Provide an Efficient Financial Portfolio for Financial and Credit Institutions Using the Game Theory Mechanism

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ABSTRACT

Objective: The two main pillars of any financial and credit institution are equipping resources and paying bank loans. Financial and credit institutions are always looking for the best combination of resources and uses to have an acceptable financial balance. In this research, by implementing the game theory structure to combine resources and uses, an acceptable portfolio is presented.
Method: Income and expenses are two competitors and the factors for finding income and expenses are banking resources and uses. Therefore, resources and uses can be considered as two competing personalities, and the balance point for these two characters in the role of player will be an acceptable answer for the financial portfolio. there are different types of deposits, and the variety of combinations of these deposits, is a set of strategies for the player-source. on the other hand, there are different types of loans with different rates, the various combinations, is a set of strategies for the player-uses.
Findings: A different view of banks' financial portfolio and placing it in the form of game theory is the main finding of this study. Providing a balanced financial portfolio, despite its limitations, is the result of research. In this research, the opportunity to show the results of deviation from the equilibrium point as a strategic map is provided.

Keywords:

Financial and credit institutions, financial portfolio, game theory, evolutionary algorithm, multi-objective optimization

1. Introduction

Cash is the main tool in the business process of financial and credit institutions. A group of customers provide the bank with resources by depositing, and the bank forms the economic cycle by paying loans to another group of customers. Deposits, along with expenses, enter the banks' balance sheets as debts, and on the other hand, loans, along with income, are considered as assets of banks. Maintaining the balance of assets and liabilities over a period of time is essential. The behavior of banks is corporate in nature, as it seeks to cover its costs by mediating between depositors and borrowers and creating a balance between interest received and paid. Existence of interest rates on deposits and interest rates on facilities have caused banks to need an intelligent mechanism to attract deposits and pay facilities. In addition to the intra-bank financial process, the existence of monetary and fiscal policies of the central bank has created restrictions for banks that, along with the returns and risks in the bank's financial cycle, must be considered and used in the bank's behavioral model.

In many of the world's economic systems, the banking industry is limited to one type of deposit and one type of loan, and generally administrative and personnel costs are covered by banking fees. But in some of the world's economic systems, sometimes due to economic conditions, financial and credit institutions have a variety of products to enter resources and a variety of products to pay loans. In Iran in particular, inflation and Recession create economic challenges. Therefore, the central bank uses monetary and financial tools and policies to control and manage these challenges. This has imposed various restrictions on the country's banking system, and banks are forced to balance their productivity with careful planning. One of the serious problems in the Iranian banking system is the high interest rates on deposits and loans, which are significantly different from the fees of banking services, Therefore, in the banking system of countries such as Iran, which have different types of deposits and loans, the existence of a computational model is necessary to balance income and expenses. In this regard, the management of the financial system of banks should have financial analysis and planning with the aim of profitability. Deposits and loans, which are the main body of the combination of bank assets and liabilities, are very important and vital in the form of two important tasks of resource decision-making and resource allocation decisions. Choosing the right and logical strategy in depositing and paying the bank facilities puts it in the path of efficiency and productivity. So far, various methods have been presented in the form of mathematical models for banks. In this research, the game theory mechanism has been used to present a financial portfolio to a bank branch. But this researches, has generally focused on optimizing the financial portfolio of banks, and with the aim of achieving a positive balance, mathematical models have been proposed. The distinguishing feature of this research is finding a point of balance of resources and uses with a profitability perspective in the bank. In fact, as banks seek to attract more resources and pay more for facilities, a balance between resources and uses is identified in proportion to available capacity. this is important because in recent years, the Central Bank of Iran has placed serious restrictions on overdrafts from the Central Bank. In this regard, the reader's attention is drawn to the recent instructions of the Central Bank of Iran, in which "the Governor of the Central Bank, referring to the plans of the Central Bank for monetary discipline and control of inflation, said: The performance of some banks and credit institutions in Recent months have seen a continuation and sometimes an increase in imbalances in the management of resources and uses, so that their current account balances with the central bank are still negative. This is undoubtedly in clear contradiction with the central bank's goals and inflation control policies." Therefore, in this research, the game theory mechanism has been used to present the financial basket to the bank branch. In fact, in this research, using a new and different idea, the production conditions provide an acceptable ratio of deposit and loan diversity as a strategic plan to control resources and consumption and at the same time profitability. in this research, using a new and different idea, the production conditions provide an acceptable ratio of deposit and loan diversity as a strategic plan to control resources and uses and at the same time profitability.

2 Theoretical foundations and research background

Game theory based on mathematical models analyzes methods of cooperation or competition in logical and intelligent conditions. Game theory is a branch of mathematics and is used in various sciences including economics, biology, engineering, political science, international relations, computer science, marketing and philosophy. The purpose of this knowledge is to find the optimal strategy for the players. Emile Berl (1921) first researched a number of common casino games and published several articles. In his articles, he pointed out that the results of games can be predicted through logical means. After that, although Burrell was the first to address the subject of games, game theory was known as the Hungarian mathematician John von Neumann because of his lack of ideas. Neumann showed that the outcome of games is not limited to the theory of probability, and by analyzing the game and using appropriate tricks, we can influence the outcome of the game. Neumann and Mongstern (1944) published Theory of Games and Economic Behavior. The main components of game theory are mentioned below.

