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Currency Crises in EU Candidate Countries: An Early Warning System Approach

Summary: The purpose of this paper is to develop an econometric model of early warning system (EWS) for predicting currency crises in EU candidate countries. Using actual quarterly panel data for three EU candidate countries (Croatia, Macedonia and Turkey) in the period January 2005 - June 2010, we estimate a binomial logit model, which accurately predicts potential episodes of outbreak of currency crisis. In addition, we find that real GDP growth rate, participation in an IMF loan program, current account and fiscal balance and short-term external indebtedness are the most significant common predictors of currency crises across EU candidate countries. These results imply implementing policy measures aimed at raising the growth potential of the domestic economies of EU candidate countries, monitoring their short-term external indebtedness, improving their external competitiveness, cutting public spending and increasing the confidence of residents and non-residents in their domestic banking sectors.

Key words: Currency crises, Early warning system, EU candidate countries, Logit model, Prediction.

JEL: C13, C23, C25, C51, C53, E44, F31, F32, G01.

In the last two decades, a number of currency crises have occurred, resulting in huge financial losses. The latest global financial crisis has increased the exchange rate volatility (Virginie Coudert, Cécile Couharde, and Valérie Mignon 2010). The need to avoid the incidence of currency crises in future has renewed the interest in developing early warning system (EWS) models.

Although there are some studies on currency crises in specific EU candidate countries (Baldur Thorhallsson and Peadar Kirby 2012; Inci Gumus 2013), there are no papers which investigate the common causes of currency crises across EU candidate countries. This paper contributes to the existing literature in two ways. The first contribution is that it uses actual quarterly data which allow us to overcome the disadvantages of annual and monthly data and to avoid problems associated with interpolation. The second and main contribution of this paper is that it simultaneously relates currency crises with a wide array of indicators (macroeconomic and financial variables, indicators linked to current account and capital flows and political and institutional factors) and identifies common determinants among them. We find that real GDP growth rate, participation in an IMF program, short-term external indebtedness, current account and fiscal balance are the most significant common predic-

tors of currency crises across EU candidate countries. These results imply implementing policy actions aimed at raising economic growth potential of these countries, monitoring their short-term external indebtedness, improving their external competitiveness and cutting public spending.

The paper is structured as follows: Section 1 gives an overview of the existing literature. Section 2 presents data, variables and descriptive statistics. Section 3 explains the methodology. Estimation and specification of the binomial logit model and the obtained results are presented in Section 4. Section 5 presents the policy implications and in Section 6 we draw some conclusions.

1. Literature Review

There is an abundant theoretical and empirical literature on modelling and anticipating the occurrence of currency crises (Franklin Allen and Douglas Gale 2009). Although my paper belongs to the group of empirical studies, before reviewing the relevant empirical studies on this topic, we will briefly discuss the theoretical literature on this topic. The historical development of the theoretical literature can be grouped into four generation models of currency crises (Tjeerd M. Boonman, Jan P. A. M. Jacobs, and Gerard H. Kuper 2012).

The "first generation" models of currency crises focus on the role of the weak economic and financial fundamentals, such as, the gradual decline in international reserves, growing budget and current account deficits, domestic credit growth, and gradual exchange rate overvaluation, as potential early warning indicators of currency crises. However, the crisis of the European Monetary System in 1992-1993 in Western Europe proved that sound fundamentals and good economic policies were not enough to protect some countries (UK and Spain) from speculative attacks. Motivated by these counter-examples, the so-called "second generation" models of currency crises have been developed, by adding features of self-fulfilling prophecies to currency crises. The main innovation of these models lies in identifying the role that the "expectations" of the economic agents (investors) may play in precipitating currency crises. After the Mexican tequila crisis in 1994 and especially after the Asian currency crisis in 1997, it was found that problems in the banking and financial sector trigger the outbreak of currency crises. Therefore the new, "third generation" models of currency crises additionally has included the financial sector indicators and explored how a weak banking sector can cause currency crises, and how crises can affect the rest of the economy. The "fourth generation" of currency crises models, which is still in a process of development, point out the institutional factors as the most important determinants of currency crises.

The numerous empirical studies, which predict the occurrence of a currency crisis, employ two main approaches in developing EWS models: the "signal" approach and the econometric approach. All these studies differ in terms of the definition of a currency crisis, the time span on which the model is estimated, the choice of variables, and the applied statistical or econometric method.

According to the "signal" (non-parametric) approach, a variable is considered to be issuing a warning signal that a crisis could take place if it goes beyond a certain "threshold" level during the period preceding a crisis. The "signals" approach was

pioneered by Graciela L. Kaminsky, Saul Lizondo, and Carmen M. Reinhart (1998), who find that exports, overvalued real effective exchange rate, slowdown of GDP growth, high ratio of broad money (M2) to foreign exchange reserves and equity prices issue reliable signals that a currency crisis could occur in the following twenty-four months, when those variables exceed their threshold values.

