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ANALYSIS OF THE SELECTION OF SHOE RAW MATERIAL SUPPLIERS BY FUZZY TOPSIS METHOD

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Abstract

This study is intended to determine the best alternative suppliers to meet the needs of the main raw material for shoe production. Decision making is done by considering the selected criteria based on company needs. The next step is the process of weighting the criteria using the fuzzy method. After that, processing is carried out using the TOPSIS method to determine the best alternative. This research study was conducted at MSME shoe craftsmen in Banyuresmi sub-district of Garut, West Java, Indonesia. As a result, we obtain the best alternative that has the closest distance to the positive ideal solution, and the farthest from the negative ideal solution. These results are gained by considering seven criteria, namely material price, delivery cost, material quality, delivery speed, distance, availability and flexibility. Performance metrics are made as recommendations in determining strategy if the company is not ready to use the services of a single supplier. Despite the fact, decision making utilizing fuzzy method is considered effective in selecting the best alternative.

Keywords: Fuzzy Logic, Fuzzy TOPSIS, Multi criteria decision making, Supply chain management, Supplier Selection, TOPSIS.

1. Introduction

Supplier selection is a decision selection activity in evaluating supplier performance based on several criteria in order to obtain raw materials from the best sources [1]. Supplier selection is a process that includes multi-criteria decision making, where there are many methods that can be used to make decisions based on many criteria. One of the possible methods is the fuzzy TOPSIS method. TOPSIS is a multi-criteria decision-making method with the concept that the best alternative must have the closest geometric distance to the positive ideal solution and the farthest geometric distance to the negative ideal solution, where the positive ideal solution is the best value taken from each criterion [2]. One of the reasons for using fuzzy is because decision makers tend to be more comfortable in providing qualitative assessment [3]. In addition, modeling using fuzzy numbers has been verified as an effective way of formulating problems where the information available in the field is unclear and tends to subjective [4].

Following are some of the previous studies that applied the fuzzy TOPSIS method as a tool for decision making: Supplier selection and order allocation with green criteria: An MCDM and multi objective optimization approach [5]; Sustainable supplier selection: A multicriteria intuitionistic fuzzy TOPSIS method [6]; Supplier selection among SMEs on the basis of their green innovation ability using BWM and fuzzy TOPSIS [7]; Implementation of the Fuzzy TOPSIS Method in the Application of Priority Scale Determination for Improving the Quality of Halfway House Services at UIN Maulana Malik Ibrahim Malang, Indonesia [8]. However, these studies seem to be missing the discussion of using such a multi-criteria decision-making using a smart machine like fuzzy method in a high number of demand due to a variety of causes; one of which is as the effect of hiring influencers to boost up the marketing. As a matter of fact, hiring an influencer, particularly Instagram influencers, is even considered more effective rather than consulting with a marketing firm, either within the scope of low-end business or even luxury brands [9]. Such kind of marketing strategy has been implemented in fashion industry [10], automotive [11], and even food and beverages [12].

This research study focuses on the managerial aspects carried out at an SME namely Sepatukamu. Since companies use influencer services as a marketing tool, there has been a significant increase in demand. This spike in demand raises the risk of automatic order rejection by the e-commerce system, if the order is not sent within a predetermined time. Things that often become obstacles to the production process are raw materials whose availability is uncertain and of inconsistent quality. To minimize this risk, reliable suppliers of raw materials are needed. Based on these problems, this research was carried out using the fuzzy TOPSIS method to determine the best supplier that is able to meet the needs of raw materials for shoes at Sepatukamu.

2. Methods

The research method used is fuzzy TOPSIS. The first step is to determine criteria and alternatives based on company needs, then data processing is done using the fuzzy TOPSIS method.

In Fig. 1, it can be seen that the data processing process begins with weighting the criteria and determining alternatives, after which a fuzzy decision matrix is made based on the fuzzy membership value. Then, the matrix is normalized and multiplied by the weight of each criterion, after which the value of the positive ideal solution and the negative ideal solution are determined to become a reference in determining the best alternative. In short, the whole processes are the keys to the data processing steps as all of them are intertwined. Consequently, expected results will not be able to be obtained if one of the steps is missing.

