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OPPORTUNITIES FOR DEVELOPMENT OF STRESS- TESTING ON BASIS OF MACROECONOMIC MODEL BUILDING

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Abstract

This paper presents the developed models and the results of stress testing credit risk and liquidity risk in the Russian banking system using Statistica program. The features and benefits of these models were introduced. It is concluded that the possible solution to the problem of linking the macroeconomic conditions and target parameters of the banking system using macro econometric models.

Keywords: stress testing, macroeconometric modeling, credit risk, liquidity risk, banking system, financial stability, Russia

В статье представлены разработанные модели и результаты стресс-тестирования кредитного риска и риска ликвидности банковской системы России с применением программы Statistica. Выделены особенности и преимущества моделей. Сделан вывод о возможном решении задачи увязки макроэкономических условий и базовыми параметрами банковской системы с помощью макроэконометрических моделей.

I. Introduction.

The central banks of developed and developing countries around the world are carrying out a "large-scale" stress-testing the major (or systemically important) credit institutions to assess the financial stability of the financial and banking system in case of critical downturn in the national or global economy.

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Because of the increase in the probability of occurrence of adverse events in the global economy in 2016, the European Central Bank (ECB) is bound to take into account the extremely negative scenarios of the development for European economy including that associated with the negative prospects of the Greek banking system. It is worth noting that according to the International News Agency and the Thomas Reuters financial information (The Thomson Reuters, The Thomson Corporation) and the Analysts International Rating Agency Moody's (The Moody's Investors Service, The Moody's Corporation) the share of "bad debts" in the Greek economy is about 40% of total loans in March 2016 compared with 34.2% in 2014. One of the primary tasks is ubiquitous stress testing the retail loans portfolio in financial institutions and national banking systems of different countries. Therefore, the European regulator is forced to examine the major credit institutions for the presence of a clear and comprehensive strategy to overcome the crisis coupled with the retail lending risks of the European Union and the Eurozone population.

The Financial Policy Committee (UPC) of the Bank of England (The Bank of England Prudential Regulation Authority (BoE)) together with the International Monetary Fund (IMF) has developed a scenario on which conducts a stress testing the portfolio of British banks concerning financial stability. The main risks associated with the economic downturn in China, as well as the possible challenges in the European Union.

It should be noted that the main directions of the Bank of England's work is not only to ensure the banking system financial stability at different stages of the economic cycle but also the ability to withstand shocks, for no other attraction of additional taxpayers' money. Even with the turbulence on financial markets, the Bank of England has developed a procedure for providing credit funds both to the real and financial sector of the national economy. It is impossible not to note the Bank of England's success in stress testing development because the British regulator organizes stress testing not only for asset management funds and central counterparties, but also for hedge funds until 2018.

II. Results and discussion

A credit exposure and a liquidity risk (funding risk) are the most significant and critical risks for the Russian banking sector.

Today, the Basel Committee considers two main liquidity ratios of the bank: liquidity coverage ratio (LCR) and long-term liquidity ratio - "net stable funding ratio" (PCHSF). In 2015 the first ratio has become a standard in the Russian banking system, and according to the second one the process of active and direct use in prudential supervision is not expected until 2018.

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According to a study by the Basel Committee, the supervisory authorities in different countries use over 25 modifications of the Liquidity Coverage Ratio. The developers empirically determined the 30-day period as a sufficient one for the development of anti-crisis measures to equalize the situation with liquidity on the part of the bank top management or the supervisory authority. The quality requirements of the Basel Committee to these light quick assets are reasonable and referred to the market parameters where they will be implemented, the impact of stressful conditions on the discounts for assets sale; ensure the stability conditions of their conversion into cash, etc.

On the other hand, criteria for size determination and directions of the outflows of funds were developed; among these are retail deposits ("runs by depositors" scenario provided) and unsecured sources of funding for non-financial organizations, central banks and governments. In order to implement the above requirements of the Basel Committee, the Bank of Russia has developed a corresponding Application where the LCR profile algorithm has been provided. As a result, the Liquidity Coverage Ratio (LCR) - is calculated by the following formula (1):

$$\text{Liquidity Coverage Ratio (LCR)} = \frac{\text{highly liquid assets}}{\text{net stable funding ratio per 30 days}} \times 100\% \text{ (1)}$$

However, a sufficient level of the ratio is not less than 100%. In addition to the LCR there are three statutory ratios: H2 (quick liquidity should exceed the value of 15%), H3 (day-to-day liquidity with the minimum value of 50%), H4 (long-term liquidity should not exceed the value of 120%) in the instructions No 139-I of the Central Bank of the Russian Federation. H5 ratio (overall liquidity, the liquid assets ratio to total assets except reserves shall not be less than 20%) was excluded from the list of the statutory ratios by the Central Bank of the Russian Federation.

