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Ranking the Efficiency and Soundness of Business Banks Using a Combined Method of Data Envelopment Analysis and Fuzzy VIKOR

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ABSTRACT

The present study provides a systematic method for assessing the efficiency and soundness of banks. The analysis is based on a set of benchmarks related to the financial performance of banks. In this regard, this research has explored a model for evaluating accepted banks in Tehran Stock Exchange using the data envelopment analysis method. One of the most important applications of this technique is measuring the efficiency of bank branches. In addition, paying special attention to the health of the banking system corresponds to the health of the society's economics. It is essential to implement precise analysis benchmarks to evaluate banks and other financial institutions due to their importance in the economics. One of these benchmarks is efficiency. In this study, 18 Iranian business banks have been analysed using data envelopment analysis on the basis of financial ratios. Also, their efficiency has been computed using the output-based CCR envelopment model, assuming a constant efficiency-scale ratio. The results suggest that Gardeshgari bank has been selected as the most efficient and healthy bank between 2011 and 2015 on the basis of financial and non-financial criteria, and using the trapezoidal fuzzy number method.

1 Introduction

As financial institutions around the world become more internationalized and globalized, the trading activities of the financial industry continue to rise [12]. The banking industry is one of the most sophisticated industries in the world. Since banks have a huge part of fund flow in a society, they play an important role in resource allocation and economic growth of that country. Due to internationalization, liberalization of the global financial system and competition, many bank officials and researchers have investigated methods of improving banks' health, safety, and efficiency. On the other hand, banks are now vulnerable to the increased pressure of competitions due to improvements in technology, internationalization of financial services and omission of governmental supervision on banking systems. The important role of banks in the economic system and the number of resources accessible

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to them have made it crucial to view their financial soundness and efficiency as an advantage in this competitive environment. It is worth noting that as healthy and efficient banks contribute to financial growth, unhealthy or inefficient banks can cause financial crisis. Bank officials have to consider current and future economic situations and implement new methods to increase the health and security of their bank and compete with others. That's because one of the main strategies in setting an improvement plan is to monitor the financial soundness of the banks. Due to the service-based nature and variety of their activities, it is essential to implement better and more accurate methods. Nowadays, various indices have been presented as indicators of financial soundness and efficiency of organizations that efficiency, effectiveness and productivity are some of the most important ones. Different techniques, Schweserand Temte [21] such as financial ratio and regression analysis Murphyand Orgler [18] are used to assess the performance of banks. The customary techniques have inherent limitations that make them unsuitable for depicting the sophisticated and growing nature of the banks. For instance, customary financial ratio analysis does not allow an objectively independent-combinational analysis in a performance score and it is also hard to use it for comparison purposes. A bank can be good in one aspect and bad in another, this can complicate the judgment on its financial soundness and efficiency. Combining these factors can also lead to baffling or wrong Indices. Another way of evaluating the efficiency or health of banks is using the regression method, which is a parametric method; therefore, it needs a specified generic model for production. Also, regression analysis is a central tendency method and is only suitable for multi-output single-input or multi-input single-output systems.

Data envelopment analysis is a parametric method that is based on mathematical programming and is used to measure the efficiency of a set of similar decision-making units that have multiple inputs and outputs [13]. A more efficient banking system would improve the economics dramatically, considering the current economic status. Accordingly, the aim of this research is to evaluate the efficiency of Iranian commercials banks and rank them. Since the existing methods of assessing and measuring the performance of bank units are often empirical and without scientific support, as well as due to the non-standardization of these methods, their results cannot be used in other banks. In this study, a scientific approach called data envelopment analysis and fuzzy VIKOR and trapezoidal number have been utilized to evaluate the efficiency of 18 banks. In this study, an output-based CCR method has been used to evaluate the efficiency of banks. After solving the model using the data envelopment analysis, ranking efficient banks is done through fuzzy VIKOR method. The Data Envelopment Analysis was first proposed and introduced as the CCR Model. Data Envelopment Analysis is a powerful tool for evaluating the performance of organizations in their relative performance conditions considering that banks are almost similar in terms of structure, each bank has the same executive functions, and during certain operations, they provide a specific output using certain inputs [11, 25]. Therefore, they must be characterized by suitable criteria for determining their efficiency. Thus, by measuring the relative efficiency of each unit, identifying inefficient units, and comparing the efficiency of these banks in several different periods, it can be seen that there is a positive or negative growth in productivity. Accordingly, appropriate strategies to improve the performance of these banks can be provided.

