A New Approach to Weight Allocation in Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) for Fair Decision Making

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https://doi.org/10.5109/7363506

出版情報：Evergreen. 12 (2), pp.1226-1237, 2025-06. Transdiscilinary Research and Education Center for Green Technologies, Kyushu University
バージョン：

EVERGREEN - Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 12, Issue 02, pp. 1226-1237, June, 2025

A New Approach to Weight Allocation in Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) for Fair Decision Making

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(Received January 02, 2025; Revised April 25, 2025; Accepted May 01, 2025)

Abstract: This study proposes a new approach in weight allocation on the MOORA method to support fair and objective decision-making. MOORA modification using variation values is an approach that integrates variation values into the decision-making process using the MOORA method. the variation value is used to take into account the distribution of data in each criterion, so that it can increase the sensitivity of the analysis to the differences between alternatives. The MOORA modification with this variation value is named multi-objective optimization by ratio analysis-variance (MOORA-V). The results of the implementation show that this approach results in a more stable and reliable alternative ranking, even in the face of changes in weights or fluctuations in the data. Further sensitivity analysis confirmed that this method has good robustness and can reduce reliance on biased decisions. Thus, this new approach offers a more equitable and adaptive solution in multi-criteria decision-making, opening up opportunities for further development in more efficient and effective decision support systems. Further research can be developed to address uncertain data, such as fuzzy or interval data, to increase its flexibility in handling uncertainty in decision-making, as well as computational implementation using Python to improve reproducibility, facilitate validation by other researchers, and expand the potential for application in various fields.

Keywords: decision-making; MOORA-V; sensitivity analysis; variation value; weight allocation.

1. Introduction

The multi-objective optimization (MOO) method has an important role in decision-making because it is able to handle situations involving various goals that often contradict each other[1,2]. In the decision-making process, criteria such as efficiency, cost, quality, and impact often have to be considered simultaneously, requiring a systematic and measurable approach. MOO provide a framework for evaluating alternatives based on these various criteria, helping decision-makers understand possible compromises and choose optimal or near-optimal solutions. The importance of this method also lies in its ability to increase objectivity in decisions, as MOO utilizes mathematical and analytical techniques that reduce the influence of subjective bias. Another advantage of the MOO method is its ability to integrate decision-maker preferences into the analysis, allowing for solutions that are better suited to specific needs and contexts[3].

Fair weighting in a multi-criteria optimization process is one of the main challenges in MOO-based decision-making[4,5]. This challenge arises because weighting is a very crucial step to determine the importance of each criterion, which ultimately affects the final result of the decision. One of the main difficulties is subjectivity in determining weights, where the preferences of certain

Cite: D. Desyanti et al., "A New Approach to Weight Allocation in Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) for Fair Decision Making". Evergreen, 12 (02) 1226-1237 (2025). https://doi.org/10.5109/7363506.

individuals or groups can lead to biases that do not reflect actual needs or priorities[6,7]. This is especially problematic in decision-making involving many stakeholders with different views. In addition to subjectivity, another challenge is the imbalance of scale between criteria. Some criteria may have different units of measurement or distant value scales, so careless weighting can overlook or give over-dominance to certain criteria[8]. On the other hand, when using automated weighting methods such as entropy or criteria importance through intercriteria correlation (CRITIC), a gap can occur between the mathematical results and the actual preferences of the decision-makers. Another problem that is often faced is the difficulty in adjusting weights when conditions or priorities change, especially in dynamic situations. Traditional approaches are often not flexible enough to handle these changes, resulting in decisions becoming less relevant or less optimal[9,10]. Therefore, a more adaptive, objective, and transparent weighting method is needed to ensure fair and acceptable results for all parties.

Multi-objective optimization on the basis of ratio analysis (MOORA) is one of the popular multi-criteria decision-making methods used in decision support systems. This method was developed to deal with problems with a variety of conflicting objectives by maximizing benefits and minimizing costs[11–13]. MOORA has a simple and efficient approach that incorporates a data normalization process to reduce the scale of differences between criteria, thus allowing for fair comparisons. The popularity of this method lies not only in its ease of use but also in its flexibility to be applied in a variety of fields. The main advantage of MOORA is its simplicity in calculations, which does not require complex assumptions or additional parameters like some other methods of multi-criteria decision-making[14–16]. This makes MOORA a reliable choice for solving complex decision problems in a dynamic and uncertain environment.

Weighting discrepancies in multi-criteria decision-making are often a crucial issue that can affect the final outcome of the evaluation. In some cases, certain weighting methods may not accurately reflect the importance level of the criteria, especially if the weights are determined subjectively based on the decision-making preferences[17–19]. This can lead to bias, especially if the decision involves many parties with different preferences. In addition, weighting approaches that are based solely on objective data, sometimes fail to capture the subjective or strategic values of certain criteria that are relevant to the context of the problem[20–22]. Mismatches also often arise when small changes in weights result in significant changes in alternative rankings, indicating high sensitivity to weighting parameters. In some cases, the weights of the criteria may not be in line with the actual dynamics of the system being evaluated, such as in rapidly changing market conditions or a dynamic organizational environment. Therefore, a combination of weighting methods or the development of new techniques is often necessary to overcome these limitations, resulting in fairer, more accurate, and robust assessments.