Unlike the "signal" method, the econometric approach specifies a limited dependent variable (discrete-choice) probability models (a probit or a logit model) for prediction of a currency crisis. These models estimate a probability relationship between the explanatory variables and the discrete dependent variable - probability of crisis incidence, which takes the value of one if a crisis occurs or zero, if it does not occur. Below we will briefly review some of the most important empirical studies on predicting currency crises using a logit / probit model.

Barry Eichengreen, Andrew K. Rose, and Charles Wyplosz (1995) estimate a multinomial logit model using panel data for twenty OECD countries and identify political instability, budget and current account deficits and fast growth of money, and prices as the most important determinants of currency crashes. Using a panel of annual data for over one hundred developing countries in the period 1971-1992, Jeffrey A. Frankel and Rose (1996) estimate a probit model and find that currency crises occur when output growth is low, the growth of domestic credit is high, the level of foreign interest rates are high and the ratio of FDI to debt is low. Steven Kamin, John Schindler, and Samuel Shawna (2001), estimate several EWS probit models for 26 emerging market countries and find that over time, domestic factors, such as ongoing fiscal deficits, monetary creation and over-borrowing have maintained a relatively steady contribution to vulnerability to financial crisis in most emerging market countries. By comparing the probit model to a multi-layer perceptron artificial neural network (ANN) model, Tuomas A. Peltonen (2006) also finds that the current account and government budget deficits, as well as real GDP growth are the most important indicators of currency crises in emerging markets.

Jeroen Van den Berg, Bertrand Candelon, and Jean-Pierre Urbain (2008) specify a logit EWS model based on panel data for 13 countries and find that crises are not homogenously caused by same factors and therefore suggest forming optimal country clusters. Heikki Kauppi and Pentti Saikkonen (2008) predict the U.S. crises using dynamic binary probit models in which the interest rate spread is the most important predictor.

Jorge Uxó, Jesús Paúl, and Eladio Febrero (2011) suggest an alternative approach for explaining the causes of the ongoing Eurozone crisis which by many economists (Paul Krugman 2013) is considered as a currency crisis. Instead focusing on current problems of public finances and the sovereign debt crisis, they consider the causes for current account deficits and surpluses together and link them to the unbalanced growth model developed following the introduction of the single currency - Euro.

Pierre-Olivier Gourinchas and Maurice Obstfeld (2012) estimate a logit model and identify the domestic credit growth and real currency appreciation as the most significant predictors of financial crises in both advanced and emerging economies. Frankel and George Saravelos (2012) review 83 empirical studies on EWS models and find that out of six surveyed variables the level of foreign exchange reserves, the

real exchange rate appreciation, as well as the exchange rate regime are the key determinants of currency crises both in developing and developed economies.

Linking the exchange rate predictability to economic fundamentals has recently received an important development. Pasquale Della Corte, Lucio Sarno, and Giulia Sestieri (2012) extend the model of international financial adjustment developed by Gourinchas and Hélène Rey (2007) to bilateral nominal exchange rates and find that there is a strong relationship between exchange rates and economic variables. Their results provide sound evidence that exchange rates can be explained and predicted by the economic fundamentals.

The above reviewed empirical studies find that certain fundamental macroeconomic factors determine the incidence of currency crises and that episodes of currency crises can be predicted with different level of precision. With regard to performance of probit and logit models in accurate prediction of currency crisis episodes, Fabio Comelli (2014) evaluates and compares the predictive power of logit *versus* probit models in 29 emerging market economies in the period January 1995 - December 2012 and finds that the performances of logit and probit EWS models are similar and depend on the sample size and the definition of a currency crisis. Since the logistic distribution has fatter tails than the cumulative normal one, the logit model seems more appropriate for prediction of currency crises (Matthieu Bussiere 2013a).

In this paper I employ a parametric approach and specify a binomial logit model using actual quarterly panel data on various variables for three EU candidate countries (Croatia, Macedonia and Turkey) over a five-year period of time (January 2005 - June 2010), following the approach suggested by Van den Berg, Candelon, and Urbain (2008) for forming optimal country cluster as currency crises vary across regions. There are a number of reasons for understanding the determinants of currency crises and predicting their occurrence in EU candidate countries as a group of countries:

(i) First, as pre-accession countries, they are "ex-ante more vulnerable and exposed to currency crises than EU member states" (European Commission 2010, p. i) in view of their large current account deficits and hence they heavily rely on foreign capital to finance their growth (European Commission 2010);

(ii) Second, pursuit of foreign exchange rate stability is an ultimate objective for monetary policy makers in EU candidate countries with a fixed (tightly managed) exchange rates (Croatia and Macedonia) as well as in those with floating exchange rates (Turkey), having in mind that continuous and strong pressure on their foreign exchange rates could affect price stability and increase inflation (Martin Feldkircher, Roman Horvath, and Marek Rusnak 2013);

(iii) Third, all these EU candidate countries have small, open and highly euroized economies. Therefore external pressure on their national currencies could have "... serious effects on exports and imports as well as on capital flows with potentially inflationary consequences" (Daniel Stavarek 2010, p. 3);

(iv) Fourth, EU candidate countries are supposed to join the Euro area after they become full members of EU. Hence, they will have to fulfil the five economic entry conditions known as the "convergence criteria" (or "Maastricht criteria"), and the exchange rate stability is one of them.

