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THE USE OF THE PIVOT PAIRWISE RELATIVE CRITERIA IMPORTANCE ASSESSMENT METHOD FOR DETERMINING THE WEIGHTS OF CRITERIA

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Abstract

The weights of evaluation criteria could have a significant impact on the results obtained by applying multiple criteria decision-making methods. Therefore, the two extensions of the SWARA method that can be used in cases when it is not easy, or even is impossible to reach a consensus on the expected importance of the evaluation criteria are proposed in this paper. The primary objective of the proposed extensions is to provide an understandable and easy-to-use approach to the collecting of respondents' real attitudes towards the significance of evaluation criteria and to also provide an approach to the checking of the reliability of the data collected.

Keyword: PIvot Pairwise RElative Criteria Importance Assessment, PIPRECIA, PIPRECIA-E, SWARA, criteria weights, group decision-making,

JEL Classification: D81; C61; C44

1. Introduction

Multiple Criteria Decision Making (MCDM) is becoming one of the most important and fastest-growing areas of operational research. Therefore, the result of rapid development has led to the creation of many MCDM methods (Mardani et al. 2015, Zavadskas et al. 2014,

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Stanujkic et al. 2013), such as: SAW, AHP, TOPSIS, PROMETHEE, ELECTRE, LINMAP, COPRAS, VIKOR, ARAS, MOORA, MULTIMOORA, WASPAS, SWARA, EDAS, FARE and so on. The overview of the previously mentioned methods, as well as of their application, is considered by Zavadskas et al. (2015), Gul et al. (2016), Stefano et al. (2015), Govindan and Jepsen (2016), Behzadian et al. (2010), Baležentis T. and Baležentis A. (2013).

The above-mentioned methods have successfully been applied over time for solving numerous multicriteria problems (Mardani et al. 2017, Zare et al. 2016, Kou et al. 2016, Zhou et al. 2017, Stanujkic 2016, Turskis and Juodagalviene 2016, Kaklauskas 2016, Keshavarz Ghorabaee 2016). The increasing use of multiple criteria decision-making methods indicates a good approach to problems requiring optimal decision-making and the adoption of sustainable solutions (Ignatius et al. 2016, Ou 2016).

The significance of evaluation criteria, more often called the weights of criteria or shorter – weights, can have a significant influence on the ranking results obtained by using MCDM methods. Therefore, numerous authors have proposed a variety of procedures for determining the weights of criteria (Ma, 1999), such as the LINMAP technique (Ma et al., 1999.) pairwise comparisons taken from the AHP method (Saaty 1977, 1980), the Entropy approach (Hwang and Yoon 1981), the Delphi method (Hwang and Lin 1987), CILOS, IDOCRIW (Zavadskas and Podvezko 2016), and so on.

The new Step-Wise Weight Assessment Ratio Analysis (SWARA), proposed by Kersuliene et al. (2010), can also be used for determining the weights of criteria, as well as for solving various MCDM problems.

Despite the fact that the SWARA method can be mentioned as a newly-proposed MCDM method, the same has successfully been used to solve many decision-making problems, such as those shown in Table 1.

In these decision-making problems, the SWARA method has mainly been used in combination with other MCDM methods, whereby it was used to determine the weights of criteria.

In comparison with the other methods intended to determine the weights of criteria, the SWARA method is less complex to use from the standpoint of the questioned persons [44], which has certainly had an effect on its applicability. For example, in comparison to commonly used pairwise comparisons taken from the AHP method, the SWARA method requires significantly fewer comparisons. In addition, the computational procedures of the SWARA method are also less complex compared to the computational procedures used in similar methods.

For the reason of the above said, a rise in the use of SWARA methods for solving MCDM problems can be expected to continue in the future.

Table 1

The Usage of the SWARA Method

Decision-making problems	**Authors**
Rational dispute resolution	Kersuliene et al. (2010)
An architect selection	Kersuliene and Turskis (2011)
A shopping mall location selection	Hashemkhani Zolfani et al. (2013)
A machine tool selection	Aghdaie et al. (2013a)
Market segmentation and selection	Aghdaie et al. (2013b)
A supplier selection	Alimardani et al. (2013) Yazdani et al. (2016a)
Sustainability assessment	Hashemkhani Zolfani and Saparauskas (2013)

