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Decision Support System for Selecting the Best E-Wallet using TOPSIS Method

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Abstract−A decision support system (DSS) is a system that can quickly solve problems that arise in ranking and determine the highest to lowest score for a selection. In this article, is one of the case studies that can be done using a decision support system and represents the problem ms faced when looking for the best e-wallet, the selection requires the use of a manual evaluation process that takes time to obtain results . Therefore, a decision support system was created that can support the evaluation process. This decision support system uses the TOPSIS and ROC methods used for testing which aims to determine the accuracy of the value obtained by the system, sensitivity tests are carried out on the weight value of the criteria, and modified experiments are carried out with the aim of knowing how many criteria can be added, each criterion has its own weight value to determine the ranking of alternatives. Based on the ranking, the results obtained from the calculation of the TOPSIS and ROC methods, the best is LinkAja (A5) with a value of 0.7518.

Keywords: DSS; E-Wallet Selection; ROC; TOPSIS Method

1. INTRODUCTION

The development of technology has produced many new electronic-based innovations, including *E-Wallet* . The interest of the business world and also encouragement from the government are factors in the rapid development *of E-Wallet* . *E-Wallet* is one of the electronic-based payment models that can be used to make *online transactions* via computers or *smartphones* [1]. *E-Wallet* or electronic wallet is a new breakthrough that can be used as an alternative to facilitate payment transactions via computers such as *personal computers* (PCs), laptops, and *smartphones* [2]. *E-Wallet* through Bank Indonesia regulation No.18/40/PBI/2016 concerning the Implementation of Processing which states that electronic services for storing payment instrument data include payment instruments using cards and/or electronic money that can also accommodate funds, to make payments [3]. Just by filling the balance on a digital wallet, people can make many transactions anywhere and anytime [4].

From the various choices of *E-Wallets* that are widely used throughout Indonesia, it is not uncommon for people to be confused about choosing which *E-Wallet* is superior if based on several categories such as ease of use, security, completeness of features, speed of transaction processing, and transaction costs. To overcome this problem, this study was conducted which aims to determine the best *E-Wallet alternative* through factors that can increase the use of each *E-Wallet alternative* so that it can determine which *E-wallet* is more ideal to use. Based on the description of the problem above, a system is needed that can assist in decision making for selecting the best *E-Wallet*, namely spk.

Decision Support System (DSS) is a system with information technology and artificial intelligence to help determine decision making in complex situations and more accurate results in a systematic form [5]. *Decision support system* or decision support system is a system that can help data processing to solve existing problems and get the correct decision value results [6]. The advantages obtained by using a decision support system include having an easy-to-understand concept and simple calculations and being able to provide ideal solutions to complex problems [7]. In addition to the TOPSIS method, there are many methods that can be used in decision support systems such as the SAW, WP, WASPAS, MOORA, MOOSRA, OCRA, EDAS, ARAS, MAUT and AHP methods [8].

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is a method where the best selected alternative not only has the shortest distance from the positive ideal solution, but also has the longest distance from the negative ideal solution [9]. The purpose of the TOPSIS method is to find the value of the positive ideal solution and the negative ideal solution. Maximizing the value of the benefit criteria and minimizing the value of the cost criteria is a positive ideal solution. Conversely, the negative ideal solution maximizes the value of the cost criteria and minimizes the value of the benefit criteria [10]. TOPSIS is used for several reasons, including its simple and easy-to-understand concept, its computation is efficient, and it has the ability to measure the relative performance of decision alternatives in a simple mathematical form [11].