2. Data, Variables and Descriptive Statistics

Our empirical analysis is based on actual quarterly data for three EU candidate countries, Croatia, Macedonia and Turkey, collected in the period January 2005 - June 2010 with at most 16 observations for each country. The choice of the sample countries and sample period was determined by limited data availability on quarterly basis. The data constitute a panel dataset for the group of EU candidate countries. Most of them were taken from the central banks and the state statistical offices of the sample countries. The election periods were obtained from the official web site of the European Parliament (European Parliament 2015). The timing of the crisis was identified on the basis of the country specific EMP index as described before: Croatia at 2009:Q1, Macedonia at 2009:Q2 and Turkey at 2009:Q1. These results correspond to actual timing of crises in those EU candidate countries.

The choice of predictors of currency crises which enter our model is based on the review of literature on currency crises elaborated in Section 1, the circumstances specific to the economic systems of the group of EU candidate countries and is also subject to the data availability. In the process of selection of explanatory variables we apply general-to-specific approach, starting with a relatively high number (twelve) of potential early warning indicators (the expected signs of the coefficients attached to these variables are given in brackets), which can be divided into the following five groups:

(1) Indicators linked to a current account:

Trade balance as a percentage of GDP (TRBALANCE) (-): according to the "first generation" models the ratio of trade balance to GDP is one of the most significant leading indicators of currency crises. A higher trade deficit signals appreciating foreign exchange rates which increases the likelihood of a currency crisis incidence;

Current account balance as a percentage of GDP (CURACC) lagged (-): an increase of the current account surplus indicates that there is no need to devalue the national currency and hence it is associated with lower crisis probability. On the other hand, a rise of the current account deficit as a share of GDP above a certain level is an indicator of debt unsustainability and could lead to devaluation of the national currency in order to achieve external balance. The lagged variable is used, as the cost of imports increases and export revenues decrease immediately after the devaluation, as part of the J-curve effect;

Real effective exchange rate as a deviation from HP trend (REERDIF) (-): this variable serves as a measure for the change in country's external competitiveness and is used as a proxy for appreciation or depreciation of the local currency. Strong appreciation of the real effective exchange rate hinders country's competitiveness in the foreign market, deteriorates the current account and may lead to currency crises. In our model an appreciation (overvaluation) of the real exchange rate is defined as a negative deviation of the real exchange rate from the long term HP trend.

(2) Indicators linked to capital flows:

Real interest rate differential, as a difference between domestic and foreign short-term interest rate (DIFFINTRATE) (-/+): theoretical presumptions are not entirely clear (sometimes contradictory) in this area. In times of currency crises the domestic short-term real interest rates could increase in order to prevent a possible

capital flight from the analysed country and avoid a pressure on the foreign exchange rate. On the other hand, higher domestic interest rates could also signal a liquidity crunch and outbreak of a currency crisis. An increase of this indicator above some threshold level possibly reflects a deterioration in credit risks as banks are unwilling to lend or decline in loan quality;

Short-term capital outflow (CAPITALFLIGHT) (+): capital flight, defined as one or more categories of short-term capital outflows as a rapid reaction to increased investment risks, is found to be one of the leading indicators of currency crises. It is usually preceded by a run on banks by residents. The sudden short-term capital outflow could deflate the national currency and trigger a currency crisis, especially in countries with relatively few internationally liquid assets;

Ratio of short-term external debt to GDP (DEBT) (+): short-term external debt is defined as debt that has an original maturity of one year or less. Countries with higher ratios of short-term external debt to GDP are more likely to experience significant currency depreciation.

In our model we do not include the foreign exchange reserves due to the fact that in times of financial crises the level of reserves jumps as a result of credits drawn under IMF programs (Frankel and Saravelos 2012). Second, fluctuations in foreign exchange rates cause severe distortions in the value of foreign exchange reserves, reflecting not only a volume loss, but also a paper loss on the value of currency reserves (Frankel and Saravelos 2012).

(3) Financial indicators:

Ratio of domestic bank loans to GDP, nominal (LOANS) (+): this variable is a proxy for the monetary and credit expansion and as such is playing a crucial role in explaining the incidence of currency crises. A huge and rapid growth of domestic credits indicates the fragility of a banking system. However, as the crisis unfolds, banks become more cautious in approving loans to the private sector, which results in slowing economic growth;

Growth rate of bank deposits, (DEPOSITS) (-) lagged: the causality between decline of bank deposits and foreign exchange crises has been discussed by a number of economists. A sudden and sharp decline in bank deposits is a significant leading indicator of future currency crises in the emerging market economies. However, they do not recognize a converse relationship, from currency crises to the incidence of banking crises in emerging market economies.