Game: When the resulting benefits do not depend solely on the behavior of one entity and are influenced by the behavior of one or more other entities, and the decisions of others can have a positive or negative effect on his interests, a game between several entities is formed. In any game, the two concepts of strategy and strategic thinking are important. Strategy is the skill of playing well. In addition to the need for the player to use their skills to the best of their ability, they need to think about the game of the other opponents and their decisions, to guide the outcome of the game in their favor, this issue is defined in game theory, strategic thinking.

Game structure: Each game has three main elements. Players, strategies and consequences. Players are the decision makers of the game, strategies are a set of decisions and actions that each player can make. And any subset of possible actions and decisions will be a consequence of the game.

Game classification: Games are divided into two groups of static and dynamic games. The difference between these two games is that players play simultaneously or in turns. If the players make a decision at the same time and are unaware of the decision and strategy of their opponents, a static game is formed. And if the players take turns in several consecutive stages and the turn game leads to information about the strategy and decision of rivals, a dynamic game is formed, in some cases, players will not know about the rival game despite the dynamic game. Games can be classified into two categories of games with complete information and games with incomplete information in terms of players' access to information and their level of aristocracy. In a game with complete information, players are on the same level in terms of information about the game and rivals, and none of them has private information from other players. But in a game with incomplete information, one or more players have more information than the opposing players.

Multi-objective optimization: The first optimization technique was invented by the great German mathematician Karl Friedrich Gauss (1777-1855). Due to its wide application, most of the terms used in this field go back to the contemporary period. Multi-objective optimization methods are commonly used in the fields of engineering science, their application is when to achieve the optimal solution, it is necessary to strike a balance between two or more conflicting goals. For example, in the financial decision-making process, there are always two goals: maximizing returns and minimizing risk. In this case, because there is more than one objective function, the problem is solved by using multi-objective optimization models and more than one answer is given to the decision maker, each of these answers, from a perspective, Has relative superiorityon the other answer. but no absolute superiority, in which case the set of calculated solutions is called Pareto optimal solutions. Theoretically, in two-objective optimization, we will encounter two-dimensional space, and a line can accommodate a set of infinitely distinct optimal solutions with relative superiority, and in much higher optimization, n-dimensional space proportional to the set. We will have the answer n-1 next.

NSGA-II algorithm: Various methods are used to solve multi-objective problems according to its linear and non-linear nature. One of the methods for solving nonlinear and difficult problems is to use meta-heuristic methods. The GA algorithm is one of the most practical metaheuristic algorithms that is the basis of many other metaheuristic algorithms. The developed NSGA-II algorithm is a GA algorithm that is used to solve multi-objective problems. Selection of feasible answers as the initial population and genetic manipulation of this early population using two means of transmission and mutation of new offspring will be added to the initial population. Next, the best genes are selected as the improved solutions. By repeating the transfer and mutation operations on the modified population, depending on the choice of repetition strategy, the solutions that are very close to the optimal solution will be the output of the algorithm.

The following is some recent research. Chritopoulos et al. (2020) In the research, the game theory approach has been used for fair customer allocation in a state of limited competition. The proposed model is formulated with linear constraints and a nonlinear objective function and seeks a programmatic approach that is separable from the linear approach. Nagorni et al. (2019) developed a game theory model for disaster relief. The purpose of this study is to investigate the financial and logistical aspects of humanitarian organizations for the purchase and delivery of relief items, using transportation services. This model allows the purchase of relief items locally and non-locally, and includes budget constraints for each humanitarian organization. Sohrabi and Ozgomi (2020) in their research examined the combined use of game theory and optimization algorithms. In some of these combinations, game theory is used to improve the performance of optimization algorithms, and in others, optimization methods help to solve game theory problems. Mahjoubi and Bao (2021) present game theory based strategies to improve the efficiency and effectiveness of calculations in optimizing the design of civil engineering structures. The idea is that a structural optimization problem can be dealt with as a multiplayer game with player optimization algorithms.

As mentioned, several research activities have been performed in combination with game theory to optimize activities in various sciences, some of which are multi-objective models and in some cases meta-heuristic algorithms have been used to solve them.

The use of game theory capacities in the field of finance is a topic that has been considered in this study. In this regard, banking resources and expenditures as two infrastructure indicators in the financial process, are considered as two players, and for that game design Has been.

Therefore, in this research, modeling the portfolio of financial and credit institutions with a multi-objective format based on game theory is on the agenda. Markowitz-based model is used to model strategies and meta-heuristic algorithms are used to calculate the consequences.

3 Research method

In this research, using the basics of game theory, a balancing program for the resources and uses of the banks has been proposed. This research is an analytical with inferential content in terms of purpose and applied method. In the research process, first, the problem of expression and its details are explained. Structuring a financial issue by game theory mechanism is an idea that differs from previous research . Giving personality to the two concepts of resources and uses, as two competitors, each of which can have a strategy, has been on the research agenda. The cost price for the attracted deposit has been the basis for the separation of resource strategy in the position of the first player. In the second step, the uses-player, whose main behavior is bank loan payment, can have a variety of strategies according to each of the first player strategies, through which the profit or loss of the financial portfolio is obtained.

