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OPTIMIZATION STRATEGY OF FUNDING IN SECOND-TIER BANKS

Abstract. As known, funding is a priority for banking. In pursuit of resources, banks form a funding strategy that provides the highest return on their investments in the relevant assets. This raises the question of what sources of funding to use and what assets to best direct.

In the article, the author suggests applying dynamic modeling methods, namely game theory, to optimize the funding strategy of banks. The application of the Brown-Robinson method, the Bayes, Savage, Wald and Hurwitz criteria is used for the task of bank funding optimization.

Keywords: funding strategy, bank funding, Brown-Robinson method, dynamic modeling.

Introduction. Funding in banks is of great importance in their activities, since without financing it becomes impossible for the bank to function at all. As a rule, sources of funding are deposit and non-deposit resources. The first of them are the cheapest and preferred for the bank, which creates appropriate competition in the struggle for this source of funding. Non-deposit sources are more expensive. These include interbank loans, repo transactions, issuance of securities, loans on international markets, etc.

In any case, when choosing funding sources, banks are guided by their value. The possibility of obtaining higher transfer interest becomes the goal of forming a banking funding strategy.

As O.Zh. Zhadigerova, G.M. Kadyrova developed banking system is the basis of a modernized economy, and therefore, the accumulation of large amounts of financial resources is important for large universal banks [1].

The policy of bank funding rates has been reviewed by many authors. In particular, the application of the funding rate to determine the cost of a banking product is presented in the work of A.V. Kashtanov [2]. Practical experience of applying the funding rate to assess the activities of the bank's business units is presented in the work of A.P. Shlyapin [3]. As known, the choice of funding source depends on the size of the bank, but for many Russian banks the national money market is a significant source of liquidity for the banking sector [4].

Features of funding banks in the international loan markets are considered in the work of K.A.Surovneva [5].

In turn, M.Sh.Davydov emphasizes that the funding strategy of banks directly depends on the specifics and specialization of the bank’s activities [6].

The proposal on funding banks through securities is considered by E.A. Ruzieva, A.M. Nurgaliyeva and others. [7].

As I.V. Pashkovskaya rightly emphasizes, financial risks can lead to a systemic crisis in banks; therefore, the mechanism for managing the funding strategy should be constantly monitored and improved. [8].

Regarding the application of methods for assessing funding rates, their impact on the development of banks and the economy of the country as a whole, various works also exist. For example, in the practice of EU banks, the historically official exchange rate was a good indicator of the cost of funding for banks. However, the global financial crisis of 2007-2009. and regulatory changes have had a significant impact on funding costs. The search for more stable sources of financing has changed the funding structure of banks. As a result, the price of these more stable sources of financing has risen. The author attempts to calculate a conditional marginal indicator of the cost of funding in banks, reflecting the ratio of the cost of funding and the official exchange rate [9]. A study by the Reserve Bank of Australia examines how changes in the structure and pricing of bank funding affect their total cost of funds and lending rates [10].

There is also a study in the literature that assesses the impact of financial stress of banks on the real economy based on various funding sources. [11].

Thus, the importance of the funding structure of banks is emphasized by many authors. At the same time, it should be noted that the cost of funding is of great importance. In this regard, in our work, an attempt is made to optimize the funding structure based on its cost through the use of statistical modeling.

Method of research. To solve this problem, we used models of games with nature. In particular, the Brown-Robinson iterative method, namely the analytical method using the von Neumann theorem, as well as the model of Hurwitz, Savage, Bayes and Wald.

The idea of the Brown-Robinson method is to repeatedly fictitiously conduct a "game" with a given matrix A = (a_{ij}). One draw of the "game" is called an iteration, the number of which is unlimited. With an increase in the number of iterations N, the mixed frequencies of applying pure strategy by the players approach their mixed optimal strategies [12]. Calculations are made under the assumption that players want to increase their winnings (reduce losses). It is assumed that they do not know their optimal strategies. Players make moves in accordance with the principle: the future is similar to the past, taking into account all the iterations made. The first strategy (for example, the first player) is chosen arbitrarily - possibly with the aim of increasing the possible gain.

