difficulties for developing countries. For example, capital flight has been shown to have caused an erosion of the tax base and a reduction in domestic investment. Also, as it leads to a buildup of gross foreign debt, it can fueled a currency crisis as foreign investors become doubtful about the ability and the will of the emerging economy to pay back. See, for example, Khan and Haque (1985).

[7] The phenomenon of simultaneous foreign borrowing and investing at home and abroad is not easy to rationalize within traditional debt models. Models with asymmetric information can rationalize the simultaneous borrowing and lending. Evidence of asymmetric information is reported in Frankel and Schmukler (1996). These authors show that domestic creditors predicted the 1994 Mexican crisis well before foreign bankers. In another line of inquiry, Ize and Ortiz (1987) associate exchange rate crises and capital flight with the possibility of default on public debt resulting from fiscal rigidities. For Mexico, these authors report that the capital flight-to-government external borrowing ratio oscillated about 0.70 in 1981 and increased to 1.4 in 1982, the year of the debt crisis.

approaches. The deterioration of the current account, in turn, makes investors worried about the possibility of default on foreign loans. With the banking sector in a fragile situation, the task of defending the domestic currency becomes more difficult and may lead to the eventual collapse of the domestic currency. In a similar vein, Goldfajn and Valdes (1995) show how changes in international interest rates and capital inflows are amplified by the intermediation role of banks and how such swings may also produce an exaggerated business cycle that ends in bank runs and financial and currency crashes.

Although theory does not provide an unambiguous answer as to the proximate causes of banking and currency crises, the literature does clarify what are the possible symptoms of an upcoming crisis. These symptoms, which range from recessions to exaggerated cycles in credit markets, are going to be the building blocks in the construction of the indicators of economic distress. Table 2 summarizes these symptoms and the indicators on which this paper will focus to assess the dangers of financial crises.[8] Column 1 describes the possible symptoms of crises and column 2 reports the individual possible leading indicators. Column 3 indicates whether it is a positive or a negative shock to that particular indicator the one that indicates that the economy might be prone to bank runs and speculative attacks and column 4 provides the theoretical justification.

III. Economic Distress at the Onset of Crises: Stylized Facts

Financial crises can arise just as a result of an isolated shock. For example, a runaway monetary expansion will, at some point, clash with the commitment of the monetary authority to maintain the peg. Investors trying to anticipate the inevitable collapse will generate a speculative attack that will deplete reserves and ultimately will lead to the devaluation of the domestic currency. Similarly, banking panics may be just the result of illiquidity in the banking industry due to an unexpected large increase in demand for currency. For example, Kemmerer (1910), for the United States, identifies the seasons when the money market was most "strained" as the periods of the "spring revival" and the crop-moving period of the fall. He points out that, of the six U.S. banking panics prior to 1910, four occurred in the spring.

However, financial crises can erupt as economies crumple. For example, it is true that at the time of the Latin American currency crises in the early 1980s, which became to be known as the "Debt Crisis," basically none of the Latin American countries were in fiscal balance, in fact, most of them were engaged in overly expansionary monetary policy to finance the fiscal deficits. But this was not the only distinguishing feature of these crises. External shocks were also at the core of these crises. These crises, which were preceded by an explosion of international lending to emerging markets at very low real interest rates, erupted as the industrialized economies engaged in extremely tight monetary policies in the early 1980s to fight the escalating inflation. This switch to contractionary monetary policy

[8] Detailed definitions of all the variables and their sources are provided in the Data Appendix.

provoked a sharp rise in real interest rates,[9] profound recessions in industrial countries, and plummeting commodity prices. Suddenly, the era of easy international international lending to developing countries came to an end, further complicating the economic scene of deteriorating terms-of-trade and export earnings of developing countries. The vulnerability of the Latin American countries to the withdrawal of international capital was further aggravated by the combination of financial liberalization, lack of banking supervision, and official deposit guarantees. In the phase of capital inflows in the late 1970s and early 1980s, this explosive mix led to excessive commercial bank lending, stock and real estate market booms as well as a surge in consumption. When world interest rate increased and inflows suddenly reverted to outflows, this explosive mix carried also the seeds for the dramatic surge in non-performing loans, the plunge of stocks and real estate prices, and the collapse of the banking industry. The crisis scenario was further aggravated by the real appreciation of the domestic currency and the current account deterioration brought about by the surge in consumption. The state of dollarization of these high-inflation economies also contributed to the severity of the collapse. In many countries, banks were holding a large proportion of the deposits in dollar-denominated accounts. Naturally, this added to the foreign exchange exposure of banks due to cross border lending, also denominated in dollars. As currencies collapsed, the foreign exchange exposure magnified the deterioration of the balance sheet of banks turning the virtuous circle of low interest rates in dollar-denominated debt to finance profitable peso-denominated credit to real estate ventures and to more capital inflows into a vicious-circle of bank insolvencies leading to a credit crunch, to further collapses in stock and real estate prices, to larger devaluations, and to more bank insolvencies.

The distress of the economies on the eve of financial crises was not a unique feature of the Latin American countries in the early 1980s. The vulnerability of the Asian economies at the onset of the 1997 crises re-enacted the debt crisis scenario all over again, contradicting those that claim that the virulent Asian style crises were of a new breed never seen before. Of course, fiscal deficits were not present in Asia, and interest rates in the United States were not as high as they were in 1981. But movements in exchange rates among the major currencies in the years leading to the crisis did become an important external shock to Indonesia, Malaysia, the Philippines, and Thailand. In particular, the sharp appreciation of the dollar with respect to the yen since mid-1995 was particularly damaging to these countries competitiveness because Japan was their most important trading partner and these countries were basically pegging the exchange rate to the dollar. Also, in 1997 the tight monetary conditions in Japan, a major creditor to the region,[10] which added to the vulnerability of the Japanese banking sector, anticipated possible withdrawals of Japanese funds from these countries. Moreover, towards the beginning of 1997 there were clear indications that some of the industrialized countries were at a point of switching to a more contractionary monetary stance—in fact, the Federal Reserve raised the federal funds rate in March—suggesting a future reversal of capital flows. But the most clear parallel between the debt crisis and the Asian crisis is the vulnerability of the financial sector. As in Latin American in the early 1980s, the pouring of international lending in the 1990s led to a surge in domestic credit and to skyrocketing

[9] The dramatic increase in interest rates was particularly damaging to Latin American countries because international loans to these countries had been contracted at floating rates.

[10] Total Japanese bank lending to Indonesia, Korea, Malaysia, the Philippines, and Thailand amounted to almost $100 billion by the end of 1996 about 40 percent of total international bank lending to these countries. See, *World Economic Outlook*, International Monetary Fund, 1997.

stock and real estate prices in basically all countries in East Asia.[11] This time, the boom in credit did not result in a consumption boom but in what is now widely viewed as "excessive" investment and a deteriorating current account. This time around, however, the deterioration of the financial sector was far more reaching because the deepness of financial markets in Asia. Latin American economies did not have very well developed financial markets, with most of the firms financing their expenses out of retained earnings. The economies were much less monetized (partly because of their histories of chronic inflation and even hyperinflation), with domestic credit/GDP ratios of about 20 percent. In contrast, Asian countries had more developed capital markets, their degree of monetization was far larger (domestic credit/GDP ratio oscillated about 100 percent) and firms held much larger debt-equity ratios. In fact, they skyrocketed in the mid-1990s. With the economies so debt-ridden, mostly at very short maturities and in foreign currency, it is no wonder how seemingly mild adverse external shocks[12] could have crystallized into a worst case scenario of a brutal currency crisis. While these crises are the ones that have received the most attention, our list of countries in distress in the period leading to a crisis does not end here. May be, some of the most "famous" ones are the Mexican crisis in 1994 and the so-called Tequila effect and the Scandinavian countries crises in 1992-1993.

Naturally, if the distress of the economies in the eve of crises is as widespread as these crises indicate, an early warning system of financial crises cannot limit itself to point to a problem here and a problem there, but has to incorporate the state of distress of the economy as the leading indicator of crises. The next section discusses the methodology to identify the individual leading indicators. Section V combines these indicators to capture the state of distress of the economy both in tranquil and in crisis times.

IV. Univariate Indicators

In the previous sections we noted that in many instances crises erupt as the economy collapses under the strain of losses in competitiveness, a deterioration of the current account, a profound slowdown in growth, burst of stock bubbles, and overlending cycles. One approach to quantify the state of vulnerability of the economy is to simply compute the number of those signs of frailty. However, not necessarily one or all of these problems will stir the economy into a crisis. Presumably only those sufficiently severe will make it very unlikely for the country to avoid a crisis. The question is how to define this critical cutoff, that is, decide when a current account becomes "unsustainable," or when monetary policy is "too loose," or when the real exchange rate appreciation is unlikely to be undone by deflation in the domestic economy. Knowing the distribution of the particular indicator, we can search for the critical level at which a fluctuation in an indicator makes a crisis almost unavoidable. Once this critical cutoff for each indicator is obtained, we can construct the indices of fragility of the economy. Before going into details, I provide some notation. Suppose

[11] Again, as in Latin America, the Asian economies in the early 1990s, implemented financial reforms, deregulated the domestic banking sector, and eliminated restrictions to international capital movements. Also, as in Latin America, lack of good banking regulation and supervision was pervasive in the Asian economies. Certainly, these factors magnified the harmful effects of volatile short-term international capital movements.

there are *n* possible indicators of financial crises. An indicator, X^j , is said to "signal" a crisis in period *t* if in that period the indicator crosses the critical cutoff, $\overline{X}_t^j$, that is the signaling state can be characterized as follows:

$$\{S_t^j = 1\} = \{S_t^j, | X_t^j | > | \overline{X}_t^j |\} \tag{1}$$

Equation (1) is written in absolute values because some of the variables will signal an upcoming crisis by a large decline while others may be growing excessively in the eve of a crisis. The absolute value allows to handle both critical fluctuations in the variable.

