

Early Warning Indicators for a Financial Crises. The Case of Romania

Radu SOVIANI, PhD candidate,
The Academy of Economic Studies, Bucharest
Phone: 00.40 (723) 551.514, radu@soviani.com

Abstract: This paper analyses the early signs in the economy that has the ability to predict that a financial crisis is due to happen because of the macroeconomic indicators deterioration and how other economic indicator signals the distress in the state of the economy. We specify the macroeconomic indicators we follow and we identify the symptoms associated with the associated disorder, as it is described by the economic literature as indicators that use to predict some of the internal crisis (currency, banking, balance of payment, all crisis at once). We see the dynamics of this indicators and we compare them with the the dynamics of the best leading indicators for a crisis, that were able to predict a crisis nationally, regionally or globally. We choose 7 early warning indicators that provided in-time valid signals about a crises in Romania, and we define a composite indicator for showing the distress of the economy (as each indicator can give a particular signal of distress, while the composite indicator shows the imminence of the Romanian Financial Crises of 2008-2010).

Keyword: Exchange Rate, financial crisis, currency crisis, balance of payment Crisis.

JEL Classification: E52, E58, G01

1. Conceptual and theoretical context

The models of balance of payment crisis were studying the Latin American currency crisis of the late of 1970s. The currency crash in this cases was triggered by unsustainable money financed fiscal deficits that lead to a persistent loss of international reserves.

Obstfeld (1996)⁴ develops a model of a currency crisis that focused on government officials (and central banks) concern on contradictory targets: for example reducing inflation and keeping economic activities close to a given target. Fixed exchange rate may help in achieving the growth target, but the cost is a loss of a competitiveness and a recession.

With fixed prices (generated by peg or managed floating of the exchange rate), a devaluation may restore competitiveness and help in the limitation of unemployment.

Diaz Alejandro (1985)⁵ and Velasco (1987)⁶ - for the case of Chile - model difficulties in the banking sectors as giving rise to a balance of payment crisis⁷ arguing that if central banks finance the bail out of troubled financial institutions by printing money, we have the case of a currency crash prompted by excessive money creation.

⁴ Obstfeld, M. (1996) - "Models of currency crisis with self-fulfilling features", *European Economic Review* 40, 1996, p. 1037-1047

⁵ Diaz Alejandro, C.F. (1985) - „Good-bye Financial Repression, Hello Financial Crash”, *Journal of Development Economics* 19, p. 1 - 24

⁶ Velasco, A. (1987) - "Financial crisis and balance of payments crisis: a simple model of the southern cone experience", *Journal of Development Economics*, Volume 27, Issues 1-2, October 1987, p. 263-283

⁷ Kaminski, G. (1998) - "Currency and banking crisis. The early warning of distress", *International Finance Discussion Paper*, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), p. 4

The literature on capital inflows and capital inflow problems (for example Montiel and Reinhart (1997) also suggests that a liquidity crisis is triggered by the sudden stop or the reversal in capital flows (becoming capital outflows)⁸.

Capital flight can cause serious economic difficulties for developing countries by causing an erosion of the tax base and a reduction in domestic investment. Also, as it leads to a buildup of foreign debt, it can fuel a currency crisis as foreign investors become doubtful about the ability and the will of the emerging economy to pay back (Kahn and Haque (1985)⁹)

Calomiris and Gorton (1991) pointed that crisis and panics are preceded by recessions¹⁰ and are most likely to occur when a recession follows a period of substantial credit increase, which fuels a prolonged expansion in economic activity.

Kaminsky, Reinhart, Lizondo, Diebold (1999)¹¹ are studying the 1997 Asian Crisis that have led many to claim that these crises are of a new generation and unpredictable. They contradict this theory by examining 102 crises in 20 countries and concluding that the Asian Crisis are not of a new variety. They show that as well as previous crises elsewhere, they occur when the economies are in distress, making the fragility of the economy a useful indicator of future crisis. Based on this idea, Kaminsky (1999) proposes different composite leading indicators of crisis.

Kaminsky (1998)¹² summarizes the symptoms of an upcoming crisis. They range from recessions to exaggerated cycles in credit markets and they describe whether it is a positive or a negative shock to that particular indicator that indicates that the economy might be prone to bank runs and speculative attacks.

2. The early warning indicators for the Romanian Financial Crisis

Financial crises can arise as a result of an isolated shock (for instance an expansionary monetary policy can clash with the commitment to maintain a stable (even managed float) exchange rate. Investors will try to anticipate the collapse and they might generate speculative attacks (that eventually will lead to a devaluation of the currency). Banking crisis may arise as a result of a credit crunch (illiquidity that will lead to a high demand for money and a price increase).

In the case of Romania it was mainly a problem of pro-cyclical fiscal policy (even if the unbalanced budget was showing signs of weaknesses in terms of structural deficit, not accrual deficit). The fiscal policy was expansionary and the crisis was preceded by an explosion of international lending at very low interest rates (historically). When the credit crunch arrived in the advanced economies, the money became much more needed and expensive. To avoid a depreciation of the national currency, and to compensate the pro-cyclical conduct of the fiscal policy, the National Bank of Romania switched to a contractionary monetary policy (from August 2007 to June 2008, the NBR increased the monetary policy rate from 7% to 10.25%) but this had as an effect an increase in the vulnerability of the banking sector (the lending in

⁸ Kaminski, G. (1998) - "Currency and banking crisis. The early warning of distress", International Finance Discussion Paper, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), p. 4

⁹ Kahn, M. and Haque, N., "Foreign Borrowing and Capital Flight: A formal analysis", 1985, IMF Staff Paper, Palgrave Macmillan, vol 32 (4), p. 606-628