The next s-move of the 2nd player (after s moves of the 1st player) is selected by choosing a strategy, j_s as:

$$\sum_{N=1}^{S} a_{iNjs} = \min_{1\le j\le N} \sum_{N=1}^{S} a_{iNj} = v_{min}(s)s$$

где i_1, j_1 – pairs of players strategies on 1, …, s steps; v – "game" price.

And the choice of the (s+1) 1st move of the 1st player, (after the s moves of the 2nd player) is the choice of strategy i_{s+1} according to the condition:

$$\sum_{N=1}^{S} a_{i(s+1)jN} = \max_{1\le i\le m} \sum_{N=1}^{S} a_{ijN} = v_{max}(s)s$$

The price of the game ν is known to satisfy the inequality $\nu_{min}(s) \le \nu \le \nu_{max}(s)$ [13].

The Bayesian criterion for wins allows you to choose the maximum of the expected elements of the efficiency matrix with a known probability of possible states:

$$B = \max_i \left\{ \sum_{j=1}^{n} q_j a_{ij} \right\}$$

где q_j – вес средневзвешенных эффективностей.

Wald's criterion is designed to select from the considered strategies options the option with the highest performance indicator from the minimum possible indicators for each of these options [14]. The criterion directs the decision maker to a cautious line of conduct aimed at gaining and minimizing possible risks at the same time.:

$$W = \max_i \min_j a_{ij}$$

где a_{ij} – значения эффективностей в матрице.

This criterion ensures maximization of the minimum gain that can be obtained by implementing each of the strategy options.

The Savage criterion is a criterion of extreme pessimism, but only with respect to risks. It implies the worst performance state for player A, at which the risk of each of the pure strategies is maximized.:

$$S = \max_i \min_j r_{ij}$$

The Savage criterion allows you to choose a strategy option with a lower risk compared to a higher, initially expected level of risk.

The Hurwitz criterion weighs pessimistic and optimistic approaches to the analysis of an uncertain situation and is designed to select some middle element of the efficiency matrix that differs from the extreme states - from the minimum and maximum elements:

$$H = \max_i(\gamma \max_j a_{ij} + (1-\gamma) \min_j a_{ij}$$

где γ – optimism coefficient, 0≤γ≤1.

The Hurwitz criterion allows avoiding borderline states when making a decision - unjustified optimism and extreme pessimism regarding expected returns - and choosing the most likely strategy option that provides the best efficiency.

Results. Table 1 shows the difference in percentages between attracted resources and assets. When funding, it is important to allocate them to the relevant assets as resources become available. In this case, the urgency of liabilities and bank assets is not taken into account, and only interest expenses and income are taken into account. Thus, funding is aimed at increasing the profitability of operations.

Table 1 - Data on the spread in bank funding rates

	Liability 1	Liability 2	Liability 3	Liability 4
Asset 1	2,5	3	3,7	3,5
Asset 2	2,1	3,2	4	2,8
Asset 3	3	4,1	3,2	3,8
Asset 4	2,2	3,4	3,8	3,3

Consider our case as a game of two parties (assets and liabilities), whose interests are opposite. In this case, the income of a certain asset is equal to the loss of liability. It should be noted that there is complete information about the results of the choice of an asset or liability.

Applying the Brown-Robinson method for an asset, one of the n rows of the efficiency matrix A should be selected, and for the liability, one of the columns of the same matrix.

First of all, we check the matrix for the presence of a saddle point. If it is, then we write out the solution in pure strategies. We believe that the option is chosen for the asset in such a way as to obtain the maximum income, and for the liability - vice versa. As a result, we obtain the following efficiency matrix (table 2).

Table 2 - Brown-Robinson decision matrix

Показатели	L_1	L_2	L_3	L_4	$a = \min(A_i)$
A_1	2.5	3	3.7	3.5	2.5
A_2	2.1	3.2	4	2.8	2.1
A_3	3	4.1	3.2	3.8	3
A_4	2.2	3.4	3.8	3.3	2.2
$b = \max(B_i)$	3	4.1	4	3.8	

Determine the guaranteed efficiency (profitability), determined by the lower price $a = \max(a_i) = 3$, which indicates the maximum net strategy A_3. Top cost effectiveness $b = \min(b_j) = 3$.

The saddle point (3, 1) indicates a solution to a pair of alternatives (A_3, L_1). The optimization price is 3.

