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MODELING THE ALLOCATION OF SOURCES OF FUNDING IN BANKS

Abstact. Funding in banks has a significant role, since, unlike companies, banks are 90 percent functioning at the expense of borrowed funds. On this basis, the attracted resources are the main source of funding for the activities of second-tier banks. Moreover, when redistributing funds in a bank, namely directing certain attracted resources to active operations, the order of this redistribution is important. That is, what raised funds should be used as sources of funding for certain active operations of banks.

The solution of this kind of problem in banks is possible with the use of linear and dynamic programming. The article presents an example of the use of mathematical statistics to determine the optimization of the allocation of funding for relevant active operations that can bring profit to the bank.

Keywords: funding in banks, linear programming, profit maximization, sources of funding.

Introduction. The traditional distinctive feature of banking is the purchase and retention of assets with a longer maturity and lower liquidity than their liabilities. Solving the problem of bank funding is an important example of a precautionary motive for maintaining liquidity. The rates that banks offer loans to individuals and legal entities, partly depend on the cost of funding. Banks in determining the cost of funding also take into account the liquidity risk associated with the financing of long-term assets with short-term liabilities.

Banks receive financing from four main sources: retail deposits, corporate deposits, debt securities issued and capital. More than a third of the funding of large banks accounted for deposits of individuals. Another third is accounted for by corporate deposits. Short-term and long-term loans constitute a large part of the remaining third of funding sources.

Attracting funds is only the first part of the problem of banks. The main task arises in their effective allocation to the implementation of active banking operations that generate income.

Literature review. Effective use and management of attracted financial resources is a key aspect of building a strategy for any bank. The system of financial resources management is aimed at optimizing the structure of assets and liabilities in terms of their urgency, quality and price characteristics, as well as the prevention of losses in the process of activity [1]. In this regard, modern second-tier banks focus on the use of modeling tools, analysis, quality assessment, rational use of attracted resources [2]. Some authors propose to use simulation modeling since funding considers the tasks of managing financial resources of a banking institution [3]. This approach allows us to take into account a large number of analyzed variables and a high level of uncertainty of simulated situations, as well as to reduce the complexity of mathematical analysis of dependencies.

A.I. Veselov in his work considers the use of mathematical modeling to build a matrix of funding in banks [4].

Effective banking funding T.N. Ivaschenko compares with the productivity of labor in the economy. As the main sources of funding, the author proposes the issuance of Eurobonds and the conduct of IPO by banks. Eurobond issuance, the author indicates, is the prerogative of a long term and lower interest rates [5]. At present, the international bond market dominates (80-90%) belongs to eurobonds. At the same time, there is a possibility for banks to issue various types of short-term and long-term debt obligations [6].

The study by Dimitriu M.C., Oaca S.C. recognizes the importance of developing a model that can be empirically tested to increase the efficiency of the funding process in banks. In fact, it is a mixed methodological approach that allows you to use the advantages of both qualitative and quantitative methods. Since the effectiveness of the transfer pricing model depends on various economic conditions and cannot be universal, the study uses a variety of qualitative data to ensure the use of the most appropriate structure [7].

Selyutin V.V. and Rudenko M.A. they used an approach to mathematical modeling of cash flow in bank assets and liabilities based on partial differential equations. This approach reflects the process of changing assets over time and at the "age" [8].

Faure and Gersbach are exploring the factors affecting the creation of money by banks. So, when prices are tight, the monetary system collapses, and capital requirements can restore the existence of equilibria with finite money creation, and in some cases can even realize the first best distribution [9]. A.P. Salina tested the Altman model on Kazakhstan banks [10].

Research methods. In order to optimize the distribution of funding in banks, we applied the methods of linear and dynamic programming. The use of combinatorial optimization allows you to determine the direction of distribution of funds, and the Bellman model makes it possible to determine the optimal amounts that need to be sent to fund relevant active bank operations.

