8. SIMPLIFIED PIVOT PAIRWISE RELATIVE CRITERIA IMPORTANCE ASSESSMENT (PIPRECIA-S) METHOD

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Abstract

This article aims to consider and propose the use of a simplified variant of the PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA) method. Unlike the PIPRECIA method, where the significance of the criteria is determined in regards to the previous one, in the case of the Simplified PIPRECIA method the comparison of all criteria is done in regards to the significance of the first criterion, which should facilitate the expression of respondents' attitudes, especially when attitudes of ordinary respondents are needed for research. Since the PIPRECIA method is subjective, the Simplified PIPRECIA method is specifically designed for use with interactive questionnaires designed in a spreadsheet program so that respondents can numerically and graphically see the results obtained based on their attitudes, and correct them as needed. The article discusses three examples of using the Simplified PIPRECIA (PIPRECIA-S) method for determining the criteria weights, as well as evaluating alternatives.

Keywords: criteria weights, PIPRECIA, Simplified PIPRECIA, PIPRECIA-S, website evaluation, wineries

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1. Introduction

The goal of multi-criteria decision-making (MCDM) is to enable decision-makers to analyze possible decisions and choose the most acceptable one from the set of available alternatives (Özdağoğlu *et al*., 2021; Karamaşa, 2021; Bakir *et al*., 2020). To solve a large number of different problems as efficiently as possible, over time, numerous MCDM methods have been proposed, such as Simple Additive Weighting (SAW) method (MacCrimon, 1968), ELimination Et Choice Translating REality (ELECTRE) method (Benayoun *et al*., 1966), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method (Hwang and Yoon, 1981), Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) method (Brans and Vincke, 1985), Multi-criteria optimization and compromise solution (VIKOR) method (Opricovic, 1998), and so on.

Determining the weight of the criteria is one important step in the process of evaluating alternatives using an MCDM method. Therefore, so far, numerous MCDM methods, which enable determining the criteria weights have been proposed. It is also important to mention that these methods enable the overall evaluation of alternatives, that is, solving MCDM problems. As some of these methods can be mentioned: Entropy method (Shannon, 1948), Analytic Hierarchy Process (AHP) method (Saaty, 1980), Analytic Network Process (ANP) method (Saaty and Vargas, 2001), Step-wise Weight Assessment Ratio Analysis (SWARA) method (Kersuliene *et al*., 2010), Best-Worst (BWM) method (Rezaei, 2015), PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA) method (Stanujkic *et al*., 2017), Full consistency (FUCOM) method (Pamucar *et al*., 2018), etc.

The SWARA method has been used to solve a large number of decision-making problems, such as: solving legislative tasks (Keršuliene *et al*., 2010), selecting a packaging design (Stanujkic *et al*., 2015), evaluating external walls (Ruzgys *et al*., 2014), prioritizing sustainability assessment indicators of the energy system (Zolfani and Saparauskas, 2013), and so on. Numerous extensions have been proposed for this method, such as grey (Ceo et al., 2019, Stanujkic *et al*., 2021) and fuzzy (Zarbakhshnia *et al*., 2018) extensions.

Compared to the SWARA method, the PIPRECIA method does not require sorting criteria according to the expected significance before its use. The PIPRECIA method is less commonly used than the SWARA method. Some examples of the application of this method are: website evaluation (Stanujkic *et al*., 2021), solving the transportation company selection problem (Ulutaş *et al*., 2020), measuring performance of healthcare supply chains (Biswas, 2020), personnel selection (Ulutaş *et al*., 2020), determining criteria significance in selecting reach stackers (Vesković *et al*. 2020), prioritization of road transportation risks (Memiş *et al*., 2020), determining customer satisfaction (Stanujkic *et al*., 2019), etc. Grey (Ulutaş *et al*., 2020, Stanujkic *et al*., 2021) and fuzzy (Stevic *et al*. 2018) extensions have been proposed for this method.