Now check the matrix for dominant rows and dominant columns. According to the Brown-Robinson method, the *i*-th asset strategy dominates its *k*-th strategy if $a_{ij} \geq a_{kj}$ for all $jЭN$ and at least one j $a_{ij} > a_{kj}$. In this case, the *i*-th strategy (or line) is dominant, the *k*-th is dominated.

Similarly, the *j*-th strategy of a liability dominates its *l*-th strategy if for all *jEM* $a_{ij} \leq a_{il}$ and at least one *i* $a_{ij} < a_{il}$. In this case, the *j*-th strategy (column) is called dominant, the *l*-th dominated.

From the position of the liability yield, strategy L_1 dominates strategy L_2 (all elements of column 1 are less than elements of column 2), therefore, we exclude the 2nd column of the matrix. Probability $q_2 = 0$.

From the position of a liability loss, strategy L_1 dominates strategy L_3 (all elements of column 1 are less than elements of column 3), therefore, we exclude the third column of the matrix. Probability $q_3 = 0$.

Strategy A_1 dominates strategy A_2 (all elements of row 1 are greater than or equal to the values of the 2nd row), therefore, we exclude the 2nd row of the matrix. Probability $p_2 = 0$.

Strategy A_3 dominates strategy A_1 (all elements of row 3 are greater than or equal to the values of the first row), therefore, we exclude the first row of the matrix. The probability $p_1 = 0$.

As a result, we obtain solutions to strategies (table 3).

Table 3 - Decisions after the exclusion of dominant assets and liabilities

Indicators	L_1	L_4
A_3	3	3.8
A_4	2.2	3.3

We reduced the 4 x 4 matrix to the 2 x 2 matrix. We solve the problem by the geometric method, which includes the following steps:

1. In the Cartesian coordinate system on the abscissa axis, a segment is laid out whose length is 1. The left end of the segment (point x = 0) corresponds to strategy A_1, the right to strategy A_2 (x = 1). The intermediate points x correspond to the probabilities of some mixed strategies $S_1 = (p_1, p_2)$.

2. On the left axis of the ordinates, the winnings of strategy A_1 are postponed. On a line parallel to the ordinate axis, from point 1 the winnings of strategy A_2 are postponed. The solution of the game (2 x 2) is carried out from the position of assets, adhering to the maximin strategy. Neither assets nor liabilities have dominant and duplicate strategies. The maximum optimal asset strategy corresponds to point N, for which the following system of equations can be written:

$p_1 = 1$

$p_2 = 0$

Optimization price y = 3

Now we can find the minimax strategy of the liability by writing the corresponding system of equations, excluding the strategy L_2, which gives a clearly greater loss in liability, and therefore $q_2 = 0$. $q_1 = 1$ (Figure 1).

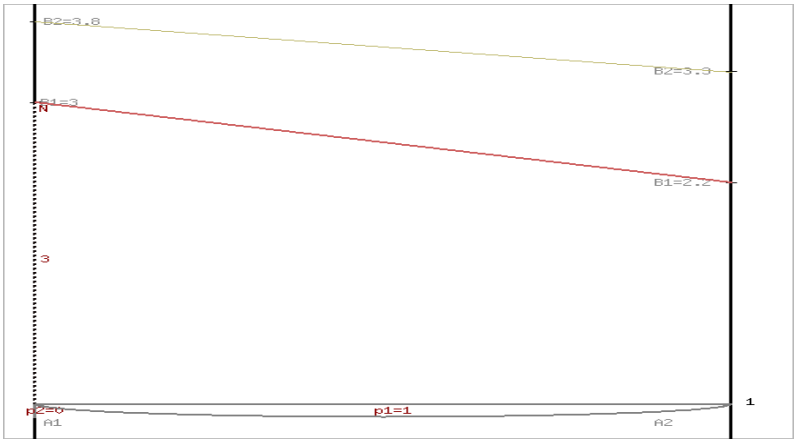

Figure 1 - Graphical optimization solution

Consider the application of the Bayes, Savage, Hurwitz and Wald criteria to optimize the funding structure for profitability.

According to Bayes criterion, the optimal strategy is the (net) Ai strategy, in which the average asset income is maximized or the average risk r is minimized.

