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Decision Support System for Choosing the Best Shipping Service for E-Commerce Using the SAW and CRITIC Methods

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Abstract

Choosing the best delivery service for e-commerce is a crucial step that can affect customer satisfaction and overall business success. In today's digital era, consumers expect fast, secure, and affordable delivery. The main problem in choosing the best shipping service for e-commerce is often related to several interrelated factors, which can affect the customer experience and business sustainability. One of the biggest challenges is ensuring that products reach customers within the promised time. Delays in delivery can lead to customer dissatisfaction and potentially damage a business's reputation. The combination of SAW and CRITIC methods provides a powerful approach to multi-criteria decision-making. By leveraging the advantages of each method, users can objectively determine the weight of the criteria and evaluate alternatives in a systematic and transparent way. This approach not only improves the accuracy of decisions but also increases decision-makers confidence in the results obtained. Based on the results of the ranking using the method that has been applied, the alternative with the highest score is Pos Indonesia (A6) with a final score of 0.82506, followed by JNE (A1) with a score of 0.76181, and Tiki (A2) with a score of 0.72127. Based on these values, Pos Indonesia ranks first as the best service provider.

1.INTRODUCING

E-commerce has experienced significant growth, triggered by the development of information technology, increasing internet access, and changing consumer behavior that increasingly relies on the convenience of online shopping[1]. E-commerce platforms allow businesses, both small and large, to reach a wider market without geographical restrictions, as well as provide consumers with easy access to compare products, prices, and services[2]. E-commerce also facilitates a variety of flexible payment methods, efficient shipping, and a customized shopping experience, attracting more and more consumers to switch from traditional shopping to online shopping[3]. Choosing the best delivery service for e-commerce is a crucial step that can affect customer satisfaction and overall business success. In today's digital era, consumers expect fast, secure, and affordable delivery. Therefore, e-commerce owners need to conduct an in-depth evaluation of the various delivery services available, considering various criteria such as delivery time, cost, service range, and customer service quality. This selection process not only aims to find a delivery service that offers the best price, but also to ensure that the product can reach the customer in good condition and on time as promised. The main problem in choosing the best shipping service for e-commerce is often related to several interrelated factors, which

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can affect the customer experience and business sustainability. One of the biggest challenges is ensuring that products reach customers within the promised time. Delays in delivery can lead to customer dissatisfaction and potentially damage a business's reputation. Business owners must balance reasonable shipping costs with quality service, in order to remain competitive in the market.

Choosing the best shipping service for e-commerce is a complex process, where various factors must be considered to reach an optimal decision. A Decision Support System (DSS) can be a very effective tool in helping e-commerce business owners analyze and choose the delivery service that best suits their needs[4]–[6]. The implementation of a decision support system in the selection of delivery services also provides additional advantages in terms of transparency and accountability. By documenting the criteria and weights used in the assessment, e-commerce owners can easily explain their decisions to stakeholders, as well as make easier comparisons between the various options available. Additionally, SPK can assist in addressing the uncertainties and risks associated with shipping, by providing an in-depth analysis of possible outcomes based on historical data and market trends. In this way, the selection of a delivery service is not only an intuitive process, but it is also supported by powerful data analysis, which ultimately improves customer satisfaction and overall success of the e-commerce business.

The Simple Additive Weighting (SAW) method is one of the techniques in multi-criteria decision-making used to evaluate and prioritize alternatives based on a number of relevant criteria[7]–[9]. This method is popular for its simplicity and ease of application. The SAW method has a number of advantages that make it popular in multi-criteria decision-making. One of the main advantages of this method is its simplicity in the calculation process and the interpretation of the results is easy to understand, making it accessible to a wide range of people, including those without a technical background. This method also provides transparency in the assessment, where users can clearly see how each alternative is judged based on specified criteria and weights. The SAW method also has several drawbacks that need to be considered. One of them is the dependence on the weight of the predetermined criteria, if this weight does not reflect the actual importance of the results obtained, it may be inaccurate. In addition, SAW assumes that all criteria are independent, which may not always be the case in practice.

The Criteria Importance Through Intercriteria Correlation (CRITIC) method is an approach used in multi-criteria decision-making to determine the weight of relevant criteria based on available data[10]–[12]. CRITIC integrates information about variability and dependability between criteria to produce more accurate and objective weights. The CRITIC method is an effective tool in determining the weight of criteria in the multi-criteria decision-making process[13]–[15]. With a data-driven approach and considering variability and relationships between criteria, CRITIC helps decision-makers to get more objective and accurate results. This is especially useful in situations where many criteria must be evaluated to choose the best alternative, such as in the selection of a delivery service for e-commerce.