During the application of the PIPRECIA method, for surveying respondents, some of the respondents suggested that it would be easier for them to always compare the significance of the criteria with the significance of the first criterion. Therefore, the Simplified PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA-S) method is proposed in this article, and the rest of this article is organized as follows: In Section 2, the PIPRECIA method is presented and the Simplified PIPRECIA method is proposed, while in Section 3 a comparison was made between the results obtained using the SWARA, PIPRECIA and Simplified PIPRECIA methods. In Section 4, the usage of the Simplified PIPRECIA method

for determining the criteria weights, evaluation of winery websites, and evaluation of alternatives in a group environment are presented. Finally, conclusions are given.

2. Preliminaries

2.1. The PIPRECIA method

The procedure for determining the relative importance of an alternative using the PIPRECIA method can be presented as follows:

Step 1. Determine the set of evaluation criteria.

Step 2. Set the relative significance s_j of each criterion, except the first, as follows:

$$s_j = \begin{cases} 1 & if C_j \succ C_{j-1} \\ 1 & if C_j = C_{j-1}, \\ 1 & if C_j \prec C_{j-1} \end{cases} \quad (1)$$

where: C_j and C_{j-1} denote the significance of criterion j and criterion j-1, respectively; and $j \neq 1$.

In the PIPRECA method, the value of s_1 is set to 1, while values of s_{j-1} belong to the interval (1, 1.9] when $C_j \succ C_{j-1}$, that is to the interval [0.1, 1) when $C_j \prec C_{j-1}$.

Step 3. Calculate the value of coefficient k_j as follows:

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

Step 4. Calculate the recalculated weight q_j as follows:

$$q_j = \begin{cases} 1 & if j = 1 \\ \frac{q_{j-1}}{k_j} & if j > 1 \end{cases}. \quad (3)$$

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

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}. \quad (4)$$

where: k denotes the number of the criteria.

2.1. The Simplified PIPRECIA (PIPRECIA-S) method

In the PIPRECIA method, the value of si is assigned based on a comparison of the significance of the evaluated criterion with the significance of the previous (j-1) criterion.

During using the PIPRECIA method so far, some respondents stated that it would be easier for them to always make comparisons with the first criterion instead of the previous one.
To enable this, one adaptation of the PIPRECIA method, named the Simplified PIPRECIA method, is proposed in this article. The change in the way of criteria comparisons was reflected in Eq. (1) and Eq. (3) so that the calculation procedure of the Simplified PIPRECIA method can be presented as follows:

Step 1. Determine the set of evaluation criteria.

Step 2. Set the relative significance s_j of each criterion, except the first, as follows:

$$s_j = \begin{cases} 1 & if C_j \succ C_1 \\ 1 & if C_j = C_1, \\ 1 & if C_j \prec C_1 \end{cases} \quad (5)$$

where: $j \neq 1$.

Similar to the PIPRECIA method, the value of s_1 is set to 1, while values of s_j belong to the interval (1, 1.9] when $C_j \succ C_1$, that is to the interval [0.1, 1) when $C_j \prec C_1$.

Step 3. Calculate the value of coefficient k_j as follows:

$$k_j = \begin{cases} 1 & if j = 1 \\ 2 - s_j & if j > 1 \end{cases}. \quad (6)$$

Step 4. Calculate the recalculated weight q_j as follows:

$$q_j = \begin{cases} 1 & if j = 1 \\ \frac{1}{k_j} & if j > 1 \end{cases}. \quad (7)$$

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

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}. \quad (8)$$

3. A simple comparison of SWARA, PIPRECIA, and Simplified PIPRECIA methods

In this section, a simple comparison of SWARA, PIPRECIA, and Simplified PIPRECIA methods is presented. Suppose that there are four criteria, where criteria C_1 and C_2 have the same significance, while criteria C_3 and C_4 are 50% less significant than the previous ones. The details of the calculation using the three methods, as well as the calculated weights of the criteria, can be summarized in Tables 1 to 3.