Subjectivity in multi-criteria decision-making can have a significant impact on the final outcome, especially if the evaluation process is not carried out objectively and transparently. Bias can appear in various forms, such as in the weighting of criteria, alternative selection, or judgment of the criteria themselves. High subjectivity is often caused by the personal preferences of the decision-maker, a lack of deep understanding of the context of the issue, or pressure from certain interested parties. Subjectivity in manual weighting systems, decisions can be influenced by the experience, perception, or intuition of the decision maker, which may not always reflect the actual conditions or needs. Combined with an objective approach and the application of validation techniques such as sensitivity analysis, it is also important to ensure that decisions are made that reflect reality and needs more accurately.[23,24] One step that can be taken is to involve various stakeholders in the early stages of criteria identification and weighting, so that a broader perspective can be accommodated.

The combination of MOORA with various weighting methods such as AHP, Entropy, MEREC, and CRITIC provides flexibility in adjusting the weighting of criteria based on the needs and context of the decision-making. MOORA-AHP combines the strength of the hierarchical structure and expert judgment of AHP with the MOORA ranking process[25], making it suitable for use when subjective preferences from experts are needed. In contrast, MOORA-Entropy leverages objective information from the data to determine weights based on the degree of uncertainty or diversity of values between alternatives[26]. MOORA-MEREC assesses the importance of each criterion through its effect on the final outcome when it is eliminated, providing an objective perspective that focuses on a direct contribution to alternative differentiation[27]. MOORA-CRITIC combines data variability and conflicts between criteria in the weighting process, resulting in weights that reflect the discriminatory strength of each criterion[28]. These four combinations allow the application of the MOORA method to be more adaptive, both to intuition-based and data-based contexts, and to provide more comprehensive and accountable ranking results.

The objective approach in the MOORA method is important because it is able to eliminate subjective biases that may arise in the process of determining the weighting of criteria. Using an objective approach, the assessment of alternatives is based on empirical and statistical data, not individual preferences. One of the proposals that is often proposed is the inclusion of variance as a basis for determining weight. The main advantage of variance lies in its ability to measure the extent to which data is spread or diversity against the average value. In multicriteria decision-making, the use of variance allows the identification of criteria that have a high degree of discrimination between alternatives. This means that the greater the variance of a criterion, the greater the ability of the criteria to distinguish the performance of alternatives from each other. This is important because criteria that are too homogeneous in value are often less informative in the evaluation process.

Modification of the MOORA method for the development of a new approach in weight allocation can be a solution to improve accuracy and fairness in the decision-making process. One innovative approach is the introduction of the dynamic weight adjustment method, where the weight of the criteria is not only calculated based on the importance of the criteria at one time, but also takes into account changes in the context or decision-making environment[29,30)]. This allows flexibility in dealing with dynamic problems. This method can identify hidden relationships between criteria and provide more accurate weights based on the apparent influence of each criterion on the outcome of the decision. By introducing a new approach, the MOORA method can become more robust, flexible, and relevant in solving a variety of complex and dynamic decision-making problems.

Modification of MOORA method can provide a fairer and more accurate solution in decision-making through various innovations. One of the key modifications is the integration of adaptive weights, where the weight of the criteria can change dynamically according to the relevance of the criteria to a particular context, resulting in more responsive decisions[31,32)]. This modification involves developing dynamic ratios in the ranking process, so that the relative contribution of the criteria to the overall goal is more accurately taken into account. To improve decision stability, sensitivity analysis can be integrated to evaluate the extent to which changes in weights or criterion values affect the final result. MOORA modifications can also be directed to account for non-linear factors that are often overlooked in traditional methods. These modifications not only improve accuracy and fairness but also strengthen confidence in the outcome of decisions, making MOORA a relevant method for solving complex and dynamic multi-criteria problems.

1.1. The need for new approaches in MOORA

In the world of decision support systems (DSS), a new approach in the MOORA method is increasingly needed to increase its effectiveness and flexibility in dealing with complex problems. MOORA is a method that is often used to solve decision-making problems with many criteria, but in practice, this method can have limitations related to the accuracy of criterion weighting and sensitivity to data changes. Therefore, it is important to develop new modifications or approaches in MOORA to address these issues. This new approach could involve applying more objective and dynamic weighting techniques, adjusting to changes in criterion weights, or integrating with other methods to handle high-dimensional data. Some of the reasons why a new approach is needed in MOORA:

Criteria complexity: modern decision-making involves many interrelated and often multidimensional criteria. MOORA conventional approach may not be flexible enough to handle criteria with a high level of complexity.

