

Percic, Stanislav; Apostoaie, Constantin-Marius; Cocris, Vasile

## Article

# Early Warning Systems for Financial Crises.A Critical Approach

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# EARLY WARNING SYSTEMS FOR FINANCIAL CRISES - A CRITICAL APPROACH

Stanislav Percic<sup>\*</sup>  
Constantin-Marius Apostoaie<sup>†</sup>  
Vasile Cocriș<sup>‡</sup>

**Abstract:** *This research paper aims to analyse some Early Warning Systems (EWS) for predicting financial crises. The importance of such a study is undeniable in the context of the current and future mix of policies applied by the monetary authority, in which financial stability and price stability play an important role. The EWS for crises enable the prediction of the occurrence of a crisis within a specified time period. Hence, the theoretical approach of the main early warning systems for crises, the models based on signal extraction and the logit/probit models represent an important stage in preventing and fighting financial crises.*

**Keywords:** financial crisis; currency crisis; Early Warning System; signal extraction; crisis prediction.  
**JEL Classification:** E44; E47; F31; F47; G01.

## INTRODUCTION

The current global financial crisis has led to an increase in the interest of policy makers and the public (after almost a decade of stability which followed after the crises of the emerging markets in the 1990s) in the Early Warning Systems (EWS) with a view to anticipating future crises. But how will these systems actually manifest themselves? How do they operate? And how efficient are they?

The experience of previous crises shows us that the incurred costs are very high for emerging economies, as well as for the developed ones. Even if these economies have their own particular characteristics, almost all of them present similarities when exposed to fundamental economic vulnerabilities, as well as to specific mechanisms which trigger the crises. The most frequent fundamental vulnerabilities are: the credit, the overrating of the price of assets, budget deficits; on the other hand, any significant event may trigger a crisis – political crises, the evolutions on the capital markets or, in the case of the current crisis, the collapse of the American market of “subprime” credits.

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<sup>\*</sup> Stanislav Percic, Faculty of Economics and Business Administration within Alexandru Ioan Cuza University of Iași, Romania, e-mail: stanislav.percic@yahoo.com.

<sup>†</sup> Constantin-Marius Apostoaie is a PhD at the Faculty of Economics and Business Administration within Alexandru Ioan Cuza University of Iași, Romania, e-mail: apostoaie\_marius@yahoo.com.

<sup>‡</sup> Vasile Cocriș is a Professor PhD at the Faculty of Economics and Business Administration within Alexandru Ioan Cuza University of Iași, Romania, e-mail: vcocris@uaic.ro.

What is an early warning system? An early warning system consists in an accurate definition of a crisis and of a mechanism which may predict crises. Researchers have adopted various approaches concerning the conceptual and practical aspects related to the definition of a crisis, as well as to the means of predicting it.

The EWS for crises enable the prediction of the occurrence of a crisis within a specified time period. Such models may apply to currency crises, as well as to banking or fiscal crises. The methods consist in the analysis of the economic and financial indicators which enable the acquisition of information related to a potential vulnerability of the balance of payments or the lack of sustainability of the exchange rate.

The remaining of this article proceeds as follows: section 1 captures a brief overview of the economic literature on the main findings on the EWS while section 2 completes it with some theoretical approaches, section 3 and 4 presents and critically analyse some methods based on signal extraction (signal - based approach) and logit/probit models (limited dependent variable – ldv) while the final part of the study resumes the main findings of this research.

## **1. LITERATURE REVIEW**

As a result of a large number of financial crises in emerging market economies in the last decade, international organizations as private sector institutions started to develop EWS models aiming to anticipate whether and when individual countries can „collide” with a financial crisis. The lead position in this „race” was taken by IMF which put important effort for developing EWS models for the above mentioned countries, resulting in papers of reference: Kaminsky, Lizondo and Reinhart (1998) and Berg and Pattillo (1999). Simultaneously a lot of central banks, like the US Federal Reserve (Kamin, Schindler and Samuel, 2001) and the Bundesbank (Schnatz, 1998), academics and different private sector institutions have designed models in the last years.

