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Research Article

An Interval PROMETHEE II Approach for Multi-Criteria Ranking Problem of the Bank Branches in Iran

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Abstract

An important and core issue for the managers of banking sector is to evaluate and rank the branches of a bank. In this study, a typical multi-criteria ranking problem for the Tose'e Ta'avon bank branches in Khuzestan province of Iran as a case study is defined and solved. For this aim, first a set of important criteria for evaluating banking sector are selected from the literature and experts of the field. Then, for coping with the uncertain nature of the real-life problems, the data of the bank branches in the selected criteria for the past years are obtained and represented as interval values. A decision framework consisting of two phases are proposed to rank the given bank branches. In the first phase the criteria are weighted by the methods such experts' opinions, interval Shannon's entropy, and linear combination of these two methods. In the second phase, the classical PROMETHEE approach is extended to its interval form and applied to rank the bank branches. By implementing the proposed solution methodology on the case study, several rankings are obtained and their similarities are compared to each other. The decision maker can consider any of the rankings for further managerial decisions.

Keywords : Multi-criteria decision making; Banking sector; PROMETHEE approach; Interval value; Uncertainty.

1 Introduction

Banking sector is of very important and crucial sectors of the economy of a country. This sector plays many important financial and social roles in a country such as performing financial transactions, a place for investments, loan payments to customers, employing people, etc. An important aim and challenge for the managers of this sector is to evaluate and rank different banks or bank branches in order to prioritize them for later decisions. For this aim, the most important criteria are cost and income based criteria. As there are many various criteria which indicate the cost and income efficiencies of a bank, ranking problem of banking sector can be modeled as a multi-criteria decision making (MCDM) prob-

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lem. This problem is difficult and complex from some aspects e.g. selecting the important criteria, collecting the data of each bank branch, uncertain nature of some of the data, determining the criteria importance weights, evaluation method, etc.

In order to evaluate and rank some bank branches, a basis is to determine the important criteria which influence the branches from income, cost, and other points of view. According to the literature of this field such as the study of Kumbirai and Webb [18] and also the study performed by Bičo and Ganić [4], the criteria such as capital amount, the amount of return on assets, liquidity, etc. are some classical criteria for assessing and evaluating banking sector (see also Said and Tumin [28]. More than the above-mentioned classical criteria, a set of criteria called CAMEL is applied for evaluating the performance of banking sector. This set of criteria consists of some main groups of criteria e.g. capital based criteria, asset quality based criteria, managerial criteria, earning based criteria, and liquidity based criteria. Theses criteria have been applied by many studies of the literature [1, 3, 9, 11, 12, 21, 26, 27, 30, 31, 32, 34]. to evaluate banking sector performance.

Another important aspect of the ranking problem of banking sector is to apply a multi-criteria decision making (MCDM) approach for ranking the bank branches under the given (or determined) criteria. Numerous approaches have been developed in the literature of multi-criteria decision making that can be used for this aim. Of the most common approaches of the literature AHP, TOPSIS, ELECTRE, PROMETHEE, SAW, MULTIMOORA, etc. can be mentioned. These approaches have been widely used in banking sector related problems. A method based on SAW approach was applied by Niroomand et al. [24] for ranking the countries from financial credit point of view. The PROMETHEE approach was applied by Kosmidou and Zopounidis [16] in order to measure banking sector performance. Brauers et al. [14] considered CAMEL based criteria and an approach based on MULTIMOORA for evaluating the Lithuanian banks. Ginevičius and Podviezko [13] also focused on the banking sector assessment problem and applied the TOPSIS approach for evaluation purposes. The TOPSIS approach also was used by Bilbao-Terol et al. [5] in order to assess governmental bond funds from sustainability point of view. A decision support system is developed by Doumpos and Zopounidis [10] for rating of banks. An integration of DEA and TOPSIS methods was used by Hemmati et al. [15] for evaluating banking sector performance. An integration of AHP and TOPSIS methods was used by Mandic et al. [2014] in order to analyze financial performance of the banks in Serbia. The classical MCDM approaches also can be hybridized for obtaining better results. The hybrid MCDM approaches have been used for banking sector related problems as well. Wu et al. [33] introduced an MCDM framework by combining the approaches AHP, SAW, TOPSIS, and VIKOR for assessing performance of banking sector in fuzzy environment. A decision framework based on fuzzy MCDM and BSC approaches was introduced by Shaverdi et al. [29] for evaluating and ranking problem of the private banking sector of Iran. An integration of AHP approach and the methods VIKOR and TOPSIS was used by Beheshtinia and Omidi [2] for evaluating and ranking problem of banking sector.