¹⁰ Kaminski, G. (1998) - "Currency and banking crisis. The early warning of distress", International Finance Discussion Paper, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), p. 5

¹¹ Kaminski, C. Reinhart, Lizondo, Diebold (1999) - "Currency and Banking Crisis - The Early Warning of Distress", Washington DC, Working Paper 178, p.1-9

¹² Kaminski, G. (1998) - "Currency and banking crisis. The early warning of distress", International Finance Discussion Paper, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), Appendix, Table 2 - Symptoms and leading indicators

foreign currency became more attractive and as a result, the exposure of the banks increased). When world interests increased and the capital inflows turned into outflows, the vulnerability of the banking sector surged, so did the non performing loans. The crisis scenario was aggravated by the real appreciation of the domestic currency and the deterioration of the current account, that was caused also by the pro-cyclical fiscal policy which caused a surge in consumption. The state of euroization of a still high-inflationary economy contributed to the severity of the collapse. As RON devaluated, the low-interest environment for foreign exchange lending magnified the deterioration of the bank balance sheets (as the debts were paid by people and companies that had revenues in the national currency) and this led to a credit crunch. A miss match of maturities (with great exposure on the short term debt) added pressures from the Romanian State to the credit market, as the treasury crowded out.

So, an early warning system for the Romanian Economy cannot limit itself to point a problem or a set of problems, but we have to incorporate the state of distress of the economy as leading indicators to the crises. For the particular case of Romania we will see the indicators that cumulatively warned about the financial distress that was developing

a) The economic, financial or currency crisis were preceded by rapid credit growth that were amplified by the financial system liberalization and the elimination of the capital account restrictions.

In the particular case of Romania, joining the NATO and the EU have additionally increased this tendency. As a result an over-borrowing cycle is forming - that is shown by the $M2^{13}$ multiplier and the growth of the internal credit to GDP ratio.

b) A relaxing monetary policy can fulfill a currency crisis. Once Romania joined the EU and the capital inflows grew rapidly, the central bank confronted also speculative capital inflows looking for carry-trade¹⁴. This conduit might be training a currency devaluation with significant effects on the banking system (overexposed in a double manner: excessive lending and internal lending in a different currency - the so called "euroization"). We follow M1 indicator.¹⁵

c) The real exchange rate. The RON appreciated by 50% between 2004 and mid 2007. The overvaluation of the RON and a weak external sector are premises for a financial crisis. They come over the weaknesses of the banking system (overexposure, not toxic assets).

The lose of competitiveness (by overvaluation) and the external market can lead to recession, bankruptcy and a depreciation of the quality of the loans - by increasing the non performing loans. As a consequence, any major shock regarding the exports (decrease as a consequence of a lower competitiveness), regarding the imports (increase as the exchange rate appreciates) as well as a strengthening of the real exchange rate is a system of the financial crisis associated with the current account deficit. We follow export, imports, and the real exchange rate¹⁶.

d) Higher international interest rates might anticipate a currency crisis that lead to a reversal of the capital inflows. The capital account problems tend to be more severe when

¹³ M2 is the intermediate money supply and includes M1 plus deposits shorter than 2 years

¹⁴ Carry-trade defines a strategy by which an investor borrows money for a low interest rate in order to invest in an assets that is going to generate a higher yield (that the cost of money). The currency carry trade is made by borrowing a low-interest rate currency and invest the money (by currency conversion) in a different currency, for a higher yield.

¹⁵ M1 is covering the cash and the current accounts

¹⁶ The real exchange rate is the nominal exchange rate (a measure of the value of the currency comparing with a basket of currencies) divided by a price deflator or a cost index

the external debt is high and it amplifies the capital outflows rising concerns regarding the sustainability of the public debt.

As a fact, Romania entered the crisis with a very low public debt (13.6% of GDP) and an external debt of 48.2% of GDP (2008). That's why this vulnerability was not major, but the short term financing of the public debt put additional pressure on costs and dynamics.

As indicators, we follow the interest rate differential (international versus domestic), public debt, capital flows, short term external debt - that are part of the troubles in the capital account.

e) Higher interest rate might be a symptom for a liquidity crisis, that lead to a decrease of the economic activity and to fragility in the banking sector (pressure on future NPLs). An increase of the loans/deposits ratio might show a decline of the quality of the loans. We follow GDP, real interest rates, loans/deposits ratio and the price of stocks

The indicators:

1. M2 multiplier: The ratio of M2 (IFS lines 34+35) to base money (IFS line 14) - 12 month percentage change
2. Domestic credit/GDP: IFS line 52 divided by IFS line 64 to obtain domestic credit in real terms, which was then divided by IFS line 99b.p. (interpolated) to obtain domestic credit/GDP ratio. Monthly real GDP was interpolated from annual data.
3. Excess M1 balances: M1 (IFS line 34) deflated by consumer prices (IFS line 64) less an estimated demand for money. The demand for real balances is determined by real GDP (interpolated IFS line 99b.p.), domestic consumer price inflation and a time trend. Domestic inflation was used in lieu of nominal interest rate, as marked determined interest rate were not available during the entire sample for a number of countries. The time trend (which can enter log-linearity, linearly or exponentially) it is motivated by its role as a proxy for financial innovation and/or currency substitution;
4. Current account deficit (data from the National Bank of Romania);
5. Real exchange rate: The real exchange rate index is derived from a nominal exchange index, adjusted for relative consumer price (IFS line 64). This measure is defined as the relative price of foreign goods (in domestic currency) to the price of domestic goods. The nominal exchange rate index is a weighted average
6. Real interest rate differential. The interest rate differential is constructed as the difference between real rates for the domestic and foreign countries. Real rates are deposit rates (IFS line 60) deflated using consumer prices (IFS line 64)
7. Capital flight. We use the consolidated foreign claims to GDP (as reported by the Bank Of International Settlement);
8. Short-term foreign debt: Liabilities of domestic residents to BIS reporting banks with maturities up to 1 year divided by total liabilities of domestic banks to BIS reporting banks, interpolated from semi-annual data. The Maturity, Sectorial and Nationality Distribution of International Bank Lending, Bank for International Settlement
9. Lending-Deposit rate Ratio: IFS line 60p divided by IFS line 60 was used in lieu of differential to ameliorate the distortions caused by large percentage points spreads observed during high inflation. Both rates are for domestic economy.