(4) Macroeconomic indicators:

Fiscal balance as a percentage of GDP (BUDGET) (-): the "first generation" currency crisis models have put forward the fiscal imbalances and unsustainable fiscal policies as the main drivers of currency crisis incidence. Their key role in explaining the occurrence of currency crises has been confirmed in a number of empirical studies on currency crises. "Higher deficits are expected to raise the probability of a crisis, since they increase vulnerability to shocks and lower investor confidence" (Kamin, Schindler, and Shawna 2001, p. 8);

Real GDP growth rate (GDP) (-): GDP growth is expected to increase the likelihood of a currency crisis as government tends to inflate the economy in order to achieve internal balance;

Participation in an IMF program (CONTROL) (-): we include this dummy variable into our model in order to isolate the effects of currency crises and political factors from larger macroeconomic patterns. Countries participating in IMF structural adjustment programs (Stand By, Extended Fund Facility or Structural Adjustment Facility Agreement), are more likely to tighten their monetary and fiscal policies (James R. Vreeland 2007). This dichotomous variable receives value 1 if the country is not participating in the IMF structural adjustment program in a given quarter, and 0 otherwise.

(5) Political and institutional factors:

Election period (ELECTIONS) (+): election periods are associated with greater possibility of devaluations than non-election periods since governments are expected to be more likely to use expansionary monetary and fiscal policies in response to financial crises in advance of upcoming elections. To measure this effect, the election-period dummy variable for a quarter *t* is coded 1 when there is an election in that quarter, and 0 otherwise.

Before moving to a logit model estimation, it is useful to gain a sense of the basic interplay between the explanatory variables and the incidence of crises in our sample. Table 1 shows descriptive statistics of the panel data for the three EU candidate countries and twelve different variables. The Jarque-Bera test rejects a normal distribution for the series in level of the following variables: GDP, CURRENT ACCOUNT, BUDGET, SHORTDEBT, DEPOSIT, LOANS, CONTROL and ELECTIONS. The null hypothesis of a unit root can be rejected for the variables BUDGET, DEPOSIT, GDP, REERDIF, SHORTDEBT, TRADE BALANCE, CAPITALFLIGHT, LOANS and DIFFINTRATE and all these series are I(1).

Table 1 Descriptive Statistics

	Mean	Median	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Probability	Obs.	Panel unit root test
BUDGET	-0.90	-1.13	6.53	-12.98	3.48	-0.52	4.45	7.70	0.02	58.00	-1.93
CAPITAL-FLIGHT	18.04	19.27	68.10	-24.80	17.14	-0.08	4.45	5.85	0.05	66.00	-0.98
CURRACC	-3.22	-4.32	18.85	-22.63	7.74	0.75	5.30	19.47	0.00	62.00	-2.09**
SHORTDEBT_GDP	43.99	39.46	81.31	21.62	16.26	0.67	2.19	6.40	0.04	62.00	-0.96
DEPOSIT	117.42	139.45	206.27	33.06	59.71	-0.34	1.48	7.16	0.03	62.00	-0.98
DIFFINTRATE	1.95	1.35	11.70	-7.20	3.84	0.30	3.31	1.14	0.57	60.00	-0.70
GDP	2.96	4.00	11.70	-14.50	4.98	-1.07	4.28	16.90	0.00	65.00	0.07
LOANS	161.50	149.92	295.13	58.19	69.57	0.35	1.80	4.96	0.08	62.00	-1.44
REERDIF	-0.04	0.16	17.14	-17.66	5.86	0.18	4.31	5.08	0.08	66.00	-0.94
TRBALANCE	-15.65	-17.45	5.79	-29.56	8.09	0.35	2.16	3.07	0.22	62.00	0.06
CONTROL	0.61	1.00	1.00	0.00	0.49	-0.43	1.19	11.10	0.00	66.00	-3.91***
ELECTIONS	0.24	0.00	1.00	0.00	0.43	1.20	2.45	16.74	0.00	66.00	-2.07**

Note: Where *, ** and *** mean statistically significant at 1%, 5% or 10% level of significance, respectively. The last column shows the panel unit root test of Jörg Breitung (2000), where the null hypothesis states that the data generating processes for all countries in the cross section has a unit root.

Source: Author's own calculation.

3. Methodology

In this section we present and discuss the logit model which will be estimated in Section 4. This model is covered in details by Jeffrey M. Wooldridge (2010) and Badi H. Baltagi (2013).