In this study we aim to apply a multi-criteria decision making framework in order to evaluate and rank the Iranian bank branches. The research highlights and contributions of this study are summarized below.

- A real case multi-criteria ranking problem of the Tose'e Ta'avon bank branches in Khuzestan province of Iran is focused.
- Idea of the experts of banking sector are used in order to select a set of important criteria based on the CAMEL criteria to evaluate bank branches.
- For more robust decisions, the data of past years for the bank branches are used in ranking procedure. Therefore, using the past data, a decision matrix with interval values is constructed. Using interval values help the managers to consider more data

of each branch for evaluating and ranking them. Therefore, a more reliable evaluation can be obtained for the ban branches.

- An interval Shannon's entropy method is used for criteria importance weight determination purpose.

- The classical PROMETHEE II approach is extended to interval form in order to rank the bank branches.

The rest of this paper is organized as follow. Section 2 presents the characteristics of the multi-criteria ranking problem of the Tose'e Ta'avon bank branches in Khuzestan provinceof Iran. Section 3 describes the proposed solution methodology consisting of criteria weight determination and multi-criteria ranking approaches. Section 4 presents computational results of the case study. The paper ends with Section 5 which includes concluding remarks.

2 The multi-criteria ranking problem of banking sector in Iran

As mentioned earlier, this study considers a multi-criteria ranking problem of the Tose'e Ta'avon bank branches in Khuzestan province of Iran. This problem is constructed in three steps as described by Figure 1.

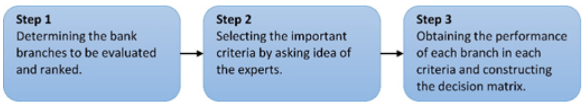

Fig. 1. The steps of defining the multi-criteria ranking problem of banking sector in Iran.

The steps of Figure 1 are detailed by the rest of this section.

2.1 Branches of the Tose'e Ta'avon bank

In this study we consider all 20 branches of the Tose'e Ta'avon bank in Khuzestan province of Iran to be assessed and ranked based on some criteria detailed by next sub-section. These banks are in Khuzestan province of Iran so that, all of them are working in approximately similar and common financial and social environment. These branches are detailed by Table 1.

Table 1: The branches of the Tose'e Ta'avon bank in Khuzestan province of Iran.

Branch code	Detailed name
Br-1	Ahvaz (Central)
Br-2	Dezfool
Br-3	Abadan
Br-4	Behbahan
Br-5	Masjed-Soleiman
Br-6	Ramhormoz
Br-7	Bandar-Mahshahr
Br-8	Izeh
Br-9	Shooshtar
Br-10	Andimeshk
Br-11	Khorramshahr
Br-12	Soosangerd
Br-13	Shadegan
Br-14	Shoosh
Br-15	Bagh-malek
Br-16	Ahvaz (Kiyanpars)
Br-17	Omidiyeh
Br-18	Hendijan
Br-19	Lali
Br-20	Ahvaz (Taleghani)

2.2 Important criteria

The branches mentioned by Table 1, should be evaluated and ranked based on some selected criteria. In order to perform such evaluation and ranking, the most important criteria from the literature of banking sector is reviewed at first. Based on the literature (as explained by Section 1) the CAMEL based criteria can be used in order to select the final criteria list. So, the selected criteria should be categorized in one of the main classes of management, capital, earnings, asset quality, and liquidity. For this aim, a group of experts from the Tose'e Ta'avon bank was selected and were asked to suggest the suitable criteria according to the CAMEL methodology. Therefore, according to the literature and the group of selected experts, 15 criteria were selected to be used for the aim of evaluating and ranking the

Table 2: The criteria selected for the proposed multi-criteria ranking problem.

Criterion code	Description	Type
2*C-1	NPL, which is obtained from total loans paid divided by all charges of a branch	2*Negative
C-2	Common income per employee	Positive
C-3	Non-common income per employee	Positive
C-4	Non-performing loans per employee	Negative
C-5	Low-cost resources	Positive
C-6	Deposited resources	Positive
C-7	Amount of bank guarantee	Positive
C-8	Benefit	Positive
C-9	Total cost price of the services	Negative
C-10	Total bank advances paid to customers per employee	Positive
C-11	Total bank account balance per employee	Positive
C-12	Income from POS machines	Positive
C-13	Average income from ATM machines	Positive
C-14	Number of customers per employee	Positive
C-15	Number of electronic customers per employee	Positive

Table 3: The weight values obtained for the criteria (for $\lambda = 0.5$).