The literature distinguishes three types of financial crises: currency crisis, banking crisis and external debt crisis. However, pure forms of crises do not exist in reality.

Kaminsky and Reinhart studied the interference between currency and banking crises and concluded that banking crises are a good leading indicator of currency crises. Also they found that financial liberalization has a robust explanatory power in predicting banking crises (Kaminsky and Reinhart, 1999).

Eichengreen and Rose, analysing the banking crises in emerging markets (using a multivariate binomial probit to estimate the probability of crises), highlighted the importance of changes in

foreign conditions in the emergence of banking crises in developing countries (Eichengreen and Rose, 1998).

Over time several methods for building an early warning system were suggested: models based on signal extraction, which consist in the monitoring of a set of indicators (Kaminsky, Lizondo and Reinhart, 1998), logit/probit models (limited dependent variable – LDV) using an econometric model of the logit/probit type (Frankel and Rose, 1996; Bussiere and Fratzscher, 2006), etc.

Even though the models of EWS for financial crises have a significant value for policy makers, enabling them to identify fundamental economic vulnerabilities and the possibilities of adopting preventive measures to reduce the risk of occurrence of crises, Berg and Pattillo claim that these models have proven to have a modest functionality in anticipating crises (Berg and Pattillo, 1999).

## **2. THEORETICAL APPROACHES**

The crisis is defined as “a significant decrease of economic activity over a time period, reflected in the decrease of the GDP, the decrease of individual income, the reduction of the level of employment, the diminution of industrial production and consumption”.

The economists analyse the crisis according to specific criteria and perceive it as a phenomenon with unfavourable consequences for institutions, organizations and social groups affected by inflation, unemployment, stagnation, recession, etc.

Sociologists argue that crises have their origin in social inequalities, in the decrease of motivation and initiative, in the rebellion against authorities, in the deficiencies manifested at the level of the social control mechanism, in the decline of the family, community, civic and religious heritage.

Historians evaluate crises at a global level and explain them through the imbalances which appear between the constitutive elements of societies as a result of the occurrence of social dynamics phenomena: the increase of the military power of some states, the intensification of automation, etc.

Psychologists perceive the crisis as the restructuring of the identity of individuals, of their sense of evaluation and capacity to assign meaning as a result of instinctual impulses, an influence of the forces of the collective unconscious.

The term financial crisis designates situations in which institutions or financial assets suddenly lose a significant part of their value. The financial crisis is a form of manifestation of the economic crisis and illustrates the lack of confidence in the financial system, a significant reduction of the volume of stock exchange trading, a dysfunction at the level of market mechanisms.

The prevention of systemic crises has started to present interest for economists and, of course, for monetary authorities, since the 1990s, following the crises which affected the European Monetary System (1992), Mexico (1994), the countries in South-East Asia, such as Thailand, Malaysia, Indonesia, Philippines and South Korea (1997) or the Russian Federation (1998).

The literature distinguishes three types of financial crises: currency crisis, banking crisis and external debt crisis. However, pure forms of crises do not exist in reality. The twin crises – currency crises and banking crises – are an important concept in economic theory. The crises in Asia (1997), the Russian Federation (1998) or Turkey (2000) are the best examples in this respect. Other types of complex crises are the currency and fiscal crises (Rocaru, Copaciu and Lapteacru, 2006): Brazil (1999) or the currency and external debt crises: Mexico (1994), Argentina (2001).

The necessity of estimating systemic crises led to the construction of a monitoring mechanism called the early warning system (EWS).

The EWS enables the anticipation of a crisis within a given future time period. Such a method can apply to currency, banking or fiscal crises. The early warning models for financial crises are built based on a series of economic and financial variables which may indicate the vulnerability of the balance of payments or an unsustainable level of the exchange rate in time: indicators of macroeconomic imbalances and of the weakness of the banking system (for example, the fiscal deficit and the growth rate of internal credit), of the overrating of the exchange rate (indicators of relative prices, the current account deficit, the growth rhythm of exports), of external vulnerability and of the contagion risk (the ratio between external liabilities and international reserves, the incidence of the crises from other countries).

