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From Transition Crises to Macroeconomic Stability? Lessons from a Crises Early Warning System for Eastern European and CIS Countries

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Abstract:

This paper uses a Markov regime-switching model to assess the vulnerability of a series of Central and Eastern European countries (i.e. Czech Republic, Hungary, Slovak Republic) and two CIS countries (i.e., Russia and Ukraine) during the period 1993–2004. For the new EU member states in Central and Eastern Europe, the results of our model show that the majority of crises in those countries can be explained by inconsistencies in the domestic policy mix and by the deterioration of macroeconomic fundamentals, as emphasized by first generation crises models, while for the CIS countries analysed, financial vulnerability type indicators were the most relevant, i.e., indicators connected with the second and third generation of crisis model better explain the vulnerability of these countries. Additionally, the set of indicators choosen by our model is rather heterogenous, supporting the superiority of a country-by-country approach.

Keywords: EU, Central and Eastern Europe, CIS, early warning system, currency crisis, Markov switching

JEL Classification: F47, P20, C22

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1. Introduction

The concept of early warning systems (EWS) has been connected with various methodologies. The pioneering paper of Kaminsky, Lizondo, and Reinhart (1998) and the implementation of an EWS for currency crises by the International Monetary Fund[1] (IMF) set the standard for the early empirical studies. A number of empirical papers dealt with financial crises of the Southeast Asian and Latin American countries. Central and Eastern Europe, and especially the CIS countries, were usually not included in those early studies.

The reasons were obvious: inconsistent and short data series, application of different methodologies for statistical reporting and rapid economic transition. In spite of these difficulties, the first empirical studies dealing with so-called transition countries appeared during the end of the nineties (see Brüggemann and Linne 1999 and 2002) using the traditional "signals" approach. Recently new methodologies have been applied to EWS construction. In this paper, we follow the study by Abiad (2003) and estimate a Markov regime-switching model with time-varying transition probabilties. The primary objective of this paper is to estimate crises that occurred in a set of different countries: Czech Republic, Hungary, Russia, Slovak Republic, and Ukraine.[2] Our model correctly identifies most of the crisis periods.

The rest of the paper is organized as follows. Section 2 provides a review of theoretical and empirical literature on currency crises. Section 3 describes the applied methodology, model and data specification. Section 4 presents the results from the EWS based on a Markov regime-switching model and makes an evaluation of the capabilities of the model, based on a comparative goodness of fit assessment. Section 5 concludes the paper.

2. Theoretical and Empirical Background

To quantify the potential vulnerability of a speculative attack, the causes of a crises must be clearly understood. The following overview of theoretical crises models represents the analytical setting for the choice of possible leading indicators in the early warning model.[3]

According to the literature, one can distinguish between three classes of theoretical models of currency crises. Following the model of Salant and Henderson (1978), Krugman (1979) and Flood and Garber (1984) developed the "so-called" *first-generation* currency crises models as response to the currency crises of Mexico and Argentina in the 1970s. In particular, the basic premise in these models is the inconsistency of domestic policies, such as an excessive money-financed fiscal deficit, with the commitment to a fixed exchange rate. Domestic credit expansion in excess of money demand growth leads to a gradual decline in international reserves. In case reserves fall to a critically low level, which is perceived as insufficient by market agents, the currency comes under attack: the attack depletes reserves immediately and the fixed exchange rate regime must be abandoned. To this class belong also models, which suggest that a real appreciation of the currency and a deterioration of the trade

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1 The IMF's EWS is described in Berg et al. (1999).

2 From the group of Central and Eastern European countries we excluded Poland, because of data availability. Other countries from the region (i.e., the Baltics, Belarus) were excluded due to the lack of open crisis during this period.

3 For a comprehensive review of the theoretical literature for the first- and second-generation crises models, see Blackburn and Sola (1993), Flood and Marion (1999) and Jeanne (2000).

or current account balance typically precede speculative attacks. Consequently, a crisis is the unavoidable and predictable outcome in an economy with a constant deterioration of its "fundamentals".

To capture the features of the crises in the European Monetary System (EMS) and in Mexico in the 1990s, a *second-generation* of currency crises models was developed (Obstfeld 1986, 1994). These models show that the government faces a trade-off between alternative policies to defend or to abandon a fixed exchange rate regime, and that the foreign exchange market could be subject to *self-fulfilling expectations* if the cost of defending the exchange rate peg rises with the expectations of private agents towards an abandonment of it. This implies the existence of *multiple equilibria*, since a change in private sector's expectations may lead to a jump from one to another equilibrium.[4] The exact timing of crises is, therefore, unpredictable. However, Krugman (1996) and Obstfeld (1996) emphasize that some weakness in the fundamentals is required before a shift in expectations can push an economy into a crisis. Thus, it is possible to identify zones of vulnerability for "fundamentals" where a crisis may or may not occur. In principle, any fundamental variable that influences the policymakers' decision whether to defend the fixed exchange rate can be considered in these models. The list of fundamentals originating from first-generation models is, therefore, expanded to output, unemployment, inflation, and domestic and foreign interest rates. An important implication of these models is that anticipating crises may be extremely difficult since a tight link between fundamentals and crises does not necessarily exist.

The Asian crisis of 1997 exhibited particular characteristics that could not be fully explained by first- and second-generation models. This led to the development of *third-generation* crises models. The focus of these models is to explain the combination of a weak financial sector with currency crises ("twin crises").[5] Within this new category, two types of currency crises models may be distinguished. On one, explicit or implicit government guarantees for private sector foreign borrowing can create a *moral hazard* problem. This typically gives rise to an asset price bubble.[6] If the asset price bubble bursts, this causes a severe liquidity problem and a contraction of economic activity as well as a costly fiscal bailout of bad loans. Therefore, expectations of an ensuing excessively expansionary monetary policy rise. Thus, like in first-generation crises models, the speculative attack on the currency originates from inconsistent domestic policies. On the other hand, currency crises can also originate from banking crises if a run on the local banking system encourages panic-stricken foreign investors to flee the country.[7] In these models, high short-term foreign capital inflows (foreign currency loans) lead to currency and maturity mismatches which causes banking system fragility. The collapse of a solvent but illiquid banking system is due to bank runs based on self-fulfilling expectations. In this setting, a currency crisis occurs because the role of the central bank as lender of last resort comes into conflict with the need to defend the fixed exchange rate. In general, third-generation currency crises models emphasize the role played by microeconomic factors implying that the list of potential indicators can be enlarged to banking deposits, short-term foreign debt and M2 to reserves, bank assets, lending deposit

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[4] What triggers the jump between multiple equilibria remains largely unexplained. Possible explanations are contagion effects or herding behaviour in the presence of imperfect information, see Masson (1999).

[5] Kaminsky and Reinhart (1996, 1999) pioneered the empirical work on twin crises. They found empirical evidence that banking crises tend to precede currency crises, but the causal link is not unidirectional since the currency crisis deepens the banking crisis.

