Early Warning System: An Assessment of Vulnerability

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Assessing Financial Vulnerability: An Early Warning System for Emerging Markets
Notes from Chapter 5
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Predicting the timing of currency and banking crises is likely to remain an elusive task for academics, financial market participants, and policymakers. Few foresaw the Asian crises and fewer still could have imagined their severity. However, recent events have highlighted the importance of improving upon a system of "early warnings." The signals approach introduced in Kaminsky and Reinhart (1996) and applied to the out-of-sample data during January 1996- June 1997 in this section allows us to glean where trouble spots may be brewing.

Needless to say, such exercises are fraught with the traditional Type I and Type II errors. Assuming the null hypothesis to be that the economy is in a state of "tranquility," a high proportion of indicators flashing leads one to reject that hypothesis in favor of the alternative, namely that a crisis is likely in the next twenty four months. Yet, a country may be "vulnerable," in the sense that a high proportion of variables are signaling trouble, yet the crisis may be averted through either good luck, good policies, or credible implicit bail-out guarantees. This would be an example of a Type II error. A recent example of this case is Brazil, in which multiple signals were flashing as early as 1997 but these warning signs did not culminate into a full-fledged crisis until 1999. Alternatively, the crisis may occur without much warning signs from the indicators, this Type I error, or "the dog that did not bark in the night" could be interpreted as evidence of contagion or multiplicity of equilibria, an issue which we will take up later an in particularly

relevant for understanding the Indonesian crisis.

Vulnerability and signals

Tables 5.1-5.4 summarize some of the key features of applying the signals approach to the recent data. The first column of the table provides information on the total number of signals from the 15 monthly indicators listed in Tables 3.1. The second column provides information on the number of monthly indicators sending signals while the third column lists the number from the top five indicators, which are real exchange rates, stock prices, the money multiplier, output and exports for banking crises and real exchange rates, stock prices, exports, M2/reserves, and output for currency crises. The next three columns give the comparable information for the eight annual indicators. On the case of the annual indicators, we focus on the top three indicators, which are short-term capital flows/GDP, current account balance/investment, and the overall budget deficit/GDP for banking crises; for currency crises the current account deficit/GDP replaces short-term capital inflows, while the other two indicators are the same. The last column gives the percent of the twenty three indicators that are signaling. The reason to highlight the number of top indicators signaling, is that these are the indicators with the lowest noise-to-signal ratios hence, a signal from these is more meaningful than a signal from a less reliable indicator.

Table 5.1 provides this information for currency crises using the thresholds reported in Table 3.2. As the last column highlights there is considerable cross-country variation, with the lowest proportion of signals coming from Egypt and the highest from the Czech Republic, which indeed floated following a speculative attack and substantial reserve losses in May 1997. Table 5.2 does exactly the same accounting exercise for "borderline" signals. Specifically, we

enlarged the size of the rejection region by five percent for all the indicators. Hence, for instance, instead of having a 10 percent threshold for stock prices for the case of currency crises, we now have a 15 percent threshold. This sensitivity analysis increases the likelihood of having a Type II error (rejecting the null hypothesis of tranquility when you shouldn't) while reducing the probability of a Type I error (not rejecting when you should). In any case, including "borderline" signals does not alter the picture for some countries (such as Argentina) but it increases the proportion of indicators signaling markedly, as well as the number of signals, for countries like Korea (from 48 to 65 percent) and South Africa (from 39 to 52 percent). The next two tables report the tally for banking crises using the original thresholds (Table 5.3) and the "borderline" scenario. Not surprisingly, the country profiles that emerge are similar as several of the indicators have common thresholds or critical values for currency and banking crises.

5.1 Signals of balance of payment crises

	Monthly indicators			Annual indicators			Total
Country	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Percent of indicators signaling**
Argentina	35	3	1	2	2	0	22
Bolivia	33	6	2	0	0	0	26
Brazil	37	5	3	0	0	0	22
Chile	34	2	1	1	1	0	13
Colombia	27	5	1	3	3	0	35
Czech Republic	77	10	3	4	2	2	52
Denmark	21	3	1	1	1	0	17
Egypt	14	3	2	0	0	0	13
Finland	74	7	1	2	2	0	39
Greece	32	8	2	3	2	0	43
Indonesia	6	3	1	1	1	0	17
Israel	24	4	1	1	1	0	22
Korea	32	8	3	3	3	0	48
Malaysia	36	9	3	0	0	0	39
Mexico	11	2	0	2	2	0	17
Norway	9	3	0	1	1	0	17
Peru	16	2	0	1	1	0	13
Philippines	59	8	1	2	2	0	43
South Africa	42	8	3	1	1	0	39
Spain	44	6	2	1	1	0	30
Sweden	55	5	1	1	1	0	26
Thailand	50	6	3	1	1	1	30
Turkey	22	4	1	3	3	0	30
Uruguay	58	5	0	1	1	0	26
Venezuela	18	5	2	1	1	0	26

