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THE CREDIT GROWTH AND ECONOMIC ACTIVITY IN BOSNIA AND HERZEGOVINA

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Abstract: *We have analyzed the impact of credit growth on economic activity in period before, during, and after credit crunch in Bosnia and Herzegovina i.e. from Q12007 to Q42012. In this period, credit growth on average proved itself as a good signal of economic contraction and economic slowdown. This is the first time that interdependence between credits and GDP in Bosnia and Herzegovina was established trough the receiver operating characteristic methodology and trough receiver-operating characteristic. The main research finding shows that level of credit growth is a good signal of substantial decrease of economic activity in case when credit growth was previously very high. The regulators and banking supervision should not allow excessive growth, because during and after credit crunch contraction of economic activity can happen even when credit growth rate is relatively high. This research is one of the first steps in creating early warning system for Bosnian economy by using banking sector data and national accounts data.*

Key words: *early warning indicators; receiver-operating characteristics; noise to signal ratio; credit growt; macroeconomic imbalances.*

JEL classification: *G01, E51, C25.*

INTRODUCTION

The Bosnia and Hercegovina's financial system is bank based which means that majority of external financing is provided by commercial banks. In period 2007-2012 BH governments were not so active on domestic financial market, so the main driver of economic activity was internal demand driven by commercial banks credits. In this period, BH went through the boom and bust credit cycle, and credit crunch happened in 2009. According to all these facts, credit growth should be a good signal for crisis event (slowdown in GDP) i.e. good Early Warning Indicator/EWI, and this is the main research hypothesis.

This research connects credit growth and GDP growth by applying signal approach i.e. receiver operating characteristic methodology. We want to answer the the

question if there is some level of credit which could trigger economic growth slowdown, with high probability and high certainty. Therefore, the research's subject is the connection between credit growth and crisis event, and the main goal is finding threshold for credit growth, which signalizes crisis event with high certainty.

The research is organized in five parts. In the first part, main facts about credit and growth are presented, and in the second, we give short review of the main literature in this field. These sections are followed by methodology, results and discussion, conclusion and list of used references.

LITERATURE REVIEW

Due to heterogeneity between even similar group of countries and poor performance of in such a way calculated signals/indicators for crisis event our research is in line with proposal (Knedlik,2015) that creating the country-specific thresholds for signals is the best way to capture crisis event. The credit growth as signal for crisis has broad and different interpretation and use, and it is connected with economic crisis, recession, economic slowdown, currency crisis, and macroeconomic imbalances. The most useful leading indicators of crisis (Babecky, et al., 2012) besides domestic housing prices, share prices and global prices is credit growth. In Macroeconomic Imbalance Procedure (European Commission, 2012) change in credit compared to the GDP is marked as one of leading indicators of macroeconomic imbalances in the financial sector. Together with external imbalances, high **indebtedness** and strong real GDP growth lending and housing boom is connected with financial crisis (Bunda & Zorzi, Signals from housing and lending booms, 2009). The same finding, interconnection between credits and external deficit in causing the crisis was found in another paper (Davis, Phoa, Mack, & Vandenabeele, 2014). In the long horizon the credit-to-GDP gap is the the best indicator of banking crisis, and in the long run debt service ratio has the same characteristic in the short run (Drehman, 2013). The banking crisis coincides or precedes very often to the currency crisis and economic crisis. The total credit rather than bank credit alone predicts with more preciseness the risk of systemic crisis (Drehman, 2013). The research in money and credit growth after economic and financial crisis (ECB, 2012) showed that M1 growth typically leads change in business cycle; change in broad money is in line with cycle, while credit growth recovers very slowly comparing economic activity. Very detailed and comprehensive research (Frankel & Saravelos, 2012), stressed the fact that usefulness of indicator in predicting crisis varies over time. It found that most robust indicators of crisis are international reserves and real exchange rate overvaluation, and some indicators, credit growth is among them, are also associated with crisis event. By applying signal approach (Kaminsky, Lizondo, & Reinhart, 1998) is found that domestic credit issue first signal 12 months before crisis occurs and that persistence of signal is in the middle of the range. The group of Hungarian authors (Lang, Cosimo, Fahr, & Ruzicka) developed broad based cyclical systemic risk indicator (d-SRI) which contains risks deriving from domestic credit, real estate markets, asset price and external balance. d- SRI predicts significant decrease in GDP three or four years ahead of crisis. After the crisis decline in bank credits to private sector must not be accompanied with slow recovery, after output touch the bottom as aftermath of financial crisis (Takatas & Upper, 2013). Another research applied to CEE-10 stressed the findings that the best signaling system presents

