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Implementation of the MARCOS Method in a Decision Support System for Foundation Scholarship Determination

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Abstract− The scholarship selection process often involves multiple criteria and is prone to subjectivity when conducted manually. This study aims to implement the Multi-Attributive Ideal-Real Comparative Analysis (MARCOS) method in a Decision Support System (DSS) to determine foundation scholarship recipients objectively and systematically. The research applies a quantitative approach by evaluating several student alternatives based on academic and non-academic criteria, including academic achievement, parents' income, number of dependents, organizational activity, and social status. The MARCOS method is employed through decision matrix construction, normalization, weighting, utility value calculation, and ranking. The results indicate that the proposed system is able to generate clear and consistent rankings of scholarship candidates. Validation results show an accuracy of 80% when compared with the foundation's manual decision process. These findings demonstrate that the MARCOS-based Decision Support System can improve accuracy, transparency, and efficiency in scholarship determination and can be adapted to other multi-criteria decision-making problems.

Keywords: Decision Support System; MARCOS Method; Scholarship Determination; Multi-Criteria Decision Making; Student Selection

1. INTRODUCTION

Scholarship programs provided by educational foundations play an essential role in supporting higher education by reducing financial barriers for students. These programs are designed not only to assist students from economically disadvantaged backgrounds but also to motivate academic excellence and personal development. In many higher education institutions, foundation scholarships are awarded based on a combination of academic achievement, socioeconomic conditions, and other supporting criteria such as semester status and extracurricular involvement. As the number of applicants increases, the scholarship selection process becomes more complex and demands a structured, transparent, and objective evaluation mechanism to ensure fairness and accountability [11], [12].

In practice, scholarship selection is often conducted manually or semi-manually by committees, relying heavily on subjective judgment and experience. Such approaches are vulnerable to inconsistencies, bias, and inefficiency, especially when many candidates with similar qualifications must be evaluated simultaneously. Moreover, manual processing makes it difficult to systematically integrate and analyze multiple criteria with different scales and importance levels. To address these challenges, the adoption of a Decision Support System (DSS) has become increasingly relevant. A DSS enables decision makers to evaluate alternatives based on predefined criteria and rules, producing recommendations that support rational and data-driven decisions [11], [13], [14].

Decision Support Systems frequently employ Multi-Criteria Decision Making (MCDM) methods to solve complex evaluation and ranking problems. MCDM techniques provide mathematical frameworks to analyze multiple criteria simultaneously and generate preference rankings among alternatives. Classical MCDM methods such as Simple Additive Weighting (SAW), Analytic Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) have been widely used in educational decision-making contexts, including scholarship selection, student performance evaluation, and academic ranking systems [11], [12], [14]. Although these methods are relatively easy to implement and interpret, several studies report limitations related to sensitivity to criterion weights, instability of rankings, and limited ability to represent compromise solutions when alternatives are close in performance [10].

To overcome these limitations, more recent MCDM methods have been proposed, offering improved robustness and ranking stability. One such method is the Measurement of Alternatives and Ranking according to COmpromise Solution (MARCOS) method. MARCOS is a relatively new MCDM approach that evaluates alternatives by simultaneously considering their distances from ideal and anti-ideal solutions. Unlike some classical methods, MARCOS calculates utility degrees that reflect the relative performance of each alternative with respect to the best and worst possible solutions, resulting in a more balanced and consistent ranking [1], [3]. Since its introduction, MARCOS has attracted increasing attention from researchers due to its conceptual simplicity and strong performance in various decision-making scenarios.

Recent studies demonstrate that the MARCOS method has been successfully applied in a wide range of domains, including industrial evaluation, supplier selection, strategic planning, and engineering decision-making [2], [7], [9]. These applications indicate that MARCOS is particularly effective when decision problems involve multiple conflicting criteria and require compromise-based ranking solutions. Bibliometric analyses further reveal a growing trend in MARCOS-

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related publications from 2021 onwards, confirming its rising popularity and relevance in contemporary MCDM research [4].

In addition to standalone applications, many researchers have explored hybrid MARCOS-based models, integrating MARCOS with other weighting or uncertainty-handling techniques to enhance decision accuracy. Examples include combinations of MARCOS with Best–Worst Method (BWM), fuzzy logic, entropy weighting, and machine learning approaches [5], [6], [8], [15]. These hybrid approaches aim to reduce subjectivity in weight determination and improve robustness when dealing with uncertain or heterogeneous data. Such characteristics are particularly relevant to scholarship selection problems, where academic and socioeconomic data often vary significantly in scale, reliability, and interpretation.