Dynamics of priority change: in real-life situations, the priority of criteria often changes according to market conditions, organizational needs, or government policies. A new approach is needed to accommodate these dynamics in order to keep the results relevant.

Data uncertainty: Data in the real world is often uncertain, ambiguous, or linguistically formed. Traditional MOORAs are less able to handle this uncertainty effectively, so it requires incorporation with methods such as fuzzy logic or probabilistic.

The need for more objective results: traditional MOORA methods often rely on subjective weighting, which can affect the neutrality of results. The integration of objective weighting techniques, can provide more transparent and trustworthy results.

Scalability and adaptability: the use of MOORA in larger projects or organizations requires a scalable approach and can be easily adapted to various contexts or scenarios.

This new approach aims to address these challenges and make MOORA more relevant in supporting complex, dynamic, and data-driven decision-making. MOORA modifications can provide more adaptive and accurate solutions in decision-making, especially in changing conditions or in analysis with many alternatives and inter-interacting criteria[33,34)].

1.2. Research contributions

The contribution of this research lies in the development and modification of the MOORA method with a more adaptive and objective approach, which aims to improve the accuracy and resilience of the decision support system in dealing with problems with many criteria and alternatives. The following is the research contribution of this study.

Improved criterion weighting accuracy: this study introduces a new method for more accurate and fair allocation of criterion weights, by reducing the subjectivity often found in conventional methods. This allows for decisions that are more representative of real conditions.

Adaptability to complex data: this new approach is designed to accommodate data that is heterogeneous, ambiguous, or uncertain. This makes MOORA more flexible in various application contexts.

Reduction of bias in decision-making: by prioritizing weight allocation based on objective data and actual conditions, this study helps to reduce bias caused by the subjective preferences of decision-makers, resulting in fairer decisions.

Contribution to MOORA literature: this study enriches MOORA literature by providing new approaches that can be used as a reference or basis for further research, especially in the development of multi-criteria methods.

Fostering fairness in decision-making: by delivering fairer and more transparent outcomes, this approach supports decision-making that aligns with the principles of fairness and openness, which are essential in the modern business and government environment.

This contribution not only expands the scope of MOORA use, but also improves the quality and fairness of the results of the decisions produced.

2. Methodology

2.1. Research framework

A research framework is a structure or framework that describes the sequence and relationships between the various components in a research. This framework serves to provide guidance and focus in carrying out research, as well as to help researchers to explain and compile research steps systematically. The research framework helps to compile a clear and systematic research flow so that the research can be carried out in an organized manner and the results are more valid and accountable. Figure 1 is the framework of the research conducted in this study.

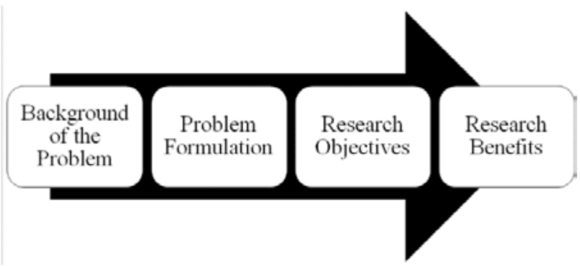

Fig. 1: Research framework

Background of the problem about the importance of fair weight allocation in multi-objective decision-making processes, especially in MOORA. This study focuses on the challenges that exist in the allocation of weights objectively and fairly, as well as their impact on more equitable and efficient decision outcomes[35].

The formulation of the problem in this study is how a new approach in weight allocation can improve fairness and effectiveness in the decision-making process using the MOORA method. What is the difference in the results obtained with the conventional weight allocation method compared to the new method.

The purpose of the research is to develop and develop a new approach in weight allocation for fairer multi-objective decision-making using the MOORA method. Assess the effectiveness of this approach compared to traditional approaches.

The benefits of research are to provide solutions in improving fairness in decision-making with a more transparent and objective weight allocation. It is hoped that this research can be used in various applications, such as supplier selection, employee selection, and performance evaluation.

2.2. MOORA

The MOORA method is one of the multi-criteria decision-making methods used to evaluate and select the best alternatives based on various criteria[36–38]. MOORA's strengths lie in the simplicity of the calculation process, transparency, and the ability to produce accurate decisions in a variety of contexts. The stages in the MOORA method are shown in Figure 2.

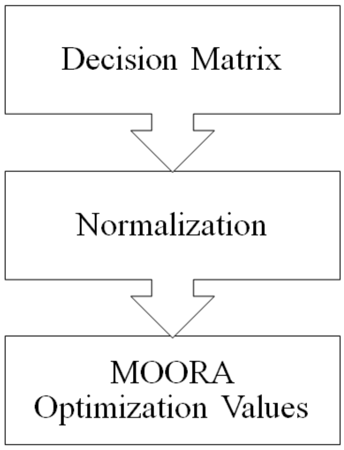

Fig. 2: Research framework

The implementation of the MOORA method produces a final score for each alternative by summing the value of the benefit criterion and subtracting the value from the cost criterion, so that the alternative with the highest score is considered the best choice. The MOORA stage has three processes that are carried out, namely.

