



# Modification of Multi-Attributive Border Approximation Area Comparison (MABAC) to Improve Multi-Criteria Assessment

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**Abstract:** Multi-criteria decision making (MCDM) is a field of study in decision-making that focuses on selecting or ranking alternatives based on several competing criteria. Multi-attributive border approximation area comparison (MABAC) is one of the methods in MCDM that is designed to evaluate and select the best alternative based on relevant criteria. The weakness of the MABAC method in the aspect of criterion weighting mainly lies in its dependence on the external weighting method. The data used in the Best Staff Selection case study included staff performance assessments based on several key criteria. The results of this data are then used in MCDM to determine the best staff based on the weight of objectively established criteria. The purpose of this study is to modify the MABAC method by integrating the geometric average method which aims to improve accuracy and objectivity in multi-criteria assessment. The results of the ranking with the MABAC-G method for the selection of the best employees show that employee 5 obtained the highest score of 0.2868 so that it is the best alternative in this assessment. The results of the comparison of the ranking of alternative selection of the best employees using the ranking from the company and the MABAC-G method obtained a Pearson correlation value of 0.9511 which shows that there is a very strong relationship between the two assessment systems. The application of research findings from MABAC-G in the future can be used in various fields that require multi-criteria decision-making with complex and uncertain data.

**Keywords:** Accuracy; MABAC; MCDM; Modification; Objectivity;

## 1. INTRODUCING

Multi-criteria decision making (MCDM) is a field of study in decision-making that focuses on selecting or ranking alternatives based on several competing criteria[1]–[3]. This approach is used to solve complex problems involving various dimensions or attributes, which often have different levels of importance. MCDM is widely applied in a variety of fields, due to its ability to provide a structured, transparent, and objective framework for evaluating complex options. MCDM helps decision-makers consider a variety of relevant perspectives, so that the resulting solutions are not only quantitatively optimal but also in accordance with the needs and preferences of stakeholders. This approach allows for the integration of qualitative and quantitative data, and can be tailored to the specific conditions of each case, such as the use of objective or subjective weighting methods[4], [5]. In addition, MCDM is also effective in dealing with uncertainty, both through the incorporation of probabilistic analysis and fuzzy set theory-based methods. With its ability to accommodate the complexity of multi-dimensional problems, MCDM has become an essential tool in supporting strategic decision-making in various sectors.

Multi-attributive border approximation area comparison (MABAC) is a method within MCDM designed to evaluate and select the best alternative based on relevant criteria[6]–[8]. This approach introduces the concept of border approximation area as a basis for assessing the extent to which

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alternatives are close to the ideal solution. In MABAC, each alternative is evaluated through a process that involves data normalization, calculation of membership functions, and determination of the value of each alternative's contribution to the border area[9]–[11]. This method has the advantage of integrating elements of various multi-criteria approaches by considering data uncertainty and relationships between criteria. MABAC is also able to handle problems with diverse data, both quantitative and qualitative, so it is flexible to be applied in various fields. With a simple but mathematically strong structure, MABAC is an effective choice in producing objective and transparent decisions. The weakness of the MABAC method in the aspect of criterion weighting mainly lies in its dependence on the external weighting method. MABAC does not have an internal mechanism to determine the weight of criteria, this can be a weakness if the weighting method used is not in accordance with the characteristics of the data or the context of the decision which can significantly affect the final result. Although the MABAC method is a very effective and widely used decision-making tool in MCDM, it has some limitations, especially in the aspects of weighting criteria and sensitivity to subjective assessment. To overcome these obstacles, modifications are needed that can improve its performance and application in various decision-making scenarios. One of the main drawbacks of MABAC is its sensitivity to criterion weights, where small changes in weights can lead to significant changes in alternative ranking results. In addition, this method is less flexible in handling incomplete or high-uncertainty data, so it needs to be combined with other approaches.

The modification of MABAC using geometric mean aims to improve accuracy and objectivity in alternative assessments based on several criteria. The geometric mean approach is more effective in handling data that has different scales and reduces bias due to extreme values or outliers, because it provides a more balanced weight to the criteria[12]–[14]. The use of geometric means also increases the durability of this method in dealing with data that is not evenly distributed or has a logarithmic pattern, resulting in a more proportional and representative evaluation. With this modification, MABAC becomes more flexible, robust, and able to provide more objective results in multi-criteria decision-making in various fields[15]–[17]. MABAC modifications also improve the method's ability to reduce dependence on extreme values, which can often dominate evaluation results when using arithmetic averages. This is especially important in decision-making where alternatives that have very high or low performance can disproportionately affect the overall weight. This modification also helps in overcoming the problems that arise when the criteria have different units of measurement, as geometric means are more suitable for data that have large variations between values. Overall, these modifications reinforce MABAC as an efficient and reliable tool for more complex and realistic multi-criteria decision-making, and are better suited to be applied in more diverse contexts, such as supplier selection, performance evaluation, and strategic planning.

