“Use of causal analysis to improve the monitoring of the banking system stability”

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USE OF CAUSAL ANALYSIS TO IMPROVE THE MONITORING OF THE BANKING SYSTEM STABILITY

Abstract

According to the stages of the banking system stability monitoring, the analysis of causal links is used to identify the causes of the crisis trends spreading and the rationale for the most effective levers of regulatory influence on the banking system parameters by the central bank.

The research is based on the use of the canonical correlation method for structuring causal links between the indicators for the assessment of the banking system stability, which are grouped into four sub-indices (assessing the intensity of credit and financial interaction in the interbank market, the effectiveness of the banking system functions, structural changes and financial disproportions in the banking system, activities of systemically important banks); the method of regression analysis and the calculation of elasticity coefficients is also used to assess the sensitivity of the banking system stability to changes in parameters that characterize the banking regulation instruments.

The article analyzes the results of quantitative and qualitative assessment of the banking system stability (comparison of actual results of the evaluation with the data for previous years and comparison of values of stability indicators with critical values). The causes of detected deviations are determined taking into account the results of applying the canonical correlations method. Regression models have been constructed to confirm the dependence of the banking system stability index on the change in parameters that characterize banking regulation instruments, and to determine the most effective of them. Practical testing of submitted proposals is realized based on the Ukrainian banking system indicators for 2007–2016.

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INTRODUCTION

Dynamic processes of financial markets globalization through the acceleration of free movement of capital, besides the positive influence on the development of national financial systems, create conditions for increasing channels of penetration and spread of crisis trends, including the emergence of a chain "contagion effects" of banking systems in the international financial space. Given the high sensitivity of the banking system to external shocks and internal imbalances, as well as the leading role in the reproductive structure of the economy and the financing of the business entities' needs, ensuring its stability is an extremely important task facing the central banks of all countries in the current and the long run.

Current negative trends in the banking system of Ukraine also raise the issue of creating effective mechanisms for identifying and neutralizing the risk distribution channels. Recent changes in the main financial indicators of the banking system development, although not critical, still confirm its fragile state after the 2014–2015 crisis. Thus, during the 2016–2017 period, the number of banks continued to decrease, as in the previous two years and in the year 2017 alone, 10 banks were liquidated. Indicators of return on assets and capital of banks were quite variable. As of January 1, 2017, the profitability of assets was –12.60%, return on capital –116.74%; at the end of the year – 0.16% and 1.31%, respectively. Despite these positive changes in the dynamics of indicators, their values were rather low. The funds of Ukrainian banks' customers during the 2016–2017 period also decreased by almost 3%, while the share of non-performing loans amounted to more than 50% (National Bank of Ukraine, 2017). In this case, the issues of monitoring the Ukrainian banking system stability are extremely relevant today and require more detailed consideration and empirical studies. At the same time, the aspects of logical explanation of existing imbalances and their interconnection, the reasons for the spread of crisis trends in the banking system and the identification of possibilities for their absorption are acquired.

The purpose of the article is to develop an integrated approach to monitoring the banking system stability using the causal analysis.

Causal analysis is focused on the study of causal relationships between variables, both on the basis of logical justification, and using mathematical tools, which makes it possible to confirm or refute their presence. In this paper, two directions of causal analysis use for improving the monitoring of the banking system stability are presented. The first direction involves the use of the canonical correlation method to identify causal relationships between indicators for assessing the banking system stability. The second one is based on the results of a regression analysis on the identification of the most significant banking regulation instruments, the main effect of which is the change in the level of the banking system stability.

1. LITERATURE REVIEW

1.1. Analysis of the approaches to assessing the banking system stability

As it is known, the banking system stability and the change in the main parameters characterizing its functioning directly affect the stability of the entire financial system of the country. Relevant conclusions are confirmed in a large number of scientific publications devoted to the evaluation and monitoring of the financial stability, mechanisms for the implementation of macro-prudential regulation. Swamy (2013) built a recursive micro VAR model, which explains the link between the parameters of measuring banking stability and the level of financial stability in developing countries. Worrell (2004) proposes to assess the stability of the financial sector based on a methodology that includes: use of financial stability indicators for early warning of a crisis, financial sector forecasting models and stress-testing of systemically important banks (SIBs). Financial imbalance is the reason for macroeconomic instability.

Slav'yuk et al. (2017) investigate the institutional causes of imbalances in financial markets. The authors state that financial intermediaries in Ukraine, working in a speculative segment of the market, carry out high-risk operations in order to generate high profits. The authors also highlight the main causes of instability in the Ukrainian financial market due to the resilience of banks along with easy access to loans and a low level of trust in the national banking system.

Caranovic and Caranovic (2015) calculate the aggregated index of financial stability by converging the Financial Development Index, the Financial Vulnerability Index, the Financial Soundness Index, and the World Economic Climate Index.

In turn, the index of financial stability includes indicators of the financial standing of banks: the ratio of capital to assets, the share of bad loans, the indicator of financial stability z-score, the ratio of liquid assets to total assets. Sere-Ejembi et al. (2014) offer a similar approach. According to them, the assessment of the financial stability in Nigeria was based on the calculation of three indices – the index of financial soundness of banks, the index of financial vulnerability of banks, and the economic environment index. The authors used the following indicators to calculate the relevant indices: capital adequacy, liquidity, asset quality and profitability of banks; the state of the external sector, the financial sector and the real economy; the GDP growth rate of other countries.

Sales et al. (2012) also propose to take into account the bank performance to assess financial stability. In addition to using the index method for assessing financial stability in Brazil, these authors propose to divide Business Cycle Decomposition into two components – financial and non-financial, each of which was evaluated using the Kalman filter.

Dumičić (2016) and Hartmann et al. (2005) consider financial stability through the systemic risks prism. Dumičić (2016) uses two indices to assess systemic risk – the accumulation of systemic risk and its consequences (materialization). In turn, according to Hartmann et al. (2005), system risk assessment involves considering the spillover effects in the banking system and the impact of banks on systemic shocks.