2*Criteria	External weights (w_j^e)	Internal ($\tilde{w}_j^{in} = \left[w_j^{in,l}, w_j^{in,u}\right]$) weights	Final weight ($\tilde{w}_j = \left[w_j^l, w_j^u\right]$)
C-1	0.06	[0.011, 0.367]	[0.035, 0.213]
C-2	0.08	[0.004, 0.467]	[0.042, 0.283]
C-3	0.09	[0.004, 0.543]	[0.047, 0.316]
C-4	0.07	[0.022, 0.349]	[0.046, 0.209]
C-5	0.09	[0.005, 0.238]	[0.047, 0.164]
C-6	0.05	[0.003, 0.306]	[0.026, 0.178]
C-7	0.09	[0.045, 0.517]	[0.067, 0.303]
C-8	0.09	[0.032, 0.372]	[0.061, 0.231]
C-9	0.06	[0.001, 0.119]	[0.030, 0.089]
C-10	0.07	[0.028, 0.576]	[0.049, 0.323]
C-11	0.06	[0.004, 0.176]	[0.032, 0.118]
C-12	0.06	[0.000, 0.161]	[0.030, 0.110]
C-13	0.05	[0.005, 0.269]	[0.027, 0.159]
C-14	0.04	[0.001, 0.062]	[0.020, 0.051]
C-15	0.04	[0.003, 0.067]	[0.021, 0.053]

Table 4: The rankings by applying the interval PROMETHEE approach for the case study.

2*Outranking flow	Importance weight determination method		
	External weights	Internal weights	Final weights
Lower bound (ϕ_i^l)	Ranking 1	Ranking 4	Ranking 7
Upper bound (ϕ_i^u)	Ranking 2	Ranking 5	Ranking 8
Average ($(\phi_i^l + \phi_i^u)/2$)	Ranking 3	Ranking 6	Ranking 9

bank branches depicted by Table 1 ([13, 14, 16]). The selected criteria are shown by Table 2 where those are divided into positive and negative criteria. The higher values of the positive criteria

Table 5: The rankings obtained for the bank branches by different experiments of Table 4.

Bank branch	Ranking 1	Ranking 2	Ranking 3	Ranking 4	Ranking 5	Ranking 6	Ranking 7	Ranking 8	Ranking 9
Br-1	2	2	2	3	2	2	3	2	2
Br-2	14	18	17	16	18	18	16	18	18
Br-3	10	9	9	11	14	12	10	12	11
Br-4	19	16	18	18	19	19	18	19	19
Br-5	6	7	7	7	10	8	7	10	8
Br-6	7	6	6	13	9	10	12	7	10
Br-7	5	3	3	6	3	5	6	3	4
Br-8	8	8	8	9	8	9	9	9	9
Br-9	4	4	5	4	5	4	5	5	5
Br-10	15	17	16	10	13	11	11	14	13
Br-11	11	10	10	15	11	13	14	11	12
Br-12	16	15	15	17	15	16	17	15	16
Br-13	17	12	14	19	12	17	19	13	17
Br-14	12	11	11	8	6	7	8	6	7
Br-15	18	19	19	12	17	14	13	17	15
Br-16	3	5	4	5	4	3	4	4	3
Br-17	13	13	13	14	16	15	15	16	14
Br-18	9	14	12	1	7	6	2	8	6
Br-19	20	20	20	20	20	20	20	20	20
Br-20	1	1	1	2	1	1	1	1	1

Table 6: The JSI values for comparing the rankings of Table 5.

2*Ranking	Ranking 1	Ranking 2	Ranking 3	Ranking 4	Ranking 5	Ranking 6	Ranking 7	Ranking 8	Ranking 9
Ranking 1	-	0.87	0.90	0.79	0.83	0.86	0.82	0.86	0.88
Ranking 2	-	-	0.95	0.74	0.83	0.79	0.75	0.85	0.81
Ranking 3	-	-	-	0.76	0.85	0.81	0.79	0.88	0.84
Ranking 4	-	-	-	-	0.78	0.88	0.95	0.78	0.86
Ranking 5	-	-	-	-	-	0.88	0.81	0.96	0.90
Ranking 6	-	-	-	-	-	-	0.90	0.88	0.96
Ranking 7	-	-	-	-	-	-	-	0.81	0.88
Ranking 8	-	-	-	-	-	-	-	-	0.90
Ranking 9	-	-	-	-	-	-	-	-	-

are better while the lower values of the negative criteria are favored.