[6] See Corsetti, Pesenti and Roubini (1998), Dooley (1997), Krugman (1998) and McKinnon and Pill (1997).

[7] See Chang and Velasco (1998), Goldfajn and Valdés (1997) and Radelet and Sachs (1998).

rate ratio, portfolio flows, stock price indices, and M2 multipliers. Table 4 in the Appendix provides a summary of potential leading indicators with respect to crises symptoms and theoretical models.

In the earlier empirical literature[8] two major approaches for predicting currency crises can be distinguished. The first one is the *signals approach*, originally presented by Kaminsky and Reinhart (1996) and Kaminsky, Lizondo and Reinhart (1998). This approach chooses thresholds for each indicator variable in order to distinguish their movements in periods preceding a crisis from their usual behavior in normal, non-crisis periods. The level of the threshold is set so that it minimizes the "noise-to-signal-ratio", i.e., the risk of false signals to the risk of missing crises. The contribution of each indicator variable to the vulnerability of a country can then easily be determined. This non-parametric approach is typically univariate[9] and does not allow testing the statistical significance levels of variables. These drawbacks can be overcome by applying multivariate *logit or probit regressions*. Eichengreen, Rose and Wyplosz (1995) and Frankel and Rose (1996) were the first to apply this method to predicting currency crises. All information about a crisis is contained in the predicted crisis probability. By comparing signals models with probit models, Berg and Patillo (1999a and 1999b) show that probit models perform slightly better in terms of predicting crises. One explanation may be the transformation of the indicator variables into binary variables in the signals approach, which entails a loss of information.

Both signals and probit/logit models require a priori dating of crises episodes before estimation. This entails many ad hoc assumptions since different methods can be applied which result in different crises dates being identified. A common procedure is to construct an *index of speculative pressure* and set a certain threshold level such that a crisis is being identified when this threshold is crossed.

On the other hand, applying a Markov switching model allows simultaneously identifying crises episodes and estimating crises forecast probabilities. Furthermore, by employing time-varying transition probabilities, the probability of switching from a tranquil regime to a crisis regime can be modeled as a function of a country's fundamentals. Markov switching models, therefore, acknowledge that periods leading to crises are intrinsically different from tranquil, non-crisis periods, and they allow determinants triggering shifts from one regime to another. The statistical significance of the determinants of crises can also be derived.

Markov switching models have been used in several empirical studies to determine currency crises.[10] However, none of them examines Central and Eastern European or CIS countries. Martinez-Peria (2002) used a Markov switching model with time-varying transition probabilities to model the currency crisis in the European Monetary System in the early 1990s. Her results indicate that the regime-switching approach identifies speculative attacks better vis-à-vis using the common threshold crisis-dating procedure. The study by Abiad (2003), to which this work is most closely related, underlines the good predictive ability of the Markov switching model. He looks at the 1997 Asian-crisis countries, but unlike

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[8] For an estensive survey of the empirical literature, see e.g. Kaminsky, Lizondo and Reinhart (1998) and Abiad (2003).

[9] Kaminsky (1998) presents a method to combine individual indicators into a composite indicator.

[10] In addition to the studies mentioned, Alvarez-Plata and Schrooten (2003), Jeanne and Masson (2000) and Fratzscher (1999) use Markov-switching models with constant transition probabilities to model the switches between multiple equilibria leading to currency crises.

Martinez-Peria, who pooled the data across countries, estimates the model for each country separately. This takes into account that the economic situation in each country is different and, therefore, different leading indicators may be significant for different countries. By assessing the predictive ability of the model, he finds that the model both correctly anticipates more crises periods in the sample and sends fewer false signals than other models.[11] In a recent study, Arias and Erlandsson (2004) also apply the Markov switching concept with time-varying transition probabilities to the Asian-crisis countries, where they correct for the bias of the estimation procedure, which would result in the selection of short-term predictors of regime switches rather than long-term ones. The predictive ability of their model is comparable to the model of Abiad.[12]

As indicated before, only few studies have looked at transition economies, and even fewer to CIS countries, including Russia. Among those, Brüggemann and Linne (2002) look at the vulnerability of 16 Central and Eastern European countries to currency crises. They find that exports, foreign exchange reserves, and the lending deposit rate ratio are the best performing indicators in signaling a crisis. The real exchange rate, banking deposits, budget deficit, industrial production, M2 multiplier, domestic credit and interest rate, M2 to reserves, short-term foreign debt, and imports are also useful in predicting a currency crisis.

3. Model Specification

The endogenous variable y_t in our model is assumed to depend on an unobserved first-order two-state Markov chain $\{s_t\}_{t=1}^{T}$ as follows:

$$y_t \mid s_t \overset{iid}{\sim} N\left(\mu_{s_t}, \sigma_{s_t}^2\right), \tag{1}$$

where s_t=0 denotes a tranquil, non-crisis state and s_t=1 a crisis state. The mean and variance of y_t are allowed to shift with the respective state s_t. Hence, the conditional density of y_t for s_t=0,1 is

$$f\left(y_t \mid s_t\right) = \frac{1}{\sqrt{2\pi}\sigma_{s_t}} exp\left(\frac{-\left(y_t - \mu_{s_t}\right)^2}{2\sigma_{s_t}^2}\right). \tag{2}$$

The transition probability matrix P_t associated with the latent regime-switching variable s_t is defined as

$$P_t = \left[\begin{array}{c|c} p_{00}^t & p_{01}^t = \left(1 - p_{00}^t\right) \\ Pr\left(s_t = 0 \mid s_{t-1} = 0; x_{t-1}\right) & Pr\left(s_t = 1 \mid s_{t-1} = 0; x_{t-1}\right) \\ = F\left(x_{t-1}^{'}\beta_0\right) & = 1 - F\left(x_{t-1}^{'}\beta_0\right) \\ \hline p_{10}^t = \left(1 - p_{11}^t\right) & p_{11}^t \\ Pr\left(s_t = 0 \mid s_{t-1} = 1; x_{t-1}\right) & Pr\left(s_t = 1 \mid s_{t-1} = 1; x_{t-1}\right) \\ = 1 - F\left(x_{t-1}^{'}\beta_1\right) & = F\left(x_{t-1}^{'}\beta_1\right) \end{array}\right]. \tag{3}$$

[11] At a cut-off probability of 50%, the model correctly calls 65% of pre-crisis periods, whereby 27% of total alarm signals are false.

[12] The model correctly calls approximately 70% of pre-crisis periods at a cut-off probability of 40%.

The transition probability p_{ij}^{t} gives the probability that state *i* in period *t*-1 will be followed by state *j* in period *t*. The two transition probabilities are time-varying, evolving as the cumulative density function of the logistic distribution *F*. The constant and the early warning indicators, which affect the state transition probabilities, are contained in vector x_{t-1}. [13] To get maximum likelihood estimates of all parameters in the regime-switching model, we use the likelihood function using the iteration described in Hamilton (1994: 692–93).