Process 1: create a decision matrix X, which contains alternative A_i values based on each criterion c_j, The decision matrix of the MOORA method is created using the formula.

$$X = \begin{bmatrix} x_{i1} & \cdots & x_{in} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Process 2: calculate the normalization value of the decision matrix that each element of the decision matrix is normalized using the formula:

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

Process 3: calculate the MOORA optimization value for each alternative is calculated by summing the value of the benefit criterion and subtracting the value of the cost criterion using the formula:

$$y_i = \sum_{j \in B} w_j * r_{ij} - \sum_{j \in C} w_j * r_{ij} \quad (3)$$

The MOORA optimization value can be adjusted by determining the weight of the criteria either subjectively or more objectively before calculating the MOORA value.

2.3. Modification MOORA

MOORA modification using variation values is an approach that integrates variation values into the decision-making process using the MOORA method. The variation value is used to take into account the distribution of data in each criterion, so that it can increase the sensitivity of the analysis to the differences between alternatives[39,40]. The MOORA modification with this variation value is named multi-objective optimization by ratio analysis-variance (MOORA-V). The stages in the MOORA-V method are shown in Figure 3.

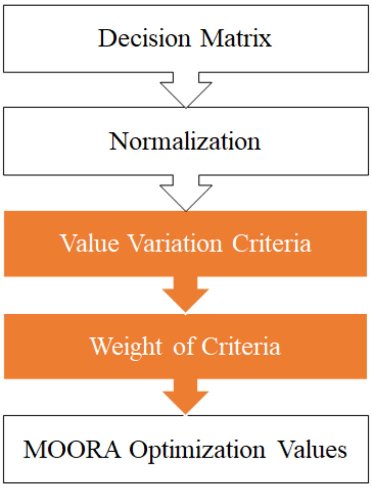

Fig. 3: Research framework

The implementation of the MOORA-V method produces a final score for each alternative by summing the value of the benefit criterion and subtracting the value from the cost criterion by adding two processes to produce the objective weight of the criterion, so that the alternative with the highest score is considered the best choice. The MOORA-V stage has five processes that are carried out, namely.

Process 1: create a decision matrix X, which contains alternative A_i values based on each criterion c_j, The decision matrix of the MOORA method is created using the formula (1).

Process 2: calculate the normalization value of the decision matrix that each element of the decision matrix is normalized using the formula (2).

Process 3: calculate the variation value for Each criterion, the variation value (σ_j^2) is calculated for each criterion (c_j) using the formula:

$$\sigma_j^2 = \frac{1}{n} \sum_{i=1}^{n} (r_{ij} - \mu_j)^2 \quad (4)$$

for the value (μ_j) is calculated using the formula:

$$\mu_j = \frac{1}{n} \sum_{i=1}^{n} r_{ij} \quad (5)$$

Process 4: calculate the criterion weight value () to generate an objective weight based on the existing data using the formula:

$$w_j = \frac{\sigma_j^2}{\sum \sigma_j^2} \quad (6)$$

Process 5: calculate the MOORA optimization value for each alternative is calculated by summing the value of the benefit criterion and subtracting the value of the cost criterion using the formula (3).

The advantages of this MOORA-V method by adding a variation process that results in objective criteria weights are:

Sensitivity to variation: by taking into account the value of variation, this method is more adaptive to criteria with data that has a large spread, thus providing more accurate results.

Reduced bias: variation helps reduce the influence of criteria with uniform data distribution, making the analysis more objective.

This modification is suitable for decision-making cases involving large-scale data or uneven distribution of values.

3. Result and Discussion

In improving fairness and accuracy in multi-criteria decision-making, a new approach to weight-sharing in MOORA has been developed. This approach aims to reduce subjective bias in the weighting process through a more objective and data-driven method. By balancing a variety of criteria that often have different levels of importance, this method offers a more transparent and fair solution in generating the final ranking. The results of its implementation show that this new approach not only improves consistency and sensitivity to data variation, but also delivers results that are more acceptable to stakeholders, making it an important innovation in multi-objective optimization.

3.1. Case study of lecturer admission

The selection of lecturer admissions is a crucial process in the world of higher education which aims to ensure the quality of teaching, research, and community service. In this case study, the selection process of prospective lecturers is the main focus to ensure that the institution gets candidates who have the competence, qualifications, and integrity that are in accordance with the needs and vision of the institution. Various criteria such as educational background, work experience, communication skills, and academic potential are often used to assess candidates objectively.

Assessment data for prospective lecturers that can be used in case studies for lecturer admissions includes several criteria used, namely TOEFL scores (C1), TKDA scores (C2), number of publications (C3), interview scores (C4), and teaching ability scores (C5). The assessment data of prospective lecturers in the selection process is shown in Table 1.

