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Decision Support System for Determining New Branch Locations Applying the Multi Attribute Utility Theory (MAUT) Method

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Abstract−The location of new branches that are close to community activities and have adequate facilities makes it easier for consumers to get the services and products they need. Determining the feasibility of new branch locations from several product or service producers still uses a system that is not accurate, which can cause problems in determining the location of new strategic and targeted branches. However, there are several obstacles in the selection of new branch locations, so technological assistance is needed in determining the location, product analysis, marketing management, and other matters concerning the development of the business being carried out. Technology that is considered efficient, easy, and flexible and is used by entrepreneurs, especially in determining the location of new branches using a decision support system using the MAUT method, is expected to help the location of new branches that are efficient and strategic. The decision support system is a conclusion and determination of the best using some data and computerized testing in each criterion so as to get valid results. After calculating each criterion and alternative, the best ranking is obtained in alternative A1 with a value of 0.7925 on Pertahanan Street.

Keywords: DSS; New Branch Location; MAUT Method

1. INTRODUCTION

Within the scope of the marketing world, new branch locations are usually proposed to meet relatively large consumer demand where a producer or entrepreneur is required to meet consumer demand. The location of the new branch is close to community activities with adequate facilities to make it easier for consumers to get the services / products needed. Determining the feasibility of new branch locations from several producers still uses an inaccurate system so that it can cause problems in determining the location of new strategic and targeted branches. This can help increase profits and benefits from adding new branch locations to entrepreneurs[1].

The location of the new branch that is opened is carried out research in advance to determine the superiority of each allocation that is chosen starting from the state of the environment, competitors and the state of good strategic location is considered to affect a business in generating benefits and is expected to achieve the goals of the entrepreneur. Determination of the location of new branches currently uses technological assistance in determining location, product analysis, marketing management, other matters concerning the development of the business being carried out. Technology that is considered efficient, easy and flexible and is used by entrepreneurs, especially in determining the location of new branches using the help of a decision support system, is expected to help the location of new branches that are efficient and strategic[2].

A decision support system is a conclusion and determination of the best using some data and computerized testing in each criterion so as to get valid results[3]–[7]. There are several types of SPK, namely Step-wise Weight Assessment Ratio Analysis Method (SWARA), Rank Order Centroid (ROC), Preference Selection Index (PSI), Multi-Attributive Border Approximation Area Comparison (MABAC), Multi-Attribute Utility Theory (MAUT), Additive Ratio Assessment (ARAS), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE I-II-III), ELECTREE I-II-III, and EXPROM I&II. In this research, the author can solve a problem using the MAUT method. MAUT is a quantitative comparison method that is used as the basis for decision-making based on a systematic way of identifying and analyzing data[8].

The benchmark for this research is based on previous research using the same method carried out in 2022 by Wahyu Harry Bai Lumban Batu et al. In determining the transfer of soccer players using the ROC and MAUT methods, the best alternative is A1 for Cristiano Ronaldo with a value of 0.587[9]. Research in 2022 conducted by Jumpa Dorisman Rajagukguk, etc. in determining candidates for ukt assistance at Budi Darma University using the ROC and MAUT methods resulted in the best ranking, namely Nur Sekartika A1 0.707[10]. esearch in 2022 conducted by Dimas Hadityo Ramadan et al. found that in applying the MAUT method of determining the eligibility of TKI with ROC weighting, the best alternative is alternative A5 on behalf of "Boby," with a value of Ui = 0.9748[11]. Research conducted in 2022 by Zaza Mutiara Arini et al. in determining the best facial wash for oily skin, applying the MAUT method with ROC produced the best ranking with a value of 0.7775 A2 ponds[12].

Therefore, the author is interested in using the MAUT method to determine the location of new branches. The author conducts this research to produce weight-value decisions and the best results in determining the location of new branches. So that groups of entrepreneurs will have no difficulty determining the location of new branches through alternatives and criteria. The use of the MAUT method is expected to be able to assist in obtaining valid alternatives to the ranking stage.