The combination of SAW and CRITIC methods is an effective approach in multi-criteria decision-making. Each method has its own strengths that can complement each other to produce more accurate and objective decisions. The combination of SAW and CRITIC methods provides a powerful approach to multi-criteria decision-making. By leveraging the advantages of each method, users can objectively determine the weight of the criteria and evaluate alternatives in a systematic and transparent way. This approach not only improves the accuracy of decisions but also increases decision-makers' confidence in the results obtained.

This research aims to implement a decision support system that can help e-commerce companies in choosing the best delivery service by using a combination of SAW and CRITIC methods. The system is designed to provide an objective assessment of various delivery services based on specified criteria. By combining the SAW method for alternative ranking and CRITIC for criterion weighting, the study produces accurate and reliable recommendations, so that e-commerce companies can make better decisions in choosing the delivery service that best suits their business needs.

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2.RESEARCH METHOD

A research framework is a structure that organizes and describes how the various elements in research relate to each other. This framework helps researchers design, develop, and execute research in a structured way. A research framework is an important tool that helps researchers plan and carry out research in a systematic and directed way. The research framework carried out is shown in Figure 1.

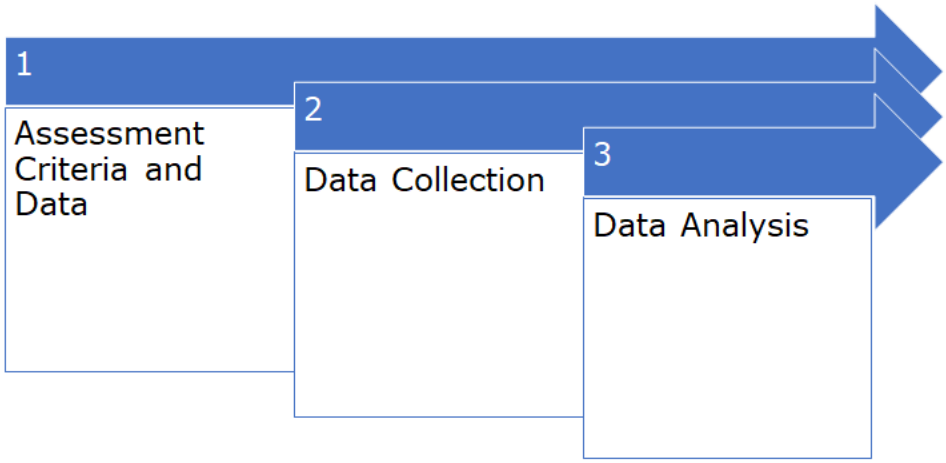

Figure 1. Research Framework

This stage of assessment criteria and data involves determining the criteria that will be used to assess alternatives or research objects. These criteria must be relevant and in accordance with the purpose of the research. In the context of selection, for example, criteria can include aspects such as quality, cost, speed, and customer service. At this stage, researchers also need to identify the data needed to assess these criteria. This data can be qualitative or quantitative and must be measurable or evaluated objectively. The importance of this stage is to ensure that all relevant aspects have been identified and will be evaluated, so that the results of the research are reliable and accurate.

Once the assessment criteria are determined, the next stage is data collection. Data collection can be done by a variety of methods, depending on the type of data needed and the purpose of the research. Commonly used methods include surveys, interviews, observations, and document analysis. In data collection, it is important to ensure that the data collected is valid and trustworthy. This process also involves the selection of a sample, which is a group of respondents or objects that will be used as a data source. Effective data collection is essential to ensure that the information obtained will provide the right and relevant insights for further analysis.

The data analysis stage is the process by which the data that has been collected is analyzed to identify patterns, trends, or relationships between variables. The analysis methods used can vary depending on the type of data and the purpose of the study. Analysis can include statistical calculations, data processing using analysis software, or the application of certain methods of SAW and CRITIC combinations. The results of the data analysis should be presented in a clear manner, using tables, graphs, or other visualizations to help readers understand the findings. Data analysis is a crucial step because this is where researchers can draw conclusions and provide recommendations based on the results of the research.

