Application of AHP and TOPSIS Method: A Case Study in the Indonesian Leather Industry

Mochammad Chaeron, Gunawan P. Madyono,
Apriani Soepardi
Department of Industrial Engineering
Faculty of Industrial Engineering
Universitas Pembangunan Nasional Veteran, Yogyakarta,
Indonesia
apriani.soepardi@upnyk.ac.id

Abstract

The UDFM is an enterprise located in Yogyakarta that produces leather products. Consumers nowadays demand of quality products with the shortest production time possible. However, quality products begin from quality raw materials that meet company's predetermined specifications. Unfortunately, raw materials often fail to fulfil the company's expectation. This discrepancy indicates that the suppliers' role is less optimized. This study was performed to enhance the selection of suppliers in the Indonesian leather firm2 based on certain criteria and sub-criteria predetermined by the company. The criteria included quality, price, delivery, service, company profile, and risk. The Analytical Hierarchy Process (AHP) and Technique for Order Preference By Similarity To Ideal Solution (TOPSIS) were employed in the selection process. After identification and assessment process completed, a proposal was submitted to select the most appropriate supplier. The results of this study showed the performance values of the four suppliers, namely supplier A of 6.25%; supplier B of 31.25%; supplier C of 43.75%; and supplier D of 18.75%. Supplier C obtained the highest performance value, which indicated that supplier C made the most appropriate main supplier for company.

Keywords
AHP, multi criteria decision-making, leather, supplier selection, TOPSIS

1. Introduction
Suppliers are business partners that ensure the availability of materials needed by a company. In the supply chain concept, suppliers play a very important role to the continuity of the company's production. Even problems in the shipping process can cause stockouts. The UDFM is a company engaged in leather tanning (sheep, goat, cow, and crocodile skin). The company, which was founded in 1981, is located in the Yogyakarta Indonesia. The production process of this company is divided into wet process and the dry process. The company currently has four suppliers to supply the production materials, produces only make-to-order products, hence the products specification requested by consumers often varies in terms of leather types, thickness, size, and colour. Each product has different specifications to fit consumers' demand and every incoming order is processed based on consumers' demand.

Delays in delivery process have always been the biggest issue. Raw material delivery from the four suppliers took 1 to 2 weeks from the mutually agreed time. In February 2019 – December 2019, supplier A made 16 late deliveries out of 176 delivery, supplier B with 23 late delivery out of 143 delivery, supplier C with 29 late delivery out of 115 delivery, and supplier D with 5 late delivery out of 86 delivery. The late delivery resulted in delayed production process. The company also suffered losses as it had to be returned the raw materials amounting to 11,509 pickle sheets. Some factors were also concerned by the company, including the quality of raw materials, prices, speed of delivery, services provided by suppliers, company profile, and risk in shipping. Problems that occur from poor performance of suppliers can potentially harm the company. Therefore, supplier evaluation should be conducted to solve the problem.

Regarding the aforementioned reasons, supplier evaluation was performed using a combination of the Analytical Hierarchy Process (AHP) method and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. Each method offered its own advantages to produce optimal values. AHP was used for weighting criteria, while TOPSIS determined the priority ranking. The main objective of this study was to select the most appropriate supplier to avoid delayed production process and any potentials that could bring losses to the company. The results of this study are expected to become a fruitful insight for the firm to improve the current supplier selection procedure.

2. Literature Review

It is only the inadequate information that makes the decision taking difficult. However, there are still other factors that influence the existing choices, with the variety of selection criteria and also the value of each criterion that make problem solving complex. Nowadays, multi criteria problem-solving methods have been widely used in various fields. After determining the problems, certain criteria are determined as benchmarks and possible alternatives which decision makers can use to solve the problems.

The Analytical Hiercachy Process (AHP) method itself is not free from shortcomings since it becomes ineffective to use in cases with many criteria and alternatives (Barbarosoglu and Yazgac 1997; De Brou et al. 2001;). Hence, other methods are needed to be combined with the AHP method in order to obtain more effective results. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method have been reported feasible to address the multi-criteria problem. TOPSIS is an alternative multi-criteria decision-making method with the smallest gap from the positive ideal solution and the largest gap from the negative ideal solution.

