A Fuzzy Logic Model for Estimation of Banking System Stability in Bulgaria

Silvia Trifonova [1 +] and Plamena Zlateva [2]

[1] University of National and World Economy, Sofia, Bulgaria

[2] Institute of System Engineering and Robotics – BAS, Sofia, Bulgaria

Abstract. The key objective of the paper is to propose a fuzzy logic model for analysis and estimation of the banking system stability in Bulgaria. The model includes two main financial indicators characterizing the performance of the banking system – capital adequacy and liquidity. The fuzzy logic model is applied for the two bank groups and the whole banking system in Bulgaria It reveals the banking system stability and its capacity absorb negative economic shocks. The results obtained from the study might be useful for the bank risk managers and the decision-making bodies.

Keywords: Fuzzy logic model, Bulgarian banking system; Bank solvency, Liquidity

1. Introduction

The banking system stability is a key precondition for the overall macroeconomic stability of the country. This issue is widely analyzed in the literature and gain particular importance during the times of crisis. Some new evidences for the European banking system stability are demonstrated in the analyses of [1-3].

Various qualitative and quantitative methods for the complex estimation of the banking system stability are developed. However, it is necessary to point out, that the estimation of banking stability is done under the subjective and uncertain conditions. The intelligent methods are an appropriate tool for estimation. Some of these methods, using the fuzzy logic theory, provide adequate processing the expert knowledge and quantitative data [4].

The key objective of the paper is to propose a fuzzy logic model for analysis and estimation of the banking system stability in Bulgaria. This objective is composed in the following two tasks: (a) to compare the current financial state of the Bulgarian banks divided into two groups; (b) to analyze the banking system stability and its capacity to meet capital and liquidity pressures.

The methodology used in the paper is a fuzzy logic model proposed by the authors, which takes into account the available banking information and the expert knowledge. The model includes three main financial indicators characterizing the financial state of the Bulgarian banking system. They cover the capital adequacy, liquidity and profitability of Bulgarian banks under the conditions of increased instability of financial markets.

The paper is organized as follows: Section 2 describes the key aspects of the banking system development in Bulgaria; Section 3 demonstrates the fuzzy logic estimation of the banking system stability using two main indicators; Section 4 presents the results from the applied model for the bank groups and the banking system in Bulgaria. The paper concludes with summarizing the results obtained from the study.

2. Banking System Development in Bulgaria

Since the second half of 2008 the Bulgarian banking system has been subject to the negative impact of the global financial and economic crisis. The major developments are observed: (a) significant slowdown in the lending growth; (b) decline in the general economic activity; (c) worsening credit portfolio with an increase in the proportion of non-performing loans; (d) rise in the bank impairment costs. In 2010 the banking system was characterized by a slow recovery [5]. Banks' strategy over this period involved boosting

[+] Corresponding author. Tel.: + 359 2 8195 505; fax: +359 2 962 39 03.
E-mail address: trifonovasilvia@yahoo.com

deposits from residents wanting low-income low-risk investment, increasing non-interest revenue, and improving flexibility to cut administrative costs. This strategy helped Bulgarian banks to manage to increase their assets. In the second half of 2010 the bank lending picked up, while the non-performing loans declined. These trends continued in 2011 as the banking system assets increased further, reflecting the sustainable growth in attracted household funds. Some major credit aggregates as corporate, housing mortgage and consumer loans demonstrated increases for the first time in 2011 since the beginning of the crisis. A the end of September 2011 the total bank assets reached around EUR 40 billion and the five biggest banks owned 52,1% of the system assets. The share of subsidiary EU banks was 70,4%, while that of EU bank branches – 4,4%. Domestic credit institutions had 22,1% of the system assets.

However, the credit risk impact was sustained and the classified exposures (watch, non-performing and loss) reached around 16% of gross banking assets and 23% of credit portfolio. Non-performing loans (over 90 days) continued to increase, reaching 14,5% in the overall credit portfolio. As a result the credit institutions' ability to generate profits continued to reflect on the impairment costs. The low growth rate of newly extended loans limited the possibility for interest income to compensate the rising impairment costs. In fact, the profits at the banking system ensured a ROA of 0,86% and ROE of 6,82% at the end of September 2011.