Decision-making problems	Authors
Investment prioritizing	Hashemkhani Zolfani and Bahrami (2014)
The evaluation of an external wall insulation	Ruzgys et al. (2014)
House locating	Haghnazar Kouchaksaraei et al. (2015) Hashemkhani Zolfani and Banihashemi (2014)
Personnel selection	Karabasevic et al. (2015b, 2015b, 2016) Urosevic et al. (2017) Karabašević et al. (2016)
The packaging design selection	Stanujkic et al. (2015)
Assessment of landslide hazard areas	Dehnavi et al. (2015)
The ranking of companies	Karabasevic et al. (2015a)
Evaluation of light supply in the public underground safe spaces	Nakhaei et al. (2016a)
Materials selection	Yazdani et al. (2016b)
Vulnerability of office buildings	Nakhaei et al. (2016b)
ERP system selection	Shukla et al. (2016)
Evaluation of third-party reverse logistic provider	Mavi et al. (2017)

Additionally, in some cases, the precise determination of a weight of criteria could require the participation of a large number of respondents. Therefore, in this manuscript, an approach that should facilitate the usage of the SWARA method in a group environment, especially when used in order to obtain attitudes from the largest number of respondents and/or when a list of the criteria sorted on the basis of their expected importance is difficult to form, is considered.

For that reason, the remaining part of the paper is organized as follows: In Section 2, the computational procedure of the SWARA method is presented and in Section 3, an innovative approach to the determination of the weights of criteria based on the SWARA method is proposed. In Section 4, an approach to checking the reliability of data collected is considered. These are followed by Section 5, in which the innovative approach proposed in Section 3 is further extended in order to enable the checking of the reliability of the data collected. In Section 6, two numerical illustrations are the subject of consideration with the aim of presenting the usability of the proposed extensions. Finally, the conclusions are given.

2. The Computational Procedure of the SWARA Method

Based on Stanujkic et al. (2015) and Kersuliene et al. (2010), the computational procedure of the ordinary SWARA method can accurately be shown through the following steps:

Step 1. Determine the set of the relevant evaluation criteria and sort them in descending order, based on their expected significances.

Step 2. Starting from the second criterion, determine the relative importance sj of the criterion j in relation to the previous j-1 criterion, and do that for each particular criterion.

Step 3. Determine the coefficient kj as follows:

$$k_j = \begin{cases} 1 & j=1 \\ s_j+1 & j>1 \end{cases} . \quad (1)$$

Step 4. Determine the recalculated weight qj as follows:

$$q_j = \begin{cases} 1 & j=1 \\ \frac{q_{j-1}}{k_j} & j>1 \end{cases} . \quad (2)$$

Step 5. Determine the relative weights of the evaluation criteria as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} , \quad (3)$$

where: wj denotes the relative weight of the criterion j.

In cases when the SWARA method is used for determining the weights of criteria, it is very important, or precisely said – necessary, that a consensus on the expected significances of the evaluation criteria should be ensured.

3. An Extension of the SWARA Method Adapted for Group Decision-making

A real difficulty that can occur when the SWARA method is used for solving real-world decision-making problems in a group environment is the forming of the list of the evaluation criteria sorted according to their expected importance.

In such cases, the respondents involved in an evaluation may have different attitudes towards the importance of the evaluation criteria. Conducting an interview with accidental passers-by with the aim of determining the factors that are relevant to the selection of something, which usually includes various categories of respondents, can be specified as one of such typical cases.

Therefore, an extended approach based on the use of the SWARA method, which is able to cope with the previously unsorted list of evaluation criteria, is considered in this section. For the purpose of application of the same, it is necessary to implement the following modifications in the ordinary SWARA computational procedure:

As the first and crucial modification of the ordinary SWARA approach, the way of allocating the values of sj should be mentioned, and they should be assigned as follows:

$$s_j = \begin{cases} >1 & when\, C_j \succ C_{j-1} \\ 1 & when\, C_j = C_{j-1} \\ <1 & when\, C_j \prec C_{j-1} \end{cases} . \quad (4)$$

The previously proposed modification also has an impact on the determining of the value of kj, which should be determined in the following manner:

$$k_j = \begin{cases} 1 & j=1 \\ 2-s_j & j>1 \end{cases} . \quad (5)$$

In the proposed approach, the remaining part of the computational procedure remains the same as in the ordinary SWARA method, i.e. Eqs (2) and (3) remain unchanged.

