

Some statistical indicators of financial crises: Evaluation of the capability to issue early warnings

Crisi Finanziarie: Capacità Segnaletica Di Alcuni Indicatori Statistici

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Riassunto: Il lavoro sviluppa e valuta un sistema per la previsione di crisi finanziarie basato su un approccio per segnali, che monitorizza diverse variabili mostranti un comportamento inusuale nei periodi precedenti le crisi. Un indicatore che superi un determinato valore soglia, lancia un segnale che potrebbe verificarsi una crisi finanziaria nei successivi 24 mesi. Nonostante alcuni falsi allarmi, la performance degli indicatori è ragionevolmente buona ed il modello si è dimostrato utile nella previsione delle crisi.

Keywords: Currency crises, leading indicators, nonparametric test, composite index.

1. The scope of the analysis

The empirical study examines 26 developing countries that experienced at least one financial crisis since the 1970s. These countries form four regional groups: Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay and Venezuela), Africa and Middle East (Egypt, Israel, Turkey and South Africa), Asia (India, Indonesia, Malaysia, Philippines, Singapore, South Korea and Thailand), Central and Eastern Europe (Bulgaria, Czech Republic, Hungary, Poland and Romania).

In the signal approach of Kaminsky, Lizondo and Reinhart (1998) or in mixed approach of Berg e Pattillo (1999), the vulnerability to a crisis is signaled when a variable deviates from its “normal” level beyond a certain threshold value. The choice of the indicators was dictated by theoretical considerations and by the availability of information. This paper adds several explanatory variables (current account deficit/GDP, foreign debt/exports, budget deficit/GDP, US yield curve, US output, oil price, US interest rates, Morgan Stanley Capital Index or MSCI, US GDP forecasts, and Emerging Markets Bond Index or EMBI) to those of the original model (real exchange rate, reserves, M2/reserves, real interest rates, exports, commercial deposits, M2 multiplier, index of equity prices, imports, output, real interest rates differential, lending to deposit ratio). For most of these variables the indicator on a given month is defined as the percentage change in the level of the variable with respect to its level a year earlier. Filtering the data by using the 12-month percentage change ensures that the variables are stationary and free from seasonal effects. The filter was not used for variables based on interest rates, for the three annual indicators (current account balance/GDP, budget deficit/GDP, foreign debt/exports), and for the deviation of the real exchange rate from the trend. Some variables signal with their high (upper) values, other with their low (lower) values. Imports and M2 multiplier proved to deliver useful signals of vulnerability both with their upper and lower values. The historical data horizon is Jan 1970 – Dec 1998. The last three years are dropped from the sample to provide a window

to evaluate the predictive capabilities of the model for the last crises. The crisis window (the time interval over which one is predicting a crisis) is set at 24 months.

2. The definition of currency crisis

A currency crisis is defined as a situation in which an attack to a currency leads to substantial reserve losses, or to a sharp depreciation of the currency, or to both. This crisis definition includes both successful and unsuccessful attacks to a currency. Crises are identified (ex-post) by the behaviour of an exchange market pressure index, that is constructed for each country. The index is the weighted average of exchange rate changes and reserves changes.

The exchange market pressure index is as follows: $emp_t = \%De_t - \alpha \%Dr_t$, where $\%De_t$ denotes the percent changes of the foreign currency per numeraire currency (that is, US dollar) at time t , $\%Dr_t$ denotes percent changes of the foreign reserves, α is the ratio of standard deviation of the rate of change of the exchange rate to the standard deviation of the rate of change of reserves. Periods in which the index is above its mean by more than 2.5 standard deviation are defined as crises.

3. The statistical method to generate predictions

The approach used in this paper is univariate, in that each variable is analysed separately. The approach involves monitoring a set of variables, country by country, and identifying when they deviate from their “normal” level beyond a certain threshold value. The thresholds are defined relative to the percentile of the distribution of the indicator by country. The threshold levels are calculated so as to strike a balance between the risks of having many false signals and the risk of missing many crises. When a variable issues a signal and a crisis follows within the crisis window, it is considered a “good” signal, when a crisis does not follow within the crisis window, it is a “bad” signal or noise. A variable, that does not issue the signal and a crisis follows, is a “missed” signal; a variable, that does not issue the signal and no crisis follows, is a “good silent” signal. The threshold is calculated so as to minimize the noise-to-signal ratio, which is the ratio of bad signal to good signal (the ratio of bad signals as a proportion of months in which false signal could have been issued and the good signals as a proportion of months in which good signal could have been issued).

4. In-sample results

The noise-to-signal ratio is the criterium to identify the reliable indicators. The indicators that have a noise-to-signal ratio lower than unity are considered helpful in predicting crises (since a signaling device that issues signal at random times, and thus with no intrinsic predictive power, would obtain, with a sufficiently large sample, a noise-to-signal ratio equal to unity). Among the 24 indicators tested, 17 proved to be useful. Table 1 shows the performance of each indicator. The critical region represents the percentile of the distribution (upper or lower) characterised by the minimum noise-to-signal. The variables are ordered according to the noise-to-signal ratio. The best

variables are: real exchange rate, current account balance/GDP, reserves and M2/reserves. The table shows also that 7 indicators have to be drop from the list of reliable indicators, since their noise-to-signal ratio is higher than unity. The share of crises correctly called is the fraction of crises in which the indicator signals at least once within the crisis window. The last column shows the conditional probability of crisis, or the probability that a crisis will occur given that the indicator is signaling that it will (it is calculated as the ratio of good signal and the sum of good and bad signal).

