5 Determinants of Currency Disturbances in Transition Economies of Central and Eastern Europe*

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Abstract

This paper explores how the "signals" approach can be used to examine determinants of currency disturbances in transition economies during 1990s. We construct the measure of a currency disturbance - an index of foreign exchange market pressure as a referent series. The "signals" approach is used in constructing an effective system of early warning indicators for each country. The system monitors the behavior of various macroeconomic and financial variables that exhibit an unusual pattern in the periods preceding a disturbance or a crisis. By comparing the resulting systems of early warning indicators we are searching for common determinants of currency disturbances in transition countries in the sample.

Keywords: currency crises, "signals" approach, early warning indicators, transition countries
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1 Introduction

A revival of the interest in the literature on financial crises came during the 1990s, when costly financial crises struck both developed and developing countries. Chronologically, there were the ERM crisis, the Mexican "tequila" crisis, the Asian crisis, the Russian crisis, the Brazilian crisis, the Turkish crisis and the Argentinean crisis, to name but the most prominent. The overall financial flows in the international financial markets accelerated enormously throughout the 1990s due to greater globalization, liberalization, interconnectedness of those financial markets and a quick development of information and telecommunications technologies. A rapid globalization process put increasing limitations on national economic policies, especially in the transition economies of Central and Eastern Europe.

Financial crashes have awakened interest in academic and political circles in creating systems for discovering the causes of the disturbances that may end up in the financial crises. If disturbances on the foreign exchange market as well as in the banking sector could be identified early enough, there might be enough time for policy makers to take measures to prevent or at least diminish the severity of such crises.

Therefore, the number of theoretical and empirical works on the potential links between banking and currency crises has grown steadily. Many of the countries that have faced currency crises have, to a greater or a lesser extent, also faced banking crises (recent examples include Finland, Mexico, Norway, Sweden, Argentina and a number of transition economies of Central and Eastern Europe).

A thorough examination of the literature on twin crises would be an extremely demanding theoretical and empirical task. Therefore, in this paper we will limit ourselves to seeing which of the signaling indicators for currency disturbances suggested in the literature might be of greatest value in transition economies. The goal of this paper is to explore how the "signals" method can be used to examine the determinants of currency disturbances in a sample of transition economies during the 1990s. In order to identify currency disturbances, we construct the index of foreign exchange market pressure individually for each country. In constructing an effective system of early warning indicators for currency disturbances we use the "signals" approach developed by Kaminsky, Lizondo and Reinhart (1997). The system monitors

the behavior of various macroeconomic and financial variables that exhibit an unusual pattern in the periods preceding a disturbance or a crisis. By comparing the resulting systems of early warning indicators we are searching for the common determinants of currency disturbances in transition countries in the sample. An especially promising fact is that the signals approach has recently been successfully supplied to a sample of transition countries for which it was possible to gather data of adequate quality to allow testing the model.

We begin this article with a short overview of theoretical and empirical analyses of currency crises in order to summarize the causes and explanations of currency crashes according to various models. The third part of our work will focus on describing the "signals" approach in designing the early warning indicators for currency disturbances in transition economies. The possibility that an earlier deterioration in key economic conditions provides a signal of upcoming crisis is our main concern. In the following section we are searching for the common determinants of currency disturbances in transition countries in the sample. All of this will provide an introduction to the final section, which examines the reliability of using the "signals" approach in the case of countries observed.

2 Theoretical and Empirical Background

A number of studies, theoretically and empirically, found various causes of currency crises and thus enabled classifying the crisis episodes into three categories.[1]

The first generation models tried to explain currency and debt crisis episodes of the Latin-American developing countries in the late 1970s and early 1980s. The basic premise in those *traditional* models is the inconsistency with which the fundamental macroeconomic variables (loose monetary policy, monetization of fiscal deficit) expanded under the fixed exchange rate regime. The roots of these models can be found in Salant and Henderson (1978), who tried to model speculative attacks on the gold market. Krugman (1979) extends the Salant-Henderson model of speculative attack onto the fixed exchange rates. In his seminal paper, Krugman suggests that, under a fixed exchange rate, currency crises *are preceded by* periods of gradual decreases in international reserves and credit expansion that exceeds the demand for money or

[1] *For a review of the literature see Blejer (1998), Flood and Marion (1998), and Jeanne (2000).*

fiscal imbalances, along with increased lending to the public sector. As a consequence, weak fundamentals stimulate speculative attacks on the domestic currency, further exhausting reserves and forcing the monetary authorities to devalue or to abandon the fixed exchange rate regime. Although Krugman's model was later revised and re-appraised, it represents the basis of the first generation models[2] which usually emphasize the following potential indicators of currency crises: movements in the real exchange rate, trade balance or current account balance, monetary expansion, monetization of fiscal deficit.

Foreign exchange market developments and expectations are put forward in the *second generation models (speculative models)*.[3] The basic premise of those models is that currency crises can occur even when macroeconomic fundamentals are consistent, driven by self-fulfilling speculative attacks (Obstfeld 1984, 1986, 1994, 1996). A crisis occurs when expectations of the foreign exchange market participants are coherently turned in one direction. That cohering factor - *the trigger* - can be anything ranging from a political event, release of some data to a change of the economic policy.[4] The very mechanism of coherence diffusion is also modeled as "rational" herd behavior of the foreign exchange market participants and foreign investors. International triggers are modeled through the contagion effects.[5]

The development of the *third generation models* of currency and financial crises intensified after the Asian crisis (1997/98). These models combine currency crises with the financial sector disturbances and weaknesses, emphasizing the effects of financial sector liberalization, weak supervision and regulation, as well as bad risk management and moral hazard of the financial institutions. An initial attempt at linking financial sector weaknesses and currency crises can be found in Diaz-Alejandro (1985). Most of

[2] *Flood and Garber (1984) construct a linear simplification of Krugman's model within a stochastic framework, and Blanco and Garber (1986) extend it to a structural model for analyzing and predicting the exact timing of a devaluation of the Mexican peso in 1973-1982. The model showed that credit growth and main monetary aggregates are significant variables in determining the probability of the crisis. Goldberg (1993), and Cumby and Wijnbergen (1989) who showed that credit growth was a main cause of the speculative attacks in Argentina in early 1980s extended that model. Dornbusch (1987) re-appraises the differences between Krugman's deterministic and Flood-Garber stochastic model in the case of Argentina.*

[3] *Ozkan and Sutherland (1995); Obstfeld (1984, 1986, 1994, 1996); Gerlach and Smets (1994).*

[4] *Some of the models do explore the self-fulfilling speculative attacks as a multiple equilibria phenomenon, which does not necessary have to lead to a currency crisis - that outcome only arises when the economic agents stop believing in the government policies (Obstfeld, 1994).*

[5] *Allen and Gale (2000); Baig and Goldfajn (1998); Caramazza, Ricci, and Salgado (2000); Eichengreen, Rose and Wyplozs (1996); Gerlach and Smets (1994); Kruger, Osakwe, and Page (1998); Masson (1998).*

the third generation models emphasize the moral hazard problem and over-lending by the financial institutions with implicit or explicit government guarantees, the creation of a speculative bubble and burst of the bubble when unfavorable fundamental developments cause the value of loans to exceed the guaranteed amount.[6] One of the key factors related to financial and currency crises is the fact that financial institutions draw funds from abroad in order to start the over-lending process. These models led to a development of the twin crisis concept.[7] Studies examining possible links between banking and currency crises, i.e. the twin crisis, are still very rare, even though greater interest has been shown in making them the subject of serious research. In short, the twin crisis concept suggests that twin crises have common roots in the deregulation of the financial system, in credit expansion and deterioration of the balance of payments. During the 1970s, when financial markets were highly regulated, there was no evidence of strong connections between currency and banking crises. The weakening of capital regulations in the 1980s and 1990s in developing as well as in developed countries strengthened this connection. All studies examining the concept of twin crises suggest that financial liberalization at times precedes banking disturbances that often reach their peak during the currency crisis (if it occurs at all).