3.1 An Innovative Approach to Determining the Weights of Evaluation Criteria

Taking into account the previously proposed modifications, the computational procedure of the innovative PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA) approach can be accurately presented as follows:

Step 1. Determine the set of the relevant evaluation criteria and sort them in descending order, based on their expected significances.

Step 2. Starting from the second criterion, determine the relative importance sj as follows:

$$s_j = \begin{cases} >1 & when\, C_j \succ C_{j-1} \\ 1 & when\, C_j = C_{j-1} \\ <1 & when\, C_j \prec C_{j-1} \end{cases} . \quad (6)$$

Step 3. Determine the coefficient kj as follows:

$$k_j = \begin{cases} 1 & j=1 \\ 2-s_j & j>1 \end{cases} . \quad (7)$$

Step 4. Determine the recalculated weight qj as follows:

$$q_j = \begin{cases} 1 & j=1 \\ \dfrac{q_{j-1}}{k_j} & j>1 \end{cases} . \quad (8)$$

Step 5. Determine the relative weights of the evaluation criteria as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} . \quad (9)$$

3.2 The Use of the PIPRECIA Method in a Group Decision-making Environment

The use of the PIPRECIA method in a group decision-making environment can accurately be demonstrated through the following steps:

Step 1. Form or define a group of the respondents who will participate in the evaluation. Depending on the objectives, the number of the participants that should be included in the research study could vary from a small number of experts and/or decision-makers to a larger number of ordinary respondents.

Step 2. Determine the set of the relevant evaluation criteria and sort them in descending order, based on their expected significances.

This step is similar to that of the ordinary SWARA method when research includes a small number of experts and/or decision-makers. However, a consensus on the expected significances of the evaluation criteria is not so easy to reach when a research study involves a larger number of respondents. In such cases, the proposed PIPRECIA method could have some advantages because it does not require the use of the sorted list of the evaluation criteria.

Step 3. Determine the relative importance of the evaluation criteria, and do so for each respondent. In this steep, each respondent expresses his/her attitudes towards the relative importance of the criteria by using Eq. (6), as follows:

$$s_j^r = \begin{cases} >1 & when\, C_j \succ C_{j-1} \\ 1 & when\, C_j = C_{j-1} \\ <1 & when\, C_j \prec C_{j-1} \end{cases} \quad (10)$$

where: s_j^r denotes the relative importance of the criterion j obtained from the respondent r.

Step 4. Determine the relative weights of the evaluation criteria, and do so for each respondent. The relative weights should be calculated by using Eqs (7), (8) and (9), for each respondent, in the following manner:

$$k_j^r = \begin{cases} 1 & j=1 \\ 2-s_j^r & j>1 \end{cases}, \quad (11)$$

$$q_j^r = \begin{cases} 1 & j=1 \\ \dfrac{q_{j-1}^r}{k_j^r} & j>1 \end{cases}, \quad (12)$$

$$w_j^r = \frac{q_j^r}{\sum_{j=1}^{n} q_j^r}, \quad (13)$$

where: k_j^r, q_j^r and w_j^r .denote the coefficient, the recalculated weight and the weight of the criterion j, respectively, determined on the basis of the respondent r.

Step 5. Determine the group relative weights of the evaluation criteria.

As a result of the evaluation that includes the R respondents, the R different weights could be obtained for each criterion, and the weights obtained in that manner could be used in accordance with the computational procedure of the MCDM method chosen for the further evaluation and selection of the most suitable alternative.

The weights so obtained can also be used for forming different types of group weights, such as fuzzy, grey or crisp group weights of criteria. Finally, as one of the simplest transformations of an individual weight of criteria to a group one could be done as follows:

$$w_j^* = \left(\prod_{r=1}^{R} w_j^r \right)^{1/R}, \quad (14)$$

$$w_j = \frac{w_j^*}{\sum_{j=1}^{n} w_j^*}, \quad (15)$$

where: w_j^* denotes the geometric mean of the weights of the criterion j obtained by surveying the respondents and R denotes the number of the respondents.

4. Checking the Reliability of Data Collected

A lack of a built-in mechanism for the calculation of the consistency of the performed pairwise comparisons can be identified as a weakness of the SWARA method, as well as of the PIPRECIA method, compared to the commonly used AHP method.

Checking the reliability of the data obtained from the respondents can be performed in two diverse ways, namely:

by using correlation techniques, such as: Pearson's correlation, Kendall's rank correlation or Spearman's correlation; and

by using the extended PIPRECIA method, i.e. by applying the bidirectional procedure for the determination of the weights of criteria.

