Application of Gray Multi-Criteria Decision-Making in Evaluating Efficient Use of Resources in Iran's Banking Industry

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ARTICLE INFO

Keywords

Internal efficiency,
gray multi-criteria decision-making,
hierarchical analysis

Article history

Received: 11 Auguest 2023

Accepted: 30 December 2023

ABSTRACT

The purpose of this research is the application of multi-criteria gray decision-making in evaluating the efficient use of resources (internal efficiency) in the banking industry of Iran. The studied sample includes 14 commercial banks from the years 2015 to 2021. In order to determine the order of importance and weight of factors predicting internal efficiency in the banking industry, first in the first phase, in order to identify the factors, according to the literature review and previous research, there are factors that are effective in evaluating the efficient use of resources (internal efficiency) in The banking industry was surveyed، In the second phase, brainstorming sessions were held with expert experts, which are completely targeted, to determine the importance and weight of factors predicting the efficient use of resources (internal efficiency) in the banking industry, using the hierarchical analysis process method, questionnaire Pairwise comparisons were made available to 35 experts. A hierarchy was designed, according to the obtained results, in the dimensions of factors predicting the effective use of resources (internal efficiency) in the banking industry, the factor "excess market return" is the first priority, the factor "irrationality of traders" is the second priority, the factor "financial leverage" in the third priority, "inflation rate" factor in the first priority, "liquidity" factor in the second priority, "interest rate risk" factor in the third priority, "liquidity risk" factor in the fourth priority, "credit risk" factor in In the fifth priority, the "economic growth" factor was placed in the sixth priority, the "market interest rate" factor in the seventh priority, the "bank size" factor in the eighth priority, and the "currency rate" factor in the ninth priority.

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1. Introduction

One of the most important sectors of the economy of any country is the banking sector, whose correct and rational management leads to the correct implementation of monetary policies and also increases social welfare. Banks perform their activities at the community level through physical branches, so the correct and logical management expressed at the level of bank branches is also taken into consideration. In the market-based economy, the banking system bears a very heavy responsibility and is one of the most important components of the country's economy. Growth and prosperity with the country's economic stagnation are closely related to the way banking institutions work. The importance and sensitivity of the banking system in the entire economic system has prompted the government to adopt and implement a set of measures called policies it is called monetary and credit. To monitor banks as an effective tool for regulating money circulation in society, facilitating commercial exchanges, and helping levers for all kinds of economic activities. Therefore, the performance of banks has attracted a lot of attention from the government, regulatory authorities, and academic researchers. Technical efficiency, as one of the most important indicators of bank performance, deals with the extent to which banks have the ability to minimize the amount of input used to produce a certain amount of output or use a certain amount of input to maximize the production of output. The technical efficiency component, that is, pure technical efficiency and scale efficiency, provides more information regarding the source of efficiency. Pure technical efficiency is related to the ability of bank managers to use the specific resources of banks. Higher efficiency is indicated by pure technical efficiency, while scale efficiency refers to the exploitation of economies of scale by operating at points where production promotes constant returns to scale. Lower scale efficiency shows that banks have more room to adjust the scale of their performance, while an increase in scale efficiency leads to an overall improvement in technical efficiency [10].

The banking industry in Iran's economy plays a major role in providing financial resources due to the lack of a capital market. Therefore, a possible deficiency in the structure and function of this department may cause possible disturbances in other departments. This means that a detailed understanding of this policy-making sector is essential. Also, after the lifting of sanctions and after the JCPOA, Iranian banks must have the necessary efficiency to be present in the world arena. Therefore, improving the efficiency of Iran's banking sector can play a significant role in the development of the financial system and economic growth of the country. The efficiency level of banks can be different according to the environmental conditions, macro economy, or risk level of the country. Therefore, it is necessary to focus on the factors affecting efficiency, the variables affecting efficiency can be divided into two groups: internal, and, external; Internal variables are variables that are affected by managerial decisions. Good management decisions lead to high profitability, which naturally results in increased efficiency. All internal variables can be extracted from the bank's financial statements and balance sheets. External variables are variables that are not under management's control but affect the bank's decision-making process. These 3 variables are divided into two groups macroeconomic variables and financial structure factors 4 [11]. All internal variables can be extracted from the bank's financial statements and balance sheets. Considering that the rapid technical and economic growth in the past few decades has made human life undergo many changes and has confronted the technologically advanced society with complex decision-making issues, this problem has introduced conflicting criteria or goals such as cost, reliability, performance, safety, and productivity. In general, the preferred information of options and criteria are presented in the form of judgments of decision-makers, and the judgments are uncertain and cannot be presented as definite numbers. In this article, in order to solve multi-criteria decision-making problems in uncertain conditions, a model based on gray system theory including relative analysis and gray numbers is proposed, and

