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DEVELOPMENT OF OPTIMIZATION MODELS AND METHODS FOR THEIR SOLUTION FOR ASSET MANAGEMENT OF COMMERCIAL BANKS IN UZBEKISTAN

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ABSTRACT

Need to study system analysis of modern models of banking activity, including bank asset management, and determination of the most promising areas for the application of economic and mathematical methods of multi-criteria optimization based raising the level financial stability jar. The purpose of the article is to increase the efficiency of a commercial bank based on the development and testing of optimization models and methods for their solution for managing bank assets. The article explores mathematical model of the problem of multi-criteria optimization of the structure of assets of a commercial bank, considering the structure of liabilities as an exogenous factor according to criteria reflecting various aspects of the bank's stability, taking into account the restrictions of the Central Bank of the Republic of Uzbekistan, using an extended classification of assets by risk and liquidity to adequately model the state of the bank's balance sheet and a method for solving a multi criteria optimization problem based on the synthesis of concessions and Pareto optimal set methods by constructing an optimal set at each Pareto step, formulating the concession value according to less important criteria and transferring them to the category of restrictions. The method makes it possible to effectively synthesize the possibilities of machine optimization and take into account the knowledge that is difficult to formalize. The conducted research allows to significantly speed up the process of developing management decisions in the bank and increase their efficiency.

KEYWORDS: *System Analysis, Bank Asset Management, Development And Testing Of Optimization Models, Decision Maker, Method For Solving The Problem Of Multi Objective Optimization, The Role Of The Banking System*

INTRODUCTION

The role of the banking system in the economy dictates special attention to ensuring their sustainable development. In this case, asset management of commercial banks plays a special role. This thesis is confirmed by a 1988 study of the causes of failures of large US commercial banks. The results of the analysis show that the main reason for the decline of troubled banks continues to be poor asset quality (98% of bankruptcies), which eventually depletes the bank's capital, and weaknesses in planning and management (90%). Insufficient attention to asset

quality management and maintaining liquidity at the proper level was the main cause of the crisis in the banking system of Uzbekistan in 1998. The existing theories of asset management of commercial banks are aimed at managing certain types of assets or are built on a one-to-one correspondence between assets and liabilities, grouped by terms and type. As a rule, the need to maintain sufficient liquidity and stability of the bank entails a "reinsurance" asset structure, characterized by low profitability, which significantly limits the bank's ability to develop.

The problem of asset management in its importance and relevance is one of the main ones in banking management. It is necessary to develop new evidence-based approaches that correspond to the goals of ensuring high profitability of banking activities in compliance with the requirements of financial stability.

In this regard, the refinement of the theoretical foundations and the justification of specific practical recommendations for the development of methods and tools for managing the assets of a commercial bank in modern conditions are important tasks of economic research. At the same time, like any process, they require constant improvement, since the problem of eliminating a certain gap between theoretical research and the main procedures for their practical application is extremely acute.

Obviously, the traditional mechanisms of bank management do not provide effective ways to achieve the optimum between the return on assets and the stability of commercial banks. The solution of this problem is possible only with the use of economic and mathematical methods, which determines the relevance and practical significance of studying the features of the functioning of commercial banks in modern conditions and issues of increasing the efficiency of managing their assets.

An urgent need is to develop the theory and practice of optimal management of commercial banking assets, using the achievements of mathematical management theory, which will ensure the stability of banks through more efficient use of available resources.

Literature review

Theoretical problems related to the influence of bank assets on its liquidity, stability and reliability are considered in a large number of works, the most fundamental of which are the works of E. Reed, R. Kotter, E. J. Dolan, J. F. Sinki, O.I. . Lavrushina, V.M. Usoskin, M.B. Dichenko, Z.T. Tomaeva, Kh. Rakhmatova, M. Muminova and other authors.

Chadin S. V. (2004) formulated the characteristic features of financial management in commercial banks, identified the main directions of its development. In the study generalized the basic principles of building a modern effective management system for a commercial bank; the concept of asset management of a commercial bank has been clarified, the author's definition of centralized asset management has been given, the role and place of the treasury in the management system of a commercial bank has been determined; the main factors influencing the effectiveness of the centralized asset management of a commercial bank have been identified and systematized; a system of centralized asset management of a commercial bank was developed and a scheme and algorithm for managing each of its elements were proposed; formulated methodological foundations for optimizing the asset management processes of a commercial bank.

