Building of Informatics, Technology and Science (BITS)
Volume 7, No 1, June 2025 Page: 759−771
ISSN 2684-8910 (media cetak)
ISSN 2685-3310 (media online)
DOI 10.47065/bits.v7i1.7395

Determining the Best E-Commerce Using the Multi Criteria Decision Making (MCDM) Method

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Submitted: **19/05/2025**; Accepted: **30/06/2025**; Published**: 30/06/2025**

Abstract−The rapid expansion of e-commerce has positively influenced lifestyles and fueled economic growth, as evidenced by rising transaction volumes and government revenue. However, challenges persist, especially in consumer security, logistics infrastructure, and taxation. The quality of e-commerce websites is crucial, serving as a primary source of customer information and ensuring secure transactions. Selecting the right e-commerce platform is also essential for business development. Despite the proliferation of e-commerce platforms offering diverse features and user-friendly interfaces, issues like product quality discrepancies, fraudulent activities, and incomplete features continue to frustrate consumers. To address these challenges and aid consumers in selecting optimal platforms, Multi-Criteria Decision Making (MCDM) methods are employed. This study explores various MCDM techniques to rank 8 major e-commerce platforms based on 5 criteria. The analysis consistently identifies Shopee as the top-performing platform. While Tokopedia, Bukalapak, Lazada, and TikTok Shop show some variations in rankings depending on the MCDM method used, Blibli, JD.ID, and OLX Indonesia maintain consistent rankings across all methods. This suggests that while Shopee demonstrates clear superiority, the subtle differences in MCDM methodologies can influence the relative rankings of other platforms.

Keywords: E-Commerce; MCDM; TOPSIS Method; SAW Method; WP Method; WASPAS Method; MOORA Method

1. INTRODUCTION

At this time, information technology has a very large influence on the progress of a business. Almost all groups are competing to create a business using various methods, one of which is to promote their business using e-commerce applications. E-commerce applications are transactions or payments made online, either through media such as the internet, television, or computers. E-commerce, also known as online stores, includes various types of software and websites that can make it easier for people to shop[1]. E-commerce businesses can also create responsive websites, making them easy to access via mobile devices[2]. E-commerce applications are widely used by individuals and entrepreneurs to make payments online.

The development of e-commerce in Indonesia has also started to increase in 2019. There has been an increase in the number of visitors to e-commerce sites, which shows the development of online shopping activities today. This increasing trend of online shopping has encouraged many companies to compete to create the best platform to meet the needs of the community[3]. With the increase in visits to e-commerce sites, it has a significant impact on economic aspects, such as increasing online financial transactions, high demand for expedition services, increasing demand for materials for packaging goods, and increasing demand for workers in the expedition sector[4]. This is marked by e-commerce companies such as Shopee, Blibli, Bukalapak, Tokopedia, Lazada, etc[5]. E-commerce opens up equal employment opportunities and provides opportunities for everyone around the world to compete and thrive in the digital world[6]. The rapid development of e-commerce has had a positive impact on people"s lives and driven the country"s economic growth, as evidenced by the increasing number of transactions and state revenues from the e-commerce sector[7]. In developing e-commerce activities, the challenges that must be faced include consumer security and protection, logistics and infrastructure issues, and taxation related to e-commerce transactions[8]. So the quality of the website is very important because it functions as a source of information for customers, so they can choose and make transactions more safely[9]. And the selection of a platform for E-Commerce must be done carefully, because the platform chosen will have an important role in the development of the E-Commerce business that will be run[10]. The emergence of various e-commerce platforms in Indonesia by offering various interesting features and offering easy user access. The problems that often occur in e-commerce, for example, the quality of the ordered product does not match consumer expectations, it is difficult to distinguish honest e-commerce from fraud, and the appearance of its features is incomplete[11]. This makes consumers annoyed because of this problem. Therefore, to help consumers choose the best and superior e-commerce application, they can use the MCDM method.

Making tough choices with lots of things to consider is where Multi-Criteria Decision Making (MCDM) comes in. Whether it"s a personal choice or a business strategy, we often have to choose the best option from several, each with its own pros and cons. This is a core problem in decision-making, and MCDM helps by evaluating multiple criteria to find the optimal solution. There are many MCDM tools and techniques used in diverse fields, from finance to engineering. This research will explore the concept of MCDM in various methods[12]–[15]. The MCDM methods that will be used in this study are the TOPSIS method, the SAW method, the WP method WASPAS method and the MOORA method. These five methods will be compared in solving problems in determining the best E-Commerce. MCDM is used in making a decision based on the final result or preference of the MCDM method. In determining

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preferences, the TOPSIS method uses positive and negative ideal solutions. The SAW method uses the sum of the performance value weights of each alternative, while the WP method uses the multiplication of the performance value weights of each criterion. The WASPAS method combines the SAW and WP methods to increase accuracy. The MOORA method uses a comparison ratio to determine the best alternative[16]–[20].

Previous research conducted by Fatimah Azahra Imran, et al in 2024, The study discusses the need for decent and affordable housing, especially for students, which is a challenge in this modern era. As a solution, a Decision Support System (DSS) with the TOPSIS method has been developed to assist the process of selecting optimal boarding houses. This system considers various important criteria such as price, distance, facilities, security, and cleanliness in providing recommendations. The final results of this system show that Kost RT5 was selected as the best boarding house with a preference value of 0.791, and this system has an accuracy rate of 93% after analyzing 20 boarding house data[21].

