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Russian Banks Financial Stability Loss Diagnostic: Multidimensional Logit-Model Approach

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Abstract. The financial stability of the banking sector characterizes the "economic health" at the national and global levels and its deterioration is a cause of financial crises. Improving the toolkit for early diagnosis of financial problems is a key element of monitoring and forecasting banking risks. The purpose of the study is to examine the specific features of intrabank factors influencing the risk of financial stability loss in Russian banks. The research hypotheses are as follows: 1) the highly significant predictors of bank's financial instability risk are return on assets and overdue loans; 2) the impact degree of financial stability factors differs for medium- and long-term horizons of risk forecasting. The authors present multidimensional logit models for estimating the probability of the loss of financial stability by banks for 6 and 12 months based on four variables: capital adequacy ratio, overdue loans fraction over 90 days, return on assets, current liquidity ratio. It was revealed that a growth of return on assets has a positive significant effect on financial stability, and an increase in overdue loans has a negative significant effect on a bank's "financial immunity". It is shown the impact degree of financial stability factors is varied for different forecast horizons: the return on assets is a more relevant factor for 6 months, and the overdue loans fraction is more important for a 12 month period. The theoretical significance consists in better scientific understanding of factors impacting on a bank's financial stability. The practical significance lies in the possibility for commercial banks to use econometric models and conclusions in analytical and risk-predictive algorithms.

Key words: commercial bank; financial stability; financial stability factors; logistic regression; probability of financial stability loss.

JEL G21, C53

1. Introduction

The financial stability of the banking sector is an indicator of economic health at the national and global levels. The strategic importance of managing a bank's financial stability lies in ensuring the competitiveness of bank as a market entity, as well as maintaining the stability of the banking system. The implementation of strategic tasks takes place at the tactical level of banking management, where the dominant role is played by the financial condition monitoring system and risk forecasting.

Under the conditions of instability and global systemic changes, bankers and researchers pay attention to the transformation of the socio-economic paradigm: VUCA-environment (Volatility, Uncertainty, Complexity, Ambiguity) is complemented by BANI-conditions (Brittle,

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Anxious, Nonlinear, Incomprehensible) [1]. That is, the modern business environment is characterized by a higher degree of financial and psychological tension and complex factor relationships.

In such circumstances, maintaining the target state of financial stability is one of the key problems of financial management. Insufficient capital and liquidity, asset quality deterioration, reduced profits worsen the solvency of banks, which is transmitted to other sectors of the economy: enterprises and individuals cannot receive money or make payments. Consequently, there are failures in the sphere of production and monetary circulation.

In addition, the specifics of reputation in the banking business are found in the customer relationship system. The loss of customer trust inevitably leads to a decrease in financial stability, and, conversely, financial problems negatively affect business reputation. In this context, ensuring the reliability and stability of the bank's activities is of particular relevance.

We believe that improving the information and analytical tools for making managerial decisions that ensure the regulation of financial flows of a commercial bank is an urgent research direction. Improving the efficiency of financial analysis and the reliability of risk forecasting allows to adjust the current functioning of bank's financial mechanism.

The *aim of this study* is to examine the specifics of intrabank factors influence on risk of financial stability loss of Russian banks.

Research hypotheses:

H1: The highly significant predictors of bank's financial instability risk are return of assets and overdue loans.

H2: Impact degree of financial stability factors differs for medium- and long-term horizons of risk forecasting.

Article structure. The introduction contains the relevance, purpose and hypothesis of this study. The second section provides a literature review on the interpretation of bank's financial stability factors and methodological approaches for analyzing and forecasting risk of financial instability. The third section defines the methodology and mathematical tools for analysis and econometric modelling The fourth section presents the results of estimating the probability of bank's financial stability loss and hypothesis testing findings. The fifth section contains discussion on research results. In conclusion the author's upshots are formulated which determined the originality and scientific novelty of the study.

2. Literature review

2.1. Research viewpoints on the interpretation of bank's financial stability and its factors

An overview of scientific papers on the theoretical understanding of financial stability allows to note that authors equate the concepts of "reliability", "stability", "sustainability", but consider them from different points of view are discussed below.

Within the framework of the resource approach, scientists believe that a sustainable bank has sufficient financial resources to carry out stable activities.

Ozili & Iorember [2] determine bank's financial stability as the ability to transform resources (human, financial, information and others) with maximum efficiency in risk and competitive environment.

Chen [3] research bank's financial stability through the prism of capital adequacy and the optimal ratio of own and borrowed resources.

Vostrikova & Panina [4] characterize the financial stability of a bank in terms of achieving goals, taking into account available financial resources.

Within the framework of the protective approach the focus is on bank's ability to withstand negative factors. In study of Papanikolaou [5] financial stability is char-

acterized as the state of an organization in which it is able to withstand shocks and eliminate imbalances without external help.

Rahman et al. [6] notes that reliable banks, like the entire financial system, optimally allocate capital, reduce investment risk and prevent disasters through the self-correction processes.

Miah & Uddin [7] consider financial stability as the ability to withstand adverse internal and external economic and financial shocks and the ability to fulfill promised obligations without external interference.

Within the framework of the combined approach, authors urge to consider financial stability comprehensively, also pointing to the trust of the bank's customers, stability and maintenance of financial indicators, adaptation to changing external and internal factors, risk management and preservation of business reputation. For example, to ensure financial stability, the Basel Committee on Banking Supervision [8] makes recommendations: improving quality and quantity of capital; setting standards for liquidity and stable financing; risk management; disclosure of information of credit institutions.

Barra & Zotti [9] describe the bank's financial stability as a complex characteristic reflecting the interrelation of different aspects of bank activities, which allows to maintain solvency, liquidity and profitability.

Halaj et al. [10] present the financial stability as a systemic category reflecting the prospects for its development and the ability to withstand systemic risks (for example, the macro-shock of the Covid-19).

We consider that in conditions of high uncertainty the combined approach is more relevant since financial stability of a bank is explored comprehensively: financial indicators, risk management, adaptation to changing external and internal factors, preservation of business reputation are taken into account.

In summary, the resemblance of various definitions is that the authors focus on the bank's ability to maintain solvency and perform its functions. The differences relate to which specific aspects of financial sustainability are being considered and which indicators are being selected for evaluation.

Financial stability criteria are set of indicators that are used to assess the financial position of a bank. They allow to determine how well the bank is functioning and whether it is able to withstand economic shocks. The dominant yardsticks for bank's financial stability are indicators of capital, assets, liabilities, profitability and liquidity (Table 1).

Table 1. **Yardsticks of bank's financial stability**

Yardsticks	Description
Capital	The bank's own funds (financial basis), which can be used to cover losses incurred as a result of risky transactions and other adverse factors. A high level of capital adequacy is a significant criterion for financial stability. The capital adequacy assessment is calculated as ratio of equity to risky assets.
Assets and liabilities	The bank's assets are a set of profitable and liquid financial resources (cash, loans, investments, other assets). Assets are assessed on the basis of their riskiness, liquidity and profitability. The bank's liabilities are obligations to customers (depositors and creditors). The assessment of liabilities includes an analysis of their structure, repayment periods and interest rates.

End of table 1

Yardsticks	Description
Profitability	A relative indicator of the profitability of banking activities. High profitability proves the effectiveness of bank's activities and the ability to generate sufficient funds to maintain financial stability. It is estimated as ratio of net profit to total assets or capital.
Liquidity	The bank's ability to meet its financial obligations in full. It is a factor of financial stability, as a lack of liquid funds can lead to bankruptcy. The liquidity assessment is based on ratio between assets and liabilities of the same maturity.

In addition to the main criteria, the researchers analyze impact of other factors on banks financial stability. According to Adusei [11], Ali & Puah [12], the bank's stability depends on bank size measured by natural logarithm of total assets. They found that banks with larger assets are more stable.

Audi et al. [13] also shows that large banks are less vulnerable to the risk of default (the study was conducted on the example of banks from the MENA region). That is, the impact of the asset scale effect known as "too big to fall" is confirmed.

Lepetit et al. [14] revealed that income diversification, as a rule, affects the bank stability: a variety of business areas makes it possible to increase the efficiency and financial stability. However, the researchers note that in times of crisis a high business diversification can create managerial difficulties for banks.

Ozili & Outa [15] analyzed the impact of loan reserves and discovered the direct correlation between reserves and financial stability. They conducted a cross-country literature study and found evidence that loan reserves are used by banks in many countries to equalize incomes and mitigate the procyclical effects of credit market fluctuations.