To be able to assess currency crises under different exchange rate regimes, the "crisis" variable to be used as dependent variable y_t is an "Index of Speculative Pressure" (ISP), defined as:

$$ISP_t = \frac{1}{\sigma_{ER}}\left(\frac{ER_t - ER_{t-1}}{ER_{t-1}}\right) + \frac{1}{\sigma_{IR}}\left(IR_t - IR_{t-1}\right) - \frac{1}{\sigma_R}\left(\frac{R_t - R_{t-1}}{R_{t-1}}\right). \quad (3)$$

In (3) above, ER denotes the nominal exchange rate (defined as domestic currency to Euro), IR denotes nominal interest rate, R denotes international reserves, and σ denotes the respective standard deviation. Every variable is determined as one-month growth rate. An increase of the ISP, therefore, originates from an increase in the nominal exchange rate (depreciation of the domestic currency) and/or a rise in interest rates and/or a decrease in reserves.

The model estimates one-month ahead forecast probabilities, which are transformed into 12-month ahead forecast probabilities.[14] This reflects a compromise between more accurate forecasts shortly before the crisis date and the fact that the model should signal a crisis as soon as possible (Arias and Erlandsson 2004). Because the estimated crisis probability cannot be compared to the actual crisis probability, it has become standard to determine a cut-off probability so that an alarm signal is being emitted if the forecasted probability is higher than this threshold. We set this cut-off probability to 50%, favoring the risk of missing crises to the risk of having more false signals at a lower cut-off probability. In this case a good signal is defined if the estimated crisis probability is higher than 50% and a crisis ensued within the next 12 month or no signal was issued and no crisis occurred. In the same way, a signal is said to be false if the forecasted crisis probability is higher than 50% and no crisis occurred during the next 12 month or no signal was issued and a crisis ensued.

4. Empirical Results

The model is estimated by using monthly data series for the Czech Republic, Hungary, Russia, the Slovak Republic, and Ukraine, taken from IMF's International Financial Statistic (IFS). This is a very heterogenous set of countries: As three of these countries entered the EU in May 2004, while two others, Russia and Ukraine, have no such perspective in the short run, and one, Russia, is largely a resource dependent economy, this set enables one to assess if a credible prospect of EU entry makes any difference in terms of both crises determinants and crises probability.

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[13] Diebold, Lee and Weinbach (1993) extended the baseline Hamilton (1989) regime-switching model to allow for time-varying transition probabilities.

[14] Here it is assumed that the indicators that influence the crisis probability neither worsen nor improve during this period.

The series cover the period 1993:12 to 2004:06. The selection of potential early warning indicators is made using as reference theoretical models of currency crises, plus specific features of the analyzed economies (for instance, its dependency on oil exports, in the case of Russia, and as an ersatz oil/gas exporter – due to the transit fees on Russian oil and gas – for Ukraine), and data availability. The tested variables are listed in Table 1 below.

We present the results for the five countries mentioned before: the Czech Republic, Hungary, Russia, the Slovak Republic and Ukraine. Our country sample is restricted for two reasons. First, for most of the remaining new EU member states the EWS just does not capture any significant "crisis event", even when using the broad definition of an ISP. This is specially, but not only, the case for currency board or quasi-currency board regimes (Estonia, Latvia, and Lithuania). Of course, this non-result is in itself an interesting one, as it may be seen as an indication of the robustness of such an extreme type of hard currency regime. Second, for other new EU member states, the EU accession countries Bulgaria and Romania, and other CIS countries, either the shortness of the usable sample, the questionable quality of the date series, or statistical problems with the data hinders interpretation of the results and puts some doubts on their overall robustness. For the five countries for which data is available and which reveal crisis events our EWS show clear, robust and interpretable results, which we will detail below.

Table 1: Tested variables

1	Deviation of real exchange rate from trend	16	Real interest rate
		17	IPI growth
2	Current account balance/GDP	18	Growth of ratio of loans on deposits
3	Real domestic credit, growth rate	19	LIBOR
4	Portfolio flows	20	Growth in bank assets
5	Lending deposit rate ratio	21	Lagged reserve ratio
6	FDI-current account deficit/GDP	22	Monetary authority credit
7	Import-export ratio	23	The ratio of non-FDI inflows
8	M2 multiplier	24	Ratio of deposits to M2
9	M2 as share of reserves	25	Changes in the ratio of deposits to M2
10	Changes of M2 as share of reserves	26	Ratio of loans to deposits
11	GDP growth	27	Brent oil price
12	Exports growth	28	Changes in Brent oil price
13	Changes in reserves	29	Budgetary position of the central government in GDP %
14	Stock prices lagged growth,	30	Changes of the budgetary position of the central
15	Lagged current account balance		government in GDP %

The final selection of explanatory variables for the model is made by using the approach of Abiad (2003). A bivariate model is estimated with only one indicator and a constant at a time to get t-statistics for the coefficients of the indicators and log-likelihood values for the corresponding model.[15] The different signs and degrees of statistical significance of various indicators confirm the country-by-country assessment, since the chosen countries exhibit different sources of vulnerability.[16] Only some indicators are significant per country: for the Czech Republic, deviation of real exchange rate from trend, current account balance as a GDP share, the growth rate of the industrial production and the FDI-current account deficit on

[15] Each indicator is standardized to be zero mean and unit variance.

[16] Results not presented here, but available from the authors upon request.

GDP, in case of Hungary the lending deposit rate ratio and the gap between foreign direct investment and current account deficit, and in case of the Slovak Republic the gap between foreign direct investment and current account deficit, for Russia the deviation of real exchange rate from trend, the LIBOR, changes in the ratio of deposits to M2 and ratio of loans to deposits, while for Ukraine only banking deposits/M2, M2/reserves and the real interest rate are significant.

However, considering that there is correlation among the indicators, the t-statistics may be misleading for the significance assessment of indicators. Therefore, the selection criterion for the multivariate models is the log-likelihood value of each bivariate model. Based on this final criterion, significant indicators have been chosen for each country. Performing a likelihood-ratio test for joint significance of indicators showed them to be significant.