5.2 “Borderline” Signals of balance of payment crises

	Monthly indicators			Annual indicators			Total
Country	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Percent of indicators signaling**
Argentina	35	3	0	2	2	0	22
Bolivia	33	8	2	0	0	0	35
Brazil	39	7	3	0	0	0	32
Chile	40	5	2	1	1	0	26
Colombia	49	7	3	3	3	0	43
Czech Republic	85	10	3	4	2	2	61
Denmark	28	5	1	2	2	0	30
Egypt	22	3	2	1	1	0	17
Finland	86	8	1	3	2	1	43
Greece	41	8	3	3	3	0	48
Indonesia	9	4	3	1	1	0	22
Israel	37	6	3	1	1	0	30
Korea	63	11	3	5	4	1	65
Malaysia	40	9	3	0	0	0	39
Mexico	24	2	0	2	2	0	17
Norway	31	7	2	1	1	0	35
Peru	26	5	1	2	2	0	30
Philippines	68	8	3	3	3	0	48
South Africa	63	10	3	2	2	0	52
Spain	55	7	2	1	1	0	35
Sweden	60	6	1	1	1	0	30
Thailand	54	6	3	1	1	1	30
Turkey	33	5	3	3	3	0	35
Uruguay	71	5	1	1	1	0	26
Venezuela	29	5	2	1	1	0	26

5.3 Signals of banking crises

	Monthly indicators			Annual indicators			Total
Country	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Percent of indicators signaling**
Argentina	36	4	0	1	1	1	22
Bolivia	42	8	2	0	0	0	35
Brazil	39	6	2	0	0	0	26
Chile	34	2	1	1	1	0	13
Colombia	38	5	2	3	3	1	35
Czech Republic	81	10	3	4	2	1	52
Denmark	24	4	0	1	1	0	22
Egypt	18	3	0	0	0	0	13
Finland	77	7	1	3	2	1	39
Greece	39	8	3	2	2	1	43
Indonesia	10	3	2	1	1	1	17
Israel	32	6	3	1	1	0	30
Korea	42	10	4	3	3	1	57
Malaysia	42	9	3	0	0	0	39
Mexico	16	4	1	2	2	0	26
Norway	30	8	2	1	1	0	39
Peru	19	5	1	1	1	0	26
Philippines	59	8	3	2	2	0	43
South Africa	55	10	3	1	1	0	43
Spain	51	7	1	1	1	0	35
Sweden	59	5	1	1	1	0	26
Thailand	53	6	2	1	1	1	30
Turkey	27	5	3	2	2	0	30
Uruguay	74	5	1	1	1	0	26
Venezuela	18	4	1	2	2	0	26

5.4 “Borderline” signals of banking crises

	Monthly indicators			Annual indicators			Total
Country	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Total signals**	**Number of indicators signaling**	**Top indicators signaling**	**Percent of indicators signaling**
Argentina	46	7	1	1	1	1	35
Bolivia	45	8	2	0	0	0	35
Brazil	44	9	3	0	0	0	39
Chile	43	7	3	1	1	0	35
Colombia	70	9	3	3	3	1	52
Czech Republic	87	10	3	4	2	2	52
Denmark	29	6	1	1	1	0	30
Egypt	24	3	0	0	0	0	13
Finland	88	8	1	3	2	1	43
Greece	50	9	4	2	2	1	48
Indonesia	14	4	3	1	1	1	22
Israel	49	8	4	1	1	0	39
Korea	74	13	5	3	3	1	61
Malaysia	49	9	3	0	0	0	39
Mexico	30	5	1	2	2	0	30
Norway	37	8	2	1	1	0	39
Peru	27	6	2	1	1	0	30
Philippines	73	8	3	2	2	0	43
South Africa	68	10	3	1	1	0	48
Spain	58	9	2	1	1	0	43
Sweden	66	8	2	1	1	0	39
Thailand	58	9	3	1	1	1	43
Turkey	35	6	3	2	2	0	35
Uruguay	86	6	1	1	1	0	30
Venezuela	34	6	2	2	2	0	35