Mkadmi et al. [16] noticed a direct correlation between bank's capitalization and financial stability, they revealed that profitability (return on assets) has a positive and significant impact on the stability of banks and return on equity has a negative and significant effect. They also concluded that net interest margin, non-interest income, bank age and size have a positive, but insignificant, effect on banking stability.

Siddika & Haron [17] found that an increase in the capital adequacy ratio significantly reduces bank risk, while higher regulatory pressure corresponds to a higher level of bank risk. The authors characterized the "regulatory paradox": the tightening of regulatory requirements, on the one hand, is aimed at increasing the financial stability of banking system, and on the other hand, complicates the financial mechanism of banks, which creates conditions for instability.

Rupeika-Apoga et al. [18] showed that credit risk has a significant negative impact on the stability of banks, while the size of bank, liquidity ratio and profitability have a significant positive impact on stability.

In the research of Shershneva et al. [19] the positive impact of liquidity on bank's financial stability is noted, since liquidity is a balance of assets and liabilities in terms of maturity and amounts, as a result the bank remains solvent. However, the authors noted the negative impact of the liquidity surplus, as low-yielding assets reduce profitability and capitalization growth.

Wagner [20] made a similar conclusion about the impact of liquidity on bank's stability. He showed that the increased liquid-

ity, paradoxically, leads banking instability and the external effects associated with bank failures. Another of his conclusions is that an increase in liquidity in normal times does not affect stability. On the contrary, an increase in liquidity during a crisis, paradoxically, reduces stability.

Bouheni & Hasnaoui [21] concluded that financial stability is cyclical and an increase in lending leads to increased risk-taking, therefore higher in rising capital can contribute to financial stability. Using the example of Eurozone banks, it was determined that lending and capital of small banks are pro-cyclical, while lending and capital of large banks are countercyclical: small banks reduce their lending activities and capital requirements during recessions, but during economic booms they increase it.

Shahriar et al. [22] proved the hypothesis that improving operational efficiency contributes to stability of banks. They demonstrated that net interest margin and non-interest income are positively related to the stability of bank, but long-term debt has a negative impact on bank's resistance.

Kasri & Azzahra [23] showed that the main factors positively influencing the stability of banks are the exchange rate, return on assets and credit growth; however, interest rates have a negative impact on stability.

Studying the presence of foreign investments in banking system, Yin [24] revealed that the arrival of foreign banks may negatively affect the stability of national banks due to increased credit risks in the host country (on a sample of 129 countries over the period 1995–2013).

There are also works showing a significant impact of the competitive environment on bank's reliability. In articles of Uhde & Heimeshoff [25], Kasman & Carvallo [26] it is concluded that increased competition contributes to strengthening financial stability. The authors believe that competition helps to improve the quality of banking services, the appearance of new banking products on the market, contributes to increasing transparency of bank activities.

Ting-Ting Yuan et al. [27], using the example of American banks, found that there is an inverse U-shaped relationship between banking competition and stability. It is noted that excessive banking competition ("invisible hand") may be one of the important triggers of financial crisis. Also, as monopolism appears, medium and small banks may face a "survival problem" and high risk-appetite, which generates inefficiency and fragility.

A separate direction of research is devoted to the analysis of effectiveness and financial stability of Islamic banks, taking into account the specifics of their activities.

Čihák & Hesse [28] showed that small Islamic banks are more financially stable than small traditional banks; large traditional banks are stronger than large Islamic banks and small Islamic banks are more reliable than large Islamic banks.

Nosheen & Rashid [29] disclosed that Islamic banks are more financially stable but are less profitable than traditional banks. It is concluded that the financial stability of Islamic banks is determined by high credit quality, sufficient capitalization, reserve characteristics, non-aggressive credit policy and investments in the real assets.

Daoud & Kammoun [30] conducted a regression analysis on data from 81 Islamic banks from 22 countries in the period 2010–2014 and reported that capital ratios, bank size, loan-to-total assets ratio, deposit-to-total assets ratio are important factors determining the stability of a bank in the Islamic banking sector.

Based on Z-scoring, Joudar et al. [31] detected a strong positive correlation between the capital adequacy ratio and financial stability of Islamic banks, while the risk level has a negative impact on financial durability. This conclusion is also true

for traditional banks: capital and risks have a multidirectional impact on the financial condition of a bank.

Thus, the review of theoretical and empirical studies has shown the multidimensional of financial stability and the multiplicity of factors that affect it. Next, we will consider approaches to financial instability prediction.

2.2. Research approaches for analyzing and forecasting risk of financial stability loss

Various methods are proposed to identify factors of instability and bankruptcy: (1) statistical models (Z-scoring, correlation regression analysis, discriminant analysis, logistic regression, probit models, stochastic frontier analysis and others); (2) intelligence models (neural networks, data envelopment analysis, feature recognition models, support vector machines and others).

The earliest works include models for predicting bank failures based on financial ratios and Z-scoring. First time it was proposed to use financial ratios to predict the probability of bankruptcy by Beaver in 1966 [32]. Beaver's model consists of five financial coefficients and allows to identify the threat of financial instability: low probability of insolvency, possible insolvency in a year, bankruptcy within five years. Advantage of this model is simplicity of assessment and ability to predict the timing of financial failure. Disadvantages are the lack of an integral coefficient and the dependence of calculations on reliability of initial financial information.

Later & Altman [33] made "innovative step" by proposing an integral Z-scoring for predicting the probability of bankruptcy. His approach includes five financial coefficients, Z-scoring and interpretation scale, which allows to determine probability level of bankruptcy (low, medium or high). In addition, Altman's model served as a methodological basis for the further development of discriminant analysis in financial sector.

Based on analysis of financial ratios, Meyer & Pifer [34] diagnosed two groups of banks: problematic and non-problematic for the period 1948–1965. The authors have identified that the key negative factors are reduction in profitability and liquidity, an increase in gap between term deposits and demand deposits. The findings made it possible to focus the attention of bankers and other researchers on imbalances in assets and liabilities of banks. Methodological novelty of their work is the use of multidimensional discriminant analysis, which significantly extended the instrumental framework of financial diagnostics.

Expanding the possibilities of regression and discriminant analysis, Sinkey [35] revealed that asset structure, loan characteristics, capital adequacy, efficiency and profitability can be used to identify problem banks. This study was descriptive basis for improving procedures of analyzing the financial situation of banks, including the Central Banks of countries.

In the early 1980s, approaches to diagnosing bankruptcy risk using binary choice models appeared. So, Ohlson [36] proposed a nine-factor logit model, where some factors take binary value of 0 or 1. Using this model, 88 % of bankrupts were correctly classified. This work was start for multidimensional logit modeling in different areas of economics.

Scott [37] conducted a comparative analysis of empirical default forecasting models to determine predictive power and founded the multifactorial logit models have higher prediction quality: the average accuracy of Z-scoring models is 71 %, and the average accuracy of logit models is 83 %.

Hardy & Pazarbasioglu [38] examined episodes of banking system problems in several countries to determine macroeconomic and financial variables as indicators of instability. Regression analysis showed that global banking crises are more related

to external factors, and internal financial variables are markers of local bank failures. The authors summarized that macroeconomic indicators can be used for stress testing of banking sector as a whole or for large banks, but for medium and small banks, macro indicators are not reliable predictors of instability.

More recent studies contain a multiplicity of different parameters for predicting the likelihood of financial instability. For example, in study of Shar et al. [39] proposed a model called "Bankometer" which evaluates 6 parameters of financial stability (S): capital adequacy ratio, capital to assets ratio, equity to total assets, non-performing loans ratio, cost-to-income ratio, loan-to-asset ratio. Criteria: if $S \geq 70$ then bank is solvent and termed as "Super Sound Bank" (with a favorable financial status); if $S \leq 50$ then bank termed as "Insolvent" (experiencing a high risk of financial distress). And, if $50 < S < 70$ then bank can be classified as a "Gray Zone" due to the susceptibility to classification errors.

Based on logistic regression Chiaramonte & Casu [40] revealed that the probability of financial stability loss and financial crisis decreases as liquidity reserves increase, while capital adequacy ratios are significant only for large banks.

Using logit-regression Alaminos et al. [41] designed bankruptcy forecasting models for Asia, Europe and America, as well as a global model. The results confirmed the superiority of the global model compared to regional models for periods up to three years before bankruptcy. The authors concluded that there is no one best methodological combination of predictors: indicators are usually selected based on the study purpose.

Stochastic frontier analysis (SFA) as a parametric analysis tool, it is used to assess the impact of various factors on the financial condition. In the work of Sanchez Gonzalez et al. [42] applied the SFA and Bayesian approach to commercial banks in order to analyze the impact of inefficiency on the time before bankruptcy of American banks.

