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EARLY WARNING MODELS FOR DEBT CRISES – CASE STUDY FOR ROMANIA, CZECH REPUBLIC AND HUNGARY

*   **Abstract.** This paper aims to achieve those early warning indicators of debt crises in Romania, Czech Republic and Hungary in the period 1999, 4th quarter up to 2013, 4th quarter. Starting from three type of indicators: external indicators related to capital account, external indicators related to current account and domestic indicators, we have computed a database of potential leading indicators containing twelve indicators for Romania, as follows: Real effective exchange rate from trend , Relative change of exports, Relative change of imports, Terms of trade, Current account balance as % of GDP, The relative change of foreign reserves, Capital account balance as % of GDP, Net external debt as % of GDP, Government debt as % of GDP, Unemployment rate, Industrial production growth, Net International investment position as % of GDP. This research aim to observe which of the potential leading indicators used in the analysis are significant in explaining the incidence of currency instability periods and give us a warning regardless any negative trends in the macroeconomic or financial activity, affecting the national or the global situation. Using econometrics techniques, we have determined those indicators which are econometrically significantly in explaining the appearance of debt crises. Weighting their role in explaining currency crisis, we have composed the early warning index of debt crises. The evaluation results suggest that there is a range of leading indicators which gave us a warning signal regarding any instability periods of debt crises which occur in the economy.*
*   **Keywords**: warning, currency crises, leading indicators.*

JEL classification: G01, E5

1. Introduction

The purpose of this paper is to capture those indicators whose behavior can reveal some information about the occurrence of a debt crisis.

Therefore, we computed a database containing three types of indicators: external indicators related to current account, external indicators related to capital account and domestic indicators. The database was collected for the period 1999 fourth quarter until 2013 fourth quarter for Romania. Analysing their behaviour and taking notes about the literature review in the field, we could assess the role of each indicator in determining a positive or negative role in the appearance of a debt crisis. Therefore, we identified those variables which gave us a warning regarding the appearance of a debt crisis and we computed an indicator of debt crisis warning for Romania. This indicator was validated through the fact that it was appropriate for detection of the last debt crisis of Romania.

The paper is organized as follows: Second section presents us the Literature review. Third section presents the Database. Fourth section presents the Methodology used and the results. Fifth section presents the Conclusions.

2.   Literature review

The analysis of Stephen G. Cecchetti, Marion Kohler and Christian Upper based on 40 systemic banking crises emphasizes that last financial crises is computed from a wide range of economic factors. The paper "This Time is Different: A Panoramic View of Eight Centuries of Financial Crises" includes African, Asian, European, Latin American countries, North America and Oceania, in the period 1800-2006 and threat external debt, domestic default, banking crises, currency crashes and inflation excesses, by constructing a composite index of financial instability that is multidimensional, concluding that "financial crises are more a way of life affecting all".

Another paper of Carmen M. Reinhart and Kenneth S. Rogoff is focused on banking crises and highlights that crises are more severe for the financial centers like UK, USA and France. They analyze for the first time in the literature the role of "housing prices" variables and find similarities of the behavior of frequency and duration of banking crises between developed and middle-income countries, highlighting that most countries experience a surge in debt in the wake of a financial crisis, with real central government debt increasing 86% on average during the three years following the crisis. Some Romanian economists used a set of prudential indicators and the aggregate monetary balance sheet to find out that the level of risk was manageable, even that accelerated during 2009 and 2010 and that the exposure of Romania's banks to foreign funds constituted an important source of risk. Professor Albulescu Claudiu Tiberiu build an early warning system based on the banking ratings deterioration using CAAMPL approach for the period 1998 – 2006 and concluded that rating downgrade and calculation of probability of banking financial distress can be determined through an early warning system.

Last crisis revealed important aspects in the current global architecture and official mechanism that facilitate global financial instability. Current crises emphasizes that the surveillance for crises prevention must be more rigorous, with a better incorporation of financial sector and regulatory issues, with better information

regarding cross-border spillover and systemic risks. If prior to the current crises were considered just vulnerabilities in emerging market economies because they are supposed to be more fragile, now there are taken in consideration the vulnerabilities in advanced economies too, because they could create broader distress through cross border linkages.

3. Database

The database contains three types of indicators: external indicators related to current account, external indicators related to capital account and domestic indicators. It was collected from Eurostat Database for Romania analysing the period 1999 fourth quarter until 2013 fourth quarter, on a quarterly basis. The rationale for which the indicators where quarterly collected it was that they could give us a warning at least few quarters before the event happened. Firstly, we started the model by collecting monthly indicators, but because not all the indicators were available in monthly frequency, thus could make us narrow our view obtained through the database collected. We have also considered that an annually database wouldn't help us, because it is very difficult to find those indicators which gave us a warning with years before the event happened, existing the possibility to omit those indicators which really gave us warning with months or quarter before.