combination of different variables, and among them is credit-to-GDP gap ((Csortos & Szalai, 2014). Regarding connection between foreign and Bosnian economy one research (Jović, Dragan, 2017) found that interest rate channel (Fed Fund Rate) has very strong and significant effect on Bosnian real sector, especially on industrial production. Another research (Jović, Dragan, 2019) concluded that without Vienna Initiative (international rescue plan for CSEE during GFC) fall in industrial production in Bosnia and Herzegovina would be even bigger. These two researches, due to its topics, are some kind of introduction in this research.

METHODOLOGY

According to one proposal (Babecky, et al., 2012) early warning indictors can be separated in three categories: the late EWI (signal is issued 1-3 quarters ahead), early (4-8 quarterly ahead) and ultra-early (9 and more quarters ahead). Because of very fact that data on loans in BH are issued at least two months ahead of GDP credit growth rate can be treated as EWI, i.e. very late EWI. Even without the time lags comparing to the crisis event (slowdown in GDP), credit growth rate is well suited to act as EWI, and we applied this approach in the research.

The heart of applied methodology is confusion matrix in relation to receiving operating characteristics i.e. to signal approach in discovering the economic downturn. In confusion matrix (Table 1), there are two possible states of economy, crisis (1), and no crisis (0), and on the other hand, signal can say there is a crisis (1) there is not crisis event (0). In two times two confusion matrix there are four main elements (see shadow area in table below), and there explanation is following. If there is a crisis which is confirmed by signal that is true positive (1, 1), and if there is no crisis despite signal that is false positive (0, 1). In situations without signal we also have two possible outcome, false negative (1,0) if there is a crisis, and signal is missing, and true negative (0, 0) if there is no crisis, a and there is no signal also.

Table 1. Confusion matrix

		Crisis	No crisis
		1	0
Signal	1	True positive/TP (1,1)	False positive/FP (0,1)
No signal	0	False negative/FN (1,0)	True negative/TN (0,0)

Source: Author

With this signal's statistics it is possible to calculate different receiver operating characteristics quality indicators and measures, and for the purpose of research we have chosen eight of them (Table 2). Theirs interpretation is very intuitive, and logical conclusion about quality of signals that they are better if we have more true than positive rates. For example, possibility of positive outcome is measured by PPV or precision, and it says what probability of predicting crisis is if signal/alarm is sent. ACC measures true signals (no matter if there are positive or negative) by comparing them to the all-possible outcomes. Intuitively it is obvious that the lower is Noise to signal rate (NtR) quality of signal is better, and we can dismiss signal if its value is

equal or more than one, or if it is only slightly below 1. TPR, FPR,FNR, TNR are getting directly by combining two compatible elements of confusion matrix. TPR is hit rate because it measures how much signal is success in hitting crisis, and its compatible value is FNR or miss rate.

