Currency Crises in the Emerging Economies

The increasing number of currency crises in emerging countries in recent years and the implied threats for a globalised financial system have generated renewed interest in the close analysis of emerging economies, in order to foresee potential difficulties and react in a timely manner to prevent their adverse effects.

Looking backward, each crisis has differed in type from the preceding one: the Latin American debt crisis in the 1980s was different from the Mexican crisis of 1994 and the crisis in South-East Asia in 1997. Theoretical analysis has responded to these differences. The so-called "first generation" models which were based on debt sustainability factors, were derived primarily in response to the crises in Latin America in the 1980s, but failed to provide adequate explanations of the crises which followed. "Second generation" models put the emphasis on the self-fulfilling nature of expectations, the authorities' determination to protect their exchange rates and the resulting cost to the economy. Initially created to explain the crises affecting the European Exchange Rate Mechanism in 1992 and 1993, these models recognise that an exchange rate crisis is not necessarily triggered by "fundamentals". However, neither of these generations of models took account of all the significant factors behind the 1997 Asian crisis. The most recent models aim to take the specific features of the Asian crisis more fully into consideration, notably by modelling behaviour linked to moral hazard and asymmetrical information which is at the root of the banking sector's difficulties. Moreover, debt sustainability, the usual cause of balance of payments crises, was not a major problem in this case. The Asian countries were faced with a liquidity crisis which made it temporarily impossible to make short-term repayments. The crisis did not threaten their ability to meet long-term repayments, as had been the case in Latin America in 1980.

Notwithstanding these typological differences, successive crises have unfolded in very similar ways. The following sequence is always present: depletion of foreign exchange reserves, capital outflow, abrupt depreciation of the currency followed by a sudden recession allowing an adjustment of the current account balance. It is therefore interesting to consider whether consistencies can be identified, not only during the crisis, but also in the events leading up to it. If certain economic variables followed a particular pattern of behaviour prior to the outbreak of crises, they could be used as "leading indicators" in predicting crises. This identification has been the subject of recent empirical studies seeking a statistical relationship between the onset of crises and the value of certain indicators. This work, carried out by Kaminsky, Lizondo and Reinhart (1996), the International Monetary Fund, the World Bank and several central banks [1], analyses economic variables from a large sample of countries over a long period. Comparison of "crisis periods" and "tranquil periods" using various statistical techniques shows that trends in certain economic variables such as a sudden widening of the current account deficit, may be correlated with the subsequent outbreak of a crisis. The identified variables can then be used to determine the probability of a crisis arising within each period, for each country, within a given time horizon.

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1 Notably the Bundesbank, the Bank of Canada, the Austrian National Bank, the Federal Reserve Bank of New York and the Federal Reserve System.

The aim of this paper is to report the findings of a study of leading indicators (scores), which make it possible to estimate the probability of crises and thus allow a better assessment of the currency risk in emerging economies [2]. The difficulty lies in finding indicators that give early warning of all crises, including the most recent ones. However, the bulk of studies in this field, for instance Frankel and Rose (1996), do not include the most recent crises simply because they were published before these crisis occurred. Furthermore, some studies examine only one type of crisis: Sachs, Tornell and Velasco (1996), for instance, studied the Mexican crisis, while Radelet and Sachs (1998) concentrated on the Asian crisis. In using a broad sample of emerging economies considered from 1980 to 1997, we have attempted to identify features common to all these crises beyond their individual specificities. This, hopefully, will enable this method to detect future crises, which, despite their specific features, may retain the same important common factors.

The first part of the paper describes some of the characteristics of the leading indicators. The second deals with the definition of crises, and the third sets out the results of the scoring approach.

Olivier BURKART
General Secretariat of the Banking Commission
General Banking System Supervision Directorate
Supervisory Policy and Research Division
Virginie COUDERT
Directorate General Operations
Directorate General Economics and International
Foreign Exchange Directorate
International Market Analysis Division

[2] A more detailed French-language version of this paper is available on the Banque de France web site (at *www.banque-france.fr*/informations bancaires et financières/la Commission bancaire et le contrôle bancaire/Études du Secrétariat général de la Commission bancaire/les documents de discussion et d'étude).