To implement the drawn goal, the problem framework is defined based on parameters and variables and a mathematical function for risk and return is presented. Then, the structure of the game includes describing the players, determining the strategies of the players, in accordance with the existing goals and constraints. and finally, the consequences of the players are calculated in accordance with the strategies and the best strategy for the resource and consumption portfolio is determined. With the available scenarios, the game will be dynamic with complete information. Meta-heuristic algorithms have been used to calculate the mathematical model introduced in the research.

4 Expressing the problem

In Iran, due to inflation fluctuations, the Central Bank tries to control liquidity and inflation through expansionary and contractionary policies. In this regard, financial and credit institutions as one of the pillars of the country's economy, have a significant share in central bank policy. Determining interest rates on deposits and facilities of banks is one of the measures and policies of the Central Bank. Banks will need a well-codified resource and cost management plan to ensure compliance with the policy.

Resource and expenditure portfolio management is one of the most important goals of financial and credit institutions. These institutions, by announcing the maximum allowable rate of the cost price of money for deposit, adjust their resource equipment program and expect the combination of different deposits with different rates to be lower than the rate set in the program. On the other hand, the payment of facilities is another action of banks to compensate the costs of equipping resources. The sum of these two activities will be reflected in the establishment of a positive balance that is the product of proper and rational planning for resources and expenditures.

In addition to achieving a positive balance in a short-term planning, banks also need to maintain an acceptable structure for the portfolio. To minimize the risk of portfolio returns, financial and credit institutions prefer to keep the shortest possible distance between the amount of different types of deposits and facilities in the program. Therefore, maximizing returns and minimizing the risk of distance between deposit and facility types are the two main goals in the branch portfolio. Achieving a portfolio of resources and expenditures in terms of the above conditions is an important issue in banks. In this study, providing a mathematical model to modify the portfolio of deposit resources and utility expenditures in the form of game theory and solving it is the main problem.

4.1 Game theory

The elements required to establish the structure of the game are as follows.

- ✓ Players: Player-1= resources and player-2= uses
- ✓ Strategies: Player-1 Strategy, Variety of different types of deposits with the desired cost of money. In order to formulate player-1 strategy, it is assumed that there are "n" different types of deposits and d_i : $for\ i = 1, \dots, n$ each is a deposit type. In this case, the set of player strategies 1 with "S1" is shown that the parameter "r" is the number of strategies. Each player-1 strategy is a combination of different types of deposits, so player-1 strategies are as follows.

$$S1 = (s_1, \dots, s_r)\ s.t.\ s_k = (d_{k1}, \dots, d_{kn})^T \quad for\ k = 1, \dots, r$$

$$S1=\begin{bmatrix} d_{11} & \dots & d_{r1} \\ \vdots & \ddots & \vdots \\ d_{1n} & \dots & d_{rn} \end{bmatrix}$$

Player-2 strategy is a combination of different types of payment facilities. It is assumed that there are "m" different types of facilities and l_j : $for\ j = 1, \dots, m$ each is a type of facility. In this case, the set of strategies of player-2 with S2 is shown that the parameter "r" is the number of strategies. Each player-2 strategy is a combination of different types of facilities so player-2 strategies are as follows.

$$S2 = (\bar{s}_{i1}, \dots, \bar{s}_{i\bar{r}})\ s.t.\ \bar{s}_{ik} = (l_{ik1}, \dots, l_{ikm}) \quad for\ k = 1, \dots, r\ \&\ i = 1, \dots, p$$

$$S2=\left(\begin{bmatrix} l_{111} & \dots & l_{1r1} \\ \vdots & \ddots & \vdots \\ l_{11n} & \dots & l_{1rn} \end{bmatrix} \dots \begin{bmatrix} l_{p11} & \dots & l_{pr1} \\ \vdots & \ddots & \vdots \\ l_{p1n} & \dots & l_{prn} \end{bmatrix}\right)$$

- ✓ Consequences:

Player-1 will consider the two costs of minimize the cost and minimize the risk to decide on the composition of the deposit. Given that the allowable ceiling for the deposit fee rate is communicated to financial and credit institutions, maximizing the difference between the deposit fee rate and the fixed rate reported for the cost price of money replaces the first goal. In general, financial risk portfolio models return returns commensurate with historical data and various methods such as mean-variance, half-mean-variance and value at risk are used, but in this study with the aim of controlling the best and least risky Deposit composition, minimize the deviation of different deposit types from the average is defined as the second goal. Financial and credit institutions have a plan to attract deposits on the agenda, which can be determined in various ways, including head-to-head, in this study, regardless of the details of the institutions' strategies, only as a parameter and as a limit the model has been displaced.

Player-2 has two goals: maximizing profits and minimizing the deviation of different types of facilities. For the second player, there are different strategies for the desired profit margin rate. To model this strategy, the expected profit margin rate and the operating profit margin rate are placed in the function of the first target, the return risk for the second player, It is inherently a diversion of one type of facility, because with the tendency of the facility to a particular type, it will be practically impossible to support the diversity of customers and the influence of the financial and credit institution will be reduced. There is a limit to the loan facility in proportion to the loan deposit and the need to block part of the deposit with the Central Bank for the second player. For ease of modeling, it is assumed that the block amount with the Central Bank is a type of facility with a fixed rate of return. The central bank will award a one percent bonus to the blocked amount, which will be considered as the benefit of such a facility.