Table 2. ROC indicators and measures

	Indicator's name	Alternative name	Calculation
1	True positive rate (TPR)	Sensitivity, Recall, hit rate	TPR = TP/(TP+FN)
2	False positive rate (FPR)	Fall-out, False alarm Type I error	FPR=FP/(FP+TN)
3	False negative rate (FNR)	Miss rate Type II error	FNR=FN/(TP+FN)
4	True negative rate (TNR)	Specificity, Selectivity	TNR = TN/(FP+TN)
5	Positive predictive value (PPV)	Precision	PPV= TP/(TP+FP)
6	Accuracy (ACC)	-	ACC = (TP+TN)/(TP+FP+FN+TN)
7	Noise to signal rate (NtR)	-	NtR = FPR/TPR
8	Area under curve (AUC)	Area under curve receiver operating characteristics (AUCROC)	The integral under ROC curve

Source: Author

The ROC is also creating by comparing TPR and FPR i.e. by plotting sensitivity against false alarm, for different signal's thresholds. In machine learning TPR and FPR are denoted as probability of detection and probability of false alarm respectively. By creating the ROC curve, we get area under curve or AUC or AUCROC, which discriminates between good and bad signals. ROC is plotted in (0, 0) and (1, 1) coordinate space, so its total value is 1. If ROC is linear, and AUC is 0.5 signal is not capable to discriminate between to states, or in our case, crisis or no crisis, and if AUC is below 0.5 we can dismiss signal completely. The more AUC is above 0.5 and closer to maximum value i.e. 1 the model and signal is better.

In order to set threshold for signal i.e. nominal annual credit growth sample is divided in ten quantiles i.e. in deciles (Table 3). The threshold for credit growth is set on first, second, third and fourth deciles i.e. on -2,03%, 0,47%, 4,86% and 5,13% respectively. The last two deciles are high, but comparing to the whole credit growth distribution these values are relatively small. In order to calculate TRP and FPR and to plot ROC curve quantiles of credit growth are connected with ratings in the way that lowest value get higher rating and so on. In the research we define crisis/crisis event in two ways, as real GDP growth rate below 1%, or as GDP growth rate below 0% i.e. negative growth rate. The distribution of credit growth rates with ten deciles uses two crisis event in order to estimate ROC curve, area under curve, and signal's performance. Real GDP growth below 1% represents slowdown in economic activity while drop in GDP below 0% is proxy for recession.

Table 3. Quantiles and associated ratings in nominal credit growth rate in banking sector of Bosnia and Herzegovina (Q1 2007 – Q2 2012)

Percentiles	Growth rates %	Rating	Interval
1	-2,03	10	to -2,03
2	0,47	9	from -2,02 to 0,47
3	4,86	8	from 0,48 to 4,86
4	5,13	7	from 4,87 to 5,13
5	5,50	6	from 5,14 to 5,50
6	6,66	5	from 5,51 to 6,66
7	22,97	4	from 6,67 to 22,97
8	29,55	3	from 22,98 to 29,55
9	31,28	2	from 29,56 to 31,28
10	31,83	1	from 31,29 to 31,83

Source: Author

EMPIRICAL DATA AND STYLIZED FACTS ABOUT CREDIT GROWTH AND ECONOMIC GROWTH IN BOSNIA AND HERZEGOVINA

For research we have chosen period Q1 2007 – Q4 2012 because of couple of reasons. In middle of this period, (2009) credit crunch is happened and that period is rich with crisis event, i.e. with big drop in GDP growth real rate. During this time horizon BH governments where not engaged on financial market at all, or were not engaged heavily, which left economy strongly dependent on banking loans. Also in this time, the old statistical methodology (NACE1) for measurement of GDP was in use.

From the beginning of 2007 until the end of 2012 credit growth was very volatile as well as real GDP growth rate. This very volatile period was part of business and financial cycle started in 2003 after bank privatization happened, and it was fueled by inflow of foreign capital and increase in domestic saving. From 2003 credit growth rate was double digit in almost all years till 2008, and due to sudden stop of foreign loans and deposits credit crunch happened. After that credit growth rate is or negative or slightly above zero. Credit growth rate started with 27,45% (Q1/2007) and ended with 4,3% (Q4/2008), on average was 12.96% and minimum was -3,19% (Table 4). Measure with coefficient of variation variability was very high and the same can be seen by comparing the highest and the lowest value.

Table 4. Credit growth rate (q/q-4) in BH, descriptive statistics, Q12007 – Q22012

Obs.	Mean	Standard deviation	Coefficient of variation	Minimum	Maximum
24	12,10	12,96	1,07	-3,19	31,83

Source: CBBH (Adapted by author).

