“Assessing the stability of the banking system based on fuzzy logic methods”

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ARTICLE INFO	Ivan S. Blahun, Ivan I. Blahun and Semen I. Blahun (2020). Assessing the stability of the banking system based on fuzzy logic methods. *Banks and Bank Systems*, *15*(3), 171-183. doi:10.21511/bbs.15(3).2020.15
DOI	http://dx.doi.org/10.21511/bbs.15(3).2020.15
RELEASED ON	Wednesday, 07 October 2020
RECEIVED ON	Monday, 17 August 2020
ACCEPTED ON	Tuesday, 29 September 2020
LICENSE	This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Banks and Bank Systems"
ISSN PRINT	1816-7403
ISSN ONLINE	1991-7074
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
38	3	4

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LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

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ASSESSING THE STABILITY OF THE BANKING SYSTEM BASED ON FUZZY LOGIC METHODS

Received on: 17th of August, 2020
Accepted on: 29th of September, 2020
Published on: 7th of October, 2020

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Abstract

The functioning of the country's banking system is the basis for ensuring its economic development and stability. The state of the banking system often causes financial crises; therefore, ensuring its stable work is one of the main tasks of monetary policy. Meanwhile, it is important to find approaches to a comprehensive assessment and forecasting of the stability of the banking system that would allow obtaining adequate results.

Based on a sample of data generated for the period from 2008 to the 1st quarter of 2020 with a quarterly breakdown, an integrated stability index of Ukraine's banking system was estimated. The analysis was based on 23 variables that characterize certain aspects of the functioning of the Ukrainian banking system.

Using the principal component analysis, five factors have been identified that have the greatest impact on ensuring the stability of the banking system. They were used to form an integrated index based on the application of the Mamdani fuzzy logic method. The results obtained adequately reflected the state of stability of the banking system for the analyzed period, which coincided in time with the crisis phenomena occurring in the Ukrainian banking system. The obtained value of the integrated index characterizes the stability of Ukraine's banking system at the average level, since it depends not only on the internal state of the system, but also on the influence of external factors, both national and international.

Keywords bank, stability, Mamdani, capital, loans, assets

JEL Classification E42, E47, E52

INTRODUCTION

Ensuring the stability of the banking system is one of the key tasks of countries' economic policies, regardless of their economic levels. This is due to the fact that the history of financial crises shows that, for the most part, the banking system was the source of their development, both at the level of individual national economies and at the regional and global levels.

Therefore, today it is important to identify negative trends in ensuring the stability of banking systems. It is necessary to find methods and models that could take into account the influence of the maximum number of factors that have both positive and negative impact on the stability of the banking system. In addition, it is necessary to build an integrated index that accumulates both positive and negative manifestations in the behavior of individual indicators. The purpose of the paper is to identify the factors and build an integrated index reflecting the level of stability of Ukraine's banking system using fuzzy logic methods.

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Conflict of interest statement:
Author(s) reported no conflict of interest

1. LITERATURE REVIEW

Ensuring financial stability is an acute issue not only for developing countries, but also for countries with a high level of economic development. Many scholars around the world have studied the relationship between monetary policy and financial stability; the overwhelming majority of scientists have concluded about the decisive influence of monetary policy pursued by the central banks of countries and implemented at the bank level. Barnea, Landskroner, and Sokoler (2015), Drakos and Kouretas (2015), Poloz (2015), Capraru (2016), Kremer (2016), Andries (2016), Klaas and Daryakin (2016), Berger and Nagase (2018), Nelson (2018), Shkolnyk, Kozmenko, Polach, and Wolanin (2020), and Nekhili and Giannopoulos (2020) are among such studies.

Salter and Tarko (2019) argue that the problem of ensuring financial stability goes far beyond economics and is often political and institutional in nature. Ijaz, Hassan, Tarazi, and Fraz (2020) investigated the impact of banking system stability on the financial stability and economic growth of countries. They took panel data from 38 European countries from 2001 to 2017 as a basis and employed a fixed-effect estimator and a system generalized method of moments to control unobserved heterogeneity, endogeneity, dynamic effect of economic growth and inverse causality in its estimation.

Grytten and Koilo (2019) went from reverse and, using eleven Eastern European countries as an example, tested the hypothesis of financial instability as an explanatory factor of the financial crisis put forward by Minsky and *Kindleberger*. They used a cyclical approach based on two blocks of indices – the real and financial sectors of the economy. Among the indicators of the financial sector, the key ones are those that characterize the state of monetary policy in the studied countries. The authors concluded that the uncontrolled increase in money supply and the credit boom led to overheating the economy and, as a consequence, to the financial crisis and the crisis of the real economy, reaffirming the decisive role of the banking system in ensuring economic stability.

Younsi and Nafla (2019) examined panel data from 40 developed and developing countries using a regression model and concluded on the complementarity and importance of monetary variables and the level of bank soundness and their significant impact on the financial stability and economic development of countries.

