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COMPARATIVE ANALYSIS OF MULTIMOORA, WASPAS AND WISP METHODS: THE CASE OF CANDIDATE SELECTION

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Abstract: *This article conducts a comparative examination of three Multi-Criteria Decision Making (MCDM) methods: Multi-Objective Optimization by Ratio Analysis plus Full Multiplicative Form (MULTIMOORA), Weighted Aggregates Sum Product Assessment (WASPAS), and Simple Weighted Sum Product (WISP). The analysis is carried out within the context of a personnel selection problem, focusing exclusively on income attributes in the MCDM framework. The results obtained from the analysis, specifically the formulated ranking lists, reveal a consensus in selecting the same alternative as the most suitable across all three MCDM methods. However, there are partial discrepancies in the ranking lists of alternatives, highlighting variations in their assessments.*
Keywords: *human resources management, personnel selection, recruitment, MULTIMOORA, WASPAS, WISP, MCDM*

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1. Introduction

Numerous authors define Multiple Criteria Decision Making (MCDM) as the process of evaluating or ranking alternatives based on a set of conflicting criteria, as asserted by Levy (2005), Gebrezgabher et al. (2014), Qin et al. (2020), and Ardil et al. (2021). Since the close of the previous century, MCDM has proven instrumental in addressing a myriad of decision-making challenges, leading to the development of various MCDM methodologies. These encompass established methods such as the Simple Additive Weighting (SAW) method (MacCrimon, 1968), ELimination and Choice Expressing REality (ELECTRE) method (Roy, 1968), DEcision MAking Trial and Evaluation Laboratory (DEMATEL) method (Gabus and Fontela, 1972), Analytic Hierarchy Process (AHP) method (Saaty, 1977), Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS) method (Hwang and Yoon, 1981), Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) method (Brans, 1982), COmplex Proportional ASsessment (COPRAS) method (Zavadskas et al. 1994), and VIKOR method (Opricovic, 1998), which stands for Multicriteria Optimization and Compromise Solution in Serbian.

In addition to these well-established MCDM methods, a notable surge in newly proposed techniques is evident. Examples include the Additive Ratio Assessment (ARAS) method (Zavadskas and Turskis, 2010), Multi-Objective Optimization by Ratio Analysis plus Full

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Multiplicative Form (MULTIMOORA) method (Brauers and Zavadskas, 2010), Weighted Aggregates Sum Product Assessment (WASPAS) method (Zavadskas et al., 2012), Evaluation Based on Distance from Average Solution (EDAS) method (Keshavarz Ghorabaee et al., 2015), COmbined COmpromise SOlution (CoCoSo) method (Yazdani et al., 2018), Simple Weighted Sum Product (WISP) method (Stanujkic et al., 2021), and others. This diversity in MCDM methods underscores the ongoing evolution and refinement of decision-making tools to address a wide array of complex scenarios.

Among the existing MCDM methods proposed so far, there are certain differences in the approaches to the evaluation of alternatives, which are particularly related to the normalization procedures and aggregation procedures used by the MCDM methods. For example, the TOPSIS method is based on the distance from the Ideal and anti-ideal alternatives in the Euclidean space and the application of the vector normalization procedure, the VIKOR method is based on the Minkovsky metric and a specific normalization procedure, while the SAW method is based on the sum of weight-normalized performance criteria and various forms of normalization.

In addition to the previously mentioned approach, there can be mentioned some MCDM methods that integrate two or more approaches, often Weighted Sum (WS) and Weighted Product (WP) approaches, such as MULTIMOORA, WASPAS, CoCoSo and Simple WISP methods. Also, different MCDM methods often use different normalization procedures and treat beneficial and non-beneficial criteria in very different ways, that is, criteria for which higher ratings are more desirable and criteria for which lower ratings are more desirable.