This period of BH's transition was characterized by very high fluctuation in real GDP growth rate also, with even higher volatility comparing to the loans (Table 5).

Real GDP growth rate was on average 1,54%, ranging from -3,35% to 12,72%, with standard deviation 2,57 larger then mean.

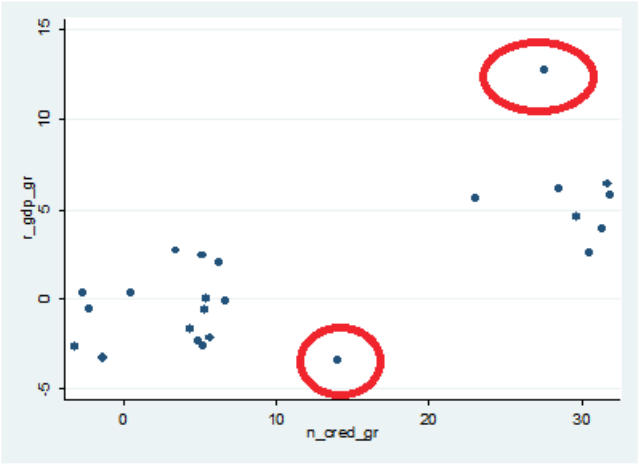
Table 5. Real GDP growth rate (q/q-4) in BH, descriptive statistics, Q12007 – Q22012

	Obs.	Mean	Standard deviation	Coefficient of variation	Minimum	Maximum
Real GDP growth rate	24	1.54	3.96	2.57	-3.35	12.72

Source: BHAS (Adapted by author).

There is a very high positive correlation between these two variables even we do not exclude two obvious outliers marked with circles (see graph 1). The variables move in the same, positive, direction.

Graph 1. Real GDP growth rate vs credit growth rate, 2007-2012.



Source: Author

Simple linear regression shows high and positive influence of credit growth on GDP growth, and it does not matter if constant is or is not included (Table 6 and Table 7). Almost all parameters in both equations are highly significant, but it seems that model without constant works better. On average 1 percentage point change in credit growth will increase GDP for around 0.2 percentage points. The high significance of regressors together with big enough R-squared shows that credit growth could be a good signal for changes in economic growth.

Table 6. GDP vs. credit, with constant

r_gdp_gr	Coefficient	Std. Err.	t	P> |t|	[95% Conf. Interval]	R-squared
n_cred_gr	0.23	0.042	5.39	0.00	0.14 - 0.32	0,57
constanta	-1.24	0.75	-1.66	0.11	-1.24 - 0.75	

Source: Author

Table 7. GDP vs. credit, without constant

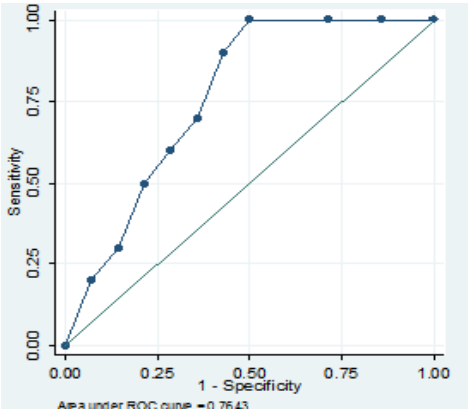
r_gdp_gr	Coefficient	Std. Err	t	P > |t|	[95% Conf. Interval]	R-squared
n_cred_gr	0.18	0.0321	5.65	0.000	0.115 - 0.247	0,58

Source: Author

RESULTS AND DISCUSSION

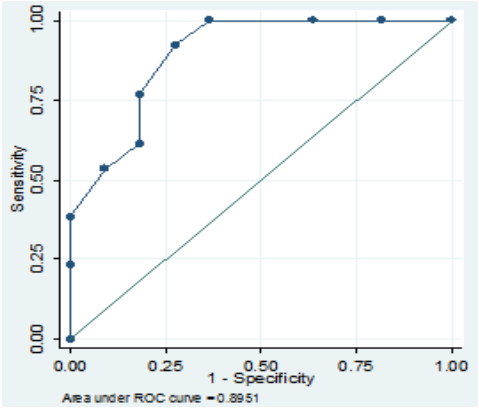
Both estimated ROC curves have high values, and they are far away from middle line, which indicates that signal has discriminatory power. AUC is above 0.5 ranging between 0,76 and 0,89.