2.3 Decision matrix

In this sub-section the decision matrix of the multi-criteria ranking problem of the Tose'e Ta'avon bank branches in Khuzestan province of Iran is established. This matrix is an $m \times n$ dimensional matrix where m is the number of branches ($m = 20$) and n is the number of criteria ($n = 15$). The decision matrix is presented as below,

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{m1} & \cdots & \tilde{a}_{mn} \end{bmatrix} \tag{2.1}$$

In this matrix $\tilde{a}_{ij} = \left[a^l_{ij}, a^u_{ij}\right]$ shows the interval performance of the bank branch i in the selected criterion j.

Matrix A contains interval type numbers. The

Table 7: The final weight values obtained by different λ values.

2*Criteria	Final weights by $\lambda = 0.2$				Final weights by $\lambda = 0.4$				Final weights by $\lambda = 0.6$				Final weights by $\lambda = 0.8$			
	w_j^l	w_j^u	$w_j^u - w_j^l$	$\frac{w_j^u+w_j^l}{2}$	w_j^l	w_j^u	$w_j^u - w_j^l$	$\frac{w_j^u+w_j^l}{2}$	w_j^l	w_j^u	$w_j^u - w_j^l$	$\frac{w_j^u+w_j^l}{2}$	w_j^l	w_j^u	$w_j^u - w_j^l$	$\frac{w_j^u+w_j^l}{2}$
C-1	0.020	0.305	0.285	0.162	0.030	0.244	0.214	0.137	0.040	0.182	0.142	0.111	0.050	0.121	0.071	0.085
C-2	0.019	0.389	0.370	0.204	0.034	0.312	0.278	0.173	0.049	0.234	0.185	0.141	0.064	0.157	0.093	0.115
C-3	0.021	0.452	0.431	0.236	0.038	0.361	0.323	0.199	0.055	0.271	0.216	0.163	0.072	0.180	0.108	0.126
C-4	0.031	0.293	0.262	0.162	0.041	0.237	0.196	0.139	0.050	0.181	0.131	0.115	0.060	0.125	0.065	0.092
C-5	0.022	0.208	0.186	0.115	0.039	0.178	0.139	0.108	0.056	0.149	0.093	0.102	0.073	0.119	0.046	0.096
C-6	0.012	0.254	0.242	0.133	0.021	0.203	0.182	0.112	0.031	0.152	0.121	0.095	0.040	0.101	0.061	0.070
C-7	0.054	0.431	0.377	0.242	0.063	0.346	0.283	0.204	0.072	0.260	0.188	0.166	0.081	0.175	0.094	0.128
C-8	0.043	0.315	0.272	0.179	0.055	0.259	0.204	0.157	0.066	0.202	0.136	0.134	0.078	0.146	0.068	0.112
C-9	0.012	0.107	0.095	0.059	0.024	0.095	0.071	0.059	0.036	0.083	0.047	0.059	0.048	0.071	0.023	0.059
C-10	0.036	0.474	0.438	0.255	0.044	0.373	0.329	0.208	0.053	0.272	0.219	0.162	0.061	0.171	0.110	0.116
C-11	0.015	0.152	0.137	0.083	0.026	0.129	0.103	0.077	0.037	0.106	0.069	0.071	0.048	0.083	0.035	0.065
C-12	0.012	0.140	0.128	0.076	0.024	0.120	0.096	0.072	0.036	0.100	0.064	0.068	0.048	0.080	0.032	0.064
C-13	0.014	0.225	0.211	0.119	0.023	0.181	0.158	0.102	0.032	0.137	0.105	0.084	0.041	0.093	0.052	0.067
C-14	0.008	0.057	0.049	0.032	0.016	0.053	0.037	0.034	0.024	0.048	0.024	0.036	0.032	0.044	0.012	0.038
C-15	0.010	0.061	0.051	0.035	0.017	0.056	0.039	0.036	0.025	0.050	0.025	0.037	0.032	0.045	0.013	0.038

interval performance of each branch in each criterion is obtained from the data of last five years where the lower and upper values of the interval are respectively the minimum and maximum values among the values of last five years. Considering interval type decision matrix for this problem has below important advantages.

- The problem of this study has a degree of uncertainty like other real-life problems. By considering the interval type decision matrix, this uncertainty is coped.

- Considering interval values of the performances, in addition to recent year's data, the data of past years also are considered in the decision procedure which means that the decision making is done under more fair and robust situation.

The provided decision matrix is used to rank the bank branches presented by Table 1. Next section of the paper deals with a solution methodology for this aim.

3 Solution methodology

As mentioned earlier, the ranking problem of this study is done to evaluate and rank the Tose'e Ta'avon bank branches in Khuzestan province of Iran based on the pre-determined criteria with interval type values. In this section a solution methodology consisting of two general phases as below is presented to solve this ranking problem.