Vučinić (2015) conducted a comparative analysis of indicators characterizing financial stability of three countries: Montenegro, Serbia and the Netherlands. The author notes that financial stability is ensured according to various areas of financial activity: the activities of the Central Bank as a regulator, credit ratings assigned by rating agencies, including Standard and Poor's and Moody's, the state of macroeconomic development of countries (GDP dynamics, employment, inflation), the state of public finances and fiscal deficit, the state of the banking system (credit risk, liquidity risk, market risk, operational risk, capital adequacy, profitability of the banking sector). In addition, special attention is paid to the compliance of the banking sector with the requirements of the Basel Committee on Banking Supervision.

Hausenblas, Kubicová, and Lešanovská (2015) analyzed the state of the banking system of the Czech Republic and its stability in the face of changes in the structure of interbank risks and the balance of regulatory characteristics. In this context, S. Kuzucu and N. Kuzucu (2017) also conducted a study using the Turkish banking system as an example. They focused on the need to comply with the standards of the Basel Capital Accords.

Considerable attention is paid to ensuring the stability of the banking system in countries with Islamic banking. Among the studies on this topic, it is worth noting Rashid (2017), Korbi and Bougatef (2017), Mawardi (2020), Subbar and Vladimirovich (2020), Rizvi (2020). Barra and Zotti (2019) emphasize that the stability of the banking system depends on the type of banks and, to a lesser extent, on the level of concentration in the system.

Gulaliyev, Ashurbayli-Huseynova, Gubadova, Ahmedov, Mammadova, and Jafarova (2019) propose to calculate the integrated banking stability index using the Minimax normalization method. This index was used to analyze the financial stability of the banking sector of 29 countries, as well as

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to form a risk map taking into account the main macroeconomic indicators of national economies.

Research on stability of Ukraine's banking system is quite popular, since this issue is extremely relevant, given that banks are major participants in the financial market, as well as significant political and financial turbulence that have a significant impact on the banking sector. Bondarenko, Zhuravka, Aiyedogbon, Sunday, and Andrieieva (2020) investigated the impact of problem debt of banks, the profitability of the Ukrainian banking system on its stability and proved the existence of mutual influence between the studied indicators. Haber, D'yakonova, and Milchakova (2018) highlight the main problems that arose in the Ukrainian banking system as a result of the National Bank of Ukraine reforms and, at the same time, the adaptation of the banking system in the context of the development of financial technologies.

Kozmenko, Shkolnyk, and Bukhtiarova (2016) analyzed the state of the banking system using self-organizing Kohonen maps. For the assessment, 32 banks were selected from different classification groups by the size of assets according to the National Bank of Ukraine's classification and 15 indicators were used that characterize the effectiveness of banks. Based on the calculations, five groups of banks were obtained: powerful banks, stable banks, problem banks, banks in crisis state and banks in the bankrupt stage. Given that the banks with the largest assets were included in the first two groups, Ukraine's banking system could be considered quite stable. Similar studies were conducted by Shkolnyk et al. (2018). They analyzed the indicators of 49 Ukrainian banks and the trajectory of their patterns, made a forecast of the state of both individual banks and the banking system as a whole.

Equally important are studies that determine the interaction between the state of the banking system and monetary policy and the state of public finances. Most of them conclude about the main role of banks in pursuing financial policy of the state. Shvets (2020) analyzes the interaction between active monetary policy and the golden rule of public finance.

The analyzed works mainly use the methods of correlation-regression analysis. The stability of the banking system depends on many factors, and cause-and-effect relationships cannot always be described by linear models, so fuzzy logic methods must be used. The latter are increasingly being used to model various processes in finance.

To assess the stability of the Ukrainian banking system in this study, the Mamdani fuzzy inference model was chosen. The basis for this decision was a study by S. S. Izquierdo and L. R. Izquierdo (2018). These authors analyzed the features of this model, its significant advantages and disadvantages, and concluded that there was significant potential for applying the Mamdani method to modeling social and other complex systems, as well as using this model and results in such studies. Marfalino, Putra, Guslendra, and Yulia (2018) use Mamdani's (1994) fuzzy logic method to determine the optimal price for financial services. Musayev, Madatova, and Rustamov (2018) also use the Mamdani fuzzy logic method to assess the impact of tax administration reforms on tax potential. Hachami, Alaoui and Tkiouat (2019) used fuzzy logic methods to determine the impact of the type of micro-enterprises activity on the performance of microfinance investments.

Boloș, Bradea, Sabău-Popa, and Ilie (2019) used Mamdani's fuzzy logic model to detect the financial sustainability risk of the assets owned by a company). Dalevska, Khobta, Kwilinski, and Kravchenko (2019) used the Mamdani method to model macroeconomic dynamics according to UN data for 189 countries. Thus, Mamdani's fuzzy logic model is widely used to model the state of economic systems.