Based on theoretical literature mentioned above, various studies tried to explain the crises by using different empirical models in order to identify significant variables or even leading indicators. Within the existing empirical literature, we can separate two key approaches: *the traditional approach* and the most recent *signaling (nonparametric) approach.* The first approach generally tries to use econometric modeling to find the causes of crises.[8] Those studies that provide qualitative description of pre-crisis events can also be considered traditional.[9] The same is the case with various parametric

[6] *Corsetti, Pesenti and Roubini (1998b); Demirguc-Knut and Detragiache (1998); Dooley (2000); Eichengreen and Rose (1998); Glick and Hutchison (2000); Gruben and McComb (1997); Irwin and Vines (1999); Kaminsky (1998); Kaminsky and Reinhart (1999); Krugman (1998, 1999); McKinnon and Phill (1995).*

[7] *Kaminsky and Reinhart (1999) did pioneering empirical work on the twin crises. An earlier version of that research was published in Kaminsky and Reinhart (1996). Theoretical models of the connection between currency and banking crises can be found in: Diaz-Alejandro (1985); Velasco (1987); Calvo (1995); Goldfajn and Valdes (1995); Miller (1998); and Chang and Velasco (1998).*

[8] *Regression and more classical econometric modeling can be found in: Frankel and Rose (1996), Eichengreen, Rose and Wyplosz (1996), Sachs, Tornell and Velasco (1996), Cumby and Wijnbergen (1989), Ötker and Pazarbasioglu (1994, 1995), Edin and Vredin (1993), Edwards (1989), Klein and Marion (1994), Kruger, Osakwe and Page (1998), Razin and Milesi-Ferritti (1997), Caramazza, Ricci and Salgado (2000), Corsetti, Pesenti and Roubini (1998a), and Eichengreen and Rose (1998).*

[9] *See Dornbusch, Goldfajn and Valdes (1995), Kamin (1988), Edwards (1989), Eichengreen, Rose and Wyplosz (1995), Frankel and Rose (1996), Eichengreen and Rose (1998), Kaminsky and Reinhart (1999) Caramazza, Ricci and Salgado (2000), Aziz, Caramazza and Salgado (2000).*

and nonparametric tests of the influence of particular variables on the exchange rate stability and *various estimates of the probability* of currency crises based on explicit theoretical models.[10] Although the majority of works focuses on the causes of currency crises, more recent works include studies of signal indicators of banking crises.[11]

The traditional methodology for estimating the probability of crisis is quite uniform. That is, studies using this method most often define crises via an index of pressure on the foreign exchange market, which is influenced by changes in the international reserves, exchange rate and interest rate.[12] The currency crisis indicator is modeled as a zero-one variable and the significance of all explanatory variables that enter the model in a linear fashion is analyzed simultaneously. The probability of crisis is estimated via probit or logit models with the maximum likelihood estimation. Because of the assumption that worsening economic conditions gradually culminate in a crisis, the models use lagged variables.

The traditional approach (estimation of likelihood) has an advantage in its simple interpretation. All information about a future crisis is contained in a single number. However, it seems that this advantage also represents a disadvantage of the method. This approach does not allow the researcher to rate indicators according to their relative predictive power. Either the variables are significant or they are not, and if they occasionally send incorrect signals, the methodology cannot detect this. This methodology can hardly be expected to tell us what "went wrong" in the global economic activity or how to reformulate the economic policy so as to avoid a crisis.

The "signals" approach as a non-parametric method attempts to overcome the limitations faced by the traditional method in building a specific early warning system for crises. The starting point is that disturbances which may lead to a crisis do not happen accidentally, but are rather a result of gradual deterioration in economic conditions. This approach begins with a detailed analysis of the behavior of variables whose movements in the pre-crisis period differ substantially from their usual behavior in normal economic conditions. Kaminsky, Lizondo and Reinhart (1997) established the

[10] *Probit/logit models were developed under the methodological influence of Blanco and Garber (1986), who used these methods in analyzing the Mexican crisis of the early 1980s.*

[11] *For example Hardy and Pazabasioglu (1998), Demirguc-Knut and Detragiache (1998).*

[12] *Using this method, Eichengreen, Rose and Wyplosz (1995, 1996) identify 77 currency crises in the years 1959 to 1973.*

"signals" approach as an alternative method to facilitate deeper understanding of the behavior of macroeconomic forces that pushed the country into the crisis. Since variables that issue warning signals can be identified easily, this method may be useful in designing adequate policy interventions. The idea of developing a system of economic indicators which can anticipate crises derives from the literature on business cycles and the methods used in forecasting business cycle turning points.[13] A major disadvantage of the method is the lack of analysis of the relationship between the currency crisis indicator (index of foreign exchange market pressure) and possible signaling indicators in a multivariate way, so the interaction among indicators is not considered. This weakness can be overcome by constructing a composite early warning indicator, which is usually calculated as a weighted sum of the individual indicators.

The implementation of the "signals" approach started only in the late 1990s, and may be very useful for multilateral financial institutions such as the IMF and World Bank (for monitoring purposes), as well as for the investment community. In the future, one can expect a more detailed empirical testing of the method's usefulness for analytical and forecasting purposes.[14]

Our motives for using the "signals" approach to estimate the vulnerability of the foreign exchange markets in Central and Eastern European Countries (CEEC) sample are as follows:

- The "signals" approach is a new analytical and forecasting method, and its improvement and increasing usage is expected;
- The "signals" method is applicable even in the situations where there are data problems, such as short series of reliable data, structural changes in the economy, frequent changes in the data methodology, a small number of crisis episodes that are also evident in the case of the transition economies.
- The last but not least important reason is the lack of regionally focused studies in the literature on currency crisis. It is clear that using a broadly defined sample of countries (consisting of both emerging and developed economies)

[13] This refers to a well-known leading economic indicators approach (barometric method) which is used in monitoring and forecasting economic activity.

[14] Thus, it is not strange that several studies examining the possibility of using this method in order to analyze currency or banking crises have already appeared. See, for example, Kaminsky, Lizondo and Reinhart (1997), Kaminsky (1998), Bruggemann and Linne (1999), Edison (2000), Goldstein, Kaminsky and Reinhart (2000), Nierhaus (2000), Glick and Hutchison (2000).

can help obtain strong and reliable results that support theoretical assumptions. However, in order to obtain more reliable early warning indicators, specific conditions and differences of the regions must be considered. Since studies focusing on CEEC area are still very rare, mainly due to statistical data problems, we are trying to contribute to a better understanding of these phenomena in the region.[15]

A more detailed description of how the "signals" approach functions is given in the following section, which shows an empirical test of the effectiveness of the method in predicting currency disturbances in the CEEC sample. The ultimate goal of the research is to identify the best signaling indicators for each country that can serve as a base for discovering common determinants of the currency disturbances of the sample.

3 Designing Early Warning Indicators for Currency Disturbances in Transition Economies

3.1 Data and Scope of the Sample

This section describes the "signals" method and some of the empirical results obtained by using this method on the sample. The sample consists of Bulgaria, Croatia, the Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia. We examine 20 currency disturbances or crises from the sample identified with the help of an index of foreign exchange market pressure. The research uses monthly data from ten transition countries from the beginning of 1990 up to the end of 2002 and a few quarterly data series. Data sources include the IMF International Financial Statistics, The Vienna Institute for International Economic Studies Database and national central banks' websites.

