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FINANCIAL CRISES ARE PREDICTABLE: THE CASE OF THE EU CANDIDATE COUNTRIES

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ABSTRACT

The purpose of our paper is to assess the relative contribution of a wide array of determinants of financial crises and to build an econometric model which will serve as a tool for predicting future financial crises. By specifying a binomial logit model based on actual quarterly panel data for the four EU candidate countries (Croatia, Macedonia, Turkey and Iceland) over a long sample period from January 2005 to September 2012, we find the GDP growth rate, the trade balance as a percentage of GDP, the ratio of bank deposits to GDP and the budget balance as a percentage of GDP the key macroeconomic determinants of financial crises incidence. The obtained empirical results give support to the thesis that financial crises are predictable.

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1. Introduction

The global financial and economic crisis of 2008, the severest one since the chronic days of the Great Depression and with worldwide simultaneous devastating economic, social and political impact has rekindled the interest of economists and policymakers in early warning system (EWS) models for explaining and predicting financial crises. The importance of understanding the causes of the financial crises and predicting them early on is especially true with the EU candidate countries that as a consequence of the recent global financial and economic crisis, have been forced to deal with multiple exogenous shocks simultaneously. In order to mitigate the severe consequences of the global financial and economic crisis (reduction in trade, capital inflows and foreign assistance), these countries have turned to international financial institutions asking for a substantial financial aid. On the other hand, the convergence towards the EU (the ongoing capital account liberalization towards its full liberalization by the time of the EU accession at the latest) could create additional problems regarding the macroeconomic stability of the EU candidate countries.

Against this background, the purpose of our paper is to assess the relative contribution of a wide array of determinants of financial crises for the group of the EU candidate countries and to build an econometric EWS model of the 2008 global financial and economic crisis which will serve as a tool for predicting future financial crises in the EU candidate countries (Croatia, Macedonia, Turkey and Iceland). The ultimate objective is to help governments of these countries, but also public and private companies in these countries to recognize vulnerability to financial crises at an earlier stage and create corrective policy actions that would mitigate the crisis impacts or prevent such crises from actually taking place.

The main theoretical contribution of this paper to the existing literature on financial crises is that it analyses the determinants of the "crisis of

the triad"[a] (banking, debt and currency crisis) of the triad in a constrained sample of economies (the EU candidate countries) and considers the crisis to have continued until the end of 2009, unlike the previous empirical studies (Obstfeld et. al., 2009, Rose and Spiegel, 2009, Berkmen et. al., 2009) which analyzed the recent crisis as it has ended in 2008.

The rest of the paper is structured as follows. Section two describes the methodology and the tested variables. The estimation of the binomial logit model, the obtained results as and a few policy recommendations derived from these results are presented in section three. The final section draws some conclusions and considers the prospects for future research.

2. Methodology

In the empirical literature, there are essentially two main approaches for constructing EWS models: the *econometric* and the "*signals" approach.* The first approach, the econometric approach estimates limited dependent variable probability models (a probit or a logit model) for prediction of the outbreak of a financial crisis.[b] On the other hand, the *"signals" approach* uses a completely different method - a non-parametric method to ascertain the risk of financial crisis.

In our paper we employ the econometric approach due to the fact it provides a framework for statistical testing of the magnitude and statistical significance of each of the individual explanatory variables on the onset of a crisis (Berg and Pattillo, 1998) and allows estimation of the probability of occurrence of a crisis in the future which is exactly the objective of our paper.

[a] The term "crisis of the triad" was introduced by Willem Buiter, Professor of European Political Economy at London School of Economics and Political Science.

[b] There are also econometric studies employing ordinary least squares and vector auto regression, but probit and logit models are the pillars of econometric studies of financial crises.

In order to answer the question of what probability different indicators have assigned to the outbreak of the current global financial crisis in the four EU candidate countries, given the information set in the period 2005:Q1 -2012:Q3, we estimate a binomial logit model. We have chosen the logit over the probit model, since it is computationally more convenient than the probit model.