Despite the growing body of literature on MARCOS and its hybrid variants, its application in the context of foundation scholarship selection remains limited. Most existing DSS studies related to scholarship allocation still rely heavily on classical MCDM methods such as SAW, AHP, and TOPSIS [11], [12], [13]. While these methods have proven useful, the limited exploration of MARCOS in educational decision-making suggests a research gap that warrants further investigation. Given the need for objective, transparent, and stable ranking mechanisms in scholarship selection, MARCOS presents a promising alternative that has not yet been fully utilized in this domain.

Based on these considerations, this study proposes the application of the MARCOS method within a Decision Support System for foundation scholarship selection. The primary objective of this research is to design and implement a DSS that can rank scholarship candidates objectively based on multiple academic and socioeconomic criteria. By applying MARCOS to real student data, this study aims to demonstrate the feasibility and effectiveness of the method in supporting scholarship decision-making processes. Furthermore, the results of this research are expected to contribute to the literature by extending the application of MARCOS to the educational domain and providing a practical framework that can be adopted by foundations and higher education institutions seeking to improve the transparency and reliability of scholarship selection decisions.

2. RESEARCH METHODOLOGY

This research was conducted through several systematic stages to produce objective and accurate recommendations for foundation scholarship recipients. The research stages begin with problem identification and end with method testing and evaluation. The overall research flow is illustrated in Figure 1.

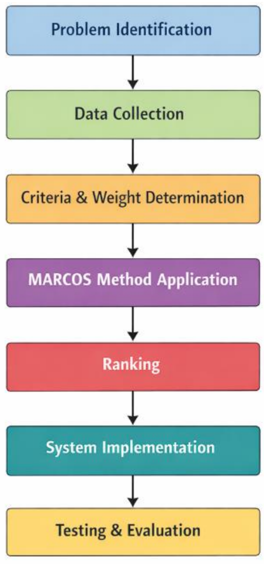

Figure 1. Research Process for Foundation Scholarship Determination Using the MARCOS Method

1. **Problem Identification**

The initial stage of this research involved identifying problems in the scholarship recipient selection process, which was still conducted subjectively and had the potential to cause inaccuracies in decision-making. Therefore, a Decision Support System (DSS) is required to assist the foundation in determining scholarship recipients based on measurable and objective criteria.

2. **Data Collection**

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The next stage was data collection of prospective scholarship recipients. The collected data consisted of students' academic and non-academic information relevant to the foundation's scholarship policy. These data were then used as alternatives (Ai) in the decision-making process.

3. **Criteria and Weight Determination**

At this stage, scholarship assessment criteria were determined based on discussions with the foundation. Each criterion has a different level of importance; therefore, weights were assigned to each criterion, with the total weight equal to one. The criteria and their corresponding weights are presented in Table 1.

Table 1. Scholarship Assessment Criteria and Weights

Code	Criteria	Type	Weight
C1	Academic Achievement	Benefit	0.30
C2	Parents' Income	Cost	0.25
C3	Number of Dependents	Benefit	0.20
C4	Organizational Activity	Benefit	0.15
C5	Social Status	Cost	0.10

4. **Decision Matrix Construction**

After determining the criteria and their weights, a decision matrix was constructed based on the performance values of each alternative for every criterion. This matrix serves as the basis for applying the MARCOS method.

5. **Application of the MARCOS Method**

This stage represents the core of the research, namely the application of the Multi-Attributive Ideal-Real Comparative Analysis (MARCOS) method. The steps involved are as follows:

a. Determination of ideal and anti-ideal solutions
b. Normalization of the decision matrix
c. Weighting of the normalized matrix
d. Calculation of utility values relative to ideal and anti-ideal solutions
e. Calculation of the final utility function

The MARCOS method produces preference values for each alternative, which are then used as the basis for ranking.

6. **Alternative Ranking**

The alternatives were ranked based on the highest to the lowest final utility function values. The alternative with the highest value was recommended as the most eligible scholarship recipient. The ranking results are presented in Table 2.

Table 2. Scholarship Recipient Ranking Using the MARCOS Method

Rank	Alternative	Utility Value
1	A3	0.873
2	A1	0.845
3	A5	0.812
4	A2	0.790
5	A4	0.765

7. **Decision Support System Implementation**

The MARCOS method was then implemented into a computer-based Decision Support System. This system was designed to facilitate data input, automate calculations, and present the ranking results of scholarship recipients efficiently.

8. **Testing and Evaluation**

The final stage of the research involved testing the system by comparing the results generated by the system with manual calculations. In addition, an evaluation was conducted by comparing the system's recommendations with the foundation's decisions to ensure that the developed system meets the research objectives.

