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TOPSIS Method In Determining The Best Package Transportation Route

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ABSTRACT

The urgent need for product transportation services during the ongoing pandemic has prompted companies to organize transportation processes effectively to ensure customers are well served. The increase in demand for goods transportation services has been driven by the pandemic, as it has necessitated social distancing and adherence to health protocols. Traditionally, transportation services rely on distance calculation technologies to determine the best route for delivering packages, which may reduce transportation efficiency. One example is the delivery service at J&T Sidamukti drop point by PT Tiki Lintas. This research aims to provide an overview of the steps involved in using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method to determine the optimal transportation route for package delivery. The use of the TOPSIS method in this study aims to improve the efficiency of transportation time by evaluating and comparing different delivery routes based on multiple criteria. Through this approach, the study intends to highlight how optimal decision-making processes can enhance the efficiency of goods transportation in a challenging context like the pandemic. The research also seeks to offer practical solutions that can be applied to similar transportation challenges, thereby contributing to the overall improvement of delivery systems. Ultimately, the findings of this study are expected to provide valuable insights into the application of decision-making models in transportation route planning, particularly in the current context of limited movement and physical distancing.

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1. INTRODUCTION

Development activities in the field of business or education, someone who has an obligation to maintain its existence in society. The first development is known and widely developed in the science and technology-based industry. Development is essentially carried out to meet the needs of society which are increasing and increasingly demanding efficient performance and effective results. Without exception in conducting trade, for the purpose of improving the quality of business processes Entrepreneurs need to influence the quality of business program results so that they will always think about and develop business activities so that the desired goals can be achieved according to the goals[1].

Now shopping with applications or websites with gadgets is popular with the public. In an era that is very advanced quickly, people want things that are easy and practical, namely by initially shopping traditionally, now they can use gadgets[2]. Buying goods online cannot be avoided with transportation and delivery services. Therefore, the transportation service must be faster in delivering items to the customer[3]. There have been several cases that have occurred from J&T, namely the shortcomings in determining the transportation route for the courier. The reason is the lack of explanation about decision making, which results in waste of transportation rates. The route is the direction of the road or path taken by public transportation to reach a destination from the initial trip[4]. Determining this route is more important for transportation services[5], [6], [7]. This is because transportation efficiency can be determined by determining the transportation route.

Transportation of goods is all carried out individually or in groups by a party that will provide assistance in the form of transporting products from between cities to between countries, through the interests of accuracy and speed. In choosing the direction or route for transporting superior products, procedures are needed that are obtained in transporting products efficiently.

A computer-based information system, including knowledge-based systems, that support decision-making in a business or organisation is called a Decision Support System (DSS)[8], [9], [10], [11]. Another way to describe DSS is as a computer system that converts data into information for use in decision-making for particular semi-structured situations[12], [13], [14]. The TOPSIS method measures performance in terms of choice alternatives using straightforward mathematics and has an easy-to-understand notion. For the aforementioned reasons, the TOPSIS technique is supposed to make more objective selections, ensuring that the chosen transportation service partner aligns with business requirements and can mitigate current issues. The best option is selected based on both the greatest gap from the negative ideal solution and the shortest distance from the positive ideal solution, according to the technology for the priority ordering approach is comparable to the ideal solution (TOPSIS) itself[15], [16]. Choosing the best package transportation, choosing notebooks, choosing speakers who are performing, and choosing exceptional pupils are just a few of the decisions that are made using the TOPSIS technique. As a result, the TOPSIS technique offers solutions from a variety of options, selecting the optimal one for the given situation. This approach compares things based on distance[17], [18].

The optimization of transportation routes is a critical concern for companies in the logistics and delivery sector, particularly in the context of increasing demand for timely and efficient package delivery. In recent years, advancements in technology, including Geographic Information Systems (GIS) and routing algorithms, have facilitated improvements in transportation planning[19][20], [21]. However, despite these advancements, issues related to transportation efficiency, especially during global disruptions such as the COVID-19 pandemic, remain a challenge. The pandemic has significantly altered transportation dynamics, increasing the need for flexible and efficient routing systems that adhere to health protocols, such as social distancing and contactless deliveries.