Table 1: Assessment data of lecturer candidates

Candidate Name	Criteria				
	C1	C2	C3	C4	C5
SA Candidates	620	750	12	90	9
CF Candidates	600	720	15	88	8
RF Candidates	650	800	10	93	8
TR Candidates	580	670	14	85	7
IH Candidates	630	790	13	91	9
AK Candidate	610	740	11	87	8
GM Candidates	590	650	9	84	6
MF Candidates	640	770	16	89	9
SH Candidates	600	700	11	86	7
DG Candidates	610	680	13	88	8

Table 1 lecturer admission assessment data plays an important role in ensuring an objective and transparent recruitment process. Considering various criteria can help in choosing the best candidates who fit the needs of the educational institution. In addition, the use of the right method in evaluation can increase the accuracy and efficiency of the selection process, so that it is expected to produce lecturers who are able to contribute significantly to the quality of education.

3.2. Implementation of the MOORA-V method

The MOORA-V method is a development of the MOORA method in this study which is used in a multi-criteria decision support system. This method serves to evaluate and determine the best alternative based on various criteria that have different properties, as well as to produce criteria weights based on the assessment data used.

The stages of the MOORA-V method in the implementation of the selection of lecturer admissions have five processes that are carried out, namely.

Process 1: create a decision matrix X, which contains alternative values based on each criterion by using (1) based on the assessment data of the lecturer admission selection in Table 1. The form of the decision matrix is as follows.

$$X = \begin{bmatrix} x_{1,1} & x_{2,1} & x_{3,1} & x_{4,1} & x_{5,1} \\ x_{1,2} & x_{2,2} & x_{3,2} & x_{4,2} & x_{5,2} \\ x_{1,3} & x_{2,3} & x_{3,3} & x_{4,3} & x_{5,3} \\ x_{1,4} & x_{2,4} & x_{3,4} & x_{4,4} & x_{5,4} \\ x_{1,5} & x_{2,5} & x_{3,5} & x_{4,5} & x_{5,5} \\ x_{1,6} & x_{2,6} & x_{3,6} & x_{4,6} & x_{5,6} \\ x_{1,7} & x_{2,7} & x_{3,7} & x_{4,7} & x_{5,7} \\ x_{1,8} & x_{2,8} & x_{3,8} & x_{4,8} & x_{5,8} \\ x_{1,8} & x_{2,9} & x_{3,9} & x_{4,9} & x_{5,9} \\ x_{1,10} & x_{2,10} & x_{3,10} & x_{4,10} & x_{5,10} \end{bmatrix}$$

The results of the matrix of assessment data results are as follows.

$$X = \begin{bmatrix} 620 & 750 & 12 & 90 & 9 \\ 600 & 720 & 15 & 88 & 8 \\ 650 & 775 & 10 & 93 & 8 \\ 580 & 670 & 14 & 85 & 7 \\ 620 & 780 & 13 & 91 & 9 \\ 610 & 740 & 11 & 87 & 8 \\ 590 & 650 & 9 & 84 & 6 \\ 640 & 770 & 16 & 89 & 9 \\ 600 & 700 & 11 & 86 & 7 \\ 610 & 680 & 13 & 88 & 8 \end{bmatrix}$$

Process 2: calculate the normalization value of the decision matrix that each element of the decision matrix is normalized using (2).

$$r_{1,1} = \frac{x_{1,1}}{\sqrt{\sum_{i=1}^{j} x_{1,1;1,10}{}^2}} = \frac{620}{1939.613} = 0.3197$$

The results of the matrix normalization value of the MOORA-V method for each alternative are presented in Table 2.

Table 2: Matrix normalization value

Candidate Name	Criteria				
	C1	C2	C3	C4	C5
SA Candidates	0.3197	0.3272	0.3017	0.3229	0.3577
CF Candidates	0.3093	0.3141	0.3771	0.3157	0.3180
RF Candidates	0.3351	0.3381	0.2514	0.3337	0.3180
TR Candidates	0.2990	0.2923	0.3520	0.3050	0.2782
IH Candidates	0.3248	0.3403	0.3268	0.3265	0.3577
AK Candidate	0.3145	0.3228	0.2766	0.3121	0.3180
GM Candidates	0.3042	0.2836	0.2263	0.3014	0.2385
MF Candidates	0.3300	0.3359	0.4023	0.3193	0.3577
SH Candidates	0.3093	0.3054	0.2766	0.3086	0.2782
DG Candidates	0.3145	0.2967	0.3268	0.3157	0.3180

Process 3: calculate the variation value for each calculated criterion using (4) and (5).