If no signal $\{S_t = 0\}$ of an impending crisis is given,

$$\{S_t^j = 0\} = \{S_t^j, | X_t^j | < | \overline{X}_t^j |\} \tag{2}$$

1. Finding "the Straw that Broke the Camel's Back"

The selection of the critical cutoff that turns the fluctuation in an economic time series into a signal tries to fulfill often conflicting criteria. If the cutoff is chosen too "tight" to reduce the number of false signals, it is likely to miss all but the most severe crises, that is the type I error (rejecting the null hypothesis of crisis when in fact there is a crisis) will be large. In contrast, if the threshold is too "lax," that is, "too close" to normal behavior, it is likely to catch all the crises but it is also likely to announce many crises that never happened, that is, send many false signals, the type II error (accepting the null hypothesis of crisis when in fact there is none) will be large. There is no general approach to choosing the size of the critical region. Following Kaminsky and Reinhart (1996), the size of the "optimal" critical region for each indicator, that is the percentage of observations of that indicator that will be considered as showing an "anomalous" behavior, is selected by performing a search over a broad range of sizes of the critical region and selecting the value that minimizes the in-sample noise-to-signal ratio, , that is computed as follows,[13]

$$w = \frac{b}{(1-a)} \tag{3}$$

[12] A caveat is in order. While the real appreciation of the Asian currencies in 1996-1997 was not as large as the real appreciation of the Latin American currencies in the early 1980s, it was far more damaging in view of the openness of the Asian economies.

[13] The size of critical region for each indicator is common across countries while the numerical value of the threshold is country specific to allow for the idiosyncratic behavior of the indicators in each country. For example, a 30-percent annual decline in stock prices may be business as usual in an emerging economy with a shallow stock market, but it may signal a burst of a bubble and a serious recession as well as a possible financial crisis in an industrial country.

where α is the size of the type I error and $ is the size of the type II error, and where both α and $ are functions of the threshold, $\overline{X}_t^j$, with " '(| $\overline{X}_t^j$ |)> 0 and $'(| $\overline{X}_t^j$ |)<0.[14]

To estimate the noise-to-signal ratio for each indicator, it is necessary to define "good" and "bad" signals. Every time that an indicator crosses the critical cutoff, sending a signal of a future crisis, there are two possible scenarios: the first, is that the crisis happens within a reasonable period of time after the signal was given—the signal was accurate—alternatively, the crisis never occurs within that time frame and the signal is labeled a false alarm. Again, there is no general accepted criterion of selection of a "reasonable period of time." In what follows, the allowed interval of time between the signal and the crisis, *h,* is defined as 24 months, thus, any signal given within the 24-month period before the beginning of the crisis is labeled a "good" signal.[15] Consistent with this selection, the onset of crises or "crisis times" is also defined as the 24-month window before the actual speculative attack against the domestic currency occurs (in the case of currency crises) and the 24-month window before the deepening of the difficulties in the banking industry (in the case of banking crises).[16] All other times will be classified as "tranquil times."[17]

2. Assessing the Performance of the Individual Indicators

Table 3 shows information on the performance of individual indicators in forecasting currency and banking crises. This table reproduces some of the results in Kaminsky, Lizondo, and Reinhart (1998) for currency crisis but provides new results on the forecasting performance of the indicators when predicting banking crises. It also examines the performance of five other widely watched indicators not examined in that paper: (1) domestic and external financial liberalization, (2) world real interest rate, (3) foreign debt, (4) capital flight, and (5) Short-term foreign debt. For each indicator and type of crisis, the first column shows the critical region, that is the percentage of observations that are identified as signaling crises, the next two columns report the size of the type I and type II error, respectively, and the last column shows the noise-to-signal ratio. Note that the forecasting ability of the different indicators varies widely. One of the best indicators is the real exchange rate, with a noise-to-signal ratio equal to 0.2 for currency crises and equal to 0.3 for banking crises. In contrast, imports do not have such a good track record. In fact, more than half of the

[14] The conventional approach in defining the null hypothesis has been of defining normal times as the null hypothesis. In this section, I define the null hypothesis as crisis times so as to make compatible my definition of bad signals with the concept of noise.

[15] Obviously, signals issued outside this 24-month window are classified as "bad" signals.

[16] The beginning of a banking crisis was identified by two types of events: (1) bank runs that lead to the closure, merging, or takeover by the public sector of one or more financial institutions and (2) if there are no runs, the closure, merging, takeover, or large-scale government assistance program of an important financial institutions. These events are often not seen as systemic at the time and thus are not seen as heralding a crisis. The deepening of the difficulties in the banking industry—the equivalent of the speculative attack—occurs sometime after the events that mark the beginning of a crisis. To make the identification of crisis times for banking problems consistent with the identification of crisis times for currency problems, the 24-month window for banking crisis is centered around the date of the beginning of the banking crisis.

[17] Sensitivity analysis were performed with 12- and 18-month windows. The results are available upon request.

signals that this indicator issues are false alarms (the noise-to-signal ratio is 1.1 for currency crises and 1.6 for banking crises).

As shown in Table 3, the new indicators of currency crises (with the exception of the dummy variable that captures deregulation in the domestic and external sector) are good predictors of crises. In particular, hikes in world interest rates seem to accentuate the vulnerability of the economy, triggering speculative attacks against the domestic currency. The noise-to-signal ratio of this variable is 0.4. As discussed in Section II, the onset of currency crises is also characterized by the coexistence of inverse capital flows, that is domestic residents simultaneously borrowing and investing in international capital markets. This phenomenon is captured by an increasing gross foreign debt and positive capital flight, that are computed respectively, using domestic residents' liabilities and assets in banks overseas (both as a proportion of foreign exchange reserves held by the central bank). In both cases, the noise-to-signal ratio is below 1. Finally, as it became clear in the Asian crisis, liquidity problems can become particularly important when in the midst of the speculative attacks external creditors may become unwilling to roll over existent short-term credits. Liquidity problems are captured using the ratio of foreign debt with one-year maturity or less to total foreign debt. Again, the noise-to-signal ratio of this variable is below 1.

As shown in this table, it is somewhat harder to anticipate banking crises than speculative attacks against the domestic currency. The average noise-to-signal ratio for all the indicators is 0.7 for currency crises and increases to 0.8 for banking crises. Still, some indicators are significantly more accurate in predicting banking crises. Notably, those indicators usually related to the liberalization of the capital account and the domestic financial sector are better in anticipating banking problems. In particular, the three indicators that capture the boom-bust credit and stock market cycles (M2 multiplier, Domestic Credit/GDP, and stock prices), the dummy variable that captures Domestic and External Financial Liberalization, and domestic real interest rates, which become positive once nominal interest rates are freed, have, on average, a noise-to-signal ratio 25 percent lower when predicting banking crises than when anticipating speculative attacks against the domestic currency. Since most of the banking crises in our sample have fueled speculative attacks against the domestic currency (the noise-to-signal ratio of banking crises when predicting currency crises is 0.3), these indicators are also better predictors of twin crises episodes than of the single episodes of currency attacks, which were the norm in the earlier part of the sample before both emerging and industrial economies implemented a wide range of financial reforms in the 1980s. Interestingly, although not unexpected on account of the pervasive presence of implicit or explicit deposit insurance in the countries examined, bank runs are not good predictors of banking crises. The noise-to-signal ratio of this indicator is above 1. Note, however, that domestic residents' assets overseas—in BIS banks—increase substantially at the onset of banking crises (a noise-to-signal ratio of 0.6) suggesting that our measure of deposits in domestic banks may not provide a comprehensive measure of bank runs and switches in domestic residents' portfolio composition at the onset of banking fragilities.

Obviously, those indicators, such as imports, with a noise-to-signal ratio equal or higher that unity introduce excessive noise, and thus are not helpful in characterizing crisis times. This statistic can thus be used for deciding which indicators to drop from the list of possible indicators. Based on the results in Table 3, when examining currency crises, the following indicators should be dropped: lending/deposit rate ratio, imports, domestic and external financial

liberalization, Similarly, the lending/deposit rate ratio, bank deposits, imports, and currency crises are not particularly useful for signaling correctly the onset of banking crises and will not be used in the construction of the composite leading indicators for financial crises.

V. Characterizing Crisis and Tranquil Times

As described above, I have divided the sample in periods leading to a crisis, crisis times, and periods with financial stability, tranquil times. Our ability to predict crises depends on whether the distress of the economy changes as the onset of the crisis approaches. Thus, this section will be devoted to characterizing crisis and tranquil times in terms of the degree of fragility of the economy.

Three possible aspects of the fragility of the economy will be examined in this section. First, I examine whether the fragility of the economy, i.e., the number of signals, in crisis times is higher than in tranquil times. Second, I study the unfolding of the distress in the economy at the onset of crises by examining the evolution of the number of signals in the economy as the country approaches a crisis (month by month over the 24-month crisis window). Third, I investigate whether the imbalances in the economy become more extreme at the onset of the crises relative to tranquil times by dividing the signals into extreme and mild signals and then comparing the average number of extreme signals (as a percentage of total signals) in crisis and tranquil times.

1. Counting the Signs of Distress

We can compute the number of signals given in a particular period by the individual indicators. Obviously, the economy may be very fragile and still many of the indicators may not signal jointly that something is wrong every single month. For example, foreign exchange reserves may drop dramatically in one month but the following month the reserve losses may not be substantial. Still, the level of foreign reserves may be critical. Similarly, the growth of domestic credit may not be larger than the threshold value every month to indicate that the domestic credit expansion has been excessive. To account for the on-going fragility across the different sectors of the economy, I estimate the index of fragility for each month by counting the number of individual indicators that have crossed the threshold in that particular month or in any of the eight preceding months.[18]

Figure 1 reports the frequency distribution of the index of fragility in crisis times (the black bars) and in tranquil times (the stripped bars) for both currency and banking crises. The results suggest that, in fact, fragility does increase at the onset of crises. For example, the mean number of signals during times of currency crises is 70 percent higher than the mean number of signals in tranquil times, with 30 percent of the currency-crisis months with more that

[18] I have also estimated the monthly index of fragility by counting the number of individual indicators that have crossed the threshold in that particular month. The results are quite similar and available upon request.

eight indicators flashing the unfolding of problems. In contrast, in at most 7 percent of the tranquil months, eight or more indicators were signaling possible fragilities. The evidence for banking crisis looks similar, with less than 1 percent of the months during crises, with no signs of distress.