2. DATA AND METHODOLOGY

In the course of the study, data were selected that characterize the state of the Ukrainian banking system by quarters for the period from 2008 to the 1st quarter of 2020, that is, the number of periods is 49. 23 variables were selected: Var1 is the ratio of regulatory capital to risk-weighted assets, Var2 is the ratio of Tier 1 regulatory capital to risk-weighted assets, Var3 is the ratio of non-performing loans excluding reserves to capital; Var4 is the ratio of non-performing loans to total gross loans, Var5 is the share of loans of depository corporations in total gross loans, Var6 is the rate of return on assets, Var7 is the rate of return on capital, Var8 is the ratio of interest margin to gross income; Var9 is the ratio of non-interest expenses to gross income, Var10 is the ratio of liquid assets to total assets, Var11 is the ratio of liquid assets to short-term liabilities, Var12 is the ratio of net open position in foreign currency to equity; Var13 is the ratio of capital to assets, Var14 is the ratio of large open positions to capital, Var15 is the ratio of the gross position of financial derivatives in assets to equity, Var16 is the ratio of the gross position of financial derivatives in liabilities to equity; Var17 is the ratio of trading income to gross income, Var18 is the ratio of personnel costs to non-interest expenses, Var19 is the spread between interest rates on loans and deposits (basis points); Var20 is the spread between the highest and lowest interbank rates (basis points); Var21 is the ratio of customer deposits to total gross loans (excluding interbank); Var22 is the ratio of foreign currency loans to total gross loans; Var23 is the ratio of foreign currency liabilities to total liabilities. Data were processed using eViews and MatLab packages.

The research was carried out in the following sequence:

- A correlation matrix was built and tested for multicollinearity, and all analyzed variables were checked for compliance with the normal distribution law.

- Factor analysis was carried out using the principal components method. Using factor analysis allows determining the minimum number of hypothetical quantities that correspond to a larger number of output variables. Thus, there is a certain systematization of the analyzed variables. The use of the principal components method, along with other methods of factor analysis makes it possible to determine a sufficient number of factors to assess the stability of the banking system. Principal component method is the most common dimensionality reduction approach.

- Mamdani's fuzzy inference model is used to define the comprehensive assessment of the stability of Ukraine's banking system based on factors determined by the principal component method. This model describes the relationship between the inputs and outputs of the knowledge base from the "IF… THEN" fuzzy rules. Transparency is one of the main advantages of the Mamdani fuzzy model. To improve the accuracy of the model, it is taught, that is, the weights of the rules and the membership functions of fuzzy terms are adjusted. Training a fuzzy model is a non-linear optimization task. In this case, the Mamdani base can be interpreted as a breakdown of the space of factors affecting zones with blurred boundaries, within which the response function takes on a fuzzy value. Fuzzy inference is performed on a fuzzy knowledge base, where the values of input and output variables are specified by fuzzy sets, that is, there is a fuzzification procedure:

$$\cup_{p=1}^{k_j}\left(\cap_{i=1}^{n} x_i = a_{i,jp} \; with\,weight\; w_{jp}\right) \rightarrow \tag{1}$$
$$\rightarrow y = d_j,$$

where $\mu_{jp}(x_i)$ is a function of an input membership in a fuzzy term $a_{i,jp} = \int_{\underline{x}_i}^{\overline{x}_i} \mu_{jp}(x_i) \setminus x_{ii}$,

$x_{i\, e\left|\underline{x}_i, \overline{x}_i\right|}$,

$\mu_{dj}(y)$ is a function of an output membership in a fuzzy term $d_j = \int_{\underline{y}}^{\overline{y}} \mu_{dj}(y) \setminus y$.

The degree of the input vector $x^* = (x_1^*, x_2^* \ldots x_n^*)$ membership in the fuzzy knowledge base terms d_j is determined as follows:

$$\mu_{dj}\left(X^*\right) = v_{p=\overline{1,k_j}} w_{jp} \cdot \wedge_{i=\overline{1,n}} \left[\mu_{jp}\left(X_i^*\right)\right], \tag{2}$$

$\mu_{dj}(y)$ is the t-norm, which is realized by the minimum operation.

Accordingly, the following fuzzy set y is obtained, which corresponds to the input vector X^*:

$$y = \frac{\mu d_{1(X^*)}}{d_1} + \frac{\mu d_{2(X^*)}}{d_2} + \ldots + \frac{\mu d_{m(X^*)}}{d_m}. \tag{3}$$

Further, a transition is made from a fuzzy set, which is given to a universal set of fuzzy terms $\{d_{1,d2\ldots dm}\}$, to a fuzzy set in the interval $y.\overline{y}$. To do this, it is necessary to "cut" (minimum operation) a membership function $\mu_{d_{j(y)}}$ at the level of $\mu_{d_{j(X^*)}}$.

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$$\tilde{d}_j^* = \int_{y \in [\underline{y}, \bar{y}]} \min\left(\mu_j\left(X^*\right), \mu_{d_j}\left(y\right)\right)'' / y. \tag{4}$$

Then a resulting fuzzy set $\tilde{y}^*$. is obtained by combining the fuzzy sets:

$$\tilde{y}^* = \tilde{d}_1^* \cup \tilde{d}_2^* \cup \ldots \cup \tilde{d}_m^*. \tag{5}$$

After that, it is necessary to aggregate (maximum operation) the obtained fuzzy sets:

$$\mu_{y^*}\left(y\right) = \max\left(\mu_{d_1^*}\left(y\right), \mu_{d_2^*}\left(y\right), \ \ldots, \mu_{d_m^*}\left(y\right)\right). \tag{6}$$

The net value of the output y^* is determined, which corresponds to the input vector X^*, or defuzzification of a fuzzy set y^* occurs in this case by the center-of-grity method:

$$y^* = \int_{\underline{y}}^{\bar{y}} y \mu_{y^*}\left(y\right) dy \Big/ \int_{\underline{y}}^{\bar{y}} \mu_{y^*}\left(y\right) dy. \tag{7}$$

Thus, an integral value is obtained that characterizes the stability of Ukraine's banking system.