For example, the MULTIMOORA method uses the Square Root normalization procedure and treats beneficial and non-beneficial criteria in the same manner, the WASPAS method uses the max normalization procedure but treats beneficial and non-beneficial criteria in a different manner, while the WISP method also uses the max normalization procedure but treats beneficial criteria in the same way as the non-beneficial criteria. From the previously mentioned, It is obviously evident that the normalization procedures used in MCDM methods are in relation to the aggregation procedures used by these MCDM methods and that the impact of non-beneficial criteria on the total utility of an alternative is determined during the normalization procedure or in the aggregation procedure, that is, the calculation of the total utility of the alternative.

Therefore, in this article, a comparison of two well-known MCDM methods, MULTIMOORA and WASPAS methods, and a newly proposed MCMD method, the Simple WISP method, was made. It was previously mentioned that these methods integrate two or more approaches and that they are based on the use of WS and WP approaches.

Previously has been stated that many MCDM problems include beneficial and non-beneficial criteria. However, the number of MCDM problems that do not include non-beneficial criteria is not at all negligible, which is why an MCDM problem that does not include non-beneficial, i.e. the problem of personnel selection, was chosen for comparing three selected MCDM methods. Therefore, the rest of this article is organized as follows: In Section 2, i.e. the Methodology section, the previously mentioned MCDM methods, MULTIMOORA, WISP and WASPAS, as well as their variants adapted for solving MCDM problems that include only beneficial criteria, are presented, while in In Section 3, a numerical example is considered with the aim of showing in detail the application of the mentioned MCDM methods and pointing out their similarities and specificities. Finally, the corresponding conclusions are given.

2. Methodology

2.1. The MULTIMOORA method

The MULTIMOORA method integrates three approaches in order to evaluate alternatives and select the most appropriate one. As a result of the using three approaches, three ranking lists are formed, and the final ranking order of alternatives is formed by applying the theory of dominance.

The computational procedure of the MULTIMOORA for evaluating *m* alternatives on the basis on *n* beneficial and non-beneficial criteria can be explained precisely using the following steps:

Step 1. Calculate the normalized ratings r_{ij} of alternatives, as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n}(x_{ij})^2}} \tag{1}$$

where x_{ij} denotes the performance of the alternative *i* to the criterion *j*.

Step 2. Calculate the overall importance y_i of the alternative *i* using RS approach, as follows:

$$y_i = \sum_{j \in \Omega_{max}} r_{ij}\, w_j - \sum_{j \in \Omega_{min}} r_{ij}\, w_j \tag{2}$$

where Ω_{max} and Ω_{min} denote set of beneficial and set of non-beneficial criteria, respectively.

Step 3. Calculate the overall utility u_i of the alternative *i* using FMF approach, as follows:

$$u_i = \frac{\prod_{j \in \Omega_{max}} r_{ij}\, w_j}{\prod_{j \in \Omega_{min}} r_{ij}\, w_j}. \tag{3}$$

Step 4. Calculate the maximum distance d_i^{max} of the alternative *i* using RP approach, as follows:

$$d_i^{max} = max_j\left(w_j \left|r_j^* - r_{ij}\right|\right). \tag{4}$$

where d_i^{max} denotes the maximum distance of the alternative *i* to the reference point r_j^*, determined as follows:

$$r_j^* = max_i\, r_{ij}. \tag{5}$$

Step 5. Rank the alternatives and determine the most appropriate one. As result of applying RS, RP and FMF approaches there are three list of values: y_i, d_i^{max}, and u_i. For using theory of dominance values in lists y_i and u_i have to be lined up descending order and values in list d_i^{max} have to be lined up in ascending order.

The ultimate decision is determined through the application of the dominance theory. To elaborate, the alternative that consistently secures the topmost position across multiple ranking lists is considered the highest-ranked option. In essence, the decision-making process hinges on identifying the alternative that consistently outperforms others by being consistently favored in the primary positions across all ranking evaluations.