2 Literature Review

Efficiency is an economic concept that would demonstrate the performance of a wide variety of economic activities in business, corporation or even national and regional economies. Efficiency is defined in various ways based on increased outputs or decreased inputs. Generally, efficiency is the outputs and inputs ratio based on a specified standard [22]. In theory, it is separately defined based on technical, allocation, and economic efficiency. Technical efficiency is the capability of an organization to produce the maximum outputs with a specific amount of inputs or using the minimum amount of input material to produce a specific amount of output. This can be stated as the ratio of the real amount of outputs to an optimum amount of outputs (maximum) with a limited number of inputs, or the ratio of the real minimum amount of inputs to the optimum amount (minimum) for a specified number of outputs [8]. Allocation efficiency (price efficiency) is another aspect of efficiency, which shows the capability of an organization to use the optimal combination of inputs with respect to their relative prices. Economic efficiency is the product of multiplying allocation efficiency by technical efficiency. In economic efficiency, both the relative price and a minimum number of inputs for a specific amount of outputs are considered.

There are several studies published mainly with the application of Data Envelopment Analysis. Tlig and Ben Hamed [26] investigated the efficiency of commercial Tunisian banks in terms of several crisp and imprecise data. Two approaches of fuzzy data envelopment analysis (FDEA), the possibility approach and the approach based on relations between fuzzy numbers (BRONF) were used to obtain the efficiency score of each bank. The results showed that in a competitive environment, no-financial inputs and outputs should be taken into account in order to obtain credible and realistic efficiency scores. Islami Bigdeli [10] evaluated the efficiency of 142 branches of Tejarat bank in a study titled "comparison and evaluation of the efficiency of banks' branches and presenting an appropriate model through a combination of three methods: data envelopment analysis, stochastic frontier analysis, and financial ratios". The inputs included the number of staff, educational level and the number of deposits. The outputs consisted of balance of deposits and concession rates.

The results indicated that among these three methods, data envelopment analysis is the best in evaluating the efficiency. Soteriou and Stavrinides [23], the DEA models were used for evaluating 575 branches of banks. Inputs used in this study included total number of employees, cost of building and furniture, cost of materials and supplies, twelve environmental variables indicating the type of insurance, commercially and financially, number of active branches to total area of deposits and loans. Outputs used in this study included the number of demand deposit account, number of long-term deposit accounts, number of housing loans, number of loans for installation and launch, and number of commercial loans. Kamvysi et al. [14], a system continuously applied on one of the great insurance companies in USA during 6 courses of 3 months was considered. The inputs of this study included labour force related to the counter operation, labour force related to non-counter operation, space of branch, per capita cost per any customer, and the rate of employment. Output of this study included (1) loans, (2) deposits, (3) number of accounts per customer, and (4) customers' satisfaction Soteriou and Stavrinides [23] applied the DEA methodology in the analysis of the service quality of bank branches from the internal client point of view, and concluded that this is an excellent tool for efficiency analysis. In his study on the performance of 27 bank branches from a European Bank, they used the number of working hours, attendance terminals, space and number of accounts as inputs. Also, they used the index of the perceived quality of the employees as outputs. They concluded that branches that had used this system have a better relationship between the inputs and the perceived quality. Esfandiar et al. [6] evaluated Iranian commercial banks using data analytics. Model inputs included general and administrative costs. The results showed that among the commercial banks, Pasargard Bank was the most efficient bank.

3 Methodology and Variables

3.1 Efficiency Evaluation Models

In recent years, several studies have been published about the use of different methodologies to specifically assess bank branches. In this study, we will use one of the best-known nonparametric techniques, the DEA – Data Envelopment Analysis. DEA is based on linear programming and is used to evaluate the relative efficiency of decision-making units (DMUs) that conduct similar tasks [4]. DEA actually uses the ratio of input and output weights to evaluate the relative efficiency of each DMU [4]. Data envelopment analysis model dedicates an efficiency grade to each decision making unit that can be used to compare the efficiency of each unit in converting inputs to outputs. However, all units that are efficient on the borderline have the same grade of one. Selecting the input-output matrix is a motivation to determine the degree of freedom required to determine data envelopment analysis, which is as follows:
Number of encounter or decision making units, number of inputs, number of outputs
Here, BCC and CCR are used to evaluate efficiency using data envelopment analysis method. While the CCR model is used to evaluate the technical efficiency (TE), pure technical efficiency (PTE) is calculated using the BCC model. Also, relative self-efficacy (SE) is calculated by CCR percentage to BCC efficiency grade [5].
Considering that efficiency of a financial institution in a specific year (each year as a separate DMU) is defined by the following formula:
Model 1:

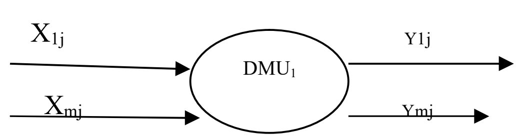
Productivity = virtual output/virtual Input (1)

Based on the CCR model, virtual input and output can be defined in such a way that virtual input of $\sum_{i=1}^{m} v_i x_i$ and virtual output of $\sum_{j=1}^{n} u_j y_j$ determine the relative weights in order to maximize them.

Model 2:

$$\theta^* = \frac{\sum_{j=1}^{n} u_j y_j}{\sum_{i=1}^{m} v_i x_i} \quad \text{Efficiency Size} \tag{2}$$

Where, ui, uj, xi, and yi are the input and output weights and values of input and output variables, respectively.
CCR Model:
Assume that DMUj (j=1,…,n) is n homogenous decision making units producing input vector Xj (j=1,…,n); $R^{m\geq 0} \in X_j$ (j= 1,… ,n) and $R^{s\geq 0} \in y_i$ (j=1,…,n), i.e. X_j vector has m components and yj vector has s components that exponent of DMUj is such.



Assume that the objective is evaluating the performance DMUo where o ϵ {1, 2, …, n}, for this reason, we say that if there isn't found the possibility of production like (X,Y) in Tc dominating on (Xo, Yo), in this case, DMUo will have a relative efficiency, otherwise, how one could say that it isn't possible to produce in Tc dominating on DMUo? This could be done by three methods: 1) If one can find a production possibility in Tc that with input less than Xo, its output is higher than or equal to Yo; 2) If one can find a production possibility in Tc that with input lower or equal to Xo, it has an output more than Yo; 3) If one can find a production possibility in Tc that with input less than Xo, it has an output higher than Yo. Now, when we consider first state, i.e. we will reduce the input, Xo, we indeed intend to find minimum e>0 by which it is possible to produce ($\theta X0$, $Y0$) on the boundary of Tc. In this case, if 0<θ, then ($\theta X0$, $Y0$) dominates on (Xo,Yo). Then we must find minimum θ that could be indicated in above properties, i.e. solving following Model 3.

$$\begin{aligned} & Min\ \theta \\ & \boldsymbol{s.t} \\ & (\theta X_0, Y_0) \in T_0 \end{aligned} \tag{3}$$

However, the condition for membership in Tc is that

$$\theta X_0 \geq \sum_{j=1}^{n} \lambda_j X_j$$

$$Y_0 \leq \sum_{j=1}^{n} \lambda_j y_j$$

$$\lambda_j \geq 0 \qquad j = 1, \dots, n$$

Then, solving the problem requires solving the linear planning as below:

$$Min\ \theta$$

$$s.t$$

$$\sum_{j=1}^{n} \lambda_j X_j \leq \theta X_0$$

$$\sum_{j=1}^{n} \lambda_j X_j \geq Y_0$$

$$\lambda_j \geq 0 \qquad j = 1, \dots, n$$

Or

$$Min\ \theta$$

$$s.t$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io}, \quad i = 1, .., m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro}, \ r = 1, \dots, s$$

$$\lambda j \geq 0 \quad j = 1, \dots, n$$

The above equation is the CCR model in the input nature called as CCR Envelope case.

3.2 Trapezoidal Fuzzy Strategy

In the trapezoidal method, calculation of the trapezoidal fuzzy weights is based on the geometric mean method of Wu et al. that is as follows:
Suppose: A is a fuzzy decision making matrix p*p whose arrays are aij. The same matrix is a paired comparison matrix, in which P is the number of options that need to be compared to each other. Also, a_{ij} = (1, m, o, and s), where 1, m, o, and s are the parameters of a membership function of the trapezoidal fuzzy number. In this membership function, the condition a_{ij} = (1, 1, 1, and 1) applies to all I parameters. Also, αi, βi, γi, and δi are the geometric means of s, o, m, and l, respectively. In addition, α, β, γ and δ are equal to the sum of α_i, β_i, γ_i, and δ_i.