Shannon's entropy is also used to weight the criteria. Finally, the proposed model was also rated, which has been used in the Iranian stock market, and its ability and usability have been evaluated. In general, in this research, the application of gray multi-criteria decision-making in evaluating the efficient use of resources (internal efficiency) in the banking industry will be investigated. Since banks are known as the main core of the monetary and financial sphere, especially in developing countries, most of the discussions are focused on the efficiency of banks. The investigations carried out in this research field, which investigates the application of gray multi-criteria decision-making in evaluating the efficient use of resources (internal efficiency) in the industry of banking has been paid, but it has not been done yet. Therefore, to clarify and contribute to the research literature, it is important to address this issue and the above cases make it necessary to conduct this research in Iran. There is a research gap in this field, so in this research, we will try to help solve the existing problem and fill a corner of this gap. This direction has been investigated in the theoretical foundations of research, the internal efficiency of banks, factors affecting internal efficiency, and gray multi-criteria decision-making. The third part is the research method and the fourth part of the article deals with the quantitative analysis of the research. At the end of the article, the contents mentioned in the research are summarized.

2. Theoretical foundations of research

2.1 The Internal efficiency of banks

The main goal of every financial organization is to improve performance, and performance evaluation is one of the best ways to improve operations in organizations. Today, various indicators have been proposed as performance criteria of organizations, which are efficiency, Effectiveness and productivity are the most important of these criteria. By definition, efficiency, doing things right; effectiveness, doing the right things and productivity is a combination of efficiency and effectiveness and includes both categories. In other words, productivity will result in measuring and evaluating the efficiency and results of an organization's activities in relation to the goals and the number of resources consumed [1]. Therefore, productivity, which is a combination of efficiency and effectiveness (at the same time), is considered a key factor in the success and growth, and development of banks in this competitive environment. Of course, activity with high efficiency and low effectiveness causes unsustainable profitability, and activity with low efficiency and high effectiveness causes unprofitable growth, and simultaneous achievement of efficiency and effectiveness at a high level will enable banks to achieve a competitive advantage, sustainable development, and sustainable profitability. Several techniques such as financial ratios [3], and regression analysis [5], Performance evaluation of bank branches is used. However, conventional techniques have many inherent limitations that make them unsuitable for representing the increasingly complex nature of branch banking. For example, traditional financial ratio analysis does not allow for independent composite evaluations objectively and in a single performance score, and it is very difficult to use them for comparative purposes. The branch may be strong in some proportions and it is weak in some other ratios, and this makes it difficult to judge the functional status of that branch. Also, simply combining these results together may cause misleading or wrong indicators. Another method to evaluate banks' performance is regression analysis. Regression analysis is a parametric method that requires a specified overall production model. Also, regression analysis is a central tendency method and is only suitable for single-input, multi-output or multi-input single-output systems [7] Data Envelopment Analysis (DEA) is a comprehensive approach that is accepted to evaluate performance in the banking industry and the popularity of this method is

mainly due to the presence of multiple inputs and outputs in this model and its suitability for investigating nonlinear relationships in analyzes [2]. Research on bank efficiency according to the model DEA is very common. DEA models used to evaluate the performance of banks act as a black box. Performance in areas such as technical, cost, profitability, and productivity are calculated with the assumption that inputs are consumed to produce outputs.

2.2 Factors affecting internal efficiency

Theoretically and empirically, the factors and components affecting the internal efficiency of banks can be investigated in two distinct general groups, including internal (micro) banking components and macroeconomic components. The first group is related to internal bank variables. These variables are under the control of bank management. The different effects of these variables in different banks are basically a reflection of differences in the banks' management policies and decision-making regarding resources and use of assets and liabilities portfolio management, capital adequacy, and costs. The conducted studies have considered different variables from this category of independent variables. In most of these studies, several important variables are common. These variables, in addition to the number of facilities provided by banks, which are the most important source of their income, include the capital adequacy ratio, types of risks, and the size of the bank. The second group of independent variables that are mentioned in the efficiency of banks is related to the conditions governing the banking industry. Among these factors are factors that mostly depend on the economic conditions governing the country, such as inflation, money supply, conditions regulation, adjustment of central bank policies, and GDP growth rate [6].

2.3 Gray multi-criteria decision making

Multi-criteria decision-making is an advanced field of operations research that is dedicated to the development and implementation of decision-support tools and methods. And it deals with complex decision-making problems such as multiple criteria, goals, or objectives of a conflicting nature. The presented tools and methods are mathematical models that aggregate criteria, views, or features and also support the decision. A decision problem is not solved equally by all decision-makers. Each decision-maker has his own preferences, experiences, and decision-making policy. Therefore, one person’s judgment is expected to be different from another’s judgment. This is a significant issue that should be considered during the development of decision models. Such issues are the focus of multi-criteria decision-making. In every public system, there are many effective factors whose mutual influence determines the state and process of growth and development of the system. Often in systems analysis, it is tried to identify the most important factors, but in practice, there are always unknown or less known factors in any system. One of the methods used to deal with such systems is gray equation analysis, which is one of the important components of gray system theory. The principle of gray equation analysis as a quantitative analysis method is based on the point that the value of closeness and correlation between two different factors in a growing dynamic process should be measured based on the similarity of their curves. The greater the degree of this similarity means that there is a higher degree of relationship between the series, and the

degree of gray equation is used to measure the degree of this similarity. According to the definition, if it is assumed, there are m behavioral series related to a system as follows:

$$X_i = \left(x_i(1).x_i(2) \ldots . x_i(n)\right)/i = 1.2 \ldots . m \quad (1)$$

