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Mechanism and Model for Decision-Making in Credit Risk Management

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***Abstract*—The article deals with the problem of risk reduction of the banks, credit portfolio. The new mechanism for credit portfolio quality management is proposed, featuring a combination of quantitative and qualitative criteria for assessing the credit portfolio quality and its monitoring. This mechanism supports decision-making on approving or rejecting a credit application in accordance with the permissible risk factors values. The model for optimization of the credit portfolio structure is developed. It provides an optimal ratio of long-term and short-term credits and ensures the maximum of the credit portfolio profitability under various credit policies.**

***Index Terms*—credit risks, credit risk management, credit portfolio optimization, credit policy decision-making**

I. Introduction

Nowadays the sector of bank lending is characterized by a steady demand growing for credit resources while increasing the share of overdue debt in the bank's credit portfolio. Credit operations are one of the main activities of the bank and provide a significant part of its income. The reliability and financial stability of banks depends on the composition and structure of the credit portfolio, as well as the adequate management process. Regarding to this the formation of a high-quality credit portfolio structure that is directly related to the credit risk level is a priority for any bank.

The purpose of any credit institution is to increase its competitiveness. To ensure the effectiveness of the bank's credit activity, this paper proposes the introduction of a new mechanism and model for managing the quality of the credit portfolio based on its diversification.

The paper provides a statistical analysis of the macroeconomic conditions for the development of lending in the Russian Federation, presents the dynamics and structure of the credit portfolio of banks. It was revealed that as of January 2019, there was a significant growth for credit financing, both for individuals and companies. Mortgage lending, car loans, loans for real investments demonstrate growth. At the same time, the negative side is the growth of overdue loans. Such an increase in the risk component in lending negatively affects the banks profitability. One of the possible directions to reduce credit risks associated with defaults on obligations is to diversify the credit portfolio according to the payments conditions and to ensure the most acceptable credit portfolio structure in terms of risk minimization.

II. Credit Processes in the Russia: the Macroeconomic Conditions

The management of a credit portfolio of any financial institution is based on an analysis of the current market situation, consumer demand and an assessment of the state of the economy as a whole. For the period of 2015-2017 years there is an increase in industrial production and a general decrease in consumer demand due to a decrease in the welfare. The monetary policy of the Bank of Russia to curb inflation had a significant impact on reducing consumer demand.

According to the Central Bank of the Russian Federation [1] (Table I) in 2017 year banking sector assets decreased by 3.5%, but by the beginning of 2018 year it increased by 6.4%. A slight increase in assets was facilitated by the population lending revival. The loans to individuals increased at the beginning of 2018, grew by 12.7%, and as of January 1, 2019, the growth amounted to 22.4%. At the same time, the attracted funds of companies and individuals in annual terms grew slightly and amounted to 2.1% and 7.4% by the beginning of 2018, and by the beginning of 2019 – 12.7% and 9.5%, which are significantly lower lending rates for these groups. As of January 1, 2018, the bank assets nominally grew by 6.4%. Growth trends persist and there is a simultaneous increase in assets in nominal and real terms.

The growth rate of the credit portfolio to private customers in real terms in the 4th quarter of 2016 slowed down by half compared to the 3rd quarter (0.8% versus 1.5%). The main support to the market in 2016 and 2017 was provided by mortgage lending. At the end of 2017, its growth amounted to 11.7%, but by the beginning of 2018, the growth rate decreased to 9.8%, the volume of mortgage lending continued during 2018. A significant impact on the dynamics of mortgage lending had a decrease in interest rates in the economy and the state program for subsidizing interest rates on the primary housing market.

Slow dynamics in 2016 was shown by segments with higher credit risks. The car loan segment was influenced by the general decline in the car market. The car credit portfolio decreased by 13.4% for the year. Support to the market, in addition to implementing the state program of preferential car loans, was provided by joint lending programs of banks and car dealers.

