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Supplier Selection Using AHP dan TOPSIS: a Case Study in The Bakery

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Abstract

The main raw materials in bread production are wheat flour. X Bakery has seven suppliers who frequently supply flour. The common problems at X Bakery related to the supply of raw materials are the different prices between each supplier, inaccuracies in delivery times, and the non-standard quality of raw materials. The purpose of this research is to choose the right raw materials supplier at X Bakery. Decision making on supplier determination is done by selecting suppliers based on the criteria determined by the company using the AHP and TOPSIS methods. The AHP method is used to determine the most influential criteria and produce a weighted criterion value. The AHP output will be used as input to the TOPSIS method for supplier ranking. Of the seven criteria, quality is the priority by X bakery, while the the selected supplier to supply wheat flour is supplier A.
Keywords: Suppliers selection, Analytic Hierarchy Process (AHP), Technique For Order Preference by Similarity to Ideal Solution (TOPSIS).

1 Introduction

The raw materials inventory with adequate quality and quantity is one of the main factors in a company line production. In its production activities, the company needs suppliers as business partners who have an important role in ensuring the availability of raw materials for the company production. Determination of suppliers as business partners is an important decision for a company, because it is related to the cost and quality of the raw materials supplied. Pujawan (2010) states that the purpose of the supplier selection process is to reduce purchase risk, build close long-term relationships and to maintain the quality of product raw materials. Selection of the right supplier can reduce the cost of raw materials and increase the company's competitiveness (Ceby and Bayraktar, 2003).

X Bakery is a micro, small and medium enterprise (UMKM) that produces various types of cakes and breads. This UMKM, which is located in Balikpapan, produces to orders and stock. The main raw materials used to produce bread are flour. X Bakery has seven suppliers who frequently supply flour. The common problems in supplying raw materials at X Bakery are the different prices between each supplier, inaccuracy in delivery times, and non-standard material quality. To increase the company's competitiveness, X Bakery must be able to determine the right supplier of raw materials. Suppliers must be able to provide raw materials at the right price, quantity, quality and time.

The purpose of this study is to determine the right supplier of wheat flour at X Bakery. Determination of suppliers is done using the Analytical Hierarchy Process (AHP) and Technique For Order Preference by Similarity to Ideal Solution (TOPSIS). The AHP method is used to determine the most influential criteria and produce a weighted criterion value. The

output of AHP will be used as input to the TOPSIS method for ranking suppliers. It is hoped that the selected potential suppliers can supply raw materials at the right price, quality and time and can work together in the long term.

2 Methodology

The research was conducted at X Bakery, Balikpapan. This study uses the AHP and TOPSIS methods to determine suppliers of wheat flour.. The research stages consist of data collection, data processing and analysis and the last is drawing conclusions.

2.1 Data Collection

Data collection was done by deliberately selecting respondents related to the research topic or purposive sampling method. At this stage, it is assumed that respondents have competence in choosing suppliers who represent factories and have the authority to provide information about the data needed in research (Merry et al., 2014).

The data collected consisted of data from interviews and questionnaires. The selected respondents are business owners, who are considered to understand the issue of raw materials and suppliers.

The questionnaire consists of two stages, the first is a pairwise comparison questionnaire conducted to obtain the weight of the criteria and sub-criteria in the completion of the AHP with different priorities and weights. The second questionnaire is a supplier selection assessment questionnaire used to give a supplier assessment weight with predetermined criteria for the completion of the TOPSIS.

Pujawan (2010) states that there are twenty-one criteria for supplier selection and evaluation. These criteria are listed in table 1 below.

Table **1.** Supplier Selection Criteria

No	Criteria	No	Criteria
1.	Quality	12.	Management and organization
2.	Delivery	13.	Operating controls
3.	Performance history	14.	Attitudes
4.	Warranties and claim policies	15.	Impression
5.	Price	16.	Packaging ability
6.	Technical capability	17.	Labor relation records
7.	Financial position	18.	Geographical location
8.	Prosedural compliance	19.	Amount of past business
9.	Communication system	20.	Training aids
10.	Reputation in industry	21.	Reciprocal arrangements
11.	Desire for Business	12.	Management and organization

2.2 Analitycal Hierarchy Process (AHP)

The AHP method, proposed by Thomas L. Saaty, from the Wharton School of Business in 1970. According to Saaty in Putri (2012), AHP is a method used in the decision-making process of complex problems such as: planning, determining alternatives, setting priorities , policy selection, resource allocation, needs determination, needs forecasting, performance planning, optimization, and conflict resolution. A problem is said to be complex if the structure of the problem is not clear and there is no availability of accurate statistical data and information, so that the input used to solve this problem is human intuition. But this intuition must come from people who correctly understand the problem to be solved (experts).