Counting Values $\sum(a_{ij}l_i)$

$\sum(a_{1,i}l_i) = 2.5*0.25 + 3*0.25 + 3.7*0.25 + 3.5*0.25 = 3.175$

$\sum(a_{2,j}l_j) = 2.1*0.25 + 3.2*0.25 + 4*0.25 + 2.8*0.25 = 3.025$

$\sum(a_{3,i}l_j) = 3*0.25 + 4.1*0.25 + 3.2*0.25 + 3.8*0.25 = 3.525$

$\sum(a_{4,i}l_j) = 2.2*0.25 + 3.4*0.25 + 3.8*0.25 + 3.3*0.25 = 3.175$

The results are listed in the matrix (table 4).

Table 4 - Bayes Decision Matrix

A_i	L_1	L_2	L_3	L_4	$\sum(a_{ij}l_j)$
A_1	0.625	0.75	0.925	0.875	3.175
A_2	0.525	0.8	1	0.7	3.025
A_3	0.75	1.025	0.8	0.95	3.525
A_4	0.55	0.85	0.95	0.825	3.175
p_j	0.25	0.25	0.25	0.25	

Choose from (3.175; 3.025; 3.525; 3.175) maximum element max=3.53. Therefore, the optimal strategy is N=3.

According to Wald's criterion, the optimal strategy is a pure strategy, which in the worst conditions guarantees maximum profitability, i.e. $a = \max(\min a_{ij})$.

Wald's criterion directs statistics to the most unfavorable conditions, i.e. this criterion expresses a pessimistic assessment of the situation (table 5).

Table 5 - Vald decision matrix

A_i	L_1	L_2	L_3	L_4	$\min(a_{ij})$
A_1	2.5	3	3.7	3.5	2.5
A_2	2.1	3.2	4	2.8	2.1
A_3	3	4.1	3.2	3.8	3
A_4	2.2	3.4	3.8	3.3	2.2

Choose from (2.5; 2.1; 3; 2.2) maximum element max=3, that mean the choice of strategy N=3.

Savage's minimum risk criterion recommends choosing the one at which the maximum risk value is minimized in the worst conditions, i.e. provided by $a = \min(\max r_{ij})$.

Find the risk matrix. In this case, risk is seen as a measure of discrepancy between the different possible outcomes of adopting certain strategies. The maximum yield in the *j*-th column $b_j = max\ (a_{ij})$ characterizes the favorable position.

1. Calculate the 1st column of the risk matrix.

$r_{11} = 3 - 2.5 = 0.5$; $r_{21} = 3 - 2.1 = 0.9$; $r_{31} = 3 - 3 = 0$; $r_{41} = 3 - 2.2 = 0.8$;

2. Calculate the 2nd column of the risk matrix.

$r_{12} = 4.1 - 3 = 1.1$; $r_{22} = 4.1 - 3.2 = 0.9$; $r_{32} = 4.1 - 4.1 = 0$; $r_{42} = 4.1 - 3.4 = 0.7$;

3. Calculate the 3d column of the risk matrix.

$r_{13} = 4 - 3.7 = 0.3$; $r_{23} = 4 - 4 = 0$; $r_{33} = 4 - 3.2 = 0.8$; $r_{43} = 4 - 3.8 = 0.2$;

4. Calculate the 4th column of the risk matrix.

$r_{14} = 3.8 - 3.5 = 0.3$; $r_{24} = 3.8 - 2.8 = 1$; $r_{34} = 3.8 - 3.8 = 0$; $r_{44} = 3.8 - 3.3 = 0.5$ (table 6).

Table 6 - Savage Decision Matrix

A_i	L_1	L_2	L_3	L_4	$\max(a_{ij})$
A_1	0.5	1.1	0.3	0.3	1.1
A_2	0.9	0.9	0	1	1
A_3	0	0	0.8	0	0.8
A_4	0.8	0.7	0.2	0.5	0.8

Choose from (1.1; 1; 0.8; 0.8) minimum element min=0.8, therefore strategy N=3.

In the rightmost column, calculate the average risk (table 7).

Table 7 - Verification of the results obtained for Savage

A_i	L_1	L_2	L_3	L_4	r_i
A_1	0.5	1.1	0.3	0.3	0.55
A_2	0.9	0.9	0	1	0.7
A_3	0	0	0.8	0	0.2
A_4	0.8	0.7	0.2	0.5	0.55

The minimum value of average risks is 0.2. Therefore, above this price, designing an experiment becomes impractical.