Kolesnikov Yu.M. (2000) adapted the theory of diversification of the investment portfolio of Markowitz to the portfolio of banking assets in general and the loan portfolio in particular. At the same time, the necessary diversification of the portfolio is determined by the low degree of correlation between individual types of assets, types of loans, borrowers (issuers), etc.; it is proved that the Savings Bank, due to its special status, is both an economic entity and an economic management body; from this point of view, an assessment was made of the implementation of the theoretical provisions identified by the research in the practice of managing the assets of the Savings Bank; methods for assessing the risk of bankruptcy of enterprises were tested (Z - Altman model, Chesser loan supervision model, Irkutsk R - model and coefficient of loss (recovery) of solvency) and appropriate recommendations are given to improve the assessment of the creditworthiness of legal entities, banks, authorities of subjects and municipalities, individuals based on them; a new approach is given to assessing the financial position of the authorities of the subject, as one of the main borrowers of the Savings Bank, based on determining the consolidated credit rating of the borrower, taking into account the values of the borrower's credit ratings calculated according to the methods of Sberbank's own methodology and according to the methodology of the rating agency "EA - Rating", as well as the value of the indicator of economic development of the region.

Rybin S.V. (2007) gave the author's interpretation of the optimal composition of banking assets, based on achieving an acceptable ratio of risk and return, taking into account the specifics of their formation in modern Russian conditions. The work carried out a classification of external and internal factors that limit the process of profit maximization in the course of managing a portfolio of banking assets, from the standpoint of consistency, the relationship between them was clarified; the use of simulation modeling as a tool for optimizing the structure of a portfolio of assets of a commercial bank is proposed as the most effective method of multivariate analysis of the behavior of the object under study at relatively low costs; a mathematical model was built for choosing optimal solutions for balancing assets and liabilities of a commercial bank, taking into account the complex influence of factor criteria, which, in addition, allows solving forecast and strategic problems, and the algorithm for its implementation is substantiated; directions have been developed to improve the methods of managing the assets of commercial banks, contributing to timely decision-making on optimizing their structure with checking sensitivity to changes in the economic situation or errors in forecasts.

Selimov T.R. (2011) clarified the methodological bases for determining the main directions for assessing the quality of asset management of commercial banks of the Republic of Dagestan, aimed at identifying the effectiveness of loans and other funds placed. The study proposes a system of methodological support for the analysis of the financial condition of commercial banks as part of an asset management strategy, which allows the use of certain indicators, methods and techniques of analysis to assess the effectiveness of bank management; the methodological provisions for analyzing the composition, structure and dynamics of loan assets are substantiated, the author's version of optimizing the structure of loan assets under the conditions of crisis phenomena is proposed; proposed measures to improve the methodology for analyzing factors affecting the quality of bank asset management:

These studies are of great theoretical and practical importance. However, there are still a number of unresolved problems, in particular, the relationship between the fundamental concepts of liquidity, solvency, reliability, stability of a commercial bank is interpreted differently; due to the extreme complexity, the problem of building a general model of a bank that combines the

management of assets, liabilities and equity capital has not been solved. In the field of private models that describe one aspect of bank management, asset management models have become widespread, scalarizing a multi criteria optimization problem according to profitability and sustainability criteria based on an explicitly or implicitly given utility function of a decision maker (DM).

Since the task of formalizing the utility function is extremely complex, the optimization models built using it have not been widely used in practice due to a significant discrepancy between the optimization results and the decision maker's expectations. Thus, the task of developing such a banking asset management model that allows more flexibility to take into account the need for a compromise between criteria with interactive consideration of the preferences of the decision maker seems to be relevant.

The main purpose of the study is to improve the efficiency of a commercial bank based on the development and testing of optimization models and methods for their solution for managing bank assets.

Methodology

The study is based on the postulates of system analysis. In the process of research and development, the main provisions and methods of mathematical economics were used: the theory of multi criteria optimization (in particular, the methods of concessions, the main criterion, normalization of criteria, convolution of additive and multiplicative types, various methods for constructing the Pareto set); elements of game theory (maximum convolution); method of multidimensional data visualization; elements of the theory and tools for designing economic information systems.