2.1.1. Adaption of the MULTIMOORA method for solving MCDM problems with only beneficial criteria

As mentioned earlier, some MCDM problems include only beneficial criteria. For solving such MCDM problems, the MULTIMOORA method must be slightly adapted as follows:

Step 1. Calculate the normalized ratings of alternatives, as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n}(x_{ij})^2}}. \tag{6}$$

Step 2. Calculate the overall importance of the alternatives using RS approach, as follows:

$$y_i = \sum_{j=1}^{n} r_{ij}\, w_j \tag{7}$$

Step 3. Calculate the overall utility of the alternatives using FMF approach, as follows:

$$u_i = \prod_{j=1}^{n} r_{ij}\, w_j. \tag{8}$$

Step 4. Calculate the maximum distance of the alternatives using RP approach, as follows:

$$d_i^{max} = max_j\left(w_j \left| r_j^* - r_{ij} \right|\right). \tag{9}$$

Step 5. Rank the alternatives as in case of using ordinary MULTIMOORA method.

2.2. The WASPAS method

The procedure for solving MCDM problem that contain m alternatives and n beneficial and non-beneficial criteria using WASPAS method can be concisely presented using the following steps:

Step 1. Calculate the normalized ratings, as follows:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{max_i\, x_{ij}} & x_{ij} \in \Omega_{max} \\ \frac{min_i\, x_{ij}}{x_{ij}} & x_{ij} \in \Omega_{min} \end{cases}. \tag{10}$$

Step 2. Calculate the relative importance $Q_i^{(1)}$, based on WS approach, as follows:

$$Q_i^{(1)} = \sum_{j=1}^{n} r_{ij}\, w_j \tag{11}$$

Step 3. Calculate the relative importance $Q_i^{(1)}$, based on WP approach, as follows:

$$Q_i^{(2)} = \prod_{j=1}^{n} {r_{ij}}^{w_j} \tag{12}$$

Step 4. Calculate the total relative importance Q_i, for each alternative, as follows:

$$Q_i = \lambda\, Q_i^{(1)} + (1-\lambda) Q_i^{(2)} = \lambda \sum_{j=1}^{n} r_{ij}\, w_j + (1-\lambda) \prod_{j=1}^{n} \left(r_{ij}\right)^{w_j}, \tag{13}$$

where λ is a coefficient and $\lambda \in [0, 1]$.
For simplicity, many calculations use a simplified form of equation (4), which has the following form:

$$Q_i = 0.5\, Q_i^{(1)} + 0.5 Q_i^{(2)}. \tag{14}$$

Step 5. Rank the alternatives and select the best one, which means that the alternative with the higher value of the total relative importance is more preferable.

2.2.1. Adaption of the WASPAS method for solving MCDM problems with only beneficial criteria

The WASPAS method does not require adaptations for evaluating alternatives based only on beneficial criteria. The only modification can be made to Eq. (10), as follows:

$$r_{ij} = \frac{x_{ij}}{max_i\, x_{ij}}, \tag{15}$$

but it is not necessary.

2.3. The WISP method

The WISP method incorporates four relationships that capture the interplay between beneficial and non-beneficial criteria, facilitating the assessment of an alternative's overall utility. The methodology for ranking and selecting the optimal alternative using WISP, within the context of a problem featuring m alternatives and n beneficial and non-beneficial criteria, is delineated through the subsequent steps, as outlined by Zavadskas et al. (2022):

Step 1. Construct a normalized decision-making matrix as follows:

$$r_{ij} = \frac{x_{ij}}{\max_i x_{ij}}. \tag{16}$$

Step 2. Calculate the values of four utility measures, as follows:

$$u_i^{sd} = \sum_{j\in\Omega_{\max}} r_{ij}w_j - \sum_{j\in\Omega_{\min}} r_{ij}w_j, \tag{17}$$

$$u_i^{pd} = \prod_{j\in\Omega_{\max}} r_{ij}w_j - \prod_{j\in\Omega_{\min}} r_{ij}w_j, \tag{18}$$

$$u_i^{sr} = \frac{\sum_{j\in\Omega_{\max}} r_{ij}w_j}{\sum_{j\in\Omega_{\min}} r_{ij}w_j}, \text{ and} \tag{19}$$

$$u_i^{pr} = \frac{\prod_{j\in\Omega_{\max}} r_{ij}w_j}{\prod_{j\in\Omega_{\min}} r_{ij}w_j}, \tag{20}$$

where: u_i^{sd} and u_i^{pd} denote differences between the weighted sum and weighted product of normalized ratings of alternative i, respectively. Similar to the previous one, u_i^{sr} and u_i^{pr} denote ratios between weighted sum and weighted product of normalized ratings of alternative i, respectively.