Yahya et al. (2017) study the impact of political stability, macroeconomic and some specific variables on the bank profitability. Their study showed that all external factors (GDP, inflation and political instability) have a significant impact on the bank's profitability.

With regard to the assessment of the stability and vulnerability of the banking system, proposals on the relevant issue are also presented in a large number of scientific works, most of which provide for the index method use. However, the composition and number of indicators for assessing these approaches have both common features and some differences.

Swamy (2013) and Kočišová (2014) assess the banking system stability in terms of capital adequacy, liquidity, profitability and bank assets quality. Petrovska and Mihajlovska (2013) use indicators of solvency assessment, credit and currency risk, profitability and liquidity risk of banks to calculate the banking system stability index. Kozaric and Zunic (2014) assess the financial sustainability of the banking sector in Bosnia and Herzegovina based on indicators of asset quality, profitability, liquidity and currency risk. Hawkesby (2000), in addition to capital adequacy, asset quality, liquidity, market risk sensitivity and profitability of banks, takes into account the level of loan security, their diversification, and related party exposures. To assess the banking sector financial stability, Popovska (2014) suggests using an integral indicator, which is formed by aggregating data by groups of indicators of the CAMELS system.

According to Shar (2010), it is advisable to assess the financial stability and vulnerability of banking institutions using the "bankometer" model. The peculiarity of the developed approach is to take into account not only the weights for each component of the aggregate indicator, but also to provide guidance on the normative values of individual indicators (capital adequacy, capital to asset ratio, liabilities to assets ratio, share of bad loans, income/expenditure ratio, share of loans in assets) and proposals for the interpretation of results at intervals of values for the sustainability indicator.

The use of the z-score technique is a common practice in assessing the banking system stability. It should be noted that the corresponding method is also used in combination with other approaches. For example, Rahim and Zakaria (2013) combine z-score with the level of bad loans, and Zahra et al. (2018), except z-score, calculate the stability index of the banking system. Another methodology that gives preference to bank profitability indicators as a criterion for determining the banking system stability is that by Gordon (2015). To assess the stability of the Jamaica banking system and monitor its status, an absorption ratio is used which reflects the agreed changes in bank profitability by the indicators of return on assets and net interest margin.

Interesting are comprehensive approaches to assessing the banking system stability (Jahn & Kick, 2012) and building a stress index for the banking sector (Hanschel & Monnin, 2005). Within the first approach, macroeconomic, financial and structural indicators were used to assess the stability of the German banking system. The distinctive feature of the second approach, as Hanschel and Monnin (2005) state, is that the methodology for defining the corresponding index is aimed at continuously taking into account the range of states, and not just the differentiation of crises from calm periods. The variables included in the index are potential symptoms of bank crises and cover four areas: market prices, aggregated bank balances, non-public information and structure data.

Researchers' suggestions regarding the assessment of the banking system stability make it possible to conclude that in most of the works analyzed, the level of the banking system stability is calculated as a weighted sum of values of sub-indices that correspond to particular areas of evaluation. As regards the content load of the constituents of the banking system stability index, existing approaches cover various aspects of its functioning and links with other economy sectors. In this case, some of the proposals are fragmented or determine the banking system stability only through the stability of banks. In order to assess the banking system stability within the framework of this study, an approach based on the consideration of the emergence (non-linearity) is used, according to which the system has other characteristics that are not in its components (Lesik, 2017). The existence of complex ties between the elements, the peculiarities of internal organization and the main functions that differentiate the banking system from banks, led to the choice of indicators for assessing its stability.

1.2. The experience of using monitoring to ensure the banking system stability

The practice of using monitoring as a management tool is quite common in almost all spheres of activity, including banking. Monitoring is considered as a process of gathering and analyzing information, on the basis of which stakeholders make conclusions about the degree to which the goals and objectives of the program or project are realized (Handbook on Planning, Monitoring and Evaluation for Development Results, 2009; Kusek & Rist, 2004; Church & Rogers, 2006; Chaplowe, 2008; Barca & Carraro, 2013; Jili & Mthethwa, 2016). According to Kusek and Rist (2004), the main monitoring functions are as follows: clarification of the program objectives; coordination of actions and necessary resources for goals achievement; transformation of goals into concrete indicators of their measurement; systematic analysis of indicators and comparison of their actual values with planned ones; generalization of information about the results of work. Barca and Carraro (2013) also noted that the following tasks should be addressed in order to build a monitoring system: the selection and calculation of key indicators and their desirable values in accordance with goals established; formation of conclusions on the implementation of goals for stakeholders and management. In addition to developing a set of indicators to measure the extent to which goals are achieved and to analyze their changes, Chaplowe (2008) suggests that causal relationships between flows of analytical information should be taken into account.

To determine the most significant factors affecting the level of the banking system stability, some scientists suggest using regression analysis. For example, Demirguc-Kunt and Detragiache (2000) recommend the use of a multivariate logit model to monitor the banking system fragility. While constructing the logit regression, the following independent variables are used: the GDP growth rate, devaluation, real interest and inflation, the ratio of budget surplus to GDP, the ratio of the monetary aggregate M2 and the volume of gold and foreign exchange reserves, the growth rate of lending, GDP per capita, and change in terms of trade. In this paper, the correlation of the classes of the banking system fragility with the probability levels of the crisis is also proposed.

Rahim and Zakaria (2013) constructed two econometric models of the financial stability index dependence, calculated by the z-score method, and the level of bad loans (endogenous factors) on the following variables: loan assets ratio, cost/income ratio, total assets, income diversity, Herfindahl index, market share of banks, inflation rate, and real GDP. Zahra et al. (2018), to identify the factors affecting the banking system stability, construct multivariate Markov switching models. Indices of industrial production, inflation rate, exchange rate, capital adequacy, loan and deposit ratio, etc. were used as independent variables.