1. Features of leading indicators

1.1. The problem under consideration

Generally speaking, a leading indicator of crises is an economic variable or a combination of variables, which upon crossing a critical threshold, emits a signal heralding a crisis which is supposed to follow within a given time horizon, generally fixed between one and two years. The ideal leading indicator emits signals only before crises. The number of signals emitted just prior to the crisis is compared to the number of false alarms in order to assess the relevance of the various indicators in a given sample comprising a number of time periods and countries. The ratio of unpredicted crises to predicted crises must also be taken into account. Generally, four types of situations may arise:

– A: the indicator predicts a crisis within a given time period and the crisis really occurs within this period (1 or 2 years);

– B: the indicator predicts a crisis but no crisis occurs. This is a "false alarm";

– C: the indicator does not predict a crisis but a crisis occurs;

– D: the indicator does not predict a crisis and no crisis occurs.

These situations are grouped in table 1. Whatever the method used to construct leading indicators, the observation space can always be divided into these four categories.

Table 1
Four types of situation

	A crisis occurs	No crisis occurs	
The indicator predicts a crisis	A Correctly predicted crises	B Wrongly predicted crises	A + B Total number of crises predicted
The indicator does not predict a crisis	C Unpredicted crises	D Correctly predicted non-crises	C + D Total number of non-crises predicted
	A + C Total number of crises	B + D Total number of non-crises	

Two types of errors are therefore possible. They correspond to the second diagonal of table 1 :

– wrongly detecting non-existent crises (square B) or;
– the failure to detect real crises (square C).

The results of the model depend on the weight given to the two types of errors. One has to choose between the latter by varying the alarm thresholds. Depending on the threshold value chosen, an indicator which detects a large number of crises (A/A + big C) will tend to give more false alarms than the same indicator with a lowered alarm threshold. This trade-off is unavoidable.

1.2. The various methods

These indicators are constructed based on statistical methods, most often the analysis of signals or Logit/Probit models.

Kaminsky, Lizondo and Reinhart (1996) used the "signal" approach. They analysed behaviour patterns of a large number of monthly economic variables relating to real economic activity, prices, foreign trade, money (M2) and finance in a wide sample of emerging economies studied over a long period. They considered that a crisis "signal" was emitted when an economic variable crossed a crucial threshold. The threshold value was calculated so as to minimise the "ratio of noise-to-good signals" equal to (B/B + D)/(A/A + C), for each variable. The authors identify and compare their performances by classifying two types of errors, as is done in table 1.

In the Probit/Logit models, an econometric regression is carried out to explain a dichotomous crisis indicator equal to 0 or 1 using different economic variables. The probabilities of a crisis occurring are derived from the values calculated by this regression. Most studies on the subject – e.g. Frankel and Rose (1996), Berg and Patillo (1998), Deutsche Bundesbank (1999) – apply this method.

This paper is based on the discriminant analysis technique which will be reviewed briefly hereunder.

1.3. The main economic variables

The indicators used in existing literature may be grouped into several categories:

– external indicators linked to the current account: real exchange rates, trade balance, growth in exports, current account, terms of trade etc.;

– indicators linked to capital flows: reserves, short-term capital flows, foreign direct investment etc.;

– debt and payment behaviour ratios: debt to gross domestic product or exports, debt service, share of short-term debt in total debt etc.;

– financial indicators: credit to the public and private sectors, its expansion and the ratio of credit to gross domestic product, money supply, stock prices, interest rates etc.;

– macroeconomic indicators: gross domestic product, investment, savings, inflation, public deficit etc.

All known indicators are systematically listed in the study by Kaminsky, Lizondo and Reinhart (1997). The study finds that the best indicators are apparently the real exchange rate, domestic credit, credit to the public sector and inflation. The trade balance, export performance, increase in money supply and gross domestic product and public deficit may also provide early warnings of crisis. The period considered in these studies did not however include the Asian crisis.

The paper by Radelet and Sachs (1998) is one of the most recent studies and therefore one of the few which includes the Asian crisis in its sample. The most significant ratios are the ratio of short-term debt to reserves (as opposed to the ratio of total debt to reserves) and trends in credit to the private sector. Neither the real exchange rate nor the current account appear to be significant.

This paper tests all the usual variables relating to national accounts, external accounts, and debt while striving to improve certain aspects of these variables. For example, overvaluation is assessed by measuring the deviation of the effective exchange rate from its long term value. Furthermore, we insert a regional contagion variable equal to the number of crises which have occurred in the region over the last quarter.

2. Defining currency crises

Prior to constructing leading indicators of currency crises, it is necessary to identify the crisis periods in the sample as a whole.