$$\mu_1 = \frac{1}{10} \sum_{i=1}^{n} r_{11,110} = 0.0316$$

$$\mu_2 = \frac{1}{10}\sum_{i=1}^{n} r_{21,210} = 0.0316$$
$$\mu_3 = \frac{1}{10}\sum_{i=1}^{n} r_{31,310} = 0.0312$$
$$\mu_4 = \frac{1}{10}\sum_{i=1}^{n} r_{41,410} = 0.0316$$
$$\mu_5 = \frac{1}{10}\sum_{i=1}^{n} r_{51,510} = 0.0314$$
$$\sigma_1^2 = \frac{1}{10}\sum_{i=1}^{n} (r_{1,1;1,10} - \mu_1)^2 = 0.0810$$
$$\sigma_2^2 = \frac{1}{10}\sum_{i=1}^{n} (r_{2,1;2,10} - \mu_2)^2 = 0.0811$$
$$\sigma_3^2 = \frac{1}{10}\sum_{i=1}^{n} (r_{3,1;3,10} - \mu_3)^2 = 0.0815$$
$$\sigma_4^2 = \frac{1}{10}\sum_{i=1}^{n} (r_{4,1;4,10} - \mu_4)^2 = 0.0810$$
$$\sigma_5^2 = \frac{1}{10}\sum_{i=1}^{n} (r_{5,1;5,10} - \mu_5)^2 = 0.0813$$

Process 4: calculate the weight value of the criteria to produce weights objectively based on the existing data using (6).

$$w_1 = \frac{\sigma_1^2}{\sum \sigma_{1,5}^2} = \frac{0.0810}{0.4059} = 0.1996$$
$$w_2 = \frac{\sigma_2^2}{\sum \sigma_{1,5}^2} = \frac{0.0811}{0.4059} = 0.1997$$
$$w_3 = \frac{\sigma_3^2}{\sum \sigma_{1,5}^2} = \frac{0.0815}{0.4059} = 0.2009$$
$$w_4 = \frac{\sigma_4^2}{\sum \sigma_{1,5}^2} = \frac{0.0810}{0.4059} = 0.1996$$
$$w_5 = \frac{\sigma_5^2}{\sum \sigma_{1,5}^2} = \frac{0.0813}{0.4059} = 0.2002$$

Process 5: calculate the optimization value of MOORA for each alternative calculated between the weight of the criteria by adding the value of the benefit criterion and subtracting the value of the cost criterion using (3).

$$y_1 = \sum_{j\in B} w_{1;5} * r_{1,1;5,1} = 0.3258$$

The results of the optimization value of the MOORA-V method for each alternative are presented in table 3.

Table 3: Optimization value

Candidate Name	Optimization Value
SA Candidates	0.3258
CF Candidates	0.3269
RF Candidates	0.3152
TR Candidates	0.3053
IH Candidates	0.3352
AK Candidate	0.3088
GM Candidates	0.2707
MF Candidates	0.3491
SH Candidates	0.2956
DG Candidates	0.3144

The MOORA-V method is one of the effective approaches in multi-criteria decision-making. This method is used to determine alternative rankings based on predetermined criteria by considering the average value and variance of each criterion, thus providing more comprehensive results. In this process, the criteria are systematically evaluated to identify the best alternatives that meet a variety of competing objectives. The results of this ranking are expected to provide a solid basis for objective, fair, and in accordance with the priorities that have been determined shown in Figure 4.

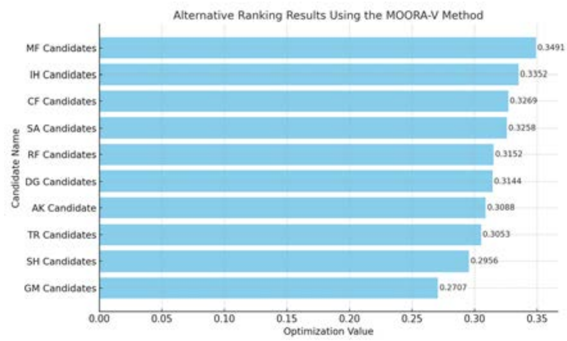

Fig. 4: Alternative ranking results using the MOORA-V method

Based on the results of the ranking using the MOORA-V method, the candidate with the first rank is MF Candidates with the highest score of 0.3491, showing the best performance among all candidates. The second place was occupied by IH Candidates with a score of 0.3352, followed by CF Candidates in third place with a score of 0.3269. SA Candidates is ranked fourth with a score of 0.3258, while RF Candidates occupies the fifth position with a score of 0.3152. Furthermore, DC Candidates is ranked sixth with a score of 0.3114, followed by TR Candidates in seventh place with a score of 0.3088. The eighth place was occupied by SH Candidates with a score of 0.3053, and the last or ninth place was filled by GM Candidates with a score of 0.2707. These results describe the order of priority based on the evaluation criteria that have been set.

3.3. Criteria weight sensitivity analysis

Criteria weight sensitivity analysis is an evaluation process to measure the impact of changes in criterion weights on the final result in multi-criteria decision-making[41–44]. This technique aims to understand the extent to which differences in criterion weights can affect alternative ratings, thus providing insight into the stability and reliability of the systems used. In the context of decision support systems, sensitivity analysis helps to identify criteria that have a dominant influence on decisions, as well as evaluate the model's resilience to uncertainty in weighting. This approach is important to ensure that the resulting decisions are not only objective but also robust to changes or variations in the criterion weight inputs.