CRITIC Method

The Criteria Importance Through Intercriteria Correlation (CRITIC) method is a technique used to determine the weight of criteria in multi-criteria decision-making by considering two main aspects, namely data variability and correlation between criteria. This method aims to calculate how important a criterion is based on how much information it contains and the extent to which it is related or unrelated

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to other criteria. The end result of the CRITIC method is an objective and data-driven weight, which can be used in a variety of decision-making methods.

Decision matrices are tabular representations used in multi-criteria decision-making processes. This matrix presents alternatives that are evaluated based on a number of criteria, where each entry in the matrix shows the performance value of an alternative against certain criteria. The decision matrix is created using the following equation.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

The second step in the CRITIC method is to normalize the criteria values so that all criteria have a comparable scale. It is important to ensure that criteria with different scales do not dominate in the calculation process, normalization is calculated using the following equation.

$$d_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

The third step in the CRITIC method is to calculate the standard deviation of each criterion indicating how much variation or spread the data for that criterion. Criteria with greater variation in data are usually considered more important, as they show significant differences between alternatives, the standard deviation of each criterion is calculated using the following equation.

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{n}(d_{ij} - \bar{d}_j)^2}{n}} \quad (3)$$

The fourth step in the CRITIC method is to calculate the correlation between the criteria pairs which shows the extent of the linear relationship between the different criteria, with the correlation value ranging from -1 to 1. A high correlation (both positive and negative) indicates that the two criteria are interrelated, while a low correlation indicates that the two criteria are independent. The correlation value between the criteria pairs is calculated using the following equation.

$$R_{ij} = \frac{\sum_{i=1}^{n}(d_{ij} - \bar{d}_j) * (d_{ij} - \bar{d}_h)}{\sqrt{\sum_{i=1}^{n}(d_{ij} - \bar{d}_j)^2} * \sqrt{\sum_{i=1}^{n}(d_{ij} - \bar{d}_h)^2}} \quad (4)$$

The fifth step in the CRITIC method is to calculate the value of the quantity of information that reflects the variation of the data for each criterion, the value of the quantity of information is calculated using the following equation.

$$C_j = \sigma_j \sum_{j=1}^{n}(1 - R_{ij}) \quad (5)$$

The sixth step in the CRITIC method is to calculate the weight of the criteria based on the variation of the data and the degree of dependence with other criteria. The weight of the criteria is calculated using the following equation.

$$W_j = \frac{C_j}{\sum C_j} \quad (6)$$

The CRITIC method provides a more objective approach in determining the weight of criteria because it considers both variability and correlation between criteria, which ultimately provides a more accurate assessment in the decision-making process.

SAW Method

Simple Additive Weighting (SAW), also known as the weighted addition method, is one of the simplest and most popular methods of multi-criteria decision-making. This method works by summing up the scores resulting from the performance of each alternative on each weighted criterion. The SAW method is perfect for cases where we have multiple alternatives and criteria, and we want to choose the best alternative based on several aspects in a balanced manner.

The first step in SAW is to compile a decision matrix that describes the performance of each alternative against each criterion, made using equation (1). The second step in SAW is to normalize the values in the decision matrix. The goal is to equalize the scale of all criteria, especially if the criteria have different units or scales, calculated using equation (7).

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$$r_{ij}\begin{cases}\frac{x_{ij}}{\max x_{ij}}\ ; jika\ j\ merupakan\ atribut\ benefit\\ \frac{min\ x_{ij}}{x_{ij}}; jika\ j\ merupakan\ atribut\ cost\end{cases} \quad (7)$$

The third step in SAW is to calculate the final score for each alternative calculated by adding the result of the multiplication, calculated using equation (8).

$$V_i = \sum_{j=1}^{n} w_j . r_{ij} \quad (8)$$

The SAW method is very useful in selecting the best alternative in situations with many criteria that can be compared directly, especially if the user needs an intuitive approach.

3.RESULTS AND DISCUSSION

In the era of rapidly evolving e-commerce, choosing the right delivery service is a crucial factor for the success of an online business. Consumers demand speed, reliability, and cost efficiency in the product delivery process, so companies need to consider various aspects before deciding on a logistics partner. DSS based on the SAW and CRITIC methods offers a structured and objective approach in determining the best delivery service. The CRITIC method is used to give weight to relevant criteria, such as cost, speed, and quality of service, based on data variation and correlation between criteria. Once the criteria weights are determined, the SAW method helps calculate the final score of each delivery service alternative to get an optimal ranking. The combination of these two methods can help make more accurate and efficient decisions, as well as improve the user experience in e-commerce.