Table 1

Calculation details obtained by using the SWARA method

	s_j	k_j	q_j	w_j	$(w_j-w_{j-1})/w_j$
C_1		1	1	0.32	
C_2	0.00	1.00	1.00	0.32	0.00
C_3	0.50	1.50	0.67	0.21	0.33
C_4	0.50	1.50	0.44	0.14	0.33
			3.11	1.00	

Table 2

Calculation details obtained by using the PIPRECIA method

	s_j	k_j	q_j	w_j	$(w_j-w_{j-1})/w_j$
C_1		1	1	0.32	
C_2	1.00	1.00	1.00	0.32	0.00
C_3	0.50	1.50	0.67	0.21	0.33
C_4	0.50	1.50	0.44	0.14	0.33
			3.11	1.00	

Table 3

Calculation details obtained by using the Simplified PIPRECIA method

	s_j	k_j	q_j	w_j	$(w_j-w_{j-1})/w_j$
C_1		1	1	0.31	
C_2	1.00	1.00	1.00	0.31	0.00
C_3	0.50	1.50	0.67	0.21	0.33
C_4	0.25	1.75	0.57	0.18	0.14
			3.24	1.00	

From Tables 1, 2, and 3 one may see that the relative importance s_j, in the above-considered methods, is not a simple relationship between the importances of the compared criteria expressed in percentages, and therefore it is not easy to introduce some predefined linguistic variables that would facilitate expression of respondents' attitudes. Therefore, it is suggested that PIPRECIA and Simplified PIPRECIA methods should be used in interactive questionnaires created in a spreadsheet program that will interactively, numerically and graphically, show respondents the results obtained based on their attitudes, and allow them to make corrections if necessary.

4. A Numerical Illustrations

The Simplified PIPRECIA method, like AHP, SWARA, or PIPRECIA methods, can be used for determining the criteria weights, as well as for completely solving MCDM problems.

Therefore, three numerical illustrations are considered in this section. In the first numerical illustration, the Simplified PIPRECIA method was used for determining the criteria weights, while in the second one, the Simplified PIPRECIA was used for evaluating alternatives, that is, the websites of selected wineries. The third numerical illustration summarizes the application of the Simplified PIPRECIA method in a group decision-making environment.

4.1. The first numerical illustration

In this case study, the use of the Simplified PIPRECIA method for determining the criteria weights for winery websites evaluating is considered. After considering similar cases of websites evaluation, the following evaluation criteria were selected:

- Visual design,
- Content, structure, and navigation,
- Technology,
- Ordering and payment, and
- Contact information.

The results obtained using the calculation procedure of the Simplified PIPRECIA method, in the case of determining criteria weights, are summarized in Table 4.

As shown in Subsection 2.1., the Simplified PIPRECIA method, values in columns labeled as k_j, q_j, and w_j were calculated using Eqs. (6), (7) and (8).

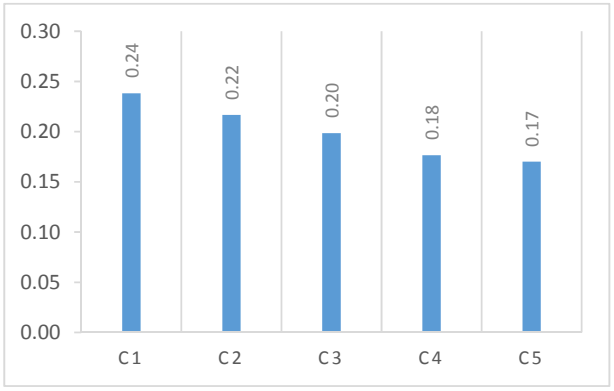
Table 4

Calculation details obtained using the Simplified PIPRECIA method

	Criterion	s_j	k_j	q_j	w_j
C_1	Visual design		1	1	0.24
C_2	Content, structure, and navigation	0.90	1.10	0.91	0.22
C_3	Technology	0.80	1.20	0.83	0.20
C_4	Ordering and payment	0.65	1.35	0.74	0.18
C_5	Contact information	0.60	1.40	0.71	0.17
				4.20	1.00

Figure 1 shows the graphical representation that the respondent sees when entering data, and it is automatically generated when entering or changing the value of s_j.

Figure 1. Graphical representation of calculated criteria weights



4.2. The second numerical illustration

In the second numerical illustration, the Simplified PIPRECIA method was used for evaluating four websites of well-known wineries from Serbia, based on the criteria mentioned in the previous case study. This numerical illustration is based on the attitudes obtained from one randomly selected respondent from a group of 15 respondents.