So who is vulnerable? Ideally, we want to take into account whether a country is vulnerable to either a currency or a banking crises, since so often the two go hand-in-hand. One would also like to give a higher weight to the more reliable indicators. Kaminsky (1998) constructs such a composite index to gauge the probability of a crisis conditioned on multiple signals from various indicators; the more reliable indicators receive a higher weight in the composite index. This methodology and its out-of-sample results are described in the latter part of this chapter.

While we do not tabulate the probability of a crisis in this exercise (this is take up in the following part of this chapter), conditioned on a composite index, in what follows, some of the information on the incidence of signals and the quality of the indicators signaling is presented in summary form for the twenty "emerging market economies" in our sample for currency and banking crises in Table 5.5. The first column tallies a count of the "weighted" signals. Each indicator either sends a signal which we assign the value of one, or does not signal, to which we assign a value of zero. Yet, simply counting the proportion of indicators signaling (as in Tables 5.1-4) does not discriminate among the highly heterogenous performance of the indicators.

To remedy this, we begin by eliminating from our list of potential leading indicators those variables which had a noise-to-signal ratio above unity; this is tantamount to stating that their marginal forecasting ability ($P(C|S)=0$ or less. As Table 3.1 highlights, for banking crises, this eliminates imports, the lending-deposit ratio, the terms of trade, government consumption growth, and FDI/GDP. For currency crises, this drops from the list the domestic-foreign interest rate differential, the lending-deposit ratio, bank deposits, central bank credit to the public sector and FDI/GDP. For the remaining indicators with noise-to-signal ratios below unity, we weighed the signal by the inverse of the noise-to-signal ratios reported in Tables 3.1-4. Hence, for a

currency crisis let's suppose that both the real exchange rate and imports are issuing a signal; the former would receive a weight of 4.55 (or 1/0.22) while the latter would only receive a weight of 1.49 (or 1/0.87). If **all** 18 remaining indicators were sending signals, the maximum value that this index could score is 30.05 for banking crises and 33.23 for currency crisis. This score is a simple sum of the inverse of the noise-to-signal for the indicators that are retained. However, it is seldom the case that every indicator signals. Table 5.5 presents the composite score of the indicators that are signaling for 20 of the emerging markets in our sample for currency and banking crises separately. The first column provides the relevant value for a currency crisis, while the second provides information on the vulnerability of the country (by this measure) relative to the remaining 19 countries. Hence, South Africa, the Czech Republic, and Thailand registered as the most vulnerable on the basis of the signals issued and the quality of those signals in the January 1996-June 1997 period.

For banking crises, the comparable exercise places the Czech Republic, Korea, and Greece as the most vulnerable. Perhaps, not surprisingly, near the bottom of the list are countries such as Mexico and Venezuela which are still recovering from their 1994-95 crises.

Lastly, to assess the extent of vulnerability to financial crises, using alternatives measures we provide information in Table 5.6 on: i) the average proportion of indicators signaling banking and currency crises; ii) average proportion of the top eight indicators (monthly and annual) that are signaling; and the average of the "weighted" indices reported in Table 5.5 for currency and banking crises. The table also ranks the countries, by these three criteria, depending on the degree of "vulnerability."

5.5 “Weighing” the signals: Currency and banking crises in emerging markets

	Currency crises		Banking crises	
Country	**Weighted signals**	**Rank**	**Weighted signals**	**Rank**
Argentina	5.41	16	7.98	10
Bolivia	6.59	12	7.30	13
Brazil	7.57	10	6.08	14
Chile	5.90	15	5.74	16
Colombia	10.59	8	11.87	6
Czech Republic*	15.42	2	17.24	1
Egypt	6.02	14	8.33	9
Greece	14.27	6	14.15	3
Indonesia*	7.54	11	8.33	9
Israel	6.30	13	10.38	8
Korea*	14.57	4	14.55	2
Malaysia*	12.46	7	7.74	12
Mexico	2.82	19	2.59	19
Peru	2.82	19	5.33	17
Philippines*	14.40	5	11.52	7
South Africa	16.52	1	12.74	4
Thailand*	14.63	3	12.09	5
Turkey	8.21	9	7.87	11
Uruguay	4.40	18	4.88	18
Venezuela	5.28	17	6.02	15

Note: An asterisk (*) denotes the country has already had a currency crisis, a banking crisis, or both in 1997-98.

