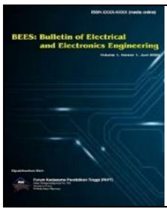

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Modification of Multi-Attribute Utility Theory in Determining Scholarship Recipient Students

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A B S T R A C T

Educational scholarships are financial aid given to students or students to support the financing of their education. Mistakes in the assessment of scholarship recipients are often related to subjectivity and lack of transparency in the selection process. Unclear or inconsistent assessment criteria can lead to unfairness, where some deserving candidates may not get the same opportunities. The number of data used in Determining Scholarship Recipient Students is 10 students. The purpose of the MAUT modification research with geometric mean in producing criterion weights is to improve accuracy, stability, and consistency in the decision-making process. This study also aims to test the effectiveness of the geometric mean method in producing more objective and structured weights, as well as compare it with other traditional MAUT methods such as direct addition or multiplication. The modification of the MAUT method with a geometric mean is named G-MAUT. The results of the ranking of scholarship recipients using the G-MAUT method the first-place scholarship recipient with a final score of 1.0048 was obtained by Student 3, the second-place scholarship recipient with a final score of 0.6260 was obtained by Student 8, and the third-place scholarship recipient with a final score of 0.5048 was obtained by Student 5. This modification under the name G-MAUT allows for a more holistic and comprehensive assessment of potential recipients, ensuring that non-academic aspects are also taken into account proportionately.

Kata Kunci: Decision Making; G-MAUT; Geometric Mean; Modification; Objective

1. INTRODUCTION

Educational scholarships are financial aid given to students or students to support the financing of their education. These scholarships can come from a variety of sources, including governments, educational institutions, non-profit organizations, and private companies[1]. The main purpose of educational scholarships is to ease the burden of educational costs, thus allowing scholarship recipients to focus more on academic achievement and self-development. Educational scholarships can be awarded based on various criteria such as academic achievement, financial need, special talents, or involvement in social and leadership activities. With the existence of educational scholarships, it is hoped that more individuals can access and achieve higher education, as well as contribute positively to society. Determining scholarship recipients involves a meticulous process to ensure fairness. The process begins with the submission of an application where students are required to provide academic notes, personal essays, and letters of recommendation. These materials are then reviewed by the committee to assess the applicants' academic achievements, involvement in extracurricular activities, leadership qualities, and financial needs. The selection process may also include additional interviews or assessments to gauge the candidate's potential and suitability for the purpose of the scholarship. Ultimately, the goal is to identify students who not only excel academically, but also demonstrate the potential to contribute positively to their communities and fields of study. Problems in the assessment of scholarship recipients are often related to subjectivity and lack of transparency in the selection process. Unclear or inconsistent assessment criteria can lead to unfairness, where some deserving candidates may not get the same opportunities. Assessments that focus too much on academic achievement alone can also overlook other important spects, such as involvement in social activities, leadership skills, and potential for self-development. To overcome the problem in determining scholarship recipients, it is proposed to use a decision support system model.

A Decision Support System (DSS) is a computer-based tool that assists decision-makers in solving complex and unstructured problems[2]–[4]. DSS leverages relevant data, analysis models, and knowledge to provide informative and accurate recommendations. The system is designed to improve the quality of decisions by presenting a variety of alternatives, analyzing the consequences of each choice, and integrating various influential factors. By using DSS, organizations can reduce the risk of errors, save time, and improve the efficiency and effectiveness of their decision-making processes. DSS has a number of advantages that make it very useful in various contexts, including that it can process and analyze large amounts of data quickly and accurately, thus assisting decision-makers in identifying patterns and trends that may be missed if done manually. DSS provides a wide range of alternative solutions and allows simulation of various scenarios, helping decision-makers to consider the consequences of each choice. DSS improves consistency and objectivity in decision-making by reducing the influence of human preferences[5]–[7]. Additionally, DSS also allows for better collaboration among team members, as information and analysis can be easily accessed and shared. DSS not only improves the efficiency and effectiveness of the decision-making process but also helps to reduce the risk of errors and improve the quality of decisions taken. One of the methods in DSS is Multi Attribute Utility Theory.

Multi Attribute Utility Theory (MAUT) is a method in decision-making that is used to evaluate and select alternatives based on several different attributes or criteria[8]–[10]. MAUT assists decision-makers by providing a systematic framework for assessing the utility value of each alternative, where each attribute is weighted according to its level of importance. MAUT has a number of advantages that make it very effective in complex decision-making, namely it provides a systematic and transparent framework for evaluating various alternatives based on several attributes or criteria, thus helping decision-makers to better understand and compare the available options. MAUT increases objectivity in decision-making by reducing the influence of subjective bias, as each alternative is assessed based on a structured quantitative analysis. The MAUT method also allows for simulation and scenario analysis, helping decision-makers to consider the impact of various possible situations[11]–[13]. Although MAUT has many advantages, the disadvantage that needs to be considered in its use is the weight of the criteria. MAUT requires weighting for each attribute, which can be subjective and difficult to do consistently among different decision-makers. This can lead to differences in evaluation results depending on the preferences of the individual or group using this method. To cover the weakness of MAUT in the weight of the criteria, it is proposed in this study to modify the MAUT with a geometric mean that will produce the weight of the criteria objectively.