There are several methods used for building an early warning system, the most important ones being (Rocaru, Copaciu and Lapteacru, 2006):

- Models based on signal extraction (signal - based approach), which consist in the monitoring of a set of indicators. If they exceed a certain threshold, which was previously calculated, this is considered a warning signal. These indicators can be calculated – composite vulnerability indicators (pressure indicators of the foreign exchange market, stability indicators of the banking system, external position indicators) – or economic and financial indicators (sentiment

indicators): the growth of the GDP, budget deficit, indicators of the capital market, spread of government bonds (Kaminsky, Lizondo and Reinhart, 1998);

- Logit/probit models (limited dependent variable – LDV): consist in the estimation of an econometric model of the logit/probit type in which the dependent variable which indicates the occurrence of the crisis is calculated based on the pressure indicator of the foreign exchange market, and the economic and financial indicators are variables which have an explanatory role. The model has the advantage that it enables the measurement of the effect of each explanatory variable on the crisis probability (Frankel and Rose, 1996; Bussiere and Fratzscher, 2006).

Even in the case of advanced econometric models, adjusted based on historical data; the obtained prognoses should be carefully assessed, for the quality of the results is limited by:

- The difficulty of generalizing past experiences based on the particularities of the currency crises from various states;
- The mutations which occurred over the years at the level of the decisive factors (for example, between the Mexican crisis and the South-East Crisis);
- The difficulty of quantifying macroeconomic characteristics which reveal a vulnerability;
- Lack of information.

### **3. METHODS BASED ON SIGNAL EXTRACTION (SIGNAL - BASED APPROACH)**

The EWS were discussed in detail in a series of papers belonging to Kaminsky, Reinhart and Lizondo - KLR.

The signals of the strategy elaborated by KLR are projected to monitor a number of variables which tend to manifest an unusual behaviour in the periods preceding a currency crisis and to send a warning signal when a variable reaches an “extreme”. A crisis is defined as a period during which a crisis indicator is significantly different from its average. For example, in case the current account deficit (expressed as a percent of the GDP) drops below a certain threshold, this indicator lights up and flickers, just like a red lamp.

A set of indicators which may be used to reflect the possibility of the occurrence of currency and banking crises may be:

- Indicators associated with financial liberalization (the M2 multiplier, the ratio between internal credit and the nominal GDP, the real passive interest rates, the ratio between the active and passive interest rates);

- Other financial indicators (real monetary mass in a restricted sense – M1, real time deposits in the banking system, the ratio between M2 and currency reserves);
- Indicators related to the current account (deviation of the exchange rate from the trend, expressed in percents, the level of imports and exports, terms of trade);
- Indicators associated with the capital account (currency reserves, interest rate differential);
- Indicators of the real sector (industrial production, stock exchange indicators);
- Fiscal variables (consolidated budget deficit expressed as a percent of the GDP).

Kaminsky (2000) conducts a detailed analysis of the indicators for the creation of an early warning system and focuses on the real exchange rate, the sudden increases in interest rates on international markets, capital flight, simultaneously with the increase in external debt, liquidity problems, the liberalization of the capital account, credit increase and the evolution of the stock exchange (captured by the M2 multiplier, the internal credit expressed as a percent of the GDP, stock exchange rates), real interest rates for banking crises (Kaminsky, 2000).

The increase over the normal level of internal credit contributes to the accumulation of pressures which will trigger the currency crisis, being favoured by capital inflows or financial deregulation measures – throughout the entire period preceding the crisis, the values of the internal credit/GDP ratio are above the trend previously registered by the same variable. The fast deterioration of the M2/international reserves ratio, triggered by the expansion of M2 and the limitation of official reserves, has also been noticed in the period preceding the crisis. Given the fact that it represents the degree to which the internal liquid liabilities are covered by reserve assets, this ratio reveals the extent to which the economy can defend itself against a speculative attack without resorting to a drastic correction of the exchange rate and can thus be considered an indicator of the investors' confidence in the internal financial system (Codirlascu, 2002).