There are previous studies related to the TOPSIS method which is used as a reference point in identifying decision making in order to obtain precise and accurate results. Such as research conducted by Irwan et al. in 2022 which discussed the Best Employee Selection process for job promotion recommendations with a measurable support system at the POLDASU HR BUREAU using a combination of the ROC and TOPSIS methods. In this study, the ROC method was applied to determine the ranking process which will also select the best alternative from a number of existing alternatives using the TOPSIS method. So that the final result of the Job Promotion

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Recommendation study that is worthy of promotion is alternative A1 with a preference value of 1,497 in the name of "Hendrik" [9]. The second study discusses the selection of smartphones that suit the needs and as a support for lecture activities for STMIK Palangkaraya students. This study was conducted by Susi Hendartie et al. in 2022 using the TOPSIS method calculation from several criteria used such as type, specifications and prices offered. From the results of the calculation using the TOPSIS method, one recommended smartphone was selected from six alternatives whose data had been studied. The smartphone is the Vivo Y17 with a value of 1.0212 which was selected as a smartphone to support lecture activities for STMIK Palangkaraya students [12]. Further research conducted by Ade Mubarok et al in 2019 discussed the Use of Decision Support Systems that can facilitate the Sharia cooperative bmt itQan in making decisions on providing financing. The Decision Support System in this study was created using the TOPSIS method. The results of this research discussion are that it can produce a decision support system for providing credit financing at the Sharia Cooperative bmt ItQan, accurate financing through data collection reports, and measurable problem solving for the decision support system for financing feasibility so that the assessment is more objective at the Sharia cooperative bmt itQan [13]. The following study was conducted by Zulvitri et al. in 2021, explaining how reliable the TOPSIS method is in considering the shortest distance in the positive ideal solution and also the longest distance in the negative ideal solution. The alternatives and criteria used in the study consisted of 5 alternatives and 3 criteria that produced positive and negative ideal solution values with a maximum value of K1 of 0.66, K2 of 0.022, K3 of 0.05 and a minimum value of K1 of 0.1, K2 of 0.017, K3 of 0.022. The highest value in the ranking was 2 people with a value of 1 and the lowest was 1 person with a value of 0.0008 [14].

The latest research conducted by R Ramadhan used the TOPSIS method which discussed student assessment based on academic and non-academic achievements consisting of 22 alternatives and 5 criteria. So that the final result of the MHS1 alternative was ranked first with a value of 0.472612509 [15].

Based on the problems above, the TOPSIS method is used in this study, because it has a simple calculation concept in producing alternatives in mathematical and accurate form. By using the TOPSIS method, it is expected to be able to help users choose *the E-Wallet* that best suits their needs through the best alternatives that have been produced through the calculation process.

2. RESEARCH METHODOLOGY

2.1 Research Stages

In order for the stages carried out to produce the best results, the steps taken in the research are as follows:

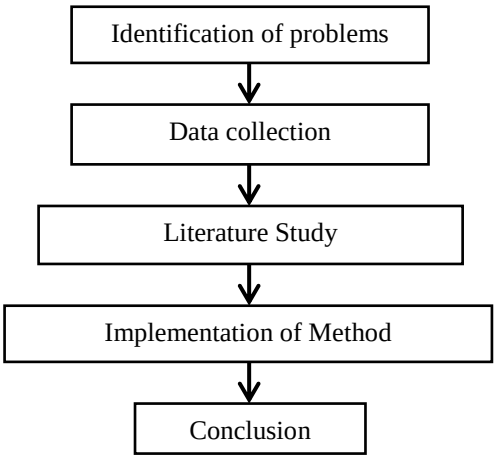

Figure 1. Research Stages

The following is an explanation of figure 1:

1. Identification of problems
   The author explains the problems in making decisions about choosing the best E-Wallet.
2. Data collection
   At this stage the author collects data that will be used in the research through observation and interviews.
3. Literature Study
   At this stage, the author looks for information and references that are relevant to the problems solved in this research.
4. Implementation of Method
   The author performs weighting by applying the ROC method and then carries out the ranking process using the TOPSIS method to obtain the best alternative.
5. Conclusion

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The author concludes the results of all stages carried out in this research.