The symptoms:

The above described indicators are part of the symptoms that Kaminsky (1999)¹⁷ identified for banking and currencies crisis.

Table 1: Symptoms and indicators on the economy identified by Kaminsky (1999) for banking and currencies crisis.

a. Symptoms	b. Indicator	c. Critical Shock Sign	d. Comments
Overborrowing Cycles	M2 Multiplier	Positive	Both banking and currency crises have been linked to rapid growth in credit fueled by liberalization of the domestic financial system and by the elimination of capital account restrictions
	Domestic credit/GDP	Positive	
	Loans in foreign currency	Positive	
Monetary Policy	‘Excess M1 Balances’	Positive	Loose monetary policy can fuel a currency crisis. The the extent that the devaluation worsens the health of the banking sector it can also trigger a banking crisis (by an increase in NPL)
Problems Current Account	Current account deficit	Positive	Real exchange rate overvaluations and a weak external sector are part of a currency crisis. They add to the vulnerability of the banking sector since a loss in competitiveness and external markets could lead to a recession, business failure and a decline in the quality of loans. Thus large negative shocks to exports and the real exchange rate and positive shocks to imports (both covered by the current account deficit) are interpreted as symptoms of the financial crisis
	Real Exchange rate	Negative	
Problems Capital Account	Real Interest Rate Differential	Positive	High world interest rates may anticipate currency crisis as the lead to capital

¹⁷ Kaminski, G. (1999) - ‘‘Currency and banking crisis. The early warning of distress’’, International Finance Discussion Paper, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), Appendix, Table 2 - Symptoms and leading indicators

a. Symptoms	b. Indicator	c. Critical Shock Sign	d. Comments
	Short term Foreign Debt	Positive	out-flows. Capital account problems become more severe when the country's foreign debt on short term increases since it may rise issues of sustainability . Kaminsky and Reinhart (1996) argue that a currency crisis may in turn deepen the banking crisis
	Capital flight	Positive	
Growth slowdown	Domestic real interest rate	Positive	Recessions and the burst of asset price bubbles precede financial crisis (Calomiris and Gorton 1991). High real interest rates could be a sign of a liquidity crunch leading to a slowdown and banking fragility. An increase in the lending/deposit ratio in the domestic economy can capture a decline in loan quality
	Lending/Deposit Ratio	Positive	
	Stock Prices	Negative	

3. Which indicators worked best for the Romanian crises

The current model is based on the assumption that the Romanian economy had a sustainable economic growth in 2000-2004 so we presume that the indicators from this period can be used as references for a sustainable economic growth (even if the economy had a large growth between 2000-2004, we have not seen a deterioration of the macroeconomic indicators).

The model:

For each indicator we calculated the average value, the variance and the standard deviation between 2000-2004. We consider that each annual indicator for 2005 - 2007 (pre-crises) will issue a signal if the difference between the yearly indicator and the average value of that indicator for 2005-2008 is higher than the standard deviation for a sustainable period of economic growth (2000-2004), or in the case of macroeconomic indicators if the difference between the annual indicator and the average for sustainable times (2000-2004), defined as DELTA, is higher than the standard deviation for tranquil times. So we have a maximum of 4 consecutive signals (for 2005, 2006, 2007, 2008) which lead us to an Intensity of the signals of (0, 0.25, 0.5, 1). Any value above 0.5 shows us that a crises is highly probable, while a value of 1 shows us that the crises is imminent. To refine the signals we define the following algorithm:

If we have consecutive signals, the signal for an year will be multiplied by a factor which will show a repetitive factor (2 for the second year in a row, 3 for the third year in a row). So, we will have a maximum of 6 points signals (one signal in 2005 added with two signals in 2006 added with three signals in 2007 added with 4 signals in 2008) and we will

define by adding signals for each year the intensity of the signal ($IS = \text{number of signal}/6$ possible signals)

Because the purpose of the model is to see if we can have early warning of distress, we will consider the values for 2005-2007 in terms of predicting the crises, while the values of 2008 ($x = \text{annual indicator} - x_m$ - the average indicator for 2005-2007 might show us if the crisis is going to further develop in the future).

Where we have percentage change (year on year) indicators - we use as reference the DELTA (which is the value of the indicator - the average level of indicators for tranquil times (2000-2004 or fractions of 2000-2004)). Each time the Delta is higher than 2 standard deviations we have a signal issued.

Where we have the actual value of the indicator - we use as reference the $(x-x_m)$, where X is the value of the annual indicator and x_m is the average value for 2005-2007 (prior to the crises). Each time the $x-x_m$ is higher than the standard deviation for tranquil times (2000-2004 or fractions of it), we have a signal issued).

a) loans to deposit ratio (year on year)

Average value 2000-2004: 18.14

Variance 2000-2004: 85.41

Standard deviation 2000-2004: 9.24

For loans to deposit ratio we have:

Table 2: Dynamics of loans to deposit ratio (2005-2008)

Dynamics loans to deposit ratio	2005	2006	2007	2008
X	20.96	55.92	18.62	41.73
X_m (2005-2007)	31.83	31.83	31.83	31.83
$X-X_m$	-10.87	24.09	-13.21	9.90
Standard deviation (2000-2004)	9.24	9.24	9.24	9.24
$(x-x_m)/\text{standard deviation}$	-1.18	2.61	-1.43	1.07
Signals	1.00	1.00	1.00	1.00
Noise to signal	1.00	2.00	3.00	4.00

Source: National Bank of Romania, own calculations.