In the long-term (strategic) aspect, the goal of each business entity is survival and sustainable development. The analysis of the relationship between the concepts of "stability" and "reliability" showed that in the most typical word usage "reliability" means the ability of an object to perform specified functions, while maintaining its main characteristics within the established limits, stability is considered as the ability to resist forces that can unbalance, t .e. stability on the development trajectory. Most often, stability is used as a characteristic of complex dynamic systems that are influenced by a large number of factors, including those with random characteristics, which include commercial banks in the market environment. Unlike resilience, reliability is a more static category.

In addition, states of stagnation and stability should be distinguished. Stagnation, in contrast to sustainability, is such a state of the bank, in which the preservation of its reliability is achieved at the cost of losing the ability to develop, to self-reform. Obviously, in a strategic perspective, such a commercial bank has no chance. Thus, the logical-terminological analysis shows that sustainability is the most fundamental goal of the bank's development. At the same time, stability as a state of dynamic equilibrium in motion is made up of current reliability and the ability to develop. The bank's ability to develop directly depends on its profitability, which allows it to expand its activities and improve the quality of work. Thus, it can be concluded

The concept of reliability needs a special study. It can be quantified in two different ways: empirical-statistical and a priori-theoretical. The first approach involves the statistical classification of banks into reliable and unreliable (by means of expert assessment or consideration of data in a time context) and the identification of quantitative indicators of any

nature (individual balance sheet items, various ratios, etc.) that most adequately reflect this division. This approach leads to the construction of reliability ratings as integral indicators reflecting the overall reliability of the bank. The paper considers both the use of standard rating methods (Kromonov, Russov, Katugin), and the methodology for constructing your own ratings, which allow you to set your own reliability criteria,

The second approach is an analytical consideration of the concept of "reliability" in order to identify its main components that have a direct quantitative assessment. To determine these parameters, a synthesis of the historical-genetic and structural-functional approaches was applied.

The historical-genetic approach implies an analysis of the evolution of the concept and sustainability factors in the development of banking. The study led to the following conclusions: the problem of maintaining the reliability of banks arose simultaneously with their appearance. Since even the first banks (change shops) issued loans from funds deposited for storage, the problem of maintaining liquidity in order to pay off current liabilities arose. Thus, at the beginning of the existence of banking activity, the reliability of banks depended on their liquidity, and liquidity was reduced to a sufficient supply of absolutely liquid assets - gold coins.

Therefore, the main method of regulating banking reliability was asset quality management - the riskiness of lending and the absolute liquidity ratio (according to modern terminology). In the 19th century, the problem of maintaining liquidity became more acute due to the transition of banks to the issuance of banknotes (bank bills at sight). Therefore, the leading banks tried to maintain the absolute liquidity ratio (the ratio of cash on hand to the total amount of banknotes issued) at a fairly high level.

The first factor of reliability is the bank's liquidity. The study showed that in practice it is sufficient to use the relevant standards of the Central Bank of the Republic of Uzbekistan (*H2-H3, H14*) as liquidity indicators, since they are based on accounting for internal reporting data and, therefore, are much more accurate than those operating only with open balance sheet liquidity indicators of Kromonov and similar rating systems.

In the 20th century, capital adequacy also gained particular importance. Sufficient capital forms a reserve that allows the bank to remain solvent and continue operations despite unforeseen losses, etc.; however, an overcapitalized bank is usually inefficient (low leverage) and non-competitive in the capital and credit markets. Therefore, it is necessary to optimize the value of this indicator at a certain average level. Two groups of coefficients were used as indicators of sufficiency:

• the first group is built on the basis of the ratio of capital funds (in various composition) to total deposits (deposits);

• the second group is based on the ratio of capital (in various modifications) and assets (of various composition).

The ratio of equity to deposits is based on the consideration of capital as a means of protecting creditors.

In the second third of the 20th century, the prevailing opinion became that the need for capital does not depend on deposits, but on assets: capital adequacy should indicate what losses a bank

can incur without prejudice to the interests of depositors and other creditors. Capital came to be viewed primarily as a shock absorber to help overcome the fall in the real value of assets.

The conducted studies confirm the correctness of this approach. If losses occur as a result of the active operations of the bank, which the latter conducts mainly on its own behalf and at its own expense, the losses are covered not from the attracted resources, but from its own funds.