The purpose of this study is to modify the MABAC method with the aim of improving accuracy and objectivity in multi-criteria assessment. This study integrates the geometric mean method in the alternative evaluation process to reduce bias due to extreme values and improve the balance of weighting between criteria of different scales. In addition, this study also explores the application of MABAC modifications in various decision-making scenarios involving data with large variations between criteria, as well as to test the effectiveness of this method in producing more accurate, fair, and representative decisions in more complex contexts. The contribution of research in the MABAC method using a geometric mean lies in improving stability and objectivity in multi-criteria decision-making. By using a geometric mean, this method is able to reduce the extreme impact of criteria weights that are too high or too low, resulting in a more balanced and accurate evaluation. This approach also improves consistency in data processing, especially in scenarios with highly variable value scales.

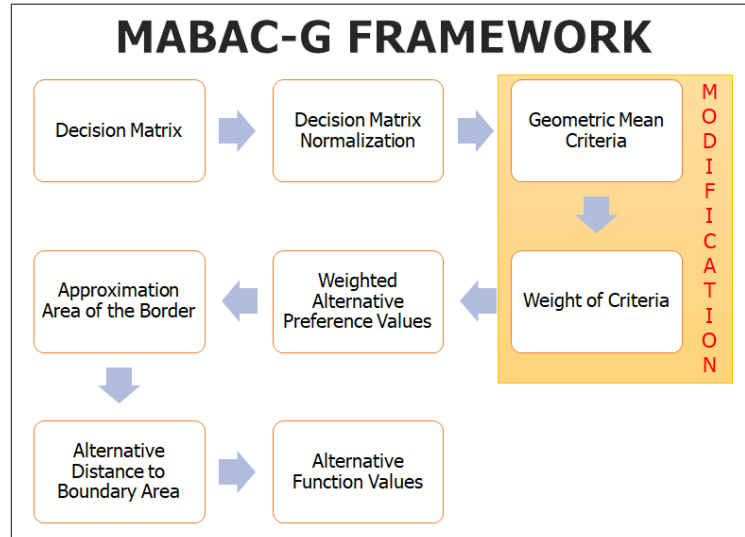
## **2. RESEARCH METHODOLOGY**

A research framework is a conceptual structure that is the basis or guide in carrying out a research. A good framework helps ensure that research is relevant, directed, and produces valid and accountable findings. The MABAC modification framework is a development of the classic MABAC method that aims to improve accuracy and flexibility in multi-criteria decision-making. With this framework, decision-



making can be carried out in a more robust and objective manner, especially in complex situations involving uncertain or varied data.

The data used in the Best Staff Selection case study consisted of an assessment of the 10 data best staff from various divisions in the company, using five main criteria, namely Leadership, Managerial Ability, Task Completion, Innovation, and Team Collaboration. The assessment was carried out using a value scale of 1 to 10 for each criterion. This data was obtained from various sources. Figure 1 is the MABAC modification framework carried out at each stage.



**Figure 1.** MABAC Modification Framework

The modified framework of the MABAC method using a geometric mean named MABAC-G offers a more robust approach in alternative ranking, especially when the data used has large variations or outliers, thus providing more stable and reliable results in decision-making. The selection of each step in the method used is based on strong theoretical justification to improve accuracy and reliability in multi-criteria decision-making. The use of geometric mean in MABAC is because geometric mean is more effective in balancing weights between criteria, especially when there is a very variable scale between data. Arithmetic averages tend to affect the final result disproportionately when there are extreme values, while geometric averages are able to maintain the relative proportion between values so that they are more stable in weight calculations.

Step 1: The decision matrix is a table used to describe the alternatives to be evaluated, along with the relevant criterion values for each alternative. Each row in the matrix represents a different alternative, while the columns represent the criteria used in the evaluation. This matrix is the basis of the decision-making process because it presents the information needed to make comparisons between the alternatives shown in the following equation.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: normalize the data so that the values in the matrix are on a uniform scale. This is important because different criteria often have different units or scales, which can affect the comparison between alternatives calculated by the following equation.

$$r_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \quad (2)$$

$$r_{ij} = \frac{x_i^+ - x_{ij}}{x_i^+ - x_i^-} \quad (3)$$

There are 2 types of equations for the MABAC-G method of matrix normalization, equation (2) for the type of benefit criterion and equation (3) for the type of cost criterion.