Table 2: The multivariate EWS models

Early Warning Indicators	Czech Republic		Hungary		Slovak Republic		Russia		Ukraine	
	Coeff.	T-stat.	Coeff.	T-stat.	Coeff.	T-stat.	Coeff.	T-stat.	Coeff.	T-stat.
Mean, s_t=0	-0.19	-2.19	-0.09	-1.06	-0.21	-2.49	-0.28	0.07	0.00	0.01
Mean, s_t=1	2.07	1.30	2.43	2.71	2.77	1.32	0.25	0.48	-0.11	-0.13
Sigma, s_t=0	0.80	12.60	0.81	10.80	0.84	13.31	0.45	0.05	0.22	14.05
Sigma, s_t=1	2.79	3.30	1.63	3.15	2.42	2.79	2.92	0.25	3.75	11.74
Deviation of real exchange rate from trend	-1.65	-1.03					0.32	1.08		
Current account balance/GDP	-1.96	-0.70	-0.27	-0.50	-0.45	-0.56				
Real domestic credit, growth rate			-0.84	-1.40	-0.60	-1.01				
Industrial product-ion, growth rate	-0.70	-0.52								
FDI-current account deficit/GDP	-0.32	-0.28	-0.24	-0.21	-0.48	-0.59				
Import export ratio					-0.41	-0.44				
Banking deposits/M2			-1.16	-0.87					-0.35	-0.13
M2/Reserves									-1.94	-1.35
Real Interest Rate									6.27	0.54
LIBOR							-1.90	1.24		
Changes in the ratio of deposits to M2							-0.45	0.56		
Ratio of loans to deposits							-0.51	0.50		
Constant ($ß_0$)	2.91	1.17	1.82	2.53	1.80	2.35	1.74	0.64	-20.63	-1.28
Constant ($ß_1$)	-0.38	-0.48	0.41	0.49	-0.88	-1.28	1.08	0.38	0.76	2.15
Number of observations	121		133		124		122		125	
Likelihood ratio test	9.26		15.61		11.68		11.73		7.98	
P-value	0.05		0.00		0.02		0.02		0.05	

The final results of the multivariate regression are shown in Table 2. As can be seen, rather traditional indicators of crises are chosen for the Czech Republic and the Slovak Republic, mostly related to external imbalances, and in the case of Hungary a mix of financial sector and external imbalances indicators is relevant. For Russia and Ukraine, the list mainly

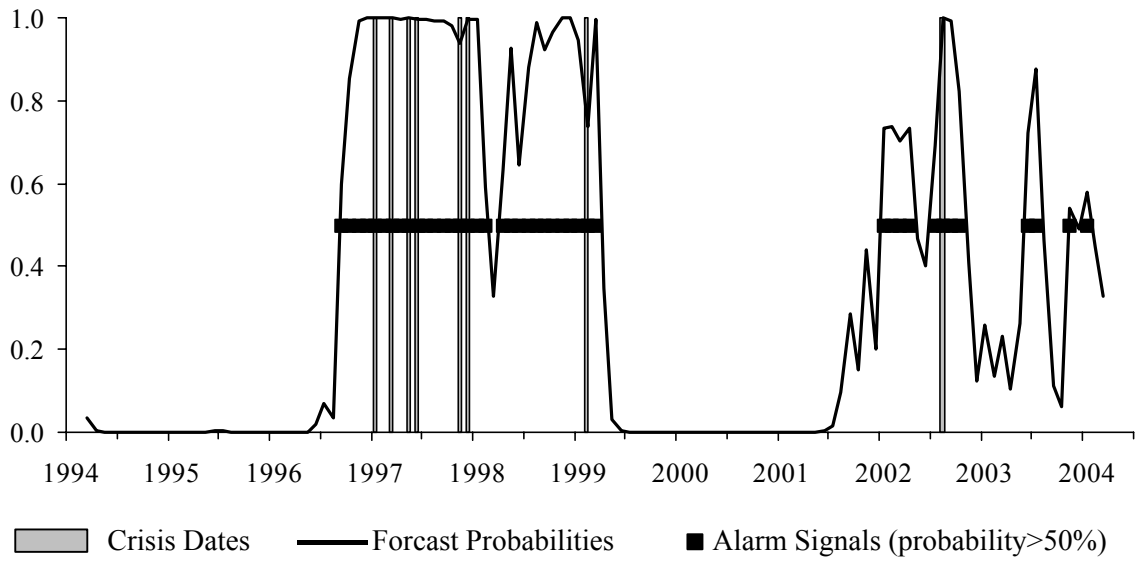
includes financial sector indicators. Furthermore, the expected conditions $\mu_0 < \mu_1$ and $\sigma_0 < \sigma_1$ hold, so that state 0 is identified as low-mean, low-volatility regime, and state 1 as high-mean, high-volatility regime.

Czech Republic

Following the results from the bivariate regression, we chose four indicators for the Czech Republic – the deviation of the real effective exchange rate from trend, current account balance to GDP, industrial production, and the gap between foreign direct investment and current account deficit to GDP. According to the selection, we conclude that balance of payment indicators play a substantial role in explaining speculative attacks in this case. Moreover, the deviation of the real effective exchange rate from trend, considered as the most complex indicator of speculative pressures, appears to be important in evaluating incoming problems.

Three out of four chosen indicators refer to external imbalances in the economy. The first-generation of theoretical models describes external imbalances as symptom of crisis. Inclusion of industrial production as indicator shows that speculative attacks in the Czech Republic could be predicted also by indicators described in the second-generation theoretical models.

Figure 1: Czech Republic – Crisis Dates, Forecast Probabilities and Alarm Signals, 1994–2004



In Figure 1, we can observe crisis periods along with the 12-month forecast probabilities and alarm signals based on 50% cut-off probability. Currency speculators in the first months after the break-up of Czechoslovakia directed their attention to the appointed monetary authorities of the Czech Republic and the Slovak Republic. Although the result of this speculative attack was not a currency crisis, international reserves of both central banks decreased significantly. We mentioned the historically first speculative attack in not-fully liberalized environment as a common feature of the Czech Republic and the Slovak Republic.

Data availability and construction of the early warning indicators averted our model to assess this experience.

In case of the Czech Republic one major currency crisis has occurred in May 1997. Our model sends alarm signals from September 1996, eight months prior to the crisis. The principal trigger of the speculative attack against the Czech crown was excessive external imbalance. High real wage growth exceeding productivity growth induced a huge current account deficit.[17] Through rapid appreciation of the real exchange rate, the domestic corporate sector could not resist growing competition pressures from abroad. As an outcome, increasing domestic absorption required an upswing in imports.

During the turbulent years of the late 1990s, our model is sending alarm signals up to beginning of the year 1999. Forecast probabilities are oscillating noticeably above the 50% threshold. One can observe contagion effect on the behaviour of the real exchange rate during year 1998. Excessive appreciation pressures at the beginning of the summer 1998 were replaced by flight of short-term foreign capital right after the Russian currency crisis erupted. Although we did not include an indicator for measuring contagion in our model, depreciation pressures against the Czech crown resulted in persistent signalling up to the end of 1998. Gibson and Tsakalaatos (2004) highlight the possible effect of the Asian crisis in 1997 and the Russian crisis in 1998 on accession countries. They found *"...the strong effect from the Russian crisis, providing the evidence that contagion is an important factor in determining the probability of speculative attacks"*.[18]

Throughout the years 2002–2003, our model is sending alarm signals sporadically.