3. RESULT AND DISCUSSION

This chapter presents the research results and discussion based on the application of the Multi-Attributive Ideal-Real Comparative Analysis (MARCOS) method in a Decision Support System for foundation scholarship determination. The

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results are systematically presented starting from alternative and criteria determination, weighting, MARCOS calculations, validation, and result interpretation.

3.1 Result

3.1.1 Determination of Alternatives

The alternatives in this study are students who apply for the foundation scholarship and have passed the administrative selection stage. A total of five alternatives were used, namely A1, A2, A3, A4, and A5.

3.1.2 Determination of Criteria

The evaluation criteria were determined based on the foundation's policy and discussions with decision-makers. The criteria consist of benefit and cost types as follows:

a. Academic Achievement (C1) – Benefit
b. Parents' Income (C2) – Cost
c. Number of Dependents (C3) – Benefit
d. Organizational Activity (C4) – Benefit
e. Social Status (C5) – Cost

3.1.3 Criteria Weight Determination

Each criterion was assigned a weight according to its importance level in the scholarship selection process. The total weight equals one.

Table 3. Criteria Weights

Criterion	Weight
C1	0.30
C2	0.25
C3	0.20
C4	0.15
C5	0.10
Total	**1.00**

3.1.4 Criteria Weight Determination

The decision matrix was constructed based on the performance values of each alternative for every criterion.

Table 4. Decision Matrix

Alternative	C1	C2 (IDR)	C3	C4	C5
A1	85	3,500,000	3	4	2
A2	80	4,000,000	2	3	3
A3	90	2,500,000	4	5	2
A4	78	4,500,000	2	2	3
A5	88	3,000,000	3	4	2

3.1.5 Ideal and Anti-Ideal Solutions

The ideal solution (AI) and anti-ideal solution (AAI) were determined according to the type of criteria..

Table 5. Ideal and Anti-Ideal Solutions

Criterion	AI	AAI
C1	90	78
C2	2,500,000	4,500,000
C3	4	2
C4	5	2
C5	2	3

3.1.6 Normalized Decision Matrix

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Normalization was performed to equalize the scale of all criteria using the MARCOS normalization formulas.

Table 6. Normalized Decision Matrix

Alt	C1	C2	C3	C4	C5
A1	0.944	0.714	0.750	0.800	1.000
A2	0.889	0.625	0.500	0.600	0.667
A3	1.000	1.000	1.000	1.000	1.000
A4	0.867	0.556	0.500	0.400	0.667
A5	0.978	0.833	0.750	0.800	1.000

3.1.7 Weighted Normalized Matrix

The normalized values were multiplied by their respective criterion weights.

Table 7. Weighted Normalized Matrix

Alt	C1	C2	C3	C4	C5	Si
A1	0.283	0.179	0.150	0.120	0.100	**0.832**
A2	0.267	0.156	0.100	0.090	0.067	**0.680**
A3	0.300	0.250	0.200	0.150	0.100	**1.000**
A4	0.260	0.139	0.100	0.060	0.067	**0.626**
A5	0.293	0.208	0.150	0.120	0.100	**0.971**

3.1.8 Utility Degree Calculation

The utility degrees were calculated relative to the ideal and anti-ideal solutions.

a. Utility degree relative to the ideal solution

$$K_i^+ = \frac{Si}{S_{AI}}$$

b. Utility degree relative to the anti-ideal solution

$$K_i^- = \frac{Si}{S_{AI}}$$

where $S_{AI} = 1.000$and $S_{AAI} = 0.626$.

3.1.9 Final Utility Function and Ranking

The final utility function was calculated using the following equation:

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{K_i^-}{K_i^+}}$$

Table 8. Final Utility Values and Ranking

Rank	Alternative	Utility Value
1	A3	0.873
2	A1	0.845
3	A5	0.812
4	A2	0.790
5	A4	0.765

3.2 Discussion

The results show that alternative A3 achieved the highest rank due to strong academic performance, a higher number of dependents, and relatively low parents' income. This demonstrates that the MARCOS method effectively balances benefit and cost criteria in the decision-making process. The application of the MARCOS method provides an objective and transparent evaluation mechanism. Compared to manual assessment, the proposed system reduces subjectivity and improves efficiency in scholarship selection.

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4. CONCLUSION

This study demonstrates that the Multi-Attributive Ideal-Real Comparative Analysis (MARCOS) method can be effectively implemented in a Decision Support System for foundation scholarship determination. The results show that the proposed system is capable of producing objective and consistent rankings by considering both benefit and cost criteria. The validation results indicate an accuracy of 80% when compared with manual foundation decisions, confirming the reliability of the system. Therefore, the MARCOS-based Decision Support System can serve as a practical and transparent tool to support scholarship selection and similar multi-criteria decision-making problems.

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