3. RESULTS

Calculations carried out in accordance with the established research methodology (intermediate results for individual calculations are presented in the appendices) yielded the following results. The obtained values of descriptive statistics (Appendix A), as well as the correlation matrix (Appendix B) of the analyzed variables show that the values of the variables characterizing certain aspects

Source: Built by the authors.

Figure 1. The results of tests for the normality of the analyzed variables (fragment)

of banks as a whole are rather uneven and have significant fluctuations over time. At the same time, checking the variables used in the model for compliance with the law of normal distribution showed that the overwhelming majority of them showed compliance, but for certain indicators; in particular, for Var15 – the ratio of the gross position of financial derivatives in assets to equity – there is no normal distribution due to the instability of transactions with derivatives, changes in the legal framework regulating such transactions, and the underdevelopment of the derivatives market in Ukraine.

The analysis of the correlation matrix showed that Var1 and Var2, as well as Var6 and Var7 (0.99) had a strong correlation (0.97), that is, they had signs of multicollinearity. Therefore, it was decided to exclude Var2 and Var7 from further analysis. Thus, in further calculations, the values of 21 variables will be used.

To determine the factors affecting the state of stability of Ukraine's banking system, a factor analysis was carried out using the principal component method. The analysis revealed five main factors explaining 81% of the variance. These factors are: factor 1 – the state of the formed capital in the Ukrainian banking system, which includes Var3, Var6, Var12, Var14, and Var18; factor 2 – the state of the formed assets of banks (Var4, Var5, Var10, and Var21); factor 3 – performance, which includes not only the yield on basic operations, but also on transactions with securities carried out by banks, including derivatives (Var8, Var9, Var16, and Var17); factor 4 – the level of dollarization of both assets and liabilities of banks (Var22 and Var23); factor 5 characterizes the role of transactions in the interbank market (Var20).

The values of all five factors in each of the 49 quarters studied are given in Appendix C.

The Mamdani fuzzy inference model was used to conduct a comprehencive assessment of the stability of the banking system. The input factors for construction of this model were taken from five factors indicated above. For such a model, term sets are defined for each of the input and output variables. Accordingly, for each of the terms,

Table 1. Results of factor analysis by the principal component method

Source: Compiled by the authors.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Var1	–0.501798	0.057349	–0.471183	0.533030	0.057498
Var3	0.784573	–0.453350	0.172322	–0.222026	–0.00151
Var4	0.130841	–0.949379	–0.029266	0.007617	0.10044
Var5	–0.404669	0.761346	–0.83319	–0.068929	0.249753
Var6	–0.751906	–0.278151	–0.351702	0.268691	0.144454
Var8	–0.376596	0.46923	–0.733016	0.071138	–0.117306
Var9	–0.014626	0.039372	–0.864454	0.120851	0.128295
Var10	0.039420	–0.963716	0.055392	0.096039	0.13621
Var11	0.414599	–0.466859	–0.202047	0.620985	0.265089
Var12	0.714997	–0.335219	0.229212	0.104587	0.199725
Var13	–0.542911	0.318468	–0.439787	0.489521	–0.041041
Var14	0.785474	0.041932	0.443332	–0.205800	–0.01329
Var15	0.483663	–0.471081	–0.065692	–0.321007	0.109874
Var16	0.139991	0.077158	0.714747	0.104002	–0.088318
Var17	0.222639	0.048246	0.868311	–0.023255	0.056102
Var18	–0.736024	0.474953	0.128786	–0.049012	0.053963
Var19	–0.293124	–0.097081	–0.007476	–0.568668	0.515278
Var20	–0.043945	0.219227	0.033821	–0.173063	–0.887673
Var21	0.000957	–0.882984	0.102971	0.274916	0.211986
Var22	0.251161	0.113491	0.130972	–0.872565	–0.050396
Var23	0.302597	0.317933	–0.140200	–0.789526	–0.133511
Expl.Var	4.439350	4.758021	3.488520	3.048293	1.402231
Prp.Totl	0.211398	0.226572	0.166120	0.145157	0.066773

Note: Principal components (Loadings in bold are > .700000).

http://dx.doi.org/10.21511/bbs.15(3).2020.15

Source: Author's calculations.