In this case, with the assumption ($\xi \in (o, 1)$, the coefficient of the gray equation and the degree of the gray equation are respectively defined by the following equations:

$$\gamma_{0i} = \gamma\left(x_5(k).x_i(k)\right) = \frac{\frac{\min}{i}\cdot\frac{\min}{k}|x_0(k) - x_i(k)| + \xi\frac{\min}{i}\cdot\frac{\min}{k}|x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \xi\frac{\min}{i}\cdot\frac{\min}{k}|x_0(k) - x_i(k)|} \quad (2)$$

and

$\gamma(X\_0.X\_i) = 1/n \sum\_(k = 1)\hat{}n(\gamma(x\_0).x\_i(k)))$

In the above equations, ξ is called the differentiation coefficient. The degree of the gray relationship $\gamma(X_0.X_I)$ is often written in form γ_{0i} and the coefficient of the gray equation $\gamma\left(x_5(k).x_i(k)\right)$at point k is often written in the form $\gamma_{0i}(k)$(Mohammadi and Moulai, 2010).

3. Research Method

The statistical population of this article includes the banks admitted to the Tehran Stock Exchange in the period between 2015 and 2021. In this research, to determine the statistical sample, banks were first homogenized by the method of systematic exclusion, and after the homogenization of the statistical population, the homogenized population was used as the research sample. The criteria used in the systematic elimination method in order to homogenize the statistical population are as follows. For this purpose, those banks of the statistical community that has the following conditions are selected as a statistical sample and the rest are excluded:

Table 1: Selecting a statistical sample by applying constraints and conditions of society

Sample	Number
The number of banks in the stock market till 1399	17 banks
The number of banks that were not present in the stock market in the years 1393-1399	2 banks
The number of banks that did not provide the financial information required for the research	1 bank
Total	14 banks
The number of banks whose data has been collected (final sample)	14 banks

The questions that are aimed at doing the research method are:

- Arrange the importance and weight of predictive factors of use of efficient resources) What is internal efficiency (in the banking industry?
- What is the degree of gray relationship between any of the options and the rank of each bank?

3.1 Measurements of research variables

The dependent variable (output) of this research is the efficiency of the bank. This variable is estimated based on the following model (yang, 2017):

$$\begin{aligned}\ln(TC) = \alpha + \sum_{m} \beta_m y_{im} + \sum_{j} \gamma_j w_{ij} + \frac{1}{2}\sum_{m}\sum_{n} \beta_{mn} y_{im} y_{in} + \frac{1}{2}\sum_{j}\sum_{k} \beta_{jk} \ln w_{ij} \ln w_{ik} \\ + \frac{1}{2}\sum_{m}\sum_{j} \psi_{mj} \ln y_{im} \ln w_{ij} + \varphi_1 \ln E_{it} + \frac{1}{2}\varphi_2 \ln {E_{it}}^2_{it} + \sum_{m} \lambda_{mt} \ln y_{im} \ln E_{it} \\ + \sum_{j} \xi_{jt} \ln w_{ij} \ln E_{it} + \theta_1 T + \theta_2 T^2 + \sum_{m} \vartheta_m \ln y_{im} T + \sum_{j} \rho_j \ln w_{ij} T + \eta_1 \ln E_{it} T \\ + \text{NPL.TL} + \varepsilon_{it}\end{aligned} \quad (3)$$

In that, TC: is the total cost (is used to estimate the efficiency of this dependent variable), Yi and wi: are components of input and output prices, E: is total bank capital, T: is time variable, and NPL .TL: are logarithm of non-operating loans ratio to the entire loan. Therefore, we cost to calculate the performance:

Ceit=1.exp (u)

where U is the residual of the equation (3). The efficiency value is equal to the residual of the regression model and this value is between zero and one. The closer this value is to one, the more efficient the bank is. The method of measuring independent variables (input), as well as the composition of the questionnaire used in the research, as well as the main indicators in evaluating the efficient use of resources in the country's banking industry, are presented in Tables 2, 3, and 4.