Table 1: Computational model of resource player outcomes tailored to strategies.

INDEX	i	INDEX OF DIFFERENT DEPOSIT TYPES I = 1,… N
VARIABLE	x_i	deposit type i
PARAMETER	Cb v_i B	Cost of money = cost of financing Deposit interest rate of type i Designated program to attract resources
OBJECTIVE FUNCTION 1 OBJECTIVE FUNCTION 2 RESTRICTION 1		$min\left(Cb-\frac{\sum_{i=1}^{n}v_ix_i}{\sum_{i=1}^{n}x_i}\right)$ $min\left(\sum_{i=1}^{n}(x_i-1/n\sum_{i=1}^{n}x_i)^2\right)$ s.t: $\sum_{i=1}^{n}(x_i)=B$

Table 2: Computational model of player's uses in accordance with strategies

INDEX	i j	INDEX OF DIFFERENT DEPOSIT TYPES $Different\ types\ of\ facilities$
VARIABLE	y_j	Type of facilities j
PARAMETER	R w_j B x_i	Expected profit margin Facility interest rate of j type Designated program to attract resources deposit type i
OBJECTIVE FUNCTION 1 OBJECTIVE FUNCTION 2 RESTRICTION 1 RESTRICTION 2 RESTRICTION 3		$min\left(R-\left(\frac{\sum_{j=1}^{m}w_jy_j+w_f\left\vert\sum_{i=1}^{n}(x_i)-\sum_{j=1}^{m}y_j\right\vert}{\sum_{j=1}^{m}y_j+\left\vert\sum_{i=1}^{n}(x_i)-\sum_{j=1}^{m}y_j\right\vert}-\frac{\sum_{i=1}^{n}v_ix_i}{\sum_{i=1}^{n}x_i}\right)\right)$ $\min\left(\sum_{j=1}^{m}(y_j-1/n\sum_{j=1}^{m}y_j)^2\right)$ s.t: $y_1=0.75x_1$ $y_2=0.1\sum_{i=1}^{n}x_i$ $\left\vert\sum_{i=1}^{n}(x_i)-\sum_{j=1}^{m}y_j\right\vert<0.2$

	Field 1	*Field 2*	*Field 3*	*Field 4*	*Field 5*	*Field 6*
Type	vector	vector	integer	vector	integer	decimal
Content	sources	Risk/return	ranking	defeated	Frequent times	distance prevailed
Role	variables	objective functions	NSGA-II algorithm			

4.2 Problem game structure The game between deposit resources and facility uses is a dynamic game with complete information. The reason for this is to run the game in two stages. In the first stage, according to the requirements and program, the amount and variety of deposit types for the first player (resources) is determined, and in the second stage, for each strategy selected by the first player, the variety of second player strategies is determined.

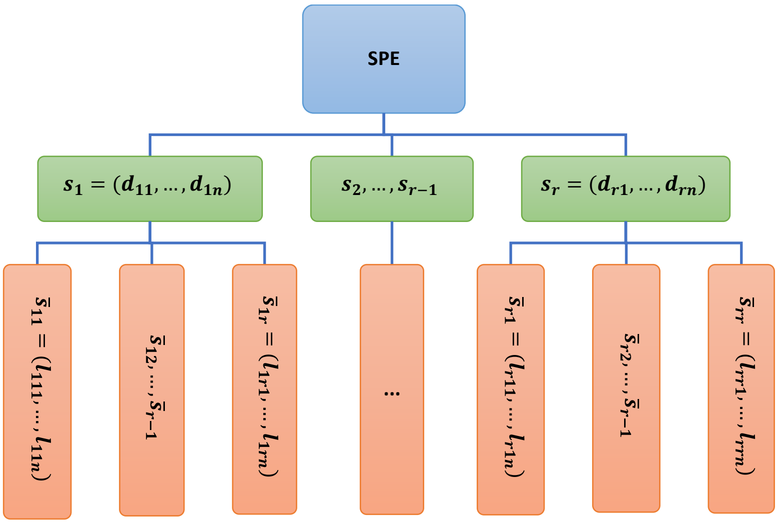

Fig. 1. Decision chart.

4.3 Chromosome structure of players

The NSGA-II meta-heuristic algorithm will be used to calculate the outcome of the game, the chromosome structure for each player is as follows:

Table 2: Matrix structure of the first player chromosome.

- The first dimension: the next m vector, in each dimension of which the amount of one type of deposit is entered.
- Second dimension: The display of the values of the objective function will be displayed separately in a two-dimensional vector.
- Third dimension: An integer value that shows the rank of a chromosome among other chromosomes.
- Fourth dimension: is a vector designed for the NS algorithm and shows the set of chromosomes from the population that are defeated by this chromosome.
- Fifth dimension: An integer designed for the NS algorithm that represents the number of times this chromosome is defeated by other chromosomes.
- Sixth dimension: is a decimal number designed for the NS algorithm and represents the numerical value of the crowding distance operator.