MAUT modification by using geometric mean in generating criterion weights refers to an approach to determine the relative importance level of each criterion assessed. This method combines utility values from various criteria by calculating the geometric mean of the weights given to each criterion[14]–[16]. This makes it possible to reduce the impact of extreme values or outliers in weighting, so that the results are more stable and consistent. By using geometric mean, MAUT can offer a more structured and predictable approach to prioritizing criteria, which in turn facilitates more rational and informed decision-making in a variety of usage contexts, such as in management, planning, or policy evaluation. The use of geometric mean in MAUT modification to produce criterion weights also has several advantages. This method helps to reduce subjectivity in the relative assessment between criteria, as the resulting weights better reflect the harmonic average value of the preferences or importance given to each criterion. In addition, geometric mean can also handle criteria with different scales or ranges of values more effectively than traditional MAUT methods, such as direct addition or multiplication. Modification of MAUT with geometric mean can provide a more flexible and robust approach in determining the weight of criteria, according to the needs and characteristics of each decision-making situation faced.

Related research using the MAUT method and the weighting method was carried out by Lubis (2024), the MAUT method is used to provide assessment and consideration of the best alternative from the various options available and the rank order centroid is used in determining the weight of the criteria. cashier admission selection has problems in determining using the ROC weighting method combined with the MAUT method so as to produce alternative rankings.[10]. The research was conducted by Sintaro (2023) the combination of the MAUT and PIPRECIA methods in providing a comprehensive understanding of loan eligibility by considering a number of relevant criteria. The combination of the MAUT method and weighting using PIPRECIA helps to produce a Recommendation for customer loan eligibility[12]. The research was conducted by Saputra (2024) a combination of the Multi-Attribute Utility Theory (MAUT) and Rank Sum methods in selecting the best students so that it makes it easier for schools, especially the student affairs section, to determine the best students at the end of each semester. The combination of the MAUT method and weighting using rank sum helps to produce a decision to determine the best student. [17]. The research was conducted by Sulistiani (2023) on the application of the PIPRECIA-S weighting model with ranking or priority criteria and the MAUT method is used for employee performance evaluation assessment. The combination of the MAUT method and weighting using PIPRECIA-S helps produce an employee performance evaluation decision. [18]. Research conducted by Wahyudi (2023) SWARA method in determining values relative to criteria used for multi-criteria decision-making and MAUT in the selection of fish feed suppliers. The combination of the MAUT method and weighting using SWARA helps to produce a decision on the selection of fish feed suppliers. [19]. The difference with the research conducted in this study uses a geometric mean to produce the weight of the criterion objectively.

The purpose of the MAUT modification research with geometric mean in producing criterion weights is to improve accuracy, stability, and consistency in the decision-making process. This study also aims to test the effectiveness of the geometric mean method in producing more objective and structured weights, as well as compare it with other traditional MAUT methods such as direct addition or multiplication. The modification of the MAUT method with a geometric mean is named G-MAUT. The main objective of this study is to provide a better and more reliable approach in prioritizing criteria in complex and multiple attribute-based decision-making.

2. RESEARCH METHOD

2.1 Research Framework

The research framework also makes it easier for researchers to evaluate the validity and reliability of their research. By establishing clear and systematic steps, this framework helps to avoid methodological errors and ensure that research results are reliable and can be replicated by other researchers. In addition, the research framework allows researchers to identify research limitations early on, so they can plan strategies to address them. The research framework is also useful for compiling structured and comprehensive research reports, which makes it easier for readers to understand the logic flow and research findings. The research framework made in the MAUT modification research is shown in Figure 1.