Step 3: geometric mean criteria of the contribution value of each alternative to the criterion is calculated using the geometric mean. Geometric mean was chosen because of its better ability to handle data that has extreme values or uneven distribution. The geometric mean gives a fairer weight to the lower criterion values and reduces the influence of extreme values that may interfere with the evaluation process calculated by the following equation.

$$GM_i = (\prod_{i=1}^n x_i)^{\frac{1}{n}} \quad (4)$$

Step 4: the criterion weights are calculated based on the value of the geometric mean to handle data that have extreme values or uneven distributions, and provide more stable results calculated by the following equation.

$$w_i = \frac{GM_i}{\sum_{i=1}^n GM_i} \quad (5)$$

Step 5: the weighted alternate preference value of each alternative is calculated by multiplying the value of the alternative contribution to each criterion by the corresponding weight. The result is a weighted alternative preference value, which reflects how the alternative is affected by each criterion and its weight is calculated by the following equation.

$$v_{ij} = (w_j * r_{ij}) + w_j \quad (6)$$

Step 6: approximation area of the border describes how close the alternative is to the best alternative based on all the criteria available. The larger the boundary area, the more optimal the alternative. This process uses pre-calculated preference values calculated by the following equation.

$$G_i = \left[ \prod_{j=1}^m v_{ij}^{\frac{1}{m}} \right] \quad (7)$$

Step 7: alternate distance to boundary area to calculate the distance between each alternate and the pre-calculated boundary area. This distance reflects how far the alternative is from the best solution in terms of conformance to the criteria. The alternative with the closest distance to the boundary area is considered a better option calculated by the following equation.

$$Q_i = v_{ij} - G_i \quad (8)$$

Step 8: The value of the alternative function is the value calculated for each alternative based on their distance to the boundary area and its contribution to the criteria. This function value is used to rank alternatives based on their proximity to the best solution, with the alternative having the highest function value considered the most appropriate calculated by the following equation.

$$S_i = \sum_{j=1}^n Q_{ij} \quad (9)$$

The end result of this MABAC modification provides more accurate alternative preference values in the context of multi-criteria decision-making.

## 3. RESULT AND DISCUSSIONS

The modification of the MABAC method is a significant step in improving accuracy and flexibility in multi-criteria assessment. This method is known for its systematic approach to measuring the degree of proximity of an alternative to an ideal solution based on an attribute boundary comparison area. MABAC-G is a development of the MABAC method that integrates the geometric mean approach in the calculation process, in order to improve accuracy and balance in multi-criteria assessment. MABAC-G offers more robust and adaptive solutions in a variety of decision-making contexts. The results of these modifications will be analyzed in depth to show the improved performance of the method in supporting more accurate and effective multi-criteria assessments.

### 3.1. Case Study: Best Staff Selection

Selecting the best staff is a complex process, given the need to consider various criteria objectively to ensure fair and accurate decisions. In this case study, staff appraisal data was collected from different divisions of the company, covering a number of key indicators relevant to individual performance and contribution to the team. Staff assessment data is shown in table 1.



Table 1. Staff Assessment Data

Name	Leadership	Managerial Ability	Task Completion	Innovation	Team Collaboration
Staff 1	8	9	7	6	8
Staff 2	7	8	8	7	9
Staff 3	9	8	9	8	7
Staff 4	6	7	6	9	8
Staff 5	8	9	8	8	9
Staff 6	7	8	9	7	8
Staff 7	9	9	8	9	7
Staff 8	8	7	7	8	9
Staff 9	7	8	6	6	8
Staff 10	8	9	8	7	9

This case study will apply MABAC-G to select the best staff by considering criteria such as performance, innovation, managerial ability, team collaboration, and task completion. This study will discuss how MABAC-G improves the quality of assessment and supports a more efficient and transparent decision-making process.

### 3.2. Implementation of the MABAC-G Method

The implementation of the MABAC-G method is a strategic step in complex multi-criteria-based decision-making. This method combines the advantages of MABAC in measuring the proximity of alternatives to the area boundary with a geometric mean approach to calculate the geometric mean value of each criterion. This process allows for more accurate and balanced assessments, especially in situations where there are scale differences or extreme data on the criteria. With systematic stages, from the normalization of the decision matrix to the calculation of the total score for the final ranking, MABAC-G provides objective and transparent results. This approach is very effective in helping more robust decision-making, as in the case study of selecting the best staff discussed in this study. An explanation of each stage of the MABAC-G method in selecting the best staff is explained in the following stages.