Data Collection

In the application of DSS to select the best delivery service in e-commerce using the SAW and CRITIC methods, data collection is a very important stage to ensure the accuracy and validity of the decisions taken. The data collected must include the performance of various delivery services based on predetermined criteria, such as delivery costs, delivery speed, service coverage, service quality, and tracking and information systems. Table 1 is the result of data collection carried out.

Table 1. Data Collection

Alternative	Shipping Cost	Shipping Speed	Service Range	Quality of Service	Tracking
A1: JNE	20.000	2	5	4	4
A2: Tiki	18.000	3	4	3	3
A3: GoSend	22.000	1	3	5	5
A4: SiCepat	19.000	2	4	4	3
A5: GrabExpress	23.000	1	2	5	5
A6: Pos Indonesia	15.000	4	5	3	2

The data sources used in the assessment of the 6 delivery service alternatives can come from secondary data from e-commerce related to shipping costs, service coverage, and delivery speed can be taken from the official reports of delivery companies.

CRITIC Method in Determining Criteria Weighting

The CRITIC method is one of the weighting methods used to assess the level of relative importance between criteria with the aim of producing objective criterion weights, especially when data are available and criteria are interrelated.

Decision matrices are tabular representations alternatives that are evaluated based on a number of criteria, where each entry in the matrix shows the performance value of an alternative against certain criteria. The decision matrix is created using equation (1).

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$$X = \begin{bmatrix} 20000 & 2 & 5 & 4 & 4 \\ 18000 & 3 & 4 & 3 & 3 \\ 22000 & 1 & 3 & 5 & 5 \\ 19000 & 2 & 4 & 4 & 3 \\ 23000 & 1 & 2 & 5 & 5 \\ 15000 & 4 & 5 & 3 & 2 \end{bmatrix}$$

The second step in the CRITIC method is to normalize the criteria values so that all criteria have a comparable scale, normalization is calculated using equation (2).

$$d_{11} = \frac{x_{11} - \min x_{11,16}}{\max x_{11,16} - \min x_{11,16}} = \frac{20000-15000}{23000-15000} = \frac{5000}{8000} = 0.625$$

Table 2 is the result of the calculation of the entire matrix normalization that has been carried out and calculated.

Table 2. The Result of the Calculation of the Entire Matrix Normalization

Alternative	Shipping Cost	Shipping Speed	Service Range	Quality of Service	Tracking
A1: JNE	0.625	0.333	1	0.5	0.667
A2: Tiki	0.375	0.667	0.667	0	0.333
A3: GoSend	0.875	0	0.333	1	1
A4: SiCepat	0.5	0.333	0.667	0.5	0.333
A5: GrabExpress	1	0	0	1	1
A6: Pos Indonesia	0	1	1	0	0

The third step in the CRITIC method is to calculate the standard deviation of each criterion is calculated using equation (3).

$$\sigma_1 = \sqrt{\frac{\sum_{i=1}^{n}(d_{11,16} - \bar{d}_{11,16})^2}{6}} = 0.3287$$

$$\sigma_2 = \sqrt{\frac{\sum_{i=1}^{n}(d_{21,26} - \bar{d}_{21,26})^2}{6}} = 0.3557$$

$$\sigma_3 = \sqrt{\frac{\sum_{i=1}^{n}(d_{31,36} - \bar{d}_{31,36})^2}{6}} = 0.3557$$

$$\sigma_4 = \sqrt{\frac{\sum_{i=1}^{n}(d_{41,46} - \bar{d}_{41,46})^2}{6}} = 0.4082$$

$$\sigma_5 = \sqrt{\frac{\sum_{i=1}^{n}(d_{51,56} - \bar{d}_{51,56})^2}{6}} = 0.3685$$

The fourth step in the CRITIC method is to calculate the correlation between the criteria pairs which shows the extent of the linear relationship between the different criteria. The correlation value between the criteria pairs was calculated using equation (4), the result of the correlation calculation between the criteria pairs in Table 3.