The task of linear programming can be represented as the following objective functions and constraints [11]:

$$\sum_{i \in A} \sum_{j \in T} C(i,j) x_{ij}$$

$$\sum_{i \in A} x_{ij} = 1 \text{ для } j \in T$$

$$\sum_{j \in T} x_{ij} = 1 \text{ для } i \in A$$

$$x_{ij} \geq 0 \text{ для } i, j \in A, T$$

Where x_{ij} – purpose of funding the i-th attracted resource for the j-th active operation of the bank.

It should be noted that x_{ij} takes the value 1 if the attracted resource is assigned to fund the corresponding active operation and 0 otherwise.

The meaning of the Bellman model is as follows. If the i-th system is currently in the S_{i-1} state at the beginning of the stage, then all subsequent resource allocations xi are selected to be optimal with respect to the state of S_i. Thus, with such distributions, funding efficiency is maximized at subsequent stages i + 1, i + 2, ..., N before the formation of the optimization process:

$$E_i = \sum_{i=1}^{N} f_j\,(S_i, x_{i+1})$$

Each transition from the state of S_i to the next is characterized by a cost function at the current stage d_{i+1} (S_i, x_{i+1}), which depends on both S_i and the time period and the applied resource allocation. Therefore, it is necessary to determine the optimal distribution of the resource x^*_i, which will ensure the optimal effect of the distribution of funds, i.e.:

$$E_i^*(S_{i-1}) = \max\,(F(S_{i-1}, x_i) + E_{i+1}^*(S_i))$$

The presented equation is the basic recurrent equation of Richard Bellman [12].

Results. Table 1 presents the options for return on investment of the respective attracted funding funds. Projects involve investments in relevant assets for profit. It is required to determine the optimal distribution of investment funding, which allows to maximize profits.

Table 1 - data on profitability when using the appropriate resources

Resource	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
Deposits	10,1	11,2	7,8	6,4	9,2	10,2
Wholesale deposits	12,3	15,1	10,3	11,1	13,0	11,2
Interbank loans	10,4	11,0	9,21	12,1	9,3	9,9
Bonds	9,8	11,3	12,0	9,0	8,7	8,9
International Bonds	8,8	9,4	10,11	11,12	12,1	9,1

Based on the available data, it can be noted that the mathematical model of the problem will be reduced to the following restrictions:

Restrictions on funding resources:

$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} = 1$

$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} = 1$

$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} = 1$

$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} = 1$

$x_{51} + x_{52} + x_{53} + x_{54} + x_{55} + x_{56} = 1$

Restrictions on projects (investments in assets):

$x_{11} + x_{21} + x_{31} + x_{41} + x_{51} = 1$

$x_{12} + x_{22} + x_{32} + x_{42} + x_{52} = 1$

$x_{13} + x_{23} + x_{33} + x_{43} + x_{53} = 1$

$x_{14} + x_{24} + x_{34} + x_{44} + x_{54} = 1$

$x_{15} + x_{25} + x_{35} + x_{45} + x_{55} = 1$

$x_{16} + x_{26} + x_{36} + x_{46} + x_{56} = 1$

Given that the goal is to maximize profitability, the objective function will take the following form:

$10,1x_{11} + 11,2x_{12} + 7,8x_{13} + 6,4x_{14} + 9,2x_{15} + 10,2x_{16} + 12,3x_{21} + 15,1x_{22} + 10,3x_{23} + 11,1x_{24} + 13,0x_{25} + 11,2x_{26} + 10,4x_{31} + 11,0x_{32} + 9,21x_{33} + 12,1x_{34} + 9,3x_{35} + 9,9x_{36} + 9,8x_{41} + 11,3x_{42} + 12,0x_{43} + 9,0x_{44} + 8,7x_{45} + 8,9x_{46} + 8,8x_{51} + 9,4x_{52} + 10,11x_{53} + 11,12x_{54} + 12,1x_{55} + 9,1x_{56} \rightarrow \max$