Step 1: The decision matrix is a table used to describe the alternatives to be evaluated, along with the relevant criterion values for each alternative. The decision matrix is made using equation (1) from the alternative assessment data shown in table 1, the results of the decision matrix are as follows.

$$X = \begin{bmatrix} 8 & 9 & 7 & 6 & 8 \\ 7 & 8 & 8 & 7 & 9 \\ 9 & 8 & 9 & 8 & 7 \\ 6 & 7 & 6 & 9 & 8 \\ 8 & 9 & 8 & 8 & 8 \\ 7 & 8 & 9 & 7 & 8 \\ 9 & 9 & 8 & 9 & 7 \\ 8 & 7 & 7 & 8 & 9 \\ 7 & 8 & 6 & 6 & 8 \\ 8 & 9 & 8 & 7 & 9 \end{bmatrix}$$

Step 2: calculate the data normalization value so that the values in the matrix are on a uniform scale using equation (2) because all criteria are beneficial, the calculation results are as follows.

$$r_{11} = \frac{x_{11} - x_{11,110}^-}{x_{11,110}^+ - x_{11,110}^-} = \frac{8 - 6}{9 - 6} = \frac{2}{3} = 0.6667$$

The results of table 2 are the entire calculation of the normalization values that have been carried out.



**Table 2.** Calculation Results from Normalization Values

Name	Leadership	Managerial Ability	Task Completion	Innovation	Team Collaboration
Staff 1	0.6667	1.0000	0.3333	0.0000	0.5000
Staff 2	0.3333	0.5000	0.6667	0.3333	1.0000
Staff 3	1.0000	0.5000	1.0000	0.6667	0.0000
Staff 4	0.0000	0.0000	0.0000	1.0000	0.5000
Staff 5	0.6667	1.0000	0.6667	0.6667	1.0000
Staff 6	0.3333	0.5000	1.0000	0.3333	0.5000
Staff 7	1.0000	1.0000	0.6667	1.0000	0.0000
Staff 8	0.6667	0.0000	0.3333	0.6667	1.0000
Staff 9	0.3333	0.5000	0.0000	0.0000	0.5000
Staff 10	0.6667	1.0000	0.6667	0.3333	1.0000

Step 3: calculation of the geometric mean value of the criterion is calculated using equation (4), the result of calculating the geometric mean value of the criterion is as follows.

$$GM_1 = \left( \prod_{i=1}^n x_{11,10} \right)^{\frac{1}{10}} = (x_{11} * x_{12} * x_{13} * x_{14} * x_{15} * x_{16} * x_{17} * x_{18} * x_{19} * x_{110})^{\frac{1}{10}}$$

$$GM_1 = (8 * 7 * 9 * 6 * 8 * 7 * 9 * 8 * 7 * 8)^{\frac{1}{10}} = 7.6459$$

$$GM_2 = \left( \prod_{i=1}^n x_{21,210} \right)^{\frac{1}{10}} = (x_{21} * x_{22} * x_{23} * x_{24} * x_{25} * x_{26} * x_{27} * x_{28} * x_{29} * x_{210})^{\frac{1}{10}}$$

$$GM_2 = (9 * 8 * 8 * 7 * 9 * 8 * 9 * 7 * 8 * 9)^{\frac{1}{10}} = 8.1649$$

$$GM_3 = \left( \prod_{i=1}^n x_{31,310} \right)^{\frac{1}{10}} = (x_{31} * x_{32} * x_{33} * x_{34} * x_{35} * x_{36} * x_{37} * x_{38} * x_{39} * x_{310})^{\frac{1}{10}}$$

$$GM_3 = (7 * 8 * 9 * 6 * 8 * 9 * 8 * 7 * 6 * 8)^{\frac{1}{10}} = 7.5289$$

$$GM_4 = \left( \prod_{i=1}^n x_{41,410} \right)^{\frac{1}{10}} = (x_{41} * x_{42} * x_{43} * x_{44} * x_{45} * x_{46} * x_{47} * x_{48} * x_{49} * x_{410})^{\frac{1}{10}}$$

$$GM_4 = (6 * 7 * 8 * 9 * 8 * 7 * 9 * 8 * 6 * 7)^{\frac{1}{10}} = 7.4291$$

$$GM_5 = \left( \prod_{i=1}^n x_{51,510} \right)^{\frac{1}{10}} = (x_{51} * x_{52} * x_{53} * x_{54} * x_{55} * x_{56} * x_{57} * x_{58} * x_{59} * x_{510})^{\frac{1}{10}}$$

$$GM_5 = (8 * 9 * 7 * 8 * 9 * 8 * 7 * 9 * 8 * 9)^{\frac{1}{10}} = 8.1649$$

Step 4: the criterion weights are obtained based on the geometric average value calculated using equation (5), the results of the criterion weight calculation are as follows.