Table 4: Matrix structure of the first player chromosome

	Field 1	*Field 2*	*Field 3*	*Field 4*	*Field 5*	*Field 6*	*Field 7*
Type	vector	integer	vector	integer	vector	integer	decimal
Content	uses	deficit/surplus	Risk/return	ranking	defeated	Frequent times	distance prevailed
Role	variables		objective functions	NSGA-II algorithm			

- The first dimension: the n-dimension vector, in each dimension of which the amount of a type of facility is entered.
- The second dimension: is an integer value in which the difference between the algebraic sum of the first member representation and the second member representation is inserted.
- Third dimension: The display of the values of the objective function will be displayed separately in a two-dimensional vector.
- Other dimensions are similar to the source chromosome.

4.4 Algorithm for calculating the initial population

Decision making for the player has limitations that complicate the implementation of the evolutionary algorithm. In order to facilitate the work, the selection of the initial population will be as follows.

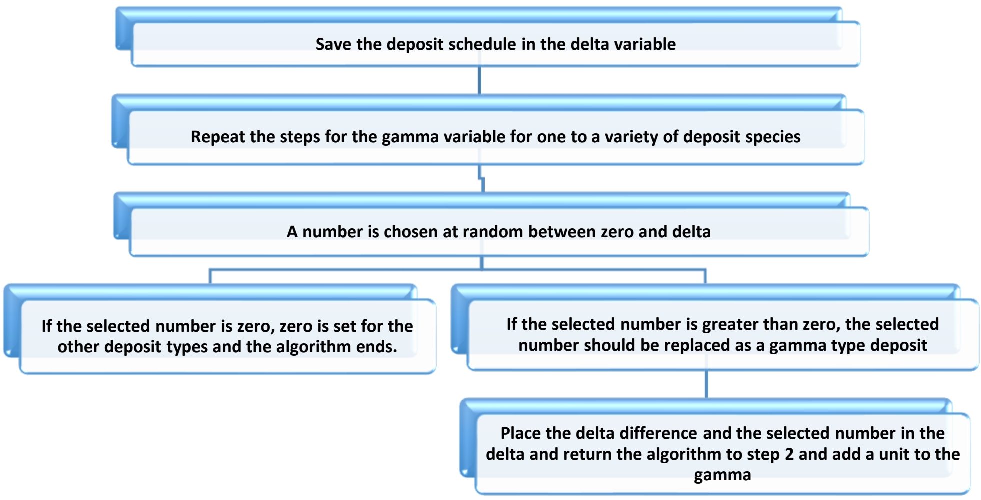

Fig. 2. Algorithm for selecting the initial population of the first player.

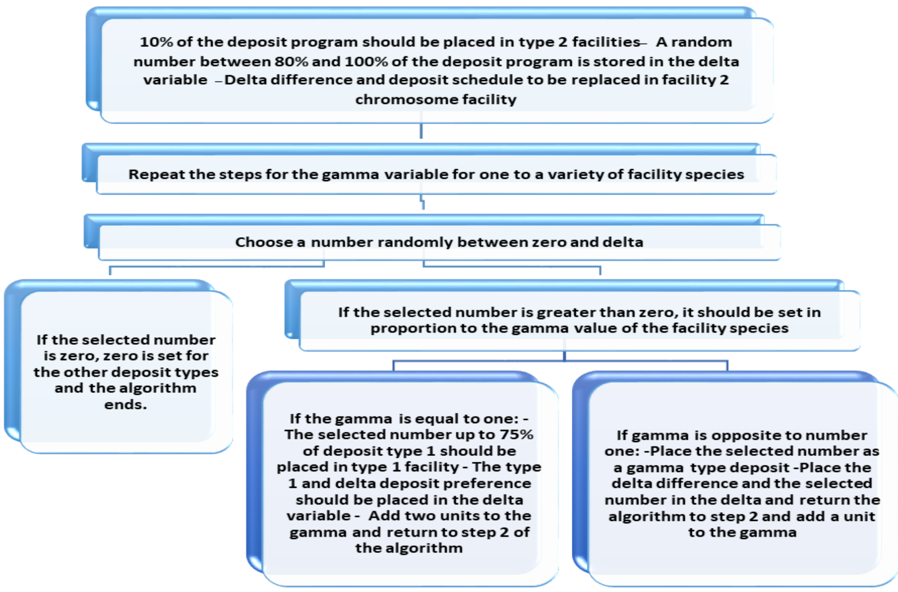

Fig. 3. The algorithm for selecting the initial population of the second player.

4.5 Crossover and mutation operator

Since the limitations of the mathematical model are taken into account when forming the initial population, the crossover operator for player 1 will be performed as follows

-Two members are randomly selected as parents

-Field 1 of child is quantified by the corresponding mean of each of the two parent genes.

For the second player, in addition to the previous steps, due to the need to set field 2, it is sufficient to place the subtraction of fields 1 for deposit players and facilities in field 2 of player 2.

For the mutant operator, the technique of doubling the value of one gene and reducing the other genes as a percentage of the growth rate of one gene has been used.

The formulas used in the mutation operator are as follows.

Table 5: Mutation operator equations.