Algorithm:
a) First Stage:
First Step: Calculation of Geometric Mean Values of α_i, β_i, γ_i, and δ_i Using Equation 1 to 4.

$$
\begin{aligned}
&[1] \quad \alpha_i = [_{j=1}^{p} \pi l_{ij}]_{ij}^{1/p} && i = 1, 2, ..., p \\
&[2] \quad \beta_i = [_{j=1}^{p} \pi m_{ij}]_{ij}^{1/p} && i = 1, 2, ..., p \\
&[3] \quad \gamma_i = [_{j=1}^{p} \pi o_{ij}]_{ij}^{1/p} && i = 1, 2, ..., p \\
&[4] \quad \delta_i = [_{j=1}^{p} \pi s_{ij}]_{ij}^{1/p} && i = 1, 2, ..., p
\end{aligned} \tag{4}
$$

Second Step: Finding α_i, β_i, γ_i, and δ_i Using Equation 5.

$$
\begin{aligned}
&\alpha = \sum_{i=1}^{p} \alpha i && i = 1, 2, ..., p \\
&\beta = \sum_{i=1}^{p} \beta i && i = 1, 2, ..., p \\
&\gamma = \sum_{i=1}^{p} \gamma i && i = 1, 2, ..., p \\
&\delta = \sum_{i=1}^{p} \delta i && i = 1, 2, ..., p
\end{aligned} \tag{5}
$$

Third Step: Calculating Wi (Trapezoidal Fuzzy Weights) Using Equation 6.

$$w_i = (\alpha_i / \delta, \beta_i / \gamma, \gamma_i / \beta, \delta_i / \alpha) \quad i = 1, 2, ..., p \tag{6}$$

b) Second Stage: Production of Inverse Fuzzy Matrix. In this stage, considering the obtained fuzzy numbers from the previous stage, paired fuzzy matrix between different parameters in created through equation 7

$$A_{ij} = [\alpha_{ij}], \alpha_{ij} \times \alpha_{ji \approx 1}, \forall i,j = 1,2,3,4..... \tag{7}$$

c) Third Stage: Calculation of the Relative Fuzzy Weight of Parameters.
The Relative Fuzzy Weight of Parameters is Calculated Using Equation 8.

$$\tilde{z} = [\tilde{a}_{ij} \otimes \otimes \tilde{a}jj] \frac{1}{n} \tag{8}$$

d) Fourth Stage: Defuzzification of the Weight of Parameters.
In this stage, to defuzzify the parameters, the geometric mean value of the fuzzy weight of different parameters are calculated using the equation (9). Accordingly, the weight of parameters is stated as an absolute number.

$$Wi = (\prod_{k=1}^{3n} Wij) \quad (9)$$

3.3 VIKOR Method

In the present study, different stages of the VIKOR method from the study have been implemented. Different stages of this method are as follows:

First Step: The Creation of Decision Making Matrix and Calculation of Normalized Values.

We assume m options and n criteria. Different options of i are indicated as Xi. For Xj option, j[th] criterion is introduced as Xij. Xij is the value of j[th] criterion. Equation (10) can be used to normalize the values of Xij, where Xij is the absolute value of i[th] option of j[th] criterion.

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}}, i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n \quad (10)$$

Second Step: Identification of the best and the worst Values The best and the worst values in each criterion are identified and named f"j and f- j, respectively (Eq. (11)).

$$f_j^* = Maxf_{ij}, \qquad i = 1,2,\ldots,m \quad (11)$$
$$f_j^- = Minf_{ij}, \qquad j = 1,2,\ldots,n$$

Third Step: Identification of the Weight of Criteria

The weight of each criterion should be identified to determine the importance of each equation. The present study will use FDAHP method

Fourth Step: Calculation of the Distance of Options from the Ideal Solution

In this stage, Eq. (12), is used to calculate the distance of each option from the ideal solution. Then, they are added to get the final value.

$$S_i = \sum_{j=1}^{n} w_i (f_j^* - f_{ij}) / (f^* - f_j^-) \quad (12)$$
$$R_i = \underset{j}{Max} \, [w_i (f_j^* - f_{ij}) / (f^* - f_j^-)]$$

Here, Si is the distance ratio of i[th] option from the positive ideal solution (the best combination) and Ri is the distance ratio of i[th] option from the negative ideal option (the worst combination). The best and the worst values are achieved through Si and Ri, respectively.