2.2 Decision Support System

Decision support systems were first introduced by Michael S. Scott in the early 1970s with the term Management Decision System, a computer-based system designed to facilitate decision making by utilizing certain data and models to solve unstructured problems [17]. According to Little, a decision support system is a computer-based information system that helps produce decisions to help management in various problems using data or models so as to provide problem-solving capabilities in certain semi-structured conditions [18].

2.3 ROC Method

The ROC method is a method that can produce weighting according to the level of importance of each criterion set [19]. The application of this method is usually formed with the statement that criterion 1 is more important than criterion 2, criterion 2 is more important than criterion 3 and so on. Then to determine the priority, a rule is given where the highest value becomes the most important criterion of the other criteria. The following is a formula that can be used to find the value of the criteria weight by applying the ROC method.

1. The level of importance of each criterion

   If $K_1 > K_2 > K_3 > K_4 > \cdots > K_n$then $W_1 > W_2 > W_3 > W_4 > \cdots > W_n$ (1)

2. Calculating the criteria weight value

   $$W_n = \frac{1}{n}\sum_{i-1}^{n}\left(1 + \frac{1}{i}\right) \quad (2)$$

   Information :
   K = Criteria
   W = N criteria weighting
   n = Criteria result
   i = N Iterations

2.4 MOORA Method

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is one of the multicriteria decision-making methods that was originally introduced by Yoon, Hwang in 1981. TOPSIS is widely used because it has a simple concept, is easy to understand and is able to calculate the distance of the ideal solution from each alternative in a systematic form [20]. The TOPSIS method can determine the ranking of each alternative that has been determined, where the best alternative has the closest distance to the positive ideal solution and has the furthest distance to the negative ideal solution. A positive ideal solution is a solution that maximizes the benefit attribute *and minimizes the cost* attribute . While a negative solution is a solution that maximizes the cost attribute *and* minimizes the *benefit* attribute .[13] The following are the stages of completing the TOPSIS method as follows:

1. Creating a normalized decision matrix

   $$X = \begin{bmatrix} X11 & X12 & X13 & \cdots & Xn1 \\ X21 & X22 & X23 & \cdots & Xn2 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ Xm1 & Xm2 & Xm3 & \cdots & Xnm \end{bmatrix} \quad (3)$$

   Where m is the number of alternatives, n is the number of evaluation criteria and xij is the performance of the alternative with respect to criterion j.

   $$rij = \frac{xij}{\sqrt{\sum_{i=1}^{m} xij^2}} \quad (4)$$

   Information :
   i = alternative result of the ith request
   j = result of the jth request criteria
   rij = 1.2 ... m normalized data values based on each criterion of each alternative
   xij = 1,2 ... n unnormalized data values based on each criterion of each alternative

2. Create a weighted and normalized decision matrix, the normalized weight matrix Y is:

   $$y_{ij} = w_i r_{ij} \quad (5)$$

3. Determine the positive ideal solution matrix and negative ideal solution matrix:
   The positive ideal solution A^+ and the negative ideal solution A^- are determined based on the normalized weight ratings (yij), as follows:

   $$\mathrm{A}^{+} = (\mathrm{y}_1^{+}, \mathrm{y}_2^{+}, \ldots, \mathrm{y}_\mathrm{n}^{+}) \quad (6)$$

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$$A^- = (y_1^-, y_2^-, \dots, y_n^-) \quad (7)$$

4. Determine the length of the range between the values of each alternative with the positive and negative ideal solution matrix.
   The span length between the alternatives $A_i$and the positive ideal solution :

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^+)^2} \quad (8)$$

   The span length between the alternatives $A_i$and the negative ideal solution

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)^2} \quad (9)$$

   Information :
   D_i^+ = length of the range of the i-th alternative with a positive ideal solution .
   y_i^+ = positive ideal solution elements [i]
   y_{ij} = weighted normalized matrix elements [i][j]
   D_i^- = length of the range of the i-th alternative with a negative ideal solution .
   y_i^- = negative ideal solution elements [i]
5. Determine the preference value for each alternative

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (10)$$

   Larger $A_i$value indicates that the alternative $V_i$is preferred.
   Information :
   V_i = n proximity of alternative ideal solutions.
   D_i^+ = length of the span between the i-th alternative and the positive ideal solution.
   D_i^- = length of the span between the i-th alternative and the negative ideal solution.

