Supplier Selection by Using Analytical Hierarchy Process (AHP) and Techniques for Order Preference Methods with Similarities to Ideal Solutions (TOPSIS)

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Abstract. One company that is engaged in drying coffee beans has problems, the problem is suppliers have not been able to meet the criteria set by the company. Within the last six months, there were coffee bean sacks that the company rejected because of the mismatch of the quality of the coffee beans obtained from suppliers with the standards set by the company so that the selection of suppliers that could meet the criteria of the company was needed. The criteria used by the company are quality, price, quantity, delivery time and response to claims. This study aims to determine the best suppliers based on criteria weights and to rank each alternative supplier. The method used by researchers for this problem is the method of Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). This method is used to determine supplier priorities. Determination of criteria and subcriteria is built based on expert answers using a questionnaire. Assessment of the importance of criteria and alternative weights based on the AHP questionnaire. The results obtained using this method indicate that the supplier who gets the first and deserves priority is PT ABC with the highest preference value of 0.8639.

1. Introduction

Along with the current development of the industry, the industry is required to compete. In facing the competition, the industry must optimize every activity carried out, starting from the procurement of raw materials, production processes to finished goods. The thing to note is, of course, the procurement of raw materials from suppliers that will be used in the production process. Exceptional supplier performance requires extensive communication and collaboration between buyers and vendors over a period of time. The frequent replacement of suppliers to get cheaper prices will not provide the best results for a long period of time [1]. To solve these problems, the researcher will use Multi-Attribute Decision Making (MADM). The MADM method used in this study was AHP and TOPSIS. The Analytic Hierarchy Process (AHP) is a basic approach to decision making introduced by Thomas L. Saaty in 1980. The purpose of AHP is to assist in organizing thoughts and judgments to obtain more effective decisions. AHP can direct how to determine the priority of a series of alternatives and the relative importance of attributes in a Multi-Criteria Decision Making (MCDM) problem [2]. The TOPSIS method is one of the best gradation methods in MADM that takes the role of group parts from the compensation decision-making model [3]. TOPSIS is based on the concept that the best-chosen alternative not only has the shortest distance from a positive ideal solution but also has the longest
distance from a negative ideal solution. This concept is widely used in several MADM models to solve
decision problems in a practical manner [4].

This method is widely used in research, one of which is research conducted by Rani Irma Handayani
(2017) regarding the Selection of Building Raw Material Suppliers using the Analytical Hierarchy
Process (AHP) Method. A supplier is the most important supplier of construction services. Since the
number of suppliers, the difficulty company is choosing suppliers with their respective advantages.
Therefore, use AHP (Analytical Hierarchy Process) for supplier selection process to make it more
objective. Broadly speaking, AHP (Analytical Hierarchy Process) is the process of comparing criteria
into alternatives, the value is generated, then the play is well to the supplier selected. By using the AHP
method the final value for each alternative was obtained by 39% Lead A, Supplier B 12% and Supplier
C 49% [5]. In addition, Lidya Merry, Meriastuti Ginting, Budi Marpaung (2013) conducted research
with the title of Selection of Fruit Suppliers using Analytical Hierarchy Process (AHP) and TOPSIS:
Case Study of Retail Companies. This study aims to determine the best suppliers by selecting suppliers
based on appropriate criteria and subcriteria. This research was conducted at PT Hero Supermarket, Tbk
by taking the fruit department object. AHP Analytical Hierarchy Process (AHP) method produces
shipping criteria (0.230), quality (0.168), service (0.154), company profile (0.138), price (0.130),
document completeness (0.106) and risk (0.074), while ranking Technique Order Preference is used by
Similarity to Ideal Solution (TOPSIS) with alternative A results, alternative C, alternative D, alternative
B [6].