Neural networks as an intelligent (nonparametric) method are often used in research on predicting bank failures. It was first introduced by Tam [43] in 1991. He investigated the effectiveness of 59 pairs of bankrupt and non-bankrupt banks and came to the conclusion that the accuracy of forecasting neural networks is higher than other parametric algorithms.

Data envelopment analysis (DEA) is a nonparametric forecasting technique. Its essence lies in defining of the efficiency boundary (the envelope hypersurface which is based on the performance indicators of analyzed object). The optimal objects are located on this boundary.

This method was first proposed by Barr et al. [44] in 1993. In this study the efficiency was associated with an indicator of financial stability, and DEA was a nonparametric tool for determining the quality of management. Inefficiency was considered as the cause of bank failures, and the authors concluded that inefficient banks are more likely to be financially unstable or bankrupt than efficient ones.

The results of DEA-prediction by Li et al. [45] also showed that banks with lower performance indicators are more likely to face a crisis or possible financial collapse.

Feature recognition models consist of two iterations: learning and object recognition. At the learning stage, object recognition rules and functional hints are generated based on the training data. At the recognition stage, these rules are used to analyze the features of objects and determine the internal structure. In study of Torky et al. [46] proposes an intelligent recognition model for selecting features to identify the causes of financial crisis and concludes that short-term interest rate function is the significant predictor of financial crisis.

Support vector machines (SVM) is a set of learning algorithms for classification and

regression analysis tasks. The essence of SVM method is to find the hyperplane that separates objects into classes in the best way. The samples closest to the separating hyperplane are called support vectors. The best class separation maximizes the distance between the support vectors and the separating hyperplane. In the works of Min & Lee [47], Erdogan [48] was made attempt to apply SVM-method to the bankruptcy forecasting and provide models with higher accuracy.

Citterio [49] conducted a comparative analysis of methods for predicting financial insolvency of banks and one of his conclusions was that statistical methods based on logit model and discriminant analysis provide the best compromise between accuracy and interpretability, while simple classifiers are a reliable alternative to more advanced approaches, especially when the interpretability of the analysis is important.

Thus, the literature review allows to summarize that widely used bank financial stability diagnostic models are based on financial coefficient analysis and logistic regression. Following this logic, the below is the result of author's modeling.

3. Methods

3.1. Methodological approach to the analysis of bank's financial stability and rating

To diagnose bank's financial stability, we offer the following group indicators calculated according to the methodology of the Bank of Russia[1]:

1) Indicator of Capital ($I_{Capital}$);
2) Indicator of Assets (I_{Assets});
3) Indicator of Profitability ($I_{Profitability}$);
4) Indicator of Liquidity ($I_{Liquidity}$).

Each indicator estimates based on several coefficients (from 3 to 8) and rates on the scale: 1 — "good", 2 — "satisfactory", 3 — "doubtful", 4 — "unsatisfactory".

For a generalized assessment, we propose an author's aggregated Financial Stability Indicator (*FSI*) by formula:

$$FSI = \sqrt[4]{I_{Capital} \cdot I_{Assets} \cdot I_{\ rofitability} \cdot I_{Liquidity}}. \quad (1)$$

As a result of the *FSI* calculation, the bank's financial stability can be characterized as follows:

1) $1 \leq FSI \leq 1{,}5$ — high stability / A-rating;

2) $1{,}5 < FSI \leq 2{,}5$ — middle (satisfactory) stability / B-rating;

3) $2{,}5 < FSI \leq 4$ — instability or financial insolvency / C-rating.

The C-Rating indicates that bank has serious financial hardship, which may lead to the inability to pay off obligations and deposits, make transfers and conduct other operations. Financial deterioration may cause the rehabilitation or revocation of license of the Bank of Russia.

Table 2 demonstrates the result of calculating the indicators of capital, assets, profitability, liquidity and aggregated *FSI* for three Russian banks. The calculation is based on data from the published annual statements of banks.

Table 2 shows that Sberbank has the highest A-rating for entire period under review. Bank Sinara and UBRD have B-rating (middle stability). In general, all three banks are financially stable, but they have satisfactory profitability indicator.

However, in modern conditions, it is necessary to pay attention not only to the analysis of the current state of bank's financial stability, but also to the development of early warning models that will identify financial problems at an early stage or hidden threats. The introduction of such models will allow a commercial bank to identify possible problems in a timely manner and take measures to strengthen the financial viability of banks, which helps to prevent future losses.

[1] Instruction № 4336-U dated 03.04.2017 "On the assessment of the economic situation of banks" URL: https://base.garant.ru/71682362/

Table 2. **Diagnostics of bank financial stability**

Sberbank of Russia				
Indicator	01.01.2020	01.01.2021	01.01.2022	01.01.2023
Capital	1.00	1.00	1.00	1.00
Assets	1.78	1.35	1.46	1.48
Profitability	2.07	1.62	1.63	2.10
Liquidity	1.12	1.13	1.14	1.12
FSI	1.43	1.25	1.28	1.37
Rating	A	A	A	A
Sinara Bank				
Indicator	01.01.2020	01.01.2021	01.01.2022	01.01.2023
Capital	1.00	1.67	1.60	2.00
Assets	2.92	2.32	2.21	1.85
Profitability	1.56	1.60	2.34	1.62
Liquidity	1.12	1.25	1.36	1.56
FSI	1.71	1.67	1.83	1.75
Rating	B	B	B	B
Ural Bank of Reconstruction and Development (UBRD)				
Indicator	01.01.2020	01.01.2021	01.01.2022	01.01.2023
Capital	1.40	2.00	1.62	2.10
Assets	1.55	1.61	1.23	1.42
Profitability	2.24	2.15	1,98	2.15
Liquidity	1.15	1.38	1.40	1.40
FSI	1.54	1.76	1.53	1.73
Rating	B	B	B	B

3.2. Logit-model design for predicting the probability of bank's financial stability loss

Management decisions are made under uncertainly conditions, which requires to operate with probabilistic categories that allow making optimal decisions. One of the models for determining the probability of bank's financial stability loss is logit-model (binary choice model).

The feature of logit-models is that the dependent variable is binary: it takes the value 1 if there is a high probability of the bank's financial stability loss, and 0 — if there is no the probability of the financial instability. With this approach, the probability of financial deterioration is in the interval [0; 1].

The logit-model for predicting the probability of financial stability loss is mathematically presented as follows:

$$P = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n)}}, \quad (2)$$

where P — is the probability of the bank's financial condition falling into a doubtful category (C-rating) and $P \in [0; 1]$; e — natural logarithm; β_0 — constant; β_i — regression coefficients; X_i — financial ratios.

The data fits into a linear regression model, which is then acted upon by a logistic function. This function describes the target categorical dependent variable.

The essence of logistic regression is that the set of initial data can be divided by the hyperplane equation into two or more classes. To define a class, it is necessary to set a boundary value.

Let's consider forecasting the probability of deterioration in the financial condition of a bank using the example of a logistics model, where independent factors are the following important financial ratios: X_1 (capital adequacy ratio); X_2 (fraction of overdue loans over 90 days); X_3 (return on assets); X_4 (current liquidity ratio).

These factors characterize the "financial health" of bank, as they have a high weight in the group indicator and reflect quality of capital, assets, liquidity and profitability.

The next methodological step is the compilation of the regression equation $Z = f(X_1, X_2, X_3, X_4)$, where *FSI* indicator is a predictive metric:

1) if *FSI* [1; 2,5], then $Z = 0$;

2) if *FSI* (2,5; 4], then $Z = 1$.

So, the linear regression model is as follows:

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4. \quad (3)$$

Data from Russian banks with different financial conditions for the period 2017–2023 years were used to obtain a training sample. We generated about 500 observations and then have obtained regressions for a horizon of 6 and 12 months:

1) bank's financial stability loss prediction model for 6 months (6M):

$$Z_{6M} = -0,115 + 0,0067X_1 + \\ + 0,0082X_2 - 0,0173X_3 + 0,0031X_4, \quad (4)$$

2) bank's financial stability loss prediction model for 12 months (12M):

$$Z_{12M} = -0,001127 + 0,0144X_1 + \\ + 0,1352X_2 - 0,0168X_3 + 0,0148X_4. \quad (5)$$

As can be seen, the most significant variables are the fraction of overdue loans (X_2) and the return on assets (X_3). The independent variables of multiple regression are not multicollinear, which was verified using the Excel analysis by the method of paired correlation.