Hungary

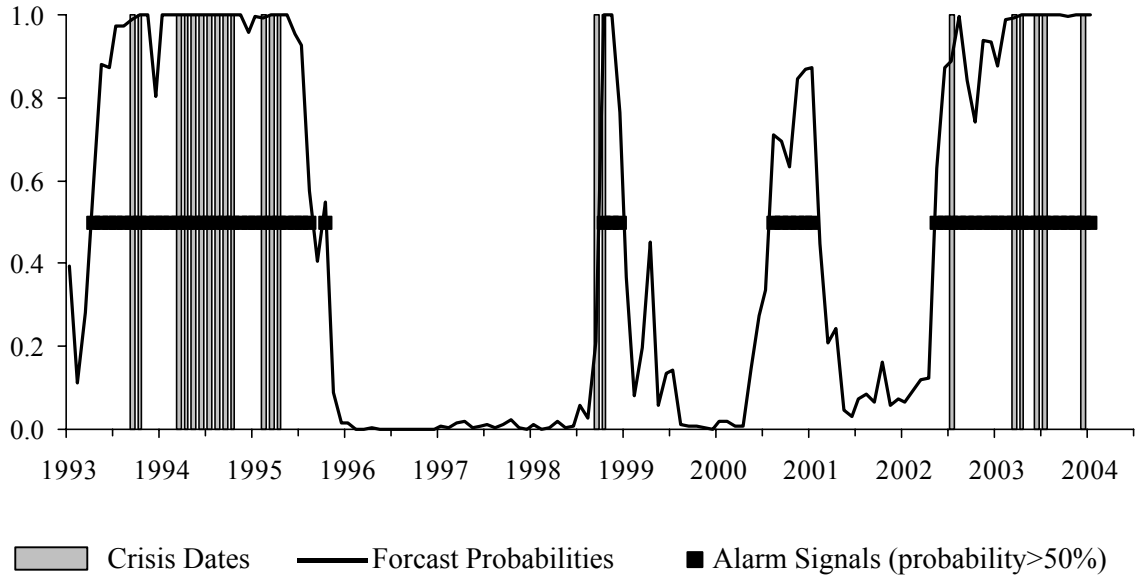
We ran the model for Hungary with four indicators – the current account balance to GDP, real domestic credit growth, the gap between FDI and current account deficit to GDP, and the ratio of banking deposits to M2. The results are shown in Figure 2.

The development of the Hungarian economy was disturbed by several devaluations of forint. During the summer of 1993, the Hungarian forint experienced three minor devaluations (June, July and September), by 9.4% overall. The first major devaluation by 8% took place in August 1994 and served as a prologue to the introduction of government stabilization measures at the end of 1994. Stabilization measures took place with a supportive effect of 9% devaluation and a switch to more flexible crawling band regime on March 1995.

[17] At the beginning of 1997 the estimations of current account deficit to GDP for the whole year 1997 oscillated around 10%, exceeding the expected inflow of long-term non-debt capital.

[18] Gibson and Tsakalatos (2004: 577).

Figure 2: Hungary – Crisis Dates, Forecast Probabilities and Alarm Signals, 1993–2004



Our outcomes correctly marked all of the cases of speculative pressures in Hungary with sufficient time in advance. After the change of exchange rate regime in March 1995 and initial devaluation of 9%, our model keeps sending signals of anticipated speculative pressures. Persistence of signals in that case could be interpreted as the result of the adopted crawling band exchange rate regime with gradual devaluations.[19]

The signals during the year 1998 can be considered as an outcome of the Russian currency crisis. Although there were no major movements in Hungarian financial markets, the negative sentiment about emerging markets after the Russian turmoil put the Hungarian forint under temporary pressure. Concerns about fiscal stability after general elections in 1998 strengthened this behaviour of the market. The signals issued during the end of 2000 and January 2001 are false signals.

The most recent speculative attack Hungary experienced took place during the first months of 2003 resulting in a 2.26% shift of the central parity to devaluation zone. Our model signals the possible currency crisis 8 months in advance of the first speculative attack against the Hungarian forint in January 2003. Continual increase in current account deficit together with low fiscal discipline embodied in growing budget deficit undermined the defence of the Hungarian forint by the central bank.

Persistence of the twin deficit phenomenon in Hungary during the year 2003 amid concerns of recurrence of speculative pressures on forint played a dominant role in the decision process of the Hungarian central bank. In an attempt to cool down the discrepancies

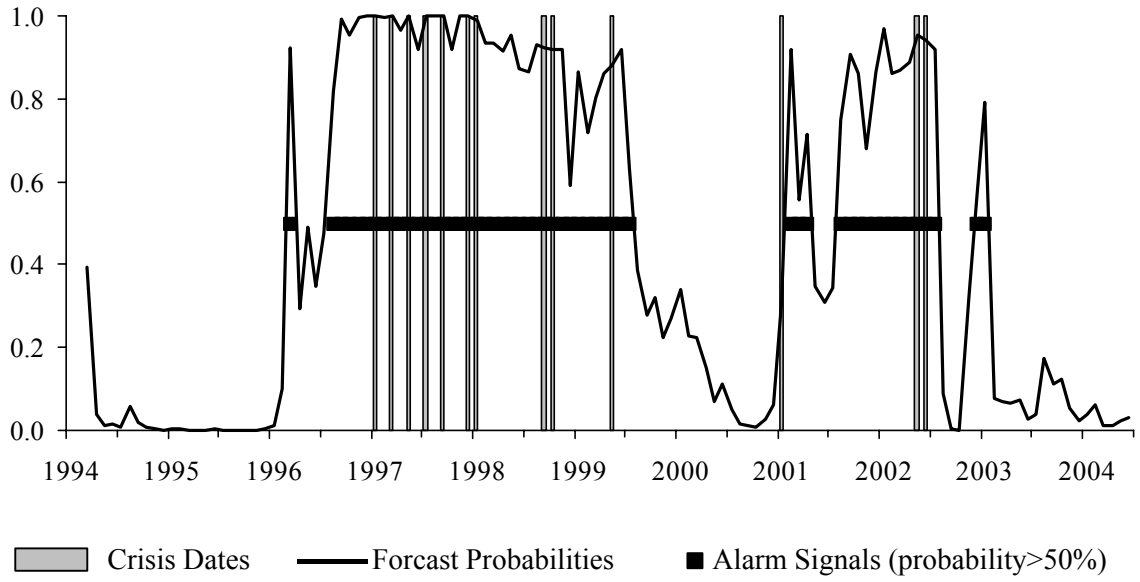
[19] The rate of devaluation in the crawling band regime decreased continuously, from 0.060% of daily devaluation in March 1995 to 0.00654% of daily devaluation in April 2001.

produced by an inconsistent policy mix, the central bank responded by two rapid hikes of its base rate by 300 basis points.[20]

Slovak Republic

In the estimated model for the Slovak Republic, we chose as indicators the current account balance to GDP, real domestic credit growth, the gap between foreign direct investment and current account deficit to GDP, and the import-export ratio. Figure 3 displays the results.

Figure 3: Slovak Republic – Crisis Dates, Forecast Probabilities and Alarm Signals, 1994–2004



The results of the bivariate regression highlight the indicators described in the first-generation of currency crises models. In line with results of the Czech Republic and Hungary most of the indicators for the Slovak Republic focus on external imbalances. Growth of domestic credit also signals overborrowing cycles, which according to the theoretical models can precede both currency and banking crisis. In the late 1990s, the Slovak banking sector was near a collapse. Rapid restructuring and gradual removal of non-performing loans[21] to consolidation agencies averted a banking crisis in the Slovak Republic.