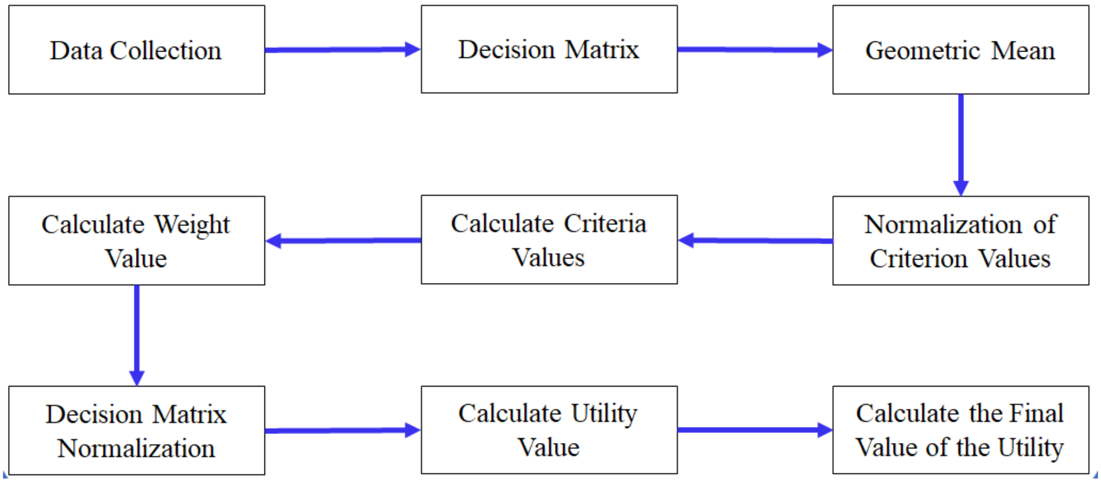

Figure 1. Research Framework

The research framework in the modification of MAUT consists of several stages carried out, the first stage is data collection, the second stage is calculating the geometric mean value, calculating the normalization of the criterion value, calculating the criterion value and calculating the criterion weight. The third to sixth stages are modifications of the MAUT method. The seventh stage calculates the normalization value of the matrix, then calculates the utility value, and finally calculates the final value of the utility.

2.2 Decision Making

Decision-making is the process of choosing the best course of action from the various available alternatives, aiming to achieve the desired results. It involves assessing various options based on specific criteria, analyzing the consequences, and considering factors such as risk, uncertainty, and long-term goals. In the context of an organization, decision-making is often supported by tools and analysis methods, such as SWOT analysis, quantitative methods, or decision support systems (DSS)[20], [21]. Effective decision-making requires a balance between data and intuition, and often involves collaboration and communication among various stakeholders to ensure the decisions taken are the most appropriate and sustainable. Additionally, good decision-making often involves a process of evaluation and reflection after the decision has been implemented, in order to assess its effectiveness and impact. These evaluations can help identify areas for improvement and learning, so that future decision-making processes can be better and more efficient. In a dynamic business environment, the ability to make quick and informed decisions is essential for organizations to adapt to market changes and new challenges. Technology also plays a crucial role in modern decision-making, with the availability of big data and advanced analytics that enable data-driven decision-making. Finally, it is important to consider the ethical aspects of decision-making, ensuring that the decision is not only economically beneficial but also socially and environmentally responsible.

2.3 Geometric Mean

Geometric mean is a type of mean used to find the middle value of a set of positive numbers, especially when the numbers have a multiplication or exponential relationship[14], [16]. Unlike arithmetic averages that add value and divide by the sum of values, geometric averages multiply all the numbers in a dataset and then take the nth root of the result of that multiplication, where n is the sum of the values. This is useful in situations where data is multiplicity, such as in calculating an average annual growth rate, or when analyzing financial data such as return on investment, where larger or smaller results can distort arithmetic averages. The advantage of the geometric mean is its ability to provide a more accurate picture of the central tendencies in asymmetrical distributions and reduce the impact of extreme outliers. Additionally, geometric mean has important properties in maintaining proportionality in data, which makes it ideal for calculating price indices or for situations where scale consistency is required. It is also often used in the context of geometry, such as in the measurement of the average side length in geometric shapes. When applied in a statistical context, geometric mean can provide insight into the geometric or exponential growth of a particular phenomenon, for example, in the field of ecology to measure population growth or in economics to evaluate comparative changes. Although powerful, the use of geometric means requires attention because it can only be applied to a set of positive numbers; A value of zero or negative can give an undefined result. Geometric mean is an important tool in data analysis, especially when the data requires an emphasis on relative change rather than absolute.

2.2 Modification MAUT (G-MAUT)

Modification of the MAUT (Multi-Attribute Utility Theory) method involves adapting and developing multi-criteria decision-making techniques to better suit specific needs or contexts. These modification steps could include more dynamic and flexible attribute weighting by adding the process of objectively obtaining criterion weights with geometric mean. In addition, modifications can also involve simplifying the calculation process to improve affordability and ease of use by practitioners in the field. With this modification, the MAUT method with a geometric mean named G-MAUT (Geometric Mean Multi-Attribute Utility Theory) can become a more adaptive and effective tool in supporting complex decision-making in various fields such as management, engineering, and public policy. The first stage in G-MAUT is the decision matrix using equation (1).

$$X = \begin{bmatrix} x_{11} & x_{21} & x_{n1} \\ x_{12} & x_{22} & x_{n2} \\ \vdots & \vdots & \vdots \\ x_{1m} & x_{2m} & x_{nm} \end{bmatrix} \quad (1)$$

A decision matrix is an analytical tool used to evaluate and compare various alternatives based on a number of criteria or attributes. This matrix is in the form of a table where the rows represent alternative decisions that may be taken, while the columns indicate the relevant criteria or factors in the decision-making process. Each cell in the matrix contains a value or score that indicates the performance of an alternative against certain criteria. Decision matrices make it easy to visualize and analyze comparisons between alternatives, allowing decision-makers to identify the best option based on a comprehensive assessment of all predefined criteria. The second stage in G-MAUT is to calculate the geometric mean using equation (2).