However, the alternative which has the smallest gap from the positive ideal solution does not necessarily have the largest gap from the negative ideal solution. Therefore, TOPSIS considers both gaps to the positive ideal solution and the gap to the negative ideal solution simultaneously. TOPSIS results in optimal outcome by determining the relative proximity of an alternative to the positive ideal solution. TOPSIS will rank alternatives based on the priority value of the relative proximity of an alternative to the positive ideal solution. The rank is then used as a reference for decision makers to choose the best desired solution. TOPSIS has been used in many fields, including financial investment decisions, company performance comparisons, industry-specific comparisons, operating system selection, customer evaluation, and robot design (De Brou et al. 2001; Jadidi et al. 2010)

The combination of AHP and TOPSIS was chosen on the grounds that the AHP method has advantages in pairwise comparison matrices and performs consistency analysis, while the TOPSIS method can solve practical decision making because its context is relatively simple and easy to understand, computationally efficient, and able to measure the relative performance of decision alternatives. The combination of AHP and TOPSIS methods can be applied to a decision support system that regards numerous objects to be analysed based on the theories included in the AHP and TOPSIS methods (Onder and Sundus 2013).

3. Methods

The steps in the data analysis using AHP and TOPSIS method are described as follows. In general, the AHP measurement includes:

1. Determining the criteria.
2. Arranging the criteria based on the pairwise comparison matrix.
3. Adding up the value of each column from the values of the other criteria matrix elements.
4. Dividing every element in the column by the total element per column that correspond to the values of the pairwise comparison matrix elements and the total of each column above. Hence, the normalization matrix can proceed by dividing each element in the column by the appropriate number of per-columns.
5. Adding up each row in the matrix, then calculating the priority value by dividing each number of rows by the number of elements or the number of criteria.
6. Testing the consistency based on the multiplication of the pairwise comparison matrix with the priority criteria.
7. Calculating the consistency index and the consistency ratio.

While the procedures of TOPSIS are presented as follows:

1. Creating a normalized decision matrix.
2. Creating a weighted normalized decision matrix.
3. Determining the positive ideal solution matrix & negative ideal solution matrix.
4. Determining the gap between the values of each alternative and the positive ideal solution matrix.

5. Determining the gap between the value of each alternative and the negative ideal solution matrix.
6. Determining the preference value for each alternative.

The results of data analysis were then tested for the hierarchical consistency using the AHP method. The hierarchical consistency test tested whether the level of confidence in the data remained consistent when the when data collection using same instrument and object repeated. After the questionnaire was declared valid with the provisions of CR < 0.1, the TOPSIS method was then performed.

4. Data Collection

The data of this study were obtained from interviews and questionnaires. Interviews were conducted to obtain variables and indicators of elements that might affect the level of supplier performance. These indicators were later used as input in formulating the questionnaire. The questionnaires were then distributed to the respondent of this study, the owner of the UDFM.

Table 1. The Criteria and Sub Criteria

No.	**Criteria**	**Sub Criteria**
1.	Quality	Product Defect Specification Conformity
2.	Price	Product Price Delivery Cost Payment Method Discount
3.	Delivery	Time of Delivery Distribution Capability
4.	Service	Flexibility Responsibility After Sale Service
5.	Company Profile	Performance History Capability List of Consumers
6.	Risk	Location Economic Stability

The criteria and sub-criteria (Table 1) above are then developed into a pairwise comparison matrix for each level. Pairwise comparisons were first carried out by comparing level 2 and level 1, where the criteria were compared with the targets wot be then compared to the sub-criteria. Completion of the pairwise comparison matrix was done by the head of the company from the top of the diagonal line left to right and numbers 1 to 9 are used as comparison numbers. Table 2 explains the meaning of the weighing of numbers 1 to 9 for each criterion, sub-criteria, and between alternatives.

Table 2. Ratio Weight Scale (Saaty 1990)

Scale	Interpretation
1	Both elements are equally important
3	One element is more important than the other
5	One element is highly more important than the other
7	One element is obviously more important than the other
9	One element is absolutely more important than the other

2, 4, 6, 8	Values between the two are close

The decisions from decision makers were then converted as the weighting value. After that, logical consistency test was performed.

Table 3. Pairwise Comparison Matrix

CRITERIA	**Quality**	**Price**	**Delivery**	**Service**	**Profile**	**Risk**
Quality	1.00	0.25	0.14	0.25	0.20	0.33
Price	4.00	1.00	0.57	1.00	0.80	1.33
Delivery	7.00	1.75	1.00	1.75	1.40	2.33
Service	4.00	1.00	0.57	1.00	0.80	1.33
Profile	5.00	1.25	0.71	1.25	1.00	1.67
Risk	3,00	0.75	0.43	0.75	0.60	1.00

The Figure 1 presents the data of the pairwise comparison matrix based on the criteria from the questionnaires distributed to the objects of this research.