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2. RESEARCH METHODOLOGY

2.1 Decision Support System

A decision support system is a computer-based system that is able to determine the results of valid and systematic decisions in solving a problem that occurs. Decision support systems themselves are often used by companies or organizations that are having problems in terms of decision-making[13]–[18]. They are often used in decision support systems such as WP, TOPSIS, MOORA, MOOSRA, and SAW[19].

2.2 New Branch Location

Location is a place for certain groups in terms of marketing products or services with common goals and interests. The location of the new branch that is applied to increase the profit of the company or group is due to a market demand for providing services or products to facilitate consumers in the economy.

2.3 MAUT Method

The MAUT method is a comparison that combines various risks and criteria to find solutions. The MAUT method also takes into account the problem by converting several criteria into values or numbers on a scale of 0 to 1. Where 0 is the worst and 3-1 is the best. The following are the steps in calculating the MAUT method[20]–[24]:

1. Preparing the decision matrix

$$X_{ij}=\begin{bmatrix} r_{11} & \cdots & r_{1j} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{i1} & \cdots & r_{ij} & \cdots & r_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mj} & \cdots & r_{mn} \end{bmatrix}; \text{i} = 1,\ldots, \text{m}, \text{j} = 1,\ldots,\text{n} \quad (1)$$

2. Calculating Normalization Matrix (r_{ij}^{*})
   For Benefit criteria

$$(r_{ij}^{*}) = \frac{r_{ij} - \min(r_{ij})}{\max(r_{ij}) - \min(r_{ij})} \quad (2)$$

   For Cost criteria

$$r_{ij=}^{*}\ 1 + \left(\frac{\min(r_{ij}) - r_{ij}}{\max(r_{ij}) - \min(r_{ij})}\right) \quad (3)$$

3. Calculating Marginal Utility Value (u_{ij})

$$u_{ij} = \frac{e^{\left(r_{ij}^{*}\right)^{2}} - 1}{1{,}71} \quad (4)$$

4. Calculating the Final Utility Value (Preference Value)

$$U_i = \sum_{j}^{n} = 1\ u_{ij}\ .\ w_j \quad (5)$$

2.4 Research Stages

In making this research, there are several stages carried out by the author. The following are the stages of research described as follows:

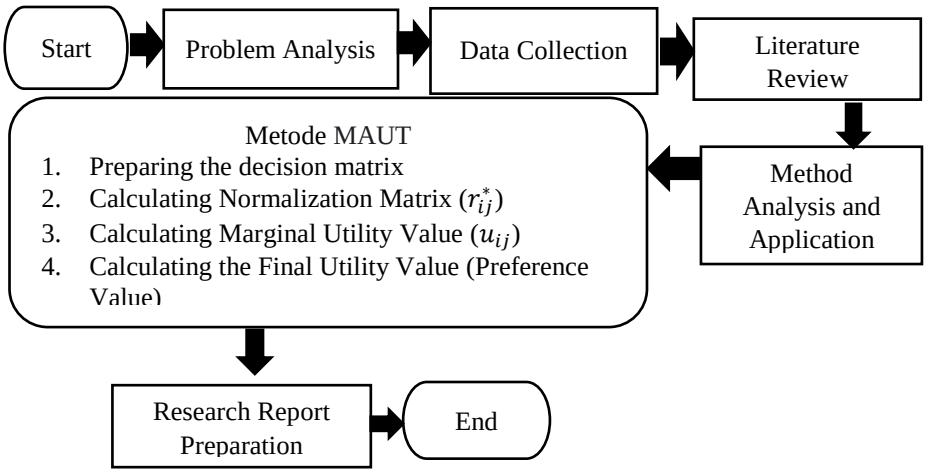

Figure 1. Research Framework

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The explanation of the research stages in Figure 1 is as follows:

1. Problem Analysis
   Problem solving and data analysis when conducting surveys before planning and calculation.
2. Data Collection
   Make observations to understand the steps in choosing a strategic location.
3. Literature Study
   Helps the author to understand the SPK and MAUT methods by reading reviews or references related to other research.
4. Analysis and application of methods
   Implementation of the MAUT method in the data sample calculation process.
5. Research Report
   Research report as a written result in the form of the core of the research.