Therefore, we chose to use quarterly data for a better efficiency of the issued signals consisting in the fact that allows timely reaction from the decision factors, as policy makers.

The indicators used are presented in the bellow table.

Table 1.Indicators

Type of indicator	Indicator
External indicator (current account)	Real effective exchange rate from trend
External indicator (current account)	Relative change of exports
External indicator (current account)	Relative change of imports
External indicator (current account)	Terms of trade
External indicator (current account)	Current account balance as % of GDP
External indicator (capital account)	The relative change of foreign reserves
External indicator (capital account)	Capital account balance as % of GDP
Domestic indicator	Net external debt as % of GDP
Domestic indicator	Government debt as % of GDP

Domestic indicator	Unemployment rate
Domestic indicator	Industrial production growth
Domestic indicator	Net International investment position as % of GDP

Source: Eurostat Database

Analyzing their behavior and taking notes about the literature review in the field, we could assess the role of each indicator in determining a positive or negative role in the appearance of a debt crisis.

4.   Methodology
4.1   Hypothesis of research

The main hypothesis of the research represents the fact that there are potential leading indicators which could gave us warning signals regarding the appearance of a debt crises. If the behaviour of some indicators is analysed in the context of the specific economy, we can identify some vulnerabilities and threats which could have a negative effect against the economy of a country.

Therefore, in the following pages we have review the behaviour of the potential leading indicators:

a. **Real effective exchange rate from trend** represents a measure of international competitiveness of each country. It is used a proxy in order to determine the over or under evaluation.

   Hypothesis1.1: An overvalued real exchange rate represents a high probability of appearance of currency crisis. Therefore, we have considered that an increase of real effective exchange rate represents a higher probability of appearance of currency crisis, therefore, enters with positive sign in the debt crises debt index.

   Hypothesis1.2: An undervalued real exchange rate represents a lower probability of appearance of currency crisis.

Figure 1. Real effective exchange rate deviation from trend
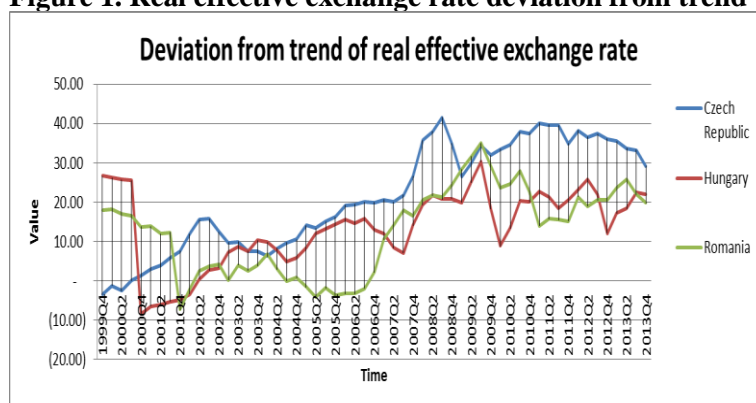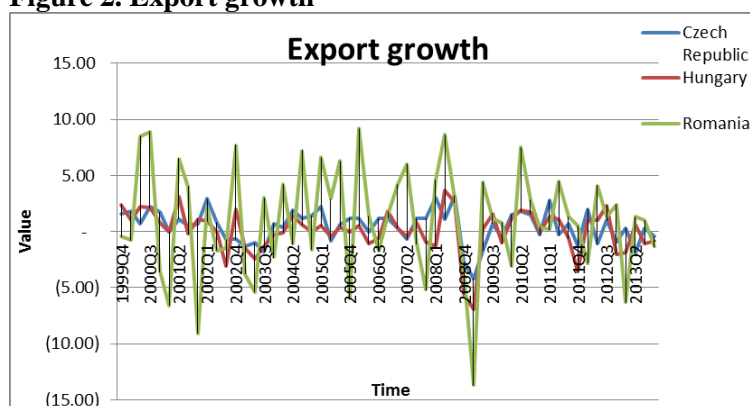

Source: Eurostat database, own calculations

a. **Relative change of exports** represents a measure of international competitiveness of a country.

A decrease in exports growth may be determined by a overvaluation of national (domestic) currency. If the decrease of exports growth is produced by other reason that exchange rate, thus can put pressure on depreciation of national currency.

Hypothesis2: In both cases, the decrease of exports growth is considered a potential leading indicator for depreciation of the national currency, therefore it enters with negative sign in the debt crises index.

Figure 2. Export growth

Source: Eurostat database, own calculations

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b. Relative change of import growth represents a measure of international dependence of a country.

Hypothesis3: An increase of this index can determine the depreciation of national currency and therefore can determine a high probability of occurrence of currency and debt crisis.