2.5 *E-Wallet*

E-Wallet or electronic wallet is an electronic-based service in the form of software or application where money is stored in the form of a balance that can be accessed and used via *smartphone* . Electronic wallets function to store electronic money in the form of a balance that can be refilled so that users can make transactions with other users remotely [16].

3. RESULTS AND DISCUSSION

3.1 Determination of Criteria

Table 1. Criteria Data

Code	Criteria	Weight	Type
C1	Ease of Use	0.2567	*Benefits*
C2	Transaction Security	0.1567	*Benefits*
C3	Transaction Processing Speed	0.0900	*Benefits*
C4	Completeness of Features	0.0400	*Benefits*
C5	Admin feeTransaction	0.4567	*Cost*

Based on Table 1 above, the determination of *e-wallet* uses 5 criteria. Where code C1 with information on user convenience, code C2 with information on transaction security, code C3 with information on transaction process speed, code C4 with information on completeness of features and code C5 with information on transaction costs. The importance weight values that will be used in applying the calculation method are shown in Table 2 below:

Table 2. Importance Weight Values of User Ease Criteria

Scale	Criteria Weight
Very easy	4
Easy	3
Quite Easy	2
Not easy	1

Furthermore, the importance weight values that will be used in applying the calculation method are shown in Table 3 below:

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Table 3. Importance Weight Value of Transaction Security Criteria

Scale	Criteria Weight
Very Safe	4
Safe	3
Safe Enough	2
Not safe	1

Then, the importance weight values that will be used in applying the calculation method are shown in Table 4 below:

Table 4. Importance Weight Value of Transaction Processing Speed Criteria

Scale	Criteria Weight
Very fast	4
Fast	3
Pretty Fast	2
Not Fast	1

So the importance weight values that will be used in applying the calculation method are in Table 5 below:

Table 5. Importance Weight Values of Feature Completeness Criteria

Scale	Criteria Weight
Very Complete	4
Complete	3
Quite Complete	2
Incomplete	1

3.2 Determination of Alternatives

In this study, 5 alternative e-wallets were used which will be selected to determine the best *e-wallet*.

Table 6. Alternative Data

Code	Alternative
A1	Funds
A2	OVO
A3	GoPay
A4	ShopeePay
A5	LinkAja
A6	Flip
A7	My Pocket
A8	Document
A9	i.pocket

E-wallet criteria values in Table 7 below:

Table 7. Alternative Data and *E-Wallet* Criteria Values

Code	Alternative	Criteria				
		C1	C2	C3	C4	C5
A1	Funds	Very easy	Safe	Fast	Quite Complete	Rp2,500.00
A2	OVO	Easy	Safe	Pretty Fast	Quite Complete	Rp3,000.00
A3	GoPay	Easy	Safe Enough	Fast	Complete	Rp2,000.00
A4	ShopeePay	Easy	Safe	Fast	Incomplete	Rp. 5,000.00
A5	LinkAja	Quite Easy	Safe Enough	Pretty Fast	Quite Complete	Rp7,000.00
A6	Flip	Easy	Safe Enough	Pretty Fast	Incomplete	Rp4,000.00
A7	My Pocket	Easy	Safe Enough	Fast	Quite Complete	Rp3,500.00
A8	Document	Quite Easy	Safe Enough	Fast	Complete	Rp2,500.00
A9	i.pocket	Easy	Safe	Pretty Fast	Quite Complete	Rp4,500.00

The suitability ratings that will be used in applying the calculation method are shown in Table 8 below:

Table 8. Suitability Rating

Code	Alternative	Criteria				
		C1	C2	C3	C4	C5
A1	Funds	4	3	3	2	Rp2,500.00

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Code	Alternative	Criteria				
		C1	C2	C3	C4	C5
A2	OVO	3	3	2	2	Rp3,000.00
A3	GoPay	3	2	3	3	Rp2,000.00
A4	ShopeePay	3	3	3	1	Rp. 5,000.00
A5	LinkAja	2	2	3	2	Rp7,000.00
A6	Flip	3	2	2	1	Rp4,000.00
A7	My Pocket	3	2	3	2	Rp3,500.00
A8	Document	2	2	3	3	Rp2,500.00
A9	i.pocket	3	3	2	2	Rp4,500.00

3.3 Application of TOPSIS Method

After the required data is complete, starting from criteria data, alternative data to suitability rating data. Then the next stage is the application of the TOPSIS method to determine the best alternative so that the best *e-wallet is obtained* in this study.

1. Determine the decision matrix Xij obtained from the suitability rating.

$$X_{ij} = \begin{bmatrix} 4 & 3 & 3 & 2 & 2500 \\ 3 & 3 & 2 & 2 & 3000 \\ 3 & 2 & 3 & 3 & 2000 \\ 3 & 3 & 3 & 1 & 5000 \\ 2 & 2 & 3 & 2 & 7000 \\ 3 & 2 & 2 & 1 & 4000 \\ 3 & 2 & 3 & 2 & 3500 \\ 2 & 2 & 3 & 3 & 2500 \\ 3 & 3 & 2 & 2 & 4500 \end{bmatrix}$$

2. Calculate the normalized matrix Rij using equation 4
   Calculation on criteria C1

$$|x_1| = \sqrt{4^2 + 3^2 + 3^2 + 3^2 + 2^2 + 3^2 + 3^2 + 2^2 + 3^2} = 8.8318$$

$$r_{11} = \frac{x_{11}}{|x_1|} = \frac{4}{8.8318} = 0.4529$$

$$r_{21} = \frac{x_{21}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

$$r_{31} = \frac{x_{31}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

$$r_{41} = \frac{x_{41}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

$$r_{51} = \frac{x_{51}}{|x_1|} = \frac{2}{8.8318} = 0.2264$$

$$r_{61} = \frac{x_{61}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

$$r_{71} = \frac{x_{71}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

$$r_{81} = \frac{x_{81}}{|x_1|} = \frac{2}{8.8318} = 0.2264$$

$$r_{91} = \frac{x_{91}}{|x_1|} = \frac{3}{8.8318} = 0.3396$$

Perform the above calculations to obtain the normalization results of C2 to C5. From the calculation results above, the normalization matrix is obtained as below:

$$R_{ij} = \begin{bmatrix} 0.4529 & 0.4008 & 0.3692 & 0.3162 & 0.2054 \\ 0.3396 & 04008 & 0.2461 & 0.3162 & 0.2465 \\ 0.3396 & 0.2672 & 0.3692 & 0.4743 & 0.1643 \\ 0.3396 & 0.4008 & 0.3692 & 0.1581 & 0.4109 \\ 0.2264 & 0.2672 & 0.3692 & 0.3162 & 0.5753 \\ 0.3396 & 0.2672 & 0.2461 & 0.1581 & 0.3287 \\ 0.3396 & 0.2672 & 0.3692 & 0.3162 & 0.2876 \\ 0.2264 & 0.2672 & 0.3692 & 0.4743 & 0.2054 \\ 0.3396 & 0.4008 & 0.2461 & 0.3162 & 0.3698 \end{bmatrix}$$

3. Calculating the Y matrix

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$y_{11} = w_1 r_{11} = (0.4529) * (0.2567) = 0.1162$