The initial matrix (data of table 1) is modified by multiplying all its elements by (-1) and then adding them with the maximum element of the matrix. At the same time, the modified matrix should not contain negative elements:

$$\begin{bmatrix} 5 & 3,9 & 7,3 & 8,7 & 5,9 & 4,9 \\ 2,8 & 0 & 4,8 & 4 & 2,1 & 3,9 \\ 4,7 & 4,1 & 5,89 & 3 & 5,8 & 5,2 \\ 5,3 & 3,8 & 3,1 & 6,1 & 6,4 & 6,2 \\ 6,3 & 5,7 & 4,99 & 3,98 & 3 & 6 \end{bmatrix}$$

Now we will reduce the matrix in rows. For this, at least one zero will appear in the previous matrix. Then we perform a similar reduction along the columns of the matrix. In each column we define the minimum element. After subtracting the data of the minimum elements, we obtain a fully reduced matrix:

$$\begin{bmatrix} 1,1 & 0 & 3,4 & 4,8 & 2 & 1 \\ 2,8 & 0 & 4,8 & 4 & 2,1 & 3,9 \\ 1,7 & 1,1 & 2,89 & 0 & 2,8 & 2,2 \\ 2,2 & 0,7 & 0 & 3 & 3,3 & 3,1 \\ 3,3 & 2,7 & 1,99 & 0,98 & 0 & 3 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \end{bmatrix}$$

We carry out a search for a feasible solution by trial and error, in which all assignments are with zero cost. To do this, we fix the value (1; 2), and remove the remaining zeros in column 2 and line 1, that is, eliminate zeroes in the cells (2; 2) and (6; 2). As a result, we obtain a matrix of the following form:

$$\begin{bmatrix} 1,1 & \mathbf{[0]} & 3,4 & 4,8 & 2 & 1 \\ 2,8 & [-0-] & 4,8 & 4 & 2,1 & 3,9 \\ 1,7 & 1,1 & 2,89 & 0 & 2,8 & 2,2 \\ 2,2 & 0,7 & 0 & 3 & 3,3 & 3,1 \\ 3,3 & 2,7 & 1,99 & 0,98 & 0 & 3 \\ 0 & [-0-] & 0 & 0 & 0 & 0 \end{bmatrix}$$

Since there is no possibility to create a system of six independent zeros in the resulting matrix, since there is only 1 zero in the matrix, the solution is invalid. Similarly, we carry out the modification of the matrix to obtain the optimal matrix, which will allow us to calculate the optimal value of profitability with an appropriate distribution. Thus, the final matrix will look like this:

$$\begin{bmatrix} 0,1 & [-0-] & 3,4 & 3,8 & 1 & \mathbf{[0]} \\ 1,8 & \mathbf{[0]} & 4,8 & 3 & 1,1 & 2,9 \\ 1,7 & 2,1 & 3,89 & \mathbf{[0]} & 2,8 & 2,2 \\ 1,2 & 0,7 & \mathbf{[0]} & 2 & 2,3 & 2,1 \\ 3,3 & 3,7 & 2,99 & 0,98 & \mathbf{[0]} & 3 \\ \mathbf{[0]} & 1 & 1 & [-0-] & [-0-] & [-0-] \end{bmatrix}$$

Thus, the matrix shows the optimal distribution of funding for active bank operations. In particular, according to the data received, individual deposits are better directed to fund the project 6, corporate

deposits to the project 2, interbank loans to the project 4, subordinated bonds to the project 3 and international bonds to fund the project 5. With this distribution the maximum value is reached:

$$P_{max} = 10,2 + 15,1 + 12,1 + 12,0 + 12,1 = 61,5$$

Let's see what amounts should be allocated to fund the relevant active operations of the bank (projects) in order to maximize profits. Table 2 shows the possible returns from investments in the relevant projects with an investment of 4-10 million KZT of funding.