Table 2: Method of measuring independent variables

Variable name	Measurement method	Source
Bank size	is equal to the natural logarithm of total assets (Tan and Ancher, 2012)	Pour Hasan et Al (2018)
Liquidity	Cash to totally assets	Pour Hasan et Al (2018)
Credit risk	This risk is between zero and one. The closer it is to zero, the lower the credit risk.	Pour Hasan et Al (2018)
Liquidity risk	Risk is the ratio of cash assets to total assets (Tan and Ancher, 2012). This risk is between zero and one. The closer to zero, the lower the liquidity risk.	Pour Hasan et Al (2018)
Inflation	The inflation rate is equal to the change in the consumer inflation index (Tan and Ancher, 2012).	Pour Hasan et Al (2018)
Interest rate risk	The ratio of total facilities to the total volume of deposits. This risk is between zero and one. The closer it is to zero, the higher the interest rate risk.	Pour Hasan et Al (2018)
Economic Growth	Gross domestic product = private consumption + investment + government consumption + (import-export) which in the	Pour Hasan et Al (2018)

	current research is directly extracted from the central bank website.	
Market interest rate	Which in the current research is directly extracted from the central bank website.	Pour Hasan et Al (2018)
Exchange rate	Which in the current research is directly extracted from the central bank website.	Pour Hasan et Al (2018)

Table 3: The composition of the questionnaire

Degree of significance in pairwise comparison	The score indicates the severity of importance	Degree of significance in pairwise comparison	The score indicates the severity of importance
Equal importance	1	High to very high importance	6
Equal to relatively weak	2	Very high importance	7
Moderate importance	3	Very high to the absolute importance	8
Moderate to relatively high	4	Absolute importance	9
High relatively	5	_	_
		-	-

Table 4: The main indicators in evaluating the efficient use of resources in the country's banking industry

Symbol	Indicator	Symbol	Indicator
X1	Bank size	X6	Interest rate risk
X2	Liquidity	X7	Economic Growth
X3	Credit risk	X8	Market interest rate
X4	Liquidity risk	X9	Exchange rate
X5	Inflation	_	_

4. Quantitative analysis of research

4.1 Evaluation of the first research question

In order to answer the first question of the research, to determine the importance and weight of the factors for evaluating the efficient use of resources in the country's banking industry, first in the first phase order to identify the factors, according to the literature review and previous researches, there are factors that are effective on the evaluation of the use of resources. The second phase of brainstorming sessions with expert experts who have experienced all the respondents identified in projects to evaluate the efficient use of resources in the banking industry of a relatively large country. And it is completely targeted, it was held and the output of these meetings, including the research literature studies, has been the extraction of more than 10 effective factors, and the output index is profit oriented. Not qualitative, therefore, identifying the factors influencing the implementation of the effective use of resources in the country's banking industry, the questionnaire has been used as a tool for collective evaluation of the opinions of the informants in the

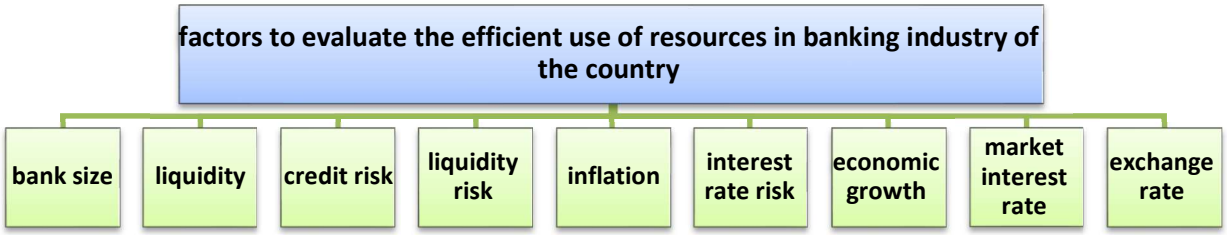
continuation of the research. And it is not a standard questionnaire as a measure of qualitative relationship, the result of which is presented in Table 5.

Table 5: The main indicators in evaluating the efficient use of resources in the country's banking industry

Symbol	Indicator	Symbol	Indicator
X1	Bank size	X6	Interest rate risk
X2	Liquidity	X7	Economic Growth
X3	Credit risk	X8	Market interest rate
X4	Liquidity risk	X9	Exchange rate
X5	Inflation	_	_

In order to determine the order of importance and weight of factors for evaluating the efficient use of resources in the country's banking industry, by using the method of hierarchical analysis, a pairwise comparison questionnaire was given to 35 experts and they were asked to rate the importance of each sub-criterion. express to others for this purpose, a hierarchical decision tree was designed, which can be seen in Figure 1, at this stage for calculation of the relative importance (weight) of each of the main factors, a questionnaire was prepared and distributed according to the two-by-two comparison format to obtain the opinions of expert experts.

Figure 1: Hierarchical decision tree of factors for evaluating the efficient use of resources in the country's banking industry



After extracting the information from the pairwise comparison table, the arithmetic mean of people's opinions was taken in such a way that for each unit, the opinions of people were added together and multiplied by one thirty-five. It should be noted that the weight of all respondents is considered the same, the results of which are presented in Table 6.