$x_i\ :\ for\ \ i = 1,..n$	
$j = rand(i)$	
$x_j\ = 2x_j$	
$rat(i) = \frac{x_i}{\sum_{i=1,i\neq j}^{n} x_i}\ for\ i = 1, \dots, n\ \&\ i \neq j$	
$x_i = x_i - rat(i) * x_j$	

5 Case study

It is planned to provide a portfolio of resources and expenses for the branches of Keshavarzi Bank. The interest rate paid for the types of Gharz al-Hasna deposits, current, short-term, special short-term and long-term are 2, 1, 10, 15, 18 percent, respectively. The interest rate received from Gharz al-Hasna, Keshavarzi, Jaleh, and Mudaraba preferential facilities is 4, 15, 18, and 21 percent, respectively. The central bank will give a one percent bonus to the banks for the blocked amount, which, according to the explanations provided, will be considered the blocked amount of a deposit with the central bank of the second type of facility with an interest rate of one percent. Estimated fixed administrative and personnel costs are estimated at 100 units per employee. Financing cost or income rate is 17%, so in case of deficit or surplus of resources, the bank branch can deviate up to 20% from the break-even point of resources and expenditures. The purpose is to provide a portfolio of resources and expenditures to the branches.

Table 6. Case study parameters.

Parameter description	Type 1	Type 2	Type 3	Type 4	Type 5
Deposit interest rate (percent)	2	1	10	15	18
Facility / loan interest rate (percent)	4	1	15	18	21
Fixed rate of financing cost (percent)	17				
Fixed rate of financing income (percent)	17				
Fixed administrative and personnel costs ($)	100 Units per employee				

5.1 Game theory

The game presented in this research is a dynamic game with complete information. Because first the first player (resources) will determine his strategies and then the second player will determine the variety of his facility strategies for each deposit strategy in proportion to the strategies of the first player, which is the determination of deposit combinations. Therefore, in the first step, using the formulas described in Table 1, according to the resource player strategies, the deposit composition, the effective deposit rate (cost of attracting the deposit) and the standard deviation of the deposit types are calculated by the NSGA-II algorithm. It is necessary to explain that since the fluctuations of the deposit interest rate are in the range of 1 to 18%, naturally the effective deposit rate will also be in this range and the resource player strategies are determining 18 deposit combinations with an effective cost rate of 1 to It is 18%.

Table 7. Strategy and consequences of the first player.

First Player Strategies (Resources)																	
s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
[1071,3680,211,22,16]	[1137,3135,675,16,37]	[999,2851,827,208,115]	[1171,2347,1004,330,148]	[1264,1984,974,411,367]	[1126,1785,998,601,490]	[1092,1498,1000,823,587]	[1114,1194,1001,850,841]	[1000,1000,1000,1000,1000]	[798,918,1002,1011,1271]	[849,580,1010,1063,1498]	[836,314,1007,1058,1785]	[785,107,898,1195,2015]	[400,146,1003,1065,2386]	[84,137,989,1179,2611]	[52,117,528,1028,3275]	[36,32,196,1002,3734]	[1,0,13,43,4943]
[5502;0]	[4544;0]	[3702;0.001]	[3044;0]	[2496;0]	[1822;0]	[1180;0]	[618;0]	[0;0]	[568;0]	[1142;0]	[1700;0]	[2420;0]	[2908;0]	[3580;0]	[4606;0]	[5472;0.001]	[7886;0]

In the second step, the second player will determine his scenarios for each of the first player strategies. The second has the role of a follower in the dynamic game and depending on the cost rate of the interest on the deposit attracted, some of its scenarios cannot be realized. This will happen due to the impossibility of response space for some scenarios. Table 8 describes the second player scenarios attributed to the first player first scenario.

Table 8. Set of doable and impossible strategies of the second player answer space for the first strategy of the first player.

Rate resources	profit marigin	Resource portfolio	Resource risk	uses portfolio	uses rates	Profit margin deviation	uses risk	Total risk
0.01	0.01	[1071,3680,211,22,16]	1395	[750,500,3697,52,1]	0.1198	-0.099	1377	1386
0.01	0.02		1395	[750,500,3720,23,7]	0.1197	-0.089	1389	1392
0.01	0.03		1395	[750,500,3750,0,0]	0.1195	-0.079	1405	1400
0.01	0.04		1395	[750,500,3750,0,0]	0.1195	-0.069	1405	1400
0.01	0.05		1395	[750,500,3750,0,0]	0.1195	-0.059	1405	1400
0.01	0.06		1395	[750,500,3750,0,0]	0.1195	-0.049	1405	1400
0.01	0.07		1395	[750,500,3727,15,8]	0.1196	-0.039	1393	1394
0.01	0.08		1395	[750,500,3726,19,5]	0.1196	-0.029	1393	1393
0.01	0.09		1395	[750,500,3741,4,5]	0.1195	-0.019	1401	1397
0.01	0.1		1395	[750,500,3750,0,0]	0.1195	-0.009	1405	1400
0.01	0.11		1395	[750,500,3633,72,45]	0.1204	0	1343	1369
0.01	0.12		1395	[750,500,2323,1008,419]	0.1305	0	693	1101
0.01	0.13		1395	[750,500,1113,1783,854]	0.1404	0	438	1034
0.01	0.14		1395	[750,500,391,1547,1812]	0.1505	0	573	1066
0.01	0.15		1395	[750,500,127,401,3222]	0.16057	0	1129	1269
0.01	0.16		1395	[750,500,0,0,3750]	0.1645	0.006	1405	1400
0.01	0.17		1395	[750,500,0,0,3750]	0.1645	0.016	1405	1400
0.01	0.18		1395	[750,500,0,0,3750]	0.1645	0.026	1405	1400
0.01	0.19		1395	[750,500,0,0,3750]	0.1645	0.036	1405	1400
0.01	0.2		1395	[750,500,0,0,3750]	0.1645	0.046	1405	1400
0.01	0.21		1395	[750,500,0,0,3750]	0.1645	0.056	1405	1400

In Table 8 and in the profit margin deviation column, which is actually a function of the second player goal, it is shown that only the 11 to 15 profit margin strategy is feasible for the second player and other second player scenarios are impossible. These results are the result of the limitations that the second player has in choosing his scenarios, so that the facilities of type 1 and 2 are practically beyond the control of the second player to choose. Because, with any arrangement it chooses for the other three types of facilities, it cannot produce the expected profit margin rates.