[15] *Examples include Bruggemann and Linne (1999), Abec-Šonje (2001), Schardax (2002).*

3.2 Defining Crises and Choices of Potential Indicators

In order to make the signals approach operational, a number of terms must be defined. Given the fact that the sample in our research comprises both countries that have experienced less and more severe currency disturbances, we use a broader definition of a crisis. Currency crises (disturbances) are defined as situations in which speculative attacks on the currency lead to a substantial depreciation, a substantial decrease in international reserves or a combination of one and the other. This analytical approach rests on a broad definition that includes both successful and unsuccessful attacks on various exchange rate regimes. Successful attacks usually end up in devaluation scenarios, while episodes of unsuccessful attacks may shake the foreign exchange market without resulting in a devaluation. We will focus our research on crises identified by the behavior of an *index of foreign exchange market pressure (FEMPI).*[16] Because of the index's relative novelty there is no consensus about a standard way of its calculation. It is usually calculated as a simple mean but more and more often as a weighted average, with standard deviations of the exchange rate and international reserves (because of different volatility of the exchange rate and international reserves) as weights.[17] In a period of higher sensitivity and volatility in the foreign exchange market the index usually exceeds two standard deviations, thus identifying currency crisis.[18]

The foreign exchange market pressure index (FEMPI) is constructed by using the rates of change in the international reserves and the real bilateral exchange rate of the national currency (NC) against the euro:[19]

$$FEMPI_t = \Delta e_t - \mathrm{std}E/\mathrm{std}R^*\Delta R_t$$

[16] *The index itself originates in the 1970s monetary approach to the balance of payments and exchange rate. By the end of 1970s, Girton and Roper (1977) formulated a monetary approach equation aimed at working regardless of the exchange rate regime. The idea of measuring the foreign exchange market pressure was revived by Eichengreen, Rose, and Wyplosz (1995) and later by Kaminsky, Lizondo and Reinhart (1997).*

[17] *Some authors incorporate interest rates in the formula alongside foreign exchange and reserves. However, we do not include them in the calculation because the interest rates in the observed economies have continuously been decreasing during the periods of financial market deregulation and structural economic changes.*

[18] *Kaminsky, Lizondo and Reinhart (1997) pronounce periods with FEMPI exceeding +/- 3 standard deviations as "turbulent", Eichengreen, Rose, and Wyplozs (1995) look for +/- 2 standard deviations violation, while Nierhaus (2000) uses +/- 1.25 standard deviations to identify currency crises in Turkey.*

[19] *Real bilateral exchange rate equals* $e_{NC/EUR,t} = E_{NC/EUR,t} * p_{EUR,t} / p_t$ *, where* $p_{EUR,t}$ *and* p_t *are HICP inflation in the eurozone, and CPI inflation in the national economies, respectively.*

where e_t is the real bilateral NC/EUR exchange rate; R_t gross international reserves (in USD); std$E$/std$R$ the ratio of standard deviations of the real exchange rate and international reserves; and Δ is the first-difference operator. The index is constructed in such a way that a depreciation of the national currency and international reserves shrinkage work in the same direction, lifting the index and exerting stronger downward pressure on the currency if it exceeds +2 standard deviations.[20] The following table shows the dates of currency crises detected by the FEMPI.

Table 1 **CURRENCY CRISES AND DISTURBANCES IN CEEC**

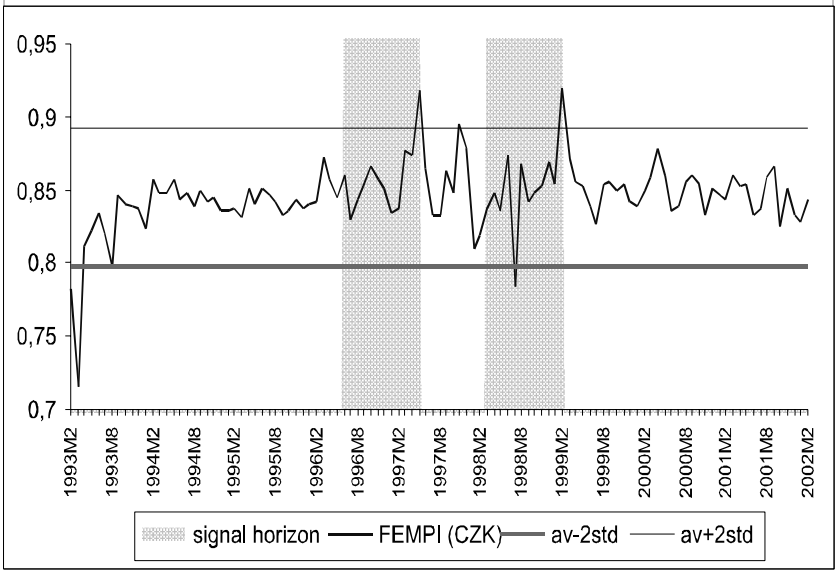
	Number of disturbances/ crises	Beginning of the disturbance or crisis	Percentage fall in reserves (monthly)	Percentage of depreciation of foreign exchange rate
Bulgaria*	3	Jul-94 May-96 Dec-96	49.2 4.4 1.3	1.5 29.7 24.6
The Czech Republic	2	May-97 Feb-99	13.0 2.7	4.4 6.1
Croatia	2	Jan/Feb-99 Jan-01	14.9 1.8	3.3 5.9
Hungary	2	Mar-95 Sep-98	0.9 6.5	4.6 3.7
Latvia	2	Sep-98 Dec-00/Jan-01	9.3 5.6	2.0 7.0
Lithuania	2	Sep-98 Dec-99	9.2 16.6	1.2 +0.3
Poland	2	Sep-98 Aug-01	5.2 +2.1	4.8 6.6
Romania	2	Nov-91 Jan-97	11.5 15.2	106.3 14.0
The Slovak Republic	1	Sep/Oct-98	17.8	4.8
Slovenia	2	Aug-95 Jun-98	6.6 9.8	1.8 4.0

**Second and third disturbances are overlapping.*
Source: *Authors' calculations.*

[20] *For analytical purposes, we use +/–1.5 standard deviation in the cases of Romania and Slovenia, and in Lithuania +/–1.25 standard deviation violation to pick up mild pressures on foreign exchange markets.*

For example, according to accessible data, FEMPI for the Czech Republic reveals two currency disturbances in the observed period (Figure 1).

Figure 1 **THE CZECH REPUBLIC: FOREIGN EXCHANGE MARKET PRESSURE INDEX**



Source: Authors' calculation.

We will try to build a system of signal indicators for the group of countries based on identified turbulent episodes. The choice of indicators whose behavior in the pre-crisis period is to be tested is based on theory and on the availability of monthly data. The list of potential indicators of crises is based on the Kaminsky-Lizondo-Reinhart list of 105 indicators, used by most studies on the signals approach as a starting point.[21] Based on the "early warning indicators" literature, the most important indicators that have been found to provide signals about upcoming currency crises are: international reserves, the real exchange rate, credit growth, inflation, fiscal deficit, real GDP growth, credit to the public sector, M4/international reserves. Table 2 shows the total of 28 potential economic and financial indicators of currency disturbances, with their

[21] *The Kaminsky-Lizondo-Reinhart list was compiled by Kaminsky, Lizondo, and Reinhart (1997) after reviewing the existing empirical literature. The authors found that as many as 43 indicators from the list were found significant in at least one of the reviewed 28 studies. Hawkins and Klau (2000) reviewed 30 more studies published since 1997, and conclude that most of the recent empirical studies base their research on the KLR list of indicators.*

expected signs in a pre-crisis period (a description of data is shown in Appendix).[22]

Table 2 **INDICATORS OF CURRENCY DISTURBANCES IN CEEC**

Indicators	Expected sign
The real effective exchange rate; The real bilateral NC/EUR exchange rate; International reserves, total; Net usable international reserves (NUIR), nc; NUIR/broad money (M4); Central bank's (CB) foreign assets/M4; Bank deposits 1; Bank deposits 2; Banks' reserves with CB/total bank assets; Exports; Trade balance; Current account balance; Capital inflow.	negative
M4 multiplier; M1 multiplier; Money supply (M1), real; Reserve money (MO), nominal and real; Domestic credit/output; Domestic credit, nominal; Bank claims on the public sector/total assets; Monetary institutions' claims on the public sector (net); CB's claims on banks; Foreign liabilities of monetary institutions; Imports; Budget deficit/output; Real money market interest rate; Real lending minus real deposit interest rate; Capital outflow.	positive

A brief summary of the stylized facts about their behavior before and during the crisis is given in Box 1.