Table 6: The average opinions of people about the evaluation factors of efficient use of resources in the country's banking industry

-	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.0000	0.4069	1.2678	1.0291	0.3970	0.6778	1.8287	0.6778	1.8287
X2	2.4579	1.0000	0.5889	2.5148	0.7811	1.8069	0.7749	1.7310	0.7135
X3	0.7888	1.6981	1.0000	1.1529	0.6911	0.6639	1.3571	0.8022	1.7393
X4	0.9717	0.3976	0.8673	1.0000	1.5663	1.3393	1.4473	0.9700	1.5237
X5	2.5189	1.2802	1.4470	0.6385	1.0000	1.5806	1.7223	1.7288	2.4224
X6	1.4754	0.5534	1.5062	0.7467	0.6327	1.0000	2.1885	1.8291	1.9986
X7	0.5468	1.2905	0.7369	0.6910	0.5806	0.4569	1.0000	1.9843	1.9414
X8	1.4754	0.5777	1.2465	1.0310	0.5784	0.5467	0.5040	1.0000	1.9843
X9	0.5468	1.4016	0.5749	0.4128	0.4128	0.5004	0.5151	0.5040	1.0000

Table 7: Prioritizing the dimensions of factors for evaluating the efficient use of resources in the country's banking industry

Dimensions of factors for evaluating the efficient use of resources in the country's banking industry	Index	Geomatic mean	Weights	Priority
Bank size	X1	0.8822	0.0959	8
Liquidity	X2	1.1936	0.1297	2
Credit risk	X3	1.0332	0.1123	5
Liquidity risk	X4	1.0464	0.1137	4
Inflation	X5	1.4795	0.1608	1
Interest rate risk	X6	1.1862	0.1289	3
Economic growth	X7	0.8947	0.0972	6
Market interest rate	X8	0.8889	0.0966	7
Exchange rate	X9	0.5978	0.0650	9
Total	-	9.2024	1.000	-

In the next step, the matrix of paired comparisons should be normalized, so we take the geometric mean on the row so that it is multiplied separately for each level and reaches the ninth power. In the last step, normalization is done to determine the weight and prioritize them on the sum of the geometric mean. We prioritize from the most weight to the least, which is presented in table 7. After determining the weight of the dimensions of the evaluation factors of efficient use of resources in the country's banking industry, compatibility was checked in comparisons by calculating the compatibility ratio. First, the weighted sum vector is obtained from the result of dividing the matrix of pairwise comparisons by the weighted vector, which is as follows;

1.0000	0.4069	1.2678	1.0291	0.3970	0.6778	1.8287	0.6778	1.8287		0.0959		0.9212
2.4579	1.0000	0.5889	2.5148	0.7811	1.8069	0.7749	1.7310	0.7135		0.1297		1.3648
0.7888	1.6981	1.0000	1.1529	0.6911	0.6639	1.3571	0.8022	1.7393		0.1123		1.0583
0.9717	0.3976	0.8673	1.0000	1.5663	1.3393	1.4473	0.9700	1.5237	*	0.1137	=	1.1136
2.5189	1.2802	1.4470	0.6385	1.0000	1.5806	1.7223	1.7288	2.4224		0.1608		1.4989
1.4754	0.5534	1.5062	0.7467	0.6327	1.0000	2.1885	1.8291	1.9986		0.1289		1.2171
0.5468	1.2905	0.7369	0.6910	0.5806	0.4569	1.0000	1.9843	1.9414		0.0972		0.9484
1.4754	0.5777	1.2465	1.0310	0.5784	0.5467	0.5040	1.0000	1.9843		0.0966		0.9115
0.5468	1.4016	0.5749	0.4128	0.4128	0.5004	0.5151	0.5040	1.0000		0.0650		0.6403

In the second step, the compatibility vector is obtained from the result of dividing the elements of the weighted sum vector by the elements of the weight, which is as follows;

0.9212		0.0959		9.6094
1.3648		0.1297		10.5223
1.0583		0.1123		9.4264
1.1136		0.1137		9.7940
1.4989		0.1608		9.3231
1.2171	.	0.1289	=	9.4427

0.9484		0.0972		9.7547
0.9115		0.0966		9.4368
0.6403		0.0650		9.8560

In the third step, the value of λmax is obtained from the average elements of the compatibility vector, which is as follows;

λ_{max} = (9.6094+10.5223+9.4264+...+9.8560)/ 9 = 9.6850

In the fourth step, the compatibility index is obtained from the following formula:

$$CI = \frac{\lambda_{max} - n}{n} \quad (4)$$

CI = (9.6850– 9) /9 = 0.0761

In the fifth step, the incompatibility ratio according to the random incompatibility index (Table 8) was stated to be equal to 1.30, it is found that this ratio is less than 0.1, which shows compatibility in the comparisons.

Table 8: Random compatibility index

n	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

CR=0.0761.1.45=0.0525 <0.1 (5)

According to the obtained results, in the dimensions of the evaluation factors of the efficient use of resources in the country's banking industry, the "inflation rate" factor with a relative weight of 0.1608 in the first priority, the "liquidity" factor with a relative weight of 0.1297 in the second priority, Factor "Interest rate risk" with relative weight: 0.1289 in the third priority, "liquidity risk" factor with relative weight: 0.1137 in the fourth priority, the "credit risk" factor with a relative weight: of 0.1123 in the fifth priority, the "economic growth" factor with a relative weight: of 0.0972 in the sixth priority, the "market interest rate" factor with relative weight: 0.0966 in the seventh priority, factor "Bank size" with relative weight: 0.0959 in the eighth priority, "Exchange rate" factor with relative weight: 0.0650 in the ninth priority.