4.1. Checking Reliability by Using Spearman's Rank Correlation Coefficient

In this approach, Spearman's rank correlation, proposed by Spearman (1904, 1906) and Kendall (1948), is chosen for the purpose of determining the reality of the data collected.

Spearman's rank correlation coefficient between two independent data series is as follows:

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n\,(n^2 - 1)} \tag{16}$$

where: ρ denotes the correlation the coefficient, di denotes the distance between the ranks for each xi, yi stands for the data pairs, x and y denote the data series, whereas n is the number of the elements in each data series, and $\rho \in [-1, 1]$.

The correlation is calculated between the weights obtained on the basis of the attitudes of the respondents involved in the evaluation and the weights are determined by using Eq. (14).

The greater value of ρr indicates higher correlation between the weights obtained from the respondent r and those obtained on the basis of the attitudes of all the respondents. The least allowable value for ρ can be defined depending on the objectives of the research study and so the surveys of the respondents whose attitudes differ significantly from those of the group can be identified.

5. The Extended PIPRECIA Method

The extended PIPRECIA (PIPRECIA-E) method is based on the use of a bidirectional approach to the determination of the weights of criteria, and it comprises the following stages:

Phase 1. Determining the weights of the criteria by using the PIPRECIA method.

Phase 2. Determining the weights of the criteria by using the inverse PIPRECIA method, wherein the assigning of the relative importance of the criteria is performed in the inverse direction, i.e. starting from the second least significant to the most important criterion.

Phase 3. Checking the reliability of the data obtained from the respondents.

Phase 4. Determining the resulting weight of the criteria.

The first phase of the PIPRECIA-E is already explained in subsection 3.1. The remaining phases of the PIPRECIA-E are explained in details in the subsections 5.1 to the 5.3, while its usage in a group environment is considered in the subsection section 5.4.

5.1. The Inverse PIPRECIA Method

In order to provide inverse pairwise comparisons, starting from the second least significant to the most significant criterion, the following modifications should be made in computational procedure of the PIPRECIA method: instead of the relative importance sj used in the inverse PIPRECIA method, the inverse relative importance of the criteria s'_j should be used, and the same should be determined as follows:

$$s'_j = \begin{cases} >1 & when\, C_j \succ C_{j+1} \\ 1 & when\, C_j = C_{j+1} \\ <1 & when\, C_j \prec C_{j+1} \end{cases} . \tag{17}$$

This modification also has an impact on the process of calculating the values of the coefficient kj and the recalculated weight qj. Therefore, the inverse coefficient k'_j and the inverse recalculated weight q'_j should be calculated as follows:

$$k'_j = \begin{cases} 1 & j = n \\ 2 - s'_j & j < n \end{cases} \text{, and} \tag{18}$$

$$q'_j = \begin{cases} 1 & j = n \\ \frac{q'_{j+1}}{k'_j} & j < n \end{cases} . \tag{19}$$

Taking into consideration the aforementioned adaptations, the computational procedure of the inverse PIPRECIA approach can accurately be presented as follows:

Step 1. Starting from the second least significant criterion, determine the inverse relative importance s'_j as follows:

$$s'_j = \begin{cases} >1 & when\, C_j \succ C_{j+1} \\ 1 & when\, C_j = C_{j+1} \\ <1 & when\, C_j \prec C_{j+1} \end{cases} . \tag{20}$$

Step 2. Determine the inverse coefficient k'_j as follows:

$$k'_j = \begin{cases} 1 & j = n \\ 2 - s'_j & j < n \end{cases} . \tag{21}$$

Step 3. Determine the inverse recalculated weight q'_j as follows:

$$q'_j = \begin{cases} 1 & j = n \\ \frac{q'_{j+1}}{k'_j} & j < n \end{cases} . \tag{22}$$

Step 4. Determine the inverse relative weights of the evaluation criteria as follows:

$$w'_j = \frac{q'_j}{\sum_{k=1}^{n} q'_k}, \quad (23)$$

where: w'_j denotes the inverse weight of the criterion j.

5.2. Checking the Reliability of the Data Obtained from the Respondents

In the PIPRECIA-E method, the checking of the reliability of the data collected is not mandatory and this phase could be omitted.

Unlike the checking procedure proposed for being used with the PIPRECIA method, in the PIPRECIA-E method the reliability of the data collected is determined on the basis of the data obtained from the same respondent by applying the PIPRECIA and the inverse PIPRECIA methods.