3. RESULT AND DISCUSSION

To get a decision on the selection of new branch locations by implementing the MAUT Method as an answer to the problem, the author calculates the method. The determination of alternatives in the selection of strategic locations is clearly described in Table 1 below:

Table 1. Alternative Data

Alternative	Location Name
A_1	Pertahanan Street
A_2	AsiaAfrika Street
A_3	Brigjen Katamso Street
A_4	A. H Nasution Street
A_5	Juanda Street
A_6	Gatot Subroto Street
A_7	Setiabudi Street

The selection of strategic locations has the required criteria and weights according to Table 2 below:

Table 2. Criteria and Weight Data

Criteria	Description	Weight	Type
C_1	Strategic Location	0,30	Benefit
C_2	Land Area	0,25	Benefit
C_3	Accessibility	0,20	Benefit
C_4	Crowd	0,10	Benefit
C_5	Rental Price	0,06	Cost
C_6	Number of Competitors	0,04	Cost
C_7	Length of Rental	0,05	Cost

The following are alternative data and criteria used in this study in selecting new branch locations:

Table 3. Alternative Data and Criteria

Alternative	C_1 (Strategic Location)	C_2 (Land Area /m^2)	C_3 (Accessibility)	C_4 (Crowd)	C_5 (Rental Price /Year)	C_6 (Number of Competitors)	C_7 (Length of Rental / Year)
A_1	Very Strategic	1300	Very Easy	Crowded	15000000	14	3
A_2	Not Strategic	800	Difficult	Not Crowded	9000000	12	1
A_3	Strategic	700	Fairly Easy	Very Crowded	14000000	15	2
A_4	Less Strategic	500	Difficult	Fairly Crowded	13000000	10	4
A_5	Not Strategic	400	Easy	Crowded	9000000	11	5
A_6	Very Strategic	600	Very Easy	Very Crowded	70000000	16	1
A_7	Less	800	Easy	Not	12000000	9	2

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Alternative	C_1 (Strategic Location)	C_2 (Land Area /m^2)	C_3 (Accessibility)	C_4 (Crowd)	C_5 (Rental Price /Year)	C_6 (Number of Competitors)	C_7 (Length of Rental / Year)
	Strategic			Crowded			

In the table above, it can be seen that there are still linguistic data, which require weighting to produce numerical values as shown in Tables 4, 5, and 6 as follows:

Table 4. Weight Values for Location (C_1)

Description	Weight
Very Strategic	4
Strategic	3
Less Strategic	2
Not Strategic	1

Table 5. Weight Values for Accessibility (C_3)

Description	Weight
Very Easy	4
Easy	3
Fairly Easy	2
Difficult	1

Table 6. Weight Values for Crowdedness (C_4)

Description	Weight
Very Crowded	4
Crowded	3
Fairly Crowded	2
Not Crowded	1

The criteria that have been weighted can be clearly seen in Table 7 below:

Table 7. Compatibility Rating Data After Weighting

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	4	1300	4	3	15000000	14	3
A_2	1	800	1	1	9000000	12	1
A_3	3	700	2	4	14000000	15	2
A_4	2	500	1	2	13000000	10	4
A_5	1	400	3	3	9000000	11	5
A_6	4	600	4	4	10000000	16	1
A_7	2	800	3	1	12000000	9	2

3.1 Application of MAUT Method

The stages of the calculation process for applying the MAUT method are described in detail in the process below:

1. Preparing the Decision Matrix

$$X_{ij} = \begin{bmatrix} 4 & 1300 & 4 & 3 & 15000000 & 14 & 3 \\ 1 & 800 & 1 & 1 & 9000000 & 12 & 1 \\ 3 & 700 & 2 & 4 & 14000000 & 15 & 2 \\ 2 & 500 & 1 & 2 & 13000000 & 10 & 4 \\ 1 & 400 & 3 & 3 & 9000000 & 11 & 5 \\ 4 & 600 & 4 & 4 & 10000000 & 16 & 1 \\ 2 & 800 & 3 & 1 & 12000000 & 9 & 2 \end{bmatrix}$$

2. Calculating Normalization Matrix (r_{ij}^*)
   For Criteria C_1 (Benefit)

   $r_{11}^* = \frac{4-1}{4-1} = 1$

   $r_{21}^* = \frac{1-1}{4-1} = 0$

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$r_{31}^{*}=\frac{3-1}{4-1}=0.66$

$r_{41}^{*}=\frac{2-1}{4-1}=0.33$

$r_{51}^{*}=\frac{1-1}{4-1}=0$

$r_{61}^{*}=\frac{4-1}{4-1}=1$

$r_{71}^{*}=\frac{2-1}{4-1}=0.33$

For Criteria C_2 (Benefit)

$r_{12}^{*}=\frac{1300-400}{1300-400}=1$

$r_{22}^{*}=\frac{800-400}{1300-400}=0.44$

$r_{32}^{*}=\frac{700-400}{1300-400}=0.33$

$r_{42}^{*}=\frac{500-400}{1300-400}=0.11$

$r_{52}^{*}=\frac{400-400}{1300-400}=0$

$r_{62}^{*}=\frac{600-400}{1300-400}=0.22$

$r_{72}^{*}=\frac{800-400}{1300-400}=0.44$

For Criteria C_3 (Benefit)

$r_{13}^{*}=\frac{4-1}{4-1}=1$

$r_{23}^{*}=\frac{1-1}{4-1}=0$

$r_{33}^{*}=\frac{2-1}{4-1}=0.33$

$r_{43}^{*}=\frac{1-1}{4-1}=0$

$r_{53}^{*}=\frac{3-1}{4-1}=0.66$

$r_{63}^{*}=\frac{4-1}{4-1}=1$

$r_{73}^{*}=\frac{3-1}{4-1}=0.66$

For Criteria C_4 (Benefit)

$r_{14}^{*}=\frac{3-1}{4-1}=0.66$

$r_{24}^{*}=\frac{1-1}{4-1}=0$

$r_{34}^{*}=\frac{4-1}{4-1}=1$

$r_{44}^{*}=\frac{2-1}{4-1}=0.33$

$r_{54}^{*}=\frac{3-1}{4-1}=0.66$

$r_{64}^{*}=\frac{4-1}{4-1}=1$

$r_{74}^{*}=\frac{1-1}{4-1}=0$

For Criteria C_5 (Cost)

$r_{15}^{*}=1+\frac{9000000-15000000}{15000000-9000000}=0$

$r_{25}^{*}=1+\frac{9000000-9000000}{15000000-9000000}=1$

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$r_{35}^{*} = 1 + \frac{9000000-14000000}{15000000-9000000} = 0.17$

$r_{45}^{*} = 1 + \frac{9000000-13000000}{15000000-9000000} = 0.34$

$r_{55}^{*} = 1 + \frac{9000000-9000000}{15000000-9000000} = 1$

$r_{65}^{*} = 1 + \frac{9000000-10000000}{15000000-9000000} = 0.84$

$r_{75}^{*} = 1 + \frac{9000000-12000000}{15000000-9000000} = 0.5$

For Criteria C_6 (Cost)

$r_{16}^{*} = 1 + \frac{9-14}{16-9} = 0.29$

$r_{26}^{*} = 1 + \frac{9-12}{16-9} = 0.58$

$r_{36}^{*} = 1 + \frac{9-15}{16-9} = 0.15$

$r_{46}^{*} = 1 + \frac{9-10}{16-9} = 0.86$

$r_{56}^{*} = 1 + \frac{9-11}{16-9} = 0.72$

$r_{66}^{*} = 1 + \frac{9-16}{16-9} = 0$

$r_{76}^{*} = 1 + \frac{9-9}{16-9} = 1$

For Criteria C_7 (Cost)