The obtained models allow to conclude that for periods of 6 and 12 months, the significance of financial stability factors is different. For 6 months, the return on assets is more significant factor of financial stability, and the level of overdue loans is more significant during 12 months. This can be explained by the fact that overdue debts and loan reserves accumulated for a year can create losses.

Substituting regressions (4) and (5) into formula (2) we get the final logit-models:

$$P(Z_{6M}) = \\ = \frac{1}{1 + e^{-(-0,115 + 0,0067X_1 + 0,0082X_2 - 0,0173X_3 + 0,0031X_4)}}, \quad (6)$$

$$P(Z_{12M}) = \\ = \frac{1}{1 + e^{-(-0,001127 + 0,0144X_1 + 0,1352X_2 - 0,0168X_3 + 0,0148X_4)}}. \quad (7)$$

To assess the quality of logit-model *P(Z)*, the *McFadden-R*^{2} formula is used:

$$McFadden - R^2 = \\ = 1 - \frac{\ln\ plausible\ function\ Z}{\ln\ plausible\ function\ Z\ with\ zero\ parameters}. \quad (8)$$

For our logit-models *McFadden-R*^{2} = = 0,31 and 0,39 (what is acceptable).

Let's set the boundary value: if $P(Z) \geq$ $\geq 0,5$ then bank is classified as "negative" (high risk of loss of financial stability), otherwise as "positive".

4. Results

The object of assessing the probability of financial deterioration is X-Bank with B-rating, its data is presented in Table 3. It can be seen that bank's indicators X_2 and X_3 do not correspond to the recommended ones: an increased level of overdue loans and low return on assets.

Based on logit-models (6) and (7) we can determine the probability of transition to C-rating for X-Bank:

$$P(Z_{6M}) = \frac{1}{1+e^{-(-0,115+0,0067\times0,11+0,0082\times0,24-0,0173\times0,015+0,0031\times0,076)}} \approx$$

$$\approx 0,47\,(<0,5);$$

$$P(Z_{12M}) = \frac{1}{1+e^{-(-0,001127+0,0144\times0,11+0,1352\times0,24-0,0168\times0,015+0,0148\times0,076)}} \approx$$

$$\approx 0,51\,(>0,5).$$

Calculation shows that for the next 6 months X-Bank is classified as "positive" (stable), but the probability of transition to C-rating is at high level. For 12 months X-Bank is classified as "negative" (unstable): high level of overdue loans and low profitability create conditions for the financial stability loss.

Thus, empirical results are as follows. Hypothesis *H1* is confirmed: the return on assets (profitability) has significant positive impact on bank's financial stability, the fraction of overdue loans (asset quality) has significant negative impact on sustainability. The level of overdue loans can devalue assets and lead to losses, which increases the risk of instability.

The result mathematically confirmed the importance of asset quality and the ability to generate profit in ensuring the bank financial stability. Asset quality has an influence on liquidity and costs: value of risk assets can decrease and lead to losses and a reduction in capital, which in turn increases the risk of insolvency.

Also, non-obvious result is obtained: there was no significant positive impact of capital adequacy and current liquidity on financial stability. The research suggests that the effect of capitalization and liquidity is ∩-shaped: up to a certain value-point an increase in capital adequacy and current liquidity provides the bank with stability, and after passing this value, on the contrary, reduces efficiency. This is "Surplus capitalization and liquidity paradox": on the one hand, normal level of capital and liquidity provides the bank with solvency reserve, but, on the other hand, excessive level reduces profitability (banks store assets in low-yield financial instruments).

As a result, the commercial bank loses revenue, market share and reduces efficiency. It can be argued that high capitalization and liquidity are important for large banks. It is economically impractical for medium and small banks to raise capital adequacy and liquidity standards to high levels.

Table 3. **Indicators for predicting probability of bank's financial deterioration**

Financial indicator	Recommended value of indicator	X-Bank data
X_1	Capital adequacy ratio ≥ 0,08	0,11
X_2	Fraction of overdue loans ≤ 0,10	0,24
X_3	Return on assets ≥ 0,02	0,015
X_4	Current liquidity ratio ≥ 0,50	0,76

Hypothesis *H2* is confirmed: indicators impact degree differs for medium- and long-term horizons of forecasting the financial risk. The return on assets is more significant factor for 6 months, the overdue loans fraction, the capital adequacy and the current liquidity are more important within 12 months. This result emphasizes the importance of time factor in predictive diagnosis of risks. Overall, the hypotheses testing results are summarized in Table 4.

Therefore, the most serious danger for Russian banks is "bad" assets: an increase in overdue loans to a critical level (more than 15 %) leads to the risk of financial stability loss. Overdue loans carry a potential threat of a new wave of crisis in banking sector.

Our results showed the bank with low performance indicators is more likely to face a possible financial downturn. The decline in profitability and the growth of overdue loans are alarming markers for bank managers. In such circumstances, changes at the tactical and strategic levels are necessary. At the tactical level, it is important to classify financial instruments and identify weaknesses that affect the reduction of financial stability. At the strategic level, stress testing of the bank for credit risk, liquidity risk, risk of capital loss and profitability is significant.

The methodical results are as follows. Author's approach for determining the bank's financial stability rating and assessing the risk of rating deterioration are proposed. Evaluation of the aggregated indicator of bank's financial stability (FSI) allows to determine the risk category of bank — its rating. Rating determines the bank to adjust its activities in the following areas: planning and forecasting, management reporting for top-management, provisions management, cost management, making decisions on the allocation of loans and identification of problem loans, determining the value of loans taking into account risk, improving the system of limits, monitoring loan portfolios. Multidimensional logit-models make it possible to predict the probability of deterioration of bank's financial condition for medium- and long-term periods. Anticipating problematic consequences is an important component of crisis management and allows for the operational restructuring of the bank's business and its management systems.

Table 4. **Hypothesis testing results**

Financial indicator	Indicator impact specifics			Descriptions
	Impact degree	Impact direction on stability	Significant impact period	
Capital adequacy ratio	Middle-significant	∩-shaped impact	12 months	Capitalization and liquidity growth increase financial stability up to a certain value-point and after passing this value lose influence on stability
Current liquidity ratio	Middle-significant	∩-shaped impact	12 months	
Return on assets	High-significant	Positive	6 months	Profitability growth increases financial stability and reduces financial instability risk
Overdue loans fraction	High-significant	Negative	12 months	Assets quality growth reduces financial stability and increases financial instability risk

5. Discussion

The theoretical review showed that the study of a bank's financial stability is in the sphere of interests of many scientists from different countries. Some analyze endogenous factors of financial stability such as capital, assets, liquidity, profitability, management efficiency. Others explore how exogenous factors affect financial reliability. At the same time, researchers unanimously agree that financial stability is a multidimensional characteristic which depends on many internal and external factors. This fact explains the existence of a wide range of approaches to analysis and assessment of financial stability. As a rule, the evaluation method is chosen depending on the purpose of analysis and the availability of reliable information.

In different countries, there are formalized methodological provisions for assessing financial stability recommended by regulatory authorities (for example, Central banks). They can be based on a rating, a point-weight approach or expert assessments. For example, in Russia there is a methodology of the Bank of Russia for assessing certain aspects of the financial situation of banks. However, this method has a disadvantage: there is no integral indicator to compare different banks.

In this study we have proposed an aggregated Financial Stability Indicator (*FSI*) calculated by four coefficients. Calculations have shown that there are differences in the indicators of financial stability: the largest Sberbank demonstrates a high level of stability (A-rating), medium-sized banks are at an average level (B-rating).

This result correlates with conclusions of Adusei [11], Ali & Puah [12], Audi et al. [13]: an increase in bank size leads to an increase in its stability. Gwachha [50] underlines that the positive relationship between the bank size and stability is the subject of discussions about whether to limit the size of bank in order to protect the financial system from future crisis.

Both study hypotheses are supported. Our analysis shows the return on assets (profitability factor) has significant positive effect on maintaining financial sustainability.

This result responds with findings of Mkadmi et al. [16], Rupeika-Apoga et al. [18], Kasri & Azzahra [22]. Authors agree that the bank's profit growth is the basis for retaining existing clients and also for attracting new customers, providing new loans and investing financial resources in priority sectors of the economy. However, there is a traditional postulate of risk management: profit growth is accompanied by an increase in risk. Hence, in the banking business, control over excess profits is necessary, since high risks can lead to stability loss.