The first step in estimation of a logit model is definition of the dependent variable - the currency crisis. In the existing literature there are different definitions of a currency crisis. In this paper I define the currency crisis using the exchange market pressure (EMP) index developed by Eichengreen, Rose, and Wyplosz (1995). According to them, the EMP index in a country *i* at time *t* is a weighted average of the percentage change in the nominal foreign exchange rate of the currency of country *i* against the Euro, percentage change in the nominal gross foreign exchange reserves expressed in Euro and the interest rate differential between the nominal short-term interest rate of the country *i* and the short-term interest rate of Germany, as the biggest trading and investment partner of the three analysed countries (Croatia, Macedonia and Turkey):

$$EMPI_{it} = \Delta e_t - \beta \Delta r_t + \gamma i dif_t \quad (1)$$

where e_t denotes the nominal exchange rate of the national currency of country *i* against the Euro at time *t*; r_t denotes the nominal international reserves expressed in Euro at time *t,* and i_t is the difference between the nominal short-term interest rates of the country *i* and Germany at time *t*. The second and the third additives are weighted by the ratio of the standard error of the percentage change of the exchange rate over the standard error of the percentage change of reserves and the interest rate differential, respectively (β, γ), which gives a larger weight to a component with smaller variance and equalizes conditional volatility. In this paper I focus on a specific event (the EMP index) as "it yields very good results, perhaps because it is easier to trace the origin of crises when they are narrowly defined" (Bussiere 2013b, p. 3). The advantage of using an EMP index is that entails both "successful" and "unsuccessful" speculative attacks on a specific currency.

The next step in predicting a currency crisis is dating the currency crises. Eichengreen, Rose, and Wyplosz (1995) define the periods of currency crises as those periods of time during which EMP index demonstrates "unusually large" values i.e. when it exceeds a given threshold level. Regarding the threshold, its level is selected arbitrarily. The selected cut-off points, vary from 1.5 (Eichengreen, Rose, and Wyplosz 1995), 1.645 (Francesco Caramazza, Luca Ricci, and Ranil Salgado 2000), 1.75 (Kamin, Schindler, and Shawna 2001), 2.0 (Reuven Glick and Michael M. Hutchison 2011), 2.5 (Hali Edison 2000) and 3.0 standard deviation above its mean (Kaminsky and Reinhart 1999). In my paper I apply a criterion of 1.5 standard deviations above the mean of the country-specific value following Eichengreen, Rose, and Wyplosz (1995). A currency crisis occurring in country *i* at time *t,* (CC_{it}) is defined as a binary dependent variable, which can take either the value of 1 (when EMP is above its mean by a number of standard deviations) or 0 (in any other case):

$$CC_{it} = \begin{cases} 1 \quad if \quad EMP_t > \mu_{EMP} + 1.5 \times \sigma_{EMP} & \text{(and 3 quarters before the onset of the crisis)} \\ 0 & \text{in any other case} \end{cases} \tag{2}$$

where σ_{EMP} is the standard deviation of the exchange market pressure index and μ_{EMP} is the index arithmetic mean.

The value of 1 is assigned to the crisis variable CC_{it} not only in the quarter when the EMP index exceeds the threshold, but also three quarters before that, having in mind that a crisis often culminates in deterioration of macroeconomic factors well before an actual currency crisis occurs. Due to short time series availability, the pre-crisis period in my paper lasts three quarters (before the moment of the onset of a financial crisis). As shown in Equation (2), the binary dependent variable (CC_{it}) is assumed to be one if the index is above the threshold level any time within a four-quarters crisis window.

As a next step we convert the currency crisis variable (CC_{it}) into a forward-looking crisis variable Y_{it} (Fabio Comelli 2013):

$$Y_{it} = \begin{cases} 1 \quad if \quad \exists \quad k = 1,...,12 \quad CC_{it+k} = 1 \\ 0 \quad otherwise \end{cases}. \tag{3}$$

This approach allows for the crises probability to occur any time within a crisis window of twelve months. Such a crisis window should provide a good trade-off between two important countervailing effects (Comelli 2013). On the one hand, economic variables show deterioration 12-19 months before a crisis and on the other hand, the earlier it is possible to identify signs of vulnerability, the more time there is for policy makers to take effective corrective actions.

In the context of our logit model, the probability of a currency crisis incidence in a country i at time t [$\Pr(Y_{i,t} = 1)$] is defined as a non-linear function of a wide range of indicators X:

$$Pr(Y_{i,t} = 1) = F(X\beta) = \frac{e^{X\beta}}{1 + e^{X\beta}}. \tag{4}$$

The estimates of β are obtained by regressing the binary dependent variable $Y_{i,t}$ on the macroeconomic indicators. The effect of the indicators on the odds is:

$$\Omega(Y_{i,t} = 1 | X) \frac{P_i}{1 - P_i}. \tag{5}$$

In the logit model, the log of the odds ratio can be modelled as a linear function of the explanatory variables. The estimated logit model explains the probability of a currency crisis occurrence for given values of a set of explanatory variables:

$$Log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{k} \beta_j X_{itj} \tag{6}$$

where P_i denotes the probability that country i will experience a currency crisis, and P_i denotes the probability that country i will not experience an exchange market pressure.