By conducting a sensitivity analysis, it can identify whether there are criteria that need to be reviewed or get more attention in the decision-making process. In addition, this method can also be used to evaluate the weighting method applied, ensuring that the weights given are objectively in accordance with their level of importance. In practice, sensitivity analysis is often used in a variety of fields. This makes the analysis of the sensitivity of the weight of the criteria an important tool in increasing transparency, validity, and accountability in the multi-criteria decision-making process.

The criteria weight sensitivity analysis was carried out to evaluate the impact of weight changes on the ranking results using the MOORA-V method. The scenario applied is to increase and decrease the weight of each criterion by 0.1, while adjusting the weight of the other criteria to still meet the normalization rule (the total weight is 1). In sensitivity analysis, the scenario evaluation approach is carried out by systematically varying the weight of each criterion to observe its effect on the results of alternative rankings. Each criterion will be changed in the weight of the criteria, there will be an increase in weights of +0.1 and +0.2, and there will be a weight reduction of -0.1 and -0.2, the results of the change in weight sensitivity will be tested 20 times to see the ranking results of each alternative. With this approach, the stability or instability of the rankings can be analyzed in more detail, thus supporting more accurate and fair decision-making based on the dynamics of criterion priority. Table 4 is a scenario in the weight of the criteria.

Table 4: Criteria weight change scenario

Criteria	Test 1	Test 2	Test 3	Test 4
TOEFL Score (w_1)	+0.1	-0.1	+0.2	-0.2
TKDA Score (w_2)	+0.1	-0.1	+0.2	-0.2
Publication (w_3)	+0.1	-0.1	+0.2	-0.2
Interview (w_4)	+0.1	-0.1	+0.2	-0.2
Teaching Ability (w_5)	+0.1	-0.1	+0.2	-0.2

The results of this test provide important information on which criteria should be considered in more depth, as well as provide recommendations on whether the current weighting model is robust enough or needs adjustment to improve the quality of decision-making. Figure 5 is a visualization of the ranking change to present these findings more clearly and informatively.

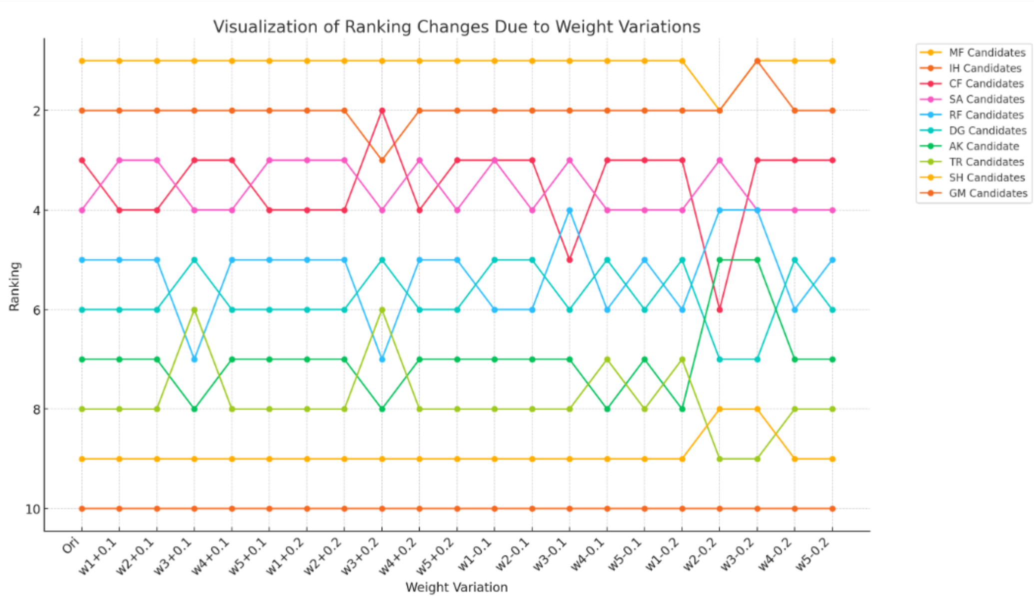

Fig. 5: Visualization of ranking changes

The results of the alternative ranking sensitivity analysis are based on changes in the weight of the criteria. This graph illustrates how the rankings of some candidates (such as MJ, IH, CF, SA, AK, and others) change over the course of 20 stages of sensitivity testing. The horizontal axis indicates the sensitivity testing stage (test 1 to test 20), while the vertical axis shows the ranking position of each candidate. From the chart, it can be seen that some candidates, such as MJ, maintained consistent rankings in the top position throughout the test. In contrast, other candidates, such as SH, showed significant fluctuations in their rankings, suggesting that the weight of the criteria greatly influenced their evaluation. This reflects the sensitivity of the analysis results to changes in criterion weights and provides insight into the stability of alternative rankings in various scenarios.