In the following, we will discuss the feasibility of strategies 1 to 10, although the arrangement of facility diversity has been towards the lowest facility interest rate, however, the minimum interest received from the facility has been more than 11 percent and in practice this strategy is not meaningful .

Similarly, despite the restrictions, the maximum interest received on the facility with a tendency to the highest interest rate on the facility will be 16.45%, and therefore it is not possible to generate a profit margin of 16% or more.

Therefore, by eliminating the impossible scenarios, the second player in Table 9 shows the final results.

Table 9. Set of feasible and optimal strategies of the second player for the set of strategies of the first player.

Row	Rate resources	Resource portfolio	uses portfolio	profit marigin	Total risk
1	0.01	[1071,3680,211,22,16]	[750,500,3633,72,45]	0.11	1369
2	0.01		[750,500,2323,1008,419]	0.12	1102
3	0.01		[750,500,1113,1783,854]	0.13	1034
4	0.01		[750,500,391,1547,1812]	0.14	1067
5	0.01		[750,500,127,401,3222]	0.15	1269
6	0.02	[1137,3135,675,16,37]	[796,500,3475,157,72]	0.1	1207
7	0.02		[796,500,2281,836,587]	0.11	933
8	0.02		[796,500,1145,1423,1136]	0.12	842
9	0.02		[796,500,455,1203,2046]	0.13	911
10	0.02		[796,500,68,299,3337]	0.14	1170
11	0.03	[999,2851,827,208,115]	[699,500,3693,56,52]	0.09	1194
12	0.03		[699,500,2306,1137,358]	0.1	857
13	0.03		[699,500,1404,1284,1113]	0.11	739
14	0.03		[699,500,412,1639,1750]	0.12	808
15	0.03		[699,500,227,346,3228]	0.13	1058
16	0.04	[1171,2347,1004,330,148]	[820,500,3360,233,87]	0.08	1015
17	0.04		[820,500,2215,839,626]	0.09	703
18	0.04		[820,500,1377,885,1418]	0.1	603
19	0.04		[820,500,245,1441,1994]	0.11	711
20	0.04		[820,500,86,84,3510]	0.12	1062
21	0.05	[1264,1984,974,411,367]	[885,500,3092,385,138]	0.07	869
22	0.05		[885,500,1996,925,694]	0.08	560
23	0.05		[885,500,914,1418,1283]	0.09	481
24	0.05		[885,500,496,604,2515]	0.1	690
25	0.06	[1126,1785,998,601,490]	[788,500,3506,107,99]	0.06	961
26	0.06		[788,500,2078,1321,313]	0.07	555
27	0.06		[788,500,880,1996,836]	0.08	488
28	0.06		[788,500,500,1103,2109]	0.09	533
29	0.06		[788,500,81,312,3319]	0.1	897
30	0.07	[1092,1498,1000,823,587]	[764,500,3590,89,57]	0.05	959
31	0.07		[764,500,2165,1249,322]	0.06	514
32	0.07		[764,500,1327,1277,1132]	0.07	311
33	0.07		[764,500,580,1089,2067]	0.08	457
34	0.07		[764,500,184,211,3341]	0.09	868
35	0.08	[1114,1194,1001,850,841]	[780,500,3530,109,81]	0.04	918