5.6 The vulnerability to financial crises in emerging markets: Alternative measures

Country	Average proportion of indicators signaling both crises	Rank	Average proportion top nine indicators signaling both crises	Rank	Average of the "weighted" signals	Rank
Argentina	29	11	11	5	6.69	14
Bolivia	35	8	22	4	6.94	12
Brazil	36	7	33	3	6.82	13
Chile	31	9	33	3	5.74	17
Colombia	48	4	44	2	11.23	7
Czech Republic*	57	2	56	1	16.33	1
Egypt	15	15	11	5	6.42	15
Greece	48	4	44	2	14.21	4
Indonesia*	22	14	44	2	7.93	11
Israel	35	8	44	2	8.34	9
Korea*	63	1	56	1	14.56	3
Malaysia*	39	6	33	3	10.10	8
Peru	30	10	22	4	4.08	19
Philippines*	46	5	33	3	12.96	6
Mexico	24	13	11	5	2.71	20
South Africa	50	3	33	3	14.63	2
Thailand*	35	8	44	2	13.36	5
Turkey	35	8	33	3	8.04	10
Uruguay	28	12	11	5	4.88	18
Venezuela	31	9	22	4	6.02	16

Note: An asterisk (*) denotes the country has already had a currency crisis, a banking crisis, or both in 1997-98.

Clustered at the top of the list are several of the countries that have had or are still undergoing a financial crises; these countries are denoted by an asterisk (*). This suggests a relatively favorable out-of-sample performance for the "signals" approach. The three measure of vulnerability provide similar rankings for most of the "extreme" cases, such as the Czech Republic, Korea, Malaysia, and the Philippines, among the countries that have already had crises and South Africa, Colombia, and Greece among those that have not. In the case of Greece, however, there was an orderly devaluation, while in Colombia's case there was both a devaluation (in August 1998) as well as serious banking sector difficulties. For countries such as Thailand and to a lesser degree Indonesia taking into account the "quality" of the indicator signalling changes the overall ranking considerably.

While this exercise allows us to weigh the relative propensity to crisis across countries at a point in time, indeed, it is akin to a static snap shot, it does not convey information on the dynamics of the process. To assess to what extent a country is becoming more or less vulnerable to crisis over time, one would need a continuum of such snap shots. The analysis in the next section of this chapter, which maps the composite index described in this section onto the time-varying probability of a crisis fills this gap and allows us to extend our out-of-sample evaluation of the signals approach.

A Composite Indicator: Methodology

In Chapters 3 and 4, we examined the likelihood of a country falling prey to a speculative attack or to a banking crisis by focusing on the information provided by individual indicators. That is, we assessed the odds of a currency crisis after, for example, an appreciation of the domestic currency or the probability of a banking crisis following the collapse of the stock

market. This exercise was useful because it allowed us to discriminate among the types of indicators that may be useful in anticipating the onset of financial crises. At the same time, as discussed in the previous section, this focus on individual signs of trouble may result in an partial picture of an economy in the eve of financial crises. This is because, while currency and banking crises may arise as a result of an isolated shock, most of the time they are preceded by more systemic problems in the economy, including the financial sector.[1]

Most often, crises erupr 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 the "credit crunches" that typically follow overlending cycles. Thus, we need to combine these individual manisfestations of problems into an indicator of economic distress that is continuously evolving.

As discussed earlier, one straightforward way of capturing the fragility of the economy at the onset of a 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 higher the odds of a financial collapse. However, the number of individual indicators "signaling" does not fully use the information provided by the univariate indicators because it does not account for the different forecasting ability of each variable.

[1] See Kaminsky (1998) for a test of the multiplicity of economic problems before crises.