While various optimization methods have been proposed in the literature to enhance route planning, the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method has not been extensively applied in the context of package transportation during periods of crisis. Existing studies often focus on traditional methods such as shortest path algorithms (Dijkstra, A*) or more sophisticated machine learning techniques[22], but they lack a comprehensive evaluation of the flexibility and adaptability of the TOPSIS method for real-time decision-making in logistics[4]. Moreover, research examining the integration of social distancing protocols and the optimization of delivery routes remains scarce[23]. This research aims to bridge this gap by exploring how the TOPSIS method can optimize transportation routes in a pandemic scenario, offering a systematic approach to improve operational efficiency under constraints such as limited physical interaction and health protocols.

2. RESEARCH METHOD

The "Technique for Order Preference by Similarity to Ideal Solution" (or TOPSIS) is a technique for choosing the best option among several options based on specific standards. Yoon and Hwang first presented the TOPSIS method, one of the multicriteria decision-making techniques, in 1981[24], [25]. TOPSIS is able to identify the solution that best meets the specified requirements. Furthermore, the relative weight of each criterion that is thought to be significant in the decision-making process can be integrated using this method. Researchers working on decision support system design are interested in this approach because of its straightforward yet powerful concept for solving challenging issues[26]. The optimal option is chosen by TOPSIS according to how far away it is from the negative ideal solution and how near it is to the positive ideal solution. This approach is solved by sorting the alternatives by rank and choosing the one with the least distance from the positive ideal solution and the largest distance from the negative ideal solution. TOPSIS is a decision-making technique that ranks options according to how close they are to the optimal option[27], [28]. The chosen option is the one that is both the closest to the positive ideal solution and the farthest from the negative ideal solution[29]. A negative ideal solution is one that minimises profit and maximises costs, whereas a positive ideal solution is one that maximises the profit attribute and minimises the cost attribute. The following are the stages in the TOPSIS method, namely.

1. First determine the criteria that will be used as a benchmark for solving the problem. Criteria are attributes of an object or solution that will be assessed after being classified according to needs.
2. Determine the normalized decision matrix
3. Determine the weighted normalized decision matrix.
4. Determine the positive ideal solution matrix and the negative ideal solution matrix
5. Calculate the distance or distance of the weighted value of each alternative to the positive negative ideal solution.
6. Calculate the preference value of each alternative.
7. Perform ranking.

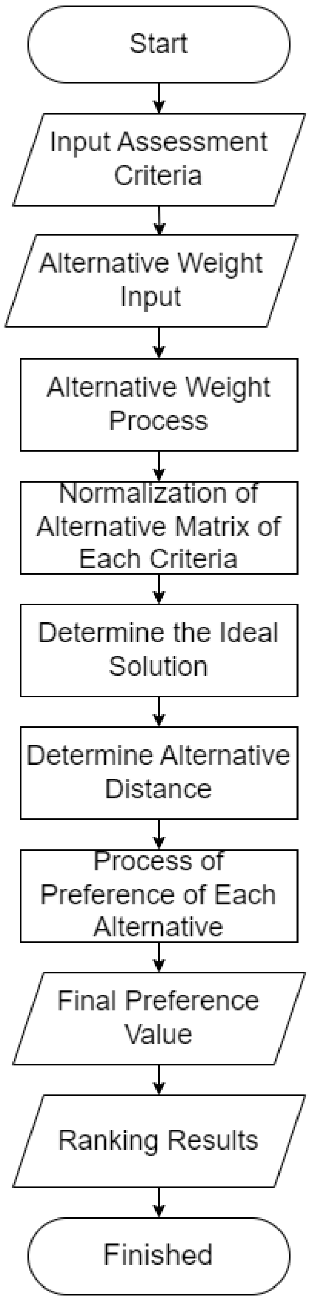

Figure 1. TOPSIS Flowchart

The TOPSIS method includes several procedures as follows [19].