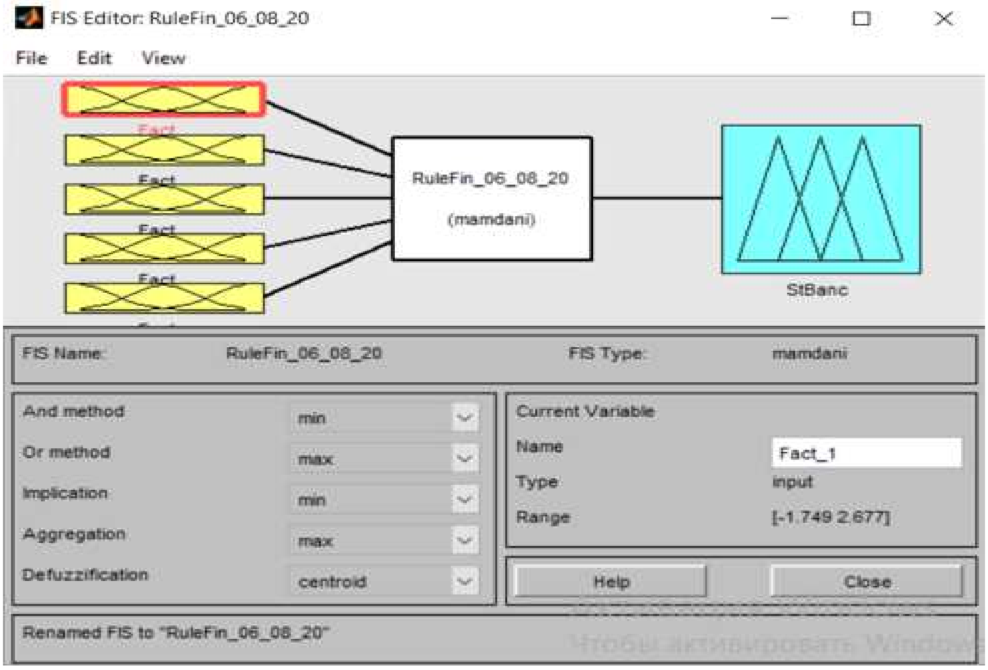

Figure 2. The Mamdani model constructed

membership functions are given in the form of a normally distributed function.

As a result, a knowledge base was built in the form of a system of rules consisting of 204 rules, such as: If (Fact_1 isvus) and (Fact_2 isvus) and (Fact_3 isvus) and (Fact_4 isvus) and (Fact_5 isvus) Then (StBancisvus) (1).

Therefore, the values of a comprehencive assessment of the stability of the banking system were calculated in each of the specified periods – quarters (49 quarters) (see Figure 2). The highest indicator of the stability of the Ukrainian banking system was observed in 2012, followed by a gradual decline, which decreased significantly in 2014 and 2015. During this period, there is a significant de-

Source: Compiled by the authors.

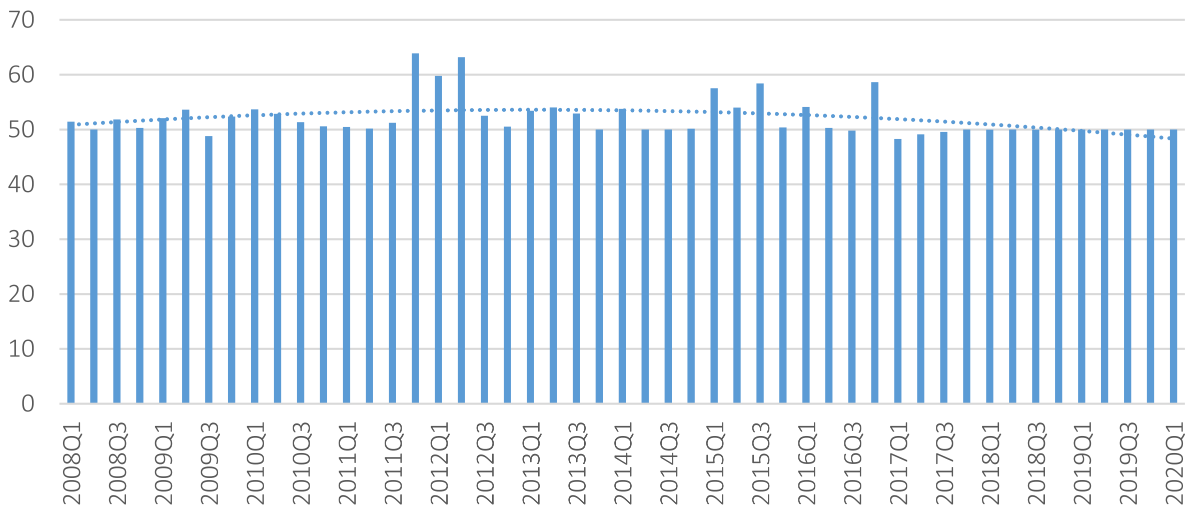

Figure 3. Dynamics of the integrated index of Ukraine's banking system stability and the polynomial trend calculated by the Mamdani fuzzy logic method

crease in the volume of banks' assets, significant losses due to political events that led to the financial and economic crisis in Ukraine – the loss of control over part of the territory in the east of the country and the loss of the Autonomous Republic of Crimea. In addition, during 2014–2017, the National Bank of Ukraine carried out a large-scale reform to cleanse the banking system from low-quality banks with low transparency – 75 of 180 banks are currently operating in the market. At the same time, the approaches to monetary policy have radically changed, and the structure of the National Bank of Ukraine itself has been reformed. All this is reflected in the integrated index, which shows significant unstable dynamics during this period. Starting from the 3rd quarter of 2017, the value of the integrated index remained almost at the same level and amounted to 50%. This is due to the fact that during this period the largest stage of the reform of the banking system was actually completed. At this time, the maximum number of banks was withdrawn from the market, and those banks that continued to leave the market had insignificant assets and did not significantly affect the performance of the banking system as a whole.