Checking the reliability of the data collected can be performed by using the Spearman, or any other, correlation coefficient.

5.3. Determining the Resulting Weight of Criteria.

The weights w″ of criteria in PIPRECIA-E should be calculated in the following manner:

$$w''_j = \frac{1}{2}(w_j + w'_j). \quad (23)$$

where: w_j, w'_j and w''_j denote the weights of the criterion j, obtained by applying the PIPRECIA, inverse PIPRECIA and PIPRECIA-E methods, respectively.

5.4. The Use of PIPRECIA-E for Obtaining Respondents' Attitudes

The PIPRECIA-E method is proposed with the aim of providing a simple and effective approach to obtaining the real attitudes of the respondents that are not prepared for being interviewed. By using the PIPRECIA-E method, as well as the procedure proposed for checking the reliability of the data obtained, all inadequate surveys can be discarded.

After that, group weights could be calculated as follows:

$$w^*_j = \left(\prod_{r=1}^{R} w''^r_j\right)^{1/R}, \quad (24)$$

$$w_j = \frac{w^*_j}{\sum_{j=1}^{n} w^*_j}. \quad (25)$$

where: wj denotes the group weight of the criterion j, w''^r_j denotes the weight of the criterion j obtained from the respondent r, and R denotes the number of the respondents.

6. Numerical Illustrations

In this section, the two numerical illustrations borrowed from two case studies are considered in order to explain the proposed approach and present its usability.

6.1. The First Numerical Illustration

In the first numerical illustration, some partial results adopted from the case study conducted for the purpose of selecting the most appropriate promoter are presented. For that purpose, the results obtained from the three Human Resource Managers (HRM) involved in the research study are discussed. In the referenced case study, the team consisted of the three Human Resource Managers (HRMs) made the evaluation and selection of the most appropriate promoter on the basis of the six criteria.

The weights of the evaluation criteria obtained from the first of the three HRMs, by using the PIPRECIA method, are accounted for in Table 2.

Table 2

The Responses Obtained from the First of the Three HRMs and the Weights of the Criteria

	Criteria	sj	kj	qj	wj
C1	Personality		1	1	0.19
C2	Self-confidence	1	1.00	1.00	0.19
C3	Communication and presentation skills	1	1.00	1.00	0.19
C4	Interview preparedness	0.75	1.25	0.80	0.15
C5	Education	1	1.00	0.80	0.15
C6	Past experience	0.8	1.20	0.67	0.13

In Table 3, the weights of the criteria obtained by using the ordinary SWARA method, also obtained on the basis of the responses obtained from the first of the three HRMs, are presented.

Table 3

The Responses and the Weights of the Criteria Obtained from the First HRM by Using the Ordinary SWARA Method

	Criteria	sj	kj	qj	wj
C1	Personality		1	1	0.19
C2	Self-confidence	0	1.00	1.00	0.19
C3	Communication and presentation skills	0	1.00	1.00	0.19
C4	Interview preparedness	0.25	1.25	0.80	0.15
C5	Education	0	1.00	0.80	0.15
C6	Past experience	0.2	1.20	0.67	0.13

As one may see from Tables 2 and 3, the obtained weights of the criteria are similar to each other, which confirms the validity of the proposed PIPRECIA method.

The advantages of the proposed approach can be more precisely identified on the basis of the response obtained from the responses given by the second and the third HRMs, as is shown in Tables 4 and 5.

Table 4

The Responses Obtained from the Second of the Three HRMs and the Weights of the Criteria

	Criteria	sj	kj	qj	wj
C1	Personality		1	1	0.19
C2	Self-confidence	1	1.00	1.00	0.19
C3	Communication and presentation skills	0.95	1.05	0.95	0.18
C4	Interview preparedness	0.85	1.15	0.83	0.16
C5	Education	0.85	1.15	0.72	0.14
C6	Past experience	1.1	0.90	0.80	0.15

Table 5

The Responses Obtained from the Third of the Three HRMs and the Weights of the Criteria

	Criteria	sj	kj	qj	wj
C1	Personality		1	1	0.18
C2	Self-confidence	1	1.00	1.00	0.18
C3	Communication and presentation skills	1.05	0.95	1.05	0.19
C4	Interview preparedness	0.9	1.10	0.96	0.17
C5	Education	0.7	1.30	0.74	0.13
C6	Past experience	1	1.00	0.74	0.13

As one may see from Table 4, the HRM2 used the advantages of the proposed approach when evaluating Criterion C6 by assigning greater significance to it in relation to Criterion C5. The mentioned advantage was also used by the HRM3 when Criterion C3 was evaluated.