2. Do Problems Mount as the Crisis Becomes Closer?

The evidence just presented may not reflect accurately the level of distress of the economy when the crisis erupts because it just provides the average index of fragility for the 24 months in the crisis window. But problems could mount as the time of the final collapse approaches. Obviously, if the number of signals only increases in the months close to the crisis, the index of fragility will not be a good leading indicator of crises, it will be at the most a coincident indicator. To measure the extent of the problems at different moments of time, Figure 2 reports the evolution of the index of fragility on average over the 76 currency crises, the top panel, and over the 26 banking crises, the bottom panel, for each of the 24 months in the crisis window. Again, as in Figure 1, the index of fragility for each month is computed by counting the number of individual indicators that have crossed the threshold in that particular month or in any of the eight preceding months.

Interestingly, the number of signals increases only slightly as the crisis approaches, with the average number of signals in the last six months of the crisis window being not very different from the average number of signals in the first six months of the crisis window.

3. Mild and Extreme Signals

The index of fragility discloses one possible measure of vulnerability of the economy, that of the number of indicators behaving in an anomalous way. It does not pay attention to the severity of the "anomalous" behavior. For example, a real appreciation of the domestic currency of about 15 percent may have been classified as indicating a critical deterioration of competitiveness for a particular country. In some cases, this real appreciation may not lead to a currency crisis, and in fact the real appreciation may be unwound by a decline in the rate of inflation of the country relative to world levels (see, for example Goldfajn and Valdes (1996)). However, if the appreciation reaches 30 percent, investors may view the deterioration of the competitiveness of the economy as unsustainable and impossible to be undone just by deflation in the domestic economic, and thus they will assign a little chance to the survival of the peg. The odds of a speculative attack will be larger in this event. In this case, the real appreciation will only be undone through a nominal devaluation. For this other measure of the distress in the economy, that of the intensity of the imbalances, to become a reliable indicator of crises, the severity of the problems should become more acute in the months preceding the crises.

The degree of severity of the signal is captured by classifying the signals into mild and extreme. For example, if the size of the critical region is 10 percent and the indicator signals an upcoming crisis when it is falling too much, the indicator will be considered as issuing a mild signal when the growth rate of this indicator falls between the 5th and the 10th percentile of the distribution. The indicator will be considered as issuing an extreme signal, when the growth rate of this indicator is in the 5th percentile of the distribution. Figure 3 reports the frequency distribution of extreme signals in tranquil and crisis times.[19] This figure together with Figure 1 suggest that, in fact, the severity of the imbalances does increase at the onset of crises. While, as shown in Figure 1, the mean number of **total** signals in crisis times is about 70 percent higher than in tranquil times, the mean number of **extreme** signals in crisis times is almost 90 percent higher than in tranquil times. On average, as expected, the economy deteriorates in crisis times on two accounts: the number of problems and the severity of the imbalances.

VI. The Early Warnings of Distress

We can combine the information provided by all the indicators to assess the likelihood of an upcoming crisis. In what follows, I discuss four possible ways of combining them to produce useful and reliable indices of vulnerabilities in the balance-of-payments and the banking sector.

1. The Composite Indicators

As described in the previous section, one straightforward way of capturing the fragility of the economy at the onset of crisis is to keep track of the number of signals being issued in the different sectors of the economy. Presumably, the larger the number of red flags coming from different sectors of the economy, the highest the odds of a financial collapse. As before, let us denote by X the vector of n indicators. In any period, there may anywhere between zero and n signals. Thus, the first composite indicator is I_t^1 and is defined as follows,

$$I_t^1 = \sum_{j=1}^{n} S_t^j \tag{4}$$

where S_t^j is equal to one if variable j (X_t^j) crosses the threshold in period t and zero otherwise.

The number of signals, however, may not be the best composite leading indicator of crises. This statistic does not discriminate between the signal provided by a mild anomalous behavior of a variable and the signal provided by an extreme aberrant behavior of that variable. As discussed in the previous section, an extreme real appreciation of the domestic currency may signal a future crisis with more accuracy than just a mild appreciation. To account for this

[19] Again, as in Figures 1 and 2, the index of fragility for each month is computed by counting the number of individual

information, let's define for each variable two different thresholds, $\overline{X}_m^j$ the mild threshold and $\overline{X}_e^j$, the extreme threshold. X_t^j will issue a mild signal in period t, $\mathrm{SM}_t^j = 1$, when $|\overline{X}_m^j| \lhd X_t^j \lhd |\overline{X}_e^j|$ and it will issue an extreme signal, $\mathrm{SE}_t^j = 1$ when $|\overline{X}_e^j| \lhd X_t^j$. Thus, the second composite indicator, I_t^2, accounts for the intensity of the signal of each univariate indicator. This indicator is defined as,

$$I_t^2 = \sum_{j=1}^{n} (\mathrm{SM}_t^j + 2\,\mathrm{SE}_t^j) \tag{5}$$

According to (5), extreme signals will have twice the weight of a mild signal. In this case the index of fragility can take values between 0 and $2n$.

As discussed before, the economy may be vulnerable and still many of the indicators may not signal jointly that something is wrong every single month. If output collapses one month, the stock market sharply declines the following month, foreign exchange reserves are depleted within two months, and exports decline substantially within three months, we cannot assert at the end of the last month that the only sign of distress in the economy is the loss of export markets. Overall, the problems are multiple. To capture the on-going deterioration in fundamentals, we can estimate the following composite indicator.

$$I_t^3 = \sum_{j=1}^{n} S_{t-s,t}^j \tag{6}$$

where $S_{t-s,t}^j$ is equal to one if the variable j signals at least once in period t or in the previous s periods and zero, otherwise. As in Section V, s is set equal to eight.

The three composite indicators just described, however, do not fully use the information provided by the univariate indicators because they do not account for the different forecasting accuracy of each variable. One possible way of combining this information is to weight the signals of different variables by the inverse of their noise-to-signal ratio. Thus, the fourth composite indicator is I_t^4 and it is defined as follows,

$$I_t^4 = \sum_{t=1}^{m} \frac{S_t^j}{w^j} \tag{7}$$

where ω^j is the noise-to-signal ratio of variable j.

As we did with each single indicator, we could choose a critical value for each composite indicator so that when the composite indicator crosses the threshold, a crisis is deemed to be "imminent." This methodology is

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indicators that have crossed the threshold in that particular month or in any of the eight preceding months.

equivalent to deciding the "optimal stopping-time," that is, at each point in time the decision maker faces the choice of whether to signal an upcoming crisis or not to signal one and wait for more observations. In what follows, I instead examine the probabilities of crises implicit in each composite indicator, treating these probabilities as forecasts of crises. When we do this, we can also statistically assess the informational content of such probability forecasts generated with the four composite leading indicators.

2. Probabilities of Crises: Estimation and Forecasting Ability

Using the empirical joint distribution of the indicators as well as the empirical distribution of crises, we can construct a sample-based vector of conditional probabilities (for both currency and banking crises) for each indicator of fragility and construct four sets of probability forecasts of banking and currency crises as follows:

$$\mathrm{P}(C_{t,t+h} \mid I_i^k < I_t^k < I_j^k) = \frac{\text{months with } I_i^k < I_t^k < I_j^k \text{ and a crisis within } h \text{ months}}{\text{Months with } I_i^k < I_t^k < I_j^k} \tag{8}$$

where P denotes probability, $C_{t,t+h}$ is the occurrence of a crisis in the interval $[t,t+h]$ and k = 1,2,3,4.

These four methods of constructing a composite leading indicator can also be evaluated. I follow Diebold and Rudebusch (1989) in evaluating the leading-indicator forecasts of crises in terms of accuracy and calibration.

Two tests are implemented to evaluate the composite indicators in terms of accuracy. They evaluate the average closeness of predicted probabilities and observed realizations, as measured by a zero-one dummy variable. Suppose we have T probability forecasts $\{\mathrm{P}_t^k\}_{t=1}^T$ where P_t^k is the probability of crisis in $[t,t+h]$ conditional on information provided by the composite indicator I^k in period t. Similarly, let $\{\mathrm{R}_t\}_{t=1}^T$ be the corresponding time series of realizations; R_t equals one if a crisis occurs between t and t+h and equals zero otherwise. The quadratic probability score for indicator k is:

$$\mathrm{QPS}^k = 1/T \sum_{t=1}^{T} 2(\mathrm{P}_t^k - \mathrm{R}_t)^2 \tag{9}$$

The QPS ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy.

The second scoring-rule is the log probability score (LPS), given by

$$\mathrm{LPS}^k = -1/T \sum_{t=1}^{T} [(1-R_t)\ln(1-\mathrm{P}_t^k) + \mathrm{R}_t \ln(\mathrm{P}_t^k)] \tag{10}$$

The LPS ranges from 0 to 4, with a score of 0 corresponding to perfect accuracy. The LPS depends exclusively on the probability forecast of the event that actually occurred, assigning as a score the log of the assessed probability. The loss function associated with LPS differs from that corresponding to QPS, as large mistakes are penalized more heavily under LPS.

The calibration of a probability forecast refers to closeness of forecast probabilities and observed relative frequencies. Overall forecast calibration is measured by the global squared bias:

$$GSB^k = 2(\overline{P}^k - \overline{R})^2 \tag{11}$$

where $\overline{P}^k = \sum_{t=1}^{T} P^k$ and $\overline{R} = \sum_{t=1}^{T} R$ Clearly, GSB ranges from 0 to 2, with GSB = 0 corresponding to perfect global calibration, which occurs when the average probability forecast equals the average realization.

3. The Results

The top two panels in Table 4 show the Quadratic Probability Score (QPS), the log Probability Score (LPS), and the Global Squared Bias (GSB) for the forecasting probabilities of the four composite indicators. The performance of these composite indicators is compared to the performance of the best univariate indicator, the real exchange rate. The table also reports the performance of these indicators against that of a naive forecast that is captured using the unconditional probability of crisis.[20] Each test is performed for both currency and banking crises using the data from January 1970 to June 1995. The score statistics are reported separately for "Crisis Times"[21] and for "Tranquil Times"[22] to examine whether the performance of the different leading indicators varies across regimes.