Figure 3. Import growth
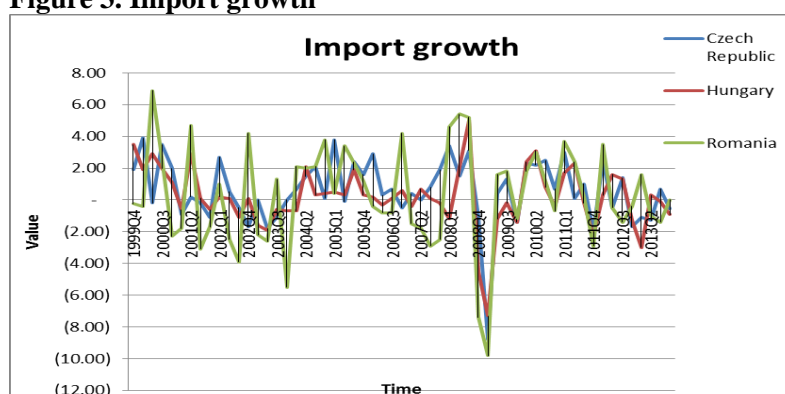
Source: Eurostat database, own calculations

c. Terms of trade index are determined as a fraction between exports of a country and imports of the same country.

Hypothesis4.1: The increase of this index leads to the improvement of the balance of payments of a country, having a decreased probability of occurrence of a crisis.

Hypothesis4.2: A deterioration of this index can determine an increase probability of occurrence of currency crisis and debt crisis
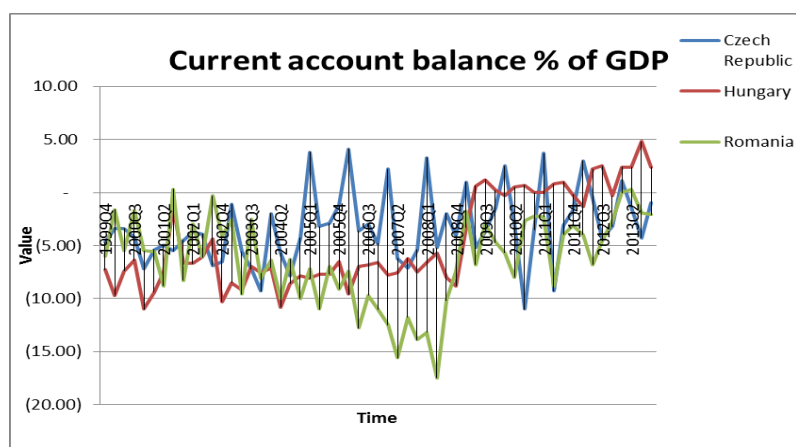
Figure 4. Terms of trade
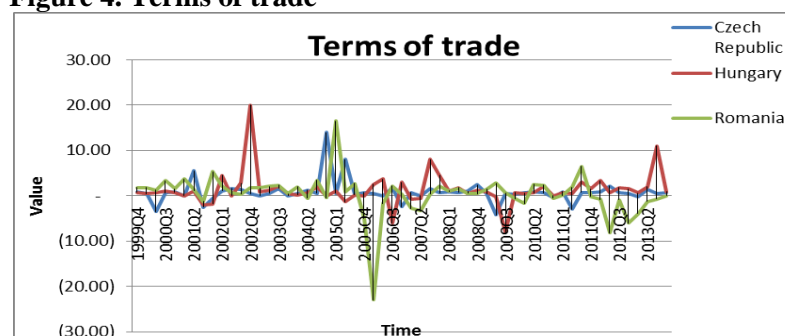
Source: Eurostat database, own calculations

d. An increase of **current account balance as % of GDP** is associated with massive inflows of capital which are intermediated by national financial system and which can facilitate the appearance of asset price booms and credit booms.

Hypothesis5: The current account surplus reveals a low probability of depreciation and therefore a low probability of occurrence of debt crisis.

**Figure 5. Current account balance as percentage of GDP**

Source: Eurostat database, own calculations

e. An increase of **capital account balance as % of GDP**   is associated with massive inflows of capital which are intermediated by national financial system and which can facilitate the appearance of asset price booms and credit booms.

Hypothesis6: The capital account excedent reveal a low probability of depreciation and therefore a low probability of occurrence of debt crisis.

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**Figure 6. Capital account balance as percentage of GDP**
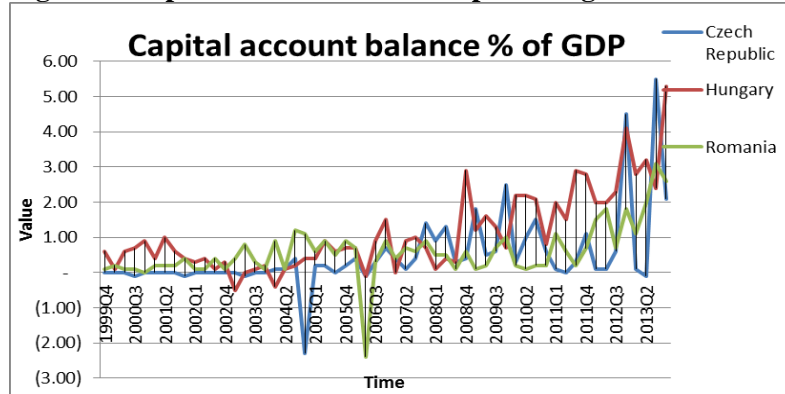
Source: Eurostat database, own calculations

f. **The relative change of foreign reserves.** The decrease of foreign exchange reserves is an indicator which manifests pressure on depreciation of national currency. The total value of foreign exchange reserves reveals the ability of a country to fulfil its foreign debts obligation.