TABLE I
THE MAIN CHARACTERISTICS OF CREDIT OPERATIONS IN THE BANKING SECTOR

Characteristic	Data				
	1.01.2017	1.01.2018	1.10.2018	1.12.2018	1.01.2019
Credits to non-financial organizations, including:	25864.1	25961.9	28112.7	28290.9	28448.9
Overdue dept	1734.5	1722.3	1874.3	1894.1	1849.5
Credits to individual entrepreneurs	433.4	438.6	453.8	465.5	469.7
Credits to individuals, including:	10784.7	12151.9	14147.2	14706.6	14872.5
Overdue dept	856.3	846.8	812.8	812.9	757.7

III. CREDIT PORTFOLIO QUALITY: METHODS AND MANAGEMENT TOOLS

Credit portfolio is a set of credit provided by the bank that is structured by quality criteria and reflects the socio-economic and monetary relations between the bank and its customers to ensure the return of loan debt. The credit portfolio quality determines the structural property of the credit portfolio, providing the maximum level of profitability with an acceptable credit risk level and balance liquidity.

The regulation of the credit portfolio and its quality is carried out by two subjects – the regulator and the credit organization itself. The management methods of the regulator (Bank of Russia) are aimed at observing the reserve requirements, at observing the standards imposed on the level of credit risk and are defined in the following regulatory documents [2], [3]. In credit organization the assessment the credit portfolio quality is carried out using the following approaches and methods:

- the method of ratios [4]–[7], based on financial indicators of 20 coefficients for assessing profitability, liquidity and credit risks characterizing the credit portfolio quality;
- scenario approach (or stress testing) [8]–[11], aimed at modeling various scenarios of changes in the state and structure of the credit portfolio. The sensitivity of the bank to risk factors is analyzed. The result of stress testing is the identification of significant factors affecting the risks and the assessment of possible losses as a result of risk events;
- the method of internal ratings [12]–[16], developed in accordance with the standards of the Basel Committee and is designed to take into account the borrower's credit risk and the credit risk of a financial instrument. The result is the assignment of a specific rating to the borrower, the determination of the borrower's risk level and allows to build an adequate system of relations with a specific borrower (in accordance with its rating), establish lending conditions.

As can be seen from the above classification of methods, one of the cornerstones in analyzing the credit portfolio quality is an adequate assessment of the credit risk of the portfolio. Therefore, the substantiation of risk measures is gaining great scientific importance [17], [18].

In decision theory, probabilistic statistical methods are most often used to describe uncertainties (first of all, non-numerical data statistics methods, including interval statistics and interval mathematics) [19]. Fuzzy set theory methods and conflict theory methods are also useful. Mathematical tools for risk assessment are used in simulation and econometric models, usually implemented in the form of software products.

Risk assessment is carried out on the basis of a number of methods, which is determined by the nature of the risk and its factors. Two groups of methods are widely used – statistical, based on the use of empirical data, and expert, based on the opinion and intuition of specialists. In statistical methods, if the possible value of the risk-related damage is described by the distribution function, its characteristics such as mathematical expectation, median and quantiles, variance, standard deviation, coefficient of variation, linear combination of mathematical expectation and mean square deviation (for example, traditional the confidence interval for determining damage can be estimated by the rule of three sigma – mathematical expectation plus or minus three sigma), mathematical expectation loss function. In this case, the losses assessment problem is described as the problem for assessing one or more of the characteristics listed above. More often, such an assessment is carried out according to empirical data – on a sample of losses – corresponding to similar cases that have occurred previously. In the absence of empirical material, it remains to rely on expert estimates.

If the uncertainty is probabilistic and the losses are described by a random variable, then risk minimizing may consist in minimizing the mathematical expectation of losses as a result of the occurrence of a risk situation, in minimizing the standard deviation of losses from their average expected value, in minimizing a linear combination of mathematical expectation and standard deviation, maximizing the mathematical expectation of the utility function, etc.

One of the common risk measures at present is the value-at-risk (VaR), which was first used by J. P. Morgan in 1994 and recommended by the Basel Committee [11]. VaR determines the maximum losses that a company may receive with a given probability. With its great popularity, this measure has a number of drawbacks – it does not take into account possible large losses that are unlikely. S. Uryachev [19], [20]

proposed a measure of conditional value-at-risk (CVaR), which determines the mathematical expectation of incomes less than VaR. This measure of risk more adequately assesses risk when the distribution density of expected income has a heavy tail. At present, the development of dimensionless (index) risk measures, combining quantile risk measures, level measures, and various indices, is underway [17]–[22].