According to these calculations we have 3 consecutive signals between 2005-2007 and another signal in 2008 (showing that the indicator is going to further adjust in the future). Having in mind that the crises occurred in 2008, the 3 consecutive signals conduct to an intensity factor of 1 (maximum for 2004-2007). The highest signal was sent in 2006 where the $(x-x_m)$ was 2.6 times higher than the standard deviation.

The signals are considered to be valid in tranquil times (non-crises), so we do not consider as valid the signal sent in 2008 (when the crises already manifested, since we want to predict the crises, not to validate it).

So, the IS for loans to deposit ratio equals 1, fully signaling a crises.

If we want to verify this indicator for 2009-2013, we have the following results (and we compare with the standard deviation for tranquil and sustainable times (2000-2004), which had a value of 9.24):

Table 3: Dynamics loans to reposit ratio (2009-2013)

Dynamics loans to deposit ratio	2009	2010	2011	2012	2013
X	-73.06	-16.14	35.57	21.11	8.97
X _m	12.37	12.37	12.37	12.37	12.37
X-X _m	-85.43	-28.51	23.20	8.74	-3.40
Standard deviation (2000-2004)	9.24	9.24	9.24	9.24	9.24
(x-x _m)/standard deviation	-9.25	-3.08	2.51	0.95	-0.37
Signals	1.00	1.00	1.00	0.00	0.00
Noise to signal	0.00	0.00	1.00	0.00	0.00

Source: National Bank of Romania, own calculations.

Since the crises was already manifesting in 2009 and 2010, we do not consider as valid the signals in 2009 and 2010 (even if they show as an adjustment of the indicator), but just the signals in 2011, 2012, 2013. According to this estimate, we have an IS of $1/6 = 0,16$ in 2011-2013, mainly because of the signal in 2011, which is not enough for signaling a crises since the 2012 and 2013 (valid signals) where not indicating any crises.

b) M2/M1 % change (annual)

We have an average value (x_m) of 2.47% between 2002-2004 (we exclude the 2001 factor as being irrelevant since the ratio, as absolut level, was five time higher than the average, and a standard deviation of 5.47 (2002-2004). For each year the difference between yearly indicator (x) and the average value for the indicator (2005-2007) (x_m) is higher than the standard deviation (2000-2004) we have a signal (and this signal is multiplied by the repetitive factor).

For 2002-2004 we have

* average value: 2.78

* variance 29.93

* standard deviation: 5.47

For M2/M1 % change we have the following calculated data (2005-2008):

Table 4: M2/M1 % change (2005-2008)

M2/M1 % change	2005	2006	2007	2008
X	-9.81	-15.73	-17.39	0.15
X _m (2005-2007)	-14.31	-14.31	-14.31	-14.31
X-X _m	4.50	-1.42	-3.08	14.46
Delta (x-X _m (2002;2004))	-12.59	-18.51	-20.17	-2.63
Delta/standard deviation	-2.30	-3.38	-3.69	-0.48
Signals	1.00	1.00	1.00	0.00
Noise to signal	1.00	2.00	3.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

According to this calculation, we have 3 consecutive signals (2005, 2006, 2007) which conduct to an Intensity Signal of 6/6 (1). Since the IS is higher than 50%, we consider that M2/M1 % change is a relevant factor for signaling a crises (especially that the ratio Delta/standard deviation was higher than 2 standard deviation for each of the three years. So, the M2/M1 % change fully signaled a crises.

If we want to verify this indicator for 2009-2013, we have the following results (and we compare with the standard deviation for tranquil and sustainable times (2002-2004), which had a value of 5.47):

Table 5: M2/M1 % change (2009-2013)

M2/M1 % change	2009	2010	2011	2012	2013
X	27.23	3.91	1.20	-0.84	3.617
Xm	1.97	1.97	1.97	1.97	1.97
X-Xm	25.26	1.94	-0.77	-2.81	1.65
Delta (x-xm (2002-2004))	24.45	1.13	-1.58	-3.62	0.84
Delta/standard deviation	4.47	0.21	-0.29	-0.66	0.15
Signals	1.00	0.00	0.00	0.00	0.00
Noise to signal	0.00	0.00	0.00	0.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

In 2009-2013 we had a single shock signal (in 2009, but we do not consider this as valid since 2009 was already a crises time) so the IS value is zero for 2010-2013, which shows no crises foreseen. As a result, we consider as relevant the M2/M1 % change indicator for signaling a crises.

c) Current account deficit signals:

We have an average value (xm) of -4.575% between 2000-2004 and a standard deviation of 1.97 (for 2000-2004), resulted from our calculations. For each year the difference between yearly indicator (x) and the average value for the indicator (2005-2007) (xm) is higher than the standard deviation (2000-2004) we have a signal (and this signal is multiplied by the repetitive factor).