The big challenge to undertaking the estimation of the logit model is the definition of the dependent variable i.e. the financial crisis. In our logit framework we define the binary dependent variable using the common for empirical studies method of identifying episodes of financial crises, namely, the exchange market pressure index ($EMPI_{it}$).[c] Following the model-independent approach originally developed by Eichengreen et al. (1995), we construct the EMP index as a weighted average of the percentage change in the nominal foreign exchange rate of the national currency 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 relevant EU candidate country and the short-term interest rate of Germany, as the biggest trading and investment partner of the four analyzed countries (Croatia, Macedonia, Turkey and Iceland):

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

Where, e_t - the nominal exchange rate of the national currency against the Euro in period of time t; r_t – the nominal international reserves expressed in Euro; i_t - the difference between the nominal short-term interest rates of the relevant EU candidate country and Germany. 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.

[c] The seminal paper on the exchange market pressure index is Girton, L. and Roper, D., "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience", *American Economic Review,* Vol. 67(4), (1977): 537–48.

The EMP index signals a financial crisis episode (*ex post*) when its value exceeds a given threshold level. One limitation of this "conversion" rule of the EMP index into a binary variable is the arbitrariness of the choice of the threshold. In our paper we apply a criterion of 1.5 standard deviations above the mean of the country-specific EMP index (Girton and Roper, 1977), which identifies the highest index values in the sample EMP index, in order to define the threshold of a crisis in the exchange market.

Following this definition of the threshold value, a financial crisis is defined as a binary dependent variable as follows:

$$\begin{aligned} \textit{Financial crisis } (Y_{it}) &= 1 \textit{ if } EMP_t > \mu_{EMP} + 1{,}5 \times \sigma_{EMP} \textit{ (and three quarters before the onset of the crisis)} \\ &= 0 \textit{ in any other case} \end{aligned} \quad (2)$$

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

In addition to the clear definition of crisis, it is also important to define the required output of the model. Our objective is to predict the occurrence of a financial crisis in a cluster of countries (the EU candidate countries) within a particular period of time, and not to predict the exact timing of a crisis.

Since a crisis often culminates in the deterioration of macroeconomic indicators well before an actual financial crisis occurs, the value of 1 is assigned to the crisis variable Y_{it} not only in the quarter when the EMP index exceeds the threshold, but also three quarters before that. Because of the short time series, it was decided that the pre-crisis period lasts three quarters (before the moment of the onset of a financial crisis), the time interval when various signalling indicators of a financial crisis should signal the outbreak of a financial crisis in the sample. On the other hand, the four-quarters inclusion window is justified by the fact that the focus of this paper is on the period leading up to the crisis, rather than the crisis itself. Therefore, as shown in equation (2), the binary dependent variable (Y_{it}) is assumed to be one if the index is above the threshold any time within a four-quarters crisis window. 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 (Fratzscher and Bussiere, 2002). On the one hand, economic variables show deterioration 12-19 months before a crisis (Kaminsky et.al, 1998) 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.

The next step in construction of an EWS model is selecting the explanatory variables which will enter the logit model. The choice of these variables is based on the previous literature on financial crises, the circumstances specific to the economic systems of the group of EU candidate countries and is also subject to the data availability. Our approach was to include a relatively wide array of potential early warning indicators (eleven explanatory variables) that are commonly used in empirical modelling of financial crisis: fiscal variables (government budget balance as a percentage of GDP), financial sector variables (ratio of domestic bank loans to GDP, decline in total bank deposits to GDP), external sector (current account) variables (trade deficit as a percentage of GDP, current account deficit as a percentage of GDP, growth rate of exports, real effective exchange rate as a deviation from HP trend), capital account variables (real interest rate differential as a difference between domestic and foreign short-term interest rate, capital flight proxied by the rate of change of portfolio investments and the ratio of gross external debt to export and domestic real sector variables (real GDP growth rate).

Our empirical analysis is based on actual quarterly data for the sample of the four EU candidate countries (Croatia, Macedonia, Turkey and Iceland) collected in the period 2005:Q1 to 2012:Q3 with at most 31 observations for each country. In absence of actual monthly data for most of the explanatory variables for the sample countries, we have decided to use actual quarterly data. We have avoided interpolating the actual quarterly data into monthly data due to some econometric issues. Namely, by using interpolated series we use information about future economic conditions that was not available to economic agents at the time. They are forced to use forecasts of the key economic variables when they make their investment decisions simply because the actual information is not available.