$$w_1 = \frac{GM_1}{\sum_{i=1}^n GM_{1,5}} = \frac{7.6459}{7.6459 + 8.1649 + 7.5289 + 7.4291 + 8.1649} = \frac{7.6459}{38.9338} = 0.1964$$

$$w_2 = \frac{GM_2}{\sum_{i=1}^n GM_{1,5}} = \frac{8.1649}{7.6459 + 8.1649 + 7.5289 + 7.4291 + 8.1649} = \frac{8.1649}{38.9338} = 0.2097$$

$$w_3 = \frac{GM_3}{\sum_{i=1}^n GM_{1,5}} = \frac{7.5289}{7.6459 + 8.1649 + 7.5289 + 7.4291 + 8.1649} = \frac{7.5289}{38.9338} = 0.1934$$

$$w_4 = \frac{GM_4}{\sum_{i=1}^n GM_{1,5}} = \frac{7.4291}{7.6459 + 8.1649 + 7.5289 + 7.4291 + 8.1649} = \frac{7.4291}{38.9338} = 0.1908$$

$$w_5 = \frac{GM_5}{\sum_{i=1}^n GM_{1,5}} = \frac{8.1649}{7.6459 + 8.1649 + 7.5289 + 7.4291 + 8.1649} = \frac{8.1649}{38.9338} = 0.2097$$

Step 5: calculate the weighted preference value of each alternative is calculated using equation (6), the result of calculating the weighted preference value is as follows.

$$v_{11} = (w_1 * r_{11}) + w_1 = (0.1964 * 0.6667) + 0.1964 = 0.3273$$

The results in table 3 are the overall calculation of the weighted preference value of each alternative that has been made.

**Table 3.** Calculation Results of Calculation of Weighted Preference Values

Name	Leadership	Managerial Ability	Task Completion	Innovation	Team Collaboration
Staff 1	0.3273	0.4194	0.2578	0.1908	0.3146
Staff 2	0.2618	0.3146	0.3223	0.2544	0.4194
Staff 3	0.3928	0.3146	0.3868	0.3180	0.2097
Staff 4	0.1964	0.2097	0.1934	0.3816	0.3146
Staff 5	0.3273	0.4194	0.3223	0.3180	0.4194
Staff 6	0.2618	0.3146	0.3868	0.2544	0.3146
Staff 7	0.3928	0.4194	0.3223	0.3816	0.2097
Staff 8	0.3273	0.2097	0.2578	0.3180	0.4194
Staff 9	0.2618	0.3146	0.1934	0.1908	0.3146
Staff 10	0.3273	0.4194	0.3223	0.2544	0.4194

Step 6: the calculation of the approximate value of the existing criteria is calculated using equation (6), the result of calculating the approximate value of the area of the criteria is as follows.

$$G_1 = \left[ \prod_{j=1}^m v_{11,110}^{1/10} \right] = 6.24156E - 06^{0.1} = 0.3017$$

$$G_2 = \left[ \prod_{j=1}^m v_{21,210}^{1/10} \right] = 1.33273E - 05^{0.1} = 0.3254$$

$$G_3 = \left[ \prod_{j=1}^m v_{31,310}^{1/10} \right] = 4.01243E - 06^{0.1} = 0.2886$$

$$G_4 = \left[ \prod_{j=1}^m v_{41,410}^{1/10} \right] = 2.8087E - 06^{0.1} = 0.2785$$

$$G_5 = \left[ \prod_{j=1}^m v_{51,510}^{1/10} \right] = 1.33273E - 05^{0.1} = 0.3254$$

Step 7: calculate the distance between each alternative and the boundary area using equation (7), the result of calculating the distance between each alternative and the boundary area is as follows.

$$Q_1 = v_{11} - G_1 = 0.3273 - 0.3017 = 0.0256$$

The results in table 4 are the overall calculation of the distance between each alternative and the boundary area of each alternative that has been carried out.

**Table 4.** Calculation of the Distance Between each Alternative and the Boundary Area

Name	Leadership	Managerial Ability	Task Completion	Innovation	Team Collaboration
Staff 1	0.0256	0.0940	-0.0308	-0.0877	-0.0109
Staff 2	-0.0398	-0.0109	0.0337	-0.0241	0.0940
Staff 3	0.0911	-0.0109	0.0981	0.0395	-0.1157

Staff 4	-0.1053	-0.1157	-0.0953	0.1031	-0.0109
Staff 5	0.0256	0.0940	0.0337	0.0395	0.0940
Staff 6	-0.0398	-0.0109	0.0981	-0.0241	-0.0109
Staff 7	0.0911	0.0940	0.0337	0.1031	-0.1157
Staff 8	0.0256	-0.1157	-0.0308	0.0395	0.0940
Staff 9	-0.0398	-0.0109	-0.0953	-0.0877	-0.0109
Staff 10	0.0256	0.0940	0.0337	-0.0241	0.0940

Step 8: calculate the value of the alternative function is the value calculated for each alternative based on its distance to the boundary area and its contribution to the criterion calculated using equation (8), the result of calculating the value of the alternative function is as follows.