[22] *Having used several definitions of deficit/output and domestic credits/output indicators, our list has actually expanded to 37 indicators.*

Box 1. **STYLIZED FACTS ON THE BEHAVIOR OF THE INDICATORS OF CURRENCY DISTURBANCES**

- In pre-crisis periods, the domestic currency is either heavily overvalued or else exposed to a strong pressure to appreciate. Therefore, **real effective and real bilateral NC/EUR exchange rates** usually bear negative signs.
- We can also expect to see a reduction of **international reserves** (gross and net) due to moves to defend the proclaimed exchange rate parity. **The ratio of net usable reserves to M4 and the ratio of foreign assets of the CB to M4** ***(reserves adequacy ratio)*** are considered good indicators of currency crises. Depositors, especially in developing and emerging markets, will take shelter in the currency they consider a safe haven for keeping their financial wealth as the government economic policies lose their credibility.
- In the case of **M4 and M1 multipliers,** we may expect a positive sign. An increase in the multiplier with an unchanged monetary base signals an expansionary monetary policy and likely pressure, leading to a deterioration of the domestic currency.
- The **growth of money supply and reserve money** also means that the monetary policy is expansionary, causing pressure for the domestic currency to deteriorate, so we expect a positive sign.
- **Credit expansion** is considered a strong signal of currency and banking disturbances to come. It usually accompanies the phases of the "business cycle"and domestic financial liberalization. So **the ratio of credits to output** and **growth of bank credits to domestic sectors** are related positively to currency (and banking) disturbances.[23]
- Out of the models of the twin crisis we included the following indicators of banking sector vulnerability which can also provoke currency disturbances:[24] **total bank deposits** (expected to fall before/during the banking crisis, due to a run on banks), the **ratio of bank reserves to total bank assets** (expected to fall because of the increase of bank assets - i.e. the credit boom), the **ratio of bank claims on the public sector to total assets,** and the **monetary institutions' claims on the central government** (expected to grow in the pre-crisis period due to a monetization of the public deficit), **CB claims on banks** (these grow as their liquidity shrinks), and **foreign liabilities of the monetary institutions** (increasing their external vulnerability).
- **Exports** have negative expected signs in pre-crisis episodes (weak output and exports either weaken the exchange rate, or an overvalued exchange rate slows down exports and output).
- We except to see an **import** increase in the pre-crisis period (helped by an overvalued currency), which also worsens the **balance of trade** and **current account balance** (expected negative signs).
- A widening of the **budget deficit/output** usually causes monetary expansion, hence the currency crisis (as established in the first generation models).

[23] *Kindleberger (1996) warned long ago that financial crisis could be associated with certain phases in the business cycle.*

[24] *We include them because banking disturbances have occurred almost simultaneously as currency disturbances during 1997/98/99 in some of the observed CEEC.*

- **Interest rates** are usually very weak indicators of the currency crises, while being better indicators of the banking crises. An increase in nominal (and real) interest rates could mean shrinking liquidity in the financial system, while large differences between real lending and deposit rate can signal a risk increase and deterioration of the bank portfolio, as well as lack of competition and supervisory and regulatory weaknesses.
- Reduced **capital inflows** can be a sign of international financial markets disturbances, as well as of distrust in the local government's economic policy. This indicator can signal so-called "spillover effects" within regions as in 1998, when a currency crisis in one Asian country affected another, drying out capital inflows in the whole region.
- Increased **capital outflows** can trigger a currency crisis and may deepen banking problems if they are closely linked to shrinking bank deposits.

3.2.1 The Signal Horizon, Signals and Critical Values (Thresholds)

The signal horizon is the period before a crisis during which the behavior of the indicators signals the upcoming crisis. We chose a horizon of 12 months before each disturbance. A signal emitted within 12 months prior to the outbreak of currency disturbances constitutes a good signal. A signal emitted before that date is correspondingly a bad or false signal. An indicator provides a warning signal within a 12-month window if it exceeds a critical value (threshold). The critical values are set to achieve a certain balance between the risk of having *false signals (noise)* and the risk of ignoring *good signals* of a crisis which is in fact looming. However, there are no general rules for determining the critical value. If the threshold is set very high, the indicator is likely to ignore all but the most severe crises. If the critical value is set very low, there is a risk of catching a number of false warning signals in tranquil times. We set the critical values k in relation to percentiles of the distribution of observations of the indicator I_t, in order to discriminate between "normal" and "abnormal" behavior of an individual indicator. In most cases we use 25% percentile of the distribution (if the indicator falls prior to currency disturbances) or 75% percentile of the distribution (if the indicator rises prior to crisis). After determining the thresholds, we determine the total number of good and false signals in *crisis* and *tranquil times*:

a) for indicators with positive expected signs in pre-crisis period it holds:

$$S_t = 1, \text{ if } I_t > k, \qquad S_t = 0, \text{ if } I_t \leq k$$

b) for indicators with negative expected signs in pre-crisis period it holds:

$$S_t = 1, \text{ if } I_t < k, \qquad S_t = 0, \text{ if } I_t \geq k$$

S_t is a binary signal variable, constructed by virtue of the principle set above. An indicator sends a good signal if S_t=1 and a crisis occurs within the signal horizon, or S_t=0 and no crisis occurs within a tranquil period. On the contrary, an indicator issues a false signal if S_t=1 and no crisis breaks out within a tranquil period, or S_t=0 and a crisis breaks out within the signal horizon. For each of the indicators we are trying to obtain an optimum set of country specific thresholds, which was defined as the one that minimized the ratio of bad to good signals.[25]

3.2.2 Performance of Individual Indicators for Countries in the Sample

The most important criterion for assessing the effectiveness of indicators is the confirmation of their reliability in signaling a future crisis. The performance of each indicator can be estimated in terms of the following matrix (Table 3):

Table 3 **MATRIX FOR ESTIMATING INDIVIDUAL CURRENCY CRISIS INDICATORS**

	Crisis within signal horizon	**No crisis tranquil times**	**Total**
Signal was sent (S_t = 1)	*A*	*B*	*A*+*B*
No signal was sent (S_t = 0)	*C*	*D*	*C*+*D*
Total	*A*+*C*	*B*+*D*	*A*+*B*+*C*+*D*
Good signals	*A*	*D*	*A*+*D*
Good as % of total	*A*/(*A*+*C*)	*D*/(*B*+*D*)	(*A*+*D*)/(*A*+*B*+*C*+*D*)
False as % of total	*C*/(*A*+*C*)	*B*/(*B*+*D*)	(*B*+*C*)/(*A*+*B*+*C*+*D*)

Sources: Kaminsky, Lizondo and Reinhart (1997), Nierhaus (2000).

In the above matrix, *A* is the number of months in which the indicator issued good signals of an upcoming crisis, *B* is the number of months with bad signals (noise), *C* is the number of months without a signal but that were followed by a crisis, and *D* is the number of months without a signal and no subsequent crisis.

[25] *The threshold has been lowered to the 33.3%-th or the 66.67%-th percentile in individual cases, to obtain the minimal value of the adjusted noise-to-signal ratio.*

An ideal indicator is one that produces a signal in every month within the signal horizon, so that $A > 0$ and $C = 0$, or one which does not produce any signals in the time horizon that is not to be followed by a crisis, so that $D > 0$ and $B = 0$. Based on this matrix and following Kaminsky, Lizondo, Reinhart (1997), it is possible to calculate measures that can help rank the indicators according to their predictive power. As an example, we present the information on the performance of individual indicators of currency disturbances for the Czech Republic.