Table 1: Performance of the indicators

Variables	Number of crises	Critical region	Noise-to-signal ratio					Probability of crisis
			Total	Latina America	Africa and Middle East	Asia	Central and Eastern Europe	
Real exchange rate	91	0,10	0,33	0,28	0,14	0,35	3,46	0,47
Current account balance / GDP	49	0,12	0,35	0,42	0,09	0,60	0,48	0,44
Reserves	75	0,10	0,42	0,40	1,08	0,41	0,20	0,37
M2 / reserves	71	0,14	0,47	0,32	0,84	0,71	0,14	0,37
Foreign debt / exports	83	0,10	0,62	0,51	0,25	1,46	0,80	0,33
Real interest rates	61	0,10	0,71	1,06	0,66	0,44	1,18	0,32
Exports	75	0,10	0,72	0,49	1,26	0,75	0,83	0,25
Commercial deposits	63	0,11	0,74	0,68	0,78	0,82	0,94	0,27
Budget deficit / GDP	49	0,18	0,77	1,68	0,54	1,45	0,37	0,29
M2 multiplier (lower threshold)	69	0,19	0,77	0,71	1,06	0,67	1,31	0,26
Stock index	47	0,19	0,81	0,64	0,93	0,84	1,03	0,25
US yield curve	45	0,13	0,82	0,89	0,69	1,69	0,31	0,27
Imports (lower threshold)	95	0,20	0,84	0,68	0,80	1,02	1,78	0,25
M2 multiplier (upper threshold)	69	0,14	0,86	0,60	0,92	1,41	1,66	0,24
US output	95	0,13	0,89	0,70	0,92	1,26	1,18	0,24
Output	51	0,19	0,97	0,97	0,79	0,83	1,84	0,25
Imports (upper threshold)	95	0,10	0,99	1,33	0,64	1,01	0,61	0,23
Real interest rates differential	61	0,20	1,02	1,27	1,00	0,75	1,37	0,25
Oil price	95	0,14	1,06	1,49	0,80	0,70	1,40	0,19
US interest rates	95	0,20	1,10	1,40	0,85	0,94	0,44	0,21
US GDP forecasts	95	0,20	1,20	1,03	1,32	1,48	1,31	0,17
Lending to deposit ratio	43	0,12	1,34	1,60	1,14	1,50	0,99	0,16
EMBI	29	0,17	1,47	1,04	4,17	2,36	1,28	0,18
MSCI	43	0,20	1,54	1,13	1,59	2,05	1,86	0,16

Calculating the Kendall (1948) multiple correlation coefficient, based on the ranks, it has been verified the homogeneous behaviour of the indicators among different regions. With a suitable transformation we sampled the Kendall coefficient with the Friedman (1940) test, where the statistic test for enough large samples is distributed as a χ^2 (chi-square) with d.o.f. equal to the number of indicators minus one. As the observed χ^2 (37.33) is significantly above the χ^2 at 5% (35,17), it is reasonable to reject the null hypothesis that the behaviour of the indicators among different areas may be heterogeneous. This allows us to use the indicators or an appropriate composite index.

5. Out-of-sample results

In order to calculate the probability of crisis associated to each country, it is necessary to develop a composite crisis indicator. It sums the number of indicators that are signaling at any point of time that there is a crisis, weighting more heavily the signal issued by indicators shown to have more reliable forecasting performance. The weights it uses are the inverse of the noise-to-signals ratios. The composite indicator is defined as follows:

$$I_t = \sum_j S_{ij} * w_j^{-1} / \sum_j w_j^{-1} \quad \text{for } j = 1, 2, \dots, 24$$

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

It is possible to calculate for each range of value of the composite index an associated probability of future crisis $P(C_{t, t+h} | I_r \leq I_t < I_v)$, where P denotes the relative frequency, $C_{t, t+h}$ is the occurrence of a crisis in the interval $(t, t+h)$, h is the crisis window (24 months), I_t is the weighted index, I_r and I_v denote lower and upper intervals for the composite index indicator. $P(C_{t, t+h} | I_r \leq I_t < I_v)$ may be assumed as the probability that a crisis will occur within h months at time t , given that the composite indicator I_t falls within the range I_r and I_v . We verified a very high linear correlation, $r=0,99$, between the value of the composite index and the probability of crisis.

Fig. 1 and 2 show an example of the out-of-sample performance of the exchange market pressure index and of the composite index of future crisis for the years preceding the last Turkey crisis. The emp_t signals a crisis in 1994 and one in 2001. The composite index has been able to predict the crises reasonably well, with the value of the index more elevated prior to both crises periods.

Fig. 1: Exchange market pressure index

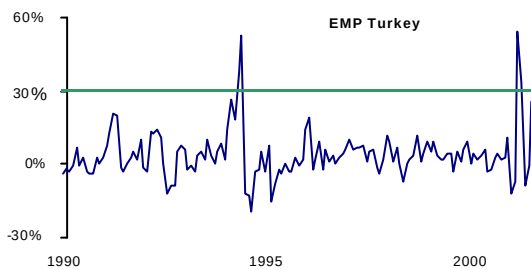


Fig. 2: Composite index of currency crisis



6. Conclusions

Considering the poor performance of market indicators such as agencies' ratings and interest rates in predicting currency crises, a more articulated early warning system proved to be necessary. The performance of our set of indicators is mixed: they give rise to some false alarms, but they can anticipate reasonably in advance most of the crises. Once a composite index is developed, the forecasting performance improves. There are still some false alarms, but they are smoothed by the index. This model is not able to predict the exact timing of crises, but it is a good diagnostic tool to show the vulnerabilities to financial crises.

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