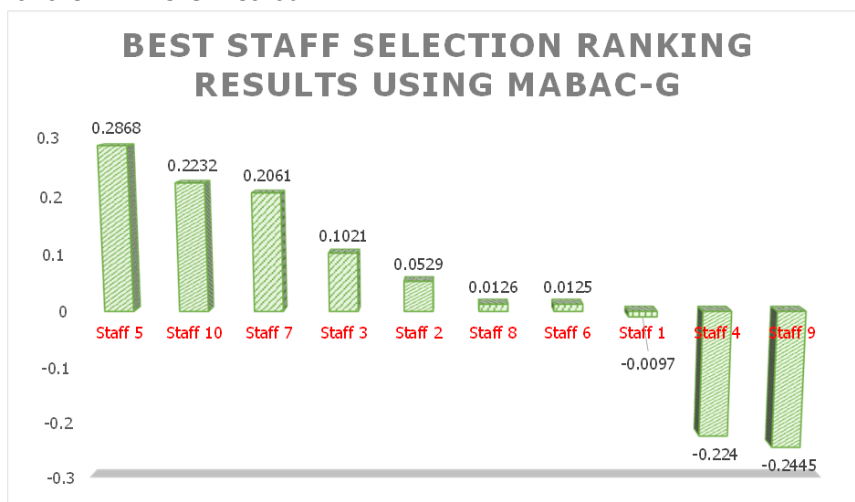
$$S_1 = \sum_{j=1}^n Q_{11,51} = 0.0256 + 0.0940 + (-0.0308) + (-0.0877) + (-0.0109) = -0.0097$$

The results in table 5 are the entire calculation of the function value of each alternative that has been carried out.

**Table 5.** Calculation of the Function Value of Each Alternative

Name	Alternative Function Values
Staff 1	-0.0097
Staff 2	0.0529
Staff 3	0.1021
Staff 4	-0.2240
Staff 5	0.2868
Staff 6	0.0125
Staff 7	0.2061
Staff 8	0.0126
Staff 9	-0.2445
Staff 10	0.2232

The MABAC-G method is a development of the MABAC method that integrates geometric mean aspects to improve accuracy in alternative assessments. With this approach, the results of alternative ranking reflect the balance between the objectivity of the criterion weights and the sensitivity to the relationship between attribute values. The ranking generated by the MABAC-G method provides a more comprehensive view because it considers the uncertainty in the data, Figure 2 is the ranking result of the application of the MABAC-G method.



**Figure 2.** Best Staff Selection Ranking Results Using MABAC-G



The ranking results using the MABAC-G method for the selection of the best staff showed that Staff 5 obtained the highest score of 0.2868, placing it as the best alternative in this assessment. Followed by Staff 10 with a score of 0.2232 and Staff 7 with a score of 0.2061, which ranked second and third. Meanwhile, Staff 3 and Staff 2 are also ranked positive with scores of 0.1021 and 0.0529, respectively. On the other hand, Staff 8 (0.0126) and Staff 6 (0.0125) recorded scores close to zero, indicating a relatively neutral performance. However, Staff 1, Staff 4, and Staff 9 received negative scores, -0.0097, -0.224, and -0.2445, respectively, indicating lower performance than other staff. These results provide objective insights into staff performance based on criteria evaluated with the MABAC-G approach.

### 3.3. Comparison Results of Alternative Ranking of Best Staff Selection

The comparison of the ranking of the best staff selection alternatives between the ranking of the company and the MABAC-G method illustrates the fundamental difference in the evaluation approach used. Rankings from companies are often based on subjective judgments that involve individual perceptions, which can be influenced by interpersonal relationships, personal experiences, and certain biases. On the other hand, the MABAC-G method is a more objective and structured technique in conducting evaluations, as it uses a data-driven approach that considers various predetermined criteria and weighting accordingly. Table 6 is the result of a comparison of rankings in the selection of the best staff.