Table 4 **PERFORMANCE OF INDIVIDUAL INDICATORS FOR CURRENCY DISTURBANCES: THE CZECH REPUBLIC**

	Indicators	Noise-to-signal ratio $[B/(B+D)]/[A/(A+C)]$	% good signals $A/(A+C)$	% false signals $B/(B+D)$	P crisis/signal $A/(A+B)$	P crisis/signal - P crisis $[A/(A+B)] - [(A+C)/(A+B+C+D)]$
		1	2	3	5	6
1	Real money market interest rate	0.26	58	15	54	31
2	NUIR / M4,yoy	0.32	67	22	53	26
3	CB claims on DMB's	0.33	50	17	50	25
4	Net usable reserves (NUIR),nc	0.44	42	18	45	18
5	Exports, USD	0.48	42	20	42	16
6	Real effective exchange rate	0.52	42	22	28	11
7	Reserve money, M0, nominal	0.55	50	28	40	13
8	International reserves, USD	0.56	38	21	39	13
9	Foreign liabilities of monetary institutions	0.56	50	28	38	13
10	DMBs' deposits 1	0.56	50	28	38	13
11	DMBs' deposits 2	0.56	38	21	38	13
12	Foreign assets /M4, yoy	0.64	46	29	37	10
13	Reserve money, M0, real	0.64	46	29	37	10
14	Claims on gen.government, net, monet. instit.	0.67	46	31	33	8
15	Domestic credits / output	0.70	33	23	33	7
16	NUIR/M4	0.72	42	30	33	7
17	Foreign assets /M4	0.72	42	30	33	7
18	Domestic credits/output (ind,ma)	0.80	29	23	30	4
19	Domestic credits / output (CPI)	0.84	29	25	29	3
20	Capital outflows	0.87	25	22	29	3
21	Budget deficit/output (CPI)	0.96	21	20	24	1
22	Real bilateral exchange rate, nc/euro	0.98	25	24	22	0
23	Trade balance	0.99	33	33	26	0
24	Budget deficit/output	1.01	33	34	23	0
25	Capital inflows	1.04	25	26	25	-1
26	Current account balance	1.04	25	26	25	-1
27	Budget deficit/output (ind)	1.20	21	25	20	-3
28	Real lending-real deposit rate	1.20	29	35	20	-3
29	Budget deficit/output (ind,ma)	1.25	25	31	19	-4
30	DMBs' reserves/total assets	1.27	21	26	21	-4
31	Domestic credits/ output (ind)	1.45	25	36	19	-7
32	M4/M0	2.33	17	39	13	-12
33	M1/M0	3.67	8	31	8	-17
34	Domestic credit, nominal	5.00	8	42	6	-19
35	Imports, USD	5.14	8	43	6	-20
36	DMBs' claims on public sector/total assets	10.33	4	43	3	-22
37	Money supply, M1, real	$+\infty$	0	35	0	-29

Source: Authors' calculations.

The key measure calculated on the basis of the matrix is *the adjusted noise-to-signal ratio* (the first column of Table 4). The ratio provides information on the ability of the indicator to produce correct signals and to avoid false signals. Analytically, the adjusted noise-to-signal ratio is the ratio of false signals' share in tranquil times to good signals' share in crisis period (in terms of the above metrics, $[(B/B+D)] / [(A/A+C)]$. The lower this ratio comes in for an indicator (close to zero), the more successful is the indicator in predicting currency disturbances. If an indicator issues signals at random times, the expected value of the ratio is equal to unity. Therefore, all those variables with noise-to-signal ratio equal to or higher than unity should not be considered credible.

The second column shows the number of good signals as a percentage of the number of months in which good signals could have been emitted. The maximum score (100%) would belong to an indicator that sent signals every month within the signal horizon before every observed crisis. The third column shows the ratio of false signals to the number of months during tranquil times. The last measure of "noisiness" of the indicators is the difference between the probability of a crisis conditional on a signal from the indicator and the unconditional probability of a crisis (the fifth and the sixth column of Table 4). For those indicators that have "predictive power" (whose adjusted noise-to-signal ratio is lower than unity), the conditional probability (in terms of the above metrics $A/(A+B)$) would be higher than the unconditional one $((A+C)/(A+B+C+D))$.

The results of the "signals" approach used in this in-sample analysis can serve as a basis for designing an early warning system for currency disturbances. *The early warning system* for each country should consist of the indicators with the adjusted noise-to-signal ratio lower than unity. They should also detect the disturbance early enough and emit a persistent signal within the signal horizon.[26]

According to the results of the "signals" method given in the Appendix, we provide a short overview of currency disturbances scenarios in the observed CEEC.

FEMPI detected three currency disturbances in *Bulgaria*, two of which have overlapping signal horizons (in 1996). These points indeed coincide with turbulent periods in 1996,

[26] *Combining the information provided by the set of early warning indicators can be employed in producing useful indices of vulnerability of the foreign exchange market. The idea is to construct a composite indicator of currency disturbances by weighting the signals of each individual indicator.*

which were also accompanied by a hyperinflationary economic environment. After a severe banking crisis in the course of 1996, when the number of banks was almost halved, a currency crisis begins. The troublesome episode with "twin" crisis elements ended in the introduction of a currency board. There are almost 30 indicators that have proved to be good signals in this case. Thus, Bulgaria has shown to be a solid member of the sample for testing of the method. Top ranked signals are reserve adequacy ratio, along with other versions of international reserves movements, reserve money, interest rates and budget deficit. Such a combination of signaling variables typical of both banking and currency crisis confirms that the impulse to the 1997 episode came from the banking sector. We acknowledge that the fiscal sector was also problematic.

The Czech Republic experienced two currency disturbances, with the money market interest rate being a leading indicator. Such a result sets the trigger of disturbances in the capital markets, and suggests that "twin" disturbances might have occurred. Indicators that follow interest rates further support this claim (NUIR/M4, central bank claims on banks, foreign liabilities of monetary institutions etc.). The IMF (1998) reports speculative attacks on the koruna in 1997, after which a fixed exchange rate regime was abandoned. After the foreign exchange market pressure in 1999, the central bank introduced an inflation targeting mechanism.

FEMPI revealed two disturbances in *Croatia*. The first currency disturbance happened at the beginning of 1999 after the 1998/99 banking crisis peaked. The CNB eased the depreciation pressures through foreign exchange interventions. Worsened liquidity of the banking and real sector limited the banks' ability to control their own liquidity, so they had no power to launch a coordinated speculative attack. Furthermore, the fact that the sale of domestic securities to foreigners was not yet liberalized and that the government financed itself largely in the international markets helped Croatia avoid a full-blown crisis. That is why it is not surprising that all indicators linked to credits given to/by deposit banks, have proved to be good signals. On the contrary, the 2001 disturbance was brought about by a combination of the monetary relaxation and partial capital account liberalization.

A country that seems to be less prone to crises and disturbances than other members of the sample is *Hungary*. FEMPI registered only two milder pressures, which might be due to overvalued currency. That is why the real effective exchange rate behaves as a

good signaling indicator in a pre-crisis period, which obviously spurred imports (the best-ranked indicator).

In *Latvia* signals that were exerted were typically symptomatic of currency disturbances caused by an expansionary monetary policy. Although early 1990s passed relatively quietly, Latvia did have two currency disturbances at the end of the decade.

Lithuania, like many other countries in the sample, experienced currency disturbances in 1998 and in 2001. Budget deficit/output ratio had risen in periods preceding crises, providing information on the cause of the outbreak - fiscal trigger with implications for monetary policy (monetization of the deficit). Credible signaling of domestic credits and claims on government was also registered. In the external sector, probably due to the Russian crisis, exports moved downward, which does fit into the theoretical scenario of a contagion effect. Having withstood an international crisis spillover in 1998, the currency board remained (IMF, 1999).

Poland's best indicators strongly suggest that the currency disturbance came along with problems in the banking sector marked by a fall in deposits, rise in real money market interest rates and gap between the real lending and real deposit rate. The contagion effects and fiscal monetization might be partial explanations as well, as the trade balance and budget deficit indicators also emitted signals.

Romania had severe currency crises on two occasions in the 1990s. At the beginning of the decade, they were perpetuated by political changes, while the 1997 episode impulse belongs to the monetary and banking sector. The reserve adequacy ratio produces warning signals with a 50 percent probability.[27] The lack of confidence in the domestic currency is evident. There is strong evidence that troubles were provoked by the monetary expansion, as is stated by the IMF, in order to finance the public sector imbalances.

Slovakia experienced only one disturbance in the observed period. FEMPI detected a relatively large decrease in the international reserves towards the end of 1998. Widespread expectations of a post-election devaluation, the Russian episode and fiscal sector weaknesses may have provided an impetus for the disturbance.