In this case study, the websites of the following wineries were evaluated:

- Zvonko Bogdan Winery (Zvonko Bogdan Winery, https://www.vinarijazvonkobogdan.com/)
- Jovic Winery (Winery Jovic, https://vinarijajovic.rs/en/)
- Matalj winery (Matalj winery, http://www.mataljvinarija.rs/)
- Malca Wine Cellar (Malca Wine Cellar, http://www.podrummalca.com/)

It should be emphasized that the order of the alternatives in the following tables does not correspond to the order of the listed websites, because the aim of this case study is not to favor or promote any of mentioned wineries. This case study aims to present and consider the applicability of one MCDM method. Anyone who wants to check the usability of the Simplified PIPRECIA method can conduct similar evaluations and gain their attitudes and views on its usage.

The results of the evaluations of the four websites based on the first criterion, C_1 - Visual design, are shown in Table 5. The mentioned evaluation was also performed using Equations (5) - (8).

Table 5

Calculation details and weights (relative importance) of the considered alternatives concerning criterion C_1

	s_j	k_j	q_j	w_{i1}
A_1		1	1	0.28
A_2	0.97	1.03	0.97	0.27
A_3	0.6	1.40	0.71	0.20
A_4	0.92	1.08	0.93	0.26
			3.61	1.00

The results of evaluating websites of wineries from Serbia based on the remaining four criteria are shown in Tables 6 to 9.

Table 6

The relative importance of the considered alternatives concerning criterion C_2

	s_j	k_j	q_j	w_{i2}
A_1		1	1	0.25
A_2	0.9	1.10	0.91	0.23
A_3	0.9	1.10	0.91	0.23
A_4	1.1	0.90	1.11	0.28
			3.93	1.00

Table 7

The relative importance of the considered alternatives concerning criterion C_3

	s_j	k_i	q_i	w_{i3}
A_1		1	1	0.26
A_2	1	1.00	1.00	0.26
A_3	0.9	1.10	0.91	0.24
A_4	0.95	1.05	0.95	0.25
			3.86	1.00

Table 8

The relative importance of the considered alternatives concerning criterion C_4

	s_j	k_j	q_j	w_{i4}
A_1		1	1	0.27
A_2	0.8	1.20	0.83	0.22
A_3	0.8	1.20	0.83	0.22
A_4	1.05	0.95	1.05	0.28
			3.72	1.00

Table 9

The relative importance of the considered alternatives concerning criterion C_5

	s_j	k_j	q_j	w_{i5}
A_1		1	1	0.26
A_2	0.9	1.10	0.91	0.24
A_3	0.95	1.05	0.95	0.25
A_4	1	1.00	1.00	0.26
			3.86	1.00

Based on the data from Tables 4 - 9, the final decision matrix shown in Table 10 was formed, which was used for the evaluation of the considered winery websites.

Table 10

The final ranking of the websites of the considered wineries

	C_1	C_1	C_3	C_4	C_5	S_i	Rank
w_j	0.24	0.22	0.20	0.18	0.17		
A_1	0.28	0.25	0.26	0.27	0.26	0.2640	2
A_2	0.27	0.23	0.26	0.22	0.24	0.2452	3
A_3	0.20	0.23	0.24	0.22	0.25	0.2255	4
A_4	0.26	0.28	0.25	0.28	0.26	0.2653	1

The overall utility of alternative i, S_i, was calculated using the well-known Eq. (9) applied in the AHP and SWARA methods, which has the following form:

$$S_i = w_j w_{ij}, \tag{9}$$

where: w_j denotes the weight of criterion j and w_{ij} denotes the significance of alternative i concerning criterion j.

From Table 10 one may see that the winery website denoted by A_4 is the most appropriate based on the attitudes of one respondent. However, it should be emphasized that the S_i of the winery website denoted by A_1 also has a slightly lower value and that there is no big difference in the value of S_i between the considered websites, which was expected because wine in Serbia is not just wine. In Serbia, wine is treated as art or even poetry.

4.3. The third numerical illustration

In this numerical illustration, the use of the Simplified PIPRECIA method in a group decision-making environment is considered, on the example of selecting a laptop computer.