**Table 6.** Comparison Results of the Best Staff Selection Ranking

Name	Ranking Using MABAC-G	Ranking of Companies
Staff 5	1	1
Staff 10	2	4
Staff 7	3	1
Staff 3	4	2
Staff 2	5	5
Staff 8	6	7
Staff 6	7	6
Staff 1	8	8
Staff 4	9	9
Staff 9	10	10

Based on the results of the ranking of the best staff selection using the MABAC-G method, there are several conformities and differences between individual rankings and company rankings. Staff 5 ranked first in both, demonstrating consistency in performance both individually and in the corporate context. Staff 10 ranked second according to the MABAC-G method, but the company's ranking placed it in fourth place, reflecting the individual's higher potential than the company's perception. Staff 7, despite only being ranked third in the individual rankings, is considered superior at the company level by ranking first. Staff 3 ranked fourth individually but rose to second place in the corporate context, demonstrating a significant contribution to organizational performance. On the other hand, Staff 2 and Staff 8 showed almost the same ranking consistency on both methods, i.e. in the fifth and sixth ranks, respectively. Staff 6, Staff 1, Staff 4, and Staff 9 show a fixed order between individual and company ratings, reflecting similar performance evaluations on both sides. This data provides an overview of how differences in individual and company assessments can reveal hidden potentials or specific challenges that need to be considered in staff management.

The results of the comparison of the ranking of the best staff selection alternatives using the ranking from the company and the MABAC-G method, Pearson's correlation value of 0.9511 shows that there is a very strong relationship between the two evaluation systems. This indicates that although the ranking of the company is based on subjective assessment, the resulting ranking results are almost in line with the ratings obtained through the MABAC-G method, which relies on a data-driven objective approach. This high correlation value indicates that despite differences in the approaches used, the two





methods provide a consistent assessment of staff performance, which provides additional validity to the ranking results that have been carried out.

## 4. CONCLUSION

The modification of the MABAC method is a significant step in improving accuracy and flexibility in multi-criteria assessment. This method is known for its systematic approach to measuring the degree of proximity of an alternative to an ideal solution based on an attribute boundary comparison area. MABAC-G is a development of the MABAC method that integrates the geometric mean approach in the calculation process, in order to improve accuracy and balance in multi-criteria assessment. MABAC-G offers more robust and adaptive solutions in a variety of decision-making contexts. The results of these modifications will be analyzed in depth to show the improved performance of the method in supporting more accurate and effective multi-criteria assessments. The results of the ranking of the best staff selection using the MABAC-G method, there are several conformities and differences between individual rankings and company rankings. Staff 5 ranked first on both, demonstrating consistency in performance both individually and in the corporate context. Staff 10 ranked second according to the MABAC-G method, but the company's ranking placed it at the fourth rank, which reflects the individual's higher potential than the company's perception. This data provides an overview of how differences in individual and company assessments can reveal hidden potentials or specific challenges that need to be considered in staff management. The results of the comparison of alternative rankings for the selection of the best employees using the ranking from the company and the MABAC-G method, the Pearson correlation value of 0.9511 shows that there is a very strong relationship between the two assessment systems. This shows that although the company's ranking is based on subjective assessment, the resulting ranking results are almost in line with the ratings obtained through the MABAC-G method which relies on a data-based objective approach. This high correlation value shows that despite the differences in the approaches used, the two methods provide consistent employee performance assessments, thus providing additional validity to the ranking results that have been carried out.

Modification of the MABAC method in MCDM must provide tangible benefits in order to improve the effectiveness of decision-making. One of the main benefits is the increased accuracy of alternative rankings, where these modifications should be able to produce more stable and representative ratings against real conditions. In addition, the modified MABAC-G must be more sensitive to changes in the weight of the criteria, so that the resulting decisions are more adaptive to the dynamics of the problems faced. Another expected advantage is its ability to overcome the weaknesses of the conventional MABAC method, such as limitations in handling large-scale data or data with a high level of uncertainty. Thus, these modifications can increase the flexibility of the method in various decision-making contexts, making it more reliable in various application areas.

## 5. REFERENCES

- [1] S. I. Ali *et al.*, "Risk quantification and ranking of oil fields and wells facing asphaltene deposition problem using fuzzy TOPSIS coupled with AHP," *Ain Shams Eng. J.*, vol. 15, no. 1, p. 102289, 2024, doi: <https://doi.org/10.1016/j.asej.2023.102289>.
- [2] A. M. Barasin, A. Y. Alqahtani, and A. A. Makki, "Performance Evaluation of Retail Warehouses: A Combined MCDM Approach Using G-BWM and RATMI," *Logistics*, vol. 8, no. 1, p. 10, Jan. 2024, doi: [10.3390/logistics8010010](https://doi.org/10.3390/logistics8010010).
- [3] S. Haoues, M. A. Yaltese, S. Belhadi, S. Chihaoui, and A. Uysal, "Modeling and optimization in turning of PA66-GF30% and PA66 using multi-criteria decision-making (PSI, MABAC, and MAIRCA) methods: a comparative study," *Int. J. Adv. Manuf. Technol.*, vol. 124, no. 7–8, pp. 2401–2421, 2023.
- [4] M. Baydaş, M. Yılmaz, Ž. Jović, Ž. Stević, S. E. G. Özuyar, and A. Özçil, "A comprehensive MCDM assessment for economic data: success analysis of maximum normalization, CODAS, and fuzzy approaches," *Financ. Innov.*, vol. 10, no. 1, p. 105, Mar. 2024, doi: [10.1186/s40854-023-00588-x](https://doi.org/10.1186/s40854-023-00588-x).
- [5] S. K. Sahoo and S. S. Goswami, "A Comprehensive Review of Multiple Criteria Decision-Making (MCDM) Methods: Advancements, Applications, and Future Directions," *Decis. Mak. Adv.*, vol. 1, no. 1, pp. 25–48, Dec. 2023, doi: [10.31181/dma1120237](https://doi.org/10.31181/dma1120237).
- [6] D. Tešić, M. Radovanović, D. Božanić, D. Pamucar, A. Milić, and A. Puška, "Modification of the DIBR and