[27] *Kaminsky, Lizondo, Reinhart (1997) asserts that good indicators announce disturbances with probability ranging from 28 to 32 percent.*

Two negligible currency disturbances in *Slovenia* were registered in 1995 and 1998. Persistent capital inflows in 1997 posed a threat to monetary stability (IMF, 1998), and as a variable they do issue good signals in the country. The best ranked indicators were reserve money, the real bilateral exchange rate and import growth.

3.3 Searching for Common Signals of Currency Disturbances in the Sample

Thanks to the results obtained from each country in the sample, we are able to further investigate the existence of common causes of currency disturbances in the region. To examine this issue, we constructed "the group matrix". It comprises all 37 indicators as well as information on the total number of good and bad signals for the sample. This approach solves the dilemma of how to calculate the performance of indicators for the region. That is why the "matrix" value of the adjusted noise-to-signal ratio for each indicator is lower than the one obtained by calculating the simple average of noise-to-signal ratios for each indicator across the countries. The "matrix" results indeed verify the theoretical presumptions on the behavior of various economic and financial indicators in pre-crisis periods.

The results of how indicators perform regarding the disturbances in the region are given in Table 5. The top ranked indicators with a noise-to-signal ratio of about 0.5 are growth of reserve money, reserve adequacy ratio and foreign liabilities of monetary institutions. These findings confirm the results of previous empirical works dealing with larger samples of countries. As we argued earlier, the fall of the reserve adequacy ratio has proved to be a good signal, even in the group. Continued expectations of possible severe currency disturbances among depositors force monetary authorities to keep the level of international reserves high enough to respond to increased demand for foreign currency. The rise in foreign liabilities also exposes the economies to a higher risk of currency crisis. However, the need to finance development usually turns the emerging markets towards the international financial markets, making them vulnerable to external disturbances. Since the real reserve money is the best-ranked indicator, we can assume that the monetary policy was relatively expansionary in 1990s causing pressure on domestic currencies. This exercise has also shown that large budget deficits can trigger monetary expansion, making the markets vulnerable to currency disturbances, as the first generation models suggest.

Table 5 **PERFORMANCE OF INDICATORS FOR CURRENCY DISTURBANCES IN THE SAMPLE OF TRANSITION ECONOMIES**

	INDICATORS	Number of crisis months	Total observations used	noise-to-signal ratio [B/(B+D)] / [A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] – [A+C/(A+B+C+D)] 5
1	Reserve money, M0, real	181	896	0.53	46	25	32	12
2	NUIR/M4	159	691	0.56	44	25	35	12
3	Foreign liabilities of monetary institutions	163	756	0.58	43	25	32	10
4	Real money market interest rate	175	741	0.61	42	26	34	10
5	Money supply, M1, real	154	684	0.61	40	24	32	9
6	Budget deficit/output (ind)	73	348	0.64	36	23	29	8
7	Budget deficit/output (ind,ma)	97	456	0.67	36	24	29	8
8	Foreign assets /M4	171	795	0.69	42	29	28	6
9	Budget deficit/output (CPI)	121	525	0.71	31	22	30	7
10	NUIR / M4,yoy	175	856	0.72	39	28	26	6
11	DMBs' reserves/total assets	139	659	0.73	33	24	27	6
12	Domestic credits / output (CPI)	140	610	0.74	36	27	29	6
13	CB claims on DMB's	187	867	0.74	35	26	27	5
14	Domestic credits / output	188	780	0.75	36	27	30	6
15	Real effective exchange rate	222	1235	0.75	34	25	23	5
16	Domestic credits/ otuput (ind)	92	410	0.77	36	28	27	5
17	DMBs' deposits 1	132	626	0.77	39	30	26	5
18	Capital inflows*	62	267	0.79	34	27	28	5
19	Foreign assets /M4, yoy	163	743	0.79	34	27	26	4
20	Real bilateral exchange rate, nc/euro	219	1053	0.80	32	25	25	4
21	Real lending-real deposit rate	187	916	0.80	36	29	24	4
22	Budget deficit/output	145	588	0.81	33	26	30	5
23	Net usable reserves (NUIR),nc	163	750	0.81	33	26	25	3
24	Claims on gen.government, net, monet. instit.	187	827	0.82	37	27	29	0
25	International reserves, USD	187	937	0.90	32	29	22	2
26	Reserve money, M0, nominal	211	972	0.91	31	29	23	1
27	Domestic credit, nominal	187	834	0.92	32	30	24	2
28	Capital outflows*	66	302	0.96	27	26	23	1
29	Domestic credits/output (ind,ma)	116	510	0.97	28	28	23	0
30	Current account balance*	50	207	1.00	28	28	24	0
31	Imports, USD	204	981	1.03	30	31	20	-1
32	Trade balance	204	992	1.05	31	33	20	-1
33	DMBs' claims on public sector/total assets	211	969	1.09	27	30	20	-2
34	M4/M0	187	858	1.18	28	33	19	-3
35	DMBs' deposits 2	199	871	1.24	27	33	19	-4
36	M1/M0	173	740	1.26	25	31	20	-3
37	Exports, USD	204	952	1.28	26	33	18	-3

Among the indicators with credible predictive power, we can also find a number strong signals of the banking sector vulnerability which obviously provoked currency crisis episodes in the region. For example, the ratio of banks' reserves to total assets as well as the central bank's claims on deposit banks have emitted good signals in pre-crisis periods in many of the countries. Evidently, the challenge of faster growth in order to meet the criteria for joining the European Union makes this region vulnerable to various domestic and external factors.

4 Concluding Remarks

The main conclusion that follows from our research is that "signals" method can be useful as the basis for an early warning system of currency crises in CEEC. Despite the fact that many of the countries from the sample did not experience severe currency crises resulting in a major devaluation or change in the exchange rate regime in the 1990s, the "signals" approach helped us to identify the indicators that anticipate episodes of turbulence in the region. We should stress that the results of the "signals" approach are consistent with previous empirical works on this subject as many of the signaling indicators, which prove to be useful under this approach, receive support from the theoretical and empirical literature presented in Section 2. We tried to identify warning indicators for currency disturbances in CEEC by taking into account a broad variety of economic and financial indicators. The selection of indicators is based on the assumption that currency crises are usually preceded by symptoms coming from all of sectors of the economy.

The measure of currency disturbances calculated in Section 3 allows us to detect the dates of mild pressures on foreign exchange markets, or even real crises episodes in the region. The majority of countries were able to avoid a full-blown crisis, unlike those which were forced to abandon their previous exchange rate regime. For example, Bulgaria, the Czech Republic and Romania switched to another exchange rate regime after being exposed to strong speculative attacks on their domestic currencies. This research proposes a specific early warning system for each country, recording the signals issued by indicators when they exceed the critical value.

The indicator that has proved to be trustworthy in anticipating disturbances in Bulgaria is the reserve adequacy ratio (with a probability of crisis conditional on the

signal from the indicator amounting to 70 percent and an noise-to-signal (NTS) ratio of 0.18). Similarly, the reserve adequacy ratio is also Romania's most trustworthy indicator with an NTS of 0.09 and 100 percent of good signals emitted in the pre-crisis period. In the Czech Republic, the best-ranked indicator was the real money market interest rate (*P* crisis/signal is 54 percent) with an NTS ratio of 0.26. Real effective and real bilateral exchange rates are Croatia's best indicators that issue early warning signals with an NTS of 0.22 and 0.32 respectively. Interestingly, we may confirm some previous works (Bruggemann and Linne, 1999) that found that imports in Hungary proved to be the best warning indicator with an NTS ratio of 0.37. Latvia has had a problem with money growth, as indicated by real reserve money, as well as real money supply with an NTS of 0.23 and 0.33 respectively. Contrary to Hungary, Lithuania has experienced periods of substantial decrease in exports, which perform as the best indicator with an NTS ratio of 0.15. Poland's best indicator, bank's deposits, suggests that there may be elements typical of a "twin" crisis. Banking problems seem to be the trigger for currency disturbances in Slovakia, with central bank claims on deposit banks being the leading indicator with an NTS of 0.14. Reserve money was shown to be the most credible signal in Slovenia with an NTS of 0.35.