$y_{12} = w_2 r_{12} = (0.4008) * (0.1567) = 0.0628$

$y_{13} = w_3 r_{13} = (0.3692) * (0.0900) = 0.0332$

$y_{14} = w_4 r_{14} = (0.3162) * (0.0400) = 0.0126$

$y_{15} = w_5 r_{15} = (0.2054) * (0.4567) = 0.0938$

Perform the calculation to obtain alternative results A2 to A9. Thus producing the Y matrix, as below:

$$y_{ij} = \begin{vmatrix} 0.1162 & 0.0628 & 0.0332 & 0.0126 & 0.0938 \\ 0.0871 & 0.0628 & 0.0221 & 0.0126 & 0.1126 \\ 0.0871 & 0.0418 & 0.0332 & 0.0189 & 0.0750 \\ 0.0871 & 0.0628 & 0.0332 & 0.0063 & 0.1876 \\ 0.0581 & 0.0418 & 0.0332 & 0.0126 & 0.2627 \\ 0.0871 & 0.0418 & 0.0221 & 0.0063 & 0.1501 \\ 0.0871 & 0.0418 & 0.0332 & 0.0126 & 0.1313 \\ 0.0581 & 0.0418 & 0.0332 & 0.0189 & 0.0938 \\ 0.0871 & 0.0628 & 0.0221 & 0.0126 & 0.1689 \end{vmatrix}$$

4. Looking for positive ideal solutions and negative ideal solutions
   Positive:$A^+ = (y_1^+, y_2^+, \dots, y_n^+)$

   $y_1^+ = \max\{y_{11}; y_{21}; y_{31}; y_{41}; y_{51}; y_{61}; y_{71}; y_{81}; y_{91}\}$

   $y_1^+ = \max\{0.1162; 0.0871; 0.0871; 0.0871; 0.0581; 0.0871; 0.0871; 0.0581; 0.0871\} = 0.1162$

   $y_2^+ = \max\{y_{12}; y_{22}; y_{32}; y_{42}; y_{52}; y_{62}; y_{72}; y_{82}; y_{92}\}$

   $y_1^+ = \max\{0.0628; 0.0628; 0.0418; 0.0628; 0.0418; 0.0418; 0.0418; 0.0418; 0.0628\} = 0.0628$

   $y_3^+ = \max\{y_{13}; y_{23}; y_{33}; y_{43}; y_{53}; y_{63}; y_{73}; y_{83}; y_{93}\}$

   $y_1^+ = \max\{0.0332; 0.0221; 0.0332; 0.0332; 0.0332; 0.0221; 0.0332; 0.0332; 0.0221\} = 0.0332$

   $y_4^+ = \max\{y_{14}; y_{24}; y_{34}; y_{44}; y_{54}; y_{64}; y_{74}; y_{84}; y_{94}\}$

   $y_1^+ = \max\{0.0126; 0.0126; 0.0189; 0.0063; 0.0126; 0.0063; 0.0126; 0.0189; 0.0126\} = 0.0189$

   $y_5^+ = \max\{y_{15}; y_{25}; y_{35}; y_{45}; y_{55}; y_{65}; y_{75}; y_{85}; y_{95}\}$

   $y_1^+ = \max\{0.0938; 0.1126; 0.0750; 0.1876; 0.2627; 0.1501; 0.1313; 0.0938; 0.1689\} = 0.2627$

   $A^+ = \max\{0.1162; 0.0628; 0.0332; 0.0189; 0.2627\}$

   Negative $A^- = (y_1^-, y_2^-, \dots, y_n^-)$ideal solution :

   $y_1^- = \min\{y_{11}; y_{21}; y_{31}; y_{41}; y_{51}; y_{61}; y_{71}; y_{81}; y_{91}\}$

   $y_1^+ = \min\{0.1162; 0.0871; 0.0871; 0.0871; 0.0581; 0.0871; 0.0871; 0.0581; 0.0871\} = 0.0581$

   $y_2^- = \min\{y_{12}; y_{22}; y_{32}; y_{42}; y_{52}; y_{62}; y_{72}; y_{82}; y_{92}\}$

   $y_1^+ = \min\{0.0628; 0.0628; 0.0418; 0.0628; 0.0418; 0.0418; 0.0418; 0.0418; 0.0628\} = 0.0418$