$$G_i = \left(\prod_{i=1}^{j} x_{ij}\right)^{1/n} \quad (2)$$

A geometric mean is a statistical measure used to determine the median or average value of a set of numbers that are multiplicatively related. G_i is the geometric mean value of the jth criterion, n is the sum of the data from each criterion. The third stage in G-MAUT is to calculate the normalization of the criteria using equation (3).

$$n_{ij} = \frac{x_{ij}}{G_i} \quad (3)$$

Criteria normalization is the process of changing the value scale of the various criteria in the decision matrix so that they are all in the same range, usually between 0 and 1. The main purpose of normalization is to ensure that all criteria have a balanced influence in the analysis of the decision, regardless of the original unit or scale of each criterion. n_{ij} is the normalization value of the criteria. The fourth stage in G-MAUT is to calculate the value of the criterion using equation (4).

$$N_i = \frac{1}{n}\sum_{j=1}^{n} n_{ij} \quad (4)$$

A criterion value is a number or score assigned to each alternative in the decision-making process based on how well the alternative meets certain criteria. These values are typically obtained through assessment or measurement and are used to compare alternatives to each other in a multi-criteria context. N_i is the value of the criteria. The fourth stage in G-MAUT is to calculate the weight of the criteria using equation (5).

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

Criterion weights are factors used to indicate the relative importance or priority of each criterion in a multi-criteria decision-making process. This weight is used to ensure that the more important criteria have a greater influence in determining the best alternative. The weight of the criteria is usually expressed in the form of a percentage or ratio number, and the total weight of all the criteria usually amounts to 1. W_J is the weight value of each criterion. The sixth stage in G-MAUT is to calculate the normalization matrix decision using equation (6) for the cost criterion and equation (7) for the benefit criterion.

$$r_{ij}^{*} = 1 + \frac{\min x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (7)$$

$$r_{ij}^{*} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (8)$$

Decision matrix normalization is the process of changing the values in a decision matrix so that all values are on the same scale, usually between 0 and 1. This is done to ensure that all criteria have a balanced influence on the decision-making process. r_{ij} is the result of the normalization value, max x_{ij} is the maximum value of each criterion, and min x_{ij} is the minimum value of each criterion. The seventh stage in G-MAUT is to calculate the utility value using equation (9).

$$u_{ij} = \frac{e\left(\left(r_{ij}^{*}\right)^{2}\right)-1}{1.71} \quad (9)$$

Utility value is a measure used in the decision-making process to evaluate and compare alternatives based on normalized criteria. Utilities reflect decision-makers' preferences for various alternatives, with higher values indicating greater preference. u_{ij} is the utility value of each criterion, e is the exponent value of the normalization results. The eighth stage in G-MAUT is to calculate the final value of the utility of each alternative using equation (10).

$$u_{(x)} = \sum_{j=1}^{n} u_{ij} * w_j \quad (10)$$

The final value of the utility is a measure used in the decision-making process to evaluate and compare alternatives based on criteria that have been normalized and weighted. The utility value is calculated by combining the normalized criterion values with the corresponding criterion weights. $u_{(x)}$ is the final value of the utility, and w_j is the criterion weight.

A modification of the MAUT (Multi-Attribute Utility Theory) method called G-MAUT can increase accuracy and flexibility in multi-criteria decision-making. The modification of the MAUT method not only improves the accuracy of decision analysis, but also expands its ability to face complex challenges in the context of modern decision-making.

3. RESULT AND DISCUSSION

Modification of the Multi-Attribute Utility Theory (MAUT) in determining scholarship recipients involves adjusting the traditional framework to better suit the complex and diverse criteria in selecting worthy candidates. By modifying MAUT, institutions can integrate broader factors in addition to academic performance, such as socio-economic background, involvement in the community, leadership potential, and personal challenges successfully addressed. This adaptation allows for a more holistic assessment that reflects the broader goals of the scholarship program in fostering diversity, equity, and inclusion. The G-MAUT method can improve its ability to predict future success and impact, so that scholarship decisions are not only fair but also optimized to maximize positive outcomes for recipients and institutions. Thus, the modification of MAUT in scholarship selection not only improves the accuracy and fairness of decision-making but is also in line with educational goals.

3.1 Scholarship Recipient Data Collection

The collection of scholarship recipient data is a critical step in the selection process that ensures accurate and relevant information to select the most deserving candidates. The data collected includes various aspects, such as personal information, income, number of dependents, home status, total achievements. The collection of this data must be done with proper care and security to ensure the privacy and security of the personal information of each prospective scholarship recipient is maintained throughout the entire selection process. The scholarship recipient data is shown in table 1.