Table 3. The Result of the Correlation Between the Criteria Pairs

	Shipping Cost	Shipping Speed	Service Range	Quality of Service	Tracking
Shipping Cost	0	1.9798	1.8017	0.0686	0.0255
Shipping Speed	1.9798	0	0.2439	1.9564	1.9418
Service Range	1.8017	0.2439	0	1.7651	1.7534
Quality of Service	0.0686	1.9564	1.7651	0	0.0768
Tracking	0.0255	1.9418	1.7534	0.0768	0

The fifth step in the CRITIC method is to calculate the value of the quantity of information is calculated using equation (4).

$$C_1 = \sigma_1 \sum_{j=1}^{n}(1 - R_{11,16}) = 1.2741$$

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$C_2 = \sigma_2 \sum_{j=1}^{n}(1 - R_{21,26}) = 2.1777$
$C_3 = \sigma_3 \sum_{j=1}^{n}(1 - R_{31,36}) = 1.9793$
$C_4 = \sigma_4 \sum_{j=1}^{n}(1 - R_{41,46}) = 1.5787$
$C_5 = \sigma_5 \sum_{j=1}^{n}(1 - R_{51,56}) = 1.3994$

The sixth step in the CRITIC method is to calculate the weight of the criteria based on the variation of the data and the degree of dependence with other criteria. The weight of the criteria is calculated using equation (6(.

$$W_1 = \frac{C_1}{\sum C_{1,5}} = \frac{1.2741}{1.2741+2.1777+1.9793+1.5787+1.3994} = \frac{1.2741}{8.4092} = 0.1515$$
$$W_2 = \frac{C_2}{\sum C_{1,5}} = \frac{2.1777}{1.2741+2.1777+1.9793+1.5787+1.3994} = \frac{2.1777}{8.4092} = 0.2590$$
$$W_3 = \frac{C_3}{\sum C_{1,5}} = \frac{1.9793}{1.2741+2.1777+1.9793+1.5787+1.3994} = \frac{1.9793}{8.4092} = 0.2354$$
$$W_4 = \frac{C_4}{\sum C_{1,5}} = \frac{1.5787}{1.2741+2.1777+1.9793+1.5787+1.3994} = \frac{1.5787}{8.4092} = 0.1877$$
$$W_5 = \frac{C_5}{\sum C_{1,5}} = \frac{1.3994}{1.2741+2.1777+1.9793+1.5787+1.3994} = \frac{1.3994}{8.4092} = 0.1664$$

The CRITIC method provides a more objective approach in determining the weight of criteria because it considers both variability and correlation between criteria, which ultimately provides a more accurate assessment in the decision-making process.

Implemention the SAW Method in Choosing the Best Shipping Service for E-Commerce

The Implementation of the SAW Method in Choosing the Best Shipping Service for E-Commerce is one of the multi-criteria decision-making methods used to determine the best alternative based on several criteria. In the context of choosing the best delivery service for e-commerce, the SAW method can help integrate the assessment of different delivery services based on a number of relevant criteria. The first step in SAW is to compile a decision matrix that describes the performance of each alternative against each criterion, made using equation (1).

$$X = \begin{bmatrix} 20000 & 2 & 5 & 4 & 4 \\ 18000 & 3 & 4 & 3 & 3 \\ 22000 & 1 & 3 & 5 & 5 \\ 19000 & 2 & 4 & 4 & 3 \\ 23000 & 1 & 2 & 5 & 5 \\ 15000 & 4 & 5 & 3 & 2 \end{bmatrix}$$

The second step in SAW is to normalize the values in the decision matrix. The goal is to equalize the scale of all criteria, especially if the criteria have different units or scales, calculated using equation (7).

$$r_{11} = \frac{min\ x_{11,16}}{x_{11}} = \frac{15000}{20000} = 0.75$$

Table 3 is the result of the calculation of the entire matrix normalization that has been carried out and calculated.

Table 3. The Result of the Calculation of the Entire Matrix Normalization SAW Method

Alternative	Shipping Cost	Shipping Speed	Service Range	Quality of Service	Tracking
A1: JNE	0.75	0.5	1	0.8	0.8
A2: Tiki	0.833	0.75	0.8	0.6	0.6
A3: GoSend	0.682	0.25	0.6	1	1
A4: SiCepat	0.789	0.5	0.8	0.8	0.6
A5: GrabExpress	0.652	0.25	0.4	1	1
A6: Pos Indonesia	1	1	1	0.6	0.4

The third step in SAW is to calculate the final score for each alternative calculated by adding the result of the multiplication, calculated using equation (8).

$$V_1 = (w_1 * r_{11}) + (w_2 * r_{21}) + (w_3 * r_{31}) + (w_4 * r_{41}) + (w_5 * r_{51})$$
$$V_1 = (0.1515 * 0.75) + (0.2590 * 0.5) + (0.2354 * 1) + (0.1877 * 0.8) + (0.1664 * 0.8)$$

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$V_1 = 0.76181$

Table 4 is the result of the calculation of the final score for each alternative.