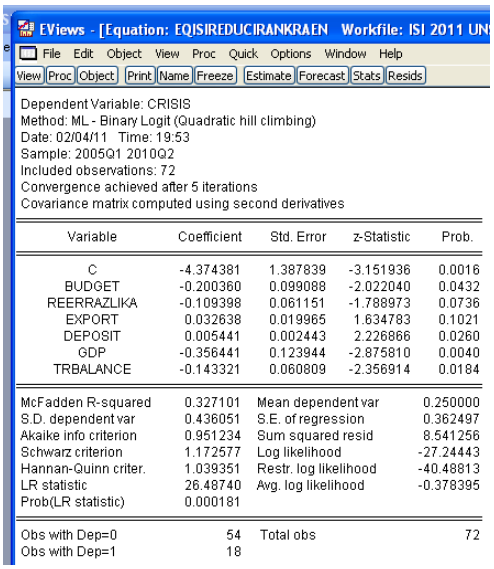
The timing of the crisis was identified on the basis of the country specific EMP index as described before: Croatia: 2009Q1; Macedonia: 2009Q2; Turkey: 2009Q1 and Iceland: 2009Q1. The reliability of this

statistics-based crisis dating system is confirmed by the actual occurrence of financial crisis in these countries. The majority of the data are taken from the central banks and the state statistical offices of the EU candidate countries.

3. Estimation results

To identify the determinants of financial crises in the economies of the EU candidate countries, we have started with logit model that estimates a large number of explanatory variables suggested by the prior theoretical and empirical analyses of financial crises. The degree of statistical significance of 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. 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 lead to elimination of insignificant variables and those with wrong signs and specification of final model with 6 statistically significant indicators (see Figure 1).

FIGURE 1. ESTIMATION OF THE BINOMIAL LOGIT MODEL



Source: Author's calculation

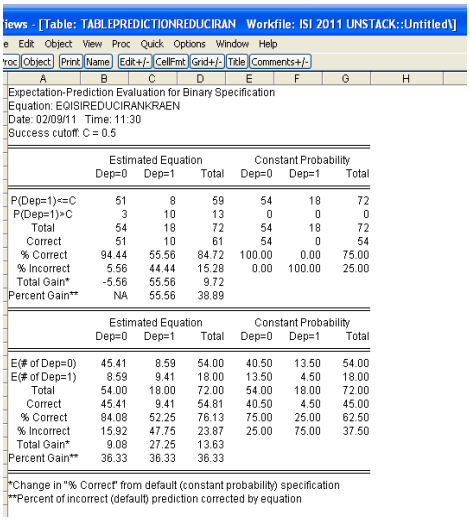
The statistical characteristics of the model are favourable. Namely, the resultant regression contains six variables, all with expected sign. The variable GDP is highly significant at level of 1% significance and the other variables are statistically significant at level of significance of 5%, except variable REER and EXPORT which are significant at 10% level.

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 financial crisis incidence in the EU candidate countries increases when the ratio of budget surplus to GDP is decreasing, the real effective exchange rate is appreciating below the trend, the trade balance deficit is worsening, total bank deposits are declining, exports are decreasing and the indicator of economic growth, the GDP growth rate is declining.

Turning to the economic interpretation of our results, the estimates from the specification in above table give a sense of very strong impact of GDP growth rate, trade balance as a percentage of GDP, bank deposits relative to GDP and budget balance as a percentage of GDP in predicting the incidence of a financial crisis in the EU candidate countries.

To use the estimated logit model as a forecasting model of a financial crisis, it is necessary to evaluate 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 cutoff value which separates the pre-crisis period from the tranquil period was set at 0.5. The model correctly calls about 85% of the observations at the selected cutoff value. The model accurately predicted a crisis in as many as 55.56% of cases (quarters) and accurately predicted a tranquil period in 94.44%. Tranquil periods are those which are not followed by a crisis within 4 quarters. The measures of expectation-prediction table (Table 2) show that the model has considerable potential to predict in sample financial crisis. The model was unsuccessful in predicting crisis in only 15.28%.