Setiawansyah and Very Hendra Saputra conducted research in 2023, this study successfully applied the SAW method with PIPRECIA-S weighting for the election of school organisation chairman. As a result, Jamaludin was elected chairman with the highest score (1,821), followed by Bustomi (1,763) and Budiman (1,698). Respondents in the questionnaire mostly (98%) agreed or strongly agreed with the results of this election, indicating that the method used was effective and acceptable[22].

Previous research conducted by Dinda Fransiska in 2020, the results of his research showed that the WP (Weighted Product) method was effective in providing the best alternative decisions in choosing e-commerce. The decision-making process is carried out by calculating the value of the criteria, improving the weights, and calculating the S and V vector values, then determining the largest value and ranking. The results of the criteria assessment show that customer trust and product quality are more important than ease of application, promotion, and appearance. From the calculations carried out, the e-commerce with the highest value is chosen as the best and recommended to be selected[11].

Fahrul Mahdi, et al conducted research in 2023. In the study, in order to select permanent employees from contract employees, companies often faced challenges due to a lack of objectivity. This research proves that the use of WASPAS and ROC methods, focusing on various important factors, can improve the effectiveness of the selection process. The application of these methods results in more precise and optimal decisions in selecting the best candidates. The contract employee with code A2 was selected as the best candidate to be appointed as a permanent employee with the highest utility value of 0.982. This selection is based on the results of calculations using the ROC and WASPAS methods, which consider various predetermined criteria[23].

Kusmanto, dkk (2022) In order to minimise the risk of loan defaults, this research creates a computer-based system to select potential borrowers. The system uses two calculation methods to determine the priority order of the most eligible borrowers, namely the MOORA and MOOSRA methods. Thus, this system is able to help identify prospective borrowers who are potentially problematic with a higher level of accuracy, so as to reduce the number of bad debts[24].

2. RESEARCH METHODOLOGY

2.1 Research Stages

The research process involves a series of activities carried out by researchers to produce new knowledge. The series of steps in research can be seen in the illustration attached below (Figure 1).

Figure 1. Research Stages

Based on the illustration in Figure 1, the stages described above include several important processes. First, problem analysis, which is an in-depth effort to understand the root of the problem in a structured manner. Second, literature observation, which includes reviewing, evaluating, and combining various reference sources that are relevant to the research topic. Next, data collection, a systematic procedure for obtaining the information needed to answer research questions or achieve certain goals. This data can be in the form of numbers, text, or visuals, obtained from various sources. Fourth, comparative analysis of MCDM methods, namely communication and evaluation of various multi-criteria decision-making (MCDM) methods. In this study, a comparison will be made of five MCDM methods, namely TOPSIS, SAW, WP, WASPAS, and MOORA. Finally, the report, which is the result of observations, research, or certain activities, either in written or oral form.

2.2 MCDM

Multi-Criteria Decision Making (MCDM) provides a structured framework for navigating complex choices. When confronted with numerous potential solutions, each assessed against a range of potentially conflicting criteria, MCDM

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techniques offer a systematic approach to identify the most desirable option. Instead of relying on a single metric, these methods enable decision-makers to weigh and integrate diverse factors, leading to a more comprehensive and informed selection. Essentially, MCDM facilitates the prioritization of alternatives by simultaneously considering multiple relevant attributes. The field encompasses a diverse array of methodologies, each tailored to address specific decision-making scenarios. The selection of an appropriate MCDM technique hinges on the nature of the problem, the characteristics of the criteria, and the preferences of the decision-maker. Among the widely recognized methods are. here are many MCDM methods that can be used based on each problem faced, these MCDM methods include TOPSIS, SAW, WP, WASPAS, MOORA, ARAS, GADA, OCRA, MAUT, MOOSRA, CoCoSo, PSI, AHP, ROC, EDAS, MABAC, and many more methods[25]–[30].

2.3 TOPSIS Method

TOPSIS, short for Technique for Order Preference by Similarity to Ideal Solution[31], serves as a structured framework for enhancing the precision of decision-making processes. It operates within the realm of multi-criteria decision analysis, a field dedicated to resolving complex choices involving numerous factors. At its core, TOPSIS aims to identify the optimal alternative by evaluating each option"s relative proximity to a theoretically perfect solution, known as the positive ideal solution. Simultaneously, it assesses the divergence of each option from a diametrically opposed, least desirable solution, the negative ideal solution. This method essentially quantifies how well each potential choice aligns with the most favorable attributes while minimizing its deviation from the least desirable characteristics. By considering both positive and negative ideals, TOPSIS provides a robust and balanced approach to selecting the most suitable option from a set of alternatives[32]. The initial steps in solving a problem in the TOPSIS method are to form a decision matrix as equation 1 below.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & . & . & x_{n1} \\ x_{21} & x_{22} & . & . & x_{n2} \\ . & . & . & . & . \\ . & . & . & . & . \\ x_{m1} & x_{m2} & . & . & x_{nm} \end{bmatrix} \quad (1)$$

Where m is the number of alternatives, n is the number of evaluation criteria and x_{ij} is the performance of the alternative with respect to criterion j. The second stage is to calculate the normalisation of the decision matrix using equation 2 below.