Fifth Step: Calculate the VIKOR Value of Qij

For each i, this value can be calculated using equation 13:

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1 - v)\left[\frac{R_i - R^*}{R^- - R^*}\right] \quad (13)$$

Here $S^- = \underset{i}{Max}\, S_i$ majorityand v is the weight of the $R* = \underset{i}{Min}\, R_i$ و $R^- = \underset{i}{Max}\, R_i$ ، $S^* = \underset{i}{Min}\, S_i$ ، strategy compatible with the criterion or maximum group utility.

$\left[\frac{S_i - S^*}{S^- - S^*}\right]$ indicates the distance ratio of i[th] option from the negative ideal option, which corresponds to maximum compatibility with i^{th} ratio.

$\left[\frac{R_i - R^*}{R^- - R^*}\right]$ is the distance ratio of i^{th} option from the ideal option, which corresponds to incompatibility with the i^{th} ratio?

Sixth Step: Ranking Options According to the Values of Qi, Si, Ri

In this stage, options are ranked based on the calculated values of Qi, Si, Ri.

Seventh Step: Suggestion of a Compromise Solution

A compromise solution for the A (1) option (which has the best ranking based on the value of Qi (minimum value)) is proposed according to the following two conditions:

1- Acceptable Advantage $Q(A^{(2)})$ _ $Q(A^{(1)}) \geq DQ_i$:

2- Acceptable stability in decision making: A (1) should have the best value according to Si and Ri

4 Model Assessment

To assess the model in data envelopment method, the weight of each input and output should be first calculated using the raw data. The current study applied the variables as inputs and outputs according to Table 1.

Table 1: Input and Output Variables.

Row	Title	Researches	Number/Index
1	Sum of the Rights of the Stockholders	[2], [19], [15]	Input
2	Fixed assets	[7], [19]	Input
3	Sum of Deposits	[2],[24] [15],[1]	Input
4	Total Income	[1], [3],[15]	Output
5	ROA Index	[7], [16],[17] ,[20]	Output
6	ROE Index	[7], [16],[17], [20]	Output

Table 2: Units and their Abbreviations

Abbreviation	Full Name
DMU 1	Eghtesede Novin Bank
DMU 2	Ansar Bank
DMU 3	Parisan Bank
DMU 4	Passargad Bank
DMU 5	Tejarat Bank
DMU 6	Dey Bank
DMU 7	Sarmaye Bank
DMU 8	Sina Bank
DMU 9	Saderat Bank
DMU 10	Kar Afarin Bank
DMU 11	Gardeshgari Bank
DMU 12	Mellat Bank
DMU 13	Post Bank Iran
DMU 14	Hekmat Iranian Bank
DMU 15	Saman Bank
DMU 16	Shahr Bank
DMU 17	Resalat Bank
DMU 18	Ghavamin Bank

Table 3 reports the dataset.

4.1 Efficiency Results

Table 4 summarized the estimated efficiency based on the conducted data envelopment method (the efficiency in the fixed condition is determined with respect to the scale) and this value is always between 0 and 1.

Table 3: Banks' Input and Output Volumes

	ROE	ROA	Total Revenue	Total Deposit	Fix Assets	Total Equity
Eghtesede Novin Bank	0.19415	0.0108	11263150	292355217	3991533	18936788
Ansar Bank	0.25556	0.01562	9165194	168342276	5836673	12736485
Parisan Bank	0.03476	0.00177	9578685	413600294	5227206	28052773
Passargad Bank	0.18722	0.02846	20893240	348674163	8271988	67528074
Tejarat Bank	0.08043	0.0052	30475722	707271470	42555444	61174142
Dey Bank	0.30139	0.02049	6296754	85934525	5044318	7957737
Sarmaye Bank	0.01059	0.00041	11741945	71032762	670056	5377489
Sina Bank	0.17093	0.01578	5848483	125257694	2220617	13757214
Saderat Bank	0.07906	0.0067	56303246	814077595	59456525	93105332
Kar Afarin Bank	0.24869	0.03303	6457250	82592544	5634990	14885922
Gardeshgari Bank	0.03677	0.00203	1918930	67524280	5286922	4110100
Mellat Bank	0.25011	0.01267	70542368	933511976	41980727	73180609
Post Bank Iran	-0.6292	-0.0285	2523101	36249829	3598016	2054336
Hekmat Iranian Bank	0.08556	0.01964	1259374	1.4256362	1823917	4660766
Saman Bank	0.09363	0.00443	7740046	179595237	3358505	1135257
Shahr Bank	0.16371	0.00833	6629956	167801446	12680638	121567
Resalat Bank	1.15436	0.00083	2004305	46811798	2407037	33998
Ghavamin Bank	0.14744	0.00204	1526534	423357000	5313507	6276671