Laker (1999), for the purpose of monitoring the financial stability, determines the necessity of using descriptive analysis, which gives an intuitive understanding of how crises develop. This approach also involves analyzing past trends in financial stability indicators. Brave and Butters (2011) take into account cross-correlation between financial variables and consider historical changes in the overall stability index, while Caranovic and Caranovic (2015) suggest analyzing the volatility of the values of individual sub-indices during the period. Proposals for improving the monitoring of the banking system stability by identifying the links between the indicators for assessing financial stability of banks are presented by Kozaric and Zunic (2014). Polius and Sahely (2011) emphasize the substantiation of key indicators for monitoring the banking sector reliability using cluster and discriminatory analysis, and classification trees.

In monitoring financial stability, including that aimed at preventing currency crises, Sarlin (2011) considers it expedient to develop self-organizing maps, which are a visualization tool. Ryan (2017) offers the visualization of the systemic risk assessment results, and for this purpose the author uses heat mapping to highlight areas of high risk and compare risk levels over different periods of time. Flood et al. (2016), Sinenko and Lielkalne (2015) also emphasize that visual analytics is a necessary and effective tool for navigating financial information, and its use increases the effectiveness of monitoring and allows us to make well-argued decisions for the macro prudential policies development. In particular, Sinenko and Lielkalne (2015) use risk maps or cobweb diagrams while emphasizing the expediency of taking the thresholds of risk indicators into account.

Mörttinen et al. (2005) consider the monitoring of the banking system stability as a complex process combining the following analytical procedures: the current assessment of the financial situation in the banking sector; analysis of risks that are sources of banking crises; stress testing of the banking system, which includes analysis of the banks' resilience to the identified risks.

The analysis of proposals for monitoring the banking system stability makes it possible to conclude that most of the existing approaches only cover certain stages of monitoring and the peculiarities of their implementation. Of course, there are also complex approaches, but from the point of view of content-based monitoring, which is a continuous process, they lack recommendations on the logical combination of the individual procedures' results. To that end, monitoring of the banking system stability is proposed to be carried out at the following interconnected stages: the formation of the analytical basis for the study; comparison of the actual assessment results with the data for previous years; comparison of the calculated values of partial indicators with critical (threshold) ones signaling the crisis trends availability; analysis of the causes and consequences of the revealed deviations of the general index, sub-indices and partial indicators; developing recommendations for ensuring the banking system stability in the future.

2. RESEARCH METHODOLOGY

The analytical basis for the causal analysis use is as follows: the results of a complex integrated assessment of the banking system stability and the determining the conformity of the values of four sub-indices and the general index to qualitative levels according to the scale established by the Fibonacci law (Bezrodna & Lesik, 2017); interval scales for the values of separate indicators of the banking system stability, built on the three-sigma rule and justified critical values of indicators signaling the crisis trends existence (Lesik, 2017).

The analysis of the results of quantitative and qualitative assessment of the banking system stability allows specifying the problems in its functioning. Therefore, the means of canonical analysis is proposed to identify causal relationships between stability assessment indicators, which will form a logical diffusion chain of crisis phenomena. The advantage of this method is that it is possible to determine the influence of factors not on one resultant indicator, but at the same time on several indicators. Within the procedure for calculating canonical correlations, the initial parameters (productive and explanatory indicators) are replaced by their linear combinations (weighted sums), and the correlation between the new canonical variables is as follows (Dubrov et al., 2003):

$$\begin{cases} U = a_1x_1 + a_2x_2 + \ldots + a_qx_q \\ V = b_1y_1 + b_2y_2 + \ldots + b_py_p \end{cases}, \quad (1)$$

where $x_1, \ldots, x_q$ and $y_1, \ldots, y_p$ – the set of explanatory and result indicators, respectively; $a_1, \ldots, a_q$ and $b_1, \ldots, b_p$ – canonical weights determining the contribution of the corresponding index to the values of canonical variables *U* and *V*, respectively.

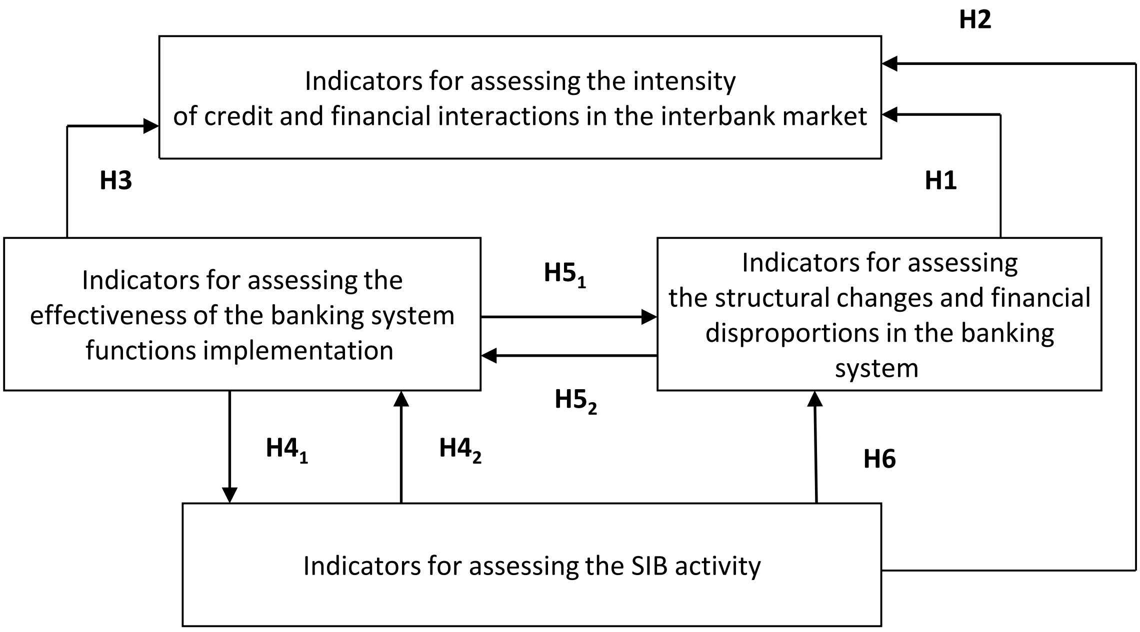

Figure 1. Hypothetically determined causal relationships between indicators for assessing the banking system stability