We confirm the significant negative impact of overdue loans growth on bank financial stability. This means that higher levels of credit risk increase the risk of bank instability. Banks with a high risk-appetite often feel the high impact of profitability factor. This is a so-called "risk trap". Wishing to receive high interest income, banks issue risky loans and in future face an increase in overdue debts, and as a result, financial flows and incomes are reduced. This condition leads to a decrease in liquidity and solvency, which forces banks to increase borrowing to patch temporary "liquidity holes". The above illustrates the main problem of banking financial management — achievement of a triangular balance "profitability-risk-liquidity".

An unobvious finding is the ambiguous contribution of capitalization growth and increased liquidity to bank's financial stability. A normal level of capital adequacy and current liquidity is significant stability factor, but excess level does not ensure efficiency and stability ("Surplus capitalization and liquidity paradox").

We believe that high capitalization and liquidity are important for large banks. Our conclusion is correlates with Wagner's opinion that banks with higher liquidity ratios are likely to be fewer stable [20]. Therefore, perhaps surprisingly, we find that although increased liquidity reduces the main cause of instability, further stability does not increase.

An important diagnostic aspect is the national banking business environment. These are regulatory requirements, traditions, competitive climate and socio-economic features. And researchers study the financial stability factors in the context of country characteristics. The development of predictive analysis methodology is an urgent direction in the context of the diversity and divergence of factors affecting the financial condition of modern banks. Against the background of geopolitical challenges, economic system parameters are being reconfigured in many countries: interest rates are rising, stock volatility is increasing and restrictions on cross-border payments are being introduced. In conditions of instability, long-term planning becomes difficult. For banks (especially medium and small), this means reduced opportunities to borrow and invest long-term money, and as a result, the need to change business-models.

Regarding the limitations of this study.

Firstly, the study is conducted on the analysis of several indicators using public statements of Russian banks. For a deeper understanding of the causes of financial stability loss, management and funding performance indicators should be additionally used, which are not reflected in published reports. So, insider information expands analytical scope for risk assessment.

Secondly, the regression analysis is based on banks financial indicators for 2017–2023. During this period, Russian banks faced global challenges such as COVID-19 and the Russian financial shock of 2022, which worsened financial data.

Therefore, we consider that exploration of financial stability factors should be differentiated: during an economic well-being and in crises period.

6. Conclusion

Banks are important mediators of financial flows at the national and global levels. The deterioration of banks' financial stability is a cause of financial crises, disrupting the normal functioning of economic systems. In order to prevent financial deterioration in a timely manner, it is necessary to predict and analyze many factors and parameters of banks' activities. The difficulty is that banks cannot influence the key external factors affecting their financial mechanism (market interest rates, foreign exchange rates, competitive climate, demand for loans, propensity to save).

On the contrary, internal factors are manageable and can be adjusted. Accordingly, this study focused on the development of methodological toolkit for analyzing and predicting the financial stability of a bank based on the consideration of significant intrabank indicators. As a result, the following theoretical and practical results are obtained.

First, the analysis of researcher's views led to the conclusion that financial stability is multidimensionality and dynamic characteristic of bank activity. Concept opinions of researchers on the bank's financial stability can be divided into resource approach, protective approach and combined approach. We consider that the viewpoint plurality expands the scientific understanding of features of financial mechanism in bank sector. For example, an interesting and unexpected conclusion of some researchers is the model of non-interest-bearing Islamic banking is more stable compared to traditional banking. This conclusion should be taken into account when developing investment products in traditional banks.

Second, the authors proposed an aggregated Financial Stability Indicator (*FSI*) and rating scale (A, B and C ratings). Evaluation have shown there are differences among the analyzed banks: the largest Sberbank has demonstrated a high level of stability (A-rating), medium-sized banks are at an average level (B-rating). At the same time, all banks have a satisfactory level of profitability (this factor should be in the area of special attention of bank managers).

Third, the most significant internal factors of bank's financial stability have been identified. The bank size and the return on assets have significant positive impact, the overdue loans fraction has significant negative effect on stability. However, an increase in profitability and risk can lead to financial stability loss. Banks with high-risk appetite may find themselves in a "risk trap". The impact of capital adequacy and current liquidity is found in the context of "Surplus paradox": a surplus in capitalization and liquidity does not have significant positive impact on banking stability. It was also revealed that the impact degree of financial stability factors is different: the return on assets is more significant factor for 6 months, the overdue loans fraction, the capital adequacy and the current liquidity are more important within 12 months. Hence, the time boundary of risk assessment should be taken into account in financial forecasting.

Fourth, predictive models for probability assessment of bank's financial stability loss based on multidimensional logistic regression are proposed. The advantage of multidimensional forecasting models is that they better reflect the relationship between independent variables and predictor. The author's approach reflects the influence of the most important explanatory variables on financial insolvency and at the same time has a high interpretability.

The results of this study may be useful for commercial banks in the setting up algorithms for analyzing and forecasting the financial position and may also be of interest to other researchers in field of banking risk management. In the context of future research, the following can be assumed. First, the range of studies on the impact of efficiency on financial stability will expand. Secondly, the research direction "Machine Learning Models for Bankruptcy Prediction" will be developed, since multidimensional intelligent models have a higher predictive ability. Development of digital intelligent technologies will make it possible to design scenarios and algorithms for more effective forecasting of risks and future bank's "financial health".

References

1. Khalatur, S., Velychko, L., Pavlenko, O., Karamushka, O., Huba, M. (2021). A Model for Analyzing the Financial Stability of Banks in the VUCA-world Conditions. *Banks and Bank Systems,* Vol. 16, Issue 1, 182–194. https://doi.org/10.21511/bbs.16(1).2021.16

2. Ozili, P.K., Iorember, P.T. (2023). Financial Stability and Sustainable Development. *International Journal of Finance & Economics.* https://doi.org/10.1002/ijfe.2803

3. Chen, Y. (2022). Bank Interconnectedness and Financial Stability: The Role of Bank Capital. *Journal of Financial Stability,* Vol. 61, 101019. https://doi.org/10.1016/j.jfs.2022.101019

4. Vostrikova, L.A., Panina, I.V. (2020). Analysis of the bank's financial condition based on open data. *Proceedings of Voronezh State University. Series: Economics and Management,* No. 2, 13–26. (In Russ.). https://doi.org/10.17308/econ.2020.2/2898

5. Papanikolaou, N.I. (2018). A Dual Early Warning Model of Bank Distress. *Economics Letters,* Vol. 162, 127–130. https://doi.org/10.1016/j.econlet.2017.10.028

6. Rahman, S.M.K., Chowdhury, M.A.F., Tania, T.C. (2021). Nexus Among Bank Competition, Efficiency and Financial Stability: A Comprehensive Study in Bangladesh. *The Journal of Asian*

Finance, Economics and Business, Vol. 8, Issue 2, 317–328. https://doi.org/10.13106/jafeb.2021.vol8.no2.0317

7. Miah, M.D., Uddin, H. (2017). Efficiency and Stability: A Comparative Study between Islamic and Conventional Banks in GCC Countries. *Future Business Journal,* Vol. 3, Issue 2, 172–185. https://doi.org/10.1016/j.fbj.2017.11.001

8. Asghar, M., Rashid, A., Abbas, Z. (2022). Basel III Effects on Bank Stability: Empirical Evidence from Emerging Countries. *The Journal of Asian Finance, Economics and Business,* Vol. 9, Issue 3, 347–354. https://doi.org/10.13106/jafeb.2022.vol9.no3.0347

9. Barra, C., Zotti, R. (2022). Financial Stability and Local Economic Development: The Experience of Italian Labor Market Areas. *Empirical Economics,* Vol. 62, 1951–1979. https://doi.org/10.1007/s00181-021-02071-x

10. Halaj, G., Martinez-Jaramillo, S., Battiston, S. (2024). Financial Stability through the Lens of Complex Systems. *Journal of Financial Stability,* Vol. 71, 101228. https://doi.org/10.1016/j.jfs.2024.101228

11. Adusei, M. (2015). The Impact of Bank Size and Funding Risk on Bank Stability. *Cogent Economics & Finance,* Vol. 3, 1111489. https://doi.org/10.1080/23322039.2015.1111489

12. Ali, M., Puah, K.H. (2018). Does Bank Size and Funding Risk Effect Bank's Stability? A Lesson from Pakistan. *Global Business Review,* Vol. 19, Issue 5, 1166–1186. https://doi.org/10.1177/0972150918788745

13. Audi, M., Kassem, M., Roussel, J. (2021). Determinants of Banks Fragility in the MENA Region Using a Dynamic Model. *The Journal of Developing Areas,* Vol. 55, No. 1. https://doi.org/10.1353/jda.2021.0007