The first speculative attack in a not-fully liberalised environment started right after the break-up of Czechoslovakia and the monetary separation in 1993. After depletion of international reserves, the National Bank of Slovakia came up with a 10% devaluation of the

[20] The first base rate increase took place in May, while the second rate hike the central bank of Hungary pursued, was at the end of November. In both cases, the increase of the base interest rate was 300 basis points.

[21] The estimated costs of this overall removal of non-performing loans are about 105 billion Slovak crowns (about 12% of nominal GDP in 1999).

Slovak crown against a currency basket without widening the oscillation bands.[22] The main incentive for the devaluation was the defence of an initially low level of international reserves. Since our model starts to evaluate the vulnerability periods from early 1994, this speculative attack could not be detected.

The Slovak Republic experienced several speculative attacks during its transition. Although the inconsistent policy mix and unfavourable development of macroeconomic fundamentals predispose the Slovakian economy to speculative attacks, currency speculators succeeded only once – in the fall 1998. The model identifies almost persistent crisis experience during the year 1997, and the forecasted crisis probability is above the 50% threshold signalling a crisis up to spring of 1999.

In May 1997, a speculative attack against the Slovak crown was led by currency speculators, few days after they attacked the Czech crown. Although the strength of the Slovak economy in terms of international reserves was smaller when compared to the Czech economy, the first speculative attack against its currency was unsuccessful. But devaluation pressures on the currency peg forced the central bank to increase interest rates substantially. According to Arvai and Vincze (2000), the main reason, why the speculative attack against the Slovak crown was not successful is that speculative capital inflow had been relatively low in the preceding years.

The successful speculative attack in the fall of 1998 ended with the abandonment of the pegged exchange rate regime. Besides large external imbalances and political uncertainty before general elections, contagion from the Russian crisis played an important role. Abandonment of the pegged regime was followed by a depreciation of about 20% after the exchange rate regime of the Slovak crown changed to a managed float. Model outcomes are in line with historical speculative pressures against the Slovak crown, since alarm signals are emitted before the excessive volatility periods of May 1997 and October 1998.

During the years 2001 and 2002 a high current account deficit and uncertainty about general election in 2002 increased depreciation pressures against the Slovak crown. Politically motivated increases in public sector wages and pensions put pressures on the fiscal side and, through empowered domestic absorption, on the external balance. The response of the National Bank of Slovakia was a massive intervention aiming at halting the fall of value of the Slovak crown.[23]

Russia

For Russia the deviation of real exchange rate from trend, the LIBOR, changes in the ratio of deposits to M2, and the ratio of loans to deposits have been chosen as indicators for the multivariate model. Those indicators are mostly linked to the so-called second and third generation crises models, and they highlight Russia's *financial* vulnerabilities.

Figure 4 shows that the issued signals are very much in line with the stylised description of the Russian crisis during the 1990s.

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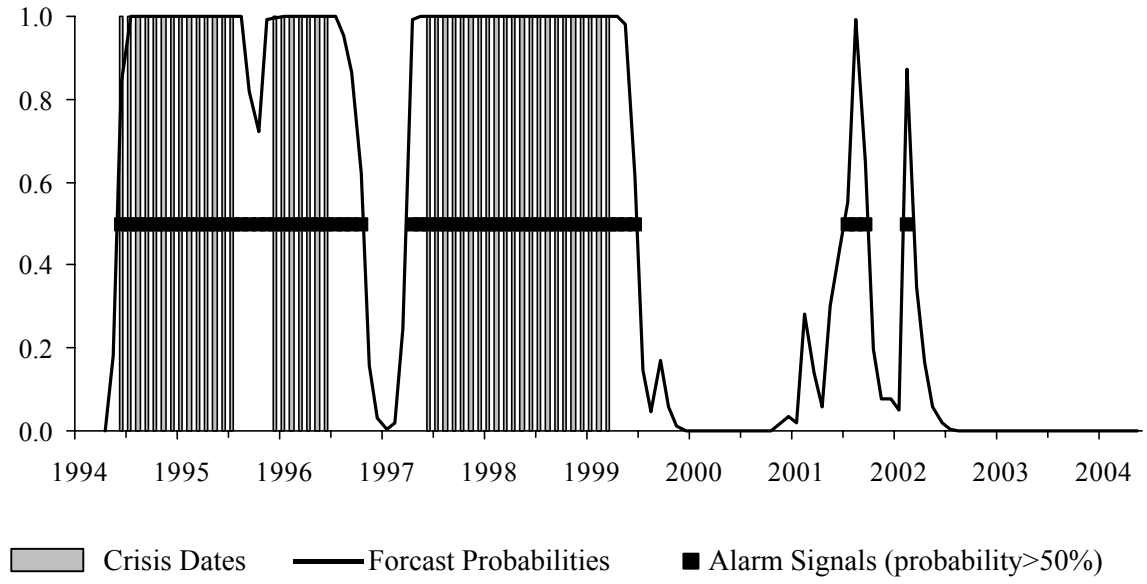
[22] After the political break-up of Czechoslovakia and the following monetary separation, both succession countries pegged its own currency to basket with relatively narrow oscillation bands (± 0.5% from central parity).

[23] During May 2002, the central bank decided to increase interest rates to cool down excessive demand pressures.

Figure 4: Russia – Crisis Dates, Forecast Probabilities and Alarm Signal, 1994–2004



The dissolution of the Soviet Union at the end of 1991 was followed by the usual sharp GDP downturn (the "transitional recession", see Bakanova et al. 2004). A certain macroeconomic stabilization around the mid 1990s was followed by the introduction of a pegged exchange rate regime with a crawling band against the US dollar, from July 1995 onwards, replacing the previous "dirty float".

However, the start of the Asian crisis in 1997 spread a negative shock throughout emerging markets. This external shock decreased investment confidence in Russia and caused capital outflows, forcing the Bank of Russia to defend the band. Although during the exchange market interventions in November 1997 the Bank of Russia lost over USD 6 billion of its liquid reserves, which was equal to two thirds of total reserves at that time, the exchange band was successfully defended in that occasion.

Nevertheless, after renewed attacks in the run up to August 1998, the government was forced to default its domestic debt obligations: this is the onset of the famous Russian 1998 crisis, which also had substantial regional implications, including crises in some of countries covered by this paper.

The Russian Ruble was devalued and the exchange rate band was abandoned, leading to the adoption of a "dirty floating" regime (effectively, still a nominal exchange rate targeting, see Esanov, Merkl and Vinhas de Souza 2005). One consequence of the sharp depreciation was a rapid initial acceleration in inflation. However, the GDP fall was much less severe and prolonged than expected, given first, the gains in competitiveness from the devaluation in industrial sector with plenty of excess capacity, and the still ongoing increase in energy commodities prices (oil and gas), which represent almost 50% of Russia's exports. Those two factors – plus the undeniably more sustainable monetary and fiscal policy mix pursued since 1999, which is also related to the previous factors, given the importance of the energy sector in terms of fiscal revenues in Russia – have underpinned a GDP growth of almost 7% per year since 1999 (see Vinhas de Souza and Havrylyshyn, forthcoming 2006).