The KLR approach is generally univariate, each indicator being analysed separately. This approach involves the monitoring of these variables from country to country and the identification of the moments when a variable deviates from normalcy. These extreme values are said to issue a warning signal about a possible currency crisis. A “good” signal is one which is followed by a crisis within a specified time period. When a variable issues a signal and the signal is not followed by a crisis, the signal is designated as being “false” (Kaminsky and Reinhart, 1999). The performance or efficiency of indicators can be determined according to the matrix below (Table 1):

**Table 1 – Analysis of the issued signal depending on the specified period**

	<b>Crisis during the specified period</b>	<b>No crisis during the specified period</b>
<b>Signalling a crisis</b>	A (good signal)	B (false signal)
<b>Failure to signal a crisis</b>	C (failed signal)	D (calm)

Source: Shi, J., Gao, Y. (2010), pp. 254 – 275.

In order to simultaneously capture an indicator's capacity of issuing good signals and of not issuing false signals, Kaminsky suggests the use of the noise to signal ratio, defined as a fraction between the ratio between the signalling of a crisis which does not occur and the periods without crisis ( $B / (B+D)$ ) and the ratio between the signalling of a real crisis and the periods of crisis ( $A / (A+C)$ ) (Kaminsky, 1998). For an indicator which issues random signals and for a sufficiently large sample, the law of large numbers involves a noise to signal ratio equal to 1. Thus, those indicators which have a noise to signal ratio bigger than 1 have an extremely low power of signalling crises (Rocaru, Copaciu and Lapteacru, 2006).

Based on these indicators, Kaminsky and Reinhart examined 26 banking crises and 76 currency crises in 20 countries over the period 1970-1995 and reached the conclusion that the problems in the banking sector generally precede currency crises – the currency crisis depends on the banking crisis (Kaminsky and Reinhart, 1999). Another important conclusion that the authors have reached is that financial liberalization usually precedes a banking crisis. In addition, the crises occur during the entry into recession of the economy after a period of prolonged boom which was supported by crediting, capital inflows and an overrated exchange rate (Cheang, 2008).

#### **4. LOGIT/PROBIT MODELS (LIMITED DEPENDENT VARIABLE – LDV)**

The method based on signal extraction is a non-parametric approach which is usually univariate and does not allow the testing of the statistical significance level of the variables. These shortcomings can be overcome by applying the logit/probit model. Eichengreen, Rose and Wyplosz and Frankel and Rose were the first to apply this method for predicting currency crises (Eichengreen, Rose and Wyplosz, 1995; Frankel and Rose, 1996). All the information about a crisis is comprised by the probability of predicting the crisis. By comparing the model based on signal extraction with the probit models, Berg and Patillo show that the probit models are better for predicting crises (Berg and Patillo, 1999).

The logit/probit models consist in the evaluation of an econometric logit/probit model in which the dependent variable which signals the occurrence of the crisis is calculated based on the pressure indicator on the foreign exchange market, and the explanatory variables are the economic



and financial indicators. The advantage of this model is that it enables the measurement of the effect of each explanatory variable on the crisis probability (Frankel and Rose, 1996, or Bussiere and Fratzscher, 2002).

The construction of a warning model which relies on a multinomial logit involves the following stages (Rocaru, Copaciu and Lapteacru, 2006):

- The calculation of a pressure indicator of the foreign exchange market: this indicator enables the definition of the crisis interval which includes not only the successful attacks affecting a currency (forcing a central bank to give up the fixed system), but also moments of external vulnerability when the measures taken by the monetary authority or the country's favourable external situation made it possible to avoid a currency crisis;

- The calculation of the currency crisis indicator;
- The calculation of the crisis indicator per se (multinomial);
- The approximation of the model by using the econometric method of the multinomial logit type;
- Establishing the optimum threshold for signalling a currency crisis.