4.1 Evaluation of the second research question

The purpose of prioritizing each of the options and the ranking of each of the banks according to the factors of the implementation of the evaluation of the efficient use of resources in the country's banking industry, according to the weights obtained from the indicators obtained in the previous step and according to the statistical population of the research, which includes accepted banks. They are active in the financial industry of the country. After selecting the statistical sample by applying the restrictions and conditions of

the society and the availability of their financial information in the period of the financial year ending in March 2019, the number of 14 banks as the final options are reviewed.

Table 9: The main options in evaluating the efficient use of resources in the country's banking industry

The option under consideration	Index
Eghtesad novin bank	A1
Ansar bank	A2
Iran zamin bank	A3
Parsian bank	A4
Pasargad bank	A5
Tejarat bank	A6
Hekmat Iranian bank	A7
Dey bank	A8
Saman bank	A9
Sina bank	A10
Saderat Iran bank	A11
Qavamin bank	A12
Karafarin bank	A13
Mellat bank	A14

In order to prioritize each of the options and the ranking of each of the banks according to the implementation factors of efficient use of resources in the country's banking industry, the resource index

Table 10: Gray decision matrix in evaluating the efficient use of resources in the country's banking industry

	X1	X2	X3	X4	X5	X6	...	Y1
At.	-	-	+	+	+	+		-
W.	0.0959	0.1297	0.1123	0.1137	0.1608	0.1289		1.0000
A1	19.8649	0.1622	0.0230	0.0486	0.0900	0.0026		0.1117
A2	19.4086	0.0192	0.0113	0.0035	0.0900	0.0015		0.1404
A3	18.9356	0.0080	0.0218	0.0714	0.0900	0.0013		0.1658
A4	20.3002	0.0405	0.0119	0.0965	0.0900	0.0012		0.0937
A5	20.1029	0.0057	0.0270	0.0048	0.0900	0.0002		0.0377
A6	20.9125	0.0327	0.0112	0.0247	0.0900	0.0000		0.0196
A7	17.4318	0.0274	0.0314	0.0137	0.0900	0.0014		0.9377
A8	19.1613	0.0648	0.1759	0.1601	0.0900	0.0200		0.1840
A9	19.3712	0.1637	0.0157	0.0125	0.0900	0.0011		0.1570
A10	18.9678	0.0226	0.0052	0.2386	0.0900	0.0090		0.2475
A11	21.1023	0.0425	0.1074	0.0107	0.0900	0.0007		0.0250
A12	20.1728	0.0053	0.0550	0.0201	0.0900	0.0009		0.0649
A13	18.7862	0.1071	0.0121	0.0109	0.0900	0.0005		0.3668
A14	21.3268	0.0449	0.0092	0.1601	0.0900	0.0025		0.0174

in the country's banking industry is based on the gray theory method of evaluating each of the options with usage is given in Table 10. In response to the second question of the research, the weights of each index were collected, by multiplying each index by the obtained weights, and the weighted matrix is obtained, the results of which are presented in Table 11. In the next step, the gray matrix is normalized, so that for positive factors, each number in Table 10 is divided by the difference of the highest upper limit (Equation

7) and for negative factors, each number is divided by the difference of the lowest lower limit (Equation 6) presented in Table 11.

$$x_1^*(k) = \frac{x_i^{(o)}(k) - minx_i^{(o)}(k)}{maxx_i^{(o)}(k) - minx_i^{(o)}(k)} \tag{6}$$

$$x_1^*(k) = \frac{max\, x_i^{(o)}(k) - x_i^{(o)}(k)}{maxx_i^{(o)}(k) - minx_i^{(o)}(k)} \tag{7}$$

Table 11: The weighted gray decision matrix in evaluating the efficient use of resources in the country's banking industry

	X1	X2	X3	X4	X5	X6	...	Y1
A1	1.9044	0.0210	0.0026	0.0055	0.0145	0.0003		0.1117
A2	1.8607	0.0025	0.0013	0.0004	0.0145	0.0002		0.1404
A3	1.8153	0.0010	0.0025	0.0081	0.0145	0.0002		0.1658
A4	1.9461	0.0052	0.0013	0.0110	0.0145	0.0002		0.0937
A5	1.9272	0.0007	0.0030	0.0005	0.0145	0.0000		0.0377
A6	2.0048	0.0042	0.0013	0.0028	0.0145	0.0000		0.0196
A7	1.6712	0.0036	0.0035	0.0016	0.0145	0.0002		0.9377
A8	1.8370	0.0084	0.0197	0.0182	0.0145	0.0026		0.1840
A9	1.8571	0.0212	0.0018	0.0014	0.0145	0.0001		0.1570
A10	1.8184	0.0029	0.0006	0.0271	0.0145	0.0012		0.2475
A11	2.0230	0.0055	0.0121	0.0012	0.0145	0.0001		0.0250
A12	1.9339	0.0007	0.0062	0.0023	0.0145	0.0001		0.0649
A13	1.8010	0.0139	0.0014	0.0012	0.0145	0.0001		0.3668
A14	2.0446	0.0058	0.0010	0.0182	0.0145	0.0003		0.0174

In the next step, the above two formulas are used to form the gray normalized weighted matrix for normalization, and the normalized weighted matrix is given in Table 12.