Particularly, one can see that the 1998 crisis is clearly f*orewarned* by our model.

Ukraine

For Ukraine only banking deposits/M2, M2/reserves and the real interest rate variables were used in the final multivariate model, again reflecting second and third generation type of crisis determinants, i.e. financial sector vulnerabilities.

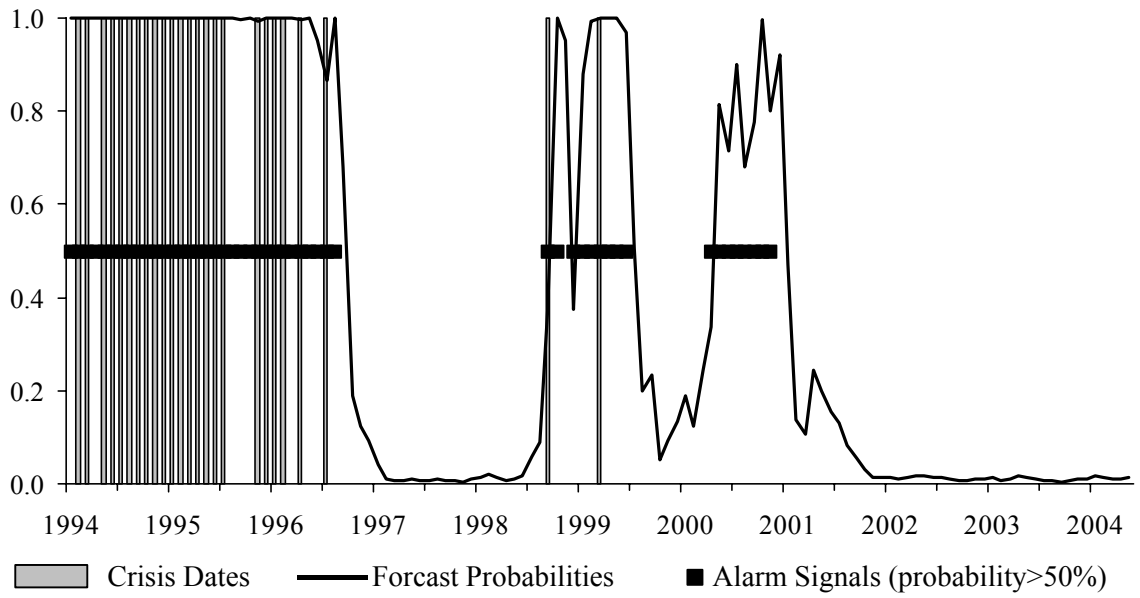
Figure 5 reveals that this small multivariate EWS reflects the crisis period and vulnerability of the Ukraine quite well (see Vinhas de Souza et al. 2005). The first years of transition resulted in substantial adjustment costs for Ukraine. This was partly due to unfavourable initial conditions: Ukraine had one of the highest shares of large-scale intermediate goods industrial enterprises of the former Soviet Union, highly integrated and dependent on the rest of the USSR economy. As a result, Ukraine suffered one of the largest declines in output among the CIS, with manufacturing output declining by over 60% in the first five years of "transition". Monetary and fiscal policies were clearly on an unsustainable path during this period: budget deficits were close to 10% of GDP (a substantial part of which was linked to para-fiscal operations to support the energy sector). As these deficits were largely monetised, they also resulted in inflation, which reached almost 5000% in 1993.

In 1994 an initial stabilization program was finally attempted. Similarly to other adjustment programmes in Eastern Europe, it included price and import/exports liberalization, the unification of the exchange rate, some limited fiscal consolidation and the introduction in 1996 of a national currency, the hryvnia, which was linked to the US Dollar via an exchange rate band of 1.7–1.9 hryvnia/USD. These measures were successful in bringing down inflation from 400% in 1994 to 10% in 1997. Nevertheless, the persistent fiscal deficits were incompatible with a fixed exchange rate regime. The situation came to a head with contagion from the Russian crisis in August 1998. Foreign reserves fell to just over a week of imports, forcing the authorities to devalue the hryvnia (by more than 50%) and to introduce strict restrictions on foreign exchange transactions. Inflation briefly increased, but returned to a downward trend by the early 2000s.

In December 1999, Viktor Yushchenko, a former Central Bank Governor who had built a solid reformist reputation during and after the 1998 crisis, was appointed Prime Minister. He moved fast to introduce reforms during its brief period in power (he was voted out of office in April 2001 by a coalition of "oligarch" and Communist parties, after only 16 months in power). The strong growth resumption in Ukraine (interrupted in late 2004–2005 by the policy disorganization linked to the change in power in the country) is considered by most analysts to be linked to the fiscal and tax reforms initiated during this period, and to the devaluations of hryvnia in 1998–99 and its posterior linking to the USD (given that most of Ukraine's external markets are in the euro area, this implied a further depreciation of the hryvnia from 2003 onwards: a *real* cumulative depreciation of 40% happened since 1998) and the resumption of growth in major CIS markets.

During subsequent years the government continued its efforts towards hardening budget constraints and making the tax system more transparent. Also, in 2000 a free-floating exchange rate regime was introduced (de-facto the hryvnia has been kept at almost constant rate with respect to US dollar, by means of foreign exchange market interventions). Since 2000 the trade and current accounts show surpluses, which lead to an increase of the money supply, as often the monetary authorities refrained from sterilizing these inflows. The main reason behind the lack of effective sterilization was lack of sterilization instruments and ineffectiveness of NBU rates as a monetary policy tool. Also, due to the success of the stabilization policy, the demand for financial assets increased, leading to high growth rates of money supply and a credit boom.

Figure 5: Ukraine – Crisis Dates, Forecast Probabilities and Alarm Signals, 1994-2004



Therefore, one might see above that there was a concentration of crises episodes until 1996, when the Ukrainian national currency was introduced after the first stabilization program. This was followed by a tranquil period, which ended with the spillover of the Russian crisis in 1998. It is rather surprising that this crisis period was *almost* predicted by the 12-month forecast, according to which the crisis probability increased to 38% from virtually zero in a very short period of time. Due to our sample, the instability associated with the Yushchenko election is not registered. The figure also reveals that the introduction of a de-jure floating exchange rate regime in 2000 was followed by warnings, which where not related to *actual* crises events.

Forecast Assessment

For assessing the predictive ability of our model, we constructed several goodness-of-fit measures which have become standard for early warning systems. This allows us also to compare our model to different early warning systems, although one has to take into account that this comparison is a more indicative one because of different country samples, time periods and definitions of crises. The results are shown in Table 3.