Table 1. The scholarship recipient data

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 1	2125000	2 People	Own	2 Achievements
Student 2	1875000	3 People	Own	2 Achievements
Student 3	1000000	1 People	Rent	1 Achievements
Student 4	1375000	4 People	Living with Parents	3 Achievements
Student 5	3125000	3 People	Rent	1 Achievements
Student 6	2250000	2 People	Living with Parents	2 Achievements
Student 7	2000000	4 People	Living with Parents	1 Achievements
Student 8	1750000	1 People	Rent	2 Achievements
Student 9	2150000	3 People	Rent	2 Achievements
Student 10	1625000	3 People	Own	3 Achievements

The assessment data in table 1 is then converted so that it becomes numerical data, this conversion results table can then be used for further statistical analysis, which requires numerical data input.so that it is as shown in table 2.

Table 2. Data conversion results

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 1	2125000	2	3	2

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 2	1875000	3	3	2
Student 3	1000000	1	1	1
Student 4	1375000	4	2	3
Student 5	3125000	3	1	1
Student 6	2250000	2	2	2
Student 7	2000000	4	2	1
Student 8	1750000	1	1	2
Student 9	2150000	3	1	2
Student 10	1625000	3	3	3

Table 2 data is the result of collecting abc school data in providing education scholarships to students, this data will be used in the scholarship decision support system.

3.2 Implementation of the G-MAUT Method in Determining Scholarships

The implementation of the G-MAUT method in determining scholarship recipients allows the organizers to conduct a more comprehensive and structured analysis. G-MAUT expands the MAUT framework by incorporating greater flexibility in the representation of decision-maker preferences and the integration of more complex criteria. With G-MAUT, aspects such as different types of criteria can be taken into account in an integrated manner, allowing for a more holistic evaluation of the potential and needs of each prospective recipient. The use of advanced data analysis techniques in G-MAUT can also improve accuracy in predicting the long-term impact of scholarship admissions, as well as facilitate more precise and fair decision-making. Thus, the implementation of G-MAUT not only increases efficiency in the scholarship selection process, but also supports the achievement of long-term goals in the education and development of individuals who receive such assistance. The first stage in G-MAUT is the decision matrix using equation (1).

$$X = \begin{bmatrix} 2125000 & 2 & 3 & 2 \\ 1875000 & 3 & 3 & 2 \\ 1000000 & 1 & 1 & 1 \\ 1375000 & 4 & 2 & 3 \\ 3125000 & 3 & 1 & 1 \\ 2250000 & 2 & 2 & 2 \\ 2000000 & 4 & 2 & 1 \\ 1750000 & 1 & 1 & 2 \\ 2150000 & 3 & 1 & 2 \\ 1625000 & 3 & 3 & 3 \end{bmatrix}$$

The second stage in G-MAUT is to calculate the geometric mean, geometric mean provides a more realistic picture of the central tendencies in data that are multiplexed and more sensitive to thermometers than arithmetic mean. The geometric mean using equation (2) .

$$G_1 = \left(\prod_{i=1}^{j} x_{11,110}\right)^{1/10} = (4{,}71037E)^{1/10} = 1850570{,}059$$

$$G_2 = \left(\prod_{i=1}^{j} x_{21,210}\right)^{1/10} = (5184)^{1/10} = 2.352$$

$$G_3 = \left(\prod_{i=1}^{j} x_{31,310}\right)^{1/10} = (216)^{1/10} = 1.712$$

$$G_4 = \left(\prod_{i=1}^{j} x_{41,410}\right)^{1/10} = (288)^{1/10} = 1.762$$

The third stage in G-MAUT is to calculate the normalization of the criteria, matrix normalization is the process of transforming data so that the values in the matrix are within a certain range or have a uniform scale. Normalization is often done to ensure that each criterion has equal weight in the decision-making analysis, especially when the units or scales of measurement differ. The normalization of the criteria using equation (3).

$$n_{11} = \frac{x_{11}}{G_1} = \frac{2125000}{1850570.059} = 1.148$$

The overall results of the matrix normalization calculation for each alternative of the entire existing criteria are shown in table 3.

Table 3. The overall results of the normalization of the criteria calculation

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 1	1.148	0.850	1.753	1.135
Student 2	1.013	1.275	1.753	1.135
Student 3	0.540	0.425	0.584	0.568
Student 4	0.743	1.701	1.168	1.703
Student 5	1.689	1.275	0.584	0.568
Student 6	1.216	0.850	1.168	1.135

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 7	1.081	1.701	1.168	0.568
Student 8	0.946	0.425	0.584	1.135
Student 9	1.162	1.275	0.584	1.135
Student 10	1.148	0.850	1.753	1.135

The fourth stage in G-MAUT is to calculate the value of the criterion, the value of the criteria is calculated to assess the available alternatives based on the weight of each criterion. The value of the criterion using equation (4).