- **Phase 1:** The importance weight value of each criterion is determined.

- **Phase 2:** The preference ranking organization method for enrichment of evaluations (PROMETHEE) approach is extended to its interval form in order to evaluate and rank the bank branches.

The above-mentioned phases are explained in the rest of this section.

3.1 Phase 1: Importance weight determination

In the first phase of the proposed solution methodology, a procedure is followed to determine importance weight values of the considered criteria. In the literature of MCDM, many approaches have been used for this aim. These approaches can be classified as, (2.1) weight determination based on opinion of experts known as external weights (see [17]), (3.2) weight determination by data of decision matrix known as internal weights (see [14, 23, 25]), and (3.3) weight determination by a combination of external and internal weights.

In this study we propose a weight determination approach which considers opinion of experts and data of the decision matrix together.

The proposed approach, first determines external crisp weight values for the criteria using opinion of the experts of the field, then determines internal interval weight values from the interval decision matrix of the problem. Finally the obtained internal and external weight values are combined for final weight values. This procedure is depicted by Figure 2.

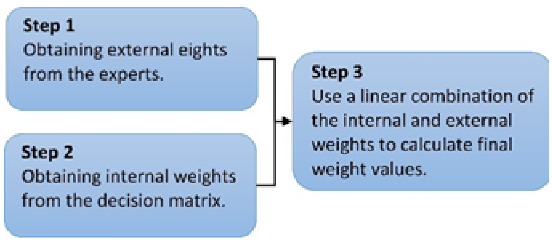

Fig. 2. Procedure of the proposed weight determination approach.

The steps for calculating the external weights of criteria (where the external weight of criterion j is shown by w_j^e) are described below.

Step 1.1. Select a number of banking sector experts (shown as s).

Step 1.2. Ask each expert to determine the score of each criterion as $sc_{pj} \in \{1, 2, \ldots, 10\}$ where sc_{pj} is the score value of criterion j determined by expert p and the highest score is 10.

Step 1.3. Calculate the external importance weight of each criterion as $w_j^e = \frac{\sum_{p=1}^{s} sc_{pj}}{\sum_{p=1}^{s}\sum_{j=1}^{n} sc_{pj}}$.

It is notable to mention that by following the above-mentioned sub-steps, the obtained weight values are crisp an also are in normalized form.

In continue, the interval Shannon's entropy approach of Lotfi and Fallahnejad [20] is used to calculate the interval internal weight values. The steps of this approach are explained as follow.

Step 2.1. Normalize the decision matrix $\tilde{A}$ shown by Eq. (2.1) as below,

$$r_{ij}^l = \frac{a_{ij}^l}{\sum_{k=1}^{m} a_{kj}^l} \qquad \forall i, j \tag{3.2}$$

$$r_{ij}^u = \frac{a_{ij}^u}{\sum_{k=1}^{m} a_{kj}^u} \qquad \forall i, j \tag{3.3}$$

Step 2.2. For interval entropy of each criterion the lower and upper bounds (shown by h_j^l and h_j^u respectively) are calculated as below,

$$h_j^l = \min\left\{-h_0\sum_{i=1}^{m} r_{ij}^l \ln r_{ij}^l, -h_0\sum_{i=1}^{m} r_{ij}^u \ln r_{ij}^u\right\}, \forall j \tag{3.4}$$

$$h_j^u = \max\left\{-h_0\sum_{i=1}^{m} r_{ij}^l \ln r_{ij}^l, -h_0\sum_{i=1}^{m} r_{ij}^u \ln r_{ij}^u\right\}, \forall j \tag{3.5}$$

where $h_0 = (\ln m)^{-1}$, $r_{ij}^l = 0 \Longrightarrow r_{ij}^l \ln r_{ij}^l = 0$, and $r_{ij}^u = 0 \Longrightarrow r_{ij}^u \ln r_{ij}^u = 0$.