a) Formula for Calculating Normalization.
b)

$$R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

c) Calculate the weighted normalization value.

$$y_{ij} = w_i r_{ij} \tag{2}$$

d) Determining the positive ideal solution matrix and the negative ideal solution matrix. Positive ideal solution (A+) is calculated based on:

$$A^+ = (y1^+, y2^+, y3^+, \dots\ , yn^+)$$

Negative ideal solution (A-) is calculated based on:

$$A^- = (y1^-, y2^-, y3^-, \dots\ , yn^-)$$

e) Determining the distance between the value of each alternative with the positive ideal solution matrix and the negative ideal matrix.
The distance between alternative Ai and the positive ideal solution is formulated as:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_i^+\right)^2},\ i=1,2,3,\ \dots\ m \quad (3)$$

The distance between alternative Ai and the negative ideal solution is formulated as:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_i^-\right)^2},\ i=1,2,3,\ \dots\ m \quad (4)$$

f) Determining the preference value for each alternative.
The closeness of each alternative to the ideal solution is calculated based on the formula.

3. RESULTS AND DISCUSSION

During package transportation, the Freight Service must: identify the direction of transportation quickly and practically without adding to the transportation rate by using the TOPSIS method. To find out the direction or the most superior transportation route, there are 3 alternative locations for the transportation route, namely:

A1 = Sutomo
A2 = Iskandar Muda
A3 = Pelita

There are 5 criteria that are used as a reference in decision making, namely:

C1 = Distance of Product Recipient
C2 = Travel Limitation (Damaged/Good)
C3 = Travel Duration
C4 = Type of Transportation (Regular/Trucking)
C5 = Travel Distance

The level of importance of each criterion is also assessed from 1 to 5, presented in table 1 and table 2.

Table 1. Criteria Names and Weights

Criteria Name	Criteria Weight
Distance of Product Recipient	5
Travel Limitation (Damaged/Good)	3
Travel Duration	2
Type of Transportation (Regular/Trucking)	5
Travel Distance	3

Table 2. Alternative Assessment Based on Criteria

Alternative	Criteria				
	C1	C2	C3	C4	C5
A1	4	3	3	4	3
A2	4	4	3	5	3
A3	5	3	4	4	4

1. Calculate the Normalization value and weighted normalization value using the formula:

$r11 = \frac{4}{\sqrt{4^2+4^2+5^2}}$ = 0,5298
$r21 = \frac{4}{\sqrt{4^2+4^2+5^2}}$ = 0,5298
$r31 = \frac{5}{\sqrt{4^2+4^2+5^2}}$ = 0,6622
$r12 = \frac{3}{\sqrt{3^2+4^2+3^2}}$ = 0,5145
$r22 = \frac{4}{\sqrt{4^2+4^2+5^2}}$ = 0,6860
$r32 = \frac{3}{\sqrt{3^2+4^2+3^2}}$ = 0,5145
$r13 = \frac{3}{\sqrt{3^2+3^2+4^2}}$ = 0,5145
$r23 = \frac{3}{\sqrt{3^2+3^2+4^2}}$ = 0,5145
$r33 = \frac{4}{\sqrt{3^2+3^2+4^2}}$ = 0,6860
$r14 = \frac{4}{\sqrt{4^2+5^2+4^2}}$ = 0,5298
$r24 = \frac{5}{\sqrt{4^2+5^2+4^2}}$ = 0,6622
$r34 = \frac{4}{\sqrt{4^2+5^2+4^2}}$ = 0,5298
$r15 = \frac{3}{\sqrt{3^2+3^2+4^2}}$ = 0,5145
$r25 = \frac{3}{\sqrt{3^2+3^2+4^2}}$ = 0,5145
$r35 = \frac{4}{\sqrt{3^2+3^2+4^2}}$ = 0,6860