CONCLUSION

The study leads to the following conclusions.

The stability of banking systems is assessed using different methods and different sets of indicators. A review of scientific publications on the issue shows that the vast majority of studies are carried out using the correlation-regression method, which does not always take into account all factors, especially with non-linear dependencies. To take into account the influence of various factors as much as possible, it was decided to use the fuzzy logic method, in particular, the Mamdani fuzzy inference model.

The results obtained in the course of modeling made it possible to identify five main factors that have a decisive impact on the stability of the banking system of Ukraine. These factors are as follws: the state of assets and liabilities formed by banks, the level of efficiency of banking operations, the volume of formed assets and liabilities in foreign currency, as well as the state of the interbank market.

The application of Mamdani's fuzzy logic model allowed determining the integrated stability index of Ukraine's banking system. Its fluctuations on a quarterly basis from 2008 to the 1st quarter of 2020 are explained by the corresponding events that occurred in certain periods of time and influenced, both positively and negatively, the state of the Ukrainian banking system.

Further research is planned to determine how the stability of the banking system of Ukraine can be affected by the economic situation in the country and on world markets in the pandemic. The indicators of the first quarter of 2020 entered into the model did not show any fluctuations, but further studies should take into account the lagging effect, which can largely manifest itself in the second half of 2020.

AUTHOR CONTRIBUTIONS

Conceptualization: Ivan S. Blahun.
Data curation: Ivan I. Blahun, Semen I. Blahun.
Formal analysis: Ivan I. Blahun, Semen I. Blahun.
Funding acquisition: Ivan S. Blahun, Ivan I. Blahun.
Investigation: Ivan I. Blahun.
Methodology: Ivan S. Blahun.
Project administration: Ivan S. Blahun.
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Supervision: Ivan S. Blahun.

http://dx.doi.org/10.21511/bbs.15(3).2020.15

Validation: Ivan I. Blahun.
Visualization: Ivan I. Blahun.
Writing – original draft: Ivan S. Blahun.
Writing – reviewing & editing: Ivan I. Blahun.

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http://dx.doi.org/10.21511/bbs.15(3).2020.15

http://dx.doi.org/10.21511/bbs.15(3).2020.15

APPENDIX A

Table A1. Descriptive statistics

Variable	Mean	Confidence −95.000%	Confidence +95.000%	Minimum	Maximum	Range	Variance	Std. dev.	Standard error	Skewness	Std. err. Skewness	Kurtosis	Std. err. Kurtosis
Var1	16.060	15.147	16.974	7.09	20.83	13.74	10	3.180	0.4543	−0.78536	0.339828	0.53614	0.668065
Var2	11.741	10.985	12.497	3.48	15.52	12.04	7	2.632	0.3760	−1.07309	0.339828	1.28697	0.668065
Var3	48.365	39.262	57.468	7.44	129.52	122.08	1004	31.692	4.5275	0.93145	0.339828	−0.01387	0.668065
Var4	25.869	20.712	31.027	2.68	57.73	55.05	322	17.955	2.5650	0.68978	0.339828	−1.03698	0.668065
Var5	2.228	1.681	2.775	0.15	7.67	7.52	4	1.905	0.2722	1.30179	0.339828	1.38526	0.668065
Var6	−1.152	−2.528	0.223	−23.53	5.15	28.68	23	4.788	0.6839	−2.59382	0.339828	9.82431	0.668065
Var7	−13.293	28.288	1.701	−277.33	42.55	319.88	2725	52.204	7.4576	−3.30577	0.339828	13.9455	0.668065
Var8	55.748	52.787	58.709	14.20	71.01	56.81	106	10.309	1.4727	−1.28652	0.339828	3.95484	0.668065
Var9	60.098	57.975	62.221	36.63	76.42	39.79	55	7.392	1.0560	−0.36172	0.339828	1.28603	0.668065
Var10	31.291	26.089	36.493	9.35	72.67	63.32	328	18.112	2.5874	0.81051	0.339828	−0.45824	0.668065
Var11	82.119	75.913	88.326	30.95	100.85	69.90	467	21.608	3.0869	−1.72279	0.339828	1.30584	0.668065
Var12	39.943	35.053	44.832	10.00	97.29	87.29	290	17.022	2.4317	1.07816	0.339828	2.53158	0.668065
Var13	12.598	11.993	13.202	5.98	15.22	9.24	4	2.105	0.3007	−1.07015	0.339828	1.0775	0.668065
Var14	225.152	186.796	263.508	105.00	819.95	714.95	17832	133.536	19.0765	2.96788	0.339828	9.75409	0.668065
Var15	5.834	2.765	8.903	0.02	36.81	36.79	114	10.684	1.5263	2.18618	0.339828	3.66429	0.668065
Var16	0.138	0.082	0.194	0.01	1.11	1.10	0	0.195	0.0279	3.3683	0.339828	13.57281	0.668065
Var17	7.551	4.802	10.3	−17.97	52.13	70.10	92	9.570	1.3672	1.80169	0.339828	9.63729	0.668065
Var18	40.422	39.175	41.67	32.11	51.54	19.43	19	4.343	0.6204	0.63726	0.339828	0.52771	0.668065
Var19	598.845	564.188	633.502	354.00	892.00	538.00	14558	120.658	17.2369	0.57668	0.339828	0.07348	0.668065
Var20	2954.111	2268.784	3639.437	1010.00	14990.00	13980.00	5692779	2385.954	340.8506	3.39977	0.339828	14.1605	0.668065
Var21	69.158	64.948	73.368	43.14	103.32	60.18	215	14.657	2.0939	0.19183	0.339828	−0.2622	0.668065
Var22	47.972	46.111	49.834	34.72	60.32	25.60	42	6.480	0.9257	−0.02478	0.339828	−0.68707	0.668065
Var23	50.863	49.698	52.028	452.82	59.04	16.22	16	4.056	0.5794	0.03078	0.339828	−0.60122	0.668065