As a result of the canonical analysis, the canonical roots are calculated, representing a pair of weighed sums. For each canonical root, the value of the correlation coefficient between the corresponding pair of canonical variables (r_{UV}), statistics χ^2 , level of significance (p), and lambda are determined. One of the main criteria for checking the statistical significance of canonical roots is the analysis of the significance level, which should not exceed 0.05. To substantiate the most significant indicators that make the greatest contribution to the relationship between canonical variables of U (explanatory) and V (resulting), the absolute values of canonical weights and loading of canonical factors are investigated.

The basis for the causal analysis within the first direction is the formation of hypotheses (H1-H6) on the presence of causal relationships between groups of indicators for assessing the banking system stability (Figure 1).

The total redundancy indicator is used, which shows the variability of the resulting characteristics due to the change in explanatory characteristics to confirm or reject the hypotheses on the correctly determining factors of causes and results in the implementing the canonical analysis by means of software package Statistica 8.0.

The second direction of causal analysis use involves the construction of models of linear and polynomial regression, which show the dependence of the values of the banking system stability index (Y) on the change in parameters that characterize the banking regulation tools as one of the Central Bank's functions. From there, the following factor characteristics (X) for the regression analysis are selected: NBU discount rate (X_1); weighted average refinancing rate for all instruments (X_2); the Index of the First Stock Trading System (X_3), the weighted average yield of the Bonds of the Internal State Loan (X_4), the volume of public securities market operations (X_5), the average reserve requirement (X_6), official reserve assets (X_7), currency interventions of the NBU (X_8), balance of payments (X_9), mandatory economic ratios of capital (X_{10}– X_{12}), liquidity (X_{13}– X_{15}), credit risk (X_{16}– X_{19}), investment (X_{20}– X_{21}), the average value of the rates of deductions to reserves to cover active banking operations risks (X_{22}), and hryvnia rate to US dollar (X_{23}). In addition to identifying the relationship between the resulting and factor characteristics within the regression analysis, it is proposed to calculate the elasticity coefficients that represent the percentage change in the function as a result of 1% change in the arguments. Thus, it is possible to assess the sensitivity of the banking system stability index, before changing the values of X_1– X_{23}.

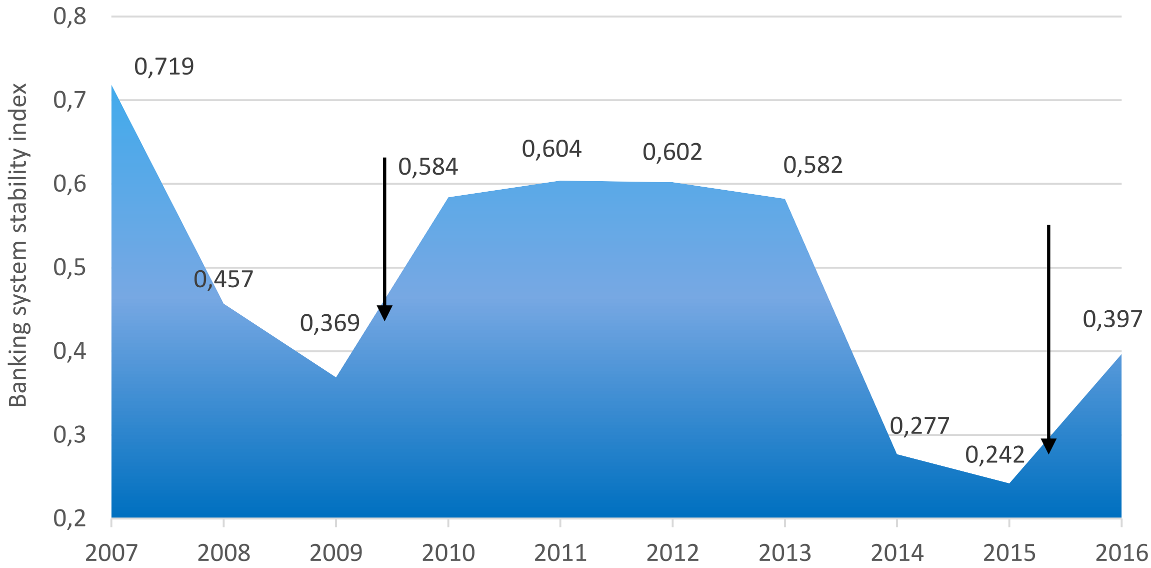

Figure 2. Dynamics of changes in the stability index of the Ukrainian banking system for the 2007–2016 period

Formulas for calculating the partial elasticity coefficient (E_x) for the linear regression model and the mean elasticity coefficient ($\overline{E}$) for n-th polynomials are as follows:

$$E_x = b \cdot \frac{\overline{x}}{\overline{y}}, \qquad (2)$$

$$\overline{E} = f'\overline{x} \cdot \frac{\overline{x}}{\overline{y}}, \qquad (3)$$

where b – regression coefficient; $f'\overline{x}$ – derivative of the first order for x; $\overline{x}$ – mean of factor characteristic; $\overline{y}$ – mean of resultant characteristic.