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

The next stage is to multiply the normalisation results with the importance weights of each criterion or known as weighted normalisation which can use the following equation 3.

$$y_{ij} = w_i r_{ij} \quad (3)$$

Next step Determine the positive ideal solution matrix and negative ideal solution matrix, The positive ideal solution A^+ can use the formula equation 4 and and the negative ideal solution A^- can use the formula equation 5 below.

$$A^+ = (y_1^+, y_2^+, \dots, y_n^+) \quad (4)$$

$$A^- = (y_1^-, y_2^-, \dots, y_n^-) \quad (5)$$

Equations 4 and 5 above can be adjusted based on predetermined conditions, including to find y_i^+, if j is a benefit attribute, the $max_{y_{ij}}$ value is taken but if j is a cost attribute, the $min_{y_{ij}}$ value is taken. Meanwhile, to determine the value of y_i^- the opposite of y_i^+. The next step is to determine the distance between two alternative positive ideal solutions using equation 6 and negative solutions using equation 7 below.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij-} y_i^+)^2} \quad (6)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij-} y_i^-)^2} \quad (7)$$

The last step in the TOPSIS method is to find the preference value for each alternative (V_i) which can use the following equation 8:

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (8)$$

The greater the V_i value obtained, the more the alternative is prioritised or the best and preferred over other alternatives.

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2.4 SAW Method

One of the methods used in the Decision Support System is the Simple Additive Weighting (SAW) method[33] is a way of finding the weighted sum of each alternative of performance on all attributes which in the normalisation process requires a decision matrix (X) which will be compared with all alternative levels that have been determined. In the SAW method, the first step is to create a decision matrix based on predetermined criteria, then normalise the matrix that has been made previously based on the type of attribute so that a matrix is obtained. The normalisation of the benefit attribute can use equation 9, while the cost attribute can use equation 10 so that a normalised matrix (R) is obtained. The final step is to calculate the preference value of each alternative based on the previously calculated normalisation results using equation 11.

$$R_{ij} = \frac{x_{ij}}{Max_{xij}} \tag{9}$$

$$R_{ij} = \frac{Min\, x_{ij}}{x_{ij}} \tag{10}$$

$$V_i = \sum_{j=1}^{n} R_{ij} * W_j \tag{11}$$

The description of the SAW method formula includes X_{ij} is the data converted into matrix form, R_{ij} is the normalised performance level, V_i is the ranking of each preference value and W_j is the weight or importance of each criterion[34].

2.5 WP Method

The Weighted Product (WP) technique[35] is frequently employed in multi-criteria decision-making scenarios, primarily because it offers a computationally streamlined approach. Its core mechanism involves scaling each alternative"s performance on a given criterion by a corresponding weight, which reflects the criterion"s relative importance. This weighted scaling is achieved through multiplication, effectively representing the proportional contribution of each criterion to the overall evaluation.

The WP method"s implementation follows a structured sequence of steps. Initially, each criterion is assigned a numerical weight (denoted as "w"), signifying its significance in the decision process. If these weights have already been established by the decision-maker or through a prior analysis, this initial step can be bypassed. However, if the weights need to be derived, they can be determined using a specific mathematical formula, often referred to as "equation 12". This equation is designed to quantify the relative importance of each criterion, ensuring that the weights accurately reflect the decision-maker"s priorities.

$$W_j = \frac{w_j}{\sum w_j} \tag{12}$$

Following the weight assignment, the next crucial step is the calculation of the preference vector value, symbolized as "S". This value is computed using "equation 13", which typically involves multiplying each alternative"s criterion values raised to the power of their corresponding weights. This process effectively aggregates the weighted performances of each alternative across all criteria, resulting in a numerical score that represents the overall preference for that alternative.

$$S_i = \prod_{j=1}^{n} {X_{ij}}^{W_j} \tag{13}$$

Finally, the preference vector value "V" is determined using "equation 14". This stage often involves normalizing the "S" values, typically by dividing each "S" value by the sum of all "S" values. This normalization process transforms the preference vector into a relative scale, allowing for a direct comparison of the alternatives. The resulting "V" values represent the final ranking or prioritization of the alternatives, with higher values indicating a stronger preference[36].

$$V_i = \frac{S_i}{\sum S_i} \tag{14}$$

This "S" vector, the "alternative preference vector", holds the initial scores of each option. Each option, denoted as "i", is evaluated against several criteria, labeled "j". The performance of option "i" on criterion "j" is represented by "X". Each criterion "j" is assigned a weight, "w", reflecting its importance in the overall decision. The total number of criteria considered is "n". The sum of all these weights is represented as "∑w". This "V" vector reflects the final, adjusted scores of each option, taking into account the relative importance and nature (benefit or cost) of each criterion. Thus, "S" represents the preliminary evaluation, and "V" signifies the refined, final ranking of the alternatives[37].

2.5 WASPAS Method

The WASPAS (Weighted Aggregated Sum Product Assessment) method is a method in MCDM that is used to assess alternatives based on several relevant criteria. This method combines weighted judgement and aggregated product summation to produce a preference or performance value for each alternative. In the WASPAS method, each criterion is given a weight to describe its level of importance, then a calculation is made by multiplying the weights and values

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of the related criteria, and the results are summed. The results of this calculation are used to compare and rank alternatives in the decision-making process. The WASPAS method begins by preparing a decision matrix that can be seen in equation 15, after which normalising based on the type of criteria determined previously. Normalisation for Benefit type criteria can use equation 16 and normalisation for cost type criteria can use equation 17. The final stage is to calculate the preference value (Qi) according to the following equation 18 [38][39].