Bulgarian banks are grouped by the Banking Supervision Department of the Bulgarian National Bank (BNB) with a view to highlighting the banking system developments. The group classification of banks does not imply elements of rating. The position of the banks in individual groups depends on the amount of their assets and changes at the end of each reporting period. The first group consists of the five largest banks based on their total assets in the reporting period, the second group includes the other Bulgarian banks and the third group comprises foreign bank branches in Bulgaria.

Group I consists of UniCredit Bulbank, DSK Bank, United Bulgarian Bank, Raiffeisenbank (Bulgaria), and Eurobank EFG Bulgaria.

Group II includes First Investment Bank, Corporate Commercial Bank, Piraeus Bank Bulgaria, Société Générale Expressbank, Central Cooperative Bank, Cibank, Allianz Bank Bulgaria, MKB Unionbank, Bulgarian Development Bank, Investbank, ProCredit Bank (Bulgaria), Municipal Bank, International Asset Bank, Bulgarian-American Credit Bank, D Commerce Bank, Emporiki Bank – Bulgaria, Tokuda Bank, Texim Private Entrepreneurial Bank, and TBI Bank (former NLB Banka Sofia).

In order to analyze the banking system stability and its capacity to absorb negative economic shocks and to meet liquidity pressure, the current study takes into consideration the following two main indicators:

- Solvency (Capital Adequacy) Ratio
- Coefficient of Liquid Assets

The **solvency ratio** is the key measure of the bank capital adequacy. It is measured as a proportion between its capital base (own funds) and its risk-weighted assets.

The capital base of a bank is formed as a sum of the tier-one capital (initial capital) and the tier-two capital (supplementary capital), less the amounts of several reductions. The tier-one capital of Bulgarian banks comprises the following items: 1) registered and paid-up capital which fully absorbs losses in the event of bankruptcy or liquidation; 2) Reserve fund with the exception of premium reserve related to cumulative preferred stock; 3) other reserves for general purposes formed out of the profit after paying the profit tax due; 4) retained earnings from previous years; 5) interim profit, reduced by taxes due, any foreseeable dividend payments and other allowances; 6) undated instruments. The tier-two capital comprises the following elements: 1) revaluation reserves for the real estate occupied by the bank; 2) the amounts attracted by the bank in permanent debt/capital (hybrid) instruments and other financial instruments, including permanent cumulative preferential shares; 3) the amounts attracted as a subordinated term debt as well as term cumulative preferential shares and subordinated term debt-equity (hybrid) instruments. The risk-weighted assets are the amount of risk-weighted assets for credit risk, market risk and operational risk.

The risk-weighted assets for credit risk consist of: risk weighted assets for credit risk and dilution risk in

banking book; risk weighted assets for counterparty risk in the overall business; risk-weighted assets for settlement risk in the overall business. The risk-weighted assets for market risk consist of: risk-weighted assets for market risk in the trading book; risk-weighted assets for foreign exchange risk in the overall business; risk weighted assets for commodity risk in the overall business. The risk-weighted assets for operational risk are calculated for the overall business of the banks. According to the Bulgarian legislation, the overall capital adequacy ratio may not be less than 12%. The Basel Capital Accord requires that banks meet a minimum capital ratio of 8% of total risk weighted assets.

The **coefficient of liquid funds** is a key measure of the liquidity of banks. According to the Regulation No. 11 of the BNB on bank liquidity management and supervision, banks should manage their liquidity in a manner that ensures they can regularly and immediately meet their daily obligations, both in a normal banking environment and in a crisis. The coefficient of liquid funds is measured as a ratio between the amount of available liquid assets and the amount of deposits and other bank's liabilities. The bank liquid assets include: 1) cash and cash balances with the BNB; 2) balances on current accounts with other banks and interbank deposits with a term of up to 7 days; 3) tradable debt securities issued by central governments or central banks which are assigned 20% or more favorable risk weight according to the capital adequacy regulation; 4) treasury bills and bonds of the Bulgarian government; 5) tradable debt securities issued by institutions which are assigned 20% or more favorable risk weight in accordance with the capital adequacy regulation; 6) tradable debt securities issued by international banks for development and international organizations; 7) gold in bullions or plates with weights accepted by gold markets.