We highlight the set of valid control actions, described using the corresponding set of control parameters. The ability to influence risk characteristics that determine the purpose achievement is formalized as the choice of the control parameter value. In this case, the control parameter can be a number, a vector, can be an element of a finite set, or have a more complex mathematical nature. The main problem is the correct formulation of the risk management purpose. Since there is a whole range of different risk characteristics, the optimization of risk management often comes down to solving the problem of multi-criteria optimization. For example, the problem is to simultaneously minimize the average losses (the mathematical expectation of losses) and the losses deviation (standard deviation).

There are different methods for credit portfolio quality management aimed at reducing credit risk:

- methods for assessment and methods for borrower credit worthiness improvement;
- delimitation of powers for credit decision making depending on the credit value and potential losses;
- monitoring of payment discipline and interconnection organization with troubled borrowers;
- the protective conversion of the credit terms stipulated by the contract conditions (information support improvement, fines, penalties, forfeits, in interest rates increasing);
- increasing the efficiency of internal special organizational structures (security services);

as well as management methods aimed at the consequences of risk events:

- diversification of the credit portfolio;
- limitation of loan value issued to one borrower.

IV. Mechanism for Credit Portfolio Management

In general, banking activities have the following main types of risks: credit risk, interest rate risk and liquidity risk. Credit risk is associated with defaults on obligations, in the context of growth in lending volumes is systemically important and initiates other risks. This type of risk is manifested in the form of full or partial non-repayment of the credit (accrued interest and commission payments) or deferred repayment of the credit. Interest rate risk arises as a result of adverse fluctuations in the interest rate, which leads to an increase in the cost of paying interest on deposits or a decrease in income from investments, as well as income from loans granted. Liquidity risk is manifested in the likelihood of the inability to meet the expected or suddenly arising situation of the need for cash financial resources of the organization.

For the effective functioning of the banking system in conditions of increased demand for credit resources, therefore, increasing credit risks, a mechanism is needed to ensure an increase in the quality of the credit portfolio by achieving an acceptable risk / return ratio depending on the risk appetite of the decision maker. We propose the credit portfolio management mechanism which is presented in the form of a structural and functional scheme and consists of the following stages, Fig. 1.

Stage 1. Clients classification. To effectively manage the risks of the bank lending activities, it is first necessary to determine the requirements for customers (clients) that would be attractive enough for them and at the same time guarantee an influx of deposits and repayment of loans.

The development of individual requirements for each client is not productive. Therefore, it is advisable to identify a customers group with similar characteristics (loan conditions, loan amount and type of client – individual or company) and properties using cluster analysis methods. In this study we use customers classification parameter like credit maturity (short and long term).

Stage 2. Risk assessment by clients groups. If the distribution of the expected income of the credit portfolio is close to normal, then as a measure of risk, we can use the rate of return variation or the VaR.

Stage 3. Development of an optimal clients base structure. The purpose of this stage is to obtain a set consisting of the numbers of each class of customers, providing the minimum aggregate risk (losses) that may be incurred by the bank in the event customers fail to fulfill their obligations. Moreover, each group of customers is characterized by the following characteristics: group size, total group income, specific working capital for each client, coefficient of variation of deviations in the amount of cash flow in case of violation of the contracts conditions. In this case, the search for optimal structures is conducted from the perspective of the decision maker's attitude to risk. This stage is implemented using the mathematical programming model and is presented in the next section.

Stage 4. Management of the clients structure. At this stage, the existing customer structure (credit portfolio) is managed to bring it closer to the calculated optimal one. The analysis of the inconsistency of the existing and optimal structures is carried out according to the selected groups, the elements of which have similar individual properties that reflect the interests of the clients included in a particular group. In accordance with these interests, the strength of each class should be influenced. Management methods are: interest rate policy, a set of requirements for borrowers to obtain a loan, the flexibility to work with loans (the possibility of extending and early repayment of loans), a set of fixed parameters for services or their individual nature.