3.4. Discussion

The modification of the MOORA-V method aims to improve flexibility and accuracy in solving complex decision-making problems. By integrating adjustments to the weighting mechanism or adding normalization techniques adapted to specific data distributions, the modified MOORA-V demonstrates increased robustness in handling various decision criteria. This approach addresses some limitations of the original method, particularly in situations where scale differences between criteria can disproportionately affect outcomes.

During implementation, the modified MOORA-V method showed more stable rankings, even under varying conditions such as changes in the number of criteria or fluctuations in the dataset. The sensitivity analysis was carried out by changing the weights of each criterion by +0.1, +0.2, −0.1, and -0.2 to measure their impact on alternative rankings. The results of the analysis show that changes in the weight of the criteria with a high level of importance can cause a significant shift in ranking, while the change in weight on the criteria with low influence does not have a large impact. This suggests that the modified MOORA-V remains sensitive to key criteria but is more stable overall than the original method.

In addition, these modifications also ensure transparency and ease of interpretation by simplifying computational steps without compromising the integrity of the decision-making process. This aspect is crucial to support the adoption of this method in a variety of practical scenarios. Overall, the modified MOORA-V offers a more comprehensive and adaptive tool for multi-criteria decision-making, opening up opportunities for further development in decision support systems.

A comparison of rankings was conducted in this study between the MOORA-V method, as well as the combination of MOORA with various weighting techniques such as Entropy, MEREC, and CRITIC to provide a comprehensive picture of the sensitivity and consistency of the resulting decisions. MOORA as a basic method shows stability in multi-criteria evaluation, while integration with objective weighting methods such as Entropy and MEREC allows for increased objectivity in determining criterion weights based on data variation and relevance. On the other hand, the use of the CRITIC method in combination with MOORA highlights the importance of conflicts and correlations between criteria as the basis for weighting. MOORA-V as a modified version of MOORA also introduces a new approach to optimization value adjustment, thus providing an alternative perspective in ranking. By comparing the final results of each method, it can be identified which method is most adaptive to weight changes and most consistent in producing the best alternative rankings. The results of the ranking comparison are shown in table 5.

Table 5: Alternative ranking comparison results

Candidate Name	Rank MOORA			
	MOORA-V	ENTROPY	MEREC	CRITIC
MF Candidates	1	1	1	1
IH Candidates	2	3	3	2
CF Candidates	3	2	2	3
SA Candidates	4	5	4	4
RF Candidates	5	8	8	7
DG Candidates	6	6	5	5
AK Candidate	7	7	7	8
TR Candidates	8	4	6	6
SH Candidates	9	9	9	9
GM Candidates	10	10	10	10

Based on the candidate ranking data using the MOORA method and its variations, it can be seen that MF Candidates consistently rank first in all approaches, both MOORA-V, MOORA with Entropy, MEREC, and CRITIC weighting. This shows the stability and dominance of MF Candidates' performance in various evaluation scenarios. IH Candidates and CF Candidates swap positions between second and third place depending on the weighting method used, indicating that both have a competitive performance but are sensitive to the weighting criteria. SA Candidates remained stable in fourth place on most methods, showing a medium level of consistency. Meanwhile, RF Candidates experienced a significant decline in rankings when applied objective weighting methods such as Entropy and MEREC, from fifth position (MOORA-C) to eighth position, reflecting the effect of weight on their relative performance. Other candidates such as DG, AK, and TR Candidates showed moderate fluctuations in rankings, while SH and GM Candidates consistently ranked at the bottom (ninth and tenth), indicating relatively lower performance in all evaluation approaches. Overall, this comparison illustrates the impact of using objective weighting methods on ranking results and helps identify the most stable and adaptive performers.

4. Conclusion

The new approach to weight allocation using the MOORA-V method makes a significant contribution to creating fairer and more transparent decision-making. By emphasizing an objective weighting mechanism and based on data characteristics, this approach is able to reduce the potential for bias that often arises due to subjectivity in the weighting process. In addition, this approach provides greater flexibility in handling different types of data and criteria, so it can be adapted to a variety of decision-making contexts, both on a small and large scale.

The results of the implementation show that this new approach not only results in a more stable ranking of alternatives, but also increases confidence in the decision process because the resulting weights reflect the relative importance between criteria more accurately. The sensitivity analysis also confirmed that the approach had a good robustness level, with weight changes having only minimal impact on the overall ranking. Thus, this new approach provides an effective solution for more fair, accurate, and adaptive multi-criteria decision-making, while opening up opportunities for further development in modern decision support systems.

Further research can be developed to address uncertain data, such as fuzzy or interval data, to increase its flexibility in handling uncertainty in decision-making, as well as computational implementation using Python to improve reproducibility, facilitate validation by other researchers, and expand the potential for application in various fields. Thus, the research contribution is not only theoretical but also practical, supporting the development of adaptive decision support systems that are easily integrated into the real environment.

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