It is known that computers with better features have higher prices. It is also known that when choosing a computer, many computer characteristics should be taken into account, such as CPU characteristics, RAM characteristics, graphics card and display characteristics, and so on. In addition, the choice of the most adequate computer is often limited by the amount of the fund intended for the purchase of IT equipment.

Due to the simpler presentation of the procedure of applying the Simplified PIPRECIA method in a group decision-making environment, in this numerical illustration, 4 laptops were evaluated, whose price does not exceed 700 euros, based on five complex criteria, which are as follows:

- CPU,
- Screen,

- Storage,
- RAM, and
- Graphics.

The above-mentioned criteria are complex because, for example, the CPU has many characteristics that need to be considered when evaluating laptops, such as brand, model, clock speed, cache size, and so on. It is similar to other selected criteria. For example, when evaluating RAM, the following characteristic should be considered: capacity, type of memory, speed, latency, etc.

The evaluation of laptops was performed based on the attitudes of three IT specialists from the Faculty of Applied Management, Economics, and Finance - MEF, Belgrade, Serbia. The evaluation was performed on four laptops whose features were available on the following web addresses at the time of the evaluation:

- https://www.tehnomanija.rs/it-shop/laptop-racunari/hp-240-g8-2x7j3ea.html
- https://www.tehnomanija.rs/it-shop/laptop-racunari/asus-p2451fa-eb1528r.html
- https://www.tehnomanija.rs/it-shop/laptop-racunari/asus-x515ja-wb503t.html
- https://www.tehnomanija.rs/it-shop/laptop-racunari/lenovo-ideapad-5-laptop-82lm0049ya.html

As in the previous evaluation, it should be noted that in the further evaluation the designation of the alternatives is not the same as the order of the above-mentioned laptops.

The criteria weights obtained from the first IT specialist, as well as the calculation details, are shown in Table 11, while the criteria weights obtained from the three IT specialists, as well as the arithmetic mean of three criteria weights, are shown in Table 12. It should be noted here that the criteria weights, as well as the further evaluation, were performed for laptops intended for medium-demanding office users.

Table 11

Criteria weights calculated based on the attitudes of the first of three IT specialists

	Criterion	s_j	k_j	q_j	w_j^1
C_1	CPU		1	1	0.19
C_2	Screen	1.2	0.80	1.25	0.24
C_3	Storage	1.3	0.70	1.43	0.28
C_4	RAM	0.8	1.20	0.83	0.16
C_5	Graphics	0.5	1.50	0.67	0.13
				5.18	1.00

Table 12

Criteria weights were calculated based on the attitudes of three IT specialists

	s_j^1	s_j^2	s_j^3	w_j^1	w_j^2	w_j^3	$\overline{w}_j$
C_1				0.19	0.19	0.19	0.19
C_2	1.20	1.20	1.20	0.24	0.24	0.24	0.24
C_3	1.30	1.30	1.30	0.28	0.28	0.28	0.28
C_4	0.80	0.80	0.80	0.16	0.16	0.16	0.16
C_5	0.50	0.50	0.50	0.13	0.13	0.13	0.13

The relative importance of the four considered laptops concerning the first criterion, CPU, is shown in Table 13, while the ratings, relative importance of all considered laptops obtained from the three respondents, as well as the arithmetic means of relative importance, are shown in Table 14.

Table 13

The relative importance of laptops concerning the first criterion, based on the attitudes of the first of three IT specialists

	s_j	k_j	q_j	i_{ij}^1
A_1		1	1	0.26
A_2	1	1.00	1.00	0.26
A_3	1	1.00	1.00	0.26
A_4	0.8	1.20	0.83	0.22
			3.83	1.00

Table 14

The relative importance of laptops concerning the first criterion

	s_j^1	s_j^2	s_j^3	i_{i1}^1	i_{i1}^2	i_{i1}^3	$\bar{i}_{i1}$
A_1				0.26	0.26	0.26	0.26
A_2	1.00	1.00	1.00	0.26	0.26	0.26	0.26
A_3	1.00	1.00	1.00	0.26	0.26	0.26	0.26
A_4	0.80	0.90	0.85	0.22	0.23	0.22	0.22

The relative importance of the remaining four criteria, as well as their mean values, are shown in Tables 15 to 18.