Thus, the generally accepted economic substance of the liquidity coverage ratio is to determine the funding ratio detection with easy and quick (free and highly liquid) current liability assets from the bank in case of the stress scenario. With regard to classical financial analysis this ratio is derived one from the current liquidity ratio used in the liquidity analysis of non-financial companies' balance.

Taking into account the economic substance of the used liquidity ratios by the Central Bank of Russia and the Basel Committee for purposes of determining the level and further factor

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analysis of the Russia's banking system liquidity as a whole (at the macroeconomic level) it makes most sense to use the most universal and methodological simple ratio that allows to assess the level and liquidity dynamics of the whole system. We believe such ratio is the ratio between the most liquid assets to current liabilities without any additional adjustments complicating the economic interpretation of the analysis results. For the purpose of factor analysis and further stress testing we calculated this ratio on the banking system of Russia as a whole - on the basis of consolidated banking data of the Central Bank "An overview of the banking sector." The following formula was used for our calculation (2):

$$\text{RiskLikv} = \frac{DS + SBR - KSKO}{(SO + SKR + DUL + DFL - SR + CR)} \quad (2),$$

where **DS** – monetary funds, precious metals and gems; **SBR** – accounts with Bank of Russia and other authorized bodies in other countries; **KSKO** –corresponding accounts in credit organizations; **SO** – organizations funds deposited in current and other accounts; **SKR** – clients' funds in the calculations; **DUL** – deposits and other corporate deposits (except banking institutions); **DFL** – private deposits; **SR** – accounts receivable; **CR** – moneylenders.

Liquidity ratio system principles:

- simple additive and multiplicative form, which allows to give a single-valued economic factors interpretation on the final figure, and to compare impact factors;

- factors were selected on the basis of the Central Bank of Russia actual reporting form under the principle of materiality (i.e. assets and liabilities ratios of the Russian banking system that have a negligible share in total assets, haven't been included in the numerator and denominator) – the principle of optimum and sufficient number of factors has been provided;

- no additional analytical calculations that contain a large proportion of subjectivity and thereafter give a probabilistic nature to the final figure (for example, in LCR calculating an *expected* monetary outflow need to be made), the ratio is based only on direct statistics;

- each element (factor) of the numerator and denominator corresponds a methodologically comparable ratio of a particular bank of the second level (which is calculated on the Bank's balance sheet) at the macroeconomic level; this allows to estimate the impact of changes in individual banks (e.g. systemically-important banks) or their *groups* on the general macroeconomic liquidity ratio by the *direct* calculation method.

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- stability of the present table's methodology calculation ("Review of the banking sector of the Russian Federation") allows to use sufficiently long time series for *econometric techniques*.

Calculations of the **RiskLikv** indicator are based on the Central Bank of the Russian Federation data for the 4th quarter 2007 - 3rd quarter of 2015 demonstrate that the average level of liquidity by the method (3.2) is about 15.5%, the minimum one is 12.6%, the maximum one is 27.4 %, variation around the average deviation of the arithmetic average is about 14%. There is a slight tendency to reduce the calculated liquidity level of the Russian banking system (Figure 1) according this indicator.

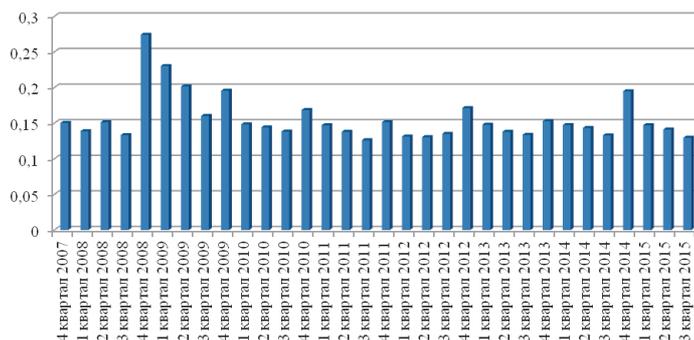


Figure 1 – Dynamics of the liquidity risk level of the Russian banking system in the 4th quarter of 2007 – 3rd quarter of 2015 according to the RiskLikv indicator.

The author has made a statistical study of an array of macroeconomic information aimed at identifying factors affecting the liquidity risk of the Russian banking system in general. For the purposes of this study we have built an array of information according to the quarterly review (analysis period – 1 quarter) - time series of six information units: the GDP; Banking system; monetary policy; real sector; household income and expenditure; foreign economic activity.