In the final section we show that it is possible to explain the common symptoms of currency disturbances in emerging markets of Central and Eastern Europe. Specific conditions in those countries, such as structural reforms, domestic and external financial liberalization process, foreign indebtedness and domestic sectors' imbalances in the observed period add to the likelihood of currency disturbances. We cannot neglect the signals of spillover effects within the region as in 1998, when the currency crisis in Asian countries and Russia affected a number of emerging countries, thereby drying out capital inflows. The analysis of the sample suggests that many of the variables that proved to be reliable signals of currency disturbances are consistent with theoretical and empirical literature focusing on the causes of currency crises. Indicators that have proven to be particularly useful in anticipating crises include reserve money growth, reserve adequacy ratio, foreign liabilities of monetary institutions, real money market interest rate, budget deficit, real effective exchange rate and domestic credits growth. Even though we have not examined banking crises, the appearance of strong signals of banking sector disturbances could partially explain the currency crisis episodes in the region.

Nevertheless, while the "signals "approach may be a useful analytical tool in anticipating crises, such a system is also subject to limitations. The problem may arise from a short list of referent dates, the shortness of time series and the bi-variate character of the approach. The last can be overcome by constructing and evaluating the performance of composite indices for each country consisting of the best signaling indicators. As in any such system, it is impossible to incorporate a number of unexpected political events and institutional issues that may be relevant for assessing the warning system in each country. Still, the evidence presented in this paper and other previous works has provided some support for using the "signals" approach in order to explain or even anticipate the rising vulnerability of the foreign exchange market.

The accession process to the EU for all of the observed countries obliges them to pursue structural reforms and further liberalize their capital accounts. These types of analyses may allow enough maneuvering space for policy makers to prevent or at least minimize negative consequences of any future currency crises in the light of the integration processes.

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Appendix

Data Appendix

Sources:

a. IMF International Finance Statistics
b. The Vienna Institute for International Economics Studies Database
c. Web sites of central banks

The indicators are expressed in annual growth rates, with the exception of exchange rates, interest rates and budget deficit as a share of output.

1. **The real effective exchange rate** - is a weighted average of the index of bilateral exchange rates of the national currency against a basket of currencies corrected for the relevant relative price indices (the ratio of price indices in partner countries and domestic prices).
2. **The real bilateral exchange rate NC/EUR** - is a nominal bilateral exchange rate NC/EUR multiplied by HICP inflation in Euro-zone and divided by the national CPI.
3. **International reserves, total**, USD.
4. **Net usable international reserves (NUIR)** in USD, NUIR = foreign assets - foreign liabilities.

5/6. **NUIR/broad money (M4)** - broad money comprises money (M1), savings and time deposits, foreign currency deposits as well as bonds and money market instruments. Additionally, this series form another indicator as annual growth rates.

7/8. **CB foreign assets/broad money (M4)**.

9. **M4 multiplier** - M4/M0, M0 is base (reserve) money.
10. **M1 multiplier** - (M1/M0).
11. **Money supply (M1),** real.

12/13. **Reserve money (M0),** nominal and real.

14/15/16/17. **Domestic credit/output** - total banks credits to domestic sectors, quarterly GDP data were interpolated considering the monthly change in the CPI deflator, industrial output and seasonally adjusted output.

18. **Domestic credits,** nominal.
19. **Bank deposits 1** - sum of demand, time and foreign currency deposits.
20. **Bank deposits 2** - calculated as broad money minus currency in circulation.
21. **Ratio of banks' reserves to total bank assets**.
22. **Ratio of banks'claims on public sector to total assets**.
23. **Monetary institutions' claims on public sector (net)**.
24. **CB claims on deposit banks**.
25. **Foreign liabilities of monetary institutions**.
26. **Export growth**.
27. **Import growth**.
28. **Trade balance**.

29/30/31/32. **Budget deficit/output**, quarterly GDP data were interpolated considering the monthly change in the CPI deflator, industrial output and seasonally adjusted output.

33. **Real money market interest rate**.
34. **Real lending minus real deposit interest rates**.
35. **Current account balance** in USD, quarterly.
36. **Capital inflow** in USD, quarterly.
37. **Capital outflow** in USD, quarterly.

Performance of Indicators for Currency Disturbances

Bulgaria

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] – [(A+C)/(A+B+C+D)] 5
1	NUIR/M4	0.18	59	11	70	40
2	Foreign assets /M4	0.18	78	14	70	40
3	International reserves, USD	0.28	58	16	50	28
4	NUIR / M4,yoy	0.29	53	15	50	28
5	Reserve money, M0, real	0.30	62	18	40	24
6	Real lending-real deposit rate	0.33	52	17	50	25
7	Net usable reserves (NUIR),nc	0.35	47	17	45	23
8	Budget deficit/output	0.37	67	25	36	19
9	Budget deficit/output (CPI)	0.37	67	25	36	19
10	Budget deficit/output (ind)	0.37	67	25	36	19
11	Budget deficit/output (ind,ma)	0.37	67	25	36	19
12	Foreign liabilities of monetary institutions	0.48	42	20	40	16
13	Imports, USD	0.51	42	21	28	12
14	DMBs' reserves/total assets	0.54	37	20	37	13
15	Real effective exchange rate	0.55	45	25	39	13
16	Domestic credits/output (ind,ma)	0.59	37	22	37	11
17	DMBs' claims on public sector/total assets	0.59	37	22	35	11
18	CB claims on DMB's	0.59	37	22	35	11
19	Trade balance	0.59	50	30	25	9
20	Domestic credit, nominal	0.61	37	22	35	10
21	Exports, USD	0.64	33	21	24	8
22	Domestic credits / output (CPI)	0.72	32	23	32	7
23	Domestic credits/ otuput (ind)	0.72	32	23	32	7
24	Foreign assets /M4, yoy	0.74	32	23	30	6
25	Claims on gen.government, net, monet. instit.	0.74	32	23	30	6
26	Capital inflows	0.80	30	24	30	4
27	Current acount balance	0.80	30	24	30	4
28	M4/M0	0.89	26	23	26	2
29	Real bilateral exchange rate, nc/euro	0.96	26	25	28	1
30	Domestic credits / output	0.97	26	25	25	1

The Czech Republik

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	Real money market interest rate	0.26	58	15	54	31
2	NUIR / M4,yoy	0.32	67	22	53	26
3	CB claims on DMB's	0.33	50	17	50	25
4	Net usable reserves (NUIR),nc	0.44	42	18	45	18
5	Exports, USD	0.48	42	20	42	16
6	Real effective exchange rate	0.52	42	22	28	11
7	Reserve money, M0, nominal	0.55	50	28	40	13
8	International reserves, USD	0.56	38	21	39	13
9	Foreign liabilities of monetary institutions	0.56	50	28	38	13
10	DMBs' deposits 1	0.56	50	28	38	13
11	DMBs' deposits 2	0.56	38	21	38	13
12	Foreign assets /M4, yoy	0.64	46	29	37	10
13	Reserve money, M0, real	0.64	46	29	37	10
14	Claims on gen.government, net, monet. instit.	0.67	46	31	33	8
15	Domestic credits / output	0.70	33	23	33	7
16	NUIR/M4	0.72	42	30	33	7
17	Foreign assets /M4	0.72	42	30	33	7
18	Domestic credits/output (ind,ma)	0.80	29	23	30	4
19	Domestic credits / output (CPI)	0.84	29	25	29	3
20	Capital outflows	0.87	25	22	29	3
21	Budget deficit/output (CPI)	0.96	21	20	24	1
22	Real bilateral exchange rate, nc/euro	0.98	25	24	22	0
23	Trade balance	0.99	33	33	26	0