The top and middle panels evaluate the in-sample (January 1970-December 1995) forecasting performance of each indicator. As shown in the top panel, the real exchange makes a substantial improvement over the unconditional forecast of currency crises, with the forecasting accuracy in tranquil times increasing substantially more than in crisis times. This result is consistent with the results in Table 3, where it is shown that the real exchange rate is a very conservative indicator issuing a small number of distress signals both in tranquil times (small type II error) and also in crisis times (large type I error). Overall, the four composite indicators perform better—in terms of accuracy—than the

[20] The unconditional probability of crisis is estimated as the ratio of the number of months in the crisis window (24 months × number of crises) over the total number of months in the sample: January 1970-December 1995. The unconditional probabilities of currency and banking crises are 29 and 10 percent, respectively.

[21] "Crisis times" for currency crises refers to the 24 months before a crisis and for banking crises it refers to the 24 months around the beginning of a crisis.

[22] All the indicators forecast both currency and banking crises. Thus, an indicator may show that there is distress in the economy when a currency crisis is brewing or when banking problems are surfacing. To avoid penalizing the performance of the indicators in tranquil times, "Tranquil Times" in both panels exclude both the 24 months before currency crises and the 24 months around the beginning of banking crises.

real exchange rate, but the larger improvements this time are obtained when forecasting in crisis times, suggesting that in fact, crises erupt when economies are in distress.

As shown in the middle panel, all indicators score worse when predicting the onset of the banking crises, --i.e., the 24 months around the beginning of the banking crises. This holds regardless of the loss function used. As it was examined before, the real exchange rate makes some improvement over the unconditional forecast of financial crises in general. For example, the quadratic probability score declines from 0.024 and 1.620 for the naive forecast of currency crises to 0.018 and 1.589 for the real exchange rate forecast during tranquil and crisis times, respectively. The composite indicators outperformed in general the real exchange rate when forecasting the onset of crisis, but were in general outperformed by the real exchange rate during tranquil times.

Overall, the composite leading indicator that accounts for forecasting accuracy of the univariate indicators, I^4, performs the best when predicting both currency and banking crises while the indicator that accounts for the persistence of the fragilities, I^3, performs better than the composite indicator with just the number of signals.[23]

The bottom panel reports the out-of-sample forecasting accuracy of the best leading indicator, I^4. The forecasting accuracy of this indicator out-of-sample is basically similar to the one in-sample, indicating the usefulness of the methodology in trying to anticipate crises.

Table 5 reports the conditional probabilities of both currency and banking crises using the best performing indicator, the one that weights each signal with the inverse of the noise-to-signal ratio. As shown in this table, the odds of a currency crisis increase sharply as the signs of vulnerability of the economy increase, with the probabilities of a currency crisis reaching almost 1 when the indicator is about 15 or larger. For banking crises, the accuracy of the composite indicator is somewhat smaller with conditional probabilities of crises only increasing to about 40 percent.

Using the information on the monthly value of the composite indicator, I^4, and the conditional probabilities of crises in Table 5, we can construct series of probabilities of crises for the twenty countries both in-sample, from January 1970 to December 1995, and out-of-sample, from January 1996 to December 1997.

Figures 4 and 5 report, respectively, the time-series probabilities of currency and banking crises implicit in the composite indicator which accounts for the noise-to-signal ratio of each variable for all the twenty countries for the period January 1970- December 1997. The shaded areas in the figures are "crisis times."

Interestingly most of the financial crises are preceded by fragile economies. The average probability of currency crisis in the eve of the speculative attack (the crisis window) more than duplicates from its average value in tranquil times (from 19 to 39 percent). The same is true for banking crises, with the average probability of banking problems increasing from 8 to 17 percent, suggesting an increase in the vulnerability of the economy in the midst of banking problems. It is still true that some crises occur when there are not signs of vulnerability of the economy, for

[23] These results suggest that forecasts of crises could be improved by combining the last two indicators into one by computing the average of signals over some interval of time, with the signals weighted by its corresponding noise-to-signal ratio.

example, the two currency crises in Argentina in the late 1980s and beginning of the 1990s. But those crises are linked to the hyperinflation that engulfs Argentina in those three years and is just a product of the profound deterioration of the fiscal accounts.

4. The 1997-1998 Twin Crises: Asia and Latin America[24]

The Asian meltdown in 1997 has ignited a hot debate about the driving forces of crises. While some have argued that deteriorating market fundamentals are at the core of the currency and banking crises, others have stressed the role of herding behavior in international capital markets as the sole culprit of the collapse. The estimations in the paper can throw some light into this debate.

Before examining these probabilities, it is interesting to examine in more detail the built up of the crises in these four countries. Thailand constitutes the perfect picture of the typical financial crisis, with the onset of the crisis as the economy enters a marked slowdown in growth (to about 6 percent in 1996 and forecasted at that time to fall even further), following a prolonged boom in economic activity (about 8 to 14 percent growth rates in the period 1988-1995) that is, in part, fueled by heavy capital inflows and rapid credit creation.[25] As in Latin America in the 1980s and Mexico in 1994, this extremely high expansion in credit raises questions about the asset quality of the banks. Another source of vulnerability of the Thai banking system is the banks' investment in nonbank financial institutions with large-scale exposure to the domestic property market. The explosive growth in Thailand in the early 1990s comes to an end with the real appreciation of the domestic currency and the corresponding loss of exports markets (the annual growth rate of exports falls from a peak of 30 percent per year in 1994 to about 0 in 1996). Already in 1996, financial fragilities are also quite evident. In May 1996 there is a run against the Bangkok National Bank, which is later rescued by the central bank. The collapse of the real estate market and stock prices compounds the problems of the financial sector. Finally, the increase in interest rates in 1997 to prop up the baht puts the nail in the coffin of the already defunct banking sector.

The boom-bust cycle in lending is also evident in the Philippines, fueled not only by capital inflows but also by a reform to the banking sector, which entails a dramatic reduction in reserve requirements. Bank credit increases by 44 percent a year in 1995-1996, with this doubling of loans in 2 years raising questions about asset quality in the future. As in Thailand, the rapidly expanding credit is an important contributor to the rally in stock and real estate markets. By the end of 1996, according to the estimates of the central bank of the Philippines, commercial banks' property loans account for 10 percent of total loans. Total banks' exposure to the property sector may have been even higher since

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[24] While the data is updated to include December 1997, the data becomes more sparse in the last six months of 1997, thus a decline in the probabilities of crises in the last six months of the sample may reflect this lack of data on the leading indicators.

[25] Short-term capital inflows to Thailand amounts to 7-10 percent of GDP in each of the years 1994-1996.

property is a common form of loan collateral.[26] Naturally, the exposure of banks to the real estate sector contributes to the fragility of the banking industry in the aftermath of the decline of property prices. As in other countries in the region, foreign currency exposure increases in the Philippines in the 1990s through foreign borrowing to finance domestic lending and also through the rapid expansion of foreign currency deposits.[27] Consumer lending also increases and fuels a surge in consumption, leading to a deterioration of the current account, which is accentuated by the real exchange rate appreciation of the domestic currency. The loss of competitiveness and the accompanying steady weakening of exports anticipate a future decline in growth and also contribute to a substantial deterioration of the quality of banks' assets, further reducing the odds of survival of many individual financial institutions. Overall, in Thailand and the Philippines, about 70 percent of the indicators are signaling the deterioration of the macroeconomic fundamentals in the two years prior to the collapse of the peg in July 1997. The probabilities of currency crises for Thailand and the Philippines increase from a low of 20 percent in 1995 to about 100 and 80 percent, respectively, in 1997. The estimated probabilities of banking crises also show increasing financial fragilities, with the probabilities of a banking crisis in Thailand increasing from about 5 percent in 1995 to almost 40 percent in 1996. Similar pattern is observed in the Philippines, but the growth in probabilities is more moderate.

Malaysia has a number of features in common with Thailand. It is also affected by the slowdown in the region, though to a much smaller degree. It also has current account deficits similar in magnitude to those in Thailand in the period 1990-1995, although in 1996 the outlook of the external sector improves somewhat with the current account/GDP ratio declining to -5.3 percent (In Thailand the current account/GDP ratio in 1996 is still -8.0 percent). And as Thailand, Malaysia accumulates debt rapidly in the 1990s. The real estate market also surges as in Thailand.[28] Malaysia is also suffering from financial fragilities as a result of the high degree of leverage of the economy[29] and the large exposures to the property and stock markets. For Malaysia, 70 percent of the indicators are showing signs of distress at the onset of the crisis, with the probabilities of currency and banking crises increasing about seven times in the 1996-1997 period to 70 percent and 30 percent, respectively.

Indonesia, however, looks somewhat different at the onset of the crisis. While it is true that as the other countries in the area, it is exhibiting banking fragilities,[30] and short-term debt sharply exceeds available foreign exchange reserves,[31] the current account deficit is not deteriorating as fast,[32] the slowdown in growth is not yet evident, and the real exchange rate does not appreciate as much as in the other countries in the region. In fact, only very few

[26] See *International Capital Markets: Development, Prospects, and Key Policy Issues*, 1997.
[27] While banks are required to maintain balanced FCDU books by lending in foreign currency, still banks bear the foreign exchange exposure because many borrowers may experience servicing difficulties in the event of a devaluation.
[28] In Malaysia as in Thailand, the stock market indices of the property sector tripled in the early 1990s.
[29] In fact, Malaysia has one of the highest credit-to-GDP ratio in the world.
[30] In fact, the beginning of banking crisis in Indonesia can be dated to November 1992 when a large bank (Bank Summa) collapses and triggers runs on three smaller banks.
[31] Short-term foreign debt is about 1.7 times the stock of foreign exchange reserves of the country.
[32] In fact, in 1996, the current account deficit only reaches 3.5 percent of GDP.

indicators are showing signs of anomalous behavior in the months prior to the crisis,[33] with the probabilities of crises showing a stable pattern in 1996-1997.[34]

As the financial crisis in Asia intensifies in 1997, financial markets in Latin American countries also come under pressure. The pressure escalates in 1998 as the crisis engulfs Russia in the summer of 1998, with some of the currencies, such as the Mexican peso declining by about 25 percent against the dollar in the first 9 months of 1998. While countries can fall prey of speculative attacks even with immaculate market fundamentals as panic spreads out and contagion takes over, it is also true that, overall, those with more severe vulnerabilities are the ones that are in general the hardest hit when euphoria ends and gloom sets in. The out-of-sample probabilities of crisis estimated in Figures 4 and 5 can suggest a "market fundamentals" assessment of the odds of full blown-out financial crisis in Latin America.