Row	Rate resources	Resource portfolio	uses portfolio	profit marigin	Total risk
36	0.08		[780,500,2121,1271,328]	0.05	467
37	0.08		[780,500,1060,1717,943]	0.06	303
38	0.08		[780,500,299,1553,1868]	0.07	441
39	0.08		[780,500,171,148,3401]	0.08	870
40	0.09	[1000,1000,1000,1000,1000]	[700,500,3796,1,3]	0.03	1007
41	0.09		[700,500,2750,482,568]	0.04	621
42	0.09		[700,500,1388,1581,831]	0.05	293
43	0.09		[700,500,650,1394,1756]	0.06	345
44	0.09		[700,500,168,677,2955]	0.07	704
45	0.1	[798,918,1002,1011,1271]	[559,500,3273,364,304]	0.03	814
46	0.1		[559,500,1982,1264,695]	0.04	411
47	0.1		[559,500,1273,1053,1615]	0.05	320
48	0.1		[559,500,376,1191,2374]	0.06	537
49	0.1		[559,500,50,158,3733]	0.07	982
50	0.11	[849,580,1010,1063,1498]	[594,500,3099,519,288]	0.02	775
51	0.11		[594,500,1962,1121,823]	0.03	429
52	0.11		[594,500,1040,1308,1558]	0.04	357
53	0.11		[594,500,423,904,2579]	0.05	608
54	0.11		[594,500,11,25,3870]	0.06	1050
55	0.12	[836,314,1007,1058,1785]	[585,500,3085,577,253]	0.01	814
56	0.12		[585,500,1940,1203,772]	0.02	502
57	0.12		[585,500,1119,1195,1601]	0.03	442
58	0.12		[585,500,518,750,2647]	0.04	674
59	0.12		[585,500,22,43,3850]	0.05	1074
60	0.13	[785,107,898,1195,2015]	[550,500,2221,878,851]	0.01	625
61	0.13		[550,500,1049,1524,1377]	0.02	529
62	0.13		[550,500,416,1135,2399]	0.03	685
63	0.13		[550,500,75,157,3718]	0.04	1064
64	0.14	[400,146,1003,1065,2386]	[280,500,2053,1054,1113]	0.01	701
65	0.14		[280,500,945,1609,1666]	0.02	678
66	0.14		[280,500,381,1067,2772]	0.03	855
67	0.14		[280,500,52,36,4132]	0.04	1242
68	0.15	[84,137,989,1179,2611]	[59,500,1299,2128,1014]	0.01	742
69	0.15		[59,500,686,1689,2066]	0.02	765
70	0.15		[59,500,459,542,3440]	0.03	1030
71	0.16	[52,117,528,1028,3275]	[36,500,1063,1076,2325]	0.01	772
72	0.16		[36,500,258,1042,3164]	0.02	971
73	0.17	[36,32,196,1002,3734]	[25,500,404,976,3095]	0.01	947
74	0.17		[25,500,28,28,4419]	0.02	1334
75	0.18	[1,0,13,43,4943]	[1,500,19,19,4461]	0.01	1348

Table 10. Choose the best portfolio.

Row	Rate resources	Resource portfolio	uses portfolio	profit marigin	Total risk
42	0.09	[1000,1000,1000,1000,1000]	[700,500,1388,1581,831]	0.05	293

According to the information in Table 8, there are a total of 75 strategic-optimal combinations out of 378 possible strategies for game players. The best strategy among these 75 scenario combinations is the 42-line strategy that has the lowest risk (deviation from the average). And is introduced as SPE game.

Therefore, the best program can be presented to a bank branch with the assumptions of Table 6 Strategy as described in Row 42 of Table 9.

It should be noted that, for each of the strategies, a model is solved for the parameters that are changing, so for each of the strategies, the mathematical model is solved once. Which is a lot of calculations and is not cost effective without using MATLAB software and its capabilities. Finally, using the game theory mechanism among the strategies, a balanced strategy is introduced.

the purpose of this study is to provide a reasonable financial portfolio to the bank while considering its limitations and requirements. Deviation from the plan can be inevitable for a variety of purposes, but having a plan that, despite some limitations, meets the minimum performance expectation, is needed as a basis. As shown in Table 10. A combination of a deposit with a 9% interest rate and a combination of loans with return of 5% interest margin is a reasonable and acceptable portfolio. Of course, these calculations are based on the limitations that exist. The reason for using the game theory mechanism in this research is to calculate an equilibrium point. Of course, it should be noted that in the strategies that have been calculated, there are results of deviations from this equilibrium point, and it is not unlikely that some of these deviations will be evaluated in a positive direction and will be considered as a desirable, but it should be emphasized again that the goal of the research was to calculate an equilibrium point as a roadmap and a basis for work.

6 Conclusion

In this study, with a different view from the research done so far in the field of optimization in the field of financial management, finding a balance point for the resource and uses portfolio the branches of Iranian banks that have restrictions on loan payment and resource absorption, is on the agenda. The basis of the work is based on game theory, so that the resources and uses of the two players are assumed to each have strategies for which the decision maker seeks to find a point of equilibrium. This is done by modeling players' strategies using Markowitz-based models and then solving them through meta-heuristic algorithms. Return is expressed as one of the main pillars of the model in the form of deposit cost optimization and profit margin optimization, and risk is actually considered as a deviation from the average of different types of deposits and loans. The reason for this is that in the program presented to a financial institution, the decision-making headquarters tries to use the maximum capacities in the variety of types of deposits and facilities and does not even tend to a specific type. The models are completely dependent on the interest rate on the deposit and the interest on the facility. The decision maker needs to have the important capacity data of a branch to present the program, so in proportion to the number of manpower, the number B is considered as the total program. The details of the program, which is actually the amount of deposits and loans, have been considered in this research. The greater the tendency towards cheap deposits, the more profitable margins can be achieved with the tendency of loans towards expensive ones, but this issue will cause serious restrictions for the branches that are supposed to implement the specified program, The reason for this is that: the branch can accept only a small range of customers and the risk of the program will be reduced, on the contrary, with the tendency of the proposed portfolio towards expensive deposits, in addition to limiting the acceptance of depositor customers, there will be serious restrictions on payment loans And the branch will have to limit loan-customers. The model is solved for a real example where the deposit rate fluctuations are between 1 and 18 and the loan rate fluctuations are between 1 and 21. The output shows that, by combining the effective deposit rate of 9 and the profit margin rate of 5, the smallest deviation from the average for the portfolio will be the figure that can be presented as a reasonable and acceptable plan.

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