After calculating the gray normalized weight matrix according to the maximum values for each criterion, we consider the value of the hypothetical ideal option.

$$x_1^*(k) = 1 - \frac{\left|x_i^{(o)}(k) - OB\right|}{\max\left(maxx_i^{(o)}(k) - OB, OB - minx_i^{(o)}(k)\right)} \tag{8}$$

$$\gamma[x_0^*(k), x_1^*(k)] = \frac{\Delta_{min} + \varepsilon\Delta_{max}}{\Delta_0(k) + \varepsilon\Delta_{max}} \qquad 0 < \gamma[x_0^*(k), x_1^*(k)] \le 1 \tag{9}$$

Which OB means the target value.

Hypothetical ideal option:

Max={[0.0000,1.0000] , [0.0000,1.0000] , [0.0000,1.0000] , [0.0000,1.0000] , [0.0000,0.0000] , [0.0000,1.0000] ,..., [0.0000,1,0000]}

Table 12: The normalized gray decision weight matrix in evaluating the efficient use of resources in the country's banking industry

	X1	X2	X3	X4	X5	X6	...	Y1
A1	0.6247	0.9900	0.8958	0.8084	0.0000	0.8702		0.1025
A2	0.5075	0.0877	0.9647	1.0000	0.0000	0.9235		0.1337
A3	0.3861	0.0173	0.9028	0.7114	0.0000	0.9365		0.1613
A4	0.7364	0.2221	0.9608	0.6043	0.0000	0.9383		0.0829
A5	0.6858	0.0024	0.8725	0.9946	0.0000	0.9885		0.0221
A6	0.8936	0.1730	0.9650	0.9099	0.0000	1.0000		0.0024
A7	0.0000	0.1395	0.8465	0.9568	0.0000	0.9307		1.0000
A8	0.4440	0.3758	0.0000	0.3337	0.0000	0.0000		0.1810
A9	0.4979	1.0000	0.9388	0.9620	0.0000	0.9449		0.1517
A10	0.3943	0.1095	1.0000	0.0000	0.0000	0.5494		0.2501
A11	0.9424	0.2350	0.4011	0.9694	0.0000	0.9626		0.0082
A12	0.7037	0.0000	0.7084	0.9293	0.0000	0.9555		0.0516
A13	0.3477	0.6426	0.9596	0.9685	0.0000	0.9740		0.3797
A14	1.0000	0.2502	0.9766	0.3337	0.0000	0.8744		0.0000

To determine the degree of gray possibility, one must first calculate the sum of the differences between the numbers of the normalized gray weight matrix and the hypothetical ideal option, which is called the deviation matrix according to equation (8), then by normalizing the obtained weights on the deviation matrix and using from equation (9) on the line for all options, their final weight is obtained. Any option whose ratio of the total distance from the indicators is less is considered a better option, the result of these calculations is given in Table 13.

Table 13: The final weight of options for evaluating the efficient use of resources in the country's banking industry

Index	**The option under consideration**	**Degree of gray possibility**	**Rank**
A1	Eghtesad Novin Bank	0.6030	4
A2	Ansar Bank	0.5204	11
A3	Iran Zamin Bank	0.5336	10
A4	Parsian Bank	0.5546	6
A5	Pasargad Bank	0.5123	12
A6	Tejarat Bank	0.6198	2
A7	Hekmat Iranian Bank	0.6067	3
A8	Dey Bank	0.3587	14
A9	Saman Bank	0.6398	1
A10	Sina Bank	0.4862	13
A11	Saderat Iran Bank	0.5695	5
A12	Qavamin Bank	0.5541	7
A13	Karafarin Bank	0.5533	8
A14	Mellat Bank	0.5520	9

According to the obtained results, the "Saman Bank" option with a relative weight: of 0.6398 first place, the "Trade Bank" option with a Relative weight: of 0.6198 Second place, option "Hekmat Iranian Bank" with a relative weight: of 0.6067 third place, option "Eqtesad Novin Bank" with a relative weight: of 0.6030 ranked fourth, "Saderat Iran Bank" option with a relative weight: of 0.5695 rank Fifth, "Parsian Bank" option with a relative weight: of 0.5546. Sixth place, "Qavamin Bank" option with a relative weight: of 0.5541 Seventh place, "Karafarin Bank" option with a relative weight: of 0.5533. Eighth place, "Mellat Bank" option with a relative weight: of 0.5520 ninth rank, "Iran Zamin Bank" option with a relative weight: of 0.5336 tenth rank, "Saman Bank" option with a relative weight: of 0.6398 eleventh rank, "Ansar Bank" option with a relative weight: of 0.5204 twelfth rank, "Sina Bank" option with a relative weight: of 0.4862, thirteenth rank, "Dey Bank" option with a relative weight: of 0.3587, ranks fourteenth.