A first approach consists in using a factual approach or obtaining expert judgements. A currency crisis can thus be deemed to have occurred if there has been a sharp depreciation of the exchange rate, if the government has announced a devaluation, has suddenly modified the exchange rate regime, restricted capital flows, or has shut down the currency market for a few hours. Using this approach, Kaminsky and Reinhart (1996) drew up a list of crises for a large number of countries. The drawback with this approach is that it introduces an element of subjectivity.

A second approach consists of applying a rule on a statistical basis. The economic literature proposes different rules for the detection of crises, by, for instance fixing thresholds beyond which depreciations of the currency and losses in foreign exchange reserves become crises. We, first of all, endeavoured to reproduce these indicators in order to compare them. The comparison showed that the results differed according to the indicator used. We then decided to select the indicator based on a rule, which corresponded most closely to the crises listed in Kaminsky and Reinhart's study (1996), and to complement it with a judgement of experts.

2.1. Simultaneous currency crises indicators in existing literature

"Indicators of pressure on the currency markets" are calculated as weighted averages of variations in exchange rates and foreign exchange reserve losses. They therefore also make it possible to identify crises which have failed to materialise. This was done by Sachs, Tornell and Velasco (1996) who studied the following indicator *Ind*:

$$Ind = (e/V(e) + r/V(r))/(1/V(e) + 1/V(r))$$

where *e* stands for the exchange rate against the dollar and *r* for reserves. The two series are considered on a quarterly basis and the reserves are put into negative mode. *V* is the conditional variance.

This indicator can be easily transformed into a dichotomous variable. There is a currency crisis if the indicator exceeds a specific threshold, equal to the mean plus two or three standard deviations. This method is used for instance by Kaminsky and Reinhart (1997) or Corsetti, Pesenti and Roubini (1998). Further measures must be applied to countries which have experienced periods of hyperinflation. For these countries, the sample is split into two in order to separate hyperinflationary periods from others so as to calculate the mean and the standard deviations.

The indicators of "actual crises" take into consideration only the crises which have actually led to a depreciation of the exchange rate. Such indicators refer only to exchange rate variations; foreign reserve losses are set aside. Frankel and Rose (1996) and Milesi-Ferretti and Razin (1998), who studied emerging and developing economies, used the variation in nominal exchange rates as their sole indicator. This choice may be justified by the fact that, for emerging economies, attacks on the currency generally lead to depreciation. After the elimination of hyperinflation bias, any atypical depreciations of the exchange rate are then considered to be currency crises.

The indicator used by Frankel and Rose (1996) is the most simple: it is equal to 1 when the depreciation of the exchange rate exceeds 25% in one quarter and if it tops the depreciation of the former period by 10%. This takes into account possible hyperinflation.

Milesi-Ferretti and Razin's indicators are founded on the Frankel and Rose indicator in order to take hyperinflationary trends into account. They also provide additional definitions. The first of their indicators is equal to 1 when the depreciation of the exchange rate exceeds 25% in one quarter, and is double the former period's depreciation; further, the preceding depreciation must have been less than 40%. The second indicator is equal to 1 when the depreciation of the exchange rate is superior to 15% in one quarter, and if it tops the rate of the former period by 10%; at the same time the preceding depreciation should have been less than 10%.

2.2. The simultaneous currency crisis indicator selected

Each of the above-mentioned indicators was calculated. They all generally take account of the large crises, such as those in Latin America in 1982 and in Asia in 1997. But a number of points appear as crises for certain indicators but not for others. The Frankel and Rose indicator, for example, identifies a greater number of crises than the other indicators and appears to reveal crises where there are none, notably in Brazil. Those of Kaminsky, Lizondo and Reinhart are more selective in identifying crises.

The points identified by Kaminsky and Reinhart's chronological analysis of crises (1996) are very close to those revealed by Milesi-Feretti and Razin's indicator. It was therefore decided to merge these two indicators and to study points where the component indicators give opposite results by submitting them to the judgement of emerging country experts. This analysis led us to modify a number of points (four crises were added and two removed).

2.3. The crises in the studied sample

The studied sample comprises 15 emerging countries from different continents : Asia (Indonesia, Malaysia, Philippines, Thailand), Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, Peru), Europe (Hungary, Poland, Turkey) and Africa (South Africa). The period under review spans from the first quarter of 1981 (1981: 1) to the fourth quarter of 1997 (1997: 4). Data is collected every quarter when available. It is extracted from the International Monetary Fund's *International Financial Statistics*. Data relating to indebtedness is taken from the World Bank's *World Debt Tables*. Data available only on a annual basis was calculated on a quarterly basis.