14. Lepetit, L., Nys, E., Rous, P., Tarazi, A. (2008). Bank Income Structure and Risk: An Empirical Analysis of European Banks. *Journal of Banking & Finance,* Vol. 32, Issue 8, 1452–1467. https://doi.org/10.1016/j.jbankfin.2007.12.002

15. Ozili, P.K., Outa, E. (2017). Bank Loan Loss Provisions Research: A Review. *Borsa Istanbul Review,* Vol. 17, Issue 3, 144–163. https://doi.org/10.1016/j.bir.2017.05.001

16. Mkadmi, J.E., Baccari, N., Ncib, A. (2021). The Determinants of Banking Stability: The Example of Tunisia. *International Academic Journal of Accounting and Financial Management,* Vol. 8, No. 1. https://doi.org/10.9756/IAJAFM/V8I1/IAJAFM0801

17. Siddika, A., Haron, R. (2019). Capital Regulation and Ownership Structure on Bank Risk. *Journal of Financial Regulation and Compliance,* Vol. 28, No. 1, 39–56. https://doi.org/10.1108/JFRC-02-2019-0015

18. Rupeika-Apoga, R., Zaidi, S.H., Thalassinos, Y.E., Thalassinos, E.I. (2018). Bank Stability: The Case of Nordic and Non-Nordic Banks in Latvia. *International Journal of Economics and Business Administration,* Vol. VI, Issue 2, 39–55. https://doi.org/10.35808/ijeba/156

19. Shershneva, E.G., Bakr Hasan, H.B., Al Hadabi, J. (2020). Econometric Modeling of the Bank's Short-Term Liquidity Dynamics Based on Multi-Factor Regression. *Journal of Applied Economic Research,* Vol. 19, No. 1, 79–96. https://doi.org/10.15826/vestnik.2020.19.1.005

20. Wagner, W. (2007). The Liquidity of Bank Assets and Banking Stability. *Journal of Banking & Finance,* Vol. 31, Issue 1, 121–139. https://doi.org/10.1016/j.jbankfin.2005.07.019

21. Bouheni, F.B., Hasnaoui, A. (2017). Cyclical Behavior of the Financial Stability of Eurozone Commercial Banks. *Economic Modelling,* Vol. 67, 392–408. https://doi.org/10. 1016/j.econmod.2017.02.018

22. Shahriar, A., Mehzabin, S., Ahmed, Z., Dongul, E.S., Azad, A.K. (2023). Bank Stability, Performance and Efficiency: An Experience from West Asian Countries. *IIM Ranchi Journal of Management Studies,* Vol. 2, Issue 1, 31–47. https://doi.org/10.1108/IRJMS-02-2022-0017

23. Kasri, R.A., Azzahra, C. (2020). Determinants of Bank Stability in Indonesia. *Signifikan: Jurnal Ilmu Ekonomi,* Vol. 9, No. 2, 153–166. https://doi.org/10.15408/sjie.v9i2.15598

24. Yin, H. (2019). Bank Globalization and Financial Stability: International Evidence. *Research in International Business and Finance,* Vol. 49, 207–224. https://doi.org/10.1016/j.ribaf.2019.03.009

25. Uhde, A., Heimeshoff, U. (2009). Consolidation in Banking and Financial Stability in Europe: Empirical Evidence. *Journal of Banking & Finance,* Vol. 33, Issue 7, 1299–1311. https://doi.org/10.1016/j.jbankfin.2009.01.006

26. Kasman, A., Carvallo, O. (2014). Financial Stability, Competition and Efficiency in Latin American and Caribbean Banking. *Journal of Applied Economics,* Vol. 17, Issue 2, 301–324. https://doi.org/10.1016/S1514-0326(14)60014-3

27. Yuan, T.-T., Gu, X.-A., Yuan, Y.-M., Lu, J.-J., Ni, B.-P. (2022). Research on the Impact of Bank Competition on Stability — Empirical Evidence from 4631 Banks in US. *Heliyon,* Vol. 8, Issue 4, e09273. https://doi.org/10.1016/j.heliyon.2022.e09273

28. Čihák, M., Hesse, H. (2010). Islamic Banks and Financial Stability: An Empirical Analysis. *Journal of Financial Services Research,* Vol. 38, 95–113. https://doi.org/10.1007/s10693-010-0089-0

29. Nosheen, Rashid, A. (2019). Business Orientation, Efficiency and Credit Quality Across Business Cycle: Islamic versus Conventional Banking. Are There Any Lessons for Europe and Baltic States? *Baltic Journal of Economics,* Vol. 19, Issue 1, 105–135. https://doi.org/10.1080/1406099X.2018.1560947

30. Daoud, Y., Kammoun, A. (2020). Financial Stability and Bank Capital: The Case of Islamic Banks. *International Journal of Economics and Financial Issues,* Vol. 10, No. 5, 361–369. https://doi.org/10.32479/ijefi.10147

31. Joudar, F., Msatfa, Z., Metwalli, O., Mouabid, M., Dinar, B. (2023). Islamic Financial Stability Factors: An Econometric Evidence. *Economies,* Vol. 11, Issue 3, 79. https://doi.org/10.3390/economies11030079

32. Beaver, W.H. (1966). Financial Ratios as Predictors of Failure. *Journal of Accounting Research,* Vol. 4, 71–111. https://doi.org/10.2307/2490171

33. Altman, E.I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *Journal of Finance,* Vol. 23, Issue 4, 589–609. https://doi.org/10.1111/j.1540-6261.1968.tb00843.x

34. Meyer, P.A., Pifer, H.W. (1970). Prediction of Bank Failures. *Journal of Finance,* Vol. 25, Issue 4, 853–868. https://doi.org/10.1111/j.1540-6261.1970.tb00558.x

35. Sinkey, J.F. (1975). A Multivariate Statistical Analysis of The Characteristic of Problem Banks. *Journal of Finance,* Vol. 30, Issue 1, 21–36. https://doi.org/10.1111/j.1540-6261.1975.tb03158.x

36. Ohlson, J.A. (1980). Financial Ratios and the Probabilistic Prediction of Bankruptcy. *Journal of Accounting Research,* Vol. 18, No. 1, 109–131. https://doi.org/10.2307/2490395

37. Scott, J. (1981). The Probability of Bankruptcy: A Comparison of Empirical Predictions and Theoretical Models. *Journal of Banking and Finance,* Vol. 5, Issue 3, 317–344. https://doi.org/10.1016/0378-4266(81)90029-7

38. Hardy, D.C., Pazarbasioglu, C. (1999). Determinants and Leading Indicators of Banking Crises: Further Evidence. *IMF Staff Papers,* Vol. 46, 247–258. https://doi.org/10.2307/3867642

39. Shar, A.H., Shah, M.A., Jamali, H. (2010). Performance Evaluation of Banking Sector in Pakistan: An Application of Bankometer. *International Journal of Business and Management,* Vol. 5, No. 8, 113–118. https://doi.org/10.5539/ijbm.v5n8p113

40. Chiaramonte, L., Casu, B. (2017). Capital and Liquidity Ratios and Financial Distress. Evidence from the European Banking Industry. *The British Accounting Review,* Vol. 49, Issue 2, 138–161. https://doi.org/10.1016/j.bar.2016.04.001

41. Alaminos, D., del Castillo, A., Fernandez, M.A. (2018). A Global Model for Bankruptcy Prediction. *PLoS ONE,* Vol. 13, Issue 11, 0208476. https://doi.org/10.1371/journal.pone.0208476

42. Sanchez Gonzalez, J., Restrepo-Tobon, D., Ramirez Hassan, A. (2021). Inefficiency and Bank Failure: A Joint Bayesian Estimation Method of Stochastic Frontier and Hazards Models. *Economic Modelling,* Vol. 8, 344–360. https://doi.org/10.1016/j.econmod.2020.03.002

43. Tam, K.Y. (1991). Neural Network Models and the Prediction of Bank Bankruptcy. *Omega-International Journal of Management Science,* Vol. 19, Issue 5, 429–445. https://doi.org/10.1016/0305-0483(91)90060-7

44. Barr, R.S., Seiford, L.M., Siems, T.F. (1993). An Envelopment-Analysis Approach to Measuring the Managerial Efficiency of Banks. *Annals of Operations Research,* Vol. 45, 1–19. https://doi.org/10.1007/BF02282039

45. Li, Z., Feng, C., Tang, Y. (2022). Bank Efficiency and Failure Prediction: a Nonparametric and Dynamic Model Based on Data Envelopment Analysis. *Annals of Operations Research,* Vol. 315, 279–315. https://doi.org/10.1007/s10479-022-04597-4