5. Conclusion

The results of the research show that the factors affecting efficiency can generally be divided into two groups, internal and external; Internal variables are variables that are affected by managerial decisions. Good management decisions lead to high profitability, which naturally results in increased efficiency. All internal variables can be extracted from the bank's financial statements and balance sheet, and external variables are variables that are not under the management's control but affect the bank's decision-making process. Also, the results of this research indicate that the ranking of commercial banks based on the index of efficient use of resources (internal efficiency) and by using the method of applying for gray multi-criteria decision numbers and the close relation of open grays is a method due to simple calculations and no need to define the membership function. which is preferable to the fuzzy method and statistics and probability in conditions of uncertainty and the small number of samples:

Considering that this research has identified, analyzed, and evaluated only 9 categories of factors of efficient use of resources (internal efficiency), these banks can formulate policies to increase their allocation efficiency after examining various factors.

The findings of this research show that in terms of predicting factors of efficient use of resources (internal efficiency) in Iran's banking industry factor "excess market yield" with a relative weight: of 0.1925 in the first priority, factor "irrationality of Traders" with a relative weight: of 0.1802 in second priority, "financial leverage" factor with a relative weight: of 0.1464 in priority third, the "inflation rate" factor with a relative weight: of 0.1608 in the first priority, "Liquidity" factor with a relative weight: of 0.1297 in second priority, "interest rate risk" factor with a relative weight: of 0.1289 in third priority, "liquidity risk" factor with a relative weight: of 0.1137 in the fourth priority, "credit risk" factor with a relative weight: of 0.1123 in the fifth priority, "Economic growth" factor with a relative weight: of 0.0972 in the sixth priority, "market interest rate" factor with a relative weight: of 0.0966 in the seventh priority, "bank size" factor with a relative weight: of 0.0959 in the eighth priority "Exchange rate" factor with a relative weight: of 1.0650 is in the ninth priority. Also, according to the results obtained by "Saman Bank" with a relative weight: of 0.639 first rank, "Tejarat Bank" option with a relative weight: of 0.619 second rank, "Hekmat Iranian Bank" option with a relative weight: of 0.606, third place, option "Eqtesad novin Bank" With a relative weight: of 0.603, fourth place, option " saderat Iran bank" with a relative weight: of 0.569 ranked fifth, " Parsian Bank" option with a relative weight: of 0.554 ranked sixth, "Qavamin Bank" option with a relative weight: of 0.554, seventh rank, "karafarin Bank" option with a relative weight: of 0.553 rank eighth, "Mellat Bank" option with a relative weight: of 0.552 rank ninth, "Iran Zamin Bank" option with a relative weight: of

0.533 rank tenth, "Ansar Bank" option with a relative weight of 0.520 ranked eleventh, "Pasargad Bank" option with a relative weight: 0.512 ranked twelfth, "Sina Bank" option with relative weight: of 0.486 thirteenth rank,"Dey Bank" option with a relative weight: 0.356 ranked fourteenth.

The practical results of this research can be of interest to two general groups, the first group is the users of financial information. This group, which includes investors, lenders, and commercial bank managers, this group is actually those who directly deal with the financial effects and results of the efficiency of commercial banks are related. The second group is researchers, policymakers, and compilers of accounting standards or institutions such as the stock exchange that are interested in economic and financial issues. Most of the results of this research are in accordance with the theoretical foundations and while filling the gaps in the research done in this field, it can help managers in proper management and shareholders in investing and determining the policies and procedures of banks help. The practical results of this research can be of interest to two general groups, the first group is the users of financial information, this group includes investors, creditors, and managers of commercial banks, and this group is actually those who directly deal with the financial results and results. They are related to the efficiency of commercial banks. Most of the results of this research are in accordance with the theoretical foundations and while filling the gap of research in this field, it can help managers in proper management and shareholders in investing and determining the policies and procedures of banks.

According to the objectives of the subject under study, the following are suggested for future research:

- Repetition of the current research using gray stochastic multi-criteria decision-making method based on the theory

Repentance and Topsis. Ranking and identifying factors affecting the operational efficiency of banks using decision-making models - AHP)

TOPSIS - MCDM - MADM - MODM

- Evaluating the effectiveness of commercial banks with VIKO's multi-criteria decision-making approach

-Measurement of relative efficiency and ranking of Tejarat Bank branches with the window method.

- Ranking the speed of cost efficiency in the banking industry with the Shannon entropy ranking method.

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