$r_{17}^{*} = 1 + \frac{1-3}{5-1} = 0.5$

$r_{27}^{*} = 1 + \frac{1-1}{5-1} = 1$

$r_{37}^{*} = 1 + \frac{1-2}{5-1} = 0.75$

$r_{47}^{*} = 1 + \frac{1-4}{5-1} = 0.25$

$r_{57}^{*} = 1 + \frac{1-5}{5-1} = 0$

$r_{67}^{*} = 1 + \frac{1-1}{5-1} = 1$

$r_{77}^{*} = 1 + \frac{1-2}{5-1} = 0.75$

Based on the calculations that have been made, the matrix normalization value is obtained in the following table:

Table 8. Normalized Matrix Results

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	1	1	1	0.66	0	0.29	0.5
A_2	0	0.44	0	0	1	0.58	1
A_3	0.66	0.33	0.33	1	0.17	0.15	0.75
A_4	0.33	0.11	0	0.33	0.34	0.86	0.25
A_5	0	0	0.66	0.66	1	0.72	0
A_6	1	0.22	1	1	0.84	0	1
A_7	0.33	0.44	0.66	0	0.5	1	0.75

3. Calculating the Marginal Utility Value (U_{ij})
   For Criteria C_1

$U_{11} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{21} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{31} = \frac{e^{(0.66)^2}-1}{1.71} = 0.32$

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$U_{41} = \frac{e^{(0.33)^2}-1}{1.71} = 0.07$

$U_{51} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{61} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{71} = \frac{e^{(0.33)^2}-1}{1.71} = 0.07$

For Criteria C_2

$U_{12} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{22} = \frac{e^{(0..44)^2}-1}{1.71} = 0.12$

$U_{32} = \frac{e^{(0.33)^2}-1}{1.71} = 0.07$

$U_{42} = \frac{e^{(0.11)^2}-1}{1.71} = 0.01$

$U_{52} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{62} = \frac{e^{(0.22)^2}-1}{1.71} = 0.03$

$U_{72} = \frac{e^{(0.44)^2}-1}{1.71} = 0.12$

For Criteria C_3

$U_{13} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{23} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{33} = \frac{e^{(0.33)^2}-1}{1.71} = 0.07$

$U_{43} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{53} = \frac{e^{(0.66)^2}-1}{1.71} = 0.32$

$U_{63} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{73} = \frac{e^{(0.66)^2}-1}{1.71} = 0.32$

For Criteria C_4

$U_{14} = \frac{e^{(0.66)^2}-1}{1.71} = 0.32$

$U_{24} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{34} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{44} = \frac{e^{(0.33)^2}-1}{1.71} = 0.08$

$U_{54} = \frac{e^{(0.66)^2}-1}{1.71} = 0.32$

$U_{64} = \frac{e^{(1)^2}-1}{1.71} = 1$

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$U_{74} = \frac{e^{(0)^2}-1}{1.71} = 0$

For Criteria C_5

$U_{15} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{25} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{35} = \frac{e^{(0.17)^2}-1}{1.71} = 0.02$

$U_{45} = \frac{e^{(0.34)^2}-1}{1.71} = 0.07$

$U_{55} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{65} = \frac{e^{(0.84)^2}-1}{1.71} = 0.60$

$U_{75} = \frac{e^{(0.5)^2}-1}{1.71} = 0.17$

For Criteria C_6

$U_{16} = \frac{e^{(0.29)^2}-1}{1.71} = 0.05$

$U_{26} = \frac{e^{(0.58)^2}-1}{1.71} = 0.23$

$U_{3} = \frac{e^{(0.15)^2}-1}{1.71} = 0.01$

$U_{46} = \frac{e^{(0.86)^2}-1}{1.71} = 0.64$

$U_{56} = \frac{e^{(0.72)^2}-1}{1.71} = 0.40$

$U_{66} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{76} = \frac{e^{(1)^2}-1}{1.71} = 1$