2. Methodology
The research was conducted at a factory that is engaged in the field of drying coffee beans. The object
of research is the four suppliers in this factory, namely PT. ABC, PT. DEF, PT. MNO, PT. XYZ and
respondents who are sources of information about data requirements in this study are Purchasing
Managers, Quality Managers, Sustainability Managers, Accounting & Finance Managers. The research
was conducted from April to October 2014. The type of research design used was descriptive research
(descriptive research). This is because this research was conducted to describe systematically, factually
and accurately about the facts and characteristics of an object or a particular population [7]. Problem
solving is done by distributing to respondents. Data from the questionnaire were processed using AHP.
AHP processing results will be used as input data for the TOPSIS method. Supplier ranking will be
determined by the closest distance of the alternative value with the positive ideal solution and the farthest
distance of the alternative value from the ideal negative solution.

2.1. Data Processing Steps
The data processing stage that is carried out is:
a. Calculate the criteria weight using AHP
b. Determining supplier rankings is based on ideal positive and negative solutions with the TOPSIS
   method.

3. Result and Discussion
3.1. Calculating Weight Criteria
There are five criteria used in this study. These criteria are taken based on Dickson's theory. The five
criteria are:
K1  = quality
K2  = price
K3  = delivery time
K4  = quantity
K5  = response to claims
The above criteria are included in the questionnaire that will be used to evaluate suppliers. As for there
are four suppliers that are alternatives in the company are:
S1  = PT ABC
S2  = PT DEF
S3  = PT MNO
S4  = PT XYZ
The priority weight at level 3 is obtained from the multiplication between the weight of level 2 and the weight of level 3. The results of the calculation of priority level 3 weights can be seen in Table 1.

| Level 3 Priority Weights Total Weights |
|----------------------------------------|
| S1          | 0,0943 | 0,0376 | 0,0103 | 0,0228 | 0,0017 | 0,1559 |
| S2          | 0,173  | 0,0933 | 0,0163 | 0,0696 | 0,0053 | 0,367  |
| S3          | 0,1763 | 0,0647 | 0,038  | 0,0772 | 0,0058 | 0,3598 |
| S4          | 0,0554 | 0,0225 | 0,0095 | 0,0253 | 0,0019 | 0,1174 |

Based on the table above, level 2 priority weights are obtained by summing the priority weights of each alternative for each criterion. The results of the calculation of level 3 priority weights can be seen in Table 2.

| Level 2 Priority Weights |
|--------------------------|
| Elements                |
| Priority Weights         |
| K1          | 0,4990 |
| K2          | 0,2181 |
| K3          | 0,0741 |
| K4          | 0,1949 |
| K5          | 0,0147 |

3.2. Determining Supplier Ranking

Determining supplier ranking will be calculated using the TOPSIS method. The TOPSIS method is used to obtain preference values for each supplier alternative that will determine the priority of the supplier. The basic principle of this method is to choose the alternative with the shortest distance from the positive ideal solution and the farthest solution from the negative solution in the geometric sense. The TOPSIS method assumes that each attribute has a monotonous increase or reduced utility. This method makes it easy to find ideal positive solutions and negative ideal solutions [4]. The steps of the TOPSIS method are as follows:

a. Calculating the Normalization of the Decision Matrix

A decision matrix from alternative m and n criteria is formulated before, then the normalization matrix \( r_{ij} \) can be calculated as a method:

\[
 r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{m} f_{ij}^2}}
\]

Where \( f_{ij} \) is the i value of the criteria for alternative \( A_j \) (j = 1, ..., m; i = 1 ..., n)

b. Calculates the normalized weighted decision matrix

Weighted normalization can be calculated in the following way:

\[
 v_{ij} = w_i \cdot r_{ij}
\]

Where, \( w_i \) is the weight of i criteria or attributes

c. Determine positive ideal solutions and negative ideal solutions

For the profit criteria, the decision maker wants the maximum value of all alternatives and for the criteria of the decision maker to want the minimum value of all alternatives. Then, positive ideal solutions and negative ideal solutions can be seen as follows:

\[
 A^+ = \{V_i^+| V_n^+\} = \{(\max_j r_{ij}|i \in \Gamma), (\min_j r_{ij}|i \in \Gamma')\}
\]

\[
 A^- = \{V_i^-| V_n^-\} = \{(\min_j r_{ij}|i \in \Gamma), (\max_j r_{ij}|i \in \Gamma')\}
\]

d. Calculating Distance Between Alternative Values with Positive and Negative Ideal Solution Matrix