Hypothesis7: Therefore an increase in foreign exchange reserves enters with negative sign in debt crisis equation. (In some cases, National Banks can take measures in order to support national currency).
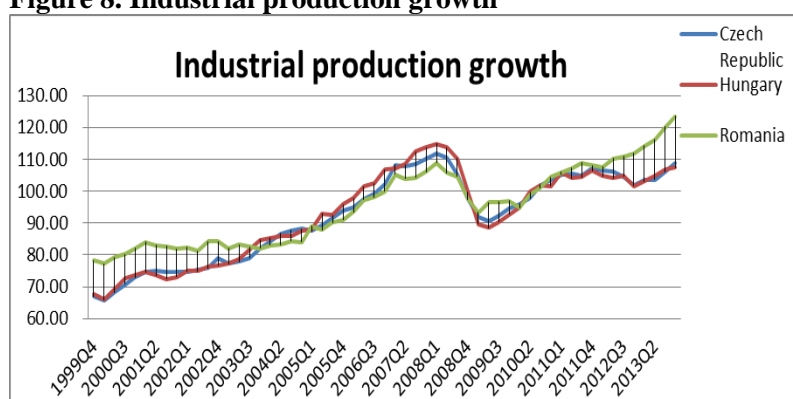
Figure 7. Growth of foreign exchange reserves
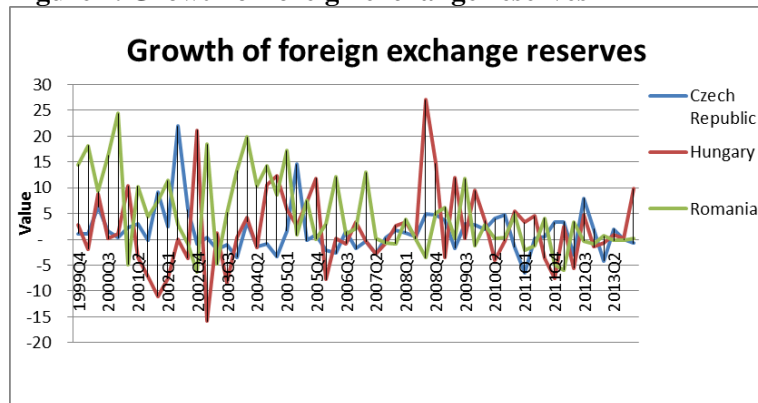
Source: Eurostat database, own calculations

g. The high leverage degree of a country's **net external debt (as % of GDP)** indicates higher vulnerabilities of the economy, outflows of capital and therefore the increase probability of occurrence of crisis.

Hypothesis8: Therefore it enters with positive sign in the debt crisis occurrence.

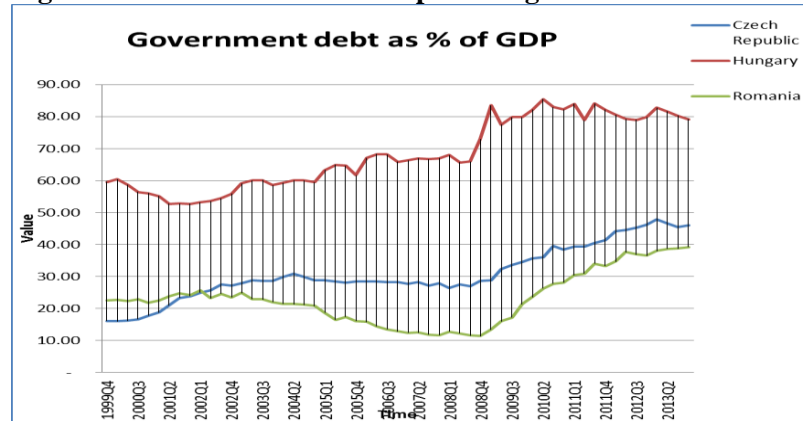**Figure 8. Industrial production growth**

Source: Eurostat database, own calculations

h. The share of governmental debt in GDP. The high leverage degree of a country's government indicates higher vulnerabilities of the economy, outflows of capital and therefore the increase probability of occurrence of crisis.

Hypothesis9: Therefore it enters with positive sign in the debt crisis occurrence.

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Figure 9. Governmental debt as percentage of GDP

Source: Eurostat database, own calculations

i. **GDP per capita/ Industrial production growth**. We have used industrial production growth as proxy for GDP per capita.

Hypothesis10: An increase of industrial production growth determines positive effects of the economy.