Table 2 - The distribution of funding amounts

Investment amount, ml KZT	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
4	7,3	10,2	6,8	7,4	8,2	10,0
5	8,1	11,1	10,8	11,4	12,0	12,3
6	5,6	12,1	9,5	11,2	9,7	9,9
7	8,2	11,3	12,0	9,0	8,7	8,9
8	10	11,4	12.1	10,0	11,2	10,9
9	9,2	10,4	11,8	11,9	12,3	12,1
10	12,3	11,7	11,1	10,8	12,0	12,4

We use the method of dynamic programming, namely the method of direct sweep to optimize the distribution of funding amounts. The first stage is a conditional optimization, at which i = 1. We believe that all funds in the amount of 10 million KZT are used to fund the project 1 (Table 3).

Table 3 - The conditional optimization matrix for i = 1

	x_1	0	4	5	6	7	8	9	10
x_2	$f_2(x_2) / F_1(x_1)$	0	7,1	7,3	5,8	8	11	9	11
0	0	0	7,1	7,3	5,8	8	11	9	11
4	7,3	7,3*	14,4*	14,6	13,1	15,3*	18,3*	16,3	
5	8,1	8,1	15,2*	15,4*	13,9	16,1	19,1*		
6	5,6	5,6	12,7	12,9	11,4	13,6			
7	8,2	8,2	15,3	15,5	14				
8	10	10	17,1	17,3					
9	9,2	9,2	16,3						
10	12,3	12,3							

In table 3, on each diagonal we determine the highest value (marked with an asterisk) and enter them into the table of values (table 4).

Table 4 - Conditional Optimization Values

S_1	0	4	5	6	7	8	9	10
$F_2(S_1)$	0	7,3	14,4	15,2	15,4	15,3	18,3	19,1
x_1	0	4	4	5	5	4	4	5

In the next stage i = 2. Let us determine the optimal distribution of funding between projects 1 and 2. In this case, the Bellman's recurrence relation will have the following form:

$$F_2(S_2) = \max\,(x_2 \le S_2)(g_2(x_2) + F_1(S_2 - x_2))$$

With this ratio, the conditional optimization matrix will have the following form (Table 5).

Table 5 - The conditional optimization matrix for i = 2

	x_2	0	4	5	6	7	8	9	10
x_3	$f_3(x_3)$ / $F_2(x_2)$	0	7,3	14,4	15,2	15,4	15,3	18,3	19,1
0	0	0	7,3*	14,4*	15,2	15,4	15,3	18,3	19,1
4	7	7	14,3	21,4*	22,2*	22,4	22,3	25,3*	
5	6	6	13,3	20,4	21,2	21,4	21,3		
6	8	8	15,3	22,4*	23,2	23,4			
7	9	9	16,3	23,4*	24,2				
8	9,8	9,8	17,1	24,2					
9	6,7	6,7	14						
10	10	10							

Similarly, as in the first stage of conditional optimization, we determine the maximum values along the matrix diagonals. Similarly, we determine at each stage of the conditional optimization, we enter the data in table 6.

Table 6 - Conditional Optimization Values

S_2	0	4	5	6	7	8	9	10
$F_3(S_2)$	0	7,3	14,4	21,4	22,2	22,4	23,4	25,3
x_2	0	1	0	4	4	6	7	4
S_3	0	4	5	6	7	8	9	10
$F_4(S_3)$	0	7,3	14,4	21,4	28,2	29	30,4	31,2
x_3	0	0	1	0	4	4	6	6
S_4	0	4	5	6	7	8	9	10
$F_5(S_4)$	0	7,3	14,5	21,6	28,6	35,4	36,3	37,6
x_4	0	0	4	4	2	4	5	4
S_5	0	4	5	6	7	8	9	10
$F_6(S_5)$								43,3
x_5	0	4	5	6	7	8	9	3

With appropriate distributions, the Bellman ratios will have the following form, respectively, at each stage:

$$F_3(S_3) = \max\,(x_3 \le S_3)(g_3(x_3) + F_2(S_3 - x_3))$$

$$F_4(S_4) = \max\,(x_4 \le S_4)(g_4(x_4) + F_3(S_4 - x_4))$$

$$F_5(S_5) = \max\,(x_5 \le S_5)(g_5(x_5) + F_4(S_5 - x_5))$$

We start the distribution from the end. In table 6, F_6 (S_5) with distribution of 10 million KZT provides the maximum value equal to 43.3. It turns out that the funding of the project 6 should be allocated 3 million KZT. The remaining amount will be:

10 - 3 = 7 million KZT

Now we will consider F_5 (S_4) with the distribution of the remaining 7 million KZT, the maximum value will be 28.6. It means that 2 million KZT should be allocated for funding project 5. Similarly, we consider all the results in table 6. As a result, funding for project 4 will be 1 million KZT, project 3 - 1 million KZT. On funding projects 1-3 remains 3 million KZT. According to the data received, it is proposed to maximize the return on the entire amount to fund the project 1.

Thus, the optimal allocation of the funding amount of 10 million KZT will be as follows:

Project 1	3 million KZT
Project 2	0 million KZT
Project 3	1 million KZT
Project 4	1 million KZT
Project 5	2 million KZT
Project 6	3 million KZT

Findings. Considering the previous calculations, we obtain the following results. Individual deposits in the amount of 3 million should be directed to fund active operations of the project 6. Interbank loans can fund project 4 operations in the amount of 1 million KZT, subordinated bonds fund project 3 operations in the amount of 1 million KZT, international bonds - project 5 operations in the amount 2 million KZT. The remaining funds in the amount of 3 million KZT (corporate deposits) should be directed to fund the project 6. As a result of this distribution, an optimal distribution of funds in the amount of 10 million KZT is achieved.

It should be noted that the tasks of this nature the bank should consider the sequence of actions and sources of funding. This mechanism can be used in banks for rational funding.

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БАНКТЕРДЕ ҚОРЛАНДЫРУ КӨЗДЕРІН БӨЛУДІ МОДЕЛЬДЕУ

Аннотация. Банктерде қорландыру маңызды рөлге ие, себебі компанияларға қарағанда банктер тартылған қаражат есебінен 90 пайызға жұмыс істейді. Осыған орай, тартылған ресурстар екінші деңгейдегі банктердің қызметін қорландырудың негізгі көзі болып табылады. Бұдан басқа, банкте қаражаттарды қайта бөлу, атап айтқанда белгілі бір тартылған ресурстарды активті орналастыру кезінде осы қайта бөлу тәртібі маңызды мәнге ие болады. Яғни қандай тартылған қаражаттарды банктердің белгілі бір активті операцияларын қорландыру көздері ретінде пайдалану қажет.

Банктегі міндеттердің осы түрін сызықтық және динамикалық бағдарламалау арқылы шешу мүмкін. Мақалада банкке пайда әкелетін тиісті активті операцияларға қорландыруды бөлуді оңтайландыру үшін математикалық статистика әдістерін қолдану мысалы берілген.

Түйін сөздер: банктерде қорландыру, сызықты бағдарламалау, пайданы жоғарылату, қорландыру көздері.

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МОДЕЛИРОВАНИЕ РАСПРЕДЕЛЕНИЯ ИСТОЧНИКОВ ФОНДИРОВАНИЯ В БАНКАХ

Аннотация. Фондирование в банках имеет значимую роль, поскольку в отличие от компаний банки на 90 процентов функционируют за счет привлеченных средств. Исходя из этого, привлеченные ресурсы являются основным источником фондирования деятельности банков второго уровня. Более того, при перераспределении средств в банке, а именно направлении определенных привлеченных ресурсов на активные операции важное

значение имеет порядок данного перераспределения. То есть какие привлеченные средства необходимо использовать в качестве источников фондирования определенных активных операций банков.

Решение данного рода задачи в банках возможно с применением линейного и динамического программирования. В статье представлен пример использования методов математической статистики для определения оптимизации распределения фондирования на соответствующие активные операции, способные принести банку прибыль.

Ключевые слова: фондирование в банках, линейное программирование, максимизация прибыли, источники фондирования.

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