For 2000-2004 we have:

* xm = -4.575

* variance: 3.88

* standard deviation: 1.97

For current account deficit between 2005-2008, we have the following situation:

Table 6: Current account deficit (% of GDP) 2005-2008

Current account deficit (% of GDP)	2005	2006	2007	2008
X	-8.6	-10.4	-13.4	-11.6
Xm	-11	-11	-11	-11
X-Xm	2.40	0.60	-2.40	-0.60
Delta (x - xm(2000;2004) = 4.575)	-4.03	-5.83	-8.83	-7.03
Signals (1 if Delta > Standard deviation (1.97))	1.00	1.00	1.00	1.00
Noise to signal	1.00	2.00	3.00	4.00

Source: National Bank of Romania, own calculations

We have this situation: For each year (2005, 2006, 2007, 2008) the difference between the yearly current account deficit and the average value (2000-2004) - considered as sustainable is much higher than the standard deviation for 2000-2004 (1.97) - from double

(2005) to quadruple (2007). Since the current account crisis already started to manifest in 2008 (the shrinking of the current account deficit) we consider as valid signals those from the period 2005-2007. So we have a total of 6 signals (from 6 possible), which give us the maximum value for $IS = 1$. This signaling approach considers that an average current account deficit of 4.575 (the average for 2000-2004) is considered as sustainable, at macroeconomic level. So, the dynamics of the current account deficit fully signaled a crisis.

If we want to verify this indicator for 2009-2013, we have the following results (and we compare with the standard deviation for tranquil and sustainable times (2000-2004), which had a value of 1.97):

Table 7: current account deficit (% of GDP) - 2009-2013

Current account deficit (% of GDP)	2009	2010	2011	2012	2013
X	-4.2	-4.4	-4.5	-4.4	-1.1
Xm	-3.72	-3.72	-3.72	-3.72	-3.72
X-Xm	-0.48	-0.68	-0.78	-0.68	2.62
Delta (x - xm(2000;2004) = 4.575)	0.38	0.18	0.08	0.18	3.48
Signals (1 if Delta > Standard deviation (1.97))	0.00	0.00	0.00	0.00	1.00
Noise to signal	0.00	0.00	0.00	0.00	1.00

Source: National Bank of Romania, own calculations

So we have just 1/15 possibility to have a crises predicted by the series of current account deficits (0.06) for 2014, which is not relevant enough for predicting a crises.

d) Real exchange rate signals:

We have an average value (xm) of 83.35 (Real Exchange Rate, BIS data, 2005=100_between 2000-2004 and a standard deviation of 3.717 (for 2000-2004), resulted from our calculations. For each year the difference between yearly indicator (x) and the average value for the indicator (2005-2007) (xm) is higher than the standard deviation (2000-2004) we have a signal (and this signal is multiplied by the repetitive factor).

For 2007, we take into consideration, for the average, the value of real exchange rate, end of period (108.83), but since we have monthly data for the real exchange rate we look at the July 2007 rate (when the RON started to depreciate against the Eur). In July 2007, the RER (Real Exchange Rate) was 119.58, while in December, the rate was 108.83

For 2000-2004, from our calculations, we have:

- * The average (Xm) = 83.35
- * The variance: 13.82
- * The standard deviation: 3.717.

So, for 2005-2008 we have the following data:

Table 8: Real Exchange Rate (2005-2008) (Ron/Eur)

Real Exchange Rate	2005	2006	July 2007	2008
X	97.9	109.56	119.58	103.41
Xm	105.43	105.43	105.43	105.43

X-Xm	-7.53	4.13	14.15	-2.02
Standard deviation (2000-2004)	3.72	3.72	3.72	3.72
(x-xm)/standard deviation	-2.03	1.11	3.81	-0.54
Signals	1.00	1.00	1.00	0.00
Noise to signal	1.00	2.00	3.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

Following the results, we see that that in each year (2005, 2006, 2007) before the crisis, the deviation from the average value of the real exchange rate was much higher than the standard deviation observed in 2000-2004 (3.72). The critical shock sign was in July 2007, when the deviation was almost 4 times higher than the standard deviation. So we have 3 consecutive signals which conduct to an IS of 6 of maximum 6 points, showing a full probability for a crisis.

So, the evolution of the real exchange rate is one of the best indicator as an early warning for the crisis, and we identify as critical shock a deviation 3 times higher than the standard deviation in tranquil times.

To verify this indicator we will watch the signals between 2009-2013:

Table 9: Real Exchange Rate (2009-2013) (Ron/Eur)

Real Exchange Rate	2009	2010	2011	2012	2013
X	100.1	99.45	100.13	97.32	100.82
Xm	99.56	99.56	99.56	99.56	99.56
X-Xm	0.54	-0.11	0.57	-2.24	1.26
Standard deviation (2000-2004)	3.72	3.72	3.72	3.72	3.72
(x-xm)/standard deviation	0.15	-0.03	0.15	-0.60	0.34
Signals	0.00	0.00	0.00	0.00	0.00
Noise to signal	0.00	0.00	0.00	0.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

As we see, there was not any signal between 2009-2013 (the deviation from the mean was each year under the standard deviation in tranquil times. So the IS between 2009-2013 is zero, showing zero probability for a crisis to occur in the future, on the exchange rate channel.

e) Real interest rate signal differential

We define the value of the real interest rate differential between -Real interest rate adjusted with the GDP deflator - data from World Bank (Romania) and the short term interest rate for the Eurozone (OECD data).

We have an average interest rate differential (xm) of 3.282 (2000-2004) and a standard deviation of 4.53 (for 2000-2004), resulted from our calculations. For each year the difference between yearly indicator (x) and the average value for the indicator (2005-2007) (xm) is higher than the standard deviation (2000-2004) we have a signal (and this signal is multiplied by the repetitive factor).