At present, the standard approach to capital adequacy analysis has been developed by the Basel Committee on Banking Supervision and Regulation, which represents the point of view of the Central Banks of the world's leading countries. According to him, the preferred method for assessing capital adequacy is the ratio based on risk-weighted assets.

In domestic practice, the use of capital adequacy indicators began in August 1992. In the instruction of the Central Bank of the Republic of Uzbekistan No. 10 “On the procedure for regulating the activities of commercial banks”, the capital adequacy of a commercial bank was determined by the minimum allowable size of the authorized capital of the bank and the maximum ratio of the total capital and the amount of assets, taking into account their riskiness. It was proposed to measure capital adequacy using the ratio of the bank's capital and the total volume of risk-weighted assets (*H1*). In all subsequent changes and additions to this Instruction, including the new Instruction of the Central Bank of the Republic of Uzbekistan "On the procedure for regulating the activities of commercial banks", which came into force in August 1997.

The study of the influence of asset quality on the stability of the bank made it possible to formulate a holistic concept of asset management in order to achieve the main goals of the bank and to identify the dialectical relationship between qualitative goals and quantitative criteria. The main goal of banking - the sustainable development of commercial banks - depends on profitability and reliability. Reliability can be described in terms of liquidity, capital adequacy, or through the use of special rating systems. At present, the main factor of capital adequacy is recognized as the structure of assets according to the degree of risk, and liquidity - the presence of a reserve of highly liquid assets and the compliance of assets and liabilities by maturity.

Effective asset management of a commercial bank requires the development of adequate quantitative models of banking activities. The bank is a complex modeling object that requires, first of all, an integrated approach. It is rather difficult to create an integrated model of a bank that would simultaneously cover liquidity management, a portfolio of assets, and the choice of the optimal structure of the resource base. Therefore, private models describing one of the aspects of the bank's activities have become widespread. When choosing conceptual provisions for building a model for ensuring the sustainable development of the bank, the main modern approaches were analyzed. One of them is liability modeling, which considers the credit market as little dependent on banking activity; the main attention is concentrated on the market of deposits and factors, leading to their attraction. In the case of perfect competition, the interest rate on deposits is considered as an argument of the fund supply function, and the bank is considered as a buyer of cash deposits, which acquires them at the advertised price; at the same time, rate variation is considered an effective tool for attracting savings from the population.

However, a study of the functioning of domestic banks showed that the prerequisites for this model in Uzbekistan are not fulfilled at all due to the low controllability of the deposit market: the bank accepts cash deposits, the total flow of which depends on the economic situation as a

whole, the welfare of the population, etc., i.e. . from those factors that are outside the bank's competence and therefore should be considered as given exogenously. Private depositors traditionally prefer the People's Bank of the Republic of Uzbekistan as the most reliable and essential correlation between the interest on deposits and the amount of funds raised: too high a percentage is perceived as a signal of the bank's dishonest intentions. Thus, the operational management of the resource base is practically impossible, and the structure of liabilities can be considered as a constant.

$X = \{x_i,\ \overline{1,N}\}$ - let be a vector of model variables; x_i - the amount of temporarily free funds invested in a particular type of assets; *N* - the total number of investment directions, the vector of variables belongs to the space of *N* - dimensional vectors $X \epsilon R^N$ (the space of model variables).

Since the physical meaning of the vector of variables is temporarily free funds invested in one or another type of asset, the vector of variables is not negative: $X \geq 0$.

The functioning of the bank is aimed at fulfilling certain goals, which are reflected by the vector of criteria, functionally related to the vector of variables $f_k(X),\ k = \overline{1,K}$, where is the set of indices of criteria K, the set of criteria $Kk \epsilon K$ can be represented as a vector – functions

$$F(X) = \{f_k(X),\ k = \overline{1,K}\}$$

In our case, each component of the vector criterion is aimed at maximizing its value, the optimization problem is written as

$$maxF(X) = \{f_k(X),\ k = \overline{1,K}\},\qquad X \geq 0$$

This imposes a mandatory restriction

$$\sum_i x_i = S;\quad i = \overline{1,n}$$

where *S* is the sum of the bank's free resources at the beginning of the trading day (determined by experts). The meaning of this restriction is that the bank does not attract resources from outside, but redistributes temporarily free funds.