To account for (i) the multiplicity of problems in the economy; (ii) the heterogeneous forecasting ability of the univariate indicators; and (iii) the **time-varying** dimension of the likelihood of a crisis (an issue that we did not address in the previous cross-country

$$I_t = \sum_{j=1}^{n} S_t^j / \omega^j$$

comparisons), we construct the following composite indicator,

In (5.1) it is assumed that there are *n* different univariate indicators. Each indicator has a differentiated ability to forecast crises and, as before, this ability can be summarized by the noise-to-signal ratio, here denoted by ω^j. S_t^j is a dummy variable that is equal to one if the univariate indicator, S^j crosses its critical threshold and is thus signaling a crisis and zero otherwise. As before, the noise-to-signal ratio is calculated under the assumption that an indicator issues a correct signal if a crisis occurs within the following 24 months. All other signals are considered false alarms.

Once we construct this composite indicator, we can then proceed as we did with the individual indicators in Chapters 2- 3 to choose a critical value for the composite indicator so that when the composite indicator crosses this threshold, a crisis is deemed to be "imminent."[2] As before, this "critical" threshold could chosen so as to be the one that minimizes the noise-to-signal ratio of the composite indicator. Moreover, we could also calculate the probability of a crisis conditional on the composite indicator signaling a crisis (i.e., crossing the critical threshold) as well as the odds of a crisis when the composite indicator is not signaling.

[2] Meaning, as in the individual indicators, in the next 24 months.

However, this procedure would not give us an exhaustive report of the extent of the built-up of weakness in the economy as the crisis approaches. Since, it is dichotomous, it will only provide two types of information–namely, signal or no signal.

To introduce shades of grey,however, we are going to proceed somewhat differently in what follows. We are going to track the build-up of weaknesses in the economy and assess the how the likelihood of a crisis evolves over time. For each value of the composite indicator at a point in time we will calculate the corresponding probability of a crisis. Hence, as the numerical value of the composite indicator increases (as the number of reliable signals increase)–so does the probability of a crisis.

The idea is to analyze the empirical distribution of the indicator jointly with the occurrences of crises and estimate probabilities of crises conditional on different values of the composite indicator. We would like to evaluate what the odds of a crisis are if none of the univariate indicators are signaling, that is when the composite indicator takes on a value of zero or when all the univariate indicators are signaling and the composite reaches its maximum value. But we would also like to evaluate the intermediate scenarios, which depend on both how many and which of the indicators are signaling, as the more reliable indicators are assigned a higher weight in the composite. For example, we would like to calculate the probability of a crises conditioned on knowing that the value of the indicator is in the 9-12 range, which as we saw from the cross- section analysis earlier in this chapter was associated with a number of the recent crises (see Table 5.5).

In practice, we can construct this set of probabilities using the information on the value of the composite indicator for all the countries in the sample together with the information on crises. Probabilities of crises are estimated as follows:

$$P(C \mid \underline{I} < I_t < \bar{I}) = A/(A+B)$$

where $\underline{I}$ is the lower bound of the range we are interested in (9 in our earlier example) and is the upper bound of the range we are interested in (12 in our example).

Hence, as before, we have the following two by two matrix,

	Crisis occurs in the following 24 months	**No crisis occurs in the following 24 months**
_____	A	B
	C	D

These probabilities will be estimated using all the information from all the countries in the sample. Once we estimate these probabilities and using the information on the number of signals being issued at any moment of time, we can construct time series probabilities of crisis for every country P_t^m is the probability of crisis of country *m* in period *t*.

Once we construct these time series of crises probabilities, we can also evaluate the forecasting ability of the composite indicator and compare its track record to that of other indicators, such our top-ranked univariate indicator, the real exchange rate. To conduct this "horserace," we follow Diebold and Rudebusch (1989) and employ the Quadratic Probability Score (*QPS*) as our metric of goodness of fit. In particular, the *QPS* evaluates the average closeness of the predicted probabilities and the observed realizations, as measured by a dummy variable that takes on a value of one when there is a crisis and zero otherwise. [3]

[3] This approach has been also to assess the ability of various indicators to anticipate turning points in the business cycle (see Diebold and Rudebusch 1989).

$$QPS^k = 1/T \sum_{t=1}^{T} 2(P^k_t - R_t)^2$$

where $k=1,2,3$ refers to the indicator, P^k_t, refers to the probability associated with that indicator and R_t are the zero-one realizations. The QPS rages from zero to two, with a score of zero corresponding to perfect accuracy.