Step 2.3. Calculate the interval degree of diversification for criterion j (denoted by $\left[d_j^l, d_j^u\right]$) as below,

$$\left[d_j^l, d_j^u\right] = \left[1 - h_j^u, 1 - h_j^l\right], \ \forall j \tag{3.6}$$

Step 2.4. Calculate the internal importance weight of each criterion in interval form (shown as $\tilde{w}_j^{in} = \left[w_j^{in,l}, w_j^{in,u}\right]$) by below equation,

$$\left[w_j^{in,l}, w_j^{in,u}\right] = \left[\frac{d_j^l}{\sum_{k=1}^{n} d_k^u}, \frac{d_j^u}{\sum_{k=1}^{n} d_k^l}\right], \quad \forall j \tag{3.7}$$

As Step 3 of the proposed weight determination approach, the final interval weight values of the criteria (shown by $\tilde{w}_j = \left[w_j^l, w_j^u\right]$ for criterion j) are calculated by combining the internal and external weights as follow,

$$\left[w_j^l, w_j^u\right] = \left[(1-\lambda)\, w_j^{in,l} + \lambda w_j^e, (1-\lambda)\, w_j^{in,u} + \lambda w_j^e\right], \ \forall j \tag{3.8}$$

where $\lambda \in (0, 1)$ is importance of the external weight values determined by decision maker.

3.2 Phase 2: Interval PROMETHEE approach

The preference ranking organization method for enrichment of evaluations (PROMETHEE) approach first was introduced by Brans [6]. Its general procedure is logical and easy to implement and it is effective for assessment and ranking of multi-criteria decision making problems. The summary of this method is depicted by flowchart of Figure 3. This is notable to mention that Brans et al. [7] proposed six main type of the preference function such as usual criterion function, U-shape criterion function, V-shape criterion function, level criterion function, V-shape criterion function with indifference area, and Gaussian criterion function. Any of these functions can be selected for applying the PROMETHEE approach for multi-criteria decision making problems.

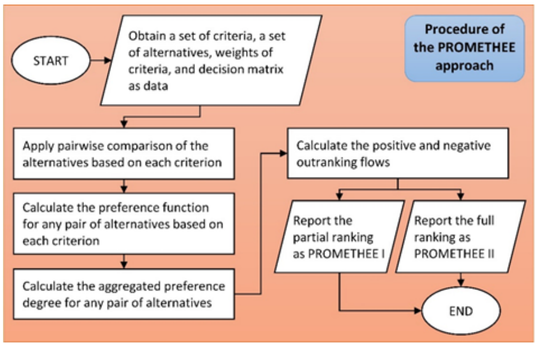

Fig. 3. Summary of the PROMETHEE approach.

In continue the classical PROMETHEE approach of Figure 3 is extended for interval type data. For this aim the following steps are proposed.

Step 1. Consider a set of criteria (indexed by $j, k \in \{1, 2, \ldots, n\}$), a set of alternatives (bank branches, indexed by $i, l \in \{1, 2, \ldots, m\}$), and the weight of each criterion determined by Section 3.2 ($\tilde{w}_j,\ j = 1, 2, \ldots, n$). Determine the interval decision matrix ($\tilde{A} = \left[\tilde{a}_{ij} = \left[a^l_{ij}, a^u_{ij}\right]\right]_{m\times n}$) according to the procedure of Section 2.

Step 2. Calculate the performance difference of the alternatives by the following formula,

$$d_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right) = \left[a^l_{ij}, a^u_{ij}\right] - \left[a^l_{lj}, a^u_{lj}\right] = \left[a^l_{ij} - a^u_{lj}, a^u_{ij} - a^l_{lj}\right], \quad i, l = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n \tag{3.9}$$

where, $d_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right)$ is the performance difference of alternatives i and l in criterion j. The performance difference is calculated for any pair of alternatives in any of the criteria.

Step 3. Calculate the preference function values by the below relationship (where $P_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right)$ is the preference function value of alternatives i and l in criterion j). In this study the V-shape criterion function with indifference area is applied for this aim. This function has been applied in the literature because of its accuracy.

$$P_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right) = \begin{cases} 0 & a^u_{ij} - a^l_{lj} \leq 0 \\ d_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right) & \text{Otherwise} \end{cases} \quad i, l = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n \tag{3.10}$$

Step 4. Calculate the interval total preference index of the pairs of alternatives over all criteria by the following formula ($\widetilde{\Pi}_{il}$ is the interval total preference index of alternative i respecting to alternative l).

$$\widetilde{\Pi}_{il} = \sum_{j=1}^{n} \tilde{w}_j d_j\left(\tilde{a}_{ij},\ \tilde{a}_{lj}\right) = \sum_{j=1}^{n} \left[w^l_j, w^u_j\right] \times \left[a^l_{ij} - a^u_{lj}, a^u_{ij} - a^l_{lj}\right], \quad i, l \in \{1, 2, \ldots, m\} \tag{3.11}$$

Note that in the matrix $\widetilde{\Pi}=\left[\widetilde{\Pi}_{il}\right]_{m\times m}$ there is no value for the diagonal elements, but all other elements should be calculated by the above-mentioned formula.