Figure 10. Net external debt as percentage of GDP
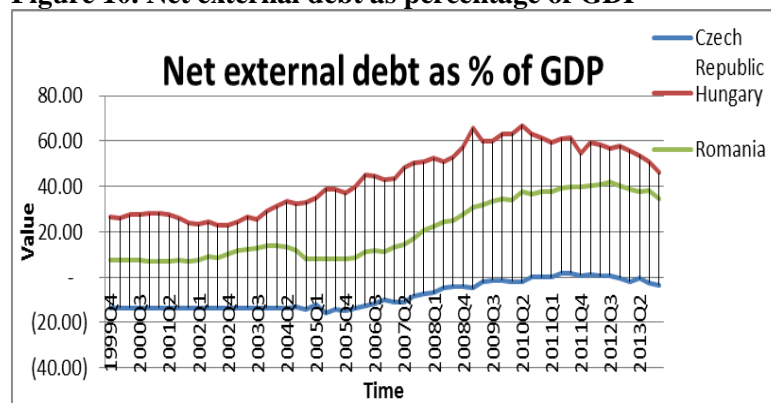
Source: Eurostat database, own calculations

j. Increased **unemployment rate** may be associated with macroeconomic threats which can affect the economy through they're cross effects on the other macroeconomic variables.

Hypothesis11: Therefore, it enters with positive in debt crisis index.

Figure 11. Unemployment rate
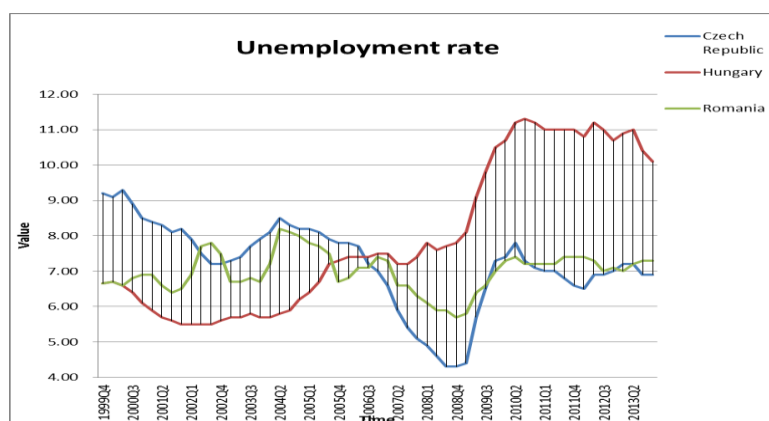
Source: Eurostat database, own calculations
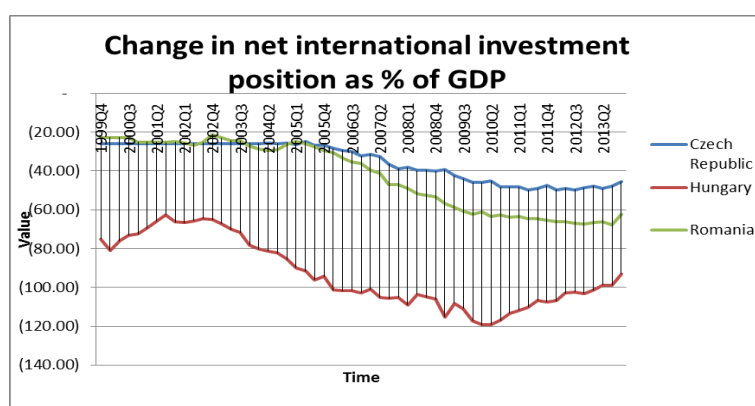
k. Change in net international investment position as % of GDP. An
increase in a country's investment position determines a decrease
probability of occurrence of crisis.

Hypothesis12: Therefore, it enters with negative sign in the debt crisis
index.

Figure 12. Change in net international investment position as % of GDP

Source: Eurostat database, own calculations

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4.2 Assessment

Taking into consideration the above evolutions of each indicator, we assessed their role in the occurrence of a debt crisis, as follows.

Therefore, we identified those variables which gave us a warning regarding the appearance of a debt crisis and we computed an indicator of debt crisis warning for Romania. This indicator was validated through the fact that it was appropriate for detection of the last debt crises of Romania.

Table 2.