Interestingly, some of the countries that in the past have experienced periodic currency and banking crises look less prone to crises in the late 1990s. Argentina, Bolivia, Mexico, and Peru are in this group.[35] Others, such as Brazil, Chile, and Colombia seem more frail, with many indicators flashing red lights. For example, for Brazil there is a marked appreciation of the real exchange rate, real interest rates increase sharply, with the lending/deposit interest rate ratio showing a marked upturn and signaling the onset of a recession and increased bankrupcies. Also, banking fragilities are present. While foreign debt has still not reached dangerous levels, there are some alarming signs of possible capital flight already surfacing in 1996.

Problems in Chile are mostly focused in its external sector. For example, the terms of trade deteriorate substantially following the collapse of the price of copper—Chile's most important single export and contribute to a deterioration of the current account. The deterioration of the current account is further fueled by an overall real appreciation of the domestic currency. While the economy is still growing in 1997, high lending-deposit interest rate spreads are already alerting of a future slowdown and perhaps increasing future bankrupcies. During 1996, there is also evidence of offsetting gross capital flows with domestic resident both borrowing from overseas while increasing their assets in BIS banks. Finally, the concentration of debt at short maturities has also increased.

The signs of fragility in Colombia are substantially more widespread. Overall in 1995-1997, mostly all financial indicators warn about an exaggerated boom-bust financial cycle, with the M2 multiplier, the ratio of domestic credit-to-GDP, "excess" M1 balances, and M2/reserves increasing substantially and the stock market declining even before the unfolding of the Asian crises. Deposits in banks also decline substantially (in real terms). Signs of vulnerability are also present in the external sector, with the domestic currency appreciating in real terms and the

[33] The indicators in this paper do not pay attention to the balance sheet of the corporate sector, which seems to be at the root of the external payments crisis in Indonesia.

[34] Although not reported in Table 4, the out-sample forecasting accuracy of the preferred composite indicator in crisis times for Malaysia, Philippines, and Thailand increases sharply compared with the in-sample performance of that indicator. In contrast, the out-of-sample performance in crisis times for Indonesia deteriorates substantially, also suggesting a different characterization of the crisis in Indonesia.

[35] The analysis in this paper does not account for the effects of contagion. The recent Brazilian crisis has largely contributed to increase Argentina's economic vulnerability. In fact, Brazil is Argentina's most important trade partner. The recent devaluation in Brazil may affect Argentina's stability. See, Kaminsky and Reinhart (1998) for an analysis of bilateral-trade link contagion effects, in general, and for the Mercosur effect, in particular.

maturity of the foreign debt declining substantially. Again in Colombia, both the deposit and the lending domestic interest rates suggest present and future fragilities.

Overall, the probabilities of currency crises for these three countries increase to about 60 to 70 percent in 1997. Interestingly, both Brazil and Colombia, the two countries that suffer full-fledge currency crises in 1998–1999 are the countries with the most fragile economies (as captured using the composite leading indicator methodology), which reinforces the usefulness of the early warnings approach in identifying those countries that are prone to suffer speculative attacks.

VII. Conclusions

Currency and banking crises are not a new phenomenon. Not only is the list of countries affected by these crises long, but it is also increasing. Financial crises can be very costly. For example, the International Monetary Fund has estimated that the average cumulative loss of output (relative to trend) per currency crisis oscillates between 4 and 7 percent, and for banking crisis increases to about 12 percent.[36] Twin crises have even more extreme effects. Cumulative output losses increase in this case to about 15 percent.[37] The fiscal costs of these crises can also be massive. Resolution costs of banking crises have in some cases reached over 40 percent of GDP (for example, in Chile and Argentina in the early 1980s).[38] For currency crises, the fiscal costs are associated with the losses of reserves that central banks suffer in their basically vain attempt to defend the peg. On average, central banks lose about 8 percent of their reserves in the 6 months prior to crisis and these losses increase to 25 percent in twin crises episodes. The associated costs can be quite daunting in view that, on average, in the six months after the crises the domestic currency depreciates about 25 percent in real terms.

Crises will continue to occur again in the future, perhaps even at an increasing rate following the globalization of capital markets. While some crises may occur when countries have immaculate fundamentals, the risk of crises increases sharply as market fundamentals deteriorate. Thus, for policy makers to be able to adopt preemptive actions, they need to identify weaknesses and imbalances early enough before crises erupt. In this regard, the development of early-warning system of vulnerability could prove to be quite useful. This paper constructs such an early warning system, that is shown to be able to accurately forecast (out-of-sample) the Asian crises. In this regard, this paper also shows that the Asian crises, far from being of a "new breed," confirm that economies in distress are at the origin of financial crises.

The results presented in this paper are a first step in the construction of a system of early warning. I have only considered macroeconomic data in the list of univariate indicators, but data of the balance sheet of financial institutions would be an important complement to the macro data. While this study focuses on the fundamentals of the domestic economy, it could also be helpful to assess whether neighbor countries are prone to crises. In this regard, it would be

[36] See, *World Economic Outlook* May 1998, page 79.
[37] See also, Kaminsky and Reinhart (1998) for a comparison of the costs of crises in different regions.

very useful to examine the propagation of crises within a region and also across regions. Preliminary steps in this direction have been undertaken in Kaminsky and Reinhart (1998).

[38] See, *World Economic Outlook,* May 1998, page 78.

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Data Appendix

The Indicators

Sources: *International Financial Statistics* (IFS), International Monetary Fund *(*IMF); *Emerging Market Indicators*, International Finance Corporation (IFC); *World Development Indicators*, The World Bank (WB). *Exchange Arrangements and Exchange Restrictions* (EAER), International Monetary Fund; *The Maturity, Sectoral, and Nationality Distribution of International Bank Lending*, Bank for International Settlements (BIS); *International Banking and Financial Market Developments*, Bank for International Settlements. When data was missing from these sources, central bank bulletins and other country-specific sources were used as supplements. Unless otherwise noted, we used 12-month percent changes.

1. M2 multiplier: The ratio of M2 (IFS lines 34 plus 35) to base money (IFS line 14).

2. Domestic credit/GDP: IFS line 52 divided by IFS line 64 to obtain domestic credit in real terms, which was then divided by IFS line 99b.p. (interpolated) to obtain the domestic credit/GDP ratio. Monthly real GDP was interpolated from annual data.

3. Domestic real interest rate: Deposit rate (IFS line 60) deflated using consumer prices (IFS line 64). Monthly rates expressed in percentage points. In levels.

4. Lending-Deposit rate ratio: IFS line 60p divided by IFS line 60 was used in lieu of differential to ameliorate the distortions caused by the large percentage point spreads observed during high inflation. Both rates are for the domestic economy. In levels.

5. "Excess" M1 balances: M1 (IFS line 34) deflated by consumer prices (IFS line 64) less an estimated demand for money. The demand for real balances is determined by real GDP (interpolated IFS line 99b.p), domestic consumer price inflation, and a time trend. Domestic inflation was used in lieu of nominal interest rates, as market-determined interest rates were not available during the entire sample for a number of countries; the time trend (which can enter log-linearly, linearly, or exponentially) is motivated by its role as a proxy for financial innovation and/or currency substitution. In levels

6. M2 / Reserves: IFS lines 34 plus 35 converted into dollars (using IFS line ae) divided by IFS line 1L.d.

7. Bank deposits: IFS line 24 plus 25 deflated by consumer prices (IFS line 64).

8. Exports: IFS line 70.

9. Imports: IFS line 71.

10. Terms of trade: The unit value of exports (IFS line 74) over the unit value of imports (IFS line 75). For those developing countries where import unit values (or import price indices) were not available, an index of prices of manufactured exports from industrial countries to developing countries was used.

11. The real exchange rate: The real exchange rate index is derived from a nominal exchange rate index, adjusted for relative consumer prices (IFS line 64). The measure is defined as the relative price of foreign goods (in domestic currency) to the price of domestic goods. The nominal exchange rate index is a weighted average of the exchange rates of the nineteen OECD countries with weights equal to the country trade shares with the OECD countries. Since not all real appreciations reflect disequilibirium phenomena, we focus on deviations of the real exchange rate from trend. The trend was specified as, alternatively, log, linear, and exponential; the best fit among these was selected on a country-by country basis. In levels.

12. Reserves: IFS line 1L.d.

13. Real interest rate differential: Interest rates in the domestic economy are compared with interest rates in the United States (Germany) if the domestic central bank pegs the currency to the dollar (Deutsche mark). The interest rate differential is constructed as the difference between real rates for the domestic and foreign countries. Real rates are deposit rates (IFS line 60) deflated using consumer prices (IFS line 64).

14. Output: For most countries, the measure of output used is industrial production (IFS line 66). However, for some countries, (the commodity exporters) an index of output of primary commodities is used (IFS lines 66aa), if industrial production is not available.

15. Stock returns: IFC global indices are used for all emerging markets: for industrial countries the quotes from the main boards are used. All stock prices are in US dollars.

16. Capital Flight: Deposits of domestic residents in BIS reporting banks interpolated from quarterly data *International Banking and Financial Market Developments*. (BIS) divided by reserves, IFS line 1L.d.

17. Short-term ForeignDebt: Liabilities of domestic residents to BIS reporting banks with maturities up to one year divided by total liabilities of domestic residents to BIS reporting banks, interpolated from semi-annual data. *The Maturity, Sectoral, and Nationality Distribution of International Bank Lending,* Bank for International Settlements.

18. Foreign Debt: Liabilities of domestic residents to BIS reporting banks. *International Banking and Financial Market Developments* (BIS).

19. World Real Interest Rate: US deposit rate (IFS line 60) deflated using consumer prices (IFS line 64). Monthly rates expressed in percentage points. In levels.

20. Domestic and External Financial Liberalization: This is a dummy variable equal to the sum of D_1, D_2, D_3, and D_4, where D_1=0 if there are separate exchange rates for some or all capital transactions and/or some or all invisibles, and one otherwise; D_2 =0 if there are restrictions on payments for capital account transactions, and one otherwise; D_3=0 if there is a surrender requirement of export proceeds, and one otherwise; and D_4=1 if domestic financial liberalization, and zero otherwise.