For 2000-2004, from our calculations, we have:

- * The average (X_m) = 2.275
- * The variance: 9.54
- * The standard deviation: 3.09

So, for 2005-2008, we have the following data and we calculate the average value for 2005-2007 (as we want to see if the model predicts the crisis of 2008)

Table 10: Real Interest Rate Differential (RIRD): 2005-2008

Real Interest Rate Differential (RIRD)	2005	2006	2007	2008
X	4.62	0.82	-4.48	-4.43
X_m	3.5	3.5	3.5	3.5
X- X_m	1.12	-2.68	-7.98	-7.93
Standard deviation (2000-2004)	3.09	3.09	3.09	3.09
(x- x_m)/standard deviation	0.36	-0.87	-2.58	-2.57
Delta (2004: RIRD= 7.29)	-2.67	-3.80	-5.30	0.05
Signals	0.00	1.00	1.00	1.00
Noise to signal	0.00	1.00	2.00	0.00
Real interest rate (Interest rate adj by GDP Deflator) -ROM	6.8	3.9	-0.2	0.2
Euro Zone short term interest rate	2.18	3.08	4.28	4.63
Interest rate differential	4.62	0.82	-4.48	-4.43

Source: World Bank Database, National Bank of Romania, own calculations

We identify as signals when the Delta (which is RIRD current year - RIRD previous year) is higher in absolute terms than standard deviation in tranquil times, and we identify as critical shock sign for the real interest rate perspective when the RIRD turns negative (2007).

In this case Delta is important since the capital investors always look at the past for comparing the yields.

According to this we have 2 consecutive signals in 2006 and 2007 which leads towards a noise to signal of 3. So, the IS is $3/6 = 0.5$, showing a high probability for a crisis (when the RIRD turns negative, the capital flows reverses from inflows to outflows).

As we defined an IS higher or equal to 0.5, we conclude that we have a valid early warning indicator in the real interest rate differential, with a critical shock sign when the deviation from the mean is higher than 2 standard deviations (in tranquil times) and the RIRD turns negative.

For verifying the model in a post-crisis period (2009-2013), we have:

Table 11: Real Interest Rate Differential (RIRD) 2009-2013

Real Interest Rate Differential (RIRD)	2009	2010	2011	2012	2013
X	11.07	7.29	6.51	5.33	6.28
X_m	7.3	7.3	7.3	7.3	7.3
X- X_m	3.77	-0.01	-0.79	-1.97	-1.02
Standard deviation (2000-2004)	3.09	3.09	3.09	3.09	3.09
(x- x_m)/standard deviation	1.22	-0.00	-0.26	-0.64	-0.33
Delta (2008: RIRD= -4.43)	15.50	-3.78	-0.78	-1.18	0.95
Signals	1.00	1.00	0.00	0.00	0.00
Noise to signal	1.00	2.00	0.00	0.00	0.00

Real interest rate (IR adj by GDP Deflator) -ROM	12.3	8.1	7.9	5.9	6.5
Euro Zone short term interest rate	1.23	0.81	1.39	0.57	0.22
Interest rate differential	11.07	7.29	6.51	5.33	6.28

Source: World Bank Database, National Bank of Romania, own calculations

We have 2 consecutive signals in 2009 and 2010 in terms of Delta and zero signals in 2011. 2012. 2013, which leads to a noise to signal of 3 and an IS of 3/15 (0.2). That shows a probability less than 0.5 for a crisis to occur, so we reject the null hypothesis that we'll have a crisis after 2013 signaled by the RIRD, and we accept the alternative hypothesis that no crisis will occur.

About the signal in 2012 (when the real interest rate was 12.03 and the real interest rate differential was 11.07) shows a sign of distress (in fact the liquidity crunch). Since this was given by the miss-match in terms of financing and the global liquidity crunch, this cannot be identified as a signal for a crisis but as a signal that the crisis was already developing.

f) "Excess M1 balances" signal

We use M1 (data from World Bank Database - <http://data.worldbank.org/indicator/FM.LBL.MONY.CN?page=2>) and the consumer price index for deflating the M1 to CPI and we calculate the time trend for M1/CPI (dynamics) from 2001 to 2004.

We also use the Real GDP (nominal terms - line 790 World Bank Database) and deflate it by CPI. We also determine a time trend for Real GDP/CPI.

For determining the M1 excess we do the ratio (M1/CPI)- (GDP/CPI). We calculate the average value, the variance and the standard deviation for 2002-2004, and we have the following results:

We exclude the data for 2001 from this calculation since the M1/IPC (2001/2000) is out of the normal range of the distribution (158.56), as the M1 in 2001 was distorted by the issuance of 4 new banknotes (500.000 lei - October 23rd 2000, 10.000 lei - September 18th 2000 and 50.000 lei and 100.000 lei in the fall of 2001). So we calculate restrict the range of each indicator for 2002-2004 corresponding to the evolution in tranquil times and extend the period to 2005, to for annual indicators

According to our calculations, we have the following data for 2002-2005, and we calculate the indicators for 2005-2007 in order to see that if the excess M1 balance predicts a crisis for 2008.

* $x_m = 9.52$

* variance: 443.58

* standard deviation: 21.06

Table 12: Excess M1 balances, 2005-2008

Excess M1 balances	2005	2006	2007	2008
X	16.35	16.75	40.65	-6.42
X_m	24.58	24.58	24.58	24.58
$X - X_m$	-8.23	-7.83	16.07	-31.00
Standard deviation (2002-2005)	21.06	21.06	21.06	21.06
Delta (x current year - x previous year), 2004 = 22.15	-5.80	0.40	23.90	-47.07

Delta/standard deviation	-0.28	0.02	1.13	-2.24
Signals	0.00	1.00	1.00	0.00
Noise to signal	0.00	1.00	2.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

In order to validate a signal, we will consider a valid signal if the Delta (x current year - x previous year is positive, in other words the excess is growing on a yearly basis), and this critical shock sign amplifies if the Delta is higher than one standard deviation (for tranquil times).

So, we have the Delta higher than the standard deviation in 2007 (signaling a loose monetary policy). The noise to signal for 2005-2007 is 3, that means that the $IS = 3/6 = 0.5$, signaling a crisis.