3. EMPIRICAL RESULTS

Ukrainian banking system stability has been assessed according to four groups of indicators, the convolution of all of which allows to construct appropriate subindices: assessing the intensity of credit and financial interactions in the interbank market (subindex_1); assessing the efficiency of the banking system functions implementation (subindex_2); assessing the structural changes and financial disproportions in the banking system (subindex_3); assessing systemically important banks (SIBs) (subindex_4). In this case, subindex_2 is formed by combining the following components: subindex_2_1, which includes indicators for assessing the currency regulation effectiveness; subindex_2_2 – assessing the monetary regulation effectiveness; subindex_2_3 – assessing the state of bank lending to the economy. The dynamics of the values of the Ukrainian banking stability index (BSI) during 2007–2016 is presented in Figure 2.

The graph shows the existence of cyclical fluctuations during the analyzed period, in particular, the period of stabilization (2010–2013) after the 2008–2009 crisis is replaced by the new crisis of 2014–2015. Starting in 2013, the banking sector of Ukraine has undergone certain changes: as a result of the private PrivatBank transformation into the state bank, and the bankruptcy of several dozen private banks, the structure of the banking system of the state has changed considerably, while the system as a whole coped with this transformation in terms of improving financial stability (Ramskyi et al., 2017). The critical changes in the banking system stability index were characteristic of 2009 and 2015, which is confirmed by the fact that in the relevant periods the system was in crisis.

As for the qualitative interpretation of the quantitative assessment, the low level of the Ukrainian banking system stability was characteristic for 2009 and 2014–2015. Such conclusions are made according to the Fibonacci law-based scale. According to the Fibonacci law, all changes occur at the level of 38.2% and 61.8%. Proceeding from this, the low level (LL) of the banking system

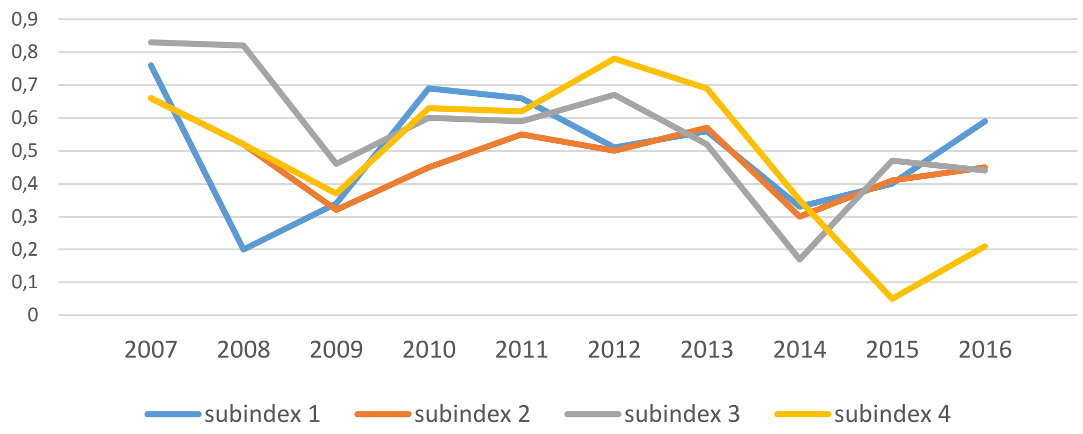

Figure 3. Dynamics of changes in values of components of the Ukrainian banking system stability index for 2007–2016

stability index corresponds to its values that fall to the interval [0; 0.382], the average level (AL) – (0.382; 0.618), and the high level (HL) – (0.618; 1). A similar scale was used for grading the values of sub-indices, the dynamics of which are shown in Figures 3 and 4.

Figure 3 clearly demonstrates that in 2014, the simultaneous decline in the values of all sub-indices of the banking system stability was observed, and in 2015, the low level of the index was due to a significant deterioration of the financial status of the first and second order significance SIB (the order is determined based on the share of SIB assets in total assets of the banking system). As for the individual components of subindex_2 (Figure 4), in 2014, the tendency to decrease in the values of all its components was also revealed. In 2015, this negative trend was observed only for subindex_2_1, which confirms the continuation of the progressive devaluation of the national currency. According to certain stages of the banking system stability monitoring, after the general results of its assessment are received, the general tendencies are decomposed, that is, the transformation is made into the plane of a detailed analysis of the revealed deviations in the values of individual sub-indices and the general index of the banking system stability (Table 1).

Despite the positive change in the stability index of the Ukrainian banking system, the values of subindex_2_3 and subindex_4 remain low, indicating the need for more intensive monitoring of indica-

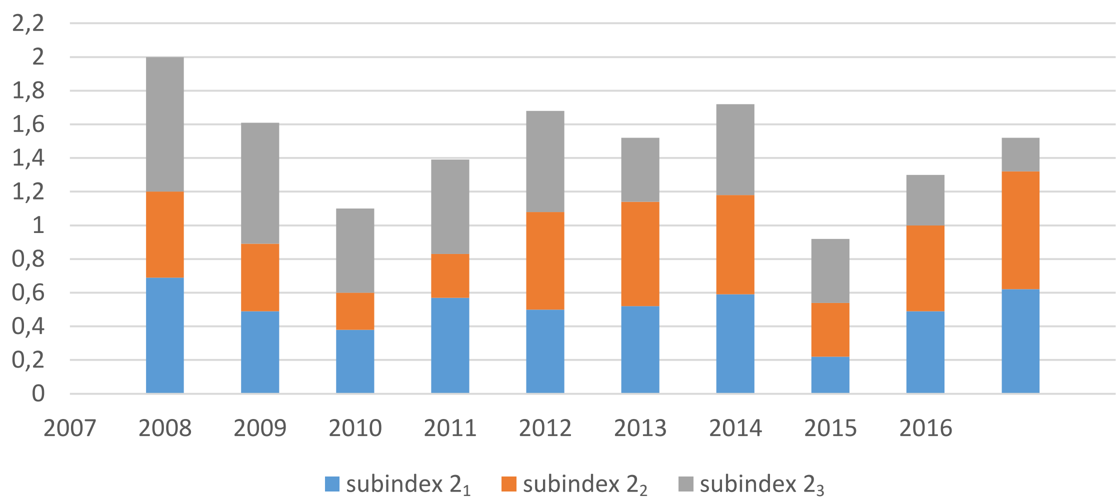

Figure 4. Dynamics of changes in values of sub-index components of the effective implementation of the Ukrainian banking system functions for 2007–2016