Table 4: Unit Efficiency

	Efficiency level	Type of Efficiency
DMU 1	0.603	Inefficient
DMU 2	0.502	Inefficient
DMU 3	1	Strong Efficiency
DMU 4	1	Strong Efficiency
DMU 5	0.816	Inefficient
DMU 6	0.464	Inefficient
DMU 7	0.157	Inefficient
DMU 8	0.747	Inefficient
DMU 9	0.66	Inefficient
DMU 10	0.738	Inefficient
DMU 11	1	Strong Efficiency
DMU 12	0.406	Inefficient
DMU 13	1	Strong Efficiency
DMU 14	1	Strong Efficiency
DMU 15	0.549	Inefficient
DMU 16	0.741	Inefficient
DMU 17	0.601	Inefficient
DMU 18	0.637	Inefficient

After categorizing the studied units into efficient and inefficient groups using data envelopment method, the inefficient units, which scored less than 1, were ranked on the basis of their efficiency score. The units that have an efficiency score of 1 cannot be ranked using classic data envelopment analysis method and that is why fuzzy VIKOR method with trapezoidal numbers are used to rank efficient nits. Table 3 lists the effectiveness of the proposed model of 18 financial institutions (banks) as study evaluation units. Indicators studied Input and output values of the listed banks are evaluated as units according to the indices presented in the table. Some of the indicators are cost-effective as inputs and some are profit-oriented as outputs. As can be seen in Table 4, the output-driven CCR model measures the performance of the banks under study, as well as the financial soundness of the banks, including Parsian, Pasargard, Gardeshgari, Post Bank and The Hekmat of Iranians is that the banks are efficient and the rest of the units studied are inefficient.

4.2 VIKOR Steps to Rank the Banks

Assume that 3 bank experts (DM1 to DM3) try to choose the best bank among 5 options (A1 to A5) based on 8 criteria (C1 to C8) using the following steps of VIKOR method.
First step: five options are chosen for evaluation.
According to the first step, we choose 5 banks that had the most efficiency during 2011 to 2015. In this case the following banks were chosen. 1- Dey, 2- Sarmaye, 3- Gardeshgari, 4- Post bank and 5- Hekmat Iranian.
Second step: eight criteria are chosen to evaluate the five options.
According to the second step the chosen criteria are as follows. 1- Share of resource attraction, 2- profitability, 3- return on assets, 4- capital adequacy ratio, 5- bad debts ratio, 6- quality of service, 7- electronic banking, 8- pricing. The reason behind choosing these variable is their compatibility with the goals and objectives of this research and their impact on evaluating the efficiency. Studied Indices have been chosen after consulting with the professors, experts and specialists who work in the field of banking and reviewing the literature.
Third step: we use the verbal variables in Table 1 to assess the most important criteria.
Table 5 shows the weight of each criterion based on the opinion of each decision maker. Then, banks are ranked using the given weights in Table 6.

Table 5: Weights of each Criterion based on each Decision Maker

	Criterion	D1	D2	D3
Share of resource attraction	C1	VH	AH	AH
profitability	C2	VH	H	M
return on assets	C3	AH	AH	AH
capital adequacy ratio	C4	VH	FH	VH
bad debts ratio	C5	H	AH	H
quality of service	C6	AH	M	VH
electronic banking	C7	VH	VH	AH
pricing	C8	VH	AH	VH

Then, the verbal evaluations of Tables 5 and 6 are converted to trapezoidal fuzzy numbers. After that, the weight of the criteria and the fuzzy ranking of options are added together to create decision making matrix in order to determine the weight of each criterion.