Graph 2. ROC_1
GDP growth rate < 0% (crisis event)



Source: Author

Graph 3. ROC_2
GDP growth rate < 1% (crisis event)



Source: Author

The main message of eight confusion matrix (Table 8 and Table 9) is that theirs false positive elements in almost all cases are very small, so in this term signal has the high level of preciseness. The second message/characteristics of confusion matrix is that in many cases signal misses the crisis (false negative). It does not show that there is a crisis even there is a crisis. The overall performance of confusion matrix, captured by increase in true positive and decrease in false negative increase with rise in credit growth threshold.

Table 8. Elements of confusion matrix, crisis event GDP growth rate < 0%

	ROC_1		ROC_2		ROC_3		ROC_4	
Treshold	**=< -2,03**		**=<0,47**		**=<4.86**		**=<5,13**	
	Crisis	**No crisis**	**Crisis**	**No crisis**	**Crisis**	**No crisis**	**Crisis**	**No crisis**
Signal	2	1	3	2	5	3	6	4
No signal	8	13	7	12	5	11	4	10

Source: Author

Table 9. Elements of confusion matrix, crisis event GDP growth rate < 1 %

	ROC_5		ROC_6		ROC_7		ROC_8	
Treshold	**=< -2,03**		**=<0,47**		**=<4.86**		**=<5,13**	
	Crisis	**No crisis**	**Crisis**	**No crisis**	**Crisis**	**No crisis**	**Crisis**	**No crisis**
Signal	3	0	5	0	7	1	8	2
No signal	10	11	8	11	6	10	5	9

Source: Author

ROC curves are better if we measure them by slowdown in economic activity (GDP < 1%), then if we want to capture drop in GDP below 0%. ROC_5, ROC_6, ROC_7 and ROC_8 perform relatively better comparing to ROC_1, ROC_2, ROC_3 and ROC_4. If we compare the second group of models (crisis event is GDP g.r < 1 %) with first one (crisis event is GDP g.r < 0 %) we can see easily that the second group of models outperforms the first group of model (Table 10 and Table 11) in all indicators; TPR, TNR, PPV, ACC are higher, and FNR, FPR and NtR are lower.

According to AUCROC, all models very good discriminate between crisis event and no crisis event. In all cases AUCROC is far above 0,5.

In all eight models, Noise to Signal ratio (NtS) is substantially below one, i.e. noise is very low comparing to correct signal (FP/TP). In two models, NtS is even zero (ROC_5 and ROC_6) because false positive cases are missing. Models with GDP lower then 0 as crisis event significantly higher NtS comparing to other group of models.

Accuracy of models, share of true positive and true negative in all events ((TP+TN)/N), is between 58% and 71%, and that is satisfactory result.

Possibility that crisis event will be predicted (positive predictive value/PPV or in short Precision) which means when signal is issued crisis event happen (TP/(TP+FP)) vary between 20% and 62%, and these results vary significantly. False positive rate is very low with maximum value of below 30%. Main objection to signal quality is value of FNR (false negative rate) which is in some cases very high. It means that there is a crisis, and signal does not ring, or in other words, crisis is missed. In terms of FNR models with higher threshold (in terms of credit growth) perform relatively better (comparing to the models with lower threshold), and the same is true for models which take slowdown in GDP as crisis event. Regarding FNR the best model is ROC_8 and this model has on average the best performance highest TPR and ACC, and lowest FNR, with all other indicators on satisfied level.