Evaluation of the effectiveness of managerial decisions, as well as an assessment of the impact of credit risk management methods on a bank's competitiveness, is carried out on the basis of quantitative methods – calculation of forecast cash

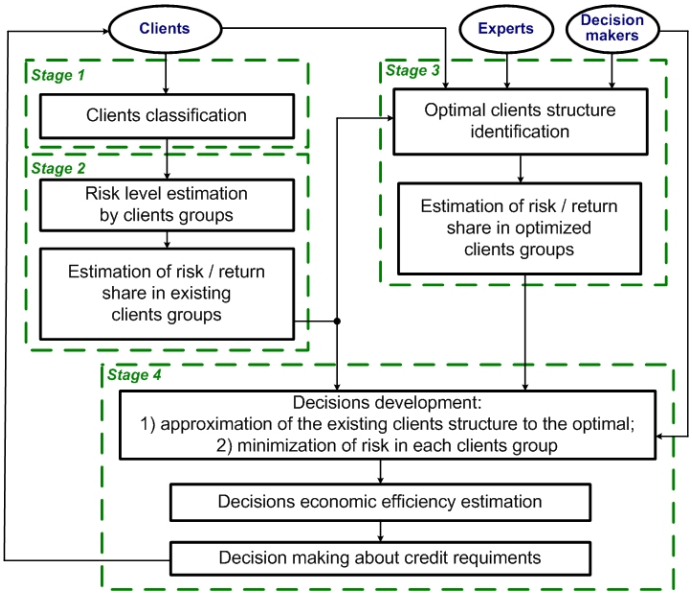

Fig. 1. Structural and functional diagram of the risk management mechanism of the bank

flows, risk levels, insurance reserve value, as well as qualitative systems analysis methods, for example, hierarchy analysis method [21]. The purpose of the analysis is to compare the existing position of the organization in the market with the position that it will occupy as a result of the proposed changes in the policy of working with clients. The advantage of this method is to take into account both quantitative and qualitative indicators of the bank.

A detailed presentation of the stages of classification and risk assessment of individual groups of clients with numerical experiments can be obtained from the study [23]. This article discusses in detail the implementation of the third stage of the described mechanism.

V. The Optimization Model for Credit Portfolio Diversification

Diversification of a credit portfolio is a method for credit risk minimizing based on the formation of individual loan conditions for each category (group) of borrowers – credit conditions, types of credit security, and maximum credit volume [24]–[28]. Diversification can be carried out according to various criteria – sectoral, geographical location, capital, ownership form, risk / return ratio, etc. We will proceed from the assumption that a higher level of return on the credit portfolio is provided by more effective approaches and methods for managing the credit risk of default by the borrower obligations. As a measure of risk, the model uses the standard deviation of the yield.

We introduce the following notation for the problem of credit portfolio diversifying: r – portfolio return; σ – portfolio risk; i – the number of credit groups in the credit portfolio, $i = 1 \dots n$; r_{ij} – profitability of the j investment included in the i credit group $j = 1 \dots m$; σ_i – risk of i credit group in the credit portfolio; r_i – average yield in the i credit group; d_i – share of the i credit group, $\sum\limits_{i=1}^{n} d_i = 1$.

The model for the optimal credit portfolio structure is proposed, in which the efficiency criterion is the maximum yield of the credit portfolio taking into account the maximum possible portfolio risk, determined on the basis of the three sigma rule:

$$\sqrt{\sum_{i=1}^{n} d_i r_i} - 3\sqrt{\sum_{i=1}^{n} d_i^2 \sigma_i^2}. \tag{1}$$

The first term in (1) reflects the yield of the credit portfolio, which is determined based on the weighted average of the specific gravity (share) of each credit group in the portfolio of returns of each credit group:

$$r = \sqrt{\sum_{i=1}^{n} d_i r_i}, \tag{2}$$

$$r_i = \frac{\sum\limits_{j=1}^{m} r_{ij}}{m}. \tag{3}$$

The second term in (1) expresses the portfolio risk provided that the elements of the credit portfolio from different groups are independent (uncorrelated) is defined as

$$\sigma = \sqrt{\sum_{i=1}^{n} d_i^2 \sigma_i^2}. \tag{4}$$

Moreover, the risk of each credit group the credit portfolio can be found by comparing the average yield of loans in this group with the profitability of each investment:

$$\sigma_i = \sqrt{\frac{\sum_{j=1}^{m} (r_{ij} - r_i)^2}{m}}. \tag{5}$$

TABLE II
INITIAL DATA ON THE INITIAL STRUCTURE OF THE CREDIT PORTFOLIO

Characteristic	Data	
	Short and medium term credits (up to 3 years)	Long term credits (over 3 years)
Share in the credit portfolio	0.41	0.59
Average yield,%	19.6	26.8
Maximum yield,%	23.3	32.0
Minimum yield,%	19.1	23.0
The standard deviation of the yield,%	1.8	4.5