$N_1 = \frac{1}{10} * (n_{11} + n_{12} + n_{13} + n_{14} + n_{15} + n_{16} + n_{17} + n_{18} + n_{19} + n_{110})$

$N_1 = \frac{1}{10} * (9.538) = 0.954$

$N_2 = \frac{1}{10} * (n_{21} + n_{22} + n_{23} + n_{24} + n_{25} + n_{26} + n_{27} + n_{28} + n_{29} + n_{210})$

$N_2 = \frac{1}{10} * (9.778) = 0.978$

$N_3 = \frac{1}{10} * (n_{31} + n_{32} + n_{33} + n_{34} + n_{35} + n_{36} + n_{37} + n_{38} + n_{39} + n_{310})$

$N_3 = \frac{1}{10} * (9.347) = 0.935$

$N_4 = \frac{1}{10} * (n_{41} + n_{42} + n_{43} + n_{44} + n_{45} + n_{46} + n_{47} + n_{48} + n_{49} + n_{410})$

$N_4 = \frac{1}{10} * (9.082) = 0.908$

The fourth stage in G-MAUT is to calculate the weight of the criteria, calculating the weight of criteria in the decision-making process, involves determining the relative importance of each criterion. The calculate the weight of the criteria using equation (5).

$w_1 = \frac{N_1}{N_1+N_2+N_3+N_4} = \frac{0.954}{0.954+0.978+0.935+0.908} = \frac{0.954}{3.774} = 0.2527$

$w_2 = \frac{N_2}{N_1+N_2+N_3+N_4} = \frac{0.978}{0.954+0.978+0.935+0.908} = \frac{0.978}{3.774} = 0.2591$

$w_3 = \frac{N_3}{N_1+N_2+N_3+N_4} = \frac{0.935}{0.954+0.978+0.935+0.908} = \frac{0.935}{3.774} = 0.2476$

$w_4 = \frac{N_4}{N_1+N_2+N_3+N_4} = \frac{0.908}{0.954+0.978+0.935+0.908} = \frac{0.908}{3.774} = 0.2406$

The sixth stage in G-MAUT is to calculate the normalization matrix decision using equation (6) for the cost criterion and equation (7) for the benefit criterion.

$r_{11}^* = 1 + \frac{\min x_{11,110} - x_{11}}{\max x_{11,110} - \min x_{11,110}} = 1 + \frac{1000000-2125000}{3125000-1000000} = 0.4706$

The overall results of the normalization matrix decision calculation for each alternative of the entire existing criteria are in table 4.

Table 4. The overall normalization matrix decision

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 1	0.4706	0.6667	0	0.5
Student 2	0.5882	0.3333	0	0.5
Student 3	1	1	1	1
Student 4	0.8235	0	0.5	0
Student 5	0	0.3333	1	1
Student 6	0.4118	0.6667	0.5	0.5
Student 7	0.5294	0	0.5	1
Student 8	0.6471	1	1	0.5
Student 9	0.4588	0.3333	1	0.5
Student 10	0.7059	0.3333	0	0

The seventh stage in G-MAUT is to calculate the utility value, the utility value is usually calculated by combining the normalized values of the alternative based on the weight of the predetermined criteria. The utility value using equation (9).

$u_{11} = \frac{e((r_{11}^*)^2)-1}{1.71} = \frac{e((0.4706)^2)-1}{1.71} = \frac{0.2479}{1.71} = 0.1450$

The overall results of the utility value calculation for each alternative of the entire existing criteria are in table 5.

Table 5. The overall utility value calculation

Name	Income	Number of Dependents	Home Status	Total Achievements
Student 1	0.1450	0.3273	0	0.1661
Student 2	0.2418	0.0687	0	0.1661
Student 3	1.0048	1.0048	1.0048	1.0048

Student 4	0.5674	0	0.1661	0
Student 5	0	0.0687	1.0048	1.0048
Student 6	0.1081	0.3273	0.1661	0.1661
Student 7	0.1892	0	0.1661	1.0048
Student 8	0.3041	1.0048	1.0048	0.1661
Student 9	0.1370	0.0687	1.0048	0.1661
Student 10	0.3777	0.0687	0	0

The eighth stage in G-MAUT is to calculate the final value of the utility of each alternative using equation (10).