Croatia

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] – [(A+C)/(A+B+C+D)] 5
1	Real effective exchange rate	0.22	43	9	77	35
2	Foreign assets /M4	0.26	50	13	60	32
3	Domestic credits / output	0.30	46	14	65	30
4	Real bilateral exchange rate, nc/euro	0.32	63	20	60	28
5	DMBs' reserves/total assets	0.35	46	16	58	26
6	CB claims on DMB's	0.35	46	16	58	26
7	NUIR/M4	0.41	58	24	48	20
8	M1/M0	0.43	42	18	53	21
9	Domestic credit, nominal	0.43	42	18	53	21
10	Capital inflows	0.55	50	27	40	13
11	Current acount balance	0.56	50	28	44	13
12	Foreign liabilities of monetary institutions	0.66	33	22	42	10
13	Claims on gen.government, net, monet. instit.	0.69	42	29	43	8
14	M4/M0	0.78	29	23	41	6
15	Budget deficit/output	0.79	29	23	44	6
16	DMBs' claims on public sector/total assets	0.82	29	24	37	5
17	Real money market interest rate	0.85	38	32	39	4
18	Trade balance	0.86	38	32	33	3

Hungary						
	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	Imports, USD	0.37	67	25	37	19
2	NUIR/M4	0.46	42	19	37	16
3	M4/M0	0.57	50	29	33	11
4	M1/M0	0.58	50	29	32	10
5	Real effective exchange rate	0.64	46	29	24	7
6	Claims on gen.government, net, monet. instit.	0.65	46	30	32	8
7	Domestic credit, nominal	0.65	46	30	32	8
8	Reserve money, M0, nominal	0.80	29	23	24	4
9	Domestic credits / output	0.84	38	32	27	3
10	Money supply, M1, real	0.93	27	25	25	1
11	Real lending-real deposit rate	0.98	33	33	17	0
12	Reserve money, M0, real	0.98	33	33	22	0

Latvia

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] – [(A+C)/(A+B+C+D)] 5
1	Reserve money, M0, real	0,23	58	13	61	35
2	Money supply, M1, real	0,33	67	22	52	26
3	Domestic credits / output	0,41	58	24	48	20
4	Domestic credits / output (CPI)	0,41	54	22	48	20
5	Foreign assets /M4, yoy	0,49	54	26	42	16
6	M4/M0	0,61	46	28	37	11
7	Reserve money, M0, nominal	0,62	33	21	36	10
8	Domestic credit, nominal	0,66	33	22	35	9
9	Claims on gen.government, net, monet. instit.	0,66	33	22	35	9
10	Imports, USD	0,72	42	30	40	8
11	NUIR / M4,yoy	0,74	42	31	32	6
12	Foreign liabilities of monetary institutions	0,78	42	32	31	5
13	Foreign assets /M4	0,81	29	24	27	4
14	Capital inflows	0,89	38	33	27	2
15	International reserves, USD	0,99	25	25	26	0

Lithuania

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	Exports, USD	0,15	67	10	73	45
2	Budget deficit/output (CPI)	0,21	58	13	70	37
3	Budget deficit/output (ind,ma)	0,21	58	13	70	37
4	Domestic credits / output (CPI)	0,25	71	18	57	32
5	Budget deficit/output	0,25	50	13	67	34
6	Budget deficit/output (ind)	0,25	50	13	67	34
7	Money supply, M1, real	0,28	58	16	54	30
8	Domestic credits / output	0,28	54	15	54	29
9	Domestic credits/output (ind,ma)	0,32	50	16	52	26
10	Domestic credits/ otuput (ind)	0,34	67	23	50	24
11	Reserve money, M0, real	0,35	50	18	48	24
12	Capital outflows	0,56	38	21	38	13
13	Claims on gen.government, net, monet. instit.	0,58	38	22	36	12
14	CB claims on DMB's	0,58	38	22	36	12
15	Reserve money, M0, nominal	0,69	3	23	32	8
16	Real lending-real deposit rate	0,69	33	23	29	7
17	Real bilateral exchange rate, nc/euro	0,7	33	23	29	7
18	Real money market interest rate	0,74	42	31	30	6
19	Domestic credit, nominal	0,75	42	31	30	6
20	DMBs' claims on public sector/total assets	0,75	42	31	30	6
21	Trade balance	0,83	38	31	32	4
22	Capital inflows	0,89	38	33	27	2
23	International reserves, USD	0,99	33	33	24	0

Poland

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	DMBs' deposits 1	0.26	83	22	45	27
2	Real money market interest rate	0.27	63	17	45	27
3	DMBs' deposits 2	0.39	67	26	36	18
4	Reserve money, M0, real	0.40	50	20	35	17
5	Real lending-real deposit rate	0.40	67	27	34	17
6	Net usable reserves (NUIR),nc	0.51	42	21	30	12
7	Foreign liabilities of monetary institutions	0.53	42	22	29	11
8	Budget deficit/output (CPI)	0.61	31	19	40	11
9	Budget deficit/output (ind)	0.61	31	19	40	11
10	Budget deficit/output (ind,ma)	0.61	31	19	40	11
11	Budget deficit/output	0.71	31	22	36	7
12	Trade balance	0.76	42	31	23	5
13	Real bilateral exchange rate, nc/euro	0.81	29	24	26	4
14	Real effective exchange rate	0.98	25	25	17	0

Romania

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	NUIR/M4	0.09	100	9	63	50
2	Foreign assets /M4	0.23	100	23	40	27
3	Foreign liabilities of monetary institutions	0.24	75	18	39	26
4	Money supply, M1, real	0.31	83	26	33	20
5	DMBs' claims on public sector/total assets	0.31	83	26	33	20
6	Claims on gen.government, net, monet. instit.	0.35	58	20	32	18
7	M1/M0	0.36	58	21	30	17
8	Net usable reserves (NUIR),nc	0.42	50	21	27	14
9	NUIR / M4,yoy	0.42	50	21	27	14
10	Capital outflows	0.46	50	23	20	10
11	Foreign assets /M4, yoy	0.47	42	19	25	12
12	DMBs' reserves/total assets	0.53	42	22	23	10
13	CB claims on DMB's	0.53	42	22	23	10
14	International reserves, USD	0.64	50	32	13	4
15	Real bilateral exchange rate, nc/euro	0.73	33	24	73	61
16	M4/M0	0.75	42	31	17	4
17	Real effective exchange rate	0.76	42	32	11	3
18	Exports, USD	0.98	58	57	17	1

Slovakia

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	CB claims on DMB's	0.14	100	14	50	37
2	DMBs' deposits 1	0.24	75	18	38	25
3	DMBs' reserves/total assets	0.29	67	19	33	20
4	DMBs' deposits 2	0.29	67	19	33	20
5	Foreign assets /M4, yoy	0.35	58	20	29	16
6	Foreign liabilities of monetary institutions	0.55	42	23	21	8
7	Imports, USD	0.55	42	23	21	8
8	Real effective exchange rate	0.56	42	23	14	6
9	International reserves, USD	0.62	50	31	19	6
10	Budget deficit/output (ind)	0.98	25	24	13	0
11	Budget deficit/output (ind,ma)	0.98	25	24	13	0

Slovenia

	Indicators	Noise-to-signal ratio [B/(B+D)]/[A/(A+C)] 1	% good signals A/(A+C) 2	% false signals B/(B+D) 3	P crisis/signal A/(A+B) 4	P crisis/signal – P crisis [A/(A+B)] –[(A+C)/(A+B+C+D)] 5
1	Reserve money, M0, nominal	0.35	50	17	46	23
2	Real bilateral exchange rate, nc/euro	0.36	46	16	44	22
3	Imports, USD	0.41	46	19	44	20
4	Reserve money, M0, real	0.57	50	29	32	10
5	Capital inflows	0.57	38	21	33	11
6	Capital outflows	0.57	38	21	33	11
7	Money supply, M1, real	0.69	33	23	29	7
8	Real money market interest rate	0.75	42	31	27	5
9	Real lending-real deposit rate	0.76	42	32	25	5
10	Budget deficit/output (CPI)	0.78	29	23	27	5
11	Budget deficit/output (ind,ma)	0.78	29	23	27	5
12	Budget deficit/output	0.82	29	24	26	4