As follows from the integrating data of the Ministry of Finance of the Russian Federation, Ministry of Economic Development of the Russian Federation, Federal Service of State Statistics, the Institute for Complex Strategic Studies, Central Bank of the Russian Federation as well as official statistics from several other sources we have built an array of quarterly data from the 4th quarter of 2007 till the 3rd quarter of 2015 composed of 32 periods and 277 variables. The criterion for the selection of variables in the

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array was theoretically based potential correlation between the state of banking system and macroeconomic environment.

Statistic package Statistica has been used while processing of present data which allows applying correlation and regression analysis to multidimensional arrays. The main criteria for research and identification of the factors affecting the liquidity risk of the Russian banking system was availability of reasonable economic interpretation, reliable correlation, confirmed by statistical criteria (Fisher and Student criteria have been used) and absence of multicollinearity between affecting factors. In general, the process of building a multiple regression model consisted in the gradual inclusion of the most significant and economically justified factors (with an unambiguous and theoretically based interpretation of probabilistic dependence) in the model.

During the research we have cut the duplicate, non-interpreted and insignificant factors in order to include factors describing the analyzed values from different perspectives in the model (i.e., so that related variables from one unit were not been included in the model).

As a result of the studying of the available research data the following model has been developed (3):

$$\mathbf{RiskLiqv} = 0.000015 \times \mathbf{Res} + 0.003543 \times \mathbf{Def} + 0.000913 \times \mathbf{U} + 0.192 \quad (3)$$

where **Res** - loss reserves, bln. RUB; **Def** - consolidated budget deficit according to the GDP ratio, %; **U** - Index of "bank lending conditions for large enterprises".

The present model and its indexes are relevant according to standard criteria (Fischer and Student criteria); it explains 73% of variations of the suggested liquidity ratio of banking system.

The designed model allows to conduct a multifactor liquidity stress testing of the Russian banking system and provides informational and analytical support and justification of the answers to the following conceptual issues of both general theoretical and applied character:

- how the growth of credit risk (increase in backup volumes) will reduce the liquidity of the banking system?
- how the deterioration of public finances (by means of increasing of the consolidated budget deficit) will cause a fall of the banking system liquidity?
- how the deterioration (tightening) of credit terms for real sector will impact on the banking system liquidity?

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- how three ways of appearing overall liquidity stress of the Russian banking system relates to each other?

According to the designed model, the power of influence on liquidity risk is **approximately equally** distributed between the three factors which are included into the **RiskLikv** model.

The advantages of this model are as follows:

- high predictive capability, which allows to make a forecast for several quarters ahead;
- use the easily interpretable variables as regressors, which are calculated according to public data;
- both quantitative and qualitative indicators, which covers *different* sources of stress (formalized level of bank lending conditions according to the method of the Central Bank of Russian Federation) are taken into account, which increases value of the model (this way of factors selection exclude the problem of multicollinearity);
- the Russian specificity is taken into account, which involves a high degree of impact of government revenues and expenditures on the economy.

On the basis of the **RiskLikv** model we demonstrate the possibility of its practical use for the purposes of liquidity risk stress testing of banking system. Let us consider 4 different scenarios of macroeconomic conditions of the banking system (Table 1).

The most optimistic scenario (stress testing No4) implies an increase of **RiskLikv** indicator to the level of 0.15 (or 15% in terms of percentage points), which is on 13% higher than the actual level achieved in the 3rd quarter of 2015 and is equal to the average index value over the past 7,5 years. However, taking into account the realities of the political and economic situation such events as a deficit-free state budget, improving loan conditions and break in the growth of loan reserves in the banking system in our opinion are unlikely.

It should be pointed out that forecasting and determining levels of factors and dependent variables are not the purpose of stress testing. However, in view of the obvious trends to the increased budget deficits and deterioration of the loan conditions in Russia as well as the growth of specific weight of the past due debt in non-financial sector, the most probable stress testing are tests No2 and No3, the results of which are expected to reduce the liquidity level of the Russian banking system by 10% and 25% respectively.

Further research of the macroeconomic modeling capabilities is associated with the studying of the credit risk's stress testing, as the central in the banking system of Russia.

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Table 1. Stress testing of the Russian banking system according to RiskLikv model.

Stress test No.	Description of scenario	Loss reserves, bln. Rub.	Consolidated budget deficit according to GDP ratio %	Bank lending conditions for large enterprises – non-financial	RiskLikv	Lowering of predictable RiskLikv level to 3d quarter of 2015, %
Test No. 1	The worst historic value of three factors	5016	-6,30	-17,70	0,12	-6%
Test No. 2	Deterioration in the actual values of factors 3d quarter of 2015 on 20%	6019,2	-3,12	4,52	0,12	-10%
Test No. 3	Deterioration in the actual values of factors 3d quarter of 2015 on 50%	7524	-3,90	5,66	0,10	-25%
Test No. 4	Deficit-free budgeted, reserves are at the level of the 3d quarter of 2015., Index of bank lending conditions is at the maximum level over the past year	5016	0,00	33,90	0,15	13%