$u_{(1)} = (u_{11} * w_1) + (u_{21} * w_2) + (u_{31} * w_3) + (u_{41} * w_4)$
$u_{(1)} = (0.1450 * 0.2527) + (0.3273 * 0.2591) + (0 * 0.2476) + (0.1661 * 0.2406)$
$u_{(1)} = 0.1614$
$u_{(2)} = (u_{12} * w_1) + (u_{22} * w_2) + (u_{32} * w_3) + (u_{42} * w_4)$
$u_{(2)} = (0.2418 * 0.2527) + (0.0687 * 0.2591) + (0 * 0.2476) + (0.1661 * 0.2406)$
$u_{(2)} = 0.1189$
$u_{(3)} = (u_{13} * w_1) + (u_{23} * w_2) + (u_{33} * w_3) + (u_{43} * w_4)$
$u_{(3)} = (1.0048 * 0.2527) + (1.0048 * 0.2591) + (1.0048 * 0.2476) + (1.0048 * 0.2406)$
$u_{(3)} = 1.0048$
$u_{(4)} = (u_{14} * w_1) + (u_{24} * w_2) + (u_{34} * w_3) + (u_{44} * w_4)$
$u_{(4)} = (0.5674 * 0.2527) + (0 * 0.2591) + (0.1661 * 0.2476) + (0 * 0.2406)$
$u_{(4)} = 0.1845$
$u_{(5)} = (u_{15} * w_1) + (u_{25} * w_2) + (u_{35} * w_3) + (u_{45} * w_4)$
$u_{(5)} = (0 * 0.2527) + (0.0687 * 0.2591) + (1.0048 * 0.2476) + (1.0048 * 0.2406)$
$u_{(5)} = 0.5084$
$u_{(6)} = (u_{16} * w_1) + (u_{26} * w_2) + (u_{36} * w_3) + (u_{46} * w_4)$
$u_{(6)} = (0.1081 * 0.2527) + (0.3273 * 0.2591) + (0.1661 * 0.2476) + (0.1661 * 0.2406)$
$u_{(6)} = 0.1932$
$u_{(7)} = (u_{17} * w_1) + (u_{27} * w_2) + (u_{37} * w_3) + (u_{47} * w_4)$
$u_{(7)} = (0.1892 * 0.2527) + (0 * 0.2591) + (0.1661 * 0.2476) + (1.0048 * 0.2406)$
$u_{(7)} = 0.3307$
$u_{(8)} = (u_{18} * w_1) + (u_{28} * w_2) + (u_{38} * w_3) + (u_{48} * w_4)$
$u_{(8)} = (0.3041 * 0.2527) + (1.0048 * 0.2591) + (1.0048 * 0.2476) + (0.1661 * 0.2406)$
$u_{(8)} = 0.6260$
$u_{(9)} = (u_{19} * w_1) + (u_{29} * w_2) + (u_{39} * w_3) + (u_{49} * w_4)$
$u_{(9)} = (0.1370 * 0.2527) + (0.0687 * 0.2591) + (1.0048 * 0.2476) + (0.1661 * 0.2406)$
$u_{(9)} = 0.3412$
$u_{(0)} = (u_{110} * w_1) + (u_{210} * w_2) + (u_{310} * w_3) + (u_{410} * w_4)$
$u_{(10)} = (0.3777 * 0.2527) + (0.0687 * 0.2591) + (0 * 0.2476) + (0 * 0.2406)$
$u_{(10)} = 0.1132$

The final result of the application of the G-MAUT method in determining scholarships is a list of scholarship recipients who are selected based on a thorough and holistic evaluation of various criteria that have been set. G-MAUT allows the incorporation of various aspects in producing utility value that reflects the relative superiority of each candidate. By using this method, scholarship organizers can ensure that decisions are based on accurate and comprehensive data analysis, which includes both quantitative and qualitative considerations. The end result is a selection of scholarship recipients who not only meet the academic requirements, but also have the economic need and potential to make a positive contribution to society, thus ensuring a fair allocation of scholarships and a broad positive impact. The results of the ranking of scholarship recipients used the G-MAUT method in Figure 2.

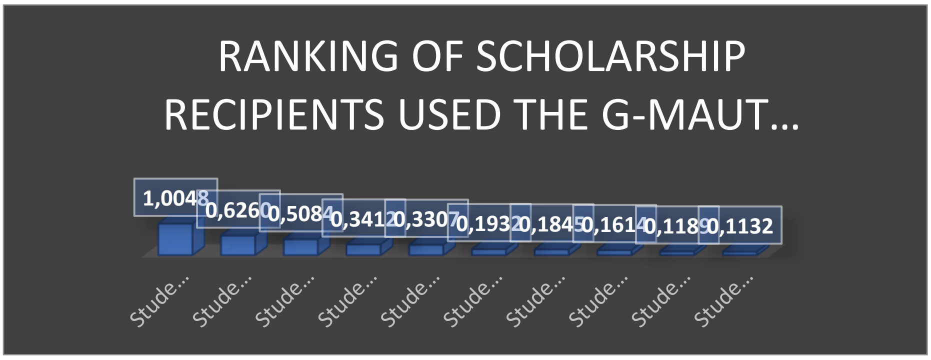

Figure 2. The Results of the Ranking of Scholarship Recipients used the G-MAUT Method

The results of the ranking of scholarship recipients using the G-MAUT method figure 2 shows that the first-place scholarship recipient with a final score of 1.0048 was obtained by Student 3, the second-place scholarship recipient with a final score of 0.6260 was obtained by Student 8, and the third-place scholarship recipient with a final score of 0.5048 was obtained by Student 5.