   $y_3^- = \min\{y_{13}; y_{23}; y_{33}; y_{43}; y_{53}; y_{63}; y_{73}; y_{83}; y_{93}\}$

   $y_1^+ = \min\{0.0332; 0.0221; 0.0332; 0.0332; 0.0332; 0.0221; 0.0332; 0.0332; 0.0221\} = 0.0221$

   $y_4^- = \min\{y_{14}; y_{24}; y_{34}; y_{44}; y_{54}; y_{64}; y_{74}; y_{84}; y_{94}\}$

   $y_1^+ = \min\{0.0126; 0.0126; 0.0189; 0.0063; 0.0126; 0.0063; 0.0126; 0.0189; 0.0126\} = 0.0063$

   $y_5^- = \min\{y_{15}; y_{25}; y_{35}; y_{45}; y_{55}; y_{65}; y_{75}; y_{85}; y_{95}\}$

   $y_1^+ = \min\{0.0938; 0.1126; 0.0750; 0.1876; 0.2627; 0.1501; 0.1313; 0.0938; 0.1689\} = 0.0750$

   $A^- = \min\{0.0581; 0.0418; 0.0221; 0.0063; 0.0750\}$

5. Find the distance between the alternative A_Iy matrix with the positive ideal solution and the negative ideal solution using equations 8 and 9.
   Positive ideal solution

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$$D_1^+ = \sqrt{\begin{matrix}(0.1162-0.1162)+(0.0628-0.0628)+(0.0332-0.0332)+\\(0.0126-0.0189)+(0.0938-0.2627)\end{matrix}} = 0.1690$$

$$D_2^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0628-0.0628)+(0.0221-0.0332)+\\(0.0126-0.0189)+(0.1126-0.2627)\end{matrix}} = 0.1534$$

$$D_3^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0418-0.0628)+(0.0332-0.0332)+\\(0.0189-0.0189)+(0.0705-0.2627)\end{matrix}} = 0.1910$$

$$D_4^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0628-0.0628)+(0.0332-0.0332)+\\(0.0063-0.0189)+(0.1876-0.2627)\end{matrix}} = 0.0814$$

$$D_5^+ = \sqrt{\begin{matrix}(0.0581-0.1162)+(0.0418-0.0628)+(0.0332-0.0332)+\\(0.0126-0.0189)+(0.2627-0.2627)\end{matrix}} = 0.0621$$

$$D_6^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0418-0.0628)+(0.0221-0.0332)+\\(0.0063-0.0189)+(0.1501-0.2627)\end{matrix}} = 0.1193$$

$$D_7^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0418-0.0628)+(0.0332-0.0332)+\\(0.0126-0.0189)+(0.1313-0.2627)\end{matrix}} = 0.1363$$

$$D_8^+ = \sqrt{\begin{matrix}(0.0581-0.1162)+(0.0418-0.0628)+(0.0332-0.0332)+\\(0.0189-0.0189)+(0.0938-0.2627)\end{matrix}} = 0.1798$$

$$D_9^+ = \sqrt{\begin{matrix}(0.0871-0.1162)+(0.0628-0.0628)+(0.0221-0.0332)+\\(0.0126-0.0189)+(0.1689-0.2627)\end{matrix}} = 0.0990$$

Negative ideal solution

$$D_1^- = \sqrt{\begin{matrix}(0.1162-0.0581)+(0.0628-0.0418)+(0.0332-0.0221)+\\(0.0126-0.0063)+(0.0938-0.0750)\end{matrix}} = 0.0658$$

$$D_2^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0628-0.0418)+(0.0221-0.0221)+\\(0.0126-0.0063)+(0.1126-0.0750)\end{matrix}} = 0.0522$$

$$D_3^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0418-0.0418)+(0.0332-0.0221)+\\(0.0189-0.0063)+(0.0705-0.0750)\end{matrix}} = 0.0335$$

$$D_4^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0628-0.0418)+(0.0332-0.0221)+\\(0.0063-0.0063)+(0.1876-0.0750)\end{matrix}} = 0.1186$$