Table 6: Ranking of the Five Options by Three Decision Makers with Different Priorities in the Criteria

Decision maker	Options	Criteria							
		C1	C2	C3	C4	C5	C6	C7	C8
D1	A1	AH	H	AH	VH	H	FH	M	M
	A2	AH	VH	M	AH	M	M	M	H
	A3	VH	H	H	AH	H	M	H	FL
	A4	AH	FH	M	H	FH	FL	AH	VH
	A5	VH	H	AH	AH	FH	FL	VH	H
D2	A1	VH	H	FH	VH	VH	H	M	FH
	A2	VH	H	M	AH	H	FH	AH	M
	A3	AH	VH	H	H	FH	M	AH	M
	A4	AH	H	H	VH	H	M	H	VH
	A5	AH	AH	AH	VH	VH	AH	VH	H
D3	A1	VH	FH	H	H	M	H	FH	FH
	A2	AH	H	FH	VH	H	FH	M	H
	A3	AH	H	H	AH	H	M	H	M
	A4	VH	FH	H	VH	FH	M	AH	H
	A5	H	H	M	AH	M	H	AH	H

Fourth step: the verbal evaluations of Table 7 and 8 are then converted to trapezoidal fuzzy numbers. Then the weight of criteria and the fuzzy ranking of options are added together and create decision making matrix and the weight of each criterion is determined. The results are shown in the table below.

Table 7: Accumulated Fuzzy Weights of Criteria and Ranking of Options

	C1	C2	C3	C4	C5	C6	C7	C8
Weight	2.98	2.31	3	2.67	2.69	2.74	2.95	2.95
A1	2.95	2.41	2.53	2.77	2.31	2.41	1.70	1.92
A2	2.98	2.67	1.70	1.70	2.18	1.92	1.98	2.18
A3	2.98	2.67	2.67	2.85	2.41	1.74	2.69	1.27
A4	2.98	2.28	2.18	2.80	2.28	1.27	2.82	2.80
A5	2.82	2.70	2.49	2.98	2.69	2.70	2.95	2.54

Table 8: Absolute Value of Decision Making Matrix and the Weight of each Criterion.

Criteria	Weight	A1	A2	A3	A4	A5
C1	(3,3,2.98,2.86)	(3,3,2.96,2.86)	(3,3,2.98,2.93)	(3,3,2.98,2.93)	(3,3,2.98,2.93)	(2.97,2.92,2.76,2.65)
C2	(2.6,2.5,2.17,1.97)	(2.8,2.64,2.19,2.02)	(2.94,2.84,2.54,2.37)	(2.94,2.84,2.54,2.37)	(2.69,2.52,2.04,1.88)	(2.94, 2.84,2.41,2.44)
C3	(3,3,3,3)	(2.83,2.58,2.41,2.3)	(2.16,1.96,1.45,1.22)	(2.91,2.76,2.34,2.16)	(2.56,2.42,1.97,1.76)	(2.65,2.58,2.41,2.32)
C4	(2.86,2.8,2.59,2.44)	(2.97,2.78,2.74,2.58)	(3,3,2.98,2.93)	(2.97,2.92,2.78,2.72)	(2.97,2.92,2.74,2.5)	(2.97,2.92,2.74,2.58)
C_5	(2.94,2.84,2.56,2.44)	(2.62,2.5,2.17,1.97)	(2.59,2.45,1.97,1.76)	(2.8,2.64,2.19,2.02)	(2.96,2.52,2.04,1.88)	(2.94,2.84,2.56,2.44)
C_6	(2.65,2.58,2.39,2-25)	(2.8,2.64,2.19,2.02)	(2.37,2.18,1.67,1.48)	(1.95,1.23,1.74,0.96)	(1.72,1.52,1.04,0,8)	(2.94,2.84,2.56,2.44)
C_7	(3,3,2.96,2.86)	(2.16,1.96,1.45,1.22)	(2.3,2.16,1.82,1.64)	(2.94,2.84,2.56,2.44)	(2.97,2.92,2.76,2.56)	(3,3,2.96,2.86)
C_8	(3,3,2.96,2.86)	(2.37,2.18,1.67,1.48)	(2.56,2.42,1.97,1.76)	(1,72,1.52,1.04,0.81)	(2.97,2.92,2.74,2.58)	(2.91,2.76,2.34,2.16)