3. Fuzzy Logic Estimation of the Banking System Stability

The idea is to design a fuzzy logic model that adequately describes the subjectivity in the analysis of the risk profile of the banking system and its capacity to meet capital and liquidity pressure.

The banking stability (*BS*) can be estimate as weighted sum of the two main financial indicators: Solvency Ratio (FI_1) and Coefficient of liquid assets (FI_2).

The following fuzzy logic model for the banking stability estimate is proposed

$$BS = w_1.FI_1 + w_2.FI_2 = w_1.\sum_{j=1}^{5} r_{1j}\mu_{1j}(FI_1) + w_2.\sum_{j=1}^{5} r_{2j}\mu_{2j}(FI_2),$$

where w_1 and w_2 are weight coefficients, which are determined on the basis of expert knowledge and empirical observations; r_{1j} and r_{2j} are elements of the node point vector $r_i = (r_{i1}, r_{i2}, r_{i3}, r_{i4}, r_{i5})$, i=1,2.

Here, the main financial indicators and the banking stability are defined as linguistic variables with five levels. The proposed five levels are set with five fuzzy subsets, correspondingly: *Very small*, *Small*, *Medium*, *Large* and *Very large*. All fuzzy subsets are with triangular membership functions.

The first linguistic variable - Solvency Ratio (FI_1) varies in the [16, 20] interval. The second linguistic variable - Coefficient of liquid assets (FI_2) varies in the [24, 28] interval.

The node point vectors $r_i = (r_{i1}, r_{i2}, r_{i3}, r_{i4}, r_{i5})$, i=1,2. are introduced for each financial indicator, as follows: $r_1 = (16,17,18,19,20)$ for FI_1; $r_2 = (24,25,26,27,28)$ for FI_2;

The financial indicators (FI_1 and FI_2) have corresponding membership function μ_{1j}, μ_{2j}, $j = 1,...,5$ to the five fuzzy subsets.

The membership functions μ_{1j}, $j = 1,...,5$ are defined with the following formula:

$$\mu_{11} = \begin{cases} 17 - FI_1 & 16 \le FI_1 < 17 \\ 0 & 17 \le FI_1 \le 20 \end{cases} \qquad \mu_{12} = \begin{cases} FI_1 - 16 & 16 \le FI_1 < 17 \\ 18 - FI_1 & 17 \le FI_1 < 18 \\ 0 & 18 \le FI_1 \le 20 \end{cases}$$

$$\mu_{13} = \begin{cases} 0 & FI_1 < 17 \\ FI_1 - 17 & 17 \le FI_1 < 18 \\ 19 - FI_1 & 18 \le FI_1 < 19 \\ 0 & 19 \le FI_1 \le 20 \end{cases}$$

$$\mu_{14} = \begin{cases} 0 & FI_1 < 18 \\ FI_1 - 18 & 18 \le FI_1 < 19 \\ 20 - FI_1 & 19 \le FI_1 \le 20 \end{cases} \qquad \mu_{15} = \begin{cases} 0 & FI_1 < 19 \\ FI_1 - 19 & 19 \le FI_1 \le 20 \end{cases}$$

The membership functions μ_{2j}, $j = 1,...,5$ of FI_2 are defined with the following formula:

$$\mu_{21} = \begin{cases} 25 - FI_2 & 24 \le FI_2 < 25 \\ 0 & 25 \le FI_2 \le 28 \end{cases} \qquad \mu_{22} = \begin{cases} FI_2 - 24 & 24 \le FI_2 < 25 \\ 26 - FI_2 & 25 \le FI_2 < 26 \\ 0 & 26 \le FI_2 \le 28 \end{cases}$$

$$\mu_{23} = \begin{cases} 0 & FI_2 < 25 \\ FI_2 - 25 & 25 \le FI_2 < 26 \\ 27 - FI_2 & 26 \le FI_2 < 27 \\ 0 & 27 \le FI_2 \le 28 \end{cases}$$

$$\mu_{24} = \begin{cases} 0 & FI_2 < 26 \\ FI_2 - 26 & 26 \le FI_2 < 27 \\ 28 - FI_2 & 27 \le FI_2 \le 28 \end{cases} \qquad \mu_{25} = \begin{cases} 0 & FI_2 < 27 \\ FI_2 - 27 & 27 \le FI_2 \le 28 \end{cases}$$

4. Results from the Applied Fuzzy Logic Model for the Banking System

Here, the proposed model is applied to the two bank groups and the banking system in Bulgaria.