21. Currency (Banking) Crisis: This is a dummy variable equal to one in the 24 months before (12 months before and 12 months after) the currency crisis (banking crisis) and zero otherwise.

Table 1

The Chronology of Banking and Currency Crises and Domestic Financial Liberalization

Country	Domestic Financial Liberalization	Banking Crisis	Currency Crisis
Argentina			June 1970
			June 1975
	1977	March 1980	February 1981
			July 1982
		May 1985	September 1986
			April 1989
			February 1990
		December 1994	
Bolivia			November 1982
			November 1983
			September 1985
		October 1987	
Brazil	1975		February 1983
		November 1985	November 1986
			July 1989
			November 1990
			October 1991
		July 1994	
Chile			December 1971
			August 1972
			October 1973
			December 1974
			January 1976
	1974-1976	September 1981	August 1982
			September 1984
Colombia	1980	July 1982	March 1983
			February 1985
Denmark			May 1971
			June 1973
			November 1979
	Early 1980s	March 1987	
			August 1993
Finland			June 1973
			October 1982
	1982-1991	September 1991	November 1991
			September 1992
Indonesia			November 1978
			April 1983
	1983-1988		September 1986
		November 1992	
Israel			November 1974
			November 1977
		October 1983	October 1983
			July 1984

Country	Domestic Financial Liberalization	Banking Crisis	Currency Crisis
Malaysia			July 1975
	1978-1985	July 1985	
Mexico	1974		September 1976
			February 1982
		September 1982	December 1982
	1991	Late 1992	December 1994
Norway			June 1973
			February 1978
			May 1986
	1980-1990	November 1988	December 1992
Peru			June 1976
		April 1983	October 1987
	1991		
Philippines			February 1970
	1980-1984	January 1981	October 1983
			June 1984
			February 1986
Spain	Begins in 1974		February 1976
			July 1977
		November 1978	December 1982
			September 1992
			May 1993
Sweden			August 1977
			September 1981
			October 1982
	1980-1990	November 1991	November 1992
Thailand			November 1978
		Early 1979	July 1981
		October 1983	November 1984
	1989-1990		
Turkey			August 1970
	1980		January 1980
	Dec. 1983-June 1987 controls reimposed	January 1991	March 1994
	1987		
Uruguay		1971	December 1971
	1976-1979	March 1981	October 1982
Venezuela	1981		
	1984-Jan. 1989 controls reim-posed		February 1994
			December 1986
			March 1989
	1989	October 1993	May 1994
			December 1995

Sources: Kaminsky & Reinhart, 1996 .

Table 2

Symptoms and Leading Indicators

Symptoms	Indicator	Critical-Shock Sign	Comments
Overborrowing Cycles	M2 Multiplier	Positive	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
	Domestic Credit/GDP	Positive	
	Domestic and External Financial Liberalization	Dummy Variable = 4	
Bank Runs	Bank Deposits	Negative	Banking crises and currency can be preceded by bank runs (see Goldfajn and Valdes, 1995)
Monetary Policy	"Excess" M1 Balances	Positive	Loose monetary policy can fuel a currency crisis (see Krugman, 1979). To the extent that a devaluation worsens the health of the banking sector it can also trigger a banking crisis.
Problems Current Account	Exports	Negative	Real exchange rate overvaluations and a weak external sector are a part of a currency crisis.They add to the vulnerability of the banking sector since a loss of competitiveness and external markets could lead to a recession, business failures, and a decline in the quality of loans. Thus, large negative shocks to exports, the terms of trade, and the real exchange rate and positive shocks to imports are interpreted as symptoms of financial crises
	Imports	Positive	
	Terms of Trade	Negative	
	Real Exchange Rate	Negative	
Problems Capital Account	Reserves	Negative	High world interest rates may anticipate currency crises as they lead to capital outflows. Capital account problems become more severe when the country's foreign debt is large and capital flight increases since it may raise issues of debt unsustainability. Debt concentrated at short maturities will increase the vulnerability of a country to external shocks. As discussed in Kaminsky and Reinhart (1996), a currency crisis may in turn deepen the banking crisis.
	M2/Reserves	Positive	
	Real Interest Rate Differential	Positive	
	World Real Interest Rate	Positive	
	Foreign Debt	Positive	
	Capital Flight	Positive	
	Short-term Foreign Debt	Positive	
Growth Slowdown	Output	Negative	Recessions and the burst of asset price bubbles precede financial crises (see Calomiris and Gorton, 1991) High real interest rates could be a sign of a liquidity crunch leading to a slowdown and banking fragility. An increase in the lending/deposit ratio in the domestic economy can capture a decline in loan quality.
	Domestic Real Interest Rate	Positive	
	Lending/Deposit Rate Ratio	Positive	
	Stock Prices	Negative	

Table 3

Characteristics of the Leading Indicators

Indicators	Currency Crises				Banking Crises			
	Size of the Critical Region (percent)	Type I Error (percent)	Type II Error (percent)	Noise-to-signal Ratio	Size of the Critical Region (percent)	Type I Error (percent)	Type II Error (percent)	Noise-to-signal Ratio
Overborrowing Cycles								
M2 Multiplier	14	83	11	0.7	10	83	8	0.5
Domestic Credit/GDP	10	88	8	0.6	5	93	4	0.6
Domestic and External Financial Liberalization	N/A	53	48	1.0	N/A	40	46	0.8
Bank Runs								
Bank Deposits	10	88	8	0.7	16	86	15	1.0
Monetary Policy								
“Excess” M1 Balances	6	92	5	0.6	9	90	8	0.8
Problems Current Account								
Exports	10	84	7	0.4	10	86	9	0.6
Imports	10	91	10	1.1	20	88	20	1.6
Terms of Trade	16	85	11	0.7	19	82	14	0.8
Real Exchange Rate	10	73	4	0.2	10	72	8	0.3
Problems Capital Account								
Reserves	15	79	12	0.6	28	64	27	0.7
M2/Reserves	13	81	10	0.5	10	88	9	0.7
Real Interest Rate Differential	11	93	7	0.9	19	82	10	0.5
World Real Interest Rate	17	82	7	0.4	20	72	14	0.5
Foreign Debt	10	88	5	0.5	26	80	9	0.5
Capital Flight	19	89	9	0.9	29	69	11	0.6
Short-term Foreign Debt	26	89	9	0.9	26	85	8	0.9
Growth Slowdown								
Output	11	88	6	0.5	14	82	9	0.5
Domestic Real Interest Rate	12	91	7	0.8	20	76	11	0.5
Lending/Deposit Rate Ratio	20	92	12	1.5	13	96	7	1.9
Stock Prices	11	87	5	0.4	10	82	5	0.3
Crises as Predictors*	N/A	81	6	0.3	N/A	79	26	1.2

**Note:* Banking for Currency then Currency for Banking.

Table 4

Scoring the Leading Indicators: 1970-1995

Currency Crises

Indicator	QPS		LPS		GSB	
	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times
Naive Forecast	0.173	1.008	0.348	1.238	0.161	1.008
Real Exchange Rate	0.115	0.979	0.265	1.257	0.092	0.886
Composite Indicator 1	0.113	0.965	0.254	1.249	0.084	0.912
Composite Indicator 2	0.114	0.980	0.255	1.266	0.084	0.936
Composite Indicator 3	0.121	0.944	0.264	1.222	0.090	0.888
Composite Indicator 4	0.110	0.862	0.240	1.161	0.071	0.735

Banking Crises

Indicator	QPS		LPS		GSB	
	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times
Naive Forecast	0.024	1.620	0.110	2.303	0.019	1.620
Real Exchange Rate	0.018	1.589	0.092	2.301	0.013	1.583
Composite Indicator 1	0.025	1.436	0.098	2.025	0.014	1.420
Composite Indicator 2	0.025	1.458	0.101	2.051	0.015	1.444
Composite Indicator 3	0.024	1.427	0.095	1.997	0.013	1.409
Composite Indicator 4	0.024	1.309	0.094	1.975	0.013	1.368

Forecasting Accuracy of Composite Indicator 4: 1996-1997

Type of Crisis	QPS		LPS		GSB	
	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times	Tranquil Times	Crisis Times
Currency	0.188	0.879	0.332	1.199	0.133	0.736
Banking	0.021	0.800	0.090	1.148	0.014	0.337

Table 5

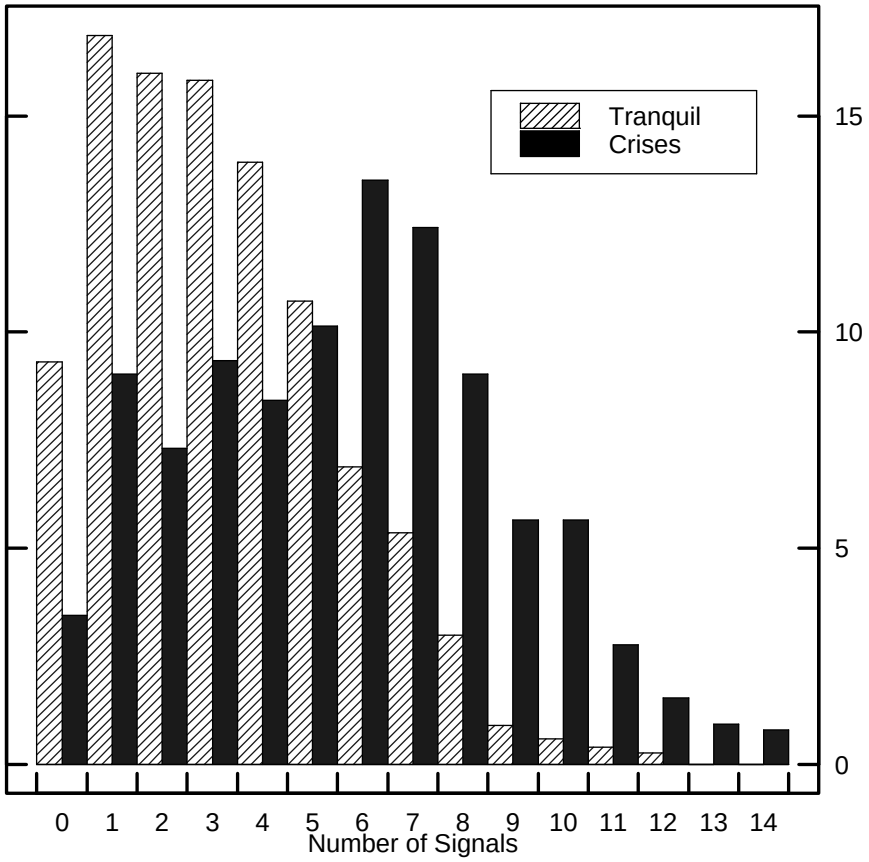
Conditional Probabilities of Financial Crises
(Using the Composite Indicator 4)