R=

$$\begin{bmatrix} 0,5298 \quad 0,5145 \quad 0,5145 \quad 0,5298 \quad 0,5145 \quad 0,5298 \quad 0,6860 \quad 0,5145 \quad 0,6622 \quad 0,5145 \\ 0,6622 \quad 0,5145 \quad 0,6860 \quad 0,5298 \quad 0,6860 \end{bmatrix}$$

W=(5,4,2,4,4)

2. Determine using formula 4 to find out the positive ideal solution matrix and the negative ideal solution matrix.

Y11 = 5 x 0,5298 = 2,649
Y21 = 5 x 0,5298 = 2,649
Y31 = 5 x 0,6622 = 3,311
Y13 = 2 x 0,5145 =1,029
Y23 = 2 x 0,5145 =1,029
Y33 = 2 x 0,6860 =1,372
Y15 = 4 x 0,5145 = 2,058
Y25 = 4 x 0,5145 = 2,058
Y12 = 4 x 0,5145 = 2,058
Y22 = 4 x 0,6860 = 2,744
Y32 = 4 x 0,5145 = 2,058
Y14 = 4 x 0,5298 = 2,119
Y24 = 4 x 0,6622 = 2,648
Y34 = 4 x 0,5298 = 2,119
Y35 = 4 x 0,6860 = 2,744

Y=[2,649 2,058 1,029 2,119 2,058 2,649 2,744 1,029 2,648 2,058 3,311 2,508 1,372 2,119 2,744]

y_1^+ = max*2,649; 2,649; 3,311+ = 3,311
y_2^+ = max*2,058; 2,744; 2,508+ = 2,744
y_3^+ = max*1,029; 1,029; 1,372+ = 1,372
y_4^+ = max*2,119; 2,648; 2,119+ = 2,648
y_5^+ = max*2,058; 2,058; 2,744+ = 2,744

A^+ = *3,311; 2,744; 1,372; 2,648; 2,744+

y_1^- = max*2,649; 2,649; 3,311+ = 2,649
y_2^- = max*2,058; 2,744; 2,508+ = 2,058
y_3^- = max*1,029; 1,029; 1,372+ = 1,029
y_4^- = max*2,119; 2,648; 2,119+ = 2,119
y_5^- = max*2,058; 2,058; 2,744+ = 2,058

A^{-} = *2,648; 2,058; 1,029; 2,119; 2,058+

3. Determine using formula 3 and formula 4 to find out the distance between the value of each alternative and the positive ideal solution matrix and the negative ideal solution matrix.

$D_1 = \sqrt{(3{,}311 - 2{,}649)2 + (2{,}744 - 2{,}058)^2 + (1{,}372 - 1{,}029)^2 + (2{,}648 - 2{,}119)^2 + (2{,}744 - 2{,}058)^2} = 1{,}3330$

$D_2 = \sqrt{(3{,}311 - 2{,}649)2 + (2{,}744 - 2{,}744)^2 + (1{,}372 - 1{,}029)^2 + (2{,}648 - 2{,}648)^2 + (2{,}744 - 2{,}058)^2} = 1{,}0131$

$D_3 = \sqrt{(3{,}311 - 3{,}311)2 + (2{,}744 - 2{,}058)^2 + (1{,}372 - 1{,}372)^2 + (2{,}648 - 2{,}648)^2 + (2{,}744 - 2{,}744)^2} = 0{,}8662$

$D_1^- = \sqrt{(2{,}649 - 2{,}649)2 + (2{,}058 - 2{,}058)^2 + (1{,}029 - 1{,}029)^2 + (2{,}119 - 2{,}119)^2 + (2{,}058 - 2{,}058)^2} = 0$