Table 15

The relative importance of laptops concerning the second criterion

	s_j^1	s_j^2	s_j^3	i_{i2}^1	i_{i2}^2	i_{i2}^3	$\bar{i}_{i2}$
A_1				0.22	0.23	0.24	0.23
A_2	1.00	1.00	1.00	0.22	0.23	0.24	0.23
A_3	1.30	1.30	1.20	0.31	0.32	0.29	0.31
A_4	1.10	1.00	1.00	0.24	0.23	0.24	0.24

Table 16

The relative importance of laptops concerning the third criterion

	s_j^1	s_j^2	s_j^3	i_{i3}^1	i_{i3}^2	i_{i3}^3	$\bar{i}_{i3}$
A_1				0.23	0.21	0.23	0.22
A_2	1.00	1.00	1.00	0.23	0.21	0.23	0.22
A_3	1.00	1.00	1.00	0.23	0.21	0.23	0.22
A_4	1.30	1.40	1.30	0.32	0.36	0.32	0.33

Table 17

The relative importance of laptops concerning the fourth criterion

	s_j^1	s_j^2	s_j^3	i_{i4}^1	i_{i4}^2	i_{i4}^3	$\bar{i}_{i4}$
A_1				0.20	0.23	0.21	0.21
A_2	1.00	1.00	1.00	0.20	0.23	0.21	0.21
A_3	1.10	1.00	1.00	0.22	0.23	0.21	0.22
A_4	1.50	1.30	1.40	0.39	0.32	0.36	0.36

Table 18

The relative importance of laptops concerning the fifth criterion

	s_j^1	s_j^2	s_j^3	i_{i5}^1	i_{i5}^2	i_{i5}^3	$\bar{i}_{i5}$
A_1				0.26	0.26	0.26	0.26
A_2	1.00	1.00	1.00	0.26	0.26	0.26	0.26
A_3	1.00	1.00	1.00	0.26	0.26	0.26	0.26
A_4	0.80	0.90	0.80	0.22	0.23	0.22	0.22

The final evaluation of the most suitable laptop, performed using Eq (9) is summarized in Tables 19 and 20.

Table 19

The criteria weights and importance of alternatives concerning the criteria

	C_1	C_1	C_3	C_4	C_5
w_j	0.19	0.24	0.28	0.16	0.13
A_1	0.26	0.23	0.22	0.21	0.26
A_2	0.26	0.23	0.22	0.21	0.26
A_3	0.26	0.31	0.22	0.22	0.26
A_4	0.22	0.24	0.33	0.36	0.22

Table 20

The final ranking of the four laptops

	C_1	C_1	C_3	C_4	C_5	S_i	Rank
A_1	0.05	0.05	0.06	0.03	0.03	0.23	3
A_2	0.05	0.05	0.06	0.03	0.03	0.23	3
A_3	0.05	0.07	0.06	0.04	0.03	0.25	2
A_4	0.04	0.06	0.09	0.06	0.03	0.28	1

As may be concluded from Table 20, the most acceptable alternative, based on the views of the three respondents, is alternative A_4.

Conclusions

The PIPRECIA method was formed based on the SWARA method, to enable determining criteria weights, without the need to sort criteria according to their expected significance before applying the method.

In this article, the simplified version of the PIPRECIA method is proposed. The Simplified PIPRECIA method has significant similarities with the PIPRECIA method, but also its

specifics. Unlike the PIPRECIA method, where each criterion is compared with the previous one, the criteria are always compared with the first criterion in the Simplified PIPRECIA method.

This method was formed based on the suggestions of the respondents who used the PIPRECIA method and based on what they suggested that it would be easier for them to always compare the significance of the criteria with the significance of the first criterion. In addition, this method is intended for use with interactive questionnaires, when collecting attitudes of respondents that are not prepared in advance for its usage.

The Simplified PIPRECIA method is primarily intended for determining the criteria weights, but it can also be applied for completely solving any MCDM problem, as well as in cases of group decision-making, as shown in the considered numerical illustrations.

As a perceived weakness of this method, it can be stated that the relative importance of the criteria is not a simple relationship between the values of the criteria being compared, expressed as a percentage, which is why it is proposed to use this method with interactive questionnaires made in a spreadsheet program.

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