Step 3. Recalculate values of four utility measures, as follows:

$$\bar{u}_i^{sd} = \frac{1+u_i^{sd}}{1+max_i\, u_i^{sd}}, \tag{21}$$

$$\bar{u}_i^{pd} = \frac{1+u_i^{pd}}{1+max_i\, u_i^{pd}}, \tag{22}$$

$$\bar{u}_i^{sr} = \frac{1+u_i^{sr}}{1+max_i\, u_i^{sr}}, \text{ and} \tag{23}$$

$$\bar{u}_i^{pr} = \frac{1+u_i^{pr}}{1+max_i\, u_i^{pr}}, \tag{24}$$

where: $\bar{u}_i^{sd}$, $\bar{u}_i^{pd}$ $\bar{u}_i^{sr}$ and $\bar{u}_i^{pr}$ denote recalculated values of u_i^{sd}, u_i^{pd}, u_i^{sr} and u_i^{pr}.

Step 4. Determine the overall utility u_i of each alternative as follows:

$$u_i = \frac{1}{4}(\bar{u}_i^{sd} + \bar{u}_i^{pd} + \bar{u}_i^{sr} + \bar{u}_i^{pr}). \tag{25}$$

Step 5. Rank the alternatives and select the most suitable one. The alternatives are ranked in descending order, and the alternative with the highest value of u_i is the most preferred one.

2.3.1. Adaption of the WISP method for solving MCDM problems with only beneficial criteria

Unlike the WASPAS method, the WISP method requires some adjustments in order to solve MCDM problems that contain only income criteria. In fact, in such cases, the WISP method uses only two utility measures, and the calculation procedure can be shown as follows:

Step 1. Construct a normalized decision-making matrix as follows:

$$r_{ij} = \frac{x_{ij}}{\max_i x_{ij}}. \tag{26}$$

Step 2. Calculate the values of two utility measures, as follows:

$$u_i^{s} = \sum_{j=1}^{n} r_{ij}w_j, \text{ and} \tag{27}$$

$$u_i^{p} = \prod_{j=1}^{n} r_{ij}w_j, \tag{28}$$

where: u_i^s and u_i^p denote the weighted sum and the weighted product of normalized ratings of alternative i, respectively.

Step 3. Recalculate values of two utility measures, as follows:

$$\bar{u}_i^s = \frac{1+u_i^s}{1+max_i\, u_i^s}, \quad (29)$$

$$\bar{u}_i^p = \frac{1+u_i^p}{1+max_i\, u_i^p}, \quad (30)$$

where: $\bar{u}_i^s$ and $\bar{u}_i^p$ denote recalculated values of u_i^s of u_i^p.

Step 4. Determine the overall utility u_i of each alternative as follows:

$$u_i = \frac{\bar{u}_i^s + \bar{u}_i^p}{2}. \quad (31)$$

Step 5. Rank the alternatives and select the most suitable one, in the same way as in the ordinary WISP method.

3. Illustrative example

In this section, the evaluation of candidates for the position of software development engineer in an IT company is considered using MULTIMOORA, WASPAS and WISP methods. In this case, five candidates were evaluated based on seven criteria, namely: C_1 – Education, C_2 – Relevant work experience, C_3 – Relevant certificates, C_4 – Communication and presentation skills, C_5 – People management skills, C_6 – Organizational and planning skills and C_7 – Foreign language skills.