4. Results

Using the econometrics computer package EViews version 6, we estimate a binomial logit model of EWS where the dependent variable, Y_{it} (occurrence of a currency crisis episode), defined in Equation (3), is regressed on a wide range of determinants that are believed to be significant factors in explaining and forecasting currency crises in EU candidate countries.

Table 2 reports the results of the logit regression for three EU candidate countries and 47 included observations. The degree of statistical significance of the binomial logit model specification is assessed with several tests. The null hypothesis that each single indicator is zero is tested with a *z*-test on each parameter. Then, the joint hypothesis that all the coefficients are zero is examined using a chi squared test.

Table 2 Estimation of the Binomial Logit Model

Variable	Coefficient	Std. error	z-statistic	Prob.
C	-0.021284	1.067013	-0.019947	0.9841
D(BUDGET)	-0.317139	0.167548	-1.892826	0.0584
CURRACC(-1)	-0.251916	0.142923	-1.762601	0.0780
D(DEPOSIT(-1))	-0.023885	0.060956	-0.391837	0.6952
CONTROL	-5.506288	3.077729	-1.789075	0.0736
D(GDP)	-1.213422	0.588419	-2.062175	0.0392
D(REERDIF)	-0.042852	0.114098	-0.375576	0.7072
D(DEBT)	0.339919	0.290900	1.168508	0.2426
D(TRBALANCE)	-0.300705	0.260621	-1.153799	0.2486
D(CAPITALFLIGHT)	0.047860	0.088860	0.538602	0.5902
D(DIFFINTRATE)	0.090008	0.295002	0.305108	0.7603
ELECTIONS	-1.721620	1.531778	-1.123936	0.2610
D(LOANS)	-0.014130	0.066630	-0.212071	0.8321
McFadden *R*-squared	0.606806	Mean dependent var		0.297872
S.D. dependent var	0.462267	S.E. of regression		0.327972
Akaike info criterion	1.032141	Sum squared resid		3.657233
Schwarz criterion	1.543884	Log likelihood		-11.255320
Hannan-Quinn criter.	1.224713	Restr. log likelihood		-28.625390
LR statistic	34.740140	Avg. log likelihood		-0.239475
Prob(LR statistic)	0.000515			

Source: Author's own calculation.

In order to approximate the explanatory power of the model, the value of McFadden R-squared and LR statistic are computed. Testing the expected sign and the statistical significance of each coefficient in the model has led to elimination of

insignificant variables and those with wrong signs and specification of a final model with five statistically significant indicators: fiscal balance as a percentage of GDP (BUDGET), current account balance as a percentage of GDP (CURACC), ratio of short-term external debt to GDP (SHORTDEBT_GDP), control by IMF (CONTROL) and the real GDP growth rate (GDP). These results are in line with the "first generation" currency crisis models and with the empirical findings of Eichengreen, Rose, and Wyplosz (1995), Kamin, Schindler, and Shawna (2001) and Peltonen (2006).

The statistical characteristics of the model are favourable. Namely, the resultant logit regression contains six variables, all with expected sign. The growth rate of real GDP (GDP) is the most significant predictor of currency crises (at 1% level of significance) and with the expected negative sign, which is in line with the results of previous empirical studies (Peltonen 2006; Rose and Mark M. Spiegel 2011; Comelli 2013). The coefficient attached to this variable suggests that an increase in the growth rate of the real GDP translates into a decrease in the likelihood of a currency crisis incidence in EU candidate countries. Economists worldwide were severely criticized for the failure to anticipate the large decline in GDP that occurred in late 2008 and early 2009 and thus to predict the timing and severity of the latest global financial crisis (Geoff Kenney and Julian Morgan 2011).

With regard to IMF control dummy (CONTROL), we document that there is a strong negative correlation between IMF interventions and the likelihood of a future currency crisis. Our results indicate that EU candidate countries participating in IMF lending programs are less prone to currency crashes than the non-borrowing countries. These findings are consistent with Luca Papi, Andrea F. Presbitero, and Alberto Zazzaro (2015). The crisis prevention role of IMF could be attributed to the macroeconomic policies and financial reforms that countries recipients of IMF loans should implement and to a direct liquidity support effect.