Step 5. Obtain the interval positive outranking flow ($\widetilde{\phi}^+_i$) and interval negative outranking flow ($\widetilde{\phi}^-_i$) for each alternative by the following formulas.

$$\widetilde{\phi}^+_i = \frac{1}{m-1} \sum_{\substack{l=1 \\ l\neq i}}^{m} \widetilde{\Pi}_{il},\ i = 1, 2, \ldots, m \qquad \widetilde{\phi}^-_i = \frac{1}{m-1} \sum_{\substack{l=1 \\ l\neq i}}^{m} \widetilde{\Pi}_{il},\ i = 1, 2, \ldots, m \tag{3.12}$$

Actually, the value of $\widetilde{\phi}^+_i$ is average of the values of row i of matrix $\widetilde{\Pi}$, where, the value of $\widetilde{\phi}^-_i$ is average of the values of column i of matrix $\widetilde{\Pi}$.

Step 6. Calculate the interval net outranking flow ($\widetilde{\phi}_i = \left[\phi^l_i,\ \phi^u_i\right]$) for each alternative by the following formula.

$$\widetilde{\phi}_i = \widetilde{\phi}^+_i - \widetilde{\phi}^-_i,\ i = 1, 2, \ldots, m \tag{3.13}$$

Step 9. Rank the alternatives according to the descending order of the net outranking flow-values. This step actually applies the concept of PROMETHEE II approach for complete ranking of the alternatives. According to this step, three different rankings of the bank branches are obtained as follow,

- ranking according to the descending order of the lower bound of the values of $\widetilde{\phi}_i$ (according to the descending order of the values of ϕ_i^l),
- ranking according to the descending order of the upper bound of the values of $\widetilde{\phi}_i$ (according to the descending order of the values of ϕ_i^u),
- ranking according to the descending order of the average of the lower and upper bound values of $\widetilde{\phi}_i$ (according to the descending order of the values of $\frac{\phi_i^l+\phi_i^u}{2}$).

This is notable to mention that, in PROMETHEE II approach a complete ranking of the bank branches is obtained as it is the aim of this study. But the difference between PROMETHEE I and PROMETHEE II approaches is that applying PROMETHEE I approach, only a partial ranking of the branches can be obtained.

4 Case study

In this section, the proposed decision framework of Section 3 is implemented to evaluate and rank the Tose'e Ta'avon bank branches in Khuzestan province of Iran based on the predetermined criteria with interval type values. For this aim, some parameters and indexes of the proposed solution approach are fixed as below,

- the Tose'e Ta'avon bank has 20 branches in Khuzestan province of Iran, therefore, $m = 20$,
- the number of criteria is 15 as detailed by Section 2, therefore, $n = 15$,
- three experts are considered for external weight determination purpose, therefor, $s = 3$,
- and, according to idea of managers of the bank, for determining the final interval weights, the external and internal weights are scaled equally, therefore, $\lambda = 0.5$.

This is notable to mention that, the experts selected for external weight determination, have both of the conditions: (2.1) working for more than 15 years in banking sector, (3.2) performing the role of a branch head (bank CEO) for more than 5 years.

After implementing the first stage of the proposed solution methodology, the outputs e.g. the values of external weights, internal weights, and final weights are obtained and reported by Table 3.

Based on the results of Table 3, according to the opinions of the experts (reflected as the external weight values), the criteria such as C-3, C-5, C-7, and C-8 are simultaneously the most important criteria. On the other hand, C-14 and C-15 are the least important criteria with the external weight value of 0.04. According to the internal weight values and considering the center of each interval, the most important criterion is C-10, while the least important criterion is C-14. According to the final weight values and considering the center of each interval, the most important criterion is C-10, while the least important criterion is C-14.

In continue, we use the obtained weight values of Table 3 in order to perform Phase 2 of the proposed solution methodology for ranking the bank branches. As there are three different important weight values for each criterion (the external weights, internal weights, and final weights), each type of the weight values can be used for the proposed interval PROMETHEE approach. Considering the ranking options of Step 9 of Section 3.2, nine experiments are defined where each experiment results in a ranking. Therefore, the rankings of Table 4 is defined to be obtained by the proposed PROMETHEE approach where the row and column of each ranking determine the characteristics of its experiment.

Now, for each experiment of Table 4 a ranking of the bank branches is obtained which is represented by Table 5.

The rankings represented by Table 5 are more or less different than each other. It is obvious that in all experiments Br-19 is the worst branch while according to 8 out of 9 experiments Br-20 is the best branch. In order to more compare the obtained rankings, the Jaccard similarity index (JSI) [19, 23, 24] is applied for any pair of the rankings. As the value of this index is between 0 and 1, for a pair of the rankings, the value of zero of this index shows no similarity of the rankings and the value of 1 shows completely similar rankings. The Jaccard similarity index values for all pairs of the rankings of Table 5 is calculated and represented by Table 6.