The estimated membership functions are shown in Table 1.

Table 1.

	FI	**data**	μ_{i1},	μ_{i2}	μ_{i3}	μ_{i4}	μ_{i5}
Group I	FI_1	19,02	0	0	0	0,98	0,02
	FI_2	24,46	0,54	0,46	0	0	0
Group II	FI_1	16,19	0,81	0,19	0	0	0
	FI_2	27,42	0	0	0	0,58	0,42
Banking system	FI_1	17,75	0	0,25	0,75	0	0
	FI_2	25,90	0	0,10	0,90	0	0

The weight coefficients are defined as: w_1 = 0,55 and w_2 = 0,45. The results from the applied fuzzy model for the bank groups and the banking system in Bulgaria are presented in Table 2.

Table 2.

	BS
Group I	21,4680
Group II	21,2435
Banking system	21,4175

The calculated results demonstrate the following conclusions: 1) the stability of the bank Group I in Bulgaria is higher that the stability of the whole domestic banking system; 2) the stability of the bank Group II is lower than the stability of the banking system. These conclusions are determined by the following major trends. The solvency ratio of the Group I is higher than the average value of Bulgaria's banking sector. The capital position of this bank Group remained stable without any negative changes during the reviewed period.

The upward trend in the growth rate of tier-one capital outstripping the growth rate of total capital requirements was sustained. As concerns the second conclusion, it should be noted that in 2011 the bank Group II demonstrated higher liquidity based on the increased deposit base of the respective credit institutions. The deposit base was generated from households and corporations. The attracted funds with the interval of over 6 months and over 1 year posted the strongest growth. Maturities extensions of attracted resources additionally strengthened the stability of funds and supported investments.

5. Conclusions

During the period under review the banking sector in Bulgaria managed successfully to absorb the negative economic shocks. The banking market over the year 2011 witnessed a progressively increasing significance of attracted funds from residents. The banking system's capital buffers endured despite the growing non-performing loans and associated impairement costs. Bulgarian banks managed to strengthen their capacity to meet liquidity pressure. The fuzzy logic model proposed in the paper serves as a reliable measurement tool for estimating the banking system stability in Bulgaria in the current uncertain global financial situation. The calculated results from the study demonstrate that the stability of bank Group I in Bulgaria has higher stability of the whole banking system. Particular importance for this trend has the increased capital adequacy ratio of the first bank group reaching higher levels that the banking system. This demonstrates the strong capital's ability of the biggest banks in Bulgaria to absorb negative economic shocks. The average values of Bulgaria's banking sector remain significantly more favourable compared with those at the European system level.

6. Acknowledgements

The authors express their gratitude to the Science Fund of the Ministry of education, youth and science of the Republic of Bulgaria for the financial support under the Grant No. 02-302/2008, titled "Situation and perspectives of the balance of payments of the Republic of Bulgaria in the context of the country's membership into the European Union".

7. References

[1] Segoviano, M.A., Ch. Goodhart, Banking Stability Measures, *IMF Working Paper*, WP/09/4, International Monetary Fund, Washington D.C., January 2009.

[2] Rodriguez, J.L., Banking Stability and the Basel Capital Standards, *Cato Journal*, Vol. 23, No. 1, 2003: 115-126.

[3] Th. Beck, D. Coyle, M. Dewatripont, X. Freixas, P. Seabright, Bailing out the Banks: Reconciling Stability and Competition. An analysis of state-supported schemes for financial institutions", Centre for Economic Policy Research, London, UK, 2010.

[4] T. Korol, A. Korodi, An Evaluation of effectiveness of Fuzzy Logic Model in Predicting the Business Bankruptcy, *Romanian Journal of Economic Forecasting,* **3**, 2011, 92-107, www.finanzaonline.com.

[5] OECD), Competition, Concentration and Stability in the Banking Sector", Policy Roundtables, DAF/Comp, 2010.