Table 10. ROC indicators and measures, crisis event GDP growth rate < 0 %

		ROC_1	ROC_2	ROC_3	ROC_4
	Indicator's name	**credit g.r. threshold =< -2,03%**	**credit g.r. threshold =< 0,47%**	**credit g.r. threshold =< 4,86%**	**credit g.r. threshold =< 5,13%**
1	True positive rate (TPR)	20	30	50	60
2	False negative rate (FNR)	80	70	50	40
3	False positive rate (FPR)	7,14	14,28	21,42	28,57
4	True negative rate (TNR)	92,85	85,71	78,57	71,4
5	Positive predictive value (PPV)	66,67	60	62,5	60
6	Accuracy (ACC)	62,5	62,5	66,7	66,6
7	Noise to signal rate (NtS)	0,357	0,476	0,4285	0,476

Source: Author

Table 11. ROC indicators and measures, crisis event GDP growth rate < 1 %

		ROC_5	ROC_6	ROC_7	ROC_8
	Indicator's name	**credit g.r. threshold =< -2,03%**	**credit g.r. threshold =< 0,47%**	**credit g.r. threshold =< 4,86%**	**credit g.r. threshold =< 5,13%**
1	True positive rate (TPR)	23,07	38,46	53,84	61,53
2	False negative rate (FNR)	76,92	61,53	46,15	38,46
3	False positive rate (FPR)	0	0	9,1	18,18
4	True negative rate (TNR)	100	100	90,9	81,81
5	Precision (PPV)	100	100	87,5	80
6	Accuracy (ACC)	58,3	66,6	70,83	70,83
7	Noise to signal rate (NtS)	0	0	0,16	0,29

Source: Author

CONCLUSION

We applied ROC methodology in order to discriminate between quality of different models with calculation of area under curve, and different signal quality indicators. The chosen time is very short, and in order to obtain enough crisis event we define it in two ways, not only as negative real GDP growth, but also as the drop of GDP below 1%. We divided also credit growth rate in deciles and put threshold on first, second, third and fourth deciles. The credit growth rate proved itself as, on average, a very good signal for crisis event, especially if we define crisis as growth of GDP below 1%. Also, the credit growth rate performed very well for signaling the drop of GDP below 0%. With these findings, we have proved the research hypothesis. The main objection to signal quality is the value of FNR (false negative rate) which is above 0,5 in four out of eight models. It means that there is a crisis, and signal does not ring, or in other words, crisis is missed. Three models have FNR below 0,5, and they perform best in terms of FNR. According to the high value of TNR all models predict

on satisfactory level absence of crisis very well. All two group of models discriminate very well between crisis event, and the absence of crisis event because noise comparing to the signal is very low, but the second group of models (with GDP growth rate below one as crisis event). Possibility that crisis event is correctly predicted (positive predictive value) is more than 60% in all models which means that false positive rates are on average very low. From the very research's results, we can draw a couple of recommendation and ideas for policymakers. It can be said forsure that GDP growth rate is very sensitive to credit growth rate, especially in the case when credit growth is high, and because of that when credit crunched occurs higher public spending must compensate for it i.e. for credit growth. In order to have room for additional public spending BH have to accumulate budget surpluses during economic expansion and it have to keep public debt on low level to facilitate expected intervention during slowdown. The policymakers and banking sector regulators may not allow credit boom anymore, because after bursting credit bubble crisis event will happen even is credit growth rate is relatively high. In order to mitigate consequences of credit crunch in providing external sources of funding internal financial market have to be more developed. In boosting economic during credit crunch government should be more oriented on borrowing through financial markets. Further research of this kind could be focused on relationship between international economic environment and GDP growth rate in Bosnia and Herzegovina. Future research can answer the question whether there are some foreign economic variables which signal downturn and or recession in BH economy. In addition, if the main goal of economic policy is reindustrialization of economy then crisis event can be significant drop in industrial activity. In addition, in relation to GDP growth rate, some of its components, which are leading indicators of recession, can be used instead of economic growth, and/or industrial activity itself.

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