With n-dimensions of euclidean distance, the distance of each alternative from a positive ideal solution can be calculated using the following formula:
\[ D_{j^+} = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_{ij^*})^2} \]

While the distance from the negative ideal solution can be calculated using the following formula:

\[ D_{j^-} = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_{ij^-})^2} \]

e. Calculating Alternative Preference Values

Alternative preference values can be calculated as follows:

\[ C_j^* = \frac{D_{j^-}}{D_{j^-} + D_{j^+}} \]

f. Sort Preference Value

Each alternative is sorted by the value \( C_j^* \) of the largest value. The best solution is an alternative solution that has the greatest value.

After calculated based on the TOPSIS steps as above, the order of the priority suppliers based on the TOPSIS method can be seen in Table 3.

| Order | Alternative | Preference Value |
|-------|-------------|------------------|
| 1     | PT ABC V2  | 0.8639           |
| 2     | PT MNO V3  | 0.7905           |
| 3     | PT XYZ V1  | 0.2151           |
| 4     | PT DEF V4  | 0.0193           |

Based on Table 3, it can be seen from the results of the TOPSIS processing carried out, it is known that S1 suppliers, namely PT ABC, are ranked first with the highest preference value of 0.8639.

4. Conclusion

The hierarchy for determining priority suppliers is arranged into 3 levels, namely goals, criteria, and alternatives. On this issue which is the goal (priority) is the ranking (order) priority of suppliers, at level 2 there are five criteria used to select priority suppliers, namely quality, price, delivery time, quantity and response to claims. In processing data using AHP, it was found that the value of consistency of each criterion and alternative was smaller than 0.1. This means the answers from respondents are consistent. From the results of TOPSIS processing carried out, it is known that S1 suppliers, namely PT ABC, are ranked first with the largest preference value of 0.8639. The supplier that ranks last is the supplier of S2 (PT DEF) with the smallest preference value of 0.193. The advantage of PT ABC as a priority supplier in this study is because PT ABC has a cheaper price, good product quality and quick response to claims when compared with other suppliers. The priority order of suppliers is PT ABC (0.8639), PT MNO (0.7905), PT XYZ (0.2151) and PT DEF (0.0193).

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References

[1]  M. R. Leenders, dkk. 1985. Purchasing and Materials Management. Amerika Serikat: Richard D. Irwin, Inc
[2]  T. L. Saaty. 1994. Fundamental of Decision Making and Priority Theory with The Analytic
[3] A. Mohammadi dan H. Aryaeefar. 2011. *Introducing A New Method to Expand TOPSIS Decision Making Model to Fuzzy TOPSIS*. The Journal of Mathematics and Computer Science, Vol. 2, No. 1, Januari 2011

[4] S. Kusumadewi. 2006. Fuzzy Multi-Attribute Decision Making (Fuzzy MADM). Yogyakarta: Graha Ilmu

[5] R. I. Handayani dan Yuni Darmianti, 2017. Pemilihan Supplier Bahan Baku Bangunan dengan Metode Analytical Hierarchy Process (AHP) pada PT. Cipta Nuansa Prima Tangerang. Jurnal Techno Nusa Mandiri, Vol. XIV, No. 1

[6] L. Merry, Meriastuti Ginting, dan Budi Marpaung. 2014. Pemilihan Supplier Buah dengan Pendekatan Metode Analytical Hierarchy Process (AHP) Dan TOPSIS: Studi Kasus Pada Perusahaan Retail. Vol. 3

[7] S. Sinulingga. 2011. Metode Penelitian. Medan: USU Press.