A Composite Indicator: Empirical Results

The methodology described in Chapter 5 was applied to the countries in the sample. In what follows, we first examine the sample probabilities of crises using the information from the composite indicator so as to have a reading on the links between the state of the economy and the eruption of banking and currency crises. Second, we examine the performance of the composite indicator both in-sample and out-of-sample and we rank the indicator ability relative to that of a naive forecast of crises and that of the best univariate indicator: the real exchange rate. Third, we examine the onset of the Asian crisis as captured by the probabilities of crises obtained using the composite indicator.

Table 5.7 reports the conditional probabilities of both currency and banking crises using the composite indicator. The left-hand side panel reports the likelihood of currency crises. When almost none of the indicators are signaling a future crisis, the composite indicator takes on values between zero and two, the probability of a currency crisis is about 10 percent, and substantially smaller than the unconditional probability of crisis, that is about 30 percent. However, the probability of a currency crisis increases sharply and nonlinearly as the signs of vulnerability of the economy increase, with the probabilities of a currency crisis reaching almost 100 percent when the indicator is about 15 or larger. The right panel reports the same evidence

for banking crises. As in the case of currency crises, the probabilities of a collapse of the banking sector increase sharply as the economy deteriorates. However, as we found with the univariate indicators, banking crises (Chapter 3) are harder to anticipate. Even when nearly all the univariate indicators are signaling, the probability of a banking crisis only climbs to about 40 percent.

Table 5.7 The Composite Indicator and Conditional Probabilities of Financial Crises

Value of indicator	**Probability of a currency crisis**	**Probability of a banking crisis**
0-1	0.10	0.03
1-2	0.22	0.05
2-3	0.18	0.06
3-4	0.21	0.09
4-5	0.27	0.12
5-7	0.33	0.13
7-9	0.46	0.16
9-12	0.65	0.27
12-15	0.74	0.37
0ver 15	0.96	n.a.
Memorandum items:		
	Unconditional probability of a currency crisis	**Unconditional probability of a banking crisis**
	0.29	0.10

The next table examines the forecasting accuracy of the composite indicator.

The top panel in Table 5.8 looks at currency crises, the bottom panel examines the same evidence for banking crises. In both cases, the performance of the composite indicator is compared to the performance of the real exchange rate--the best univariate indicator-- as well as the naive forecast based on the unconditional probability of crisis. The score statistics are reported separately for "Crisis Times" and for "Tranquil Times" to examine whether the performance of the different leading indicators varies across regimes.

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. Overall, the composite indicator performs better--in terms of accuracy-- than the real exchange rate, but the larger improvements are obtained when forecasting in crisis times, suggesting that in fact, crises erupt (more often than not) when there is widespread economic distress.

As shown in the bottom panel, all indicators score worse when predicting the onset of the banking crises, that is the 24 months around the beginning of the banking crises. 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 indicator outperforms the real exchange rate when forecasting the onset of crisis, but is in general outperformed by the real exchange rate during tranquil times. This is explained by the fact that the real exchange rate issues very few false alarms during tranquil periods.

Table 5.8. Scoring the Forecasts: Quadratic Probability Scores

	Currency crises		**Banking crises**	
Indicator	Tranquil times	Crisis Times	Tranquil Times	Crisis Times
Naive forecast	0.173	1.008	0.024	1.620
Real Exchange Rate	0.115	0.979	0.018	1.589
Composite indicator	0.024	0.862	0.024	1.309

A Composite Indicator: An Out-of-Sample Application to Southeast Asia

Using the information on the monthly value of the composite indicator and the conditional probabilities of crises in Table 5.7, we can construct series of probabilities of crises for countries both in-sample, from January 1970 to December 1995, and out-of-sample, from January 1996 to December 1997. As an illustration, Figure 1 reports, the time-series probabilities of currency crises implicit in the composite indicator for four Southeast Asian economies in the 1990s. The shaded areas in the figures are "crisis times." Table .. complements this information by providing desaggregated information on the source of the signals. This table quantifies, crisis by crisis, the number of the indicators showing "unusual" behavior in the 24-month period prior these crises, with a 1 denoting unusual behavior and a 0 denoting normal behavior.