The current account balance variable (CURRACC) has the expected negative sign and is significant at 5% level, suggesting that an increase in the level of current account balance relative to GDP is estimated to decrease the probability of currency crises which is in line with Uxó, Paúl, and Febrero (2011) and Frankel and Saravelos (2012). The ratio of short-term external debt to GDP is also found to be a significant determinant of currency crises across EU candidate countries. The larger the amount of short-term external debt to GDP, the more vulnerable a country is to a large devaluation. This finding is in line with Eichengreen, Ricardo Hausmann, and Ugo Panizza (2005) who demonstrate that higher foreign currency debt leads to an unstable macro-economic environment, with output and exchange rate volatility. The fiscal balance variable (BUDGET) is negatively associated with the likelihood of future currency crashes across EU candidate countries and this correlation is statistically significant. This finding is in line with Gumus (2013) who finds that even the mere possibility of a deficit is sufficient to generate a currency crisis since the expected depreciation reduces money demand and the government incurs revenue losses as it keeps the exchange rate fixed. "The significance of this coefficient would suggest that when countries pursue lax fiscal policies, evidenced by ever-increasing budget deficits, the probability of currency crises is increased significantly. The significance

of this variable further strengthens the argument that weak fiscal policies contribute to currency crises" (Thomson Fontaine 2005, p. 17).

Turning to other factors linked to currency crises, we find that the growth rate of bank deposits (DEPOSIT) is negatively, but not strongly associated with crisis incidence.

Table 3 Estimation of the Reduced Binomial Logit Model

Variable	Coefficient	Std. error	*z*-statistic	Prob.
C	-1.138165	0.819627	-1.388637	0.1649
D(BUDGET)	-0.189986	0.111879	-1.698147	0.0895
CURRACC(-1)	-0.232276	0.107588	-2.158931	0.0309
CONTROL	-4.237151	1.779659	-2.380877	0.0173
D(GDP)	-0.934940	0.332711	-2.810065	0.0050
D(SHORTDEBT_GDP)	0.317608	0.178557	1.778744	0.0753
D(DEPOSIT)	-0.086317	0.073131	-1.180320	0.2379
McFadden *R*-squared	0.567585	Mean dependent var		0.280000
S.D. dependent var	0.453557	S.E. of regression		0.320647
Akaike info criterion	0.792803	Sum squared resid		4.421026
Schwarz criterion	1.060486	Log likelihood		-12.82008
Hannan-Quinn criter.	0.894739	Restr. log likelihood		-29.64767
LR statistic	33.65517	Avg. log likelihood		-0.256402
Prob(LR statistic)	0.000008			

Source: Author's own calculation.

The LR statistic, which tests the joint null hypothesis that all slope coefficients except the constant are zero, is rejected at level of significance of 0%, and McFadden R^2 indicates relatively good goodness-of-fit of the model. The probability of a currency crisis incidence across EU candidate countries increases when the real GDP growth rate is declining, the country does not have an arrangement with IMF, the ratio of current account balance to GDP is decreasing, short-term external indebtedness is increasing and fiscal deficit is worsening.

In order to use the estimated logit model as a forecasting model of a financial crisis, it is necessary to assess its predictive power. Since the within-sample and out-of-sample performance is strongly related, it is sufficient to test only the within-sample performance. The ability of the estimated model to predict financial crises was evaluated using cross tabulations of correct specifications. The cut-off value, which separates the pre-crisis period from the tranquil period was set at 0.5. The model correctly calls about 84% of the observations at the selected cut-off value. The model accurately predicted a crisis in as many as 71.43% of cases (quarters) and accurately predicted a tranquil period in 88.89%. Tranquil periods are those that are not followed by a crisis within 4 quarters. The measures of expectation-prediction table (Table 4) show that the model has considerable potential to predict in the sample financial crisis. The model was unsuccessful in predicting crisis in only 16.0%.

Table 4 Prediction Ability of the Model

	Estimated equation			Constant probability		
	Dep = 0	Dep = 1	Total	Dep = 0	Dep = 1	Total
P(Dep = 1) <= C	32	4	36	36	14	50
P(Dep = 1) > C	4	10	14	0	0	0
Total	36	14	50	36	14	50
Correct	32	10	42	36	0	36
% Correct	88.89	71.43	84	100.00	0	72
% Incorrect	11.11	28.57	16.00	0.00	100.00	28.00
Total gain*	-11.11	71.43	12			
Percent gain**	NA	71.43	42.86			
E(# of Dep = 0)	31.76	4.24	36.00	25.92	10.08	36.00
E(# of Dep = 1)	4.24	9.76	14.00	10.08	3.92	14.00
Total	36.00	14.00	50.00	36.00	14.00	50.00
Correct	31.76	9.76	41.52	25.92	3.92	29.84
% Correct	88.22	69.72	83.04	72.00	28.00	59.68
% Incorrect	11.78	30.28	16.96	28.00	72.00	40.32
Total gain*	16.22	41.72	23.36			
Percent gain**	57.95	57.95	57.95			

Notes: * Change in "% Correct" from default (constant probability) specification. ** Percent of incorrect (default) prediction corrected by equation.

Source: Author's own calculation.

After we have concluded that the specified logit model is accurate in predicting currency crises in the group of EU candidate countries, we employ a χ^2 test of independence to check if there is a systematic relationship between the forecasts and the realizations. The null hypothesis assumes that the forecasts for a binary event (in this case crisis and tranquil periods) are independent from the actual outcomes. The results of the χ^2 test show that the null hypothesis is strongly rejected.