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots x_{1n} \\ x_{21} & x_{22} & \dots x_{2n} \\ \dots & \dots & \dots \dots \\ x_{mn1} & x_{mn2} & \dots x_{mn} \end{bmatrix} \quad (15)$$

$$R_{ij=\frac{x_{ij}}{Max_{xij}}} \quad (16)$$

$$R_{ij=\frac{Min\, x_{ij}}{x_{xij}}} \quad (17)$$

$$Q_i = 0{,}5 \sum_{j=1}^{n} R_{ij} W_j + 0.5 \prod_{j=1}^{n} (Rij)^{W_j} \quad (18)$$

2.6 Metode MOORA

The MOORA (Multi Objective Optimization On The Basis of Ratio Analysis) method which stands for Multi Objective Optimisation On The Basis Of Ratio Analysis is a method proposed by Zavadkas and Brauers. A relatively new method that was used for the first time by Brauers in determining a decision. The MOORA method is used in the fields of road design, management, contracting, economics and building. This method has a good level of decision making. MOORA is almost the same as the MOOSRA method, which distinguishes only in the final step of the frontier, namely when determining the preference value where the MOORA method the preference search process is carried out by subtracting the benefit criteria from the cost criteria. Meanwhile, the MOOSRA preference search process is divided between benefit criteria and cost criteria[40][41]. The process of applying the MOORA method begins by forming a decision matrix which can be seen in equation 19, then forming a normalised matrix by determining the normalisation results based on formula 20 and the final step is to calculate the preference value by subtracting the benefit criteria from the cost (G is the number of benefit attributes while (n-g) is the number of cost attributes) using equation 21.

$$x = \begin{bmatrix} x_{11} & x_{12} & .x_{1n} \\ x_{21} & x_{21} & .x_{2n} \\ . & . & . \\ x_{m1} & x_{m2} & .x_{mn} \end{bmatrix} \quad (19)$$

$$x_{ij}^{*} = \frac{Xij}{\sqrt{\sum_{i=1}^{m} {x_{ij}}^2}} \quad (20)$$

$$y_i = \sum_{j=1}^{g} W_j \; X_{ij}^{*} - \sum_{j=g+1}^{n} W_j \; X_{ij}^{*} \quad (21)$$

2.7 E-Commerce

E-ommerce can be defined as the process of buying, selling, transferring, or exchanging goods, services, or information through computer networks or the Internet, by adapting traditional business models and utilising social media on the internet. The business strategy will be successful if executed properly, which in turn can increase the number of customers, brand awareness, and revenue. The development of e-commerce in Indonesia continues to grow rapidly, which can be seen from the many e-commerce companies that have sprung up, such as Shopee, Tokopedia, Lazada, Bukalapak, Blibli, and others. With this rapid growth, competition between e-commerce platforms is getting tighter, encouraging companies to continue to innovate and improve service quality in order to attract more consumers[42][5].

3. RESULTS AND DISCUSSION

This research will analyse the results of each MCDM method in determining the best E-commerce by considering each attribute. The attributes that will be used as an assessment of each E-commerce are 5 attributes. These attributes can be seen in table 1 below.

Table 1. Assessment Criteria Table

Criteria	Describtion	Weight	Types of Criteria
C1	Product Price	0,25	Benefit
C2	Speed of Delivery	0,20	Benefit
C3	Ease of Use	0,15	Benefit
C4	Product Availability	0,10	Benefit

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Criteria	Describtion	Weight	Types of Criteria
C5	Customer Satisfaction	0,30	Benefit

In Table 1, it can be seen that each attribute is given its own criteria code to facilitate the process of applying the MCDM method (shortening the name of the criteria). In addition, it can also be seen that there are weights that have been determined by researchers with different levels of importance for each criterion. The C5 criterion has the highest importance weight among all criteria which indicates that this criterion is the most prioritised assessment (prioritised), while the C4 criterion has the lowest weight value of only 0.10 and this indicates that this criterion is not too prioritised when compared to other criteria, but still plays a role in the assessment. In addition to weights, there are also types of criteria that will affect the process of applying the MCDM method. Benefit criteria and cost criteria have different ways of calculation so this also needs to be adjusted to the criteria used. In this study, all criteria are of the benefit type.

Besides the criteria, it is necessary to record data based on those criteria. The E-commerce data will be selected using the MCDM method to obtain the best E-commerce based on each method. The following table 2 contains E-commerce data that will be used as sample data in this study.

Tabel 2. Sample Data

E-Commerce Application	C1	C2	C3	C4	C5
Shopee	2	4	5	4	5
Tokopedia	1	2	2	1	2
Lazada	3	1	4	2	4
Bukalapak	1	1	3	2	2
Blibli	2	2	2	1	2
JD.ID	2	4	2	1	3
TikTok Shop	2	1	4	4	5
OLX Indonesia	1	3	2	3	2

In Table 2, there are 8 data samples that can be used as alternatives in determining the best E-commerce with an assessment from the best specific, namely 5 to the lowest specific, namely 1. Before implementing the MCDM method, here is the decision matrix contained in each stage of the MCDM method. The following MCDM methods can be applied after the data sample is prepared and the decision matrix is created.