FIGURE 2: PREDICTION ABILITY OF THE MODEL



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Expectation-Prediction Evaluation for Binary Specification
Equation: EQISIREDUCIRANKRAEN
Date: 02/09/11 Time: 11:30
Success cutoff: C = 0.5

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
P(Dep=1)<=C	51	8	59	54	18	72
P(Dep=1)>C	3	10	13	0	0	0
Total	54	18	72	54	18	72
Correct	51	10	61	54	0	54
% Correct	94.44	55.56	84.72	100.00	0.00	75.00
% Incorrect	5.56	44.44	15.28	0.00	100.00	25.00
Total Gain*	-5.56	55.56	9.72			
Percent Gain**	NA	55.56	38.89			

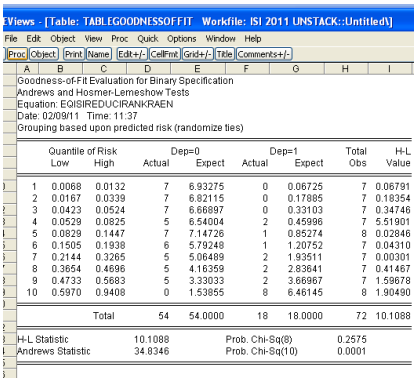
	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	45.41	8.59	54.00	40.50	13.50	54.00
E(# of Dep=1)	8.59	9.41	18.00	13.50	4.50	18.00
Total	54.00	18.00	72.00	54.00	18.00	72.00
Correct	45.41	9.41	54.81	40.50	4.50	45.00
% Correct	84.08	52.25	76.13	75.00	25.00	62.50
% Incorrect	15.92	47.75	23.87	25.00	75.00	37.50
Total Gain*	9.08	27.25	13.63			
Percent Gain**	36.33	36.33	36.33			

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

Source: Author's calculation

After we have statistically confirmed the predictive power of the logit model specifications, 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.

FIGURE 3: χ^2 TEST



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Goodness-of-Fit Evaluation for Binary Specification
Andrews and Hosmer-Lemeshow Tests
Equation: EQISIREDUCIRANKRAEN
Date: 02/09/11 Time: 11:37
Grouping based upon predicted risk (randomize ties)

	Quantile of Risk		Dep=0		Dep=1		Total	H-L
	Low	High	Actual	Expect	Actual	Expect	Obs	Value
1	0.0068	0.0132	7	6.93275	0	0.06725	7	0.06791
2	0.0167	0.0339	7	6.82115	0	0.17885	7	0.18354
3	0.0423	0.0524	7	6.66897	0	0.33103	7	0.34746
4	0.0529	0.0825	5	6.54004	2	0.45996	7	5.51901
5	0.0829	0.1447	7	7.14726	1	0.85274	8	0.02846
6	0.1505	0.1938	6	5.79248	1	1.20752	7	0.04310
7	0.2144	0.3265	5	5.06489	2	1.93511	7	0.00301
8	0.3654	0.4696	5	4.16359	2	2.83641	7	0.41467
9	0.4733	0.5683	5	3.33033	2	3.66967	7	1.59678
10	0.5970	0.9408	0	1.53855	8	6.46145	8	1.90490
		Total	54	54.0000	18	18.0000	72	10.1088

H-L Statistic	10.1088	Prob. Chi-Sq(8)	0.2575
Andrews Statistic	34.8346	Prob. Chi-Sq(10)	0.0001

Source: Author's calculation

II. CONCLUSION

To sum up, our econometric analysis of the early warning indicators of financial crisis incidence based on a binomial logit model on a panel of the four EU candidate countries allows the general conclusion that indicators of financial crisis do work, at least in our EWS model of the EU candidate countries! The estimation results of our model have identified the GDP growth rate, the trade balance as a percentage of GDP, the ratio of bank deposits to GDP and the budget balance as the top four early warning indicators of financial crises incidence in the EU candidate countries (Croatia, Macedonia, Turkey and Iceland).
The constructed EWS model in this paper is only a first step towards developing a more comprehensive EWS model. However, it should be noted that even a perfectly designed EWS model may not and can not be a substitute for sound judgment of policy makers, but only a complement to the arsenal of macroeconomic policy tools in guiding economic policy.

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