46. Torky, M., Gad, I., Hassanien, A.E. (2023) Explainable AI Model for Recognizing Financial Crisis Roots Based on Pigeon Optimization and Gradient Boosting Model. *International Journal of Computational Intelligence Systems,* Vol. 16, 50. https://doi.org/10.1007/s44196-023-00222-9

47. Min, J.H, Lee, Y-C. (2005). Bankruptcy Prediction Using Support Vector Machine with Optimal Choice of Kernel Function Parameters. *Expert Systems and Applications,* Vol. 28, Issue 4, 603–614. https://doi.org/10.1016/j.eswa.2004.12.008

48. Erdogan, B.E. (2013). Prediction of Bankruptcy Using Support Vector Machines: An Application to Bank Bankruptcy. *Journal of Statistical Computation and Simulation,* Vol. 83, Issue 8, 1543–1555. https://doi.org/10.1080/00949655.2012.666550

49. Citterio, A. (2024). Bank Failure Prediction Models: Review and Outlook. *Socio-Economic Planning Sciences,* Vol. 92, 101818. https://doi.org/10.1016/j.seps.2024.101818

50. Gwachha, K.P. (2023). An Analysis of the Determinants of Bank Stability in the Banking Industry of Nepal. *Khwopa Journal,* Vol. 5, No. 2, 196–210. https://doi.org/10.3126/kjour.v5i2.60463

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Диагностика риска потери финансовой устойчивости российских банков на основе многомерной логит-модели

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Аннотация. Финансовая стабильность банковского сектора является индикатором «экономического здоровья» на национальном и глобальном уровнях. Ухудшение финансовой устойчивости банков является причиной финансовых кризисов, нарушающих нормальное функционирование экономических систем. На тактическом уровне банковского менеджмента, где ключевую роль играет система мониторинга и прогнозирования рисков, особую актуальность приобретает совершенствование инструментария ранней диагностики финансовых проблем. Целью исследования является изучение особенностей влияния ряда внутрибанковских факторов на риск потери финансовой устойчивости российских банков. Гипотезы исследования: 1) наиболее значимыми предикторами риска финансовой несостоятельности банка являются рентабельность активов и просроченная задолженность по кредитам; 2) степень влияния факторов устойчивости отличается для средне- и долгосрочных горизонтов прогнозирования финансового риска. Авторами разработаны многомерные логит-модели оценки вероятности потери финансовой устойчивости банка на 6 и 12 месяцев на основе четырех независимых переменных: норматива достаточности собственного капитала, коэффициента просроченной задолженности свыше 90 дней, рентабельности активов, норматива текущей ликвидности. В результате выявлено, что рост рентабельности активов оказывает существенное положительное влияние на финансовую устойчивость, а увеличение доли просроченной задолженности оказывает существенное отрицательное влияние на «финансовый иммунитет» коммерческих банков. Установлено, что для средне- и долгосрочных прогнозных периодов влияние факторов финансовой стабильности различно: в течение 6 месяцев рентабельность активов является более релевантным фактором, а уровень просроченных кредитов демонстрирует более высокую значимость для горизонта 12 месяцев. Теоретическая значимость полученных результатов заключается в расширении научных представлений о специфике влияния различных факторов на финансовую устойчивость банков. Практическая значимость состоит в том, что предложенные эконометрические модели и выводы могут быть полезны коммерческим банкам при разработке алгоритмов финансового анализа и прогнозирования.

Ключевые слова: коммерческий банк; финансовая устойчивость; факторы финансовой стабильности; логистическая регрессия; вероятность потери финансовой устойчивости.

Список использованных источников

1. *Khalatur S., Velychko L., Pavlenko O., Karamushka O., Huba M.* A Model for Analyzing the Financial Stability of Banks in the VUCA-world Conditions // Banks and Bank Systems. 2021. Vol. 16, Issue 1. Pp. 182–194. https://doi.org/10.21511/bbs.16(1).2021.16

2. *Ozili P. K., Iorember P. T.* Financial Stability and Sustainable Development // International Journal of Finance & Economics. 2023. https://doi.org/10.1002/ijfe.2803

3. *Chen Y.* Bank Interconnectedness and Financial Stability: The Role of Bank Capital // Journal of Financial Stability. 2022. Vol. 61. 101019. https://doi.org/10.1016/j.jfs.2022.101019

4. *Вострикова Л. А., Панина И. В.* Анализ финансового состояния банка на основе открытых данных // Вестник ВГУ. Серия: Экономика и управление. 2020. № 2. С. 13–26. https://doi.org/10.17308/econ.2020.2/2898

5. *Papanikolaou N. I.* A Dual Early Warning Model of Bank Distress // Economics Letters. 2018. Vol. 162. Pp. 127–130. https://doi.org/10.1016/j.econlet.2017.10.028

6. *Rahman S. M.K., Chowdhury M. A.F., Tania T. C.* Nexus Among Bank Competition, Efficiency and Financial Stability: A Comprehensive Study in Bangladesh // The Journal of Asian Finance, Economics and Business. 2021. Vol. 8, Issue 2. Pp. 317–328. https://doi.org/10.13106/jafeb.2021.vol8.no2.0317

7. *Miah M. D., Uddin H.* Efficiency and Stability: A Comparative Study between Islamic and Conventional Banks in GCC Countries // Future Business Journal. 2017. Vol. 3, Issue 2. Pp. 172–185. https://doi.org/10.1016/j.fbj.2017.11.001

8. *Asghar M., Rashid A., Abbas Z.* Basel III Effects on Bank Stability: Empirical Evidence from Emerging Countries // The Journal of Asian Finance, Economics and Business. 2022. Vol. 9, Issue 3. Pp. 347–354. https://doi.org/10.13106/jafeb.2022.vol9.no3.0347

9. *Barra C., Zotti R.* Financial Stability and Local Economic Development: The Experience of Italian Labor Market Areas // Empirical Economics. 2022. Vol. 62. Pp. 1951–1979. https://doi.org/10.1007/s00181-021-02071-x

10. *Halaj G., Martinez-Jaramillo S., Battiston S.* Financial Stability through the Lens of Complex Systems // Journal of Financial Stability. 2024. Vol. 71. 101228. https://doi.org/10.1016/j.jfs.2024.101228

11. *Adusei M.* The Impact of Bank Size and Funding Risk on Bank Stability // Cogent Economics & Finance. 2015. Vol. 3. 1111489. https://doi.org/10.1080/23322039.2015.1111489

12. *Ali M., Puah K. H.* Does Bank Size and Funding Risk Effect Bank's Stability? A Lesson from Pakistan // Global Business Review. 2018. Vol. 19, Issue 5. Pp. 1166–1186. https://doi.org/10.1177/0972150918788745

13. *Audi M., Kassem M., Roussel J.* Determinants of Banks Fragility in the MENA Region Using a Dynamic Model // The Journal of Developing Areas. 2021. Vol. 55, No. 1. https://doi.org/10.1353/jda.2021.0007

14. *Lepetit L., Nys E., Rous P., Tarazi A.* Bank Income Structure and Risk: An Empirical Analysis of European Banks // Journal of Banking & Finance. 2008. Vol. 32, Issue 8. Pp. 1452–1467. https://doi.org/10.1016/j.jbankfin.2007.12.002

15. *Ozili P. K., Outa E.* Bank Loan Loss Provisions Research: A Review // Borsa Istanbul Review. 2017. Vol. 17, Issue 3. Pp. 144–163. https://doi.org/10.1016/j.bir.2017.05.001

16. *Mkadmi J. E., Baccari N., Ncib A.* The Determinants of Banking Stability: The Example of Tunisia // International Academic Journal of Accounting and Financial Management. 2021. Vol. 8, No. 1. https://doi.org/10.9756/IAJAFM/V8I1/IAJAFM0801

17. *Siddika A., Haron R.* Capital Regulation and Ownership Structure on Bank Risk // Journal of Financial Regulation and Compliance. 2019. Vol. 28, No. 1. Pp. 39–56. https://doi.org/10.1108/JFRC-02-2019-0015

18. *Rupeika-Apoga R., Zaidi S. H., Thalassinos Y. E., Thalassinos E. I.* Bank Stability: The Case of Nordic and Non-Nordic Banks in Latvia // International Journal of Economics and Business Administration. 2018. Vol. VI, Issue 2. Pp. 39–55. https://doi.org/10.35808/ijeba/156