If we calculate according to Kaminsky (when a critical shock sign is showed when the excess M1 balance is positive), we see three consecutive shock (2005, 2006, 2007) that were signaling a crisis when the excess of the „excess M1 balances” (yearly evolution) pass through the standard deviation for the tranquil times (the sustainable growth evolution), which is alternate way in which the excess M1 balance signals a crisis.

In order to verify the conclusions for 2009-2013, we assume the following null hypothesis:

H0: there will be a crisis in Romania after 2012 (based on data 2009-2012) signaled by the excess M1 balance

Table 13: Excess M1 balances (2009-2012)

Excess M1 balances	2009	2010	2011	2012
X	-11.84	-1.65	-1.16	-1.79
Xm	-4.11	-4.11	-4.11	-4.11
X-Xm	-7.73	2.46	2.95	2.32
Standard deviation (2002-2005)	21.06	21.06	21.06	21.06
Delta (x current year - x previous year), 2008 = -6.42	-5.42	10.19	0.49	-0.63
Delta/standard deviation	-0.26	0.48	0.02	-0.03
Signals	0.00	0.00	0.00	0.00
Noise to signal	0.00	0.00	0.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

According to Kaminsky, we see a critical shock sign if the X value turns positive, but each year the X is negative, so we reject the null hypothesis (that will be a crisis) and we go to the conclusions that there is no excess of M1 balance, so there won't be any crisis signaled by this.

According to our Delta calculations, in all years the absolute value of Delta/Standard Deviation in sustainable times is less than one standard deviation, so we also reject the null hypothesis. So, we do not have any crisis signaled by the M1 excess balance.

g) Short term debt signal

We have an average value (xm) of 9.62% of GDP between 2000-2004 and a standard deviation of 2.94 (for 2000-2004), resulted from our calculations. For each year the difference between yearly indicator (x) and the average value for the indicator (2005-2007) (xm) is

higher than the standard deviation (2000-2004) we have a signal (and this signal is multiplied by the repetitive factor).

For 2000-2004 we have:

* $x_m = 9.62$

* variance: 8.64

* standard deviation: 2.94

For the short term debt (2005-2007), we have the following situation, in order to see the effect on predicting the crisis of 2008.

Table 14: Short term debt (% of GDP), 2005-2008

Short term debt (% GDP)	2005	2006	2007	2008
X	19.06	30.69	34.75	27.95
X_m (2005-2007), 2008 (2005-2008)	28.17	28.17	28.17	28.11
X- X_m	-9.11	2.52	6.58	-0.16
%change (2004=14.75% of GDP)	29.24	60.99	13.24	-19.58
Standard deviation (2000-2004)	2.94	2.94	2.94	2.94
Delta ($x_{current} - x_{previous}$) ; $x_{2004}=14.75$	4.31	11.63	4.06	-6.80
Delta/standard deviation	1.47	3.95	1.38	-2.31
Signals (1 if Delta > Standard deviation (2.94))	1.00	1.00	1.00	0.00
Noise to signal	1.00	2.00	3.00	

Source: World Bank Database, National Bank of Romania, own calculations

According to Kaminsky, an increase in the short term debt (positive evolution) shows a critical shock sign as a problem for the capital account. We have positive evolution in 2005, 2006, 2007 which leads to 3 signals or a noise to signal of 6. That leads as to an IS of $6/6 = 1$, showing a full probability for a crisis (that might turn into a banking crisis).

As an alternate, in our model, we follow delta (the difference between Short term debt in the current year - Short term debt in the previous year, as GDP percentage). We find that we have 3 consecutive positive signals, that conduct to an IS = 1, showing a full probability of the crisis (and the future seeds of a banking crisis). As a critical shock sign we define if Delta is higher than 2 standard deviations (in tranquil sustainable times). For 2007 we see a delta which is more than 3 standard deviations higher, showing a critical trigger for the short term debt crisis that manifested in 2008.

To verify this scenario after the crisis (2009-2012) we have the null hypothesis

H_0 = There was a crisis in 2009-2013 triggered by the short term debt

We find the following results:

Table 15: Short term debt (% GDP) 2009-2012

Short term debt (% GDP)	2009	2010	2011	2012
X	18.70	21.01	22.92	20.48
X_m (2009-2012)	20.78	20.78	20.78	20.78

X-Xm	-2.08	0.23	2.14	-0.30
%change (2008=27.95% of GDP)	-33.09	12.32	9.10	-10.65
Standard deviation (2000-2004)	2.94	2.94	2.94	2.94
Delta (xcurrent - xprevious) ; x2008=27.95	-9.25	2.30	1.91	-2.44
Delta/standard deviation	-3.15	0.78	0.65	-0.83
Signals (1 if Delta > Standard deviation (2.94))	1.00	0.00	0.00	0.00
Noise to signal	1.00	0.00	0.00	0.00

Source: World Bank Database, National Bank of Romania, own calculations

According to Kaminsky, we have 2 positive evolutions in 2010 and 2011, which leads us to 2 consecutive signals (for 4 possible years) or a noise to signal of 3. So, the IS is 3/10, or 0.3, which is lower than 0.5 that we defined as a highly probable crisis scenario. So we reject the null hypothesis (that we are going to have a short term debt crisis) and we accept the alternate scenario - no short term debt crisis is seen for 2013 and beyond (which is supported by the reality - the deleveraging process having as an effect the reduction of the short term debt).

According to our model, we find out that the Delta in absolute value was higher than a standard deviation just in 2009. That leads to a noise to signal of 1, so we have an IS of $1/10=0.1$ which is much lower than the level of 0.5 accepted as a signal for a future crisis. Also, the negative value of the delta shows as that the adjustment started to produce, actually the crisis was in full development. So, we reject the null hypothesis and with a $IS = 0.1 < 0.5$, we accept the alternate hypothesis - there is no crisis signaled by the short term debt evolution.