The attitudes of one Human Resources Manager (HRMs) regarding the candidates are shown in Table 1

Table 1. The ratings of candidates obtained from HRM

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
	0.11	0.13	0.13	0.15	0.15	0.15	0.16
A_1	4	3	3	3	4	3	4
A_2	4	3	4	4	3	4	4
A_3	5	5	4	3	3	4	3
A_4	4	5	3	4	4	5	3
A_5	5	4	3	3	4	4	3

Table 1 also shows the weights of the criteria. The normalized matrix, obtained by applying the MULTIMOORA method, i.e. using Eq. (6) is shown in Table 2, while the overall importances, overall utilities and maximum distances of considered alternatives, calculated by using Eqs. (7), (8) and (9), are shown in Table 3.

Table 2. The normalized matrix obtained using MULTIMOORA method

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	0.40	0.33	0.39	0.39	0.49	0.33	0.52
A_2	0.40	0.33	0.52	0.52	0.37	0.44	0.52
A_3	0.51	0.55	0.52	0.39	0.37	0.44	0.39
A_4	0.40	0.55	0.39	0.52	0.49	0.55	0.39
A_5	0.51	0.44	0.39	0.39	0.49	0.44	0.39

Table 3. The ratings of candidates obtained using the MULTIMOORA method

	y_i	u_i	d_i^{max}	Ranks y_i	u_i	d_i^{max}	Σ	The final rank
A1	0.41	0.0000000020	0.034	5	5	5	15	5
A2	0.45	0.0000000035	0.029	2	3	4	9	3
A3	0.45	0.0000000041	0.021	3	2	1	6	2
A4	0.47	0.0000000054	0.021	1	1	1	3	1
A5	0.43	0.0000000033	0.021	4	4	1	9	3

The final rank of candidates, obtained using MULTIMOORA method, is also given in Table 3. As it can be observed from this table the candidate denoted as A_4 is selected as the most appropriate candidate.

The normalized matrix, obtained by applying the WASPAS method, i.e. using Eq. (15) is shown in Table 4, while the relative importances based on WS approach, relative importances based on WP approach, and total relative importances of evaluated candidates calculated by using Eqs. (11), (12) and (14), are shown in Table 5.

Table 4. The normalized matrix obtained using WASPAS method

	C1	C2	C3	C4	C5	C6	C7
A1	0.80	0.60	0.75	0.75	1.00	0.60	1.00
A2	0.80	0.60	1.00	1.00	0.75	0.80	1.00
A3	1.00	1.00	1.00	0.75	0.75	0.80	0.75
A4	0.80	1.00	0.75	1.00	1.00	1.00	0.75
A5	1.00	0.80	0.75	0.75	1.00	0.80	0.75

Table 5. The ratings of candidates obtained using the WASPAS method

	$Q_i^{(1)}$	$Q_i^{(1)}$	Q_i	Ranks
A1	0.792	0.776	0.784	5
A2	0.856	0.843	0.850	2
A3	0.852	0.844	0.848	3
A4	0.904	0.896	0.900	1
A5	0.829	0.823	0.826	4

The final rank of candidates, obtained using WASPAS method, is also given in Table 5. As it can be observed from this table the candidate denoted as A_4 is also selected as the most appropriate candidate.

The normalized matrix, obtained by applying the WISP method, i.e. using Eq. (26) is shown in Table 6.

Table 6. The normalized matrix obtained using WASPAS method

	C1	C2	C3	C4	C5	C6	C7
A1	0.80	0.60	0.75	0.75	1.00	0.60	1.00
A2	0.80	0.60	1.00	1.00	0.75	0.80	1.00
A3	1.00	1.00	1.00	0.75	0.75	0.80	0.75
A4	0.80	1.00	0.75	1.00	1.00	1.00	0.75
A5	1.00	0.80	0.75	0.75	1.00	0.80	0.75

The values of the two utility measures, calculated using Eq. (27) and Eq. (28), as well as their recalculated values, calculated using Eq. (29) and Eq.(30), are shown in Table 7.