Mandatory restrictions according to the instructions of the Central Bank of the Republic of Uzbekistan are defined as follows:

$$H_1(\bar{X}) \geq 10\%;\ \ H_2(\bar{X}) \geq 20\%;\ \ H_3(\bar{X}) \geq 30\%$$

where *H1* - capital adequacy ratio, %; *H2* - instant liquidity ratio, %; *H3* - current liquidity ratio, %.

The components of the vector of criteria are indicators reflecting the hierarchical structure of the bank's goals. As a capital adequacy criterion, the relevant standard of the Central Bank of the Republic of Uzbekistan *H1* is applied. The most significant indicators of liquidity are the norms *H2, H3*.

In addition to these standards, the values of bank reliability ratings can serve as criteria. The paper provides a comparative analysis of the ratings of Kromonov, Russov and Katugin. As a criterion for the profitability of the bank, the weighted return on assets is used

$$BD = \sum_i x_i \, d_i : A_b,$$

where x_i - the volume of investments in asset i; d_i - average return on investment in an asset; A_b- balance currency.

It should be noted that the model is a static optimization problem and is designed for short-term management of investments of temporarily free funds in various types of assets.

RESULTS AND DISCUSSIONS

The paper analyzes traditional methods for solving this problem and shows that their application in banking is difficult due to the simplification of the multi criteria nature of the problem, insufficient consideration of the knowledge of the person making the decision in the subject area. In terms of the degree of involvement of the decision maker, the methods can be classified into interactive and fully automatic.

Fully automatic methods for solving multi objective optimization problems include the main criterion method and various convolutions of criteria. They are united by the fact that the decision maker sets his preferences once, when setting the problem, and then the only solution is given after the automated procedure for solving a single-criteria optimization problem.

The simplest and most frequently used method of reducing a multi criteria problem to a single-criteria one is to single out one criterion as the main one and transfer the remaining criteria to the category of restrictions by formulating additional restrictions on the values of these criteria. This method has a number of fundamental disadvantages. First of all, this method greatly simplifies the structure of the original problem, does not take into account the difference in the values of the criteria, transferred to the category of restrictions. In addition, it is quite difficult to formulate restrictions on the values of less important criteria.

If you set limits that are too low, then the resulting point will not necessarily be Pareto-optimal (if the objective function has several extrema), and if it is too high, then the value of the objective function (main criterion) at the obtained point will be too low compared to its absolutely achievable maximum (without taking into account restrictions on other criteria).

Criteria convolution is another popular technique. There are a large number of different types of convolutions. Theoretically, all of them are based on the approach associated with the concept of the utility function of the decision maker. This approach assumes that the decision maker always has a utility function, whether or not he can specify it explicitly. This function maps the criteria vectors onto the real line so that the larger value on this line corresponds to the more preferred criteria vector. The meaning of different convolutions is to obtain one "quality factor" (combined criterion) from several criteria, thus approximately modeling the unknown (not explicitly specified) utility function of the decision maker.

However, the study showed that the main drawback of all criteria convolutions is the following: the implicit utility function of the decision maker is usually non-linear, so the "true" weights of the criteria (i.e., those weights for which the gradient of the weighted objective function coincides in direction with utility function gradient) will vary from point to point, so we can only talk about locally appropriate weights; moreover, often the decision maker cannot set the weighting coefficients at all. This is a particularly big disadvantage in relation to the banking sector, for example: according to the instant liquidity ratio, the Central Bank of the Republic of

Uzbekistan has set a limit of more than 10%. From the point of view of the stability of the bank, the usefulness of the value of this criterion, equal to 20%, one and a half times (or 50%) higher than the usefulness of the criterion value equal to 10%. However, the usefulness of the value *H2* = 100% cannot be estimated one and a half times (or 50%) greater than the value *H2* = 65%, since the value *H2* = 65% is already quite high in terms of providing liquidity. Depending on the situation in the economy, the degree of confidence in the banking system, etc. we can decide that the utility of the value *H2* = 100% is higher than the utility of the value *H2* = 65% not by 50%, but by about 25 ... 30%. Obviously, the utility of the value *H2* = 400% is exactly the same as the utility of the value *H2* = 200%, since both of these values mean the absolute liquidity of the bank, and a further increase in the value will not lead to a noticeable increase in stability. The usefulness of increasing the value of liquidity ratios gradually decreases as the absolute values of these ratios grow and drops sharply after overcoming the threshold of 100%. Thus, the main disadvantage of all methods for solving problems of multi criteria optimization, which led to their small distribution in practice, is the insufficient consideration of the preferences of the person making the decision regarding the ranking of criteria by importance that are difficult to formalize and change with the receipt of additional information.