Crt. No.	Indicator	Assessment	Debt crisis
1	Real effective exchange rate from trend	An overvalued real exchange rate represents a high probability of appearance of currency crisis. Therefore, we have considered that an increase of real effective exchange rate represents a higher probability of appearance of currency crisis, therefore, enters with positive sign in the debt crises debt index. An undervalued real exchange rate represents a lower probability of appearance of currency crisis.	Debt crisis (+)
2	Relative change of exports	A decrease in exports growth may be determined by a overvaluation of national (domestic) currency If the decrease of exports growth is produced by other reason that exchange rate, thus can put pressure on depreciation of national currency. In both cases, the decrease of exports growth is considered a potential leading indicator for depreciation of the national currency; therefore it enters with negative sign in the debt crises index.	Debt crisis (-)

3	Relative change of import growth	An increase of this index can determine the depreciation of national currency and therefore can determine a high probability of occurrence of currency and debt crisis.	Debt crisis (+)
4	Terms of trade	The index is determined as a fraction between exports of a country and imports of the same country. The increase of this index leads to the improvement of the balance of payments of a country, having a decreased probability of occurrence of a crisis. A deterioration of this index can determine an increase probability of occurrence of currency crisis and debt crisis.	Debt crisis (-)
5	Current account balance as % of GDP	An increase of current account balance as % of GDP is associated with massive inflows of capital which are intermediated by national financial system and which can facilitate the appearance of asset price booms and credit booms. The current account surplus reveals a low probability of depreciation and therefore a low probability of occurrence of debt crisis.	Debt crisis (-)
6	Capital account balance as % of GDP	An increase of capital account balance as % of GDP is associated with massive inflows of capital which are intermediated by national financial system and which can facilitate the appearance of asset price booms and credit booms. The capital account surplus reveals a low probability of depreciation and therefore a low probability of occurrence of debt crisis.	Debt crisis (-)

7	The relative change of foreign reserves	The decrease of foreign exchange reserves is an indicator which manifests pressure on depreciation of national currency. The total value of foreign exchange reserves reveals the ability of a country to fulfil its foreign debts obligation. Therefore an increase in foreign exchange reserves enters with negative sign in debt crisis equation. In some cases, National Banks can take measures in order to support national currency.	Debt crisis (-)
8	Net external debt as % of GDP	The high leverage degree of a country's net external debt indicates higher vulnerabilities of the economy, outflows of capital and therefore the increase probability of occurrence of crisis. Therefore it enters with positive sign in the debt crisis occurrence.	Debt crisis (+)
9	The share of governmental debt in GDP	The high leverage degree of a country's government indicates higher vulnerabilities of the economy, outflows of capital and therefore the increase probability of occurrence of crisis. Therefore it enters with positive sign in the debt crisis occurrence.	Debt crisis (+)
10	GDP per capita/ Industrial production growth	We have used as proxy for GDP per capita – industrial production growth. An increase of industrial production growth determines positive effects of the economy.	Debt crisis (-)
11	Unemployment rate	Increased unemployment rates may be associated with macroeconomic threats which can affect the economy through they're cross effects on the other macroeconomic variables. Therefore, it enters with positive in debt crisis index.	Debt crisis (+)

12	Change in net international investment position as % of GDP	An increase in a country's investment position determines a decrease probability of occurrence of crisis. Therefore, it enters with negative sign in the debt crisis index.	Debt crisis (-)

4.3   Computation of the debt crisis index

Therefore we have computed an index which contains each of the above indicators, with positive or negative sign depending on their role in explaining the appearance of a debt crisis, according to the table assessment. We expect that an increase of this value to reflect a cost against the economy, thus representing a distress situation, therefore a debt crisis period.

The equation of Debt Crisis Index (which is defined in the same way for the three countries in research) is presented below:

$$DCI = \sum_{i=1}^{n} REER - \sum_{I=1}^{n} EXP + \sum_{i=1}^{n} IMP - \sum_{i=1}^{n} TT - \sum_{i=1}^{n} CAGDP - \sum_{i=1}^{n} TAGDP - \sum_{i=1}^{n} GRTRES +$$
$$+ \sum_{i=1}^{n} NDEBT + \sum_{i=1}^{n} GOVGDP + \sum_{i=1}^{n} UNEMP - \sum_{i=1}^{n} INDPROD - \sum_{i=}^{n} NINTINV$$

Where:

DCI = Debt Crisis Index
i=1, n = time (expressed in quarters)
REER = Real effective exchange rate from trend
EXP = Relative change of exports
IMP = Relative change of imports
TT = Terms of trade
CAGDP = Current account balance as % of GDP
TAGDP = Capital account balance as % of GDP
GRTRES =Relative change of foreign reserves
NDEBT = Net external debt as % of GDP
GOVGDP = Government debt as % of GDP
UNEMP = Unemployment rate
INDPROD = Industrial production growth
NINTINV = Net International investment position as % of GDP

As it is visible from the bellow table, all of the three countries experiences increases of debt pressure as follows: for Romania starting with 2nd quarter of 2007, for Hungary and Czech Republic starting with 4th quarter of 2008.

The highest point of pressure was reached in 1st quarter of 2009 for Hungary, in 1st quarter of 2011 for Czech Republic and in 4th quarter of 2011 for Romania.

The difference in the moment of appearance of debt pressure as well as the different moment in which the highest point of the pressure is reached is explained by other factors which influence the economy of those countries, as well as the measures of the Government to diminish the negative effects, which are also different from one state to another.