Table 1. Comparison of the assessment findings for banking system stability during the 2015–2016 period

Indicator	Deviation of sub-index/index values for the period and the change in their qualitative levels	
subindex_1	+0.183	AL→AL
subindex_2	+0.044	AL→AL
subindex_2_1	+0.155	AL→HL
subindex_2_2	+0.143	AL→HL
subindex_2_3	-0.049	LL→LL
subindex_3	-0.03	AL→AL
subindex_4	+0.169	LL→LL
Banking stability index, BSI	+0.155	LL→AL

tors for assessing the state of uninterrupted service of the economy and SIB activity. Specifying the list of indicators whose negative changes have led to a decrease in the corresponding subindices is made taking into account the comparison of their actual and critical values (Table 2). Such indicators in 2016 for the banking system of Ukraine are: the ratio of volumes of interbank loans to NBU refinancing loans; the level of the economy dollarization; the level of financial depth; interest rate on refinancing with regard to the rate on bank loans; ratio of bank assets to GDP; the share of state capital in the authorized capital of banks; the ratio of the number of loss-making and profitable banks; the level of SIB financial stability (1^{st} order significance); and risk level of SIB loan portfolio.

According to the formulated hypotheses (Figure 1), the interaction models between the groups of indicators for assessing the banking system stability are constructed and explanatory indicators are substantiated, which most of all result in the change of the resulting parameters in the models (Table 3).

In order to ensure the Ukrainian banking system stability, in addition to enhanced monitoring of the subindex_2_3 and subindex_4 components, in the future, it is appropriate to focus also on the indicators influencing their changes in accordance with the canonical analysis results. The constructed models experimentally confirm hypotheses concerning the causal relation existence between groups of indicators for assessing the banking system stability. Figure 5 specifies the relationships between individual resulting and explanatory indicators, which is implemented taking into account the Table 3 data and the coefficients of the pair correlation between the features.

The change in the individual indicators for the assessing the banking system stability, the values of which in 2016 corresponded to the critical level, can be monitored based on the following causal relationships. The decrease in the ratio of interbank loans to NBU refinancing loans is due to an increase in the share of state capital, the number of unprofitable banks and banks with low capitalization. The increase in the number of loss-making banks in relation to profitable ones, on the one hand, influences the level of financial depth (feedback), and on the other, is determined by the growth of the economy dollarization and the share of currency assets, the interest rate refinancing relative to the rate on bank loans, the share of overdue debt bank loans, the level of riskiness of the SIB loan portfolio, as well as a decrease in the interest rate on bank loans relative to inflation, the volume of banks' assets to GDP and the level of SIB financial stability. The decrease in the share of banks' assets in GDP is negatively affected by the increase in overnight loans and the level of the SIB loan portfolio riskiness, which in turn has a direct correlation with the level of economy dollarization and is inversely proportional to the coefficient of coverage of gross international reserves of short-term external debt and interest rate refinancing relative to the rate on bank loans. An increase in the share of overnight credits also causes a change in the indicator, which shows the ratio of interest rate of refinancing and rates on bank loans. The growth of the state capital share is due to the growth of the volume of overdue debts on bank loans and the decrease in their assets, while the level of first-order SIB financial stability is sufficiently correlated with the share of foreign currency assets (feedback).

Table 2. Threshold (critical) values of indicators for assessing the banking system stability

Source: Lesik (2017).

Indicator	Course of changes in the crisis period and threshold values of indicators signaling its advent	
1. Indicators for assessing the intensity of credit and financial interactions in the interbank market (subindex_1)		
Share of NBU funds in banks liabilities, % (IL_1)	↑	More than 15.238
Ratio of volumes of interbank loans to refinancing loans of the NBU (IL_2)	↓	Less than 38.290
Share of stabilization loans in the total amount of NBU refinancing, % (IL_3)	↑	More than 39.577
Ratio of the amounts of refinancing NBU loans returned and provided during the year, % (IL_4)	↓	Less than 39.792
Ratio of volumes of interbank loans to the authorized capital of banks (IL_5)	↑	More than 11.765
Share of overnight loans in the total amount of NBU refinancing, % (IL_6)	↑	More than 48.175
2. Indicators for assessing the effectiveness of banking system function implementation (subindex_2)		
2.1. Currency regulation effectiveness (subindex_2_1)		
Ratio of NBU currency interventions (balance between purchase and sale of foreign currency) to gross international reserves (CR_1)	↓	Less than -0.559
Level of the economy dollarization, % (CR_2)	↑	More than 35.406
Share of foreign currency assets in the total assets of banks, % (CR_3)	↑	More than 50.790
Share of currency sold by banks to the population in the total volume of transactions in the cash foreign exchange market, % (CR_4)	↑	More than 67.300
Coefficient of gross international reserves coverage of short-term external debt at maturity (CR_5)	↓	Less than 0.293
2.2. Money turnover management effectiveness (subindex_2_2)		
Cash ratio, % (MR_1)	↑	More than 30.722
Level of security of the money market functioning, % (MR_2)	↑	More than 17.431
Financial depth level, % (MR_3)	↓	Less than 26.011
2.3. State of bank lending to the economy (subindex_2_3)		
Interest rate on bank loans relative to inflation, % (BC_1)	↓	Less than -7.109
Interest rate on refinancing with regard to the rate on bank loans (BC_2)	↑	More than 1.029
Bank assets to GDP ratio, % (BC_3)	↓	Less than 68.153
Bank loan arrears to GDP ratio, % (BC_4)	↑	More than 10.425
3. Indicators for assessing the structural changes and financial disproportions in the banking system (subindex_3)		
Share of banks liquidated during the year, % (STR_1)	↑	More than 13.883
Share of foreign capital in the authorized capital of banks, % (STR_2)	↓	Less than 34.186
Share of state capital in the authorized capital of banks, % (STR_3)	↑	More than 39.002
Ratio of the number of banks with low and sufficient level of capitalization (STR_4)	↑	More than 0.239
Ratio of the number of loss-making and profitable banks (STR_5)	↑	More than 0.357
4. Indicators for assessing the systemically important banks activity (subindex_4)		
Level of the SIB financial stability (1^{st} order significance) (SIB_1)	↓	Less than 15.902
Level of the SIB financial stability (2^{nd} order significance) (SIB_2)	↓	Less than 2.659
Level of public confidence to SIB (SIB_3)	↓	Less than 0.392
Level of riskiness of SIB's loan portfolio (SIB_4)	↑	More than 0.452