3.3 Discussion

Modification of Multi-Attribute Utility Theory in Determining Scholarship Recipient Students highlights how MAUT modification can improve fairness and effectiveness in scholarship recipient selection. Through the adaptation of MAUT's traditional framework, this study integrates more diverse evaluation criteria, such as academic achievement, economic conditions, extracurricular activities, and leadership potential. This modification under the name G-MAUT allows for a more holistic and comprehensive assessment of potential recipients, ensuring that non-academic aspects are also taken into account proportionately. In addition, the use of advanced data analysis technology in modified MAUT provides the ability to predict the long-term success of potential recipients, so that decisions taken are more targeted and sustainable. The results of the study show that the application of the G-MAUT method not only improves the accuracy of selection but also strengthens the purpose of the scholarship program in supporting diversity, inclusivity, and overall individual development.

Through a more comprehensive approach, the modification of MAUT also allows for the adjustment of the weight of the criteria based on the specific priorities and values of different scholarship programs. This allows scholarship providers to be more flexible in tailoring the selection process according to their strategic goals, for example in supporting students from underrepresented backgrounds or those who demonstrate outstanding leadership potential. The study also underscores the importance of transparency and fairness in the selection process, which can be achieved through clear documentation and training for the selection panel to understand and apply these methods consistently. Thus, the modification of MAUT not only improves the scholarship selection process, but also provides a model that can be replicated and adapted to various contexts and needs of other scholarship programs. The results of the ranking comparison with the G-MAUT method are as shown in Figure 3.

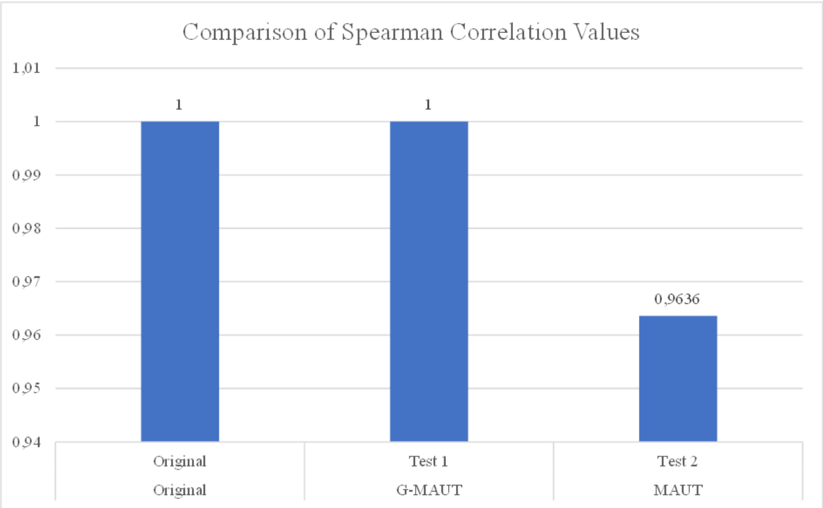

Figure 3. The results of the ranking comparison with the MAUT and G-MAUT method

The Original and G-MAUT (Test 1) methods both show a perfect correlation value of 1, which means that they give completely consistent or identical results. This shows that the Original and G-MAUT (Test 1) methods have a very strong and consistent relationship in the context of the analyzed data. The correlation value for the MAUT (Test 2) method is 0.9636, which is slightly lower than the other two methods. Although it still shows a very strong relationship, this correlation value is slightly less perfect than the value of 1 in the Original and G-MAUT (Test 1) methods. This suggests that there is a small difference in the results given by MAUT (Test 2) compared to other methods. Overall, these results show that the Original and G-MAUT (Test 1) methods are very consistent in giving the same results, while the MAUT (Test 2) method also shows a strong relationship but with little difference in correlation results.

4. CONCLUSION

The purpose of the MAUT modification research with geometric mean in producing criterion weights is to improve accuracy, stability, and consistency in the decision-making process. This study also aims to test the effectiveness of the geometric mean method in producing more objective and structured weights, as well as compare it with other traditional MAUT methods such as direct addition or multiplication. The results of the comparison of the ranking of the G-MAUT method obtained a result of 1 and the MAUT method of 0.9636 showed better results than the G-MAUT method because it used geometric averages and criterion weights to provide a more detailed and objective evaluation. By integrating normalized values and the weight of the criteria that have been set, G-MAUT is able to produce alternative rankings that are more accurate and representative. The modification of the MAUT method with a geometric mean is named G-MAUT. The main objective of this study is to provide a better and more reliable approach in prioritizing criteria in complex and multiple attribute-based decision-making. The results of the ranking of scholarship recipients using the G-MAUT method that the first-place scholarship recipient with a final score of 1.0048 was obtained by Student 3, the second-place scholarship recipient with a final score of 0.6260 was obtained by Student 8, and the third-place scholarship recipient with a final score of 0.5048 was obtained by Student 5. This modification under the name G-MAUT allows for a more holistic and comprehensive assessment of potential recipients, ensuring that non-academic aspects are also taken into account proportionately. In addition, the use of advanced data analysis technology in modified MAUT provides the ability to predict the long-term success of potential recipients, so that decisions taken are more targeted and sustainable. The results of the study show that the application of the G-MAUT method not only improves the accuracy of selection but also strengthens the purpose of the scholarship program in supporting diversity, inclusivity, and overall individual development.

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