According to the JSI values of Table 6 similarity of the obtained rankings can be investigated. The highest similarity happens between the rankings 5 and 8 and the rankings 6 and 9with $JSI = 0.96$. It means that when applying the interval PROMETHEE approach with internal weights and final weights (by considering the values of ϕ_i^u for ranking the bank branches in the procedure of the proposed PROMETHEE), the obtained rankings has similarity of %96 by the Jaccard similarity index. A similar JSI value is obtained when applying the interval PROMETHEE approach with internal weights and final weights (by considering the values of $\frac{\phi_i^l+\phi_i^u}{2}$ for ranking the bank branches in the procedure of the proposed PROMETHEE). On the other hand, the lowest similarity happens between the rankings 2 and 4 with $JSI = 0.74$. It means that the rankings obtained by the interval PROMETHEE approach with external weights and the values of ϕ_i^u for ranking the bank branches, and the interval PROMETHEE approach with internal weights and the values of ϕ_i^l for ranking the bank branches, has similarity of %74 by the Jaccard similarity index.

Furthermore, sensitivity of the weight determination phase of the proposed solution methodology is studied here. For this aim the effect of different λ values of the obtained final importance weight values is studied. For this aim the internal and external weight valuesof Table 3 is considered and the value of λ is selected from the set of values $\{0.2,\ 0.4,\ 0.6,\ 0.8\}$ in order to study the sensitivity of the final weight values. Applying the above mentioned λ values the results of Table 7 are obtained.

According to the results of Table 7, it is concluded that the final importance weight values are sensitive to the changes of the values of λ. By increasing the value of λ, two main conclusions can be drawn as given below.

- By increasing the value of λ, in in all criteria the length of the interval value of final weigh is decreased. For example in the first criterion (C-1), $\lambda = 0.2 \Longrightarrow w_1^u - w_1^l = 0.285$, $\lambda = 0.4 \Longrightarrow w_1^u - w_1^l = 0.214$, $\lambda = 0.6 \Longrightarrow w_1^u - w_1^l = 0.142$, and $\lambda = 0.8 \Longrightarrow w_1^u - w_1^l = 0.071$.

- By increasing the value of λ, in in all criteria the average of the interval value of final weigh is decreased. For example in the first criterion (C-1), $\lambda = 0.2 \Longrightarrow \frac{w_j^u+w_j^l}{2} = 0.162$, $\lambda = 0.4 \Longrightarrow \frac{w_j^u+w_j^l}{2} = 0.137$, $\lambda = 0.6 \Longrightarrow \frac{w_j^u+w_j^l}{2} = 0.111$, and $\lambda = 0.8 \Longrightarrow \frac{w_j^u+w_j^l}{2} = 0.085$. This means that based on the external and internal weight values of Table 3, by increasing the value of λ, the crisp value of the final weight is decreased.

According to this study, some advice for banking sector managers are given here. The methodology and procedure of this study can give some insights and implications for banking sector managers as below.

- The idea of considering interval value data can be used by the managers to perform any assessment study on the performance of the branches and employees.

- According to the obtained rankings, some strategies for managing the branches and improving their performance can be defined.

- The strategies like absorbing new investments, reducing the operational costs, improving interest rates, etc. can be considered to improve the weak branches.

5 Concluding remarks

In this study an important problem of banking sector was studied. A typical ranking problem of bank branches for a case study of the Tose'e Ta'avon bank branches in Khuzestan province of Iran was defined and solved. For this aim, first a set of important criteria for evaluating banking sector was selected from the literature and experts of the field. Then for coping with the uncertain nature of real-life problems, the data of the bank branches in the selected criteria was obtained for the past years and represented as interval values. A decision framework consisting of two phases were proposed to rank the given bank branches. In the first phase the criteria were weighted by the methods such as opinion of experts of the field, interval Shannon's entropy, and combinations of these methods. In the second phase, the classical PROMETHEE approach was extended to interval form and applied to rank the bank branches. By implementing the proposed solution methodology on the case study, several rankings were obtained and their similarities were compared to each other. The decision maker can consider any of the rankings for further managerial decisions.

Some new research directions can be considered to be followed by the researchers of the field. The interested researchers may consider other types of uncertainty for representing the part years data in the decision procedure. Furthermore, other multi-criteria decision making approaches can be considered for ranking the branches.

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