Table 3. Canonical models of relationships between the indicators for assessing the banking system financial stability

Models of relationships between the indicators for assessing the banking system stability	Most significant explanatory indicators
Indicators for assessing the structural changes and financial disproportions in the banking system (U_1) and the intensity of credit and financial interactions in the interbank market (V_1)	
$\begin{cases} U_1 = 0.11STR_2 - 0.73STR_3 + 0.75STR_4 - 0.55STR_5 \\ V_1 = 1.15IL_1 + 0.56IL_2 - 0.27IL_4 - 0.97IL_6 \end{cases}$ $p = 0.018567$	STR_4, STR_3, STR_5, STR_2
Indicators for assessing the SIB activity (U_2) and the intensity of credit and financial interactions in the interbank market (V_2)	
$\begin{cases} U2 = 0.41SIB_1 - 0.12SIB_2 + 0.55SIB_3 + 1.07SIB_4 \\ V2 = -0.74IL_3 + 0.65IL_4 - 0.61IL_5 + 0.50IL_6 \end{cases}$ $p = 0.013568$	SIB_3, SIB_4
Indicators for assessing the intensity of credit and financial interactions in the interbank market (U_3) and the foreign exchange regulation effectiveness (V_3)	
$\begin{cases} U3 = 0.88IL_1 + 0.25IL_2 - 0.03IL_3 - 1.18IL_6 \\ V3 = -0.82CR_1 + 0.11CR_2 - 0.57CR_3 + 1.17CR_4 \end{cases}$ $p = 0.004$	IL_6, IL_1
Indicators for assessing the intensity of credit and financial interactions in the interbank market (U_4) and the effectiveness of the money turnover regulation (V_4)	
$\begin{cases} U4 = 0.70IL_2 - 0.71IL_3 - 0.75IL_5 + 0.29IL_6 \\ V4 = -3.21MR_1 + 2.82MR_2 - 2.80MR_3 \end{cases}$ $p = 0.03422$	IL_5, IL_3
Indicators for assessing the intensity of credit and financial interactions in the interbank market (U_5) and the state of the bank lending to the economy (V_5)	
$\begin{cases} U5 = -0.32IL_1 + 0.74IL_2 - 0.19IL_3 + 1.09IL_6 \\ V5 = -1.16BC_1 - 0.81BC_2 - 0.86BC_3 - 0.43BC4 \end{cases}$ $p = 0.011724$	IL_6, IL_2
Indicators for assessing the foreign exchange regulation effectiveness (U_6) and assessing the SIB activity (V_6)	
$\begin{cases} U6 = -0.47CR_1 - 0.28CR_2 - 0.52CR_3 + 0.90CR_5 \\ V6 = 0.19SIB_1 - 0.15SIB_2 + 0.23SIB_3 - 0.87SIB4 \end{cases}$ $p = 0.035553$	CR_5, CR_3, CR_2
Indicators for assessing the SIB activity (U_7) and the state of the bank lending to the economy (V_7)	
$\begin{cases} U7 = 0.003SIB_1 - 0.15SIB_2 - 0.03SIB_3 - 0.9SIB4 \\ V7 = 0.30BC_1 + 0.0BCy_2 - 0.44BC_3 + 0.61BC_4 \end{cases}$ $p = 0.030812$	SIB_4, SIB_2
Indicators for assessing the foreign exchange regulation effectiveness and structural changes (U_8) and financial disproportions in the banking system (V_8)	
$\begin{cases} U8_1 = -0.73CR_1 + 0.05CR_2 - 0.85CR_3 + 0.46CR4 \\ V8_1 = -0.26STR_2 + 0.47STR_3 + 0.75STR_4 - 0.81STR_5 \end{cases}$ $p = 0.000178$ $\begin{cases} U8_2 = 0.89CR_1 + 0.23CR_2 - 0.51CR_3 - 0.62CR4 \\ V8_2 = 0.26STR_2 + 0.97STR_3 - 0.32STR_4 - 0.48STR_5 \end{cases}$ $p = 0.007150$ $\begin{cases} U8_3 = -0.22CR_1 + 1.17CR_2 - 0.19CR3 + 1.13CR4 \\ V8_3 = 1.50STR_2 - 1.13STR_3 + 0.96STR_4 - 0.31STR_5 \end{cases}$ $p = 0.023677$	CR_3, CR_1, CR_2

Table 3 (cont.). Canonical models of relationships between the indicators for assessing the banking system financial stability