TABLE III
THE RESULTS OF CALCULATIONS OF THE CREDIT PORTFOLIO STRUCTURE

Type of credit policy	Maximum allowable risk level,%	Credit portfolio structure,%		Rate of return,%
		Long term credit	Short-term credit	
Aggressive	13,5	42	58	28,4
Moderate	7	65	35	24,5
Conservative	5,4	7	93	19,4

The proposed model was tested on statistical data on the functioning of one of the largest banks in the Russian Federation. For the analysis, we used data on the structure of the credit portfolio, including long-term and short-term loans, Table II.

The restrictions on the risk of the credit portfolio, depending on the chosen credit policy, should be in the range of the existing risk values of the i th credit group, since the optimal portfolio is formed on the basis of the available data on the indicators of profitability and deviation of profitability of issued credit. The total risk of the credit portfolio, subject to the rule, should be in the range from 5.4% to 13.5%. The implementation of the model under various scenarios for different credit policy – conservative, moderate and aggressive, is presented in Table III.

The main purpose of an aggressive credit policy is to obtain maximum profitability, respectively, given the high risk level. The interest rate on high-risk credit is always higher than average interest rates. In accordance with the selected credit policy, the maximum credit risk level for the credit portfolio is established. The maximum risk value in an aggressive policy is 13.5%. If the risk on the credit portfolio is 13.5%, the credit portfolio will have the structure: 42% will be long-term credit and 58% – short-term and medium-term credit. With a conservative credit policy (maximum risk is 5.4%), then credit portfolio will be optimal with the following structure: 93% – short-term and medium-term credit and only 7% – long-term credit. The maximum return on the credit portfolio with the maximum risk value will be 19.4%. The main purpose of a moderate credit policy, in contrast to aggressive and conservative, is to obtain a stable average income with an average acceptable risk level. By implementing this credit policy, the bank can provide loans to both reliable borrowers and a limited number of high-risk borrowers. The maximum risk value for a moderate credit policy is at 7%, and the yield reaches 24.5%.

VI. CONCLUSION

In the work we have proved that under conditions of growing demand on credit resources in Russian economy the importance of credit risks management system is strongly increased. Empirical studies have shown that credit risks are increased nonlinearly accordingly to the main credit characteristics like credit risk level, credit terms and credit interest rate. In the context of the active changing of external and internal environment of Russian commercial banks, the engineering of the comprehensive knowledge about its activities and management of the credit portfolio quality using new approaches and tools has not only theoretical but also a practical importance.

We have highlighted the problems of credit default risks increasing under growing demand for credit resources. We have systematically analyzed approaches and methods aimed at reducing credit risks. It is shown that in order to reduce the credit portfolio risks banks need not only to apply the regulatory measures of the Bank of Russia, but also to conduct thorough scoring of borrowers and the credit portfolio as a whole.

The new mechanism has been developed for quality management of the bank's credit portfolio, which is based on the qualitative and quantitative indicators. The mechanism provides continuous scoring of the clients, allows to clients classification by homogeneity of credit histories, and provides support for management decisions on approving or rejecting a loan application in accordance with acceptable risk factors. To

model the optimal structure of the credit portfolio according to the risk / return criterion for various values of the risk appetite of the person making the decision, a model of diversification of the loan portfolio has been proposed.

The proposed approach for credit risk management differs from the another methods in that it is: firstly, allows to support decision making in credit portfolio organization by the credit terms in accordance with the acceptable credit risk level, determined by the degree of risk appetite for the decision maker; secondly, ensures maximum return on the credit portfolio and contributes to the credit organisation growth. The effectiveness and validity of the main assumptions of the proposed approach have been confirmed on actual data and the results reliability has been proved.

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