According to Marimin (2004), there are several advantages to using AHP in solving a complex problem, namely as follows: unity, complexity, interdependence, hierarchy, measuremen, consistency, synthesis, bargain, assessment and consensus and process repetition.

The stages of decision making using the AHP method, according to Merry et al., (2014) are:

1. Identify the problem, determine the goal and the desired solution.
2. Arrange problems in a hierarchy so that complex problems can be seen clearly. Starting from the objectives, criteria, sub-criteria, and alternatives used.
3. Compile a pairwise comparison matrix for each level. It begins by comparing the criteria with the objectives to be achieved, then comparing the criteria with the sub-criteria in the criteria. Comparisons are made based on the decision makers judgment by assessing the importance level of an element compared to other elements. The comparison matrix can be seen in Table 2. This matrix describes the relative contribution or influence of each element to each goal or criterion level above. The ratio value of A_i to the element A_j is a_{ij}. The A value is determined by the rule: If $a_{ij} = \alpha$, then $a_{ji} = 1/\alpha$, $\alpha \neq 0$; If A_i has the same relative importance as A_j, then $a_{ij} = a_{ji} = 1$; in particular, $a$ii = 1, for all i.

Table **2.** Pairwise Comparison Matrix

C	**A_1**	**A_2**	**A_3**	**…**	**A_n**
A_1	a_{11}	a_{12}	a_{13}	…	a_{1n}
A_2	A_{21}	A_{22}	A_{23}	…	A_{2n}
A_3	A_{31}	A_{32}	A_{33}	…	A_{3n}
…	…	…	…	…	…
A_n	A_{n1}	A_{n2}	A_{n3}	…	A_{nn}

4. Fill in the pairwise comparison matrix by decision makers based on the weights as shown in table 3.

Table **3.** Ratio Weight Scale

Weight	**Description**
1	Both elements are equaly important
3	One element is slightly more important than the other
5	One element is more important than the other

7	One element is clearly more absolutely important than the other
9	One element is absolutely important than the other
2, 4, 6, 8	The value between two value of adjacent consideration

5. Calculate the geometric mean. If there is more than one decision maker, then the geometric mean is done. This geometric value is formulated by:

$$GM = n\sqrt{(x_1)(x_2)...(x_n)} \quad (1)$$

6. Logical consistency test (CI).
7. Test the consistency using the formula CR = CI/RI, where RI is a random index of consistency. If the consistency ratio ≤ 0,1, the results of the data calculation can be justified.

2.3 Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS)

TOPSIS method is a decision-making technique from several possible alternative choices. The purpose of this method is to determine the positive and the negative ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes the cost criteria, while the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. The greater the value of the benefit criteria, the more feasible it is to be selected. The cost criterion is the opposite of the benefit criterion, the smaller the value of the criterion, the more feasible it is to be selected. In the TOPSIS method, the optimal alternative is the one closest to the positive ideal solution and farthest from the negative ideal solution (Purnomo et al, 2013).

The decision-making stages using the TOPSIS method are:

1. Develop a decision matrix. The decision matrix X refers to m alternatives that will be evaluated based on n criteria. It can be seen in table 4.

Table **4.** Ratio Weight Scale

$$X = \begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ . \\ . \\ . \\ a_m \end{array} \begin{bmatrix} X_1 & X_2 & X_3 & . & . & . & X_n \\ X_{11} & X_{12} & X_{13} & . & . & . & X_{1n} \\ X_{21} & X_{22} & X_{23} & . & . & . & X_{2n} \\ X_{31} & X_{32} & X_{33} & . & . & . & X_{3n} \\ . & . & . & & & & . \\ . & . & . & & & & . \\ . & . & . & & & & . \\ X_{m1} & X_{m2} & X_{m3} & . & . & . & X_{mn} \end{bmatrix}$$

a_i= (i = 1, 2, 3, ..., m) are the possible alternatives,
x_j= (j = 1, 2, 3, ..., n) are the attribute which the alternatives performance are measured,
$_{ij}$= alternatives performance a_i with attribute reference x_j.