Sixth Step: Determination of the Best and Worst Value for All Criteria According to the Table Below.
Seventh Step: Find Si (the Distance Ratio of I the Option from the Positive Ideal Solution (Best Combination)) Value, for Every Option in Table 8.
S8=11.40 S2=13.73 S9=11.49 S1=8.64 S1=7.19

Table 9: Determination of the Best and Worst Value for All Criteria

f^*_8= 2.95	f^*_7= 2.95	f^*_6=2.70	f^*_5= 2.69	f^*_4=2.98	f^*_3=3	f^*_2=2.28	F^*_1=2.98
f^-_8= 1.27	f^-_7= 1.70	f^-_6= 1.27	f^-_5=2.18	f^-_4=2.67	f^-_3=1.70	f^-_2=2.70	f^-_1=2.82

Eighth Step: Find Ri (the Distance Ratio of I the Option from the Negative Ideal Option (Worst Combination)) Value, for Every Option in Table 8.
R8=2.95 R2=2.69 R9=2.95 R1=2.47 R1=2.98
Ninth Step: Find Qi (VIKOR) Value for Every Option in Table 8.
Q8=0.79 Q2= 0.21 Q9= 0.8 Q1=0.11 Q1=0.5
Tenth Step: Ranking of All Options Using the Values of Si, Ri, Qi, Based on Minimum Value.
S5< S4< S1< S3< S2 R4< R2< R1= R3< R5 Q4< Q2< Q5< Q1< Q3
Finally, Third Option (Gardeshgari Bank) Was Chosen as the Best Option.

5 Conclusion

Efficiency in financial institutions is one of the major challenges of managers. Considering the vastness of the banking industry, optimal allocation of financial resources is the responsibility of the banking system. Lack of efficiency leads to higher money costs in the bank, resulting in lower profitability as well as reduced level of financial health of banks, crisis and bankruptcy in these financial institutions. Due to the basic function of the data envelopment model and the weakness of the classical models, this research was conducted to identify the efficiency and financial health of banks. Performance of 18 Iranian Banks over the period 2011-2016 was evaluated with the use of the data envelopment analysis techniques using the CCR model. The results of this step showed that the banks were classified into efficient and inefficient groups. Only 28% of the banks were efficient, including banks such as Dey, Sarmayeh, Gardeshgari, Post Bank, and Hekmat Iranian. Resource allocation, as well as profitability, health, and performance of banks may be compromised due to the efficiency weaknesses of banks.
It can be said that given the ROA, ROE and total income as inputs and total equity, total deposits, and fixed assets as outputs, low efficiency of banks may be related to banks' capital inadequacy and bank costs. Therefore, banks should be able to design plans to absorb deposits and strengthen their regulatory tools through a corporate governance system, which would allow for better allocation of resources and better profitability of affiliates that will improve efficiency. On the other hand, bank managers are recommended to close their inefficient units to efficiency by modeling efficient units and adjusting their input and output variables. Management accounting techniques can also be used to increase the level of efficiency and determine financial health. The findings are consistent with the findings of Shabahang et al. [21], Esfandiar et al. [6], Eslami Bigdeli et al. [10] and Stravondis et al. [22]. Fuzzy VIKOR was used in the second stage of the research, showing how banks are ranked in terms of their performance. Indicators such as resource absorption share, profitability, return on as-

sets, capital adequacy ratio, bad debt ratio, quality of service, e-banking and pricing were used to normalize the numbers and then weight them. After that, 5 steps of VIKOR were performed. In the first step, the best and worst values of the normalized numbers were determined. In the second step, the values of R and S were determined, and in the third step, the value of Q was determined. In the fourth step, the values of S, R and Q were put in the table and ranked the numbers from low to high, and the best rating in this section indicates which bank ranks last. In the last step, two lower values in Q, the first and second ranks, were deduced. It was found that Gardeshgari Bank is an acceptable advantage and a superior option among the mentioned banks. The findings are in line with the findings of Esfandiar et al. [6] and Eslami Bigdeli et al. [10]. Researchers are suggested to use other indicators and financial ratios to determine banks' ratings and health. It is also recommended to rank companies active in the stock exchange using this rating method and determine the top option in terms of financial health. Also, banks can be ranked using integers and other methods.

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