Therefore, it is advisable to use interactive methods of finding a solution, in which the decision maker constantly consults with the data of the program, choosing the most appropriate option. The most obvious and frequently used method in this case is the construction of the Pareto set with subsequent expert selection of the best point on it. However, the scope of the method is seriously limited by the impossibility of visualizing the Pareto set by the number of criteria greater than three.

An example of an interactive technique for finding an acceptable solution is the method of successive concessions (also called the method of optimization by successively applied criteria), which is a "softened" version of lexicographic optimization. Its essence is as follows: an analysis of the relative importance of the criteria is carried out and the criteria are arranged and numbered in descending order of importance; optimization is carried out according to the first criterion and its largest value is determined f_1^*. Next, the expert evaluates the value of the allowable reduction (concession) of this criterion Δf_1, formulates a constraint $f_1 \geq (f_1^* - \Delta f_1)$, and searches for the optimum of the second most important criterion, etc. After optimizing the last most important criterion $k = \overline{1,K}$, provided that the value of each criterion must not be less than ($f_1^* - \Delta f_1,\ k = \overline{1,K}$), the resulting solutions are considered optimal.

However, the analyzed method is limited to taking into account only the pairwise relationship of the criteria to each other, hence the complexity of choosing and justifying the values of concessions for individual criteria, since the values of concessions are not commensurate with each other due to the different economic essence of different criteria. The second disadvantage is that at each step the set of Pareto optimal points is truncated; hence, in the general case, the resulting solution is not Pareto optimal.

We have proposed a modified version of this method, devoid of these disadvantages.

Since the economic meaning and units of measurement of different criteria (which are the norms of the Central Bank of the Republic of Uzbekistan *H1-H3* and profitability) are different, it is impossible to compare the criteria by numerical values. Therefore, in this case, the procedure for solving a multi-criteria problem includes a preliminary stage - the normalization of criteria.

After normalizing the criteria, the three most important ones are selected and a set of Pareto-optimal solutions is built. To build it, it is possible to use various algorithms, we chose the Sobol - Statnikov method ($LP\tau$ - search) due to the simplicity of its implementation and the ability to vary the accuracy of calculations. The resulting approximate Pareto set is visualized on a three-dimensional graph.

In this graph, the decision maker clearly sees the possibility of a compromise between these criteria. He selects criteria with a sufficiently high value, transfers them to the category of restrictions, and with these restrictions, the problem of constructing the Pareto set is again solved according to the other three criteria. After several cycles of such a procedure, the decision maker has sufficient information about the trade-off possibilities between the criteria and can choose the most suitable option. To do this, he chooses as criteria three indicators, the most important, or whose values vary the most or are close to critical, he imposes restrictions on the rest, based on the information of the previous stages; the problem of constructing the Pareto set is solved and the decision maker chooses the best point. In this way,

This procedure, obtained by synthesizing two methods for solving multi criteria problems - the method of concessions and the Pareto method - has the following positive features: unlike the method of constructing and visualizing the Pareto set, it allows you to work with a number of criteria greater than three, while visualization of four or more dimensional Pareto sets is practically impossible. Unlike the concession method, the proposed procedure significantly reduces the number of steps, allows you to evaluate the possibility of a compromise between several criteria at each step, in addition, the final decision will be Pareto-optimal according to the three criteria recognized by the decision maker as the most important. Thus, the technique is devoid of both disadvantages of the concession method and, at the same time, is more universal than the construction of the Pareto set itself.