Table 7. The ratings of candidates obtained using the WISP method

	u_i^s	u_i^p	$\bar{u}_i^s$	$\bar{u}_i^p$	u_i	Ranks
A_1	0.792	0.0000002	0.941	0.9999997	0.9706	5
A_2	0.856	0.0000003	0.975	0.9999998	0.9874	2
A_3	0.852	0.0000004	0.973	0.9999999	0.9863	3
A_4	0.904	0.0000005	1.000	1.0000000	1.0000	1
A_5	0.829	0.0000003	0.961	0.9999998	0.9805	4

The final rank of candidates, obtained using WISP method, is also given in Table 7. As it can be observed from this table the candidate denoted as A_4 is also selected as the most appropriate candidate.

The rankings orders of candidates obtained using the MULTIMOORA, WASPAS and WISP methods are summarized in Table 8.

Table 8. The ranking order of candidates obtained using three MCDM methods

	MULTIMOORA	WASPAS	WISP
A_1	5	5	5
A_2	3	2	2
A_3	2	3	3
A_4	1	1	1
A_5	3	4	4

From Table 8 it can also be observed that candidate denoted as A_4 is selected as the most appropriate candidate using all MCDM methods.

It can also be seen from Table 8 that there is a certain difference in the ranking orders between MULTIMOORA and WASPAS methods and MULTIMOORA and WISP methods, while in this case, the ranking orders between WASPAS and WISP methods are identical.

However, such cases are quite expected considering the different normalization procedures used by the considered MCDM methods, as well as significant differences in the aggregation procedures used by the above-mentioned MCDM methods. In some cases, even small variations in criteria weights or ratings of alternatives in relation to evaluation criteria can lead to minor or major changes in the ranking orders of the considered alternatives.

Generally speaking, the use of different MCDM methods usually gives the same ranking for the first-placed alternative, and usually the ranking orders of evaluated alternatives differ to a greater or lesser extent. On the basis of numerous articles published so far in scientific and professional journals regarding the evaluation of alternatives using two or more MCDM methods, it can be concluded that the differences in ranking orders obtained using different MCDM methods differ to a greater or lesser extent, as well as that determining the similarities and differences in the results of evaluation which can be obtained by using various MCDM methods require certain simulations and analyzes.

4. Conclusion

Utilizing Multiple Criteria Decision Making (MCDM) offers a range of benefits in decision analysis and problem-solving. Firstly, MCDM enables a comprehensive consideration of multiple, often conflicting, criteria in decision-making processes, allowing for a more holistic evaluation. This approach provides decision-makers with a systematic framework to weigh various factors, promoting a more informed and balanced decision. Additionally, MCDM aids in handling complex and ambiguous situations by incorporating diverse perspectives and preferences, leading to more robust and adaptable solutions. The method fosters transparency in decision-making, as the explicit consideration of criteria and their respective weights enhances accountability and clarity. Furthermore, MCDM techniques can accommodate uncertainty and variability, contributing to a more resilient decision-making process in dynamic environments. Overall, the adoption of MCDM enhances the quality and effectiveness of decision outcomes by fostering a structured and inclusive approach to evaluating alternatives.

Therefore, in this article, the application of three MCDM methods, namely MULTIMOORA, WASPAS and WISP methods, was considered for evaluating MCDM problems that do not contain non-beneficial criteria. In order to apply the mentioned MCDM methods for solving the mentioned type of problems, the MULTIMOORA and WISP methods had to be adapted, while the WASPAS method did not require any modifications. The achieved results, i.e. the formed ranking lists, show that the same alternative was chosen as the most appropriate by applying all three MCDM methods, while the obtained ranking lists of alternatives partially differ.

Certain differences in the ranking orders of alternatives obtained by applying the aforementioned MCDM methods are certainly expected because the above-mentioned MCDM methods use different normalization procedures and also have different aggregation procedures. Determining the similarity of the ranking list of alternatives obtained by applying the mentioned MCDM methods in the case of solving different evaluation problems, requires solving a larger number of problems as well as certain simulations, which is certainly planned as a continuation of this research.

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