Table 5 χ^2 test

	Quantile of risk			Dep = 0		Dep = 1	Total	H-L
	Low	High	Actual	Expect	Actual	Expect	Obs	Value
1	5.E-05	0.0003	5	4.99889	0	0.00111	5	0.00111
2	0.0004	0.0010	5	4.99680	0	0.00320	5	0.00321
3	0.0010	0.0031	5	4.99028	0	0.00972	5	0.00974
4	0.0038	0.0196	5	4.93614	0	0.06386	5	0.06469
5	0.0235	0.0736	5	4.74722	0	0.25278	5	0.26624
6	0.0933	0.1595	5	4.38167	0	0.61833	5	0.70559
7	0.1986	0.3893	1	3.58389	4	1.41611	5	6.57761
8	0.4633	0.7123	3	2.04078	2	2.95922	5	0.76178
9	0.7183	0.8445	2	1.08524	3	3.91476	5	0.98481
10	0.8587	0.9997	0	0.23909	5	4.76091	5	0.25110
		Total	36	36.0000	14	14.0000	50	9.62587
	H-L statistic		9.6259		Prob. Chi-Sq(8)		0.2923	
	Andrews statistic		37.151		Prob. Chi-Sq(10)		0.0001	

Source: Author's own calculation.

The main result of our empirical study is that the binomial logit model of EWS can accurately anticipate the occurrence of future currency crisis episodes across EU candidate countries. In addition, we find that real GDP growth rate, participation in an IMF loan program, current account and fiscal balance are all significant and negatively related with the crisis incidence. On the other hand, short-term external debt to GDP ratio is significant and positively related with crisis incidence. The decline of deposits, although not significantly, also contributes to future occurrence of currency crises in this group of countries. In sum, the results are consistent with the "first generation" currency crisis models and with the findings of some empirical studies that use probit / logit model**.**

5. Policy Implications

From a policy perspective the obtained empirical results imply that real economic growth stands out as a key predictor of currency crisis incidence as measured through a variety of variables. This would suggest that EU candidate countries should safeguard economic growth and focus on raising the growth potential of their economies (World Bank 2013) in order to avoid occurrence of future currency crashes and mitigate huge economic losses and other negative impacts associated with them.

Given the risks that excessive short-term external indebtedness pose for EU candidate countries, it is essential that they determine and agree on the optimal level of short-term foreign debt the economy can refund, monitor such debt closely and manage it effectively to avoid future currency crises. In parallel with that, EU candidate countries which unlike other emerging countries have been characterised by large and persistent current account deficits, should focus on "improving their external competitiveness by maintaining price competitiveness, stabilising labour costs and improving productivity; all of which require extensive and difficult reforms" (Lucia Orszaghova, Li Savelin, and Willem Schudel 2013, p. 8).

The significance of the fiscal balance variable strengthens the importance of cutting public spending, adopting strict budgets and pursuing sustainable fiscal deficits, especially in those EU candidate countries that face large or rapidly increasing budget deficits. Keeping the current account and fiscal deficit below certain limits is, after all, one of the criteria for joining the EU.

With respect to the risk of deposits flight, as one of the main determinants of currency crises, it is of utmost importance for authorities of EU candidate countries facing serious loss of confidence in their banking systems, to increase the level of deposit insurance and rebuild confidence in their banking sectors (European System of Central Banks 2012).

6. Conclusions

The purpose of this paper is to develop an econometric model of EWS for explaining and forecasting currency crises across EU candidate countries and to help policymakers predict currency crashes at an earlier stage and take steps to prevent their occurrence. Methodologically, we estimate and specify a binomial logit model using actual quarterly data on a large set of different indicators of currency crises including

macroeconomic and financial variables, indicators linked to current account and capital flows as well as political and institutional factors for a panel of three EU candidate countries (Croatia, Macedonia and Turkey) over a five-year period of time (January 2005 - June 2010).

Our findings endorse the general conclusion that a logit model of EWS can correctly predict the occurrence of currency crises across EU candidate countries. Among the various indicators of currency crises, we find that the growth rate of real GDP plays a pivotal role in explaining and forecasting future outbreak of currency crises in the sample countries. In addition to the growth of domestic economic activity, we have identified participation in an IMF loan program, current account balance to GDP, short-term external indebtedness, fiscal balance as well as decline of bank deposits as the most significant early warning indicators of currency crises in the cluster of EU candidate countries.

These results imply implementing some policy actions which will reduce the risk of currency crises in the future, aimed at raising the growth potential of the domestic economies of EU candidate countries, monitoring their short-term external indebtedness, improving their external competitiveness, cutting public spending and increasing the confidence of residents and non-residents in their domestic banking sectors. Finally, our findings confirm the view that developing an econometric model of EWS that can predict currency crises reasonably well can be a difficult task.

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