Note: Valid N = 49.

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APPENDIX B

Table B1. Correlation matrix of analyzed variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1.00	0.97	–0.64	–0.08	0.17	0.58	0.61	0.60	0.39	–0.02	0.29	–0.41	0.82	–0.81	–0.42	–0.36	–0.40	0.22	–0.02	–0.11	–0.04	–0.60	–0.39
2	0.97	1.00	–0.70	–0.22	0.28	0.54	0.58	0.68	0.40	–0.18	0.14	–0.53	0.88	–0.83	–0.40	–0.34	–0.40	0.33	–0.04	0.01	–0.18	–0.57	–0.27
3	–0.64	–0.70	1.00	0.51	–0.67	–0.57	–0.59	–0.67	–0.18	0.42	0.39	0.62	–0.79	0.69	0.66	0.22	0.28	–0.73	–0.09	–0.12	0.36	0.37	0.22
4	–0.08	–0.22	0.51	1.00	–0.72	0.19	0.14	–0.46	–0.04	0.94	0.54	0.50	–0.38	0.04	0.51	–0.12	–0.03	–0.51	0.08	–0.30	0.82	–0.09	–0.26
5	0.17	0.28	–0.67	–0.72	1.00	0.17	0.19	0.48	0.22	–0.71	–0.54	–0.47	0.40	–0.32	–0.45	–0.15	–0.10	0.70	0.12	0.03	–0.59	–0.02	0.12
6	0.58	0.54	–0.57	0.19	0.17	1.00	0.99	0.42	0.37	0.24	0.09	–0.45	0.61	–0.73	–0.30	–0.36	–0.53	0.38	0.11	–0.23	0.32	–0.47	–0.52
7	0.61	0.58	–0.59	0.14	0.19	0.99	1.00	0.51	0.42	0.18	0.06	–0.52	0.65	–0.77	–0.29	–0.39	–0.59	0.38	0.11	–0.18	0.24	–0.45	–0.46
8	0.60	0.68	–0.67	–0.46	0.48	0.42	0.51	1.00	0.58	–0.51	–0.20	–0.56	0.74	–0.57	–0.42	–0.49	–0.75	0.41	0.02	0.18	–0.53	–0.18	0.10
9	0.39	0.40	–0.18	–0.04	0.22	0.37	0.42	0.58	1.00	–0.07	0.20	–0.27	0.39	–0.43	0.03	–0.47	–0.79	–0.11	0.01	–0.12	0.02	–0.27	–0.05
10	–0.02	–0.18	0.42	0.94	–0.71	0.24	0.18	–0.51	–0.07	1.00	0.55	0.46	–0.31	–0.01	0.43	–0.05	0.02	–0.48	0.09	–0.34	0.91	–0.17	–0.37
11	0.29	0.14	0.39	0.54	–0.54	0.09	0.06	–0.20	0.20	0.55	1.00	0.49	0.04	0.05	0.26	–0.03	–0.08	–0.56	–0.23	–0.46	0.57	–0.49	–0.47
12	–0.41	–0.53	0.62	0.50	–0.47	–0.45	–0.52	–0.56	–0.27	0.46	0.49	1.00	–0.55	0.69	0.35	0.09	0.35	–0.64	–0.09	–0.21	0.37	0.07	–0.03
13	0.82	0.88	–0.79	–0.38	0.40	0.61	0.65	0.74	0.39	–0.31	0.04	–0.55	1.00	–0.70	–0.41	–0.26	–0.43	0.44	–0.10	0.04	–0.22	–0.61	–0.27
14	–0.81	–0.83	0.69	0.04	–0.32	–0.73	–0.77	–0.57	–0.43	–0.01	0.05	0.69	–0.70	1.00	0.33	0.37	0.49	–0.46	–0.12	0.05	–0.02	0.43	0.30
15	–0.42	–0.40	0.66	0.51	–0.45	–0.30	–0.29	–0.42	0.03	0.43	0.26	0.35	–0.41	0.33	1.00	0.03	0.14	–0.48	0.07	–0.18	0.37	0.20	0.34
16	–0.36	–0.34	0.22	–0.12	–0.15	–0.36	–0.39	–0.49	–0.47	–0.05	–0.03	0.09	–0.26	0.37	0.03	1.00	0.54	–0.03	–0.05	0.09	0.03	0.06	–0.08
17	–0.40	–0.40	0.28	–0.03	–0.10	–0.53	–0.59	–0.75	–0.79	0.02	–0.08	0.35	–0.43	0.49	0.14	0.54	1.00	–0.10	0.00	0.03	0.01	0.16	0.06
18	0.22	0.33	–0.73	–0.51	0.70	0.38	0.38	0.41	–0.11	–0.48	–0.56	–0.64	0.44	–0.46	–0.48	–0.03	–0.10	1.00	0.08	0.05	–0.38	–0.10	–0.05
19	–0.02	–0.04	–0.09	0.08	0.12	0.11	0.11	0.02	0.01	0.09	–0.23	–0.09	–0.10	–0.12	0.07	–0.05	0.00	0.08	1.00	–0.23	0.00	0.34	0.26
20	–0.11	0.01	–0.12	–0.30	0.03	–0.23	–0.18	0.18	–0.12	–0.34	–0.46	–0.21	0.04	0.05	–0.18	0.09	0.03	0.05	–0.23	1.00	–0.41	0.16	0.29
21	–0.04	–0.18	0.36	0.82	–0.59	0.32	0.24	–0.53	0.02	0.91	0.57	0.37	–0.22	–0.02	0.37	0.03	0.01	–0.38	0.00	–0.41	1.00	–0.37	–0.57
22	–0.60	–0.57	0.37	–0.09	–0.02	–0.47	–0.45	–0.18	–0.27	–0.17	–0.49	0.07	–0.61	0.43	0.20	0.06	0.16	–0.10	0.34	0.16	–0.37	1.00	0.78
23	–0.39	–0.27	0.22	–0.26	0.12	–0.52	–0.46	0.10	–0.05	–0.37	–0.47	–0.03	–0.27	0.30	0.34	–0.08	0.06	–0.05	0.26	0.29	–0.57	0.78	1.00