Value of Indicator 4	Probability of Currency Crisis
0-1	0.10
1-2	0.22
2-3	0.18
3-4	0.21
4-5	0.27
5-7	0.33
7-9	0.46
9-12	0.65
12-15	0.74
Over 15	0.96

Value of Indicator 4	Probability of Banking Crisis
0-1	0.03
1-2	0.05
2-3	0.06
3-4	0.09
4-5	0.12
5-7	0.13
7-9	0.16
9-12	0.27
Over 12	0.37

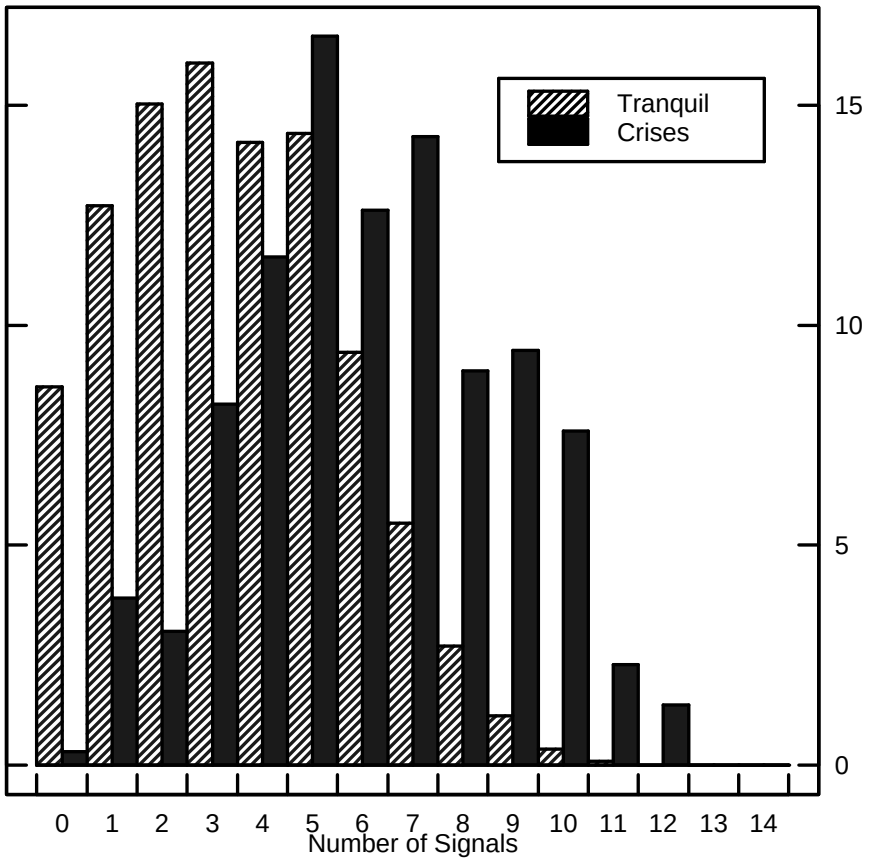
Figure 1
Frequency Distribution of the Number of Signals