On average, our model correctly assesses 78% of the observations. Forecasting the pre-crisis periods is also very impressive (71% on average), the correct assessment of tranquil periods reached 84% of observations, and only 19% of alarms where false.[24]

[24] The goodness-of-fit values differ somewhat ranging between 88% in Russia to 69% in Hungary for all observations. The results are most homogeneous for calling the tranquil periods, i.e., above 80% success rate for all countries.

Table 3: In-Sample Forecast Assessment: Measures of Predictive Power

Goodness-of-fit (cut-off probability of 50%)	Our model	Abiad (2003)	Brüggemann / Linne (2002)
a) percent of observation correctly called	78	81	74
b) percent of pre-crisis periods correctly called	71	65	16
c) percent of tranquil periods correctly called	84	89	96
d) false alarms as percent of total alarms	19	27	5

[a] This is equal to the sum of pre-crisis month correctly called and tranquil periods correctly called divided by the number of observations. – [b] This is the number of pre-crisis periods correctly called (observations for which the estimated probability of crisis is above the cut-off probability and a crisis ensues within 12 month) as share of total pre-crisis periods. – [c] This is the number of tranquil periods correctly called (observations for which the estimated probability of crisis is below the cut-off probability and no crisis ensues within 12 month) as share of total tranquil periods. – [d] A false alarm is an observation with an estimated probability of crisis above the cut-off probability not followed by a crisis within 12 month.

Comparing our model to the similar model implemented for Asian countries (Abiad 2003) and a signals approach implemented for Central and Eastern European countries (Brüggemann and Linne 2002) highlights the overall good performance of our model. In both cases less pre-crisis periods could be predicted correctly but the percent of tranquil periods predicted correctly was higher. The comparison also suggests that the Markov switch approach is especially good in predicting crisis while the signals approach clearly estimates a much smaller share of false alarms. The relatively weak performance in the case of Brüggemann and Linne (2002) may also be due to the pooling of data across countries and the longer forecasting horizon of 24 month. This supports our assumption on the superiority of using a country-by-country approach with a medium-term time horizon.

The good performance of our model may be due to the fact that crises in our country sample were mainly (but not exclusively) caused by deteriorating fundamentals and, thus, according to first-generation of crises models, are clearly predictable. Also the definition of currency crises may contribute to this result, since we set up our objective to assess not only devaluation periods, but unsuccessful speculative attacks as well.

One may also point out that, while roughly one third of the periods in our sample were estimated as having crisis warnings in the covered new EU member states, for Russia and Ukraine *almost half* of all the periods in the sample had crises warnings. Albeit some of these may be linked to structural questions (i.e., a higher dependency on more cyclical commodities in the case of Russia), this may also be seen as an indication that the EU accession process could have decreased the vulnerability of some of those countries to crises.

5. Summary and Policy Conclusion

This paper examined vulnerability periods in a series of Central and Eastern European countries during the period 1993–2004. For three new EU member states (Czech Republic, Hungary, Slovak Republic), the results of our model have shown that the majority of currency crises in those can be explained by inconsistencies in the domestic policy mix, and by the deterioration of macroeconomic fundamentals with consequent effects in terms of external imbalances, i.e., mostly traditional, first generation type of crises, which means that crises in these countries were clearly predictable.

Opposed to that, and beyond an apparently greater overall vulnerability to crises than for the new EU member states (which may be linked to the EU accession process), for the CIS countries analysed here (Russia and Ukraine), second- and third-generation, financial vulnerability type indicators were the most relevant ones. A corollary of this is that crises may not be as clearly predictable in these countries, since those sorts of crises can also be subject to selfulfilling expectations and multiple equilibria.

This study represents, to the best of our knowledge, the first attempt to apply a Markov regime-switching model to assess vulnerability periods of these countries. Although it is clear that EWS are far from perfect, and that the results do not represent a mechanical tool to avert potential crises, the surprisingly robust performance of this model leads one to conclude that the regime-switching approach may be quite useful to assess vulnerability periods in the chosen countries.

The different sets of vulnerabilities indicate different types of policy prescriptions. Given that the importance of external vulnerabilities is expected to decrease substantially for the new EU member states (especially after an eventual euro adoption), one can expect the importance of those external sustainability indicators to be reduce, and, therefore, the crises related to them. For Russia and Ukraine, the (ongoing) strengthening of their financial sectors could arguably be the priority task.

Appendix

Table 4: Leading Indicators, in Terms of Crises Symptoms and Theoretical Models

Symptom	Indicators	Generation of Crises Model*	Sign	Description
Expansionary Monetary Policy	M1	1	+	Loose monetary policy can lead to currency crises if the central bank cannot guarantee the fixed peg anymore.
	Foreign Exchange Reserves	1	–	
	Domestic Credit	1	+	
Expansionary Fiscal Policy	Budget Deficit/GDP	1	+	Loose fiscal policy can be starting point for a currency crisis if the government wants to overcome the problem by inflation.
	Public Debt/GDP	1	+	
Bank Runs	Banking Deposits/M2	3	–	Bank runs can precede (banking and) currency crises.
Overborrowing Cycles	Domestic Credit	1	+	Currency (and banking) crises can be the consequence of rapid credit growth after liberalization of the domestic financial system and the elimination of capital account controls.
	M2 Multiplier	3	+	
Current Account Problems	Exports	1	–	External imbalances and a real exchange rate overvaluation are part of a currency crisis. The loss of competitiveness can lead to recessions, business failures and a decline in the quality of loans. Therefore large negative shocks to the terms of trade, exports, the real exchange rate and positive shocks to imports are crises symptoms.
	Imports	1	+	
	Real Exchange Rate	1	–	
	Current Account Deficit/ GDP	1	+	
	Terms of Trade	1	–	
	FDI-Current Account Deficit	3	+	
Capital Account Problems	Foreign Exchange Reserves	1	–	High foreign interest rates lead to capital outflows and may therefore anticipate currency crises. Large capital inflows usually fuel a lending boom. If the country's foreign debt is large and capital flight increases capital account problems become more severe since this raises issues of debt sustainability. High short-term foreign debt increases the vulnerability of a country to external shocks.
	Interest Rate Differential	2	+/–	
	M2/Reserves	3	+	
	Short-term Foreign Debt/Reserves	3	+	
	Portfolio Flows/Total Capital Flows	3	+	
	Bank Assets/GDP	3	+	
Growth Slowdown	Real Interest Rate	1	+	Currency (and banking) crises are preceded by recessions and the burst of asset price bubbles. High real interest rates could signal a liquidity crunch, which leads to a slowdown and banking fragility. A decline in loan quality can be shown by an increase in the lending deposit rate ratio.
	Industrial Production	2	–	
	Output	2	–	
	Unemployment	2	+	
	Inflation	2	+	
	Lending/Deposit Rate Ratio	3	+	
	Stock Price Index	3	–	

Source: See Kaminsky (1998) and Rosenberg (1998).

*This column is meant to indicate from which generation of currency crises the indicator originates. Therefore, indicators originating from first- and/or second-generation crisis models are also important in explaining third-generation currency crises.

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