As the focus is on the outbreak of crises as opposed to their development, the four quarters following the crisis (which could also be considered as a crisis) were excluded from the sample. The findings were the following.

Table 2
Number of crises and non-crises (1981-1997)

Geographical areas	Number of crises	% of crises in the total number of observations	Number of non-crises	% of non-crises in the total number of observations
Total	**39**	**3.7**	**1,008**	**96.3**
Latin America	23	4.5	482	95.5
Asia	11	2.9	366	97.1
Other (Eastern Europe, Israel, Turkey)	5	3.0	160	97.0

NB: Every observation corresponds to one quarter in one country.

The prior probability of a crisis arising in any quarter in the sample is 3.7%. Therefore, in each given quarter, the prior probability of a crisis arising over one of the next four quarters is equal to 3.7% x 4 = 14.8%. The prior probabilities of a crisis breaking out differ according to the area under review: in this sample, crises are more frequent in Latin America than in Asia.

Table 3
Number of crises and non-crises per region (1981-1997)

Geographical areas	Number of crises	% of the total number of crises	Number of non-crises	% of the total number of non-crises	% of crises in the total number of observations
Latin America	23	59	482	95.5	4.5
Asia	11	28	366	97.1	2.9
Other (Eastern Europe, Israel, Turkey)	5	13	160	97.0	3.0
Total	**39**	**100**	**1,008**	**96.3**	**3.7**

3. The construction of scores

A total of approximately 30 ratios or variables which are likely to determine the probability of a crisis were selected from the findings in economic literature. The ratios were selected one by one by comparing the distribution of these ratios for the countries experiencing a crisis and those in a non-crisis period.

The ratios were then subjected to a discriminant analysis. The whole sample is divided into two observation files (countries experiencing a crisis at a given date and countries in a non-crisis period at a given date with the corresponding ratios). The latter are then examined at a given date. This group is divided into five sub-samples, depending on the lapse of time between the observation of the country and the outbreak of the crisis. The five sub-samples are as follows:

k = 1 countries observed one quarter before the crisis,
k = 2 countries observed two quarters before the crisis,
k = 3 countries observed three quarters before the crisis,
k = 4 countries observed four quarters before the crisis,
k = 5 countries which are not in a period of crisis.

The profile of the ratios is thus analysed four, three, two and one quarter before the outbreak of a crisis. During these periods, the countries under review are supposed to display a characteristic profile of ratios which distinguishes them from the countries or periods in which there is no crisis. The aim is to uncover a combination of ratios which allow countries experiencing a crisis to be distinguished from those which are not. This linear combination of *n* ratios, known as "score", is obtained via Fisher's discriminant analysis[3] . The method thus implies constructing a "score function" which reflects the economic situation of the country while determining the probability of a crisis. This analysis makes it possible to calculate the probability for a country experiencing a crisis of having a certain score. In a forward-looking perspective, the aim is however to obtain the probability of a crisis breaking out in a country at a given time (in this case, in one year), given the value of its score. By resorting to the prior probability of a crisis occurring, Bayes' formula establishes the link and associates scores with expected probabilities of crises.

Two types of scores are calculated : one is based on the whole sample of countries and periods under review (global score) and the other one on regional sub-samples (regional scores). The synthetic score selects for each country the score with the best ratios of correct classification.

3.1. The global score

The global score is composed of the following six variables: reserves relative to monetary aggregate M2, reserves relative to the total level of debt, short-term debt relative to total debt, deviation of the real effective exchange rate from its long-term value (measuring the possible overvaluation), inflation, indicator of regional contagion.

The results are consistent with theoretical explanations. An increase in the level of short-term debt relative to total debt and a rise in inflation decreases the value of a country's score and therefore increases the probability of a crisis occurring. A fall in the level of reserves relative to monetary aggregate or to total debt have a similar impact. Overvaluation of the currency and crises in neighbouring countries during the previous quarter also lower the score.