3.1 Implementation of TOPSIS Method

After all the data has been collected, such as criteria data, alternative data, and suitability rating data, the next step is the processing stage of the method used, namely the TOPSIS method in determining the best e-commerce. The stage carried out is calculating the normalized matrix R_{ij} using equation 2.

$$r_{11} = \frac{2}{\sqrt{2^2+1^2+3^2+1^2+2^2+2^2+2^2+1^2}} = \frac{2}{5{,}292} = 0{,}378$$

$$r_{21} = \frac{1}{\sqrt{2^2+1^2+3^2+1^2+2^2+2^2+2^2+1^2}} = \frac{1}{5{,}292} = 0{,}189$$

$$r_{31} = \frac{3}{\sqrt{2^2+1^2+3^2+1^2+2^2+2^2+2^2+1^2}} = \frac{3}{5{,}292} = 0{,}567$$

The normalization above is data 1 to data 3 on criterion C1, perform normalization calculations on all data samples based on criteria C1 to criteria C5 such as the calculation of r_{11} to r_{31} above. After calculating all criteria, the following is the normalization result matrix.

$$R_{ij} = \begin{bmatrix} 0.378 & 0.555 & 0.552 & 0.555 & 0.524 \\ 0.189 & 0.277 & 0.221 & 0.139 & 0.210 \\ 0.567 & 0.139 & 0.442 & 0.277 & 0.419 \\ 0.189 & 0.139 & 0.331 & 0.277 & 0.210 \\ 0.378 & 0.277 & 0.221 & 0.139 & 0.210 \\ 0.378 & 0.555 & 0.221 & 0.139 & 0.314 \\ 0.378 & 0.139 & 0.442 & 0.555 & 0.524 \\ 0.189 & 0.416 & 0.221 & 0.416 & 0.210 \end{bmatrix}$$

After the normalized matrix is formed, the next step is to calculate the Y matrix by multiplying the R_{ij} results with the criteria weights that have been determined in table 1. The calculation of Y can use the equation formula 3.

$$y_{11} = w_1 . r_{11} = (0.25) . (0{,}378) = 0.094$$

$$y_{21} = w_1 . r_{21} = (0.25) . (0{,}189) = 0.047$$

$$y_{31} = w_1 . r_{31} = (0.25) . (0{,}567) = 0.142$$

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Perform the calculation of Y_{ij} from y_{41} to y85 like the calculation of y_{11} to y_{31} above, after calculating the total value of Y_{ij}, it will produce the following Y_{ij} matrix.

$$Y_{ij} = \begin{bmatrix} 0.094 & 0.111 & 0.083 & 0.055 & 0.157 \\ 0.047 & 0.055 & 0.033 & 0.014 & 0.063 \\ 0.142 & 0.028 & 0.066 & 0.028 & 0.126 \\ 0.047 & 0.028 & 0.050 & 0.028 & 0.063 \\ 0.094 & 0.055 & 0.033 & 0.014 & 0.063 \\ 0.094 & 0.111 & 0.033 & 0.014 & 0.094 \\ 0.094 & 0.028 & 0.066 & 0.055 & 0.157 \\ 0.047 & 0.083 & 0.033 & 0.042 & 0.063 \end{bmatrix}$$

The next step is to find the positive ideal solution using equation 4 and the negative ideal solution using equation 5.

$$y_1^+ = max\{y_{11}; y_{21}; y_{31}; y_{41}; y_{51}; y_{61}; y_{71}; y_{81}\} =$$
$$max\{0.094;\ 0.047;\ 0.142;\ 0.047;\ 0.094;\ 0.094;\ 0.094;\ 0.047\} = 0.142$$
$$y_2^+ = max\{y_{12}; y_{22}; y_{32}; y_{42}; y_{52}; y_{62}; y_{72}; y_{82}\} =$$
$$max\{0.111;\ 0.055;\ 0.028;\ 0.028;\ 0.055;\ 0.111;\ 0.028;\ 0.083\} = 0.111$$

Perform a search for positive and negative ideal solutions for y_3^+ to y_5^+ such as y_1^+ and y_2^+ above (positive ideal solutions), while for negative ideal solutions it is the opposite of y_1^+ and y_2^+ above (if the positive ideal solution is searched for the maximum value, for negative ideals the minimum is searched). After the search is carried out, the results of A^+ are {0.142; 0.111; 0.083; 0.055; 0.157} and A^- are {0.047; 0.028; 0.033; 0.014; 0.063}. The next step is to find the distance between alternatives with positive and negative ideal solutions using equations 6 and 7.

$$D_1^+ = \sqrt{\sum_{j=1}^{5}((y_{11} - y_1^+)^2 + (y_{12} - y_2^+)^2 + (y_{13} - y_3^+)^2 + (y_{14} - y_4^+)^2 + (y_{15} - y_5^+)^2)} =$$
$$\sqrt{((0.094 - 0.142)^2 + (0.111 - 0.111)^2 + (0.083 - 0.083)^2 + (0{,}055 - 0.055)^2 + (0.157 - 0.157)^2)}$$
$$= 0.047$$

$$D_1^- = \sqrt{\sum_{j=1}^{2}((y_{11} - y_1^-)^2 + (y_{12} - y_2^-)^2 + (y_{13} - y_3^-)^2 + (y_{14} - y_4^-)^2 + (y_{15} - y_5^-)^2)} =$$
$$\sqrt{((0.094 - 0.047)^2 + (0.111 - 0.028)^2 + (0.083 - 0.033)^2 + (0.055 - 0.014)^2 + (0.157 - 0.063)^2)}$$
$$= 0.149$$

Perform the calculation of the distance search between the positive ideal solution for D_2^+ to D_8^+ like the calculation of D_1^+ above and for the calculation of the distance search for the negative ideal solution D_2^- to D_8^- can be done like the calculation of D_1^- above. After calculating all alternatives, the next step is to calculate the preference (v) using equation 8 as follows:

$$V_1 = \frac{D_1^-}{D_1^- + D_1^+} = \frac{0.149}{0.149 + 0.047} = \frac{0.149}{0.196} = 0.759$$

$$V_2 = \frac{D_2^-}{D_2^- + D_2^+} = \frac{0.149}{0.028 + 0.158} = \frac{0.028}{0.186} = 0.149$$

$$V_3 = \frac{D_3^-}{D_3^- + D_3^+} = \frac{0.119}{0.119 + 0.095} = \frac{0.119}{0.214} = 0.557$$

Perform preference calculations for V_4 to V_8 like the preference calculations for V_1 to V_3 above. After calculating everything, the following table 3 contains the final results along with the ranking of each alternative.