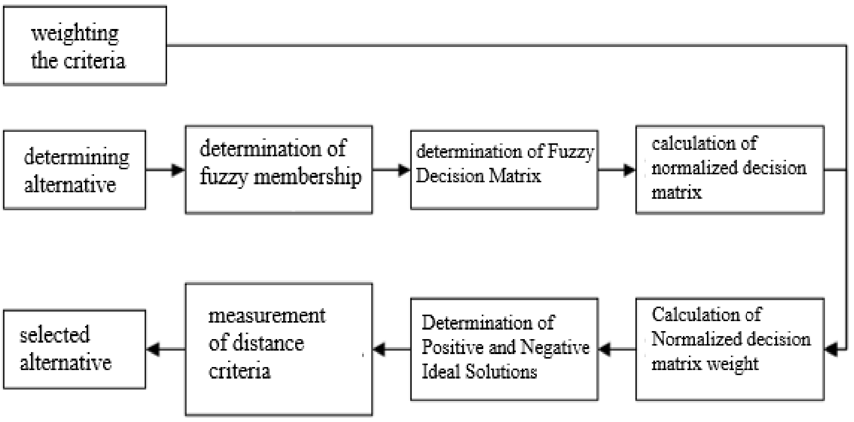

Fig. 1. Data processing steps.

3. Results and Discussion

3.1. Linguistic variable scale

The scale of the linguistic variables used can be seen in Table 1 [13]. The scale of the linguistic variables in Table 1 is used for weighting the criteria and scoring the criteria for each alternative which will later be converted into TFN (Triangular Fuzzy Number).

Table 1. Linguistic variable scale.

Linguistic Variable Scale (Criteria weight)	Linguistic Variable Scale (Criteria weighting for each alternative)
STP (Very Not Important)	SR (Very Low)
TP (Not Important)	R (Low)
CP (Quite Important)	C (Moderate)
P (Important)	T (High)
SP (Very Important)	ST (Very High)

3.2. Triangular fuzzy number

The TFN values for weighting criteria and alternative assessments are presented in Table 2.

TFN or Triangular Fuzzy Number is three numbers (l, m and u) which are represented by overlapping triangles belonging to the set $\tilde{A}$. The three numbers are used to represent the linguistic variables used for judgment by decision makers.

Table 2. TFN weighting criteria.

Linguistic Variable Scale (Weighting Criteria)	Linguistic Variable Scale (Assessment criteria for each alternative)	TFN (*Triangular Fuzzy Number*)		
STP (Very Not Important)	SR (Very Low)	0.01	0.01	0.25
TP (Not Important)	R (Low)	0.01	0.25	0.50
CP (Quite Important)	C (Moderate)	0.25	0.50	0.75
P (Important)	T (High)	0.50	0.75	1.00
SP (Very Important)	ST (Very High)	0.75	1.00	1.00

3.3. Criteria

The considered criteria are presented in Table 3.

Table 3. Supplier selection criteria.

Criteria	Alias
Material price [14]	Price of product, unit product price
Delivery cost [14]	Transportation cost
Material Quality [14]	Quality of product
Delivery speed [14, 15]	Delivery speed, speed
Distance [15, 16]	Distance, geographical location, supplier proximity
Availability [17]	Availability of goods
Flexibility [14, 15]	Flexibility, mixed flexibility

Determination of the criteria used in decision making is based on the results of literature studies in previous research, then a selection is made by the decision maker to determine what criteria are in accordance with the needs and conditions of the company.

3.4. Criteria weight

The weight of every criterium are presented in Table 4.

Table 4. Criteria weight.

Criteria	Weight		
K1	0.625	0.875	1.000
K2	0.375	0.625	0.875
K3	0.625	0.875	1.000
K4	0.500	0.750	0.875
K5	0.375	0.625	0.875
K6	0.625	0.875	1.000
K7	0.250	0.500	0.750

3.5. Scoring of CCi (Closeness Coefficient)

Scoring of CCi are presented in Table 5.

Table 5. Results of CCi calculation.

	CCi
S1	0.5718
S2	0.4370
S3	0.4510
S4	0.5524
S5	0.4670

In the table above, it can be seen that alternative 1 (S1) has the highest value, which means that it has the closest distance to the positive ideal solution and the farthest distance from the negative ideal solution. Based on the TOPSIS method approach, it can be concluded that alternative 1 (S1) is the best alternative.

3.6. Sensitivity analysis

There is no agreement on how to determine the method of sensitivity analysis. Sensitivity analysis itself can be interpreted as an analysis of the behavior of the decision making system when small changes in preferences may occur [18]. The sensitivity analysis was performed by changing the weights of the most influential criteria [19]. The results of the sensitivity analysis are presented in Fig. 2.