Figure 13. Debt crisis index
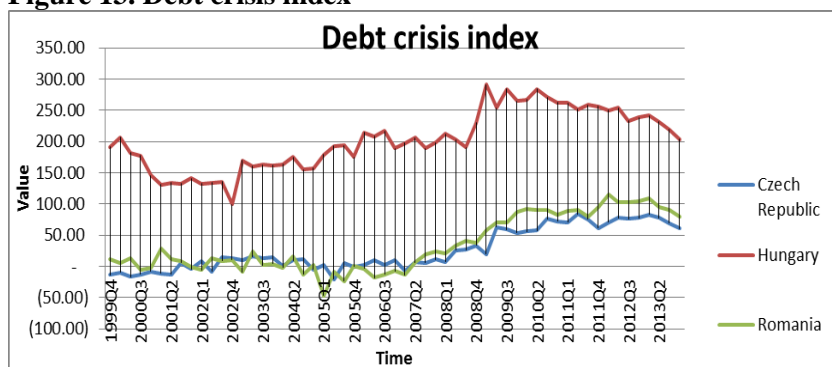
Source: Eurostat database, own calculations

4.4   Computation of the Debt crisis warning

We have estimated a regression for each country in order to see if all of those potential leading indicator influence the warning debt index.

According to the estimation results, the hypothesis of the research – that there are potential leading indicators which can bring us a warning regarding the debt crisis period are confirmed.

In the bellow table there are presented the coefficients with which the variables influence the Debt Crisis Index and their p-value (as the p-value is closer to 0, the significance of that variable in explaining the model is higher).

The results of the econometric estimation also confirms us that we have taken into account that the variable influence a debt crisis index in right direction (either positive or negative), another hypothesis of the model which was confirmed.

**Figure 14. Comparative analysis of the   regression models between
the DCI and the 12 potential leading indicators**

Country	Czech Republic		Hungary		Romania	
	Coeff.	*P-value*	*Coeff.*	*P-value*	*Coeff.*	*P-value*
Intercept	0.000	0.170	0.000	0.63	0.000	0.3281
1. REER Deviation from trend	1	0	1	0	1	0
2. Exports of goods and services	-1	0	-1	0	-1	0
3. Imports of goods and services	1	0	1	0	1	0
4. Terms of trade	-1	0	-1	0	-1	0
5. Current account balance in % of GDP	-1	0	-1	0	-1	0
6. Capital account in % of GDP	-1	0	-1	0	-1	0
7. Growth of foreign exchange reserves	-1	0	-1	0	-1	0
8. Volume index of production	-1	0	-1	0	-1	0
9. Government debt in % of GDP	0	0	0	0	1	0
10.Net external debt in % GDP	1	0	1	0	1	0
11.Net international investment	-1	0	-1	0	-1	0

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position in % of GDP - quarterly data						
12. Unemploymen t rate	1	0	1	0	1	0

* Semnificant at 1%

** Semnificant at 5%

***Semnificant at 10%

Please see the results of regression performed for all countries included in the research. Adjusted R2 is if 97,67% for Czech Republic and Hungary and 100% for Romania, this meaning that the models are described in high proportion by the potential leading indicators. Thus is on one side explained by the fact that, we have analysed at this step the econometric influence of the potential variables which have been already included in the definition of the Crisis Debt Index. In a prior research, where other few variables (macroeconomic and financial variables) were added, the explanatory power of the models decreased at about 70%, because not all of them where important in explaining the occurrence of a debt crisis.

Figure 15. Comparative analysis of the explanatory power of the models

Country	Czech Republic	Hungary	Romania
Regression Statistics			
Multiple R	1	1	1
R Square	1	1	1
Adjusted R Square	0.9767	0.9767	1
Standard Error	0.0000	0.0000	0.0000
Observations	57	57	57

Source: Eurostat Database, own calculations

Based on the coefficients provided by the econometric estimation, we have composed the **early warning index of debt crisis** for each country, as follows:

DCW=

$$\sum_{i=1}^{n} REER - \sum_{I=1}^{n} EXP + \sum_{i=1}^{n} IMP - \sum_{i=1}^{n} TT - \sum_{i=1}^{n} CAGDP - \sum_{i=1}^{n} TAGDP - \sum_{i=1}^{n} GRTRES + \sum_{i=1}^{n} NDEBT +$$

$$+ 2\sum_{i=1}^{n} GOVGDP + \sum_{i=1}^{n} UNEMP - \sum_{i=1}^{n} INDPROD - \sum_{i=}^{n} NINTINV$$

Where,

DCW= Debt Crisis Warning

In this case the debt crisis warning surprise a highest cost against the economy, thus being increased by the coefficient of the government debt, revealing the fact that the government debt indicator is one of the most important in revealing a warning regarding the probable occurrence of a debt crisis.