Table 3. Ranking of TOPSIS Method Results

Aplikasi E-Commerce	Vi	Ranking
Shopee	0.759	1
Tokopedia	0.149	7
Lazada	0.557	2
Bukalapak	0.117	8
Blibli	0.288	6
JD.ID	0.497	4
TikTok Shop	0.549	3
OLX Indonesia	0.298	5

From the preference values in table 3 above, it can be stated that V1 has the largest value, namely 0.759, therefore it can be concluded that the 1st alternative, namely Shopee, is the best E-Commerce Application compared to other E-Commerce Applications that have been determined above. In second place is Lazada with a score of 0.557 and in third place is TikTok Shop with a score of 0.549.

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DOI 10.47065/bits.v7i1.7395

3.2 Implementation of SAW Method

The steps for implementing the SAW method begin with the normalization calculation of all criteria based on equations 9 and 10. In this study, only equation 9 was used considering that all the criteria used in this study were of the benefit type. The following is a more detailed calculation of the normalization.

$$R_{11} = \frac{2}{3} = 0{,}667$$

$$R_{21} = \frac{1}{3} = 0{,}333$$

$$R_{31} = \frac{3}{3} = 1$$

Perform normalization on all criteria such as normalization of R11 to R31 in criterion C1 above, after normalization of R11 to R85, the following is the normalized matrix.

$$\text{Rij} = \begin{vmatrix} 0{,}667 & 1 & 1 & 1 & 1 \\ 0{,}333 & 0{,}5 & 0{,}4 & 0{,}25 & 0{,}4 \\ 1{,}000 & 0{,}25 & 0{,}8 & 0{,}5 & 0{,}8 \\ 0{,}333 & 0{,}25 & 0{,}6 & 0{,}5 & 0{,}4 \\ 0{,}667 & 0{,}5 & 0{,}4 & 0{,}25 & 0{,}4 \\ 0{,}667 & 1 & 0{,}4 & 0{,}25 & 0{,}6 \\ 0{,}667 & 0{,}25 & 0{,}8 & 1 & 1 \\ 0{,}333 & 0{,}75 & 0{,}4 & 0{,}75 & 0{,}4 \end{vmatrix}$$

From the normalized matrix above, the next step is to find the preference value (final result) based on the formula equation 11 by multiplying the normalized matrix with the criteria weight value in table 1, after which the results of the multiplication are added up.

$$V_1 = (0{,}667 * 0{,}25) + (1 * 0{,}20) + (1 * 0{,}15) + (1 * 0{,}10) + (1 * 0{,}30) = 0{,}917$$

$$V_2 = (0{,}333 * 0{,}25) + (0{,}5 * 0{,}20) + (0{,}4 * 0{,}15) + (0{,}25 * 0{,}10) + (0{,}4 * 0{,}30) = 0{,}388$$

Perform preference calculations for V_3 to V_8 like the preference calculations for V_1 to V_2 above. After calculating everything, the following table 4 contains the final results along with the ranking of each alternative.

Table 4. Ranking of SAW Method Results

Aplikasi E-Commerce	Vi	Ranking
Shopee	0,917	1
Tokopedia	0,388	8
Lazada	0,710	3
Bukalapak	0,393	7
Blibli	0,472	6
JD.ID	0,632	4
TikTok Shop	0,737	2
OLX Indonesia	0,488	5

From the preference values in table 4 above, it can be stated that V1 has the largest value, namely 0.917, therefore it can be concluded that the 1st alternative, namely Shopee, is the best E-Commerce Application compared to other E-Commerce Applications that have been determined above. In second place is TikTok Shop with a score of 0.737 and in third place is Lazada with a score of 0.710.

3.3 Implementation of WP Method

In this study, the application of the WP method starts from equation 13, because the weights for the criteria have been determined so that the formula for equation 12 is not used in this study. For the calculation of the preference vector search (S), it is as follows.

$$S_i = (2^{0{,}25}) * (4^{0{,}20}) * (5^{0{,}15}) * (4^{0{,}10}) * (5^{0{,}30}) = 3{,}719$$

$$S_2 = (1^{0{,}25}) * (2^{0{,}20}) * (2^{0{,}15}) * (1^{0{,}10}) * (2^{0{,}30}) = 1{,}569$$

Perform calculations for S3 to S8 like searching for preference vectors S1 and S2 above, after searching for preference vectors for all of them, the next step is to calculate the final preference vector (V) using the following equation formula 14.

$$V_i = \frac{3{,}719}{3{,}719+1{,}569+2{,}632+1{,}556+1{,}866+2{,}421+2{,}726+1{,}899} = \frac{3{,}719}{18{,}388} = 0{,}202$$

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$$V_2 = \frac{1,569}{3,719+1,569+2,632+1,556+1,866+2,421+2,726+1,899} = \frac{1,569}{18,388} = 0,085$$

Perform the calculation of the final preference vector for V3 to V8 as in the search for the final preference vectors V1 and V2 above, after calculating the preference vector values of all alternatives, the following is table 5 which contains the ranking of the results of applying the WP method.