Currency Crises



	Tranquil	Crisis
Mean	3.28	5.56
Standard Deviation	2.33	3.14

Banking Crises

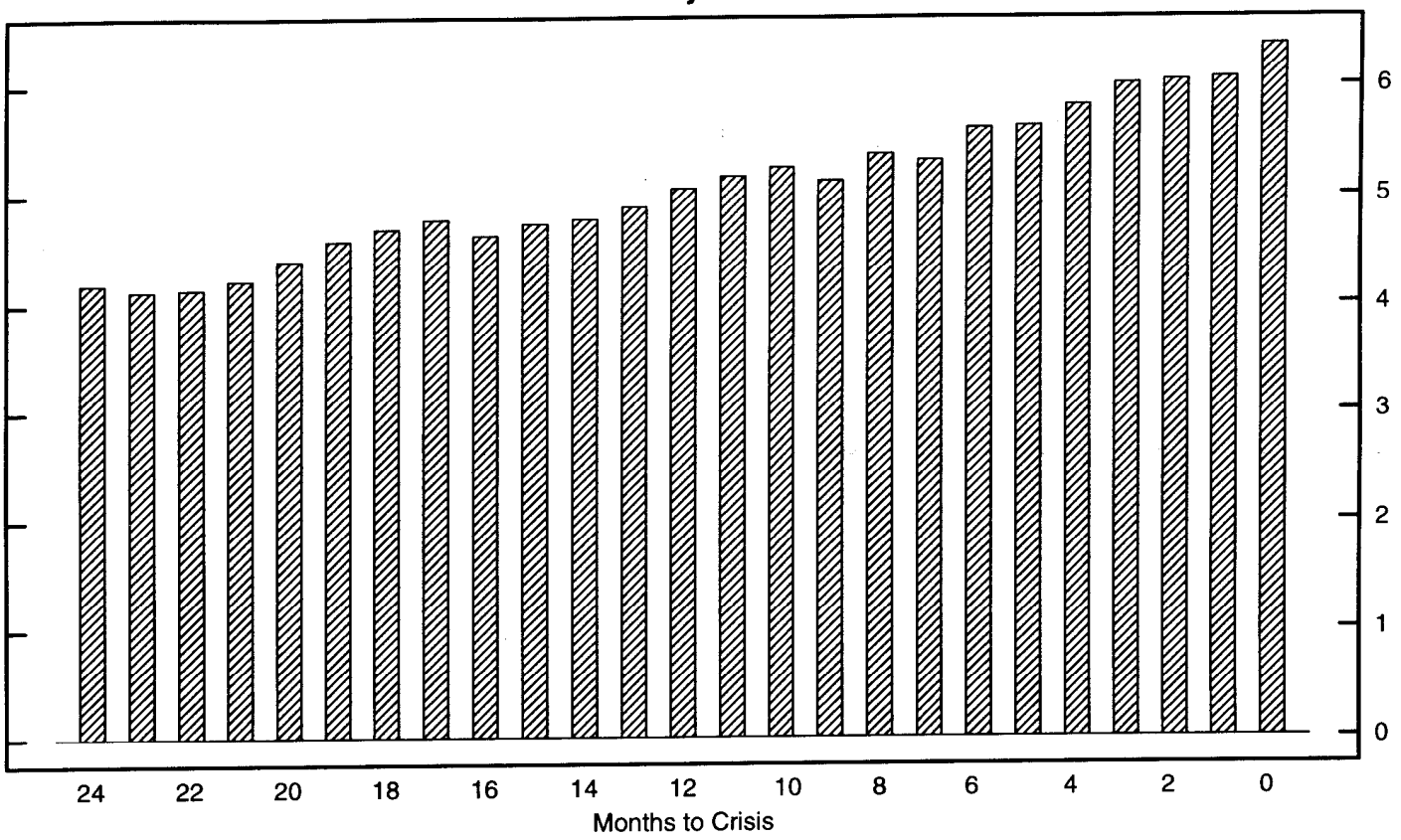


	Tranquil	Crisis
Mean	4.12	7.14
Standard Deviation	2.60	3.07

Figure 2

Evolution of the Number of Signals in Crisis Times

Currency Crises



Banking Crises

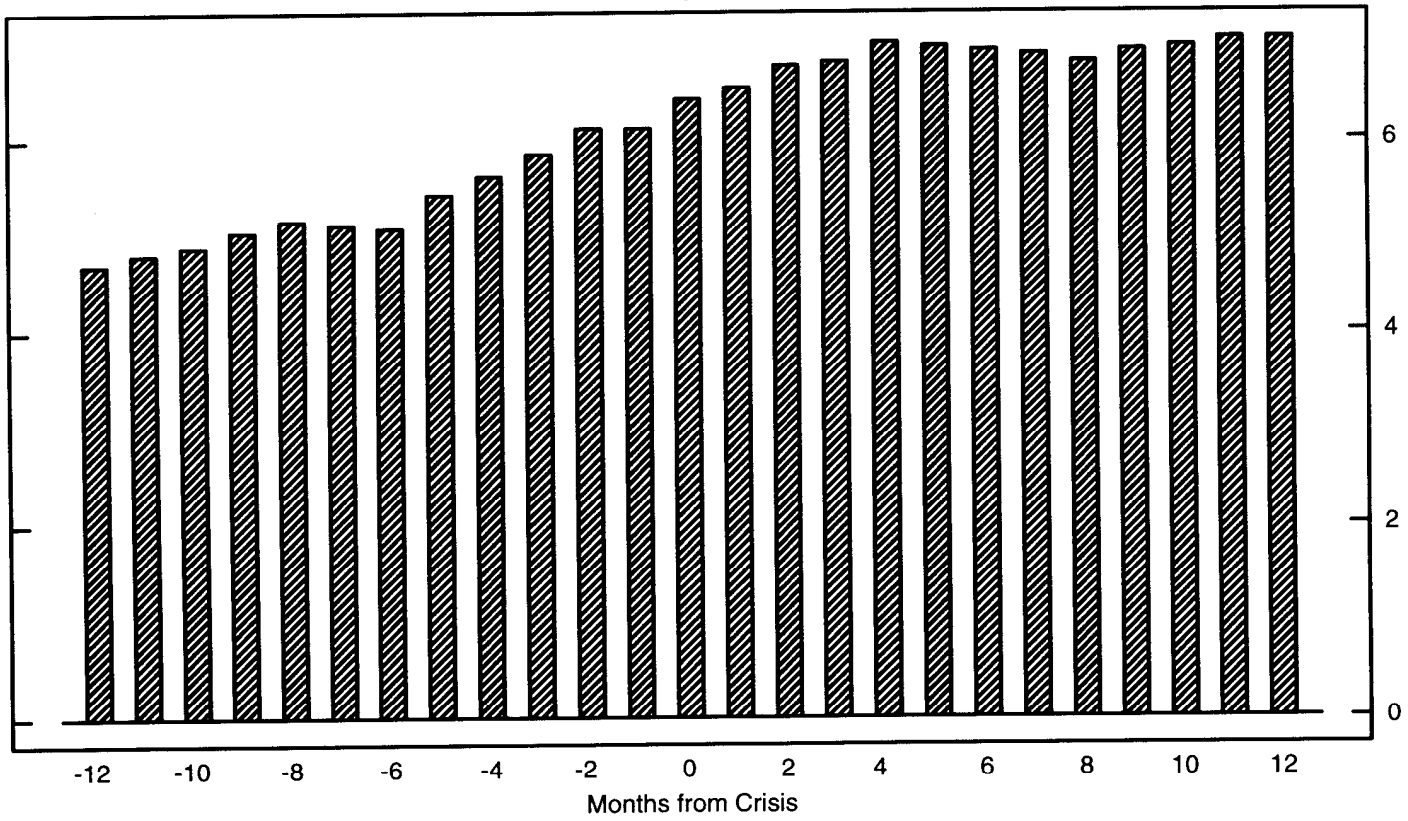
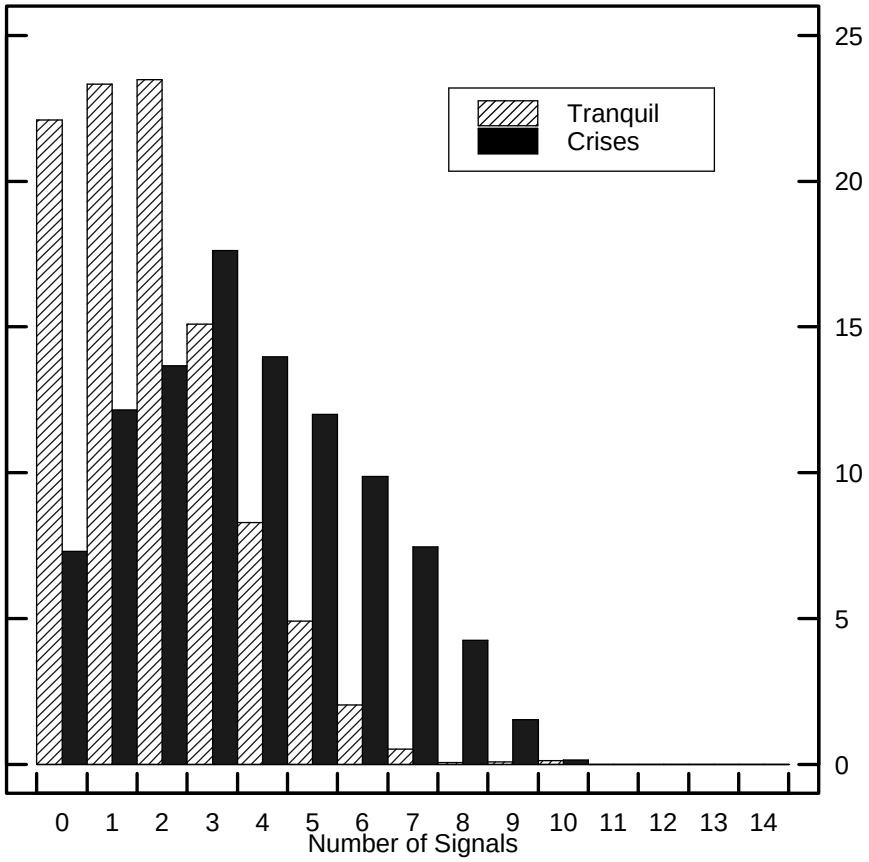


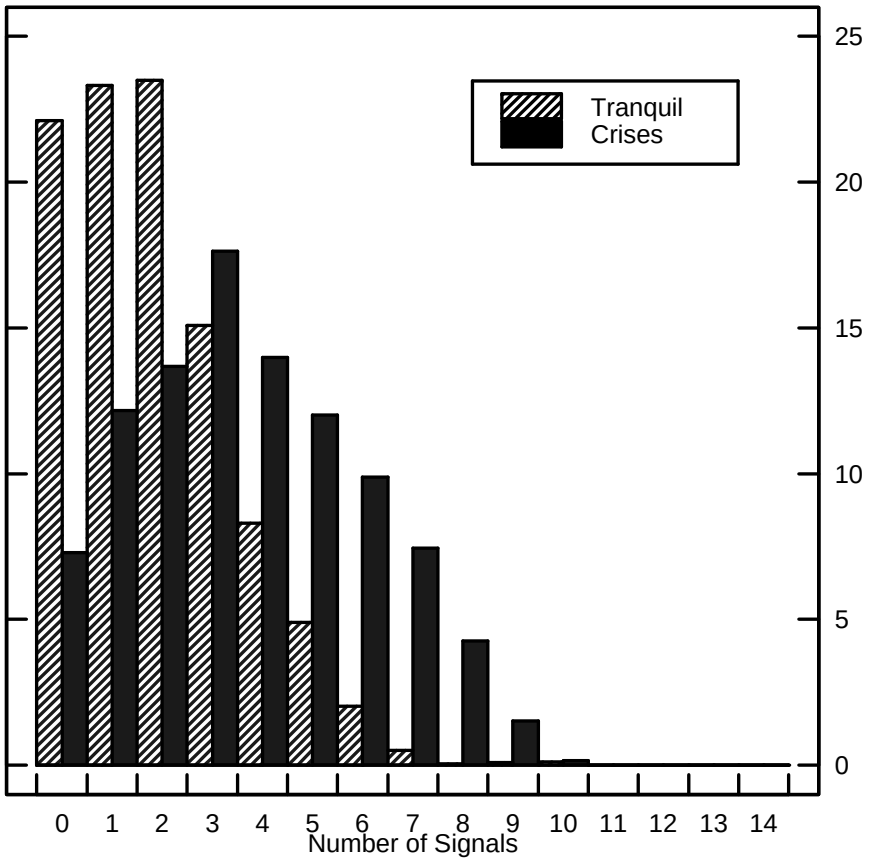
Figure 3
Frequency Distribution of the Number of Extreme Signals

Currency Crises



	Tranquil	Crisis
Mean	1.94	3.62
Standard Deviation	1.77	2.59

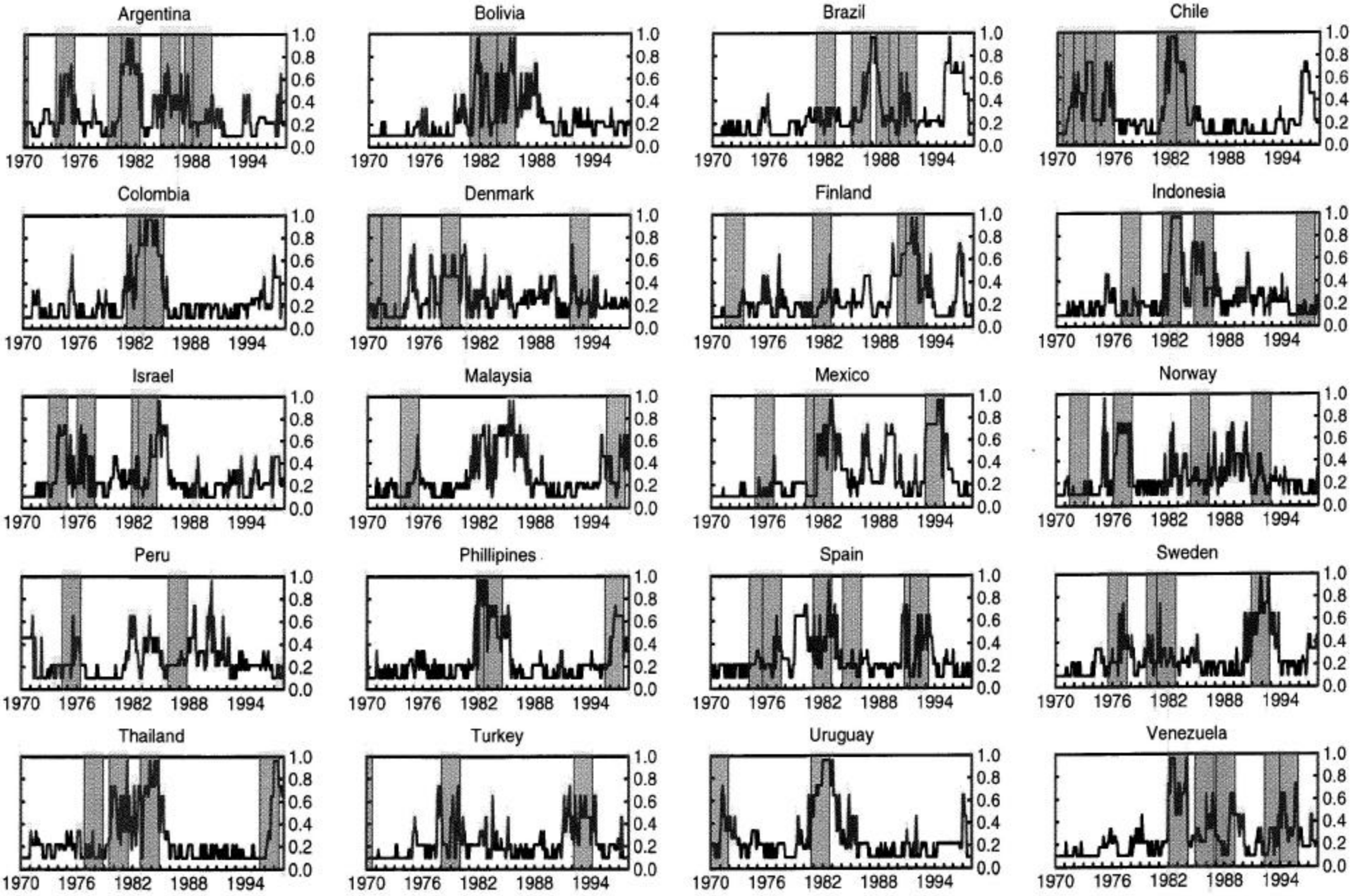
Banking Crises



	Tranquil	Crisis
Mean	2.50	4.61
Standard Deviation	2.02	2.70

Figure 4

Probability of Currency Crisis



Note: Shaded areas denote crisis windows.