The multinomial logit model is created with the help of the crisis indicator. The explanatory variables applied are those variables which can define the external, financial and economic situation of a country. The most important variables used in a model were:

- The external competitiveness indicators: an over-rated exchange rate, current account, external balance, the ratio between imports and exports – in absolute terms and as growth rhythm. The use of an effective exchange rate instead of a real exchange rate is justified by the necessity of identifying the problems related to external competitiveness and offers the possibility of evaluating the economies with a fixed exchange rate;

- External exposure: the ratio between short-term debt and reserves, total debt and reserves, as well as the growth rhythm of the short-term debt;

- Internal economic indicators: the growth of the real GDP, budget deficit, inflation rate;
- Financial indicators: the value of credits in the private sector, the value of credits at governmental level, the value of banking deposits in the private sector;

- Contamination indicators: contamination of the banking system.

The contagion indicator of the banking system is calculated by using the method suggested by Fratzscher (2000):

$$CB_{ij} = \sum_d \left( \frac{F_{dj}}{F_d} \frac{F_{di}}{F_i} \right)$$

where  $F_{di}$  represents the credits granted by country  $d$  to country  $i$ , and  $F_d$  represents the total credits granted by country  $d$ .

The countries  $d$  are countries with developed economies, whereas countries  $i, j$  ( $i \neq j$ ) are emergent countries included in the analysis of this study. The interpretation of this indicator relies on the common lender effect: if a currency crisis occurs in country  $j$  and the degree of indebtedness of country  $d$  to country  $j$  is high, the probability for country  $d$  to refuse to prolong the debt or to withdraw the capital invested in country  $i$ , increases.

The signalling of a crisis for the countries and the time period will be selected by taking into consideration an optimum threshold (a probability which exceeds this threshold is considered a crisis signal).

The selection of the time period and of the optimum threshold should be based on the number of non-signalled crises and false alarms considered optimum when it comes to making decisions related to the monetary policy. Given the following cost function (Bussiere and Fratzscher, 2006):

$$L(T) \equiv \theta * P_{CN}(T) + (1 - \theta) * P_{CS}(T)$$

where  $T$  is the probability threshold;  $PCN$  is the probability of signalling a crisis;  $\theta$  is the cost of not signalling a crisis or the degree of risk aversion.

The increase of the time period and of the probability threshold determines the increase in the number of non-signalled crises, but reduces the number of false alarms.

Frankel and Rose shifted the attention of these studies towards the modelling of currency crises for developing countries, using the probit analysis on annual data corresponding to a number of 105 countries over the period 1971-1992. They observe that the low level of direct foreign investment, the reduced international reserves, the powerful increase of internal credits, the big foreign interest rates and the overrating of the real exchange rate increase the probability of a currency crisis. Following these significant findings, the two authors reach the conclusion that their model can be used for the early signalling of a possible currency crisis (Edison, 2003).

If the dependent variable could be assigned the value 1 in the past, representing a period of crisis, or the value 0 for a normal period, it was implied that such variables behaved differently in moments of crisis and non-crisis. However, the reality is much more complex than this. Apart from the fact that the variables deviate from their normal level prior to the crisis, it has been noticed that the studied variables also behave differently during post-crisis periods. Consequently, instead of

comparing only two states (crisis and non-crisis), an early warning system may also illustrate a post-crisis trend.

## CONCLUSIONS

The number, frequency or severity of financial crises did not decrease during the last two decades; on the contrary, they intensified. Each crisis causes enormous costs in the countries in which its effects are felt. Thus, international financial institutions should invest in research concerning the EWS for crises. At present there are numerous available studies, without real convergent results, but which cover a big number of countries and a long time period, with different methods applied for different types of crises.

The EWS comprise important information and may provide, through the analysis of the crises which occurred in various countries and with the help of the models examined in this study, estimates of the probability of occurrence of a crisis, enabling at the same time the classification of the countries based on their degree of external vulnerability.

Financial stability is extremely important for any economy. Hence, ensuring financial stability through EWS for financial crises should be the main objective of all countries.

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