4. A Composite Early Warning Indicator (C-EWI).

As each economic/macroeconomic indicator studied in this paper by itself may have provided clues that a financial problem was developing in Romania, we will try to define a composite leading indicator will show that the Romanian crisis was signaled by multiple indicators in the same time.

Table 16: Indicators of shocks, critical cut-offs and symptoms for financial crisis

e. Symptoms	f. Indicator	g. Critical Shock Sign	h. Comments
Over borrowing Cycles	M2 Multiplier	Positive, $IS \geq 0.5$	Both banking and currency crises have been linked to rapid growth in credit fueled by liberalization of the domestic financial system and by the elimination of capital account restrictions

e. Symptoms	f. Indicator	g. Critical Shock Sign	h. Comments
Monetary Policy	‘Excess M1 Balances’	Positive, $IS \geq 0.5$	Loose monetary policy can fuel a currency crisis. The the extent that the devaluation worsens the health of the banking sector it can also trigger a banking crisis (by an increase in NPL)
Problems Current Account	Current account deficit	Positive, $IS \geq 0.5$	Real exchange rate overvaluations and a weak external sector are part of a currency crisis. They add to the vulnerability of the banking sector since a loss in competitiveness and external markets could lead to a recession, business failure and a decline in the quality of loans. Thus large negative shocks to exports and the real exchange rate and positive shocks to imports (both covered by the current account deficit) are interpreted as symptoms of the financial crisis
	Real Exchange rate	Negative, $IS \geq 0.5$	
Problems Capital Account	Real Interest Rate Differential	Positive, $IS \geq 0.5$	High world interest rates may anticipate currency crisis as the lead to capital out-flows. Capital account problems become more severe when the country’s foreign debt on short term increases since it may rise issues of sustainability . Kaminsky and Reinhart (1996) argue that a currency crisis may in turn deepen the banking crisis
	Short term Foreign Debt	Positive, $IS \geq 0.5$	

e. Symptoms	f. Indicator	g. Critical Shock Sign	h. Comments
Growth slowdown	Lending/Deposit Ratio	Positive, IS \geq 0.5	Recessions and the burst of asset price bubbles precede financial crisis (Calomiris and Gorton 1991). High real interest rates could be a sign of a liquidity crunch leading to a slowdown and banking fragility. An increase in the lending/deposit ratio in the domestic economy can capture a decline in loan quality

The composite indicator is the average of the IS for the 7 indicators identified by us as signaling the Romanian crises. So, we have:

Table 17: Early Warning Indicators for Romania that compound the composite index C-EWI

i. N o.	j. Indicator	k. IS (2005-2008)	l. IS (2009-2013)
1	Loans to deposit ratio	1	0.16
2	M2/M1 % change (annual)	1	0
3	Current account deficit	1	0.06
4	Real exchange rate	1	0
5	Real interest rate Differential	0.5	0.2
6	Excess M1 balances	0.5	0
7	Short term debt	1	0.1

According to our calculation, we have a C-EWI value of 0.86. As our model estimates a value higher or equal of 0.5 for signaling a crises, the value of the C-EWI (0.86) shows a high probability for a crises.

After the crisis (2009-2013), the value of C-EWI is 0,074, significant less than the reference value of 0.5. The, the C-EWI for post-crisis is signaling a very low probability for a crises.

5. Conclusions on early warning indicators

a) The analysis shows that the financial crisis in Romania was developed by a set of multiple economic problems, confirming the fact that crisis do not occur by a single bad shock;

b) As each macroeconomic indicator studied in this paper by itself may have provided clues that a financial problem was developing in Romania, the composite leading indicator shows that the Romanian crisis was signaled by multiple indicators in the same time, and the signal was very strong.

c) In the contrast to the view that the Romanian crisis could not have been anticipated, the results show that the Romanian economy was far from healthy, with clear signs of distress surfacing as early as 2005 (more than 36 months) before the crisis unfolded and strong signals 12 months before the crises developed.

d) The best individual indicators for signaling the crisis were loans to deposit ratio, M2/M1 % change, current account deficit, real exchange rate, short term debt, and we also find useful the signals sent by real interest rate differential and excess M1 balances.

e) Much of this indicators could have been adjusted before the crises unfolded, by a coherent policy mix (monetary policy and fiscal policy). By itself, the monetary policy strengthens (counter-cyclical) was not enough to compensate the lax fiscal policy (pro-cyclical).

6. References

- [1] Diaz Alejandro, C.F. (1985) - „Good-bye Financial Repression, Hello Financial Crash”, *Journal of Development Economics* 19, p. 1 - 24
- [2] Kaminski, C. Reinhart, Lizondo, Diebold (1999) - “Currency and Banking Crisis - The Early Warning of Distress”, Washington DC, Working Paper 178, p.9
- [3] Kaminski, G. (1998) - “Currency and banking crisis. The early warning of distress”, *International Finance Discussion Paper*, 629, Board of Governors of the Federal Reserve System, Number 629, October 1998), p. 2-41
- [4] Krugman, P. (1979) "A model of balance of payments crises", *Journal of Money, Credit, and Banking* 11: 311-325
- [5] Krugman, P. (1997) „Currency crisis”, prepared for NBER Conference, 1997, p. 1-10.
- [6] Krugman, P. (1996) "Are currency crises self-fulfilling?", *NBER Macroeconomics Annual*
- [7] Obstfeld, M. (1984) "The logic of currency crises", *Cahiers Economiques et Monetaires* 43:189-213.
- [8] Velasco, A. (1987) - “Financial crisis and balance of payments crisis: a simple model of the southern cone experience”, *Journal of Development Economics*, Volume 27, Issues 1-2, October 1987, p. 263-283