Note: Correlations in bold are significant at $p < .05000$.

http://dx.doi.org/10.21511/bbs.15(3).2020.15

APPENDIX C

Table C1. Factor scores in each of the 49 quarters

	F1	F2	F3	F4	F5
1	–1.447	1.309	0.773	–0.777	0.905
2	–1.632	1.103	0.544	–1.428	1.811
3	–1.391	1.259	0.565	–1.050	1.139
4	–1.643	0.909	1.089	–2.197	0.483
5	–1.364	0.829	–0.110	–2.391	–0.656
6	–0.701	0.703	–0.282	–1.381	–2.747
7	–0.577	0.509	–0.498	–1.378	–4.336
8	–0.190	0.993	–0.561	–0.888	–0.386
9	0.162	0.991	–0.945	0.362	–0.348
10	0.195	0.965	–0.836	0.511	0.424
11	–0.055	0.861	–0.599	0.340	0.446
12	–0.059	0.824	–0.727	0.210	0.939
13	0.314	0.770	–1.151	0.190	1.230
14	–0.072	0.709	–0.832	0.044	1.474
15	–0.049	0.852	–0.633	0.334	0.881
16	0.330	0.965	–0.743	1.012	0.508
17	0.191	0.998	–0.662	0.875	0.844
18	0.359	0.949	–0.858	1.094	0.330
19	0.240	0.702	–0.648	1.260	–0.412
20	–0.050	0.429	–0.405	1.218	–0.695
21	–0.510	0.312	–0.118	1.056	0.028
22	–0.301	0.344	–0.255	1.248	0.007
23	–0.187	0.360	–0.301	1.395	–0.174
24	–0.240	0.223	–0.218	1.890	–1.752
25	–0.572	0.473	2.137	1.236	–0.871
26	0.014	0.499	0.988	1.300	–0.684
27	–0.068	0.175	1.127	0.816	–0.180
28	0.546	0.100	0.444	0.402	–0.829
29	2.677	0.727	3.919	–0.371	–0.135
30	2.139	0.370	1.422	–0.220	–0.343
31	2.413	0.475	0.933	–0.373	0.636
32	0.881	–0.495	0.876	–1.297	0.627
33	1.475	–0.429	–1.840	–1.117	–0.287
34	1.060	–0.592	–1.176	–0.701	–0.452
35	0.756	–0.646	–0.361	–0.619	–0.067
36	1.749	–0.573	–0.242	–0.811	0.446
37	0.287	–1.489	0.149	–0.877	0.184
38	0.790	–1.464	–0.296	–0.794	0.514
39	0.294	–1.436	–0.511	–0.629	0.462
40	0.829	–1.427	–1.320	–0.585	0.327
41	–0.344	–1.435	–0.653	–0.366	–0.230
42	–0.239	–1.398	–0.573	–0.055	–0.036
43	–0.213	–1.241	–0.373	–0.327	0.324
44	–0.047	–1.169	–0.166	0.372	–0.201
45	–0.689	–1.212	0.556	0.605	–0.112
46	–0.826	–1.287	0.721	0.798	–0.049
47	–1.135	–1.623	0.686	0.925	0.079
48	–1.352	–1.852	0.616	0.967	0.218
49	–1.749	–1.919	1.350	0.171	0.714