Table 5. Ranking of WP Method Results

Aplikasi E-Commerce	Vi	Ranking
Shopee	0,202	1
Tokopedia	0,085	7
Lazada	0,143	3
Bukalapak	0,085	8
Blibli	0,101	6
JD.ID	0,132	4
TikTok Shop	0,148	2
OLX Indonesia	0,103	5

From the final preference vector in table 5 above, it can be stated that V1 has the largest value, namely 0.202, therefore it can be concluded that the 1st alternative, namely Shopee, is the best E-Commerce Application compared to other E-Commerce Applications that have been determined above. In second place is TikTok Shop with a score of 0.148 and in third place is Lazada with a score of 0.143.

3.4 Implementation of WASPAS Method

The initial stage of implementing the WASPAS method in selecting the best E-Commerce is to carry out normalization calculations using formula 16 because each criterion in this study is of the benefit type so that equation formula 17 is not used in this study, the following is the normalization calculation.

$$R_{11} = \frac{2}{3} = 0,667$$

$$R_{21} = \frac{1}{3} = 0,333$$

$$R_{31} = \frac{3}{3} = 1$$

Perform normalization on all criteria such as normalization of R11 to R31 in criterion C1 above, after normalization of R11 to R85, the following is the normalized matrix.

$$\text{Rij} = \begin{vmatrix} 0,667 & 1 & 1 & 1 & 1 \\ 0,333 & 0,5 & 0,4 & 0,25 & 0,4 \\ 1,000 & 0,25 & 0,8 & 0,5 & 0,8 \\ 0,333 & 0,25 & 0,6 & 0,5 & 0,4 \\ 0,667 & 0,5 & 0,4 & 0,25 & 0,4 \\ 0,667 & 1 & 0,4 & 0,25 & 0,6 \\ 0,667 & 0,25 & 0,8 & 1 & 1 \\ 0,333 & 0,75 & 0,4 & 0,75 & 0,4 \end{vmatrix}$$

Based on the normalization results above, the next step is to calculate the final value (Qi) using equation 18 as follows.

$$V_1 = 0,5((0,667 * 0,25) + (1 * 0,20) + (1 * 0,15) + (1 * 0,10) + (1 * 0,30)) + 0,5(0,667^{0,25} * 1^{0,20} * 1^{0,15} * 1^{0,10} * 1^{0,30}) = 0,910$$

$$V_2 = 0,5((0,333 * 0,25) + (0,5 * 0,20) + (0,4 * 0,15) + (0,25 * 0,10) + (0,4 * 0,30)) + 0,5(0,333^{0,25} * 0,5^{0,20} * 0,4^{0,15} * 0,25^{0,10} * 0,4^{0,30}) = 0,385$$

Perform the calculation of the final value search on V3 to V8 like the calculation of the final value of V1 and V2 above, after calculating all the alternatives, the following is table 6 which contains the results of the application of the WASPAS method that has been sorted.

Table 6. Ranking of WASPAS Method Results

Aplikasi E-Commerce	Vi	Ranking
Shopee	0,910	1
Tokopedia	0,385	8
Lazada	0,675	3
Bukalapak	0,386	7
Blibli	0,463	6
JD.ID	0,610	4

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Aplikasi E-Commerce	Vi	Ranking
TikTok Shop	0,699	2
OLX Indonesia	0,475	5

From the final preference in table 6 above, it can be stated that V1 has the largest value, namely 0,910, therefore it can be concluded that the 1st alternative, namely Shopee, is the best E-Commerce Application compared to other E-Commerce Applications that have been determined above. In second place is TikTok Shop with a score of 0.699 and in third place is Lazada with a score of 0.675.

3.5 Implementation of MOORA Method

The application of the MOORA method in selecting the best E-commerce begins with normalizing the criteria used for assessment, this normalization can be done using the following equation formula 20.

$$x_{11}^{*} = \frac{2}{\sqrt{(2^2+1^2+3^2+1^2+2^2+2^2+2^2+1^2}} = \frac{2}{5,292} = 0,378$$

$$x_{21}^{*} = \frac{1}{\sqrt{(2^2+1^2+3^2+1^2+2^2+2^2+2^2+1^2}} = \frac{1}{5,292} = 0,189$$

Perform normalization search calculations on X*31 to X*85 like the normalization search on X*11 and X*21 in the C1 criteria above, after performing calculations on all criteria, the following is the normalization result matrix X*ij.

$X^{*}_{ij} =$

0,378	0,555	0,552	0,555	0,524
0,189	0,277	0,221	0,139	0,210
0,567	0,139	0,442	0,277	0,419
0,189	0,139	0,331	0,277	0,210
0,378	0,277	0,221	0,139	0,210
0,378	0,555	0,221	0,139	0,314
0,378	0,139	0,442	0,555	0,524
0,189	0,416	0,221	0,416	0,210

The next step is to multiply the normalization results by the criteria weights in table 1 using equation formula 21.

$$y_1 = (0,25 * 0,378) + 0,20 * 0,555) + (0,15 * 0,552) + (0,10 * 0,555) + (0,30 * 0,524) = 0,501$$

$$y_2 = (0,25 * 0,189) + 0,20 * 0,277) + (0,15 * 0,221) + (0,10 * 0,139) + (0,30 * 0,210) = 0,213$$

Perform the calculation of the preference value search on y3 to y8 like the search for the preference values y1 and y2 above, after the preference calculation has been carried out on all alternatives, the following table 7 contains the final results of the application of the MOORA method along with the ranking of each alternative.