19. *Shershneva E. G., Bakr Hasan H. B., Al Hadabi J.* Econometric Modeling of the Bank's Short-Term Liquidity Dynamics Based on Multi-Factor Regression // Journal of Applied Economic Research. 2020. Vol. 19, No. 1. Pp. 79–96. https://doi.org/10.15826/vestnik.2020.19.1.005

20. *Wagner W.* The Liquidity of Bank Assets and Banking Stability // Journal of Banking & Finance. 2007. Vol. 31, Issue 1. Pp. 121–139. https://doi.org/10.1016/j.jbankfin.2005.07.019

21. *Bouheni F. B., Hasnaoui A.* Cyclical Behavior of the Financial Stability of Eurozone Commercial Banks // Economic Modelling. 2017. Vol. 67. Pp. 392–408. https://doi.org/10. 1016/j.econmod.2017.02.018

22. *Shahriar A., Mehzabin S., Ahmed Z., Dongul E. S., Azad A. K.* Bank Stability, Performance and Efficiency: An Experience from West Asian Countries // IIM Ranchi Journal of Management Studies. 2023. Vol. 2, Issue 1. Pp. 31–47. https://doi.org/10.1108/IRJMS-02-2022-0017

23. *Kasri R. A., Azzahra C.* Determinants of Bank Stability in Indonesia // Signifikan: Jurnal Ilmu Ekonomi. 2020. Vol. 9, No. 2. Pp. 153–166. https://doi.org/10.15408/sjie.v9i2.15598

24. *Yin H.* Bank Globalization and Financial Stability: International Evidence // Research in International Business and Finance. 2019. Vol. 49. Pp. 207–224. https://doi.org/10.1016/j.ribaf.2019.03.009

25. *Uhde A., Heimeshoff U.* Consolidation in Banking and Financial Stability in Europe: Empirical Evidence // Journal of Banking & Finance. 2009. Vol. 33, Issue 7. Pp. 1299–1311. https://doi.org/10.1016/j.jbankfin.2009.01.006

26. *Kasman A., Carvallo O.* Financial Stability, Competition and Efficiency in Latin American and Caribbean Banking // Journal of Applied Economics. 2014. Vol. 17, Issue 2. Pp. 301–324. https://doi.org/10.1016/S1514-0326(14)60014-3

27. *Yuan T.-T., Gu X.-A., Yuan Y.-M., Lu J.-J., Ni B.-P.* Research on the Impact of Bank Competition on Stability — Empirical Evidence from 4631 Banks in US // Heliyon. 2022. Vol. 8, Issue 4. P. e09273. https://doi.org/10.1016/j.heliyon.2022.e09273

28. *Čihák M., Hesse H.* Islamic Banks and Financial Stability: An Empirical Analysis // Journal of Financial Services Research. 2010. Vol. 38. Pp. 95–113. https://doi.org/10.1007/s10693-010-0089-0

29. *Nosheen Rashid A.* Business Orientation, Efficiency and Credit Quality Across Business Cycle: Islamic versus Conventional Banking. Are There Any Lessons for Europe and Baltic States? // Baltic Journal of Economics. 2019. Vol. 19, Issue 1. Pp. 105–135. https://doi.org/10.1080/1406099X.2018.1560947

30. *Daoud Y., Kammoun A.* Financial Stability and Bank Capital: The Case of Islamic Banks // International Journal of Economics and Financial Issues. 2020. Vol. 10, No. 5. Pp. 361–369. https://doi.org/10.32479/ijefi.10147

31. *Joudar F., Msatfa Z., Metwalli O., Mouabid M., Dinar B.* Islamic Financial Stability Factors: An Econometric Evidence // Economies. 2023. Vol. 11, Issue 3. 79. https://doi.org/10.3390/economies11030079

32. *Beaver W. H.* Financial Ratios as Predictors of Failure // Journal of Accounting Research. 1966. Vol. 4. Pp. 71–111. https://doi.org/10.2307/2490171

33. *Altman E. I.* Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy // Journal of Finance. 1968. Vol. 23, Issue 4. Pp. 589–609. https://doi.org/10.1111/j.1540-6261.1968.tb00843.x

34. *Meyer P. A., Pifer H. W.* Prediction of Bank Failures // Journal of Finance. 1970. Vol. 25, Issue 4. Pp. 853–868. https://doi.org/10.1111/j.1540-6261.1970.tb00558.x

35. *Sinkey J. F.* A Multivariate Statistical Analysis of The Characteristic of Problem Banks // The Journal of Finance. 1975. Vol. 30, Issue 1. Pp. 21–36. https://doi.org/10.1111/j.1540-6261.1975.tb03158.x

36. *Ohlson J. A.* Financial Ratios and the Probabilistic Prediction of Bankruptcy // Journal of Accounting Research. 1980. Vol. 18, No. 1. Pp. 109–131. https://doi.org/10.2307/2490395

37. *Scott J.* The Probability of Bankruptcy: A Comparison of Empirical Predictions and Theoretical Models // Journal of Banking and Finance. 1981. Vol. 5, Issue 3. Pp. 317–344. https://doi.org/10.1016/0378-4266(81)90029-7

38. *Hardy D. C., Pazarbasioglu C.* Determinants and Leading Indicators of Banking Crises: Further Evidence // IMF Staff Papers. 1999. Vol. 46. Pp. 247–258. https://doi.org/10.2307/3867642

39. *Shar A. H., Shah M. A., Jamali H.* Performance Evaluation of Banking Sector in Pakistan: An Application of Bankometer // International Journal of Business and Management. 2010. Vol. 5, No. 8. Pp. 113–118. https://doi.org/10.5539/ijbm.v5n8p113

40. *Chiaramonte L., Casu B.* Capital and Liquidity Ratios and Financial Distress. Evidence from the European Banking Industry // The British Accounting Review. 2017. Vol. 49, Issue 2. Pp. 138–161. https://doi.org/10.1016/j.bar.2016.04.001

41. *Alaminos D., del Castillo A., Fernandez M. A.* A Global Model for Bankruptcy Prediction // PLoS ONE. 2018. Vol. 13, Issue 11. 0208476. https://doi.org/10.1371/journal.pone.0208476

42. *Sanchez Gonzalez J., Restrepo-Tobon D., Ramirez Hassan A.* Inefficiency and Bank Failure: A Joint Bayesian Estimation Method of Stochastic Frontier and Hazards Models // Economic Modelling. 2021. Vol. 8. Pp. 344–360. https://doi.org/10.1016/j.econmod.2020.03.002

43. *Tam K. Y.* Neural Network Models and the Prediction of Bank Bankruptcy // Omega-International Journal of Management Science. 1991. Vol. 19, Issue 5. Pp. 429–445. https://doi.org/10.1016/0305-0483(91)90060-7

44. *Barr R. S., Seiford L. M., Siems T. F.* An Envelopment-Analysis Approach to Measuring the Managerial Efficiency of Banks // Annals of Operations Research. 1993. Vol. 45. Pp. 1–19. https://doi.org/10.1007/BF02282039

45. *Li Z., Feng C., Tang Y.* Bank efficiency and failure prediction: a nonparametric and dynamic model based on data envelopment analysis // Annals of Operations Research. 2022. Vol. 315. Pp. 279–315. https://doi.org/10.1007/s10479-022-04597-4

46. *Torky M., Gad I., Hassanien A. E.* Explainable AI Model for Recognizing Financial Crisis Roots Based on Pigeon Optimization and Gradient Boosting Model // International Journal of Computational Intelligence Systems. 2023. Vol. 16. 50. https://doi.org/10.1007/s44196-023-00222-9

47. *Min J. H., Lee Y.-C.* Bankruptcy Prediction Using Support Vector Machine with Optimal Choice of Kernel Function Parameters // Expert Systems and Applications. 2005. Vol. 28, Issue 4. Pp. 603–614. https://doi.org/10.1016/j.eswa.2004.12.008

48. *Erdogan B. E.* Prediction of Bankruptcy Using Support Vector Machines: An Application to Bank Bankruptcy // Journal of Statistical Computation and Simulation. 2013. Vol. 83, Issue 8. http://dx.doi.org/10.1080/00949655.2012.666550

49. *Citterio A.* Bank Failure Prediction Models: Review and Outlook // Socio-Economic Planning Sciences. 2024. Vol. 92. 101818. https://doi.org/10.1016/j.seps.2024.101818

50. *Gwachha K. P.* An Analysis of the Determinants of Bank Stability in the Banking Industry of Nepal // Khwopa Journal. 2023. Vol. 5, No. 2. Pp. 196–210. https://doi.org/10.3126/kjour.v5i2.60463

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