2. Constructing a Normalized Decision Matrix. The element r_{ij} is the result of the decision matrix R using the Euclidean length of a vector method as follows:

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

3. Create a weighted normalized decision matrix as follows:

$$v_{ij} = w_j . r_{ij} \tag{3}$$

4. Determine the positive ideal solution and the negative ideal solution. The positive ideal solution is denoted A^+, as follows:

$$A^+ = \left\{\left(\max v_{ij} \middle| j \in J\right), \left(\min v_{ij} \middle| j \in J'\right)\right\} = \left\{v_1^+, v_2^+, v_3^+, ..., v_n^+\right\} \tag{4}$$

While the negative ideal solution is denoted A^-, as in equation below:

$$A^- = \left\{\left(\min v_{ij} \middle| j \in J\right), \left(\min v_{ij} \middle| j \in J'\right)\right\} = \left\{v_1^-, v_2^-, v_3^-, ..., v_n^-\right\} \tag{5}$$

5. Calculating Alternatives. The calculation of separation is a measurement of the distance from an alternative to a positive ideal solution and a negative ideal solution, as in equation 6 and 7 below:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \tag{6}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \tag{7}$$

6. Calculate the relative closeness to the ideal solution using the following equation:

$$C_i = \frac{S_i}{S_i^+ + S_i^-} \tag{8}$$

7. Ranking alternatives, sorted from the largest C^+ value to the smallest value. The alternative with the largest C^+ value is the best solution.

3 Results and Discussion

Currently X Bakery has 7 suppliers that supply wheat flour, namely A, B, C, D, E, F and G. They have collaborated with X Bakery since 2017. The average flour supply from the suppliers is 250 kg per month.

To determine suppliers of flour, there are several criteria required by X bakery, including quality, price, delivery, technical capability, work history, operation control, and communication systems. Details of the criteria and sub criteria set by X Bakery can be seen in table below.

Table **5.** Supplier Criteria and Sub Criteria

Criteria	Sub Criteria
Quality	The raw material quality
	Conformance specification
	Quality consistency
Price	The raw material price
	Payment method
Delivery	Delivery time
	Delivery quantity
Comunication	Comunication type
	Comunication consistency
Work history	Ability to keep agreements
	Ability to keep number and time of order
Operation conrol	Valid data
Technical capability	Ability to meet targets

The pairwise comparison matrix was constructed based on the data from the criteria and sub-criteria weighting questionnaire. The matrix is divided into three parts, the diagonal, the top diagonal, and the bottom diagonal. The bottom of the diagonal is filled with the opposite value of the top of the diagonal, and vice versa. Table 6 shows the matrix.

Table **6.** The Pairwise Comparison Matrix

Criteria	A1	A2	A3	A4	A5	A6	A7
Quality	1,00	3,00	3,00	5,00	5,00	5,00	5,00
Price	0,33	1,00	3,00	5,00	5,00	2,00	2,00
Delivery	0,33	0,33	1,00	2,00	5,00	2,00	3,00
Comunication	0,20	0,20	0,50	1,00	3,00	3,00	2,00
Work history	0,20	0,20	0,20	0,33	1,00	0,33	0,20
Opert conrol	0,20	0,50	0,50	0,33	3,00	1,00	0,33
Tech capability	0,20	0,50	0,33	0,50	5,00	3,00	1,00

Test of consistency was conducted on the comparison of elements at each level of the hierarchy. The purpose of this test is to see the consistency of comparisons between the criteria carried out for the entire hierarchy. The test results can be seen in Table 7.