Models of relationships between the indicators for assessing the banking system stability	Most significant explanatory indicators
Indicators for assessing the state of bank lending to the economy (U_9) and structural changes and financial disproportions in the banking system (V_9)	
$\begin{cases} U9 = 0.56BC_1 + 0.54BC_2 - 0.24BC_3 + 0.63BC4 \\ V9 = 0.32STR_2 + 0.43STR_3 + 0.31STR_4 + 0.30STR_5 \end{cases}$ $p = 0.001942$	BC_4, BC_1, BC_2, BC_3
Indicators for assessing the structural changes and financial disproportions in the banking system (U_{10}) and money turnover regulation effectiveness (V_{10})	
$\begin{cases} U10 = 1.27STR_2 - 0.79STR_3 + 0.28STR4 + 0.20STR5 \\ V10 = 0.75MR_1 - 1.02MR_2 - 0.16MR_3 \end{cases}$ $p = 0.021459$	STR_2, STR_5
Indicators for assessing the SIB activity and structural changes (U_{11}) and financial disproportions in the banking system (V_{11})	
$\begin{cases} U11 = -0.38SIB_1 + 0.18SIB_2 + 0.05SIB_3 - 0.99SIB4 \\ V11 = 0.06STR_2 - 0.79STR_3 + 0.35STR_4 - 0.49STR5 \end{cases}$ $p = 0.049394$	SIB_4, SIB_1, SIB_2

An analysis of the constructed linear and polynomial models allowed to identify statistically significant ones that are suitable for further use; by calculating the elasticity factors – to assess the banking stability sensitivity to changes in parameters that characterize the most effective, in terms of influence on its level, instruments of banking regulation (Table 4).

The results of calculations of partial elasticity coefficients have shown that the increase in parameters characterizing the banking regulation instruments by 1% of the average level, both positively and negatively affects the significance of the Ukrainian banking system stability index. According to the elasticity coefficient value (taken into account by module) among the instruments of banking regulation, changes in the level of the Ukrainian banking system stability are most determined by the effectiveness of the managing foreign exchange reserves and the establishment of mandatory economic standards (current and instant liquidity, large credit risks). The rating of the indicators characterizing the banking regulation tools, according to their influence on the change in the stability index, is as follows: $X_7 > X_{14} > X_{13} > X_{17} > X_{12} > X_6 > X_2 > X_1 > X_{19} > X_{21} > X_{20}$.

In the process of the stability monitoring, consideration of its sensitivity to changing parameters that characterize banking regulation instruments will allow to predict possible deviations of the effective indicator, depending on the priorities of the Central Bank policy, and to introduce corrective measures to ensure the banking system stability.

Table 4. Substantiating the most effective bank regulation tools based on the influence on the level of Ukrainian banking system stability

Bank regulation tools (used by the NBU) and their parameters		Regression models and values of multiple correlation ratios (R)	Elasticity ratios (%) and the course of BSI changes as a result of factor characteristics increase by 1%	
Accounting policy	X_1	$Y = -0.777 \cdot X_1$, $R = 0.7773$	–0.19091	↓
Bank refinancing policy	X_2	$Y = -0.844 \cdot X_2$, $R = 0.8442$	–0.24368	↓

Table 4 (cont.). Substantiating the most effective bank regulation tools based on the influence on the level of Ukrainian banking system stability

Bank regulation tools (used by the NBU) and their parameters		Regression models and values of multiple correlation ratios (R)	Elasticity ratios (%) and the course of BSI changes as a result of factor characteristics increase by 1%	
Establishment of mandatory reserve requirements for banks	X_6	$Y = 0.364 + 2.688X_6 + 0.619\ X_6^2 - 1.444X_6^3$, $R = 0.8442$	0.313683	↑
Gold and foreign exchange reserves management	X_7	$Y = 0.749 \cdot X_7,\ R = 0.7496$	4.129	↑
Establishment of mandatory economic standards	X_{12}	$Y = -0.549 + 0.864X_{12} + 0.924X_{12}^2$, $R = 0.8116$	–0.34358	↓
	X_{13}	$Y = 0.486 - 0.187X_{13} - 0.540X_{13}^2$, $R = 0.7828$	–2.34242	↓
	X_{14}	$Y = -0.92369 + 0.11881X_{14} + 3.35911X_{14}^2 - 0.24886X_{14}^3 - 1.46582X_{14}^4$, $R = 0.8225$	2.812911	↑
	X_{17}	$Y = -0.732 \cdot X_{17},\ R = 0.7321$	–1.68	↓
	X_{19}	$Y = -0.414 - 2.325X_{19} + 2.571\ X_{19}^2 + 3.619X_{19}^3 - 2.562X_{19}^4$, $R = 0.9919$	0.123985	↑
	X_{20}	$Y = 0.633 + 0.384X_{20} - 1.929X_{20}^2 + 0.8002X_{20}^3$, $R = 0.8202$	0.000567	↑
	X_{21}	$Y = 0.639 + 2.429X_{21} + 2.849X_{21}^2 + 1.803X_{21}^3 + 1.132\ X_{21}^4$, $R = 0.7993$	0.112605	↑

CONCLUSION

The monitoring of the banking system stability involves continuous supervision (collection and accumulation of information), processing and analysis of deviations of indicators for the stability assessment in order to increase the management decisions validity and predict the future development and dynamic movement of the banking system.

The monitoring of the banking system stability involves the formation of an analytical basis: the construction of a general index through the construction of sub-indices for assessing the intensity of credit and financial interactions in the interbank market, the efficiency of the banking system functions implementation, structural changes and financial disproportions in the banking system, SIBs' activity; the development of interval scales to determine the relevance of the values of the general stability index and its sub-indices, high, average and low qualitative levels; for individual indicators, justifying threshold values signaling the crisis trends existence.

The use of causal analysis in the monitoring of the banking system stability involves: structuring the causal relationships between the indicators for its assessment, which allows to identify the most significant factors affecting the deviations of both individual indicators and the change of sub-indices; identifying the dependence of the level of the banking system stability on the parameters characterizing the banking regulation instruments – interest policy, refinancing operations of banks and securities in the open market, establishment of the mandatory reserve requirements for banks, management of gold and foreign exchange reserves, regulation of export and import of capital, establishment of mandatory economic standards and checkoff rate to reserves for covering risks of active banking operations, the exchange rate management; assessing the sensitivity of the banking system stability index to the change in the corresponding parameters and the formation of their rating by the elasticity criterion (based on the definition of the percentage change in the index due to an increase in the parameter by 1% of the average).

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