Table 7. Ranking of MOORA Method Results

Aplikasi E-Commerce	y_i	Ranking
Shopee	0,501	1
Tokopedia	0,213	8
Lazada	0,389	3
Bukalapak	0,215	7
Blibli	0,260	6
JD.ID	0,347	4
TikTok Shop	0,401	2
OLX Indonesia	0,268	5

From the final preference in table 7 above, it can be stated that y1 has the largest value, namely 0,501, therefore it can be concluded that the 1st alternative, namely Shopee, is the best E-Commerce Application compared to other E-Commerce Applications that have been determined above. In second place is TikTok Shop with a score of 0.401 and in third place is Lazada with a score of 0.389.

3.6 Comparative Analysis of MCDM Methods

In an effort to understand the differences and similarities between the five MCDM methods used, a comparative analysis was conducted on the final results produced by each method. The main focus of this analysis is on the ranking order produced by each method. By comparing the ranking of one method with another, we can identify patterns of similarities or differences in the resulting decision making. The final results of the calculation of the five methods, which include the E-commerce ranking order based on each method, are presented in visual form in Figure 2. This figure allows us to directly compare and analyze the results of each method side by side.

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ISSN 2685-3310 (media online)
DOI 10.47065/bits.v7i1.7395

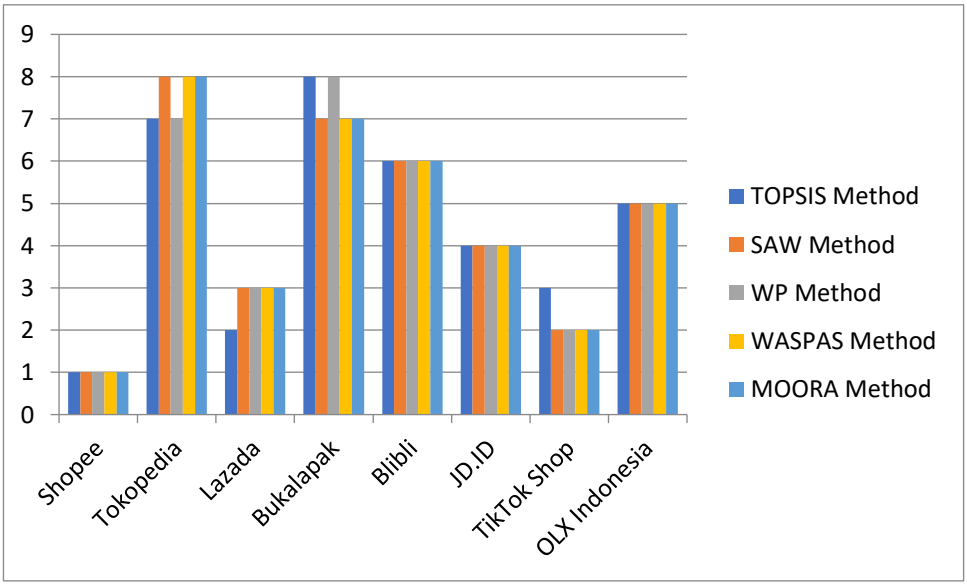

Figure 2. Comparison

Based on Figure 2 above, all MCDM methods give a rating of 1 for Shopee, showing consistency that Shopee is considered the best e-commerce based on all methods used. In Tokopedia and Bukalapak, there is a difference that is not too significant. The ranking of all methods is ranked 7 and 8. In Lazada, there is also no significant difference between one method and another. Lazada's ranking is between 2 and 3. The results of the MCDM method on Blibli are very similar, which means all methods have the same results. Blibli's ranking is in position 6. The results of the MCDM method on JD.ID are very similar, which means all methods have the same results. JD.ID's ranking is in position 4. The results of the MCDM method on TikTok Shop are very similar, which means all methods have the same results. TikTok Shop's ranking is in positions 2 and 3. The results of the MCDM method on OLX Indonesia are very similar, which means all methods have the same results. OLX Indonesia's ranking is in position 5.

Shopee consistently ranks at the top in all methods, showing excellent performance. There are variations in rankings for other E-commerce platforms, indicating that different MCDM methods can produce slightly different results. The results from Blibli, JD.ID, and OLX Indonesia have very similar results from all methods used.

4. CONCLUSION

The conclusion of this study after analyzing using various MCDM (Multi-Criteria Decision Making) methods in determining the 8 best E-commerce based on 5 criteria as an assessment consistently places Shopee as the best e-commerce, while other platforms such as Tokopedia, Bukalapak, Lazada and TikTok Shop show slightly different ranking variations between methods, although Blibli, JD.ID, and OLX Indonesia show very consistent results across all methods. This variation indicates that while Shopee is clearly superior, small differences in the results of the MCDM method can affect the ranking of other e-commerce platforms.

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Building of Informatics, Technology and Science (BITS)
Volume 7, No 1, June 2025 Page: 759−771
ISSN 2684-8910 (media cetak)
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DOI 10.47065/bits.v7i1.7395

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