Figure 16. Debt Crisis Warning
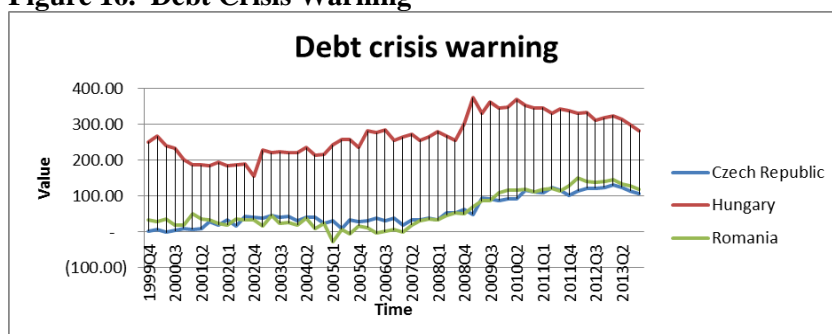
Source: Eurostat Database, own calculations

We have also composed for each country a VAR between EWI and each potential indicator and a VAR for FWI and each potential indicator in order to allow for bidirectional causality. I observed the indexes response to a shock in each potential leading indicator. Using orthogonal impulse response functions I set the lag for each indicator equal to the lead where the response function reaches its maximum, without taking into consideration its sign or its statistical significance. I allow for a minimum lag length of twelve months assuming that a potential leading indicator provides an early warning only if it predicts crisis incidence at least one year ahead so that timely policy action can be taken. Taking in consideration the fact that the lag must be enough for the early warning, but also avoiding excessive parameterization I considered minimum lag of 4 quarters, because only if it is identified in time a negative aspect in the economy can be treated.

After completing the analysis of VAR the key idea is that even if the potential indicators are significant in explaining the crisis incidence, not all of them give important signals regarding its prediction. And also another important aspect is that this model hasn't the same efficiency for all the countries in the sample. This can be caused by the fact that the

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crisis manifested different in those countries both at indicators levels and direct consequences at the economy level. The main important leading indicators are GDP growth rate, real effective exchange rate from trend and external debt.

According to the analysis, there are some significant variables which are very important in explaining the occurrence of a debt crisis which give important signals to policy makers in order to limit potential damages which can appear through such a crisis. In the future, a special attention should be granted to permanently monitoring potential leading indicators, reacting to the signals received and include those indicators in the policy measures undertaken, in order to cover all the areas of the economy and to protect against potential risks.

5. Conclusions

This analysis reveals the hypothesis of the research, that there are potential leading indicators which gave us a warning in identifying the moments of debt crisis pressure of the economy. Summarizing the main results, we found that debt crisis/ instability warning signals come at various horizons.

Another important aspect to mention is that this model – as it is defined - hasn't the same efficiency for all the countries in the sample. There are variables which are significant in explaining the debt crisis of one country, even that for the other country they have not such impact. One explanation for that fact can be the decisions taken in each country, which can differ both as measures taken, but also as effects needed to be achieved.

REFERENCES

[1]**Arellano, C. and N.R. Kocherlakota (2008),** *Internal Debt Crises and Sovereign Defaults;* Working Paper 13794;
[2]**Babecy, J., T. Havranek, J. Mateju, M. Rusnak, K. Smidkova, B. Vasicek (2011),** *Early Warning Indicators of Economic Crises-Evidence from a Panel of Developed Countries*. Working Paper Series, National Bank of Czech;
[3]**Berg,A., E. Borensztein and C. Pattilo (2004),** *Assessing Early Warning Systems: How Have They Worked in Practice?*; IMF Working Paper/04/52;
[4]**Cecchetti, S.G., M. Kohler and C. Upper (2009),***Financial Crises and Economic Activity;* NBER Working Paper Series;
[5]**DeLong,J.B. (2009),** *The Financial Crisis of 2007-2009: Understanding its Causes, Consequences-and its Possible Cures*;
[6]www.Eurostatdatabase.com

[7]**Isarescu, Mugur (2006),** *Contributions to the Theory of Macroeconomic Stabilization, Reflections of Economic Stabilization*; Governor of the National Bank of Romania;

[8]International Monetary Fund www.imf.com

[9]**Ionita, Rodica, Oana (2012***), Disertation : Early warning indicators of economic crises;*

[10]**Krugman, P. (1979),** *A Model of Balance-of-Payments Crises*; Journal of Money,Credit and Banking 11(3), pp. 311–325;

[11]**Krugman,P. (2000),** *The Return of Depression Economics*;

[12]**Kaminsky, G., S. Lizondo and C. Reinhart (1998),** *Leading Indicators of Currency Crises*. http://ideas.repec.org/p/pra/mprapa/6981.html;

[13]**Menegatti,C.and N.Roubini (2006),** *Vulnerabilities in Central and Southern Europe;*

[14]National Bank of Romania, monthly reports http://www.bnro.ro/Publicatii-periodice-204.aspx

[15]**Reinhart, C.M. and K.S. Rogoff(2008),** *This Time is Different: A Panoramic view of eight Centuries of Financial Crises*; NBER Working Paper.