Finally, the weights of the evaluation criteria obtained from the three HRMs are summarily shown in Table 6.

Table 6

The Weights of the Criteria Obtained from the Three HRMs

	Criteria	w_j^1	w_j^2	w_j^3	w_j^*	w_j
C1	Personality	0.190	0.189	0.182	0.187	0.187
C2	Self-confidence	0.190	0.189	0.182	0.187	0.187
C3	Communication and presentation skills	0.190	0.180	0.192	0.187	0.187
C4	Interview preparedness	0.152	0.156	0.175	0.161	0.161
C5	Education	0.152	0.136	0.134	0.140	0.141
C6	Past experience	0.127	0.151	0.134	0.137	0.137
	ρ	0.914	0.771	0.971		

The usability of the procedure proposed for checking the reliability of the data collected proposed in Subsection 3.1. is also presented in Table 6. The high values of Spearman's ρ confirm the reliability of the data collected.

6.2. The Second Numerical Illustration

In the second numerical illustration, some partial results adopted from the case study conducted for the purpose of the evaluation of traditional Serbian restaurants, known as kafana6, in the city of Zaječar, Serbia, are presented. On the basis of the consultations conducted with the local experts from within the field of tourism and hospitality, the following set of criteria was chosen for the purpose of making the evaluation:
C1, the interior of the building and friendly atmosphere,
C2, the courtesy and friendliness of the staff,
C3, the variety of traditional food and drinks,
C4, the quality and taste of food and drinks, including the manner of serving,
C5, the reasonable price for the quality of the services provided, and
C6, Other.

Out of about 50 persons interviewed through an e-mail questionnaire, positive feedback and the correctly completed questionnaires were received from 35 interviewed people.

The responses, the computational details and the weight of the criteria obtained from the first of the three randomly selected respondents are accounted for in Tables 7, 8 and 9.

Table 7

The Responses, the Computational Details and the Weight of the Criteria Obtained from the First of the Three Respondents, Computed by Applying the PIPRECIA Approach

Criterion	sj	kj	qj	wj
C1		1	1	0.13
C2	1.10	0.90	1.11	0.15
C3	1.20	0.80	1.39	0.19
C4	1.05	0.95	1.46	0.20
C5	0.95	1.05	1.39	0.19
C6	0.70	1.30	1.07	0.14

Table 8

The Responses, the Computational Details and the Weight of the Criteria Obtained from the First of the Three Respondents, Computed by Applying the Inverse PIPRECIA Approach

Criterion	sj	kj	qj	wj
C1	0.8	1.20	1.00	0.14
C2	0.9	1.10	1.20	0.17
C3	0.95	1.05	1.32	0.19
C4	1.2	0.80	1.39	0.20
C5	1.1	0.90	1.11	0.16
C6	0.8	1	1	0.14

6 The word kafana originates from the Turkish word kahvehane, which means a place for drinking coffee. Over time, under the influence of different cultures, kafana has obtained its own specificity in the Balkan Peninsula, also having been recognized as a place for food consumption and later for serving alcohol drinks. Nowadays, “kafanas” are still places in which people meet their friends, have celebrations, make conversations and discuss things, and so on.

The weights of the criteria obtained by using the PIPRECIA, the inverse PIPRECIA and finally the PIPRECIA-E approaches are presented in Table 9. The relatively high value of Spearman's ρ confirms the reliability of the data collected, i.e. it confirms that the first respondent gave a relatively consistent response.

The responses, the computational details and the weights obtained from the second and the third respondents are shown in Tables 10 and 11.