For Criteria C_7

$U_{17} = \frac{e^{(0.5)^2}-1}{1.71} = 0.17$

$U_{27} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{37} = \frac{e^{(0.75)^2}-1}{1.71} = 0.44$

$U_{47} = \frac{e^{(0.25)^2}-1}{1.71} = 0.04$

$U_{57} = \frac{e^{(0)^2}-1}{1.71} = 0$

$U_{67} = \frac{e^{(1)^2}-1}{1.71} = 1$

$U_{77} = \frac{e^{(0.75)^2}-1}{1.71} = 0.44$

From the calculations that have been carried out, we get the final marginal utility value as below:

Table 9. Final Marginal Utility Value

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	1	1	1	0.32	0	0.05	0.17
A_2	0	0.12	0	0	1	0.23	1

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Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_3	0.32	0.07	0.07	1	0.02	0.01	0.44
A_4	0.07	0.01	0	0.08	0.07	0.64	0.04
A_5	0	0	0.32	0.32	1	0.40	0
A_6	1	0.03	1	1	0.60	0	1
A_7	0.07	0.12	0.32	0	0.17	1	0.44

4. Calculating the Final Utility Value (U_i)

$U_1 = (0.30 * 1) + (0.25 * 1) + (0.20 * 1) + (0.10 * 0.32) + (0.06 * 0) + (0.04 * 0.05) + (0.05 * 0.17) = 0.7925$

$U_2 = (0.30 * 0) + (0.25 * 0.12) + (0.20 * 0) + (0.10 * 0) + (0.06 * 1) + (0.04 * 0.23) + (0.05 * 1) = 0.1492$

$U_3 = (0.30 * 0.32) + (0.25 * 0.07) + (0.20 * 0.07) + (0.10 * 1) + (0.06 * 0.02) + (0.04 * 0.01) + (0.05 * 0.44) = 0.2511$

$U_4 = (0.30 * 0.07) + (0.25 * 0.01) + (0.20 * 0) + (0.10 * 0.08) + (0.06 * 0.07) + (0.04 * 0.64) + (0.05 * 0.04) = 0.0633$

$U_5 = (0.30 * 0) + (0.25 * 0) + (0.20 * 0.32) + (0.10 * 0.32) + (0.06 * 1) + (0.04 * 0.40) + (0.05 * 0) = 0.172$

$U_6 = (0.30 * 1) + (0.25 * 0.03) + (0.20 * 1) + (0.10 * 1) + (0.06 * 0.60) + (0.04 * 0) + (0.05 * 1) = 0.6935$

$U_7 = (0.30 * 0.07) + (0.25 * 0.12) + (0.20 * 0.32) + (0.10 * 0) + (0.06 * 0.17) + (0.04 * 1) + (0.05 * 0.44) = 0.1872$

The final utility value that becomes the ranking can be seen as follows:

Table 10. Alternative Ranking

Alternative	Location Name	U_i Value	Rank
A_1	Pertahanan Street	0.7925	1
A_2	AsiaAfrika Street	0.1492	6
A_3	Brigjen Katamso Street	0.2511	3
A_4	A. H Nasution Street	0.0633	7
A_5	Juanda Street	0.172	5
A_6	Gatot Subroto Street	0.6935	2
A_7	Setiabudi Street	0.1872	4

According to the results of calculations using the MAUT method, the appropriate alternative according to the criteria for the location of the new branch is in alternative A1, which is the best alternative with a result of 0.7925 on Pertahanan Street.

4. CONCLUSION

From the results of the research, the authors conclude that the MAUT method can be used in the process of selecting new branch locations. The application of the MAUT method is useful to help produce more efficient testing. In this case, the factor that greatly influences the acquisition of value in the MAUT method is the greatest preference value as the best alternative producer in the first rank, which is in alternative A1, with the highest preference value of 0.7925, which is located on Pertahanan Street.

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