The Hurwitz criterion is the criterion of pessimism - optimism. The strategy for which the relation: $\max(s_i)$, где $s_i = y \min(a_{ij}) + (1-y)\max(a_{ij})$.

The Hurwitz criterion takes into account the possibility of both the worst and the best position for both the asset and the liability.

We are counting s_i.

$s_1 = 0.5*2.5+(1-0.5)*3.7 = 3.1$

$s_2 = 0.5*2.1+(1-0.5)*4 = 3.05$

$s_3 = 0.5*3+(1-0.5)*4.1 = 3.55$

$s_4 = 0.5*2.2+(1-0.5)*3.8 = 3$ (table 7).

Table 7 - Hurwitz decision matrix

A_i	L_1	L_2	L_3	L_4	$\min(a_{ij})$	$\max(a_{ij})$	$y \min(a_{ij}) + (1-y)\max(a_{ij})$
A_1	2.5	3	3.7	3.5	2.5	3.7	3.1
A_2	2.1	3.2	4	2.8	2.1	4	3.05
A_3	3	4.1	3.2	3.8	3	4.1	3.55
A_4	2.2	3.4	3.8	3.3	2.2	3.8	3

Choose from (3.1; 3.05; 3.55; 3) maximum element max=3.55, therefore strategy N=3.

Discussion. As a result of applying the Brown-Robinson method and various criteria of Bayes, Wald, Savage and Hurwitz, in all cases the strategy for asset A3 was chosen. The results obtained suggest that it is necessary to use the available funding resources (liabilities 1,2,3 and 4) to finance asset 3, since in this case the highest spread in percent is achieved.

Thus, the use of dynamic programming, a combination of its various methods, makes it possible to optimize the funding strategy. Of course, in practice, the bank can consider not 4 types of liabilities for financing 4 types of assets, as was presented in our case, but much more, which will significantly increase the electivity and allow several possible options.

To further optimize the funding strategy, namely, in order to determine the optimal amount of use of the funds of each liability for financing asset 3, dynamic programming should also be used. This topic will be discussed in a future publication.

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ЕКІНШІ ДЕҢГЕЙДЕГІ БАНКТЕРДЕ ҚОРЛАНДЫРУ СТРАТЕГИЯСЫН ОҢТАЙЛАНДЫРУ

Аннотация. Қорландырудың банк қызметі үшін бірінші кезектегі маңызы бар екендігі белгілі. Ресурстарды қалыптастыру мақсатында банктер қорландыру стратегиясын қалыптастырады, бқл оларды тиісті активтерге орналастыру барысында барынша табыстылық алуды қамтамасыз етеді. Мұнда қорландырудың қандай көздерін пайдалану және қандай активтерге оңтайлы бағыттау мәселесі туындайды.

Мақалада автор банктерді қорландыру стратегиясын оңтайландыру үшін динамикалық модельдеу әдістерін, атап айтқанда ойын теориясын қолдануды ұсынады. Браун-Робинсон әдісін, Байес критерийлерін, Сэвидж, Вальд және Гурвицаны қолдану қорландыруды оңтайландыру бойынша алға қойылған міндеті үшін қолданылады.

Түйін сөздер: қорландыру стратегиясы, банктік қорландыру, Браун-Робинсон әдісі, динамикалық модельдеу.

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ОПТИМИЗАЦИЯ СТРАТЕГИИ ФОНДИРОВАНИЯ В БАНКАХ ВТОРОГО УРОВНЯ

Аннотация. Как известно, фондирование имеет первоочередное значение для банковской деятельности. В погоне за ресурсами банки формируют стратегию фондирования, которая обеспечивает получение наибольшей доходности при их вложении в соответствующие активы. Здесь возникает вопрос, какие источники фондирования задействовать и в какие активы оптимальней направить.

Автор предлагает применить методы динамического моделирования, а именно теории игр для оптимизации стратегии фондирования банков. Применение метода Брауна-Робинсона, критериев Байеса, Сэвиджа, Вальда и Гурвица используется для поставленной задачи оптимизации фондирования.

Ключевые слова: стратегия фондирования, банковское фондирование, метод Брауна-Робинсона, динамическое моделирование.

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