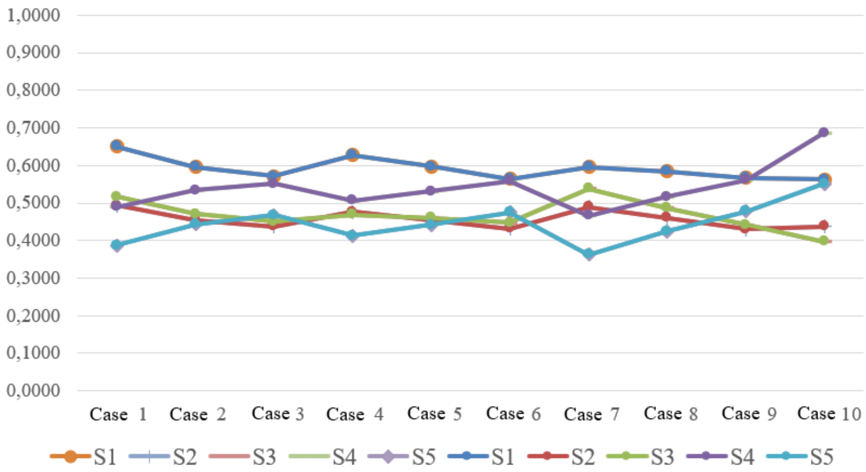

Fig. 2. Sensitivity analysis results.

In this sensitivity analysis, scenarios 1 to 9 vary the weights of the three criteria with the highest weight changed to very not important (STP), quite important (CP) and very important (SP) to test the stability of the results of decision making. The result, from the weight changes made in scenarios 1 to 9, alternative 1 (S1) remains the best alternative. Whereas for scenario 10 the weight changes are made on the three criteria for the cost to be very not important (STP), the result is that alternative 1 (S1) drops to the second rank which proves that there are variations in the results if the changes made are very extreme. This proves that the results of this decision-making method are stable and unbiased.

3.7. Performance metrics

Performance metrics is an approach in supplier evaluation based on two fuzzy TOPSIS models to categorize each alternative based on two categories of criteria, namely cost and benefit. This is done with the aim of getting an idea of how each alternative is performing and knowing what factors should be improved from each alternative [16].

Performance metrics are created to measure the performance of each alternative by classifying each alternative into four different groups. This needs to be done as a reference for decision making, if the company is not ready to use the services of a single supplier that has been selected based on the calculation of the fuzzy TOPSIS method that has been carried out.

Based on the results presented in Fig. 3, it can be seen that alternative 1 (S1), alternative 4 (S4) and alternative 5 (S5) fall into group 1, which means that these three alternatives meet company satisfaction on both dimensions, both performance and cost dimensions. Alternative 2 (S2) and alternative 3 (S3) are included in group 3, suppliers that are included in this group offer relatively low costs, but require improvements in performance dimensions. To improve the performance of these two alternatives, customers and suppliers can do the following things [16] identifying important criteria for improvement; investigating the processes affecting these criteria; and developing a program for improvement by improving the processes that affect these criteria.

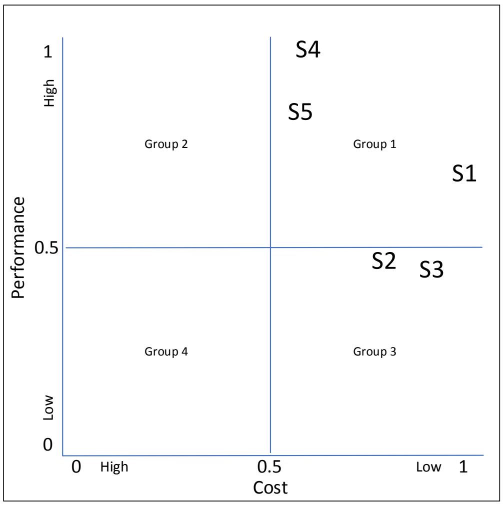

Fig. 3. Performance metrics.

4. Conclusion

This study uses the fuzzy TOPSIS method to determine the best supplier to be the only sole supplier for an SME namely Sepatukamu. The fuzzy TOPSIS method is used because of its effectiveness in dealing with problems with unclear or incomplete information such as information obtained by MSMEs with low managerial abilities. In addition, the TOPSIS fuzzy method makes it easier for inexperienced decision makers to give judgments, because people tend to be more comfortable giving assessments in a linguistic form. Based on the results of literature studies and considerations of decision makers, the criteria that must be considered in selecting the supplier at MSME Sepatukamu are 1) Material price; 2) Shipping costs; 3) Material quality; 4) Delivery speed; 5) Distance, 6) Availability; and 7) Flexibility. From the seven criteria that were considered, alternative 1 (S1) was chosen as the best alternative based on data processing using the fuzzy TOPSIS method because it has the closest distance from the positive ideal solution and the furthest distance from the negative ideal solution.

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