$$D_5^+ = \sqrt{\begin{matrix}(0.0581-0.0581)+(0.0418-0.0418)+(0.0332-0.0221)+\\(0.0126-0.0063)+(0.2627-0.0750)\end{matrix}} = 0.1881$$

$$D_6^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0418-0.0418)+(0.0221-0.0221)+\\(0.0063-0.0063)+(0.1501-0.0750)\end{matrix}} = 0.0805$$

$$D_7^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0418-0.0418)+(0.0332-0.0221)+\\(0.0126-0.0063)+(0.1313-0.0750)\end{matrix}} = 0.0646$$

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$$D_8^+ = \sqrt{\begin{matrix}(0.0581-0.0581)+(0.0418-0.0418)+(0.0332-0.0221)+\\(0.0189-0.0063)+(0.0938-0.0750)\end{matrix}} = 0.0251$$

$$D_9^+ = \sqrt{\begin{matrix}(0.0871-0.0581)+(0.0628-0.0418)+(0.0221-0.0221)+\\(0.0126-0.0063)+(0.1689-0.0750)\end{matrix}} = 0.1006$$

6. Determine preferences $V_i$using equation 10

$$V_1 = \frac{D_1^-}{D_1^-+D_1^+} = \frac{0.0658}{0.0658+0.1690} = 0.2802$$

$$V_2 = \frac{D_2^-}{D_2^-+D_2^+} = \frac{0.0522}{0.0522+0.1534} = 0.2540$$

$$V_3 = \frac{D_3^-}{D_3^-+D_3^+} = \frac{0.0335}{0.0355+0.1910} = 0.1494$$

$$V_4 = \frac{D_4^-}{D_4^-+D_4^+} = \frac{0.1186}{0.1186+0.0814} = 0.5929$$

$$V_5 = \frac{D_5^-}{D_5^-+D_6^+} = \frac{0.1881}{0.1881+0.0621} = 0.7518$$

$$V_6 = \frac{D_6^-}{D_6^-+D_6^+} = \frac{0.0805}{0.0805+0.1193} = 0.4027$$

$$V_7 = \frac{D_7^-}{D_7^-+D_7^+} = \frac{0.0646}{0.0646+0.1363} = 0.3216$$

$$V_8 = \frac{D_8^-}{D_8^-+D_8^+} = \frac{0.0251}{0.0251+0.1798} = 0.1228$$

$$V_9 = \frac{D_9^-}{D_9^-+D_9^+} = \frac{0.1006}{0.1006+0.0990} = 0.5039$$

Determine the ranking of the calculation results using the TOPSIS method by looking at the results in Table 9 below:

Table 9. Ranking Data From Alternatives

Alternative	Preference Value	Ranking
Fund (A1)	0.2802	6
OVO (A2)	0.254	7
GoPay (A3)	0.1494	8
ShopeePay (A4)	0.5929	2
LinkAja (A5)	0.7518	1
Flip (A6)	0.4027	4
My Pocket (A7)	0.3216	5
Document (A8)	0.1228	9
i.pocket (A9)	0.5039	3

4. CONCLUSION

Based on the results of the discussion and analysis conducted, it can be concluded that the application of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method in selecting the best e-wallet has proven effective in solving problems related to multi-criteria evaluation. The TOPSIS method allows for more objective decision making by considering various evaluation criteria such as merchant reach, cashback programs, transaction costs, and ease of use. The results of the analysis show that alternative A5 is the best choice with a value of 0.7518, which indicates that this alternative is closest to the ideal solution. In addition, the TOPSIS method also offers flexibility in determining the weight for each criterion, so that it can be adjusted to user priorities or specific needs. The implications of this study indicate that the selection of e-wallets does not only depend on one factor, but on a combination of various interrelated criteria. Therefore, the results of this study are expected to be a reference for users and service providers in evaluating the e-wallet that best suits their needs.

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