With the exception of Indonesia, all the Southeast Asian countries show a severe state of distress with about 65 percent of the indicators flashing signals. These currency crises are the paradigm of a typical financial crisis, with the onset of these crises occurring as the economies

enter a marked slowdown in growth after a prolonged boom in economic activity fueled by rapid credit creation.[4] This dramatic surge in credit is, in large part, explained by heavy capital inflows and partly by the reform of the financial system, which is accompanied by drastic reductions in reserve requirements. Overall, the explosive growth in these countries comes to an end with a real appreciation of the domestic currencies (which are, in differing degrees, tied to the U.S. dollar) and the corresponding loss of export markets. It is noteworthy that during the latter part of this period there is a substantive appreciation of the dollar vis-a-vis the yen.

For instance, short-term capital inflows to Thailand amount to 7-10 percent of GDP in each of the years 1994-1996, with the growth rate of credit to the nonfinancial private sector over 1990-1995 amounting to more than 23 percent. While in the early 1990s, output growth rates increase to almost 9 percent fueled in part by easy credit, this rapid economic growth in Thailand shows signs of coming 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). Financial sector fragilities are also evident, with runs against major banks starting to occur as early as May 1996. Finally, the sharp increase in interest rates in 1997 to defend the baht puts the nail in the coffin of the already defunct banking sector.[5] Overall, 75 percent of the indicators for which there is available data were exhibiting "anomalous" behavior.

[4]This is at odds with the interpretation of these crises provided in Radelet and Sachs (1998), who argue these crises are the byproduct of a financial panic.

[5] It is noteworthy that finance companies had been receiving substantial assitance from the central bank during this period.

The boom-bust cycle in lending is also evident in the Philippines, fueled as in Thailand by capital inflows but also by a dramatic reduction in reserve requirements, as they underwent financial liberalization. Bank credit increases by 44 percent a year in 1995-1996. As in Thailand, the rapidly expanding credit is an important contributor to the rally in stock and real estate markets, with a four-fold increase in prices in both markets. As in other countries in the region, foreign currency exposure increases in the Philippines in the 1990s through foreign borrowing to finance domestic lending, with foreign borrowing concentrated at short maturities. 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 anticipates a future decline in growth and also contributes to a substantial deterioration of the quality of banks' assets, further reducing the odds of survival of many individual financial institutions. Overall, in the Philippines, about 50 percent of the indicators are signaling the increased vulnerability of the economy in the two years prior to the collapse of the implicit peg in July 1997.[6]

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 shrinking to -5.3

[6] The Philippines was classified as a managed float in the IMF's exchange rate arrangements classification. Yet, even a relatively uninformed bystander could see the large scale extent of foreign exchange intervention prior to mid-1997, which kept the Philippine peso's value virtually unchanged agaist the dollar.

percent (in Thailand the current account/GDP ratio in 1996 is still -8.0 percent). Moreover, Malaysia as Thailand accumulates debt rapidly in the 1990s, with capital inflows fueling a stock and real estate market boom, with prices increasing about 300 percent in the early 1990s. Malaysia is also suffering from financial sector vulnerabilities (although not to the same extent as the other) as a result of the high degree of leveraging in the economy. Indeed, Malaysia has one of the highest credit-to-GDP ratio in the world and the banks have a large exposure to the property and equity markets. For Malaysia, about 60 percent of the indicators are showing signs of distress at the onset of the crisis.

Indonesia, however, looks somewhat different. While it is still true that, as the other countries in the area, it is exhibiting banking fragilities and short-term debt sharply exceeds available foreign exchange reserves (about 1.7 times the stock of foreign exchange reserves of the country).[7] the current account deficit is not deteriorating as fast --only reaching 3.5 percent of GDP in 1996, 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. Only very few indicators (less than 20 percent) are showing signs of strains in the economy in the months prior to the crisis. While the degree of distress in the domestic economy in the months prior to the crisis cannot explain the meltdown of the rupiah and of the economy as a whole in 1998, the flurries of financial crises in 1997 do add a severe element of instability as Indonesia and the other countries in the region are left scrambling for liquidy when Japanese banks --the major lenders to the region-- pull out rapidly across countries after the major losses suffered in the wake of the Thai crisis.[8]

[7] 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. Most state-owned banks are also experiencing serious difficulties.

[8] The reversal was, in fact, quite pronounced, from capital inflows to the region of US

$50 billion in 1996 to an outflow of US $21 billion in 1997. See, Kaminsky and Reinhart (1998b) and the next chapter for a discussion on world and regional financial links and their effects on the probability of currency crises.