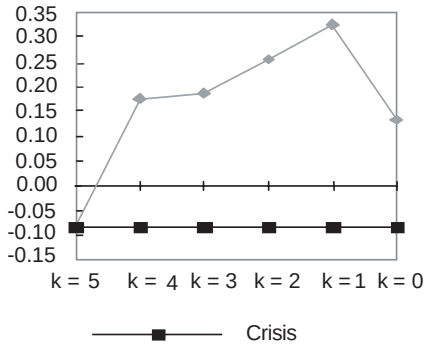
The following graphs illustrate these findings by displaying the trends in the average ratios for each group (crisis and non-crisis) at the onset of a crisis, or, in the case of a non-monotonous trend, the differences in average ratios in periods of crisis and non-crisis[4] . The graphs also include a few ratios which are present in the regional scores but not in the global score. At the onset of a crisis, ratios which include the level of debt clearly decline. The overvaluation indicator also declines, except when the crisis is effectively underway. This is due to the fact that the quarter in which the crisis occurs is included in the analysis in order not to exclude the crises taking place at the beginning of a quarter. This slightly distorts certain ratios for the quarter in which the crisis occurs (corresponding to k = 0), but more crisis periods are made available for the statistical analysis.

[3] See McLachlan (1992) for a detailed presentation of this approach.

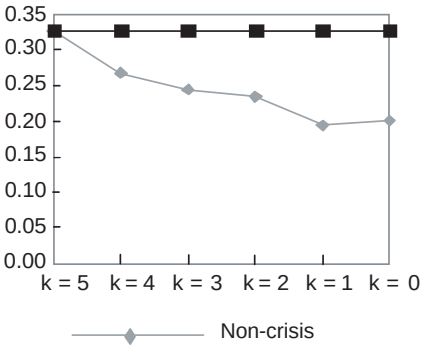
[4] The difference between the average ratios is implicit in the choice criteria of the potentially discriminant variables (whole distribution).
The graphs presented here specify this criteria by giving a rough estimate of the difference between averages.

Graphs 1 and 2

Overvaluation
Comparison of average values for different k's

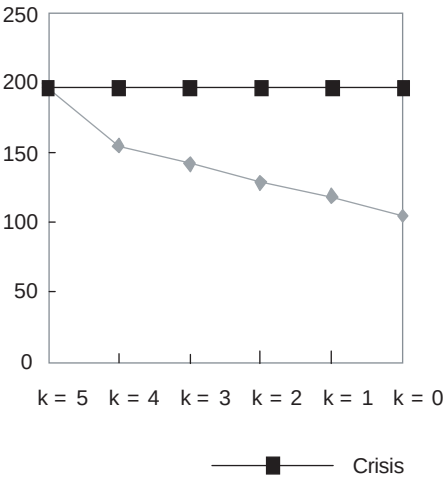


Reserves/M2
Comparison of average values for different k's

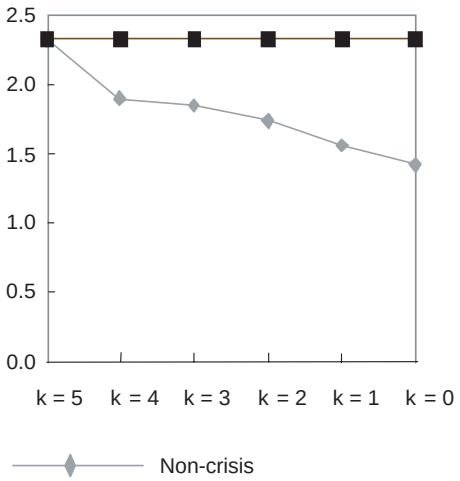


Graphs 3 and 4

Reserves/Total debt
Comparison of average values for different k's

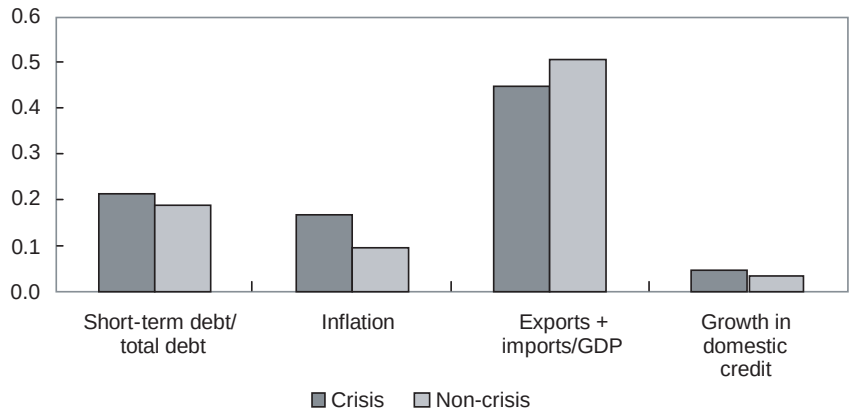


Reserves/Imports
Comparison of average values for different k's



k = 0 countries in crisis
k = 1 countries observed one quarter before the crisis
k = 2 countries observed two quarters before the crisis
k = 3 countries observed three quarters before the crisis
k = 4 countries observed four quarters before the crisis
k = 5 countries which are not in a period of crisis

Graph 5
Comparison of average values for crisis and non-crisis periods



The ratios of correct classification assess the quality of a score function by counting the number of points correctly classified. The results are satisfactory since the ratio of correct classification is approximately 80% (table 4).