Table **7.** Normalization and Priority

Criteria	A1	A2	A3	A4	A5	A6	A7	Weight	Rank
Quality	0,41	0,52	0,35	0,35	0,19	0,31	0,37	0,356	**1**
Price	0,14	0,17	0,35	0,35	0,19	0,12	0,15	0,210	**2**
Delivery	0,14	0,06	0,12	0,14	0,19	0,12	0,22	0,140	**3**
Comunication	0,08	0,03	0,06	0,07	0,11	0,18	0,15	0,0982	**4**
Work history	0,08	0,03	0,02	0,02	0,04	0,02	0,01	0,034	**7**
Opert conrol	0,08	0,09	0,06	0,02	0,11	0,06	0,02	0,064	**6**
Tech capability	0,08	0,09	0,04	0,04	0,19	0,18	0,07	0,0979	**5**

After obtaining the weights for each criterion, then a decision matrix is built. The decision matrix contains a comparison of seven alternative suppliers with each criterion. The results of the decision matrix for the selection of wheat flour suppliers can be seen in the following table.

Table **8.** Supplier Selection Matrix

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
X_1	7	7	9	7	7	7	9
X_2	7	5	5	5	7	5	5
X_3	7	7	7	9	7	7	7
X_4	7	7	7	5	7	7	7
X_5	7	5	5	5	7	5	5
X_6	5	5	7	7	7	5	5
X_7	5	7	7	5	7	5	7

From the decision matrix, then a normalized decision matrix is made, which is shown in table 9.

Table **9.** Normalized Matrix

Alternative	A1	A2	A3	A4	A5	A6	A7
A	0,408	0,425	0,498	0,419	0,378	0,445	0,517
B	0,408	0,304	0,277	0,299	0,378	0,318	0,287
C	0,408	0,425	0,387	0,539	0,378	0,445	0,402
D	0,408	0,425	0,387	0,299	0,378	0,445	0,402
E	0,408	0,304	0,277	0,299	0,378	0,318	0,287
F	0,291	0,304	0,387	0,419	0,378	0,318	0,287

G	0,291	0,425	0,387	0,299	0,378	0,318	0,402

The weighted normalized decision matrix is made by multiplying the results of the priority weights of the AHP criteria with the normalized decision matrix. The weighted normalized decision matrix can be seen in table 10.

Table **10.** Wighted Normalized Decision Matrix

Alternative	A1	A2	A3	A4	A5	A6	A7
A	0,145	0,089	0,070	0,041	0,013	0,029	0,051
B	0,145	0,064	0,039	0,029	0,013	0,020	0,028
C	0,145	0,089	0,054	0,053	0,013	0,029	0,039
D	0,145	0,089	0,054	0,029	0,013	0,029	0,039
E	0,145	0,064	0,039	0,029	0,013	0,020	0,028
F	0,104	0,064	0,054	0,041	0,013	0,020	0,028
G	0,104	0,089	0,054	0,029	0,013	0,020	0,039

The next step is to arrange a positive and a negative ideal solution, calculate the alternative distance from the positive ideal solution (S^+) and the alternative distance from the negative ideal solution (S^-) and then calculating the relative closeness to the ideal solution. Each of these values can be seen in tables 11, 12 and 13.

Table **11.** Positive and Negative Ideal Solution

Criteria	A^+	A^-
A1	0,145	0,104
A2	0,089	0,064
A3	0,070	0,039
A4	0,041	0,029
A5	0,013	0,013
A6	0,029	0,020
A7	0,051	0,028

Table **12.** Positive and Negative Alternative

Alternative	S^+	S^-
A	0,0008	0,0633
B	0,0485	0,0411
C	0,0230	0,0577
D	0,0228	0,0525
E	0,0485	0,0411
F	0,0565	0,0195
G	0,0480	0,0316

Table **13.** Relative Closeness to The Ideal Solutions

Alternative	C^+
A	0,9875

B	0,4587
C	0,7149
D	0,6972
E	0,4587
F	0,2565
G	0,3969

The selected suppliers are determined after ranking the C^+ value from the largest to the smallest. The suppliers ranking is A, C, D, B, E, G and F.

4 Conclusions

Of the seven supplier selection criteria, quality is the priority criterion by X bakery, while work history gets the lowest weight. This means that X bakery places more emphasis on the performance of current suppliers without compromising the track record of partnering. The supplier that is the priority of X bakery to supply wheat flour is supplier A, because of the seven criteria required by X bakery, supplier A has the largest weight rating.

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