Table 9

The Responses, the Computational Details and the Weight of the Criteria Obtained from the First of the Three Respondents, Computed by Applying the PIPRECIA-E Approach

Criterion	w_j	Rank	w'_j	Rank	w''_j
C1	0.135	6	0.143	5	0.139
C2	0.150	4	0.171	3	0.160
C3	0.187	3	0.188	2	0.188
C4	0.197	1	0.198	1	0.197
C5	0.188	2	0.158	4	0.173
C6	0.144	5	0.142	6	0.143
				ρ	0.771

Table 10

The Responses and the Weight of the Criteria Obtained from the Second of the Three Respondents, Computed by Applying the PIPRECIA-E Approach

Criterion	s_j	w_j	Rank	s'_j	w'_j	Rank	w''_j
C1		0.11	6	0.65	0.13	6	0.12
C2	1.2	0.13	4	1.05	0.18	2	0.15
C3	0.9	0.12	5	0.80	0.17	4	0.14
C4	1.5	0.24	1	1.15	0.20	1	0.22
C5	0.9	0.22	2	1.10	0.17	3	0.19
C6	0.8	0.18	3		0.15	5	0.17
						ρ	0.714

Table 11

The Responses and the Weight of the Criteria Obtained from the Third of the Three Respondents, Computed by Applying the PIPRECIA-E Approach

Criterion	s_j	w_j	Rank	s'_j	w'_j	Rank	w''_j
C1		0.09	6	0.50	0.12	5	0.11
C2	1.4	0.15	4	1.10	0.19	3	0.17
C3	0.7	0.12	5	0.80	0.17	4	0.14
C4	1.5	0.24	1	1.00	0.20	1	0.22
C5	1	0.24	1	1.40	0.20	1	0.22
C6	0.6	0.17	3		0.12	6	0.14
						ρ	0.657

The relatively high values of Spearman's ρ also confirm the reliability of the data collected from the second and the third respondents.

Finally, the group weights calculated by using Eqs (24) and (25) are shown in Table 12.

Table 12

The Weights of the Criteria Obtained from the Three HRMs

	Criterion	w''^{1}_{j}	w''^{2}_{j}	w''^{3}_{j}	w^{*}_{j}	w_j
C1	The interior of the building and friendly atmosphere	0.14	0.12	0.11	0.12	0.12
C2	A courtesy and friendliness of staff	0.16	0.15	0.17	0.16	0.16
C3	The variety of traditional food and drinks	0.19	0.14	0.14	0.16	0.16
C4	The quality and taste of food in drinks, including the manner of serving	0.20	0.22	0.22	0.21	0.21
C5	Reasonable price for the quality of services provided	0.17	0.19	0.22	0.19	0.20
C6	Other	0.14	0.17	0.14	0.15	0.15
	ρ	0.771	0.714	0.657		

Conclusion

In this paper, the two extensions of the SWARA method formed with the aim of enabling an easier use of this particular method in solving group multiple criteria decision-making problems are proposed.

Compared with the ordinary SWARA method, the proposed extensions of the SWARA method do not require a consensus during the formation of the lists of the evaluation criteria sorted according to their expected importance. The proposed approaches provide greater flexibility compared to the SWARA method and also enable its much wider usage in solving different MCGDM problems.

The usability of the proposed extensions has been tested and proved based on the two case studies. In the first case study, a classical paper questionnaire was used, whereas in the second, an interactive questionnaire prepared in Excel was used. The second approach to examination also enabled the participants to see the calculated weights of the criteria, in both the numerical and the graphic forms, and allowed them to make certain changes if they were not satisfied with the results obtained.

In addition to that, the non-mandatory procedures for checking the reliability of data collected are also given in the proposed extensions, which can assign certain advantages to them in comparison with the SWARA method.

In the PIPRECIA method, the correlation coefficient is calculated relative to the geometric mean calculated on the basis of the responses obtained from the surveyed respondents. Such an approach can be specified as an efficient and easy-to-use approach. However, this manner of checking the reliability of the data collected could unreasonably exclude the responses of those respondents whose attitudes substantially differ from the attitudes expressed by the majority, especially when a high value of the correlation coefficient is required.

The computational procedure of the PIPRECIA-E method is more complex compared to the computational procedure of the PIPRECIA method and is based on the bidirectional approach to the determination of the weights of criteria.

Unlike the checking procedure proposed for being used with the PIPRECIA method, in PIPRECIA-E the reliability of the data collected is determined on the basis of the data collected from the same respondent by applying the PIPRECIA and the inverse PIPRECIA approaches. Therefore, the use of the PIPRECIA-E method could have some advantages when a non-homogeneous group of respondents is involved in a research study.

While doing so, we should always keep in mind the fact that the use of the inverse PIPRECIA method is not so simple for and understandable to all respondents. Therefore, higher values for the correlation coefficient should not be required when the PIRRECIA-E method is being applied.

Finally, the initial investigations conducted in order to verify the proposed extensions of the SWARA method, the PIPRECIA and PIPRECIA-E methods, confirm their usability and point to their advantages.

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