For credit risk research of the Russian banking system, we applied the approach used above for liquidity risk modeling. At the same time, considering the various lending areas' (corporate and consumer) specificity, approach, that was proposed by us, involves separate analysis of the credit risks on loans to individuals and corporate loans. Various normative and legal databases of credit lines, conditions, volumes and approaches in the organization of these two credit directions create objective prerequisites for the separate modeling of appropriate credit risks. Moreover, it should be noted that lending to natural and legal persons, even within the same bank is fundamentally different business with their decision-making verticals and specific strategies, business units, etc. Furthermore, this approach in the research takes into account the appropriate specialization of particular bank groups in the retail and corporate lending.

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During the approach application to the factor analysis, that was applied by us for designing of RiskLikv model, for credit risk level evaluating with the aim of the banking system in Russia stress testing, it was proposed the model CredRiskUr (4):

$$\text{CredRiskUr} = 0,075589 \times \text{RasVVP} + 0,000388 \times \text{UbkTr} \quad (4)$$

where **CredRiskUr** is the share of overdue loans in the corporate loan portfolio of Russian banks; **RasVVP** is the share of final consumption expenses in the GDP%; **UbkTr** is the index of "Bank requirements for the borrower," according to the method of the Central Bank of Russian Federation.

This model explains 98% of the test values variation. This is the problem loans' level in the corporate loan portfolio of the Russian banking system, and is accurate according to statistical criteria.

CredRiskUr model is characterized by the following features:

- it has high predictive ability, connected with model's high reliability and adequacy and its coefficients according to statistical criteria (Fischer's and Student's) and with a sufficiently high coefficient of determination ($R^2 = 0,98$);
- it takes into account distribution of GDP in Russia specificity, which implies a high share of the country's GDP redistribution through the state budget and the current consumption direction (raw materials' and consumers' economic model). It is obvious that increasing in the share of GDP, that is redistributed on consumption to the detriment of gross accumulation, leads to a further deterioration of the real sector and, consequently, the level of its creditworthiness;
- the simplicity and simultaneously complexity of the model, as it takes into account, on the one hand, the most universal macroeconomic index, and, on the other hand, the commercial banks' lending policy in the form of high-quality complex index of Central Bank of Russian Federation.

According to the designed model, a macroeconomic factor (expressed through GDP distribution structure) operates on credit risk level many times stronger (almost 10 times), than banks' policy, aimed at credit risk minimization (namely it is tightening of requirements for borrowers, that are legal entities). Thus, the model effectively reflects the situation in the Russian corporate segment, established over the years.

Based on the CredRiskUr model we will carry out a corporate loan portfolio stress test of the RF banking system by

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calculating the 4 situations with macroeconomic credit conditions (Table 2):

Stress-test number	Scenario description	Using of GDP - final consumption expenditure, % of GDP	UBC of large enterprises - requirements to the borrower	The overdue corporate loans share, %	The forecasted risk level to the historical average changing, %
Stress-test No.1	The worst historical values of all three factors	0,740	-3,261	0,057	16%
Stress-test No.2	The actual values of factors worsening on the 2nd quarter of 2015 in 20%	0,857	7,716	0,062	25%
Stress-test No.3	The actual values of factors falling on the 2nd quarter of 2015 in 50%	1,071	6,173	0,079	59%
Stress-test No.4	The actual values of factors falling on the 2nd quarter of 2015 in 70%	1,214	5,447	0,090	81%
Stress-test No.5	The use of GDP is on the level of 2nd quarter of 2015, the credit conditions are the most liberal during the last 7 years (UBC = -3.261)	0,714	-3,261	0,055	12%

Based on the results of the corporate segment of the Russian banking system loan portfolio quality stress testing (at the problem loans level in total corporate sector loan portfolio), we get the following results:

- while preserving a share of GDP, directed at the final consumption at the level of the 2nd quarter of 2015 and the lending conditions liberalization to the highest level for the last 7 years, it is obtained the loan portfolio quality falling (compared with an average value for the analyzed period) by 12%;

- the most realistic scenario is that the deterioration of factors by 20% will lead to a dropping in the loan portfolio quality by 25%, while the share of overdue loans will reach 6.2%;

- a real stress scenario is a variant number 4 (interpretation is the deterioration of the macroeconomic situation with relief

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measure of requirements for borrowers by the banks by 70%) it will lead to an increasing in the problem (overdue) loans level to 9%.

Further development directions of the methodology, based on the proposed CredRiskUr model, are similar to the proposals that are set out by us for RiskLikv model. It is also possible to use this model to determine the absolute volume of (amount of) overdue loans of banking system corporate portfolio.

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