$D_2^- = \sqrt{(2{,}649 - 2{,}649)2 + (2{,}744 - 2{,}058)^2 + (1{,}029 - 1{,}029)^2 + (2{,}648 - 2{,}119)^2 + (2{,}058 - 2{,}058)^2} = 0{,}4367$

$D_3^- = \sqrt{(3{,}311 - 2{,}649)2 + (2{,}058 - 2{,}058)^2 + (1{,}372 - 1{,}029)^2 + (2{,}119 - 2{,}119)^2 + (2{,}744 - 2{,}058)^2} = 1{,}0131$

a. Determine using formula 5 to find out the preference value for each alternative.

$V_1 = \frac{0}{0+1{,}3330} = 0$

$V_2 = \frac{0{,}4367}{0{,}4367+1{,}3330} = 0{,}3012$

$V_1 = \frac{1{,}0131}{1{,}0131+0{,}8662} = 0{,}5390$

Y+ = [3.311, 2.744, 1.372, 2.648, 2.744]
Y− = [2.648, 2.058, 1.029, 2.119, 2.058]

Calculation of Distance to Ideal SolutionsUsing the Euclidean distance formula, the distance between each alternative and the positive and negative ideal solutions was calculated. The following distances were determined:

D1 (Sutomo to Y+) = 1.3330, D1− (Sutomo to Y−) = 0

D2 (Iskandar Muda to Y+) = 1.0131, D2− (Iskandar Muda to Y−) = 0.4367

D3 (Pelita to Y+) = 0.8662, D3− (Pelita to Y−) = 1.0131

The results show that the alternative A3 (Pelita) has the highest preference value (V3 = 0.5390), making it the best choice for the transportation route. This indicates that Pelita satisfies the criteria better than the other alternatives, despite the fact that Sutomo and Iskandar Muda were evaluated on several important factors like travel distance, limitations, and type of transportation. However, Pelita's optimal combination of these factors led to its selection as the best route.

This method allows Freight Services to make efficient and objective decisions regarding route selection, reducing unnecessary transportation time and costs while maintaining the required service quality. By utilizing the TOPSIS method, decision-makers are provided with a systematic and quantitative approach to evaluating transportation alternatives, which is especially beneficial in real-time logistical operations under conditions like those created by the pandemic.

The findings of this study also suggest that the TOPSIS method can be effectively applied in logistics, particularly in dynamic environments where multiple conflicting criteria need to be balanced. This research contributes to the existing body of literature by demonstrating the practical application of TOPSIS for transportation route optimization in real-world settings, especially under challenging circumstances.

4. CONCLUSION

This study successfully demonstrated the application of the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method in determining the best package transportation route for Freight Services during a challenging logistical environment, such as the one presented by the ongoing pandemic. By evaluating three alternative transportation routes—Sutomo (A1), Iskandar Muda (A2), and Pelita (A3)—against five critical criteria (Distance of Product Recipient, Travel Limitation, Travel Duration, Type of Transportation, and Travel Distance), the study provided a clear methodology for selecting the most efficient and cost-effective route.

The results show that Pelita (A3) was identified as the optimal transportation route, achieving the highest preference value (V3 = 0.5390). This route was considered superior due to its favorable balance of factors, including travel distance, type of transportation, and duration, which were critical in ensuring efficient package delivery. The use of the TOPSIS method proved to be an effective tool for handling multiple, conflicting criteria, helping decision-makers make informed and systematic choices based on real-time logistical data.

In conclusion, the application of the TOPSIS method in package transportation route optimization provides significant benefits for Freight Services, especially in a dynamic environment where quick decision-making is essential. The approach not only helps in improving operational efficiency but also supports the management of transportation costs while maintaining high service standards. Future research could explore the integration of additional criteria, such as traffic conditions or real-time disruptions, to further enhance the adaptability of the model in different logistical contexts.

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