The proposed model is a model of operational management and is built into the system of operational decision-making. The developed decision-making process functions as follows: experts analyze the balance at the beginning of the day and determine the minimum required balances on cash and correspondent accounts in other banks. Data can be obtained from the analysis of the planned outflow of funds. Thus, the amount of temporarily free funds to be distributed is determined. Further, options for investing funds (issuing loans, buying securities, etc.) are considered. Received applications for loans are analyzed and unacceptable risk options are filtered out. In the practice of regional banks, the principle of "risk premium" is almost not applied, since a borrower who has the intention not to repay a loan will more easily accept a higher interest rate. Thus, it will not be possible to compensate for losses on some of the high-risk loans with the increased yield of others, therefore loans are issued only to obviously reliable borrowers with a long credit history and/or high-quality collateral, while the interest rate on loans of one maturity group is almost the same. However, the developed model is easily adapted to the situation of issuing loans of varying degrees of risk. To do this, it is enough to assign quantitative risk assessments to loans, enter the parameter of the bank's weighted average credit risk and use it as a constraint or criterion in the multiobjective optimization problem. at the same time, the interest rate on loans of the same maturity group is practically the same. However, the developed model is easily adapted to the situation of issuing loans of varying degrees of risk. To do this, it is enough to assign quantitative risk assessments to loans, enter the parameter of the bank's weighted average credit risk and use it as a constraint or criterion in the multi objective optimization problem. at the same time, the interest rate on loans of the same maturity group is

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Further, the possibilities of investing in securities are analyzed. To take into account specific risks for each type of securities, it is possible to use specialized methods that give some quantitative assessment of the risk of securities (for example, their -coefficient), which is used as a criterion for their risk in the optimization problem.

Restrictions on investments in loans are determined by the volume of acceptable loan applications, restrictions on investments in other types of assets may be determined by an expert or by limiting the total amount of risk for these assets. After the constraints are formulated, the data is entered into the optimization program, three indicators are selected as criteria, constraints are imposed on others, and the optimization process is started. Thus, the developed optimization model is quite universal and extensible, which allows it to adapt to the specifics of taking into account the risk of certain types of assets.

It is obvious that the use of this model in the operational management of bank assets is impossible without its automation. For this purpose, a C++ program has been developed. This program is interfaced with the banking accounting system of JSCB "Agrobank". The program automatically imports balance data from JSCB "Agrobank" in dbf format. Next, optimization criteria are selected, calculation parameters are set, the program builds a Pareto - optimal set according to the selected criteria and visualizes it in three-dimensional space.

The results of the calculation are given in text form, which reports the number of found Pareto - optimal points, the minimum and maximum values of all criteria, as well as the coordinates of the conditional center of the Pareto set. The program also builds a graph that is interactive and allows consideration from different points of view. When any point is selected, the value of all criteria in it and the corresponding distribution of funds across accounts are shown.

Approbation of this model took place in the commercial bank JSCB "Agrobank". Practice has shown the advantage of the proposed optimization method in comparison with others. Thus, the points proposed as optimal according to the method of additive convolution of criteria did not satisfy the decision maker in more than 75% of cases. The application of the developed program revealed the following indicators characterizing the possibility of operational application: the average time of generating the Pareto set from ten seconds to several minutes, depending on the number of possible directions for investing funds and the required accuracy, the average number of cycles of building the Pareto set and adjusting the list of criteria and restrictions (in the task with a total number of criteria 5-6) - 4-8 cycles, the time required to analyze one Pareto set is several minutes,

The analytical capabilities of the method made it possible to model the consequences of large investments of funds in terms of their impact on the subsequent set of possibilities for a compromise between the criteria, which led to the possibility of an active credit policy and increased the average return over the period of using the program by an average of 2%, while all the values of the standards significantly exceeded the minimum required, but did not exceed the optimal reliability limits: for example, the *H2* standard ranged from 30...45%, *H3* - 90...100%. The results of testing the provisions of the study and the proposed method for optimizing the

assets of a commercial bank confirm their practical feasibility in managing the distribution of banking resources

CONCLUSIONS

The study covers a number of issues, the solution of which, in the author's opinion, should contribute to improving the efficiency of commercial bank management. In general, the study developed a new model of asset management for a commercial bank and developed a methodology for its automation and implementation. Summarizing the results of the study, the following conclusions can be drawn:

1. A systematic study of the role and place of assets in achieving the bank's goals has established the following: the bank's goal is sustainable development. Sustainability as a long-term category depends on the reliability and profitability of the bank, the ability to accumulate funds necessary for self-development. An analysis of the history and modern practice of banking reliability regulation has shown that reliability is determined by capital adequacy and liquidity, while the quality of assets plays a decisive role. Capital adequacy is the ability of the bank to continue to provide the same volume of traditional set and standard quality banking services, regardless of possible losses of one kind or another on active operations. Currently, the prevailing opinion is that the need for capital does not depend on deposits, but on assets: capital adequacy should indicate what losses the bank can incur without prejudice to the interests of depositors and other creditors. Capital is seen primarily as a shock absorber to help overcome the fall in the real value of assets. The generally accepted today is the general formula, according to which the bank's own capital is correlated with the sum of assets, weighted by risk. The same formula underlies the method for calculating capital adequacy (norm *H1*) of the Central Bank of the Republic of Uzbekistan. The bank's liquidity also strongly depends on such indicators of asset quality as the compliance of active operations with passive ones in terms of maturity, the structure of assets by the degree of liquidity, the riskiness of assets, and the return on assets. Capital is seen primarily as a shock absorber to help overcome the fall in the real value of assets. The generally accepted today is the general formula, according to which the bank's own capital is correlated with the sum of assets, weighted by risk. The same formula underlies the method for calculating capital adequacy (norm *H1*) of the Central Bank of the Republic of Uzbekistan. The bank's liquidity also strongly depends on such indicators of asset quality as the compliance of active operations with passive ones in terms of maturity, the structure of assets by the degree of liquidity, the riskiness of assets, and the return on assets. Capital is seen primarily as a shock absorber to help overcome the fall in the real value of assets. The generally accepted today is the general formula, according to which the bank's own capital is correlated with the sum of assets, weighted by risk. The same formula underlies the method for calculating capital adequacy (norm *H1*) of the Central Bank of the Republic of Uzbekistan. The bank's liquidity also strongly depends on such indicators of asset quality as the compliance of active operations with passive ones in terms of maturity, the structure of assets by the degree of liquidity, the riskiness of assets, and the return on assets. according to which the bank's equity capital is correlated with the sum of risk-weighted assets. The same formula underlies the method for calculating capital adequacy (norm *H1*) of the Central Bank of the Republic of Uzbekistan. The bank's liquidity also strongly depends on such indicators of asset quality as the compliance of active operations with passive ones in terms of maturity, the structure of assets by the degree of liquidity, the riskiness of assets, and the return on assets. according to which the bank's equity capital is correlated with the sum of risk-weighted assets. The same formula underlies the method for calculating capital adequacy (norm

H1) of the Central Bank of the Republic of Uzbekistan. The bank's liquidity also strongly depends on such indicators of asset quality as the compliance of active operations with passive ones in terms of maturity, the structure of assets by the degree of liquidity, the riskiness of assets, and the return on assets.

2. A scientific approach to bank management requires the construction of models that allow describing the processes taking place in the bank and choosing the best solution for bank management issues. Models are divided into general and private (liability and asset management models). A comparative analysis of the models showed that in general models it is rather difficult to formulate an optimization problem, the applicability of the liability management model by varying the interest rate is quite narrow, in addition, the bank does not have the ability to directly manage the structure of its deposits in the short term, and due to the underdevelopment of the interbank loan market, poorly developed infrastructure (dealing, branch networks to attract resources) and poor awareness, Uzbek banks, especially small ones, have limited opportunities for prompt mobilization of funds from external sources.

3. A multi-criteria asset management model for a commercial bank was built, which fully complies with the legislation of Uzbekistan. Consideration of methods for solving multicriteria problems revealed the low suitability of the methods of the main criterion, additive and multiplicative convolutions, since the implicit utility function of the decision maker is usually non-linear, therefore the "true" weights of the criteria (that is, those weights for which the gradient of the weighted objective function coincides direction in the gradient of the utility function) will vary from point to point. In the case of a small number of criteria (up to 3 inclusive), the best way to solve is to build a Pareto set - optimal points, allowingdecision makervisually see all the options for a compromise between the criteria and choose a point based on an expert assessment, taking into account their considerations about the significance of the criteria at a given point. In the case of a larger number of criteria, the visualization of the Pareto set is impossible. Since the number of criteria in our model is 7-8 or more, a special algorithm was developed based on the application of the concession method in a three-dimensional space of criteria.

4. The developed model of multicriteria optimization of commercial bank assets and the original algorithm for its solution made it possible to create the Elite program. The program makes it possible to analyze the possibilities of a compromise between profitability and reliability and choose the most suitable option, combining the advantages of machine optimization and interactive accounting of preferences that are difficult to formalize as a decision maker.

The conducted research allows to significantly speed up the process of developing management decisions in the bank and increase their efficiency.

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