This chapter has focused on a specific early warning system for currency crises, which basically highlights that poor domestic economic conditions, either due to mistakes in public policy or private sector behavior, are the trigger mechanism of financial crises. We have also examined, however, that this was not always the case. As we examine in greater detail in the next chapter, the frailty of an economy can be exacerbated by currency crises in other countries. For example, Indonesia falls prey of a liquidity crunch when Japanese banks recall their loans from all the Asian countries they had made loans to after suffering major losses with the devaluation of the Thai baht. Similarly, the fierce but unsucsseful speculative attack on the Argentine peso following the devaluation of the Mexican peso are difficult to explain on exclusively on the basis of economic fundamentals at the time of the attack. In the next chapter, we combine the information on the domestic economy with that of possible spillover effects from other countries in crisis.

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APPENDIX A: DATA AND DEFINITIONS

Crisis index: The index is a weighted average of exchange rate and reserve changes, with weights such that the two components of the index have equal conditional volatilities. Since changes in the exchange rate enter with a positive weight and changes in reserves have a negative weight attached, readings of this index that were three standard deviations or more above the mean were cataloged as crises. For countries in the sample that had hyperinflation, the construction of the index was modified. While a 100 percent devaluation may be traumatic for a country with low-to-moderate inflation, a devaluation of that magnitude is commonplace during hyperinflations. A single index for the countries that had hyperinflation episodes would miss sizable devaluations and reserve losses in the moderate inflation periods, since the historic mean is distorted by the high-inflation episode. To avoid this, we divided the sample according to whether inflation in the previous six months was higher than 150 percent and then constructed an index for each subsample. Our cataloging of crises for these countries coincides fairly tightly with our chronology of currency market disruptions. Eichengreen, Rose, and Wyplosz (1995) also include interest rates in this index, however, our data on market-determined interest rates for developing countries does not span the entire sample.

The indicators:

Sources: International Financial Statistics (IFS), International Monetary Fund; Emerging Market Indicators, International Finance Corporation (IFC); World Development Indicators, the World Bank, 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 to base money, (IFS lines 34 plus 35) divided by IFS line 14.

2. Domestic credit/nominal GDP: IFS line 52 divided by IFS line 99b (interpolated). Monthly nominal GDP was interpolated from annual or quarterly data.

3. Real interest rates on deposits: IFS line 60l, monthly rates, deflated using consumer prices (IFS line 64) expressed in percentage points.

4. The ratio of lending rates to deposit rates: IFS line 60p divided by IFS line60l; was used in lieu of differentials to ameliorate the distortions caused by the large percentage point spreads observed during high inflation. In levels.

5. "Excess" real balances: M1 (IFS line34) 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 line99b), 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. Excess money supply (demand) during pre-crisis periods (mc) is reported as a percent relative to excess supply (demand) during tranquil times (mt)--that is, 100 x (mc-mt)/mt.

6. M2 (in US dollars)/reserves (in US dollars): 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.

8. Exports (in US dollars): IFS line 70.

9. Imports (in US dollars): IFS line 71.

10. The 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: This measure used is based on consumer price indexes (IFS lines 64) and is defined as the relative price of foreign goods (in domestic currency) to the price of domestic goods. If the central bank of the home country pegs the currency to the dollar (Deutsche mark), the relevant foreign price index is that of the United States (Germany). Hence, for all the European countries the foreign price index is that of Germany while for all the other countries, consumer prices in the United States were used. The trend was specified as, alternatively, log-linear, linear, and exponential; the best fit among these was selected on a country-by-country basis. Deviations from trend during crisis periods (dc) were compared to the deviations during tranquil times (dt) and are shown in Figures 2 and 3 as a percent of the deviations in tranquil times (i.e.,100 x (dc-dt)/dt).

12. Reserves: IFS line 1L.d**.**

13. Domestic-foreign interest rate differential on deposits: Monthly rates in percentage points. IFS lines 60l. Interest rates in the home country are compared with interest rates in the United States (Germany) if the domestic central bank pegs the currency to the dollar (Deutsche mark). The real interest rate is given by $100 \times [((1+ i_t)p_t / p_{t+1-1}]$.

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).

15: Stock returns (in dollars): IFC global indices are used for all emerging markets; for industrial countries the quotes from the main bourses are used.

16. Overall budget balance/GDP: Consolidated public sector balance as share of nominal GD