Table 4. The Result of the Calculation of the Final Score for each Alternative

Alternative	Final Value
A1: JNE	0.76181
A2: Tiki	0.72127
A3: GoSend	0.66342
A4: SiCepat	0.68743
A5: GrabExpress	0.61185
A6: Pos Indonesia	0.82506

Alternative ranking in the selection of the best shipping service for e-commerce is carried out using the SAW and CRITIC methods. Each alternative is evaluated based on five main criteria: shipping cost, delivery speed, service coverage, service quality, and tracking and information systems. Ranking results

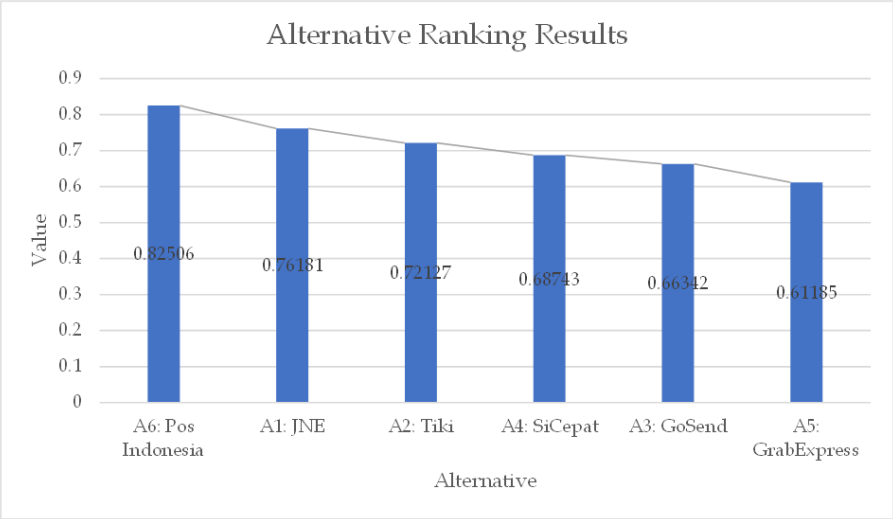

Figure 2. Alternative Ranking Result

Based on the results of the ranking using the method that has been applied, the alternative with the highest score is Pos Indonesia (A6) with a final score of 0.82506, followed by JNE (A1) with a score of 0.76181, and Tiki (A2) with a score of 0.72127. Furthermore, SiCepat (A4) is in fourth place with a value of 0.68743, followed by GoSend (A3) with a value of 0.66342. In last position is GrabExpress (A5) with a value of 0.61185. Based on these values, Pos Indonesia ranks first as the best service provider.

4.CONCLUSION

The combination of SAW and CRITIC methods is an effective approach in multi-criteria decision-making. Each method has its own strengths that can complement each other to produce more accurate and objective decisions. The combination of SAW and CRITIC methods provides a powerful approach to multi-criteria decision-making. By leveraging the advantages of each method, users can objectively determine the weight of the criteria and evaluate alternatives in a systematic and transparent way. This approach not only improves the accuracy of decisions but also increases decision-makers' confidence in the results obtained. Based on the results of the ranking using the method that has been applied, the alternative with the highest score is Pos Indonesia (A6) with a final score of 0.82506, followed by JNE (A1) with a score of 0.76181, and Tiki (A2) with a score of 0.72127. Furthermore, SiCepat (A4) is in fourth place with a value of 0.68743, followed by GoSend (A3) with a value of 0.66342. In last position is GrabExpress (A5) with a value of 0.61185. Based on these values, Pos Indonesia ranks first as the best service provider. Future research may involve case studies on more e-commerce platforms and different

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geographic regions to test the generalizations of the developed models. By overcoming these limitations, the system can provide a more robust and relevant solution in helping e-commerce companies choose the best shipping service globally.

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