Table 4
Ratio of correct classification with the global score

(in %)

	Crisis	Non-crisis
Crisis foreseen	79.6	20.4
Non-crisis foreseen	20.4	79.6

The ratio of correct classification is relatively stable as the score nears a crisis. The score's predicting capacity remains practically unchanged whether the time-frame for predictions is one, two, three or four quarters (table 5).

Table 5
Ratio of correct classification as the crisis nears

(in %)

	Crisis	Crisis in one quarter	Crisis in two quarters	Crisis in three quarters	Crisis in four quarters	No crisis in the next
Identification of a crisis	83.3	80.0	79.3	85.2	69.2	20.4
Identification of a non-crisis	16.7	20.0	20.1	14.8	30.8	79.6

In general, the crises are satisfactorily anticipated and the prospect of a crisis occurring is well identified. As far as the Asian crisis of 1997 is concerned, Thailand and the Philippines are correctly identified as high-risk countries. But the crises in Indonesia and Malaysia are not correctly predicted in the global score.

The indicator of regional contagion plays a major role in this score, in particular as far as the Asian crisis is concerned. It acts with a three-month time lag once a crisis has been observed in a region. However, when the score predicts a crisis in a country although it has not yet occurred, the contagion indicator remains unchanged for the countries in the area.

3.2. Regional scores

The preceding analysis can be improved and pursued in several directions. The sample can be split into two time periods, in order to check whether the leading indicators of crisis are the same from one period to the next. But preliminary work has demonstrated that a regional breakdown (Asia and Latin America) is more appropriate. The sample was split by region and the preceding analysis was applied to two sub-groups: Asia on the one hand and Latin America on the other.

Latin America's score function contains four variables present in the global score: – reserves relative to monetary aggregate M2, reserves relative to total debt, deviation of the real effective exchange rate from its long-term value, inflation – and one specific one: the ratio of reserves to imports. Import coverage by foreign exchange reserves is crucial in an area where current account deficits are chronic.

Asia's score function exhibits three ratios present in the global score – reserves to monetary aggregate M2, deviation of the real effective exchange rate from its long-term value and short-term debt to total debt – and three additional variables: real growth rate of domestic credit, the degree of openness (exports + imports/GDP) and the spread relative to the level of US interest rates. The findings are not surprising as the excessive growth in credit has often been identified as one of the causal factors of the recent Asian crisis. The rapidly increasing degree of openness has also no doubt destabilised certain Asian countries.

For Malaysia and the Philippines on the one hand, and Bolivia, Chile and Colombia on the other, prediction of crises is improved if the regional score is used instead of the global score.

The individual synthetic results are obtained by using for each country the score (global or regional) which provides the best result in terms of ratios of correct classification for the given country. Crises are generally well identified by this indicator. It is notably the case of the Asian crisis of 1997 in Malaysia, Thailand and the Philippines. The crisis in Indonesia, however, failed to be predicted. This difficulty is well-known and is also present in other models for the prediction of currency crises.

Table 6
Ratio of correct classification with the synthetic score

(in %)

	Crisis	Non-crisis
Crisis predicted	Prob(crisis predicted/crisis) = 83.1	Prob(crisis predicted/non-crisis) = 18.6
Non-crisis predicted	Prob(non-crisis predicted/crisis) = 16.9	Prob(non-crisis predicted/non-crisis) = 81.4

This study has shown that currency crises in emerging countries contain fundamental factors which are present before the outbreak of the crisis. It is therefore not a purely self-fulfilling phenomenon. The model presented in this study yields relatively satisfactory results for the sample considered: the ratio of correctly predicted crises and non-crises exceeds 80%. This type of score should be considered as an additional tool for taking decisions. Naturally, it cannot replace expertise, which should always supplement the information provided by the score function. This is in particular the case for countries where the quality of statistics is low.

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