- MABAC Methods by Applying Rough Numbers and Its Application in Making Decisions," *Information*, vol. 13, no. 8, p. 353, Jul. 2022, doi: 10.3390/info13080353.
- [7] S. Setiawansyah, S. H. Hadad, A. A. Aldino, P. Palupiningsih, G. Fitri Laxmi, and D. A. Megawaty, "Employing PIPRECIA-S weighting with MABAC: a strategy for identifying organizational leadership elections," *Bull. Electr. Eng. Informatics*, vol. 13, no. 6, pp. 4273–4284, Dec. 2024, doi: 10.11591/eei.v13i6.7713.
- [8] S. Chatterjee and S. Chakraborty, "Optimization of friction stir welding processes using multi-attributive border approximation area comparison (MABAC) method in neutrosophic fuzzy environment," *Int. J. Interact. Des. Manuf.*, vol. 17, no. 4, pp. 1979–1994, Aug. 2023, doi: 10.1007/s12008-023-01308-6.
- [9] S. B. Atim, "Penerapan Metode Multi-Attributive Border Approximation Area Comparison Dalam Rekomendasi Pemilihan Mobil Second," *J. Inf. Technol. Softw. Eng. Comput. Sci.*, vol. 2, no. 2, pp. 99–110, 2024, doi: 10.58602/itsecs.v2i2.111.
- [10] H. Shi, L. Huang, K. Li, X.-H. Wang, and H.-C. Liu, "An extended multi-attributive Border Approximation Area comparison method for emergency decision making with complex linguistic information," *Mathematics*, vol. 10, no. 19, p. 3437, 2022, doi: 10.3390/math10193437.
- [11] P. Liu and D. Wang, "A 2-dimensional uncertain linguistic MABAC method for multiattribute group decision-making problems," *Complex Intell. Syst.*, vol. 8, no. 1, pp. 349–360, 2022, doi: 10.1007/s40747-021-00372-3.
- [12] H. Dincer, S. Yüksel, and S. Eti, "Identifying the Right Policies for Increasing the Efficiency of the Renewable Energy Transition with a Novel Fuzzy Decision-Making Model," *J. Soft Comput. Decis. Anal.*, vol. 1, no. 1, pp. 50–62, Aug. 2023, doi: 10.31181/jscda1120234.
- [13] P. R. Pittman *et al.*, "Clinical characterization and placental pathology of mpox infection in hospitalized patients in the Democratic Republic of the Congo," *PLoS Negl. Trop. Dis.*, vol. 17, no. 4, p. e0010384, Apr. 2023, doi: 10.1371/journal.pntd.0010384.
- [14] S. Setiawansyah and Y. Rahmanto, "Implementation of the Geometric Mean Multi-Attribute Utility Theory (G-MAUT) in Determining the Best Honorary Employees," *J. Ilm. Comput. Sci.*, vol. 3, no. 2 SE-Articles, pp. 111–119, Jan. 2025, doi: 10.58602/jics.v3i2.50.
- [15] C. Feng and H. Wang, "Harmonic mean and geometric mean of a non negative random variable," *Commun. Stat. - Theory Methods*, pp. 1–0, May 2024, doi: 10.1080/03610926.2024.2349713.
- [16] S. Furtado and C. R. Johnson, "Efficiency of any weighted geometric mean of the columns of a reciprocal matrix," *Linear Algebra Appl.*, vol. 680, pp. 83–92, Jan. 2024, doi: 10.1016/j.laa.2023.10.001.
- [17] S. Goutam, S. Unnikrishnan, A. Karandikar, and A. Goutam, "Algorithm for vertical handover decision using geometric mean and MADM techniques," *Int. J. Inf. Technol.*, vol. 14, no. 5, pp. 2691–2699, Aug. 2022, doi: 10.1007/s41870-022-00935-8.