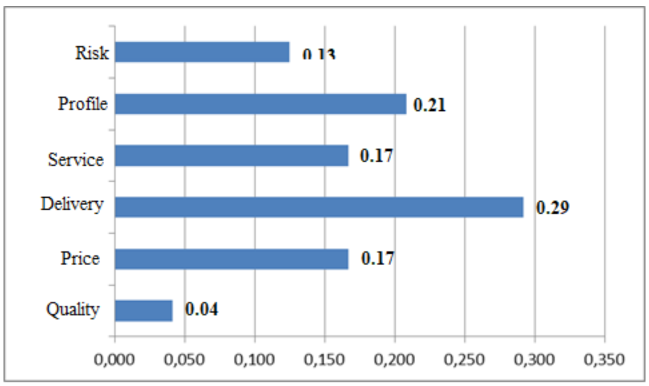

Figure 1. Results of Inter-Criteria Weighing

After the value of each criterion had been obtained, consistency test was performed. Prior to measuring the consistency ratio, the value of each criterion was first measured by dividing it with the number of the criteria. Calculating the consistency ratio using the random index (IR) 1.24 formula because the criteria is six, thus CR value was measured as follows.

$$CR = \frac{(lambda \max - n)/(n-1)}{IR}$$

since CR = -0.685 ≤ 0.1, it is regarded consistent.
The value of sub-criteria (Table 4) was recapitulated as follows.

Table 4. The Value of Each Sub-Criteria and Criteria

Sub Criteria	Weight	Criteria	Weight
Q1	0.250	Quality	0.042
Q2	0.750		
P1	0.395	Price	0.167
P2	0.395		
P3	0.130		

P4	0.079		
D1	0.250	Delivery	0.292
D2	0.750		
S1	0.091	Service	0.167
S2	0.455		
S3	0.455		
PR1	0.111	Profile	0.208
PR2	0.556		
PR3	0.333		
R1	0.250	Risk	0.125
R2	0.750		

At this stage, suppliers were compared to find the highest value from each sub criterion. The following matrix presents the data.

Table 5. The Supplier-Pairwise Comparison Matrix

Alternative	Supplier A	Supplier B	Supplier C	Supplier D
Supplier A	1.00	0.20	0.14	0.33
Supplier B	5.00	1.00	0.71	1.67
Supplier C	7.00	1.40	1.00	2.33
Supplier D	3.00	0.60	0.43	1.00

Table 6. Priority of Each Alternative

	Bobot	Ranking
Supplier A	0.063	IV
Supplier B	0.313	II
Supplier C	0.438	I
Supplier D	0.188	III

The next step was the calculation of sub criteria and criteria to be multiplied by the supplier value to form the ideal positive and ideal negative solutions. The gaps to the ideal points were the basis of ascending sorting of the list of suppliers. These steps are shown in the following Tables.

Table 7. Total Weight Value of All Suppliers

	Supplier A	**Supplier B**	**Supplier C**	**Supplier D**
Q1	0.001	0.003	0.005	0.002
Q2	0.002	0.010	0.014	0.006
Quality	**0.003**	**0.013**	**0.018**	**0.008**
P1	0.004	0.021	0.029	0.012
P2	0.004	0.021	0.029	0.012
P3	0.001	0.007	0.010	0.004
P4	0.001	0.004	0.006	0.002
Price	**0.010**	**0.052**	**0.073**	**0.031**

D1	0.005	0.023	0.032	0.014
d2	0.014	0.068	0.096	0.041
Delivery	**0.018**	**0.091**	**0.128**	**0.055**
S1	0.001	0.005	0.007	0.003
S2	0.005	0.024	0.033	0.014
S3	0.005	0.024	0.033	0.014
Service	**0.010**	**0.052**	**0.073**	**0.031**
PR1	0.001	0.007	0.010	0.004
PR2	0.007	0.036	0.051	0.022
PR3	0.004	0.022	0.030	0.013
Profile	**0.013**	**0.065**	**0.091**	**0.039**
R1	0.002	0.010	0.014	0.006
R2	0.006	0.029	0.041	0.018
Risk	**0.008**	**0.039**	**0.055**	**0.023**

5. Results and Discussion

Table 8. Results of Gap Measurement from the Ideal Positive Solution to Ideal Negative Solution

	Supplier A	Supplier B	Supplier C	Supplier D
A+	0.120821534	0.040273845	0	0.080547689
A-	0	0.080547689	0.120821534	0.040273845

Table 9. Ordered List of Suppliers

Supplier	Distance	Rank
A	0	4
B	0.667	2
C	1	1
D	0.333	3

Delivery appeared as the strongest criterion out of seven criteria in determining the best supplier with value of 29.17%. It indicates that delivery criterion is the most decisive criteria to concern in determining suppliers for the company the timeliness of delivery is the company's main priority as any delay in delivery leads to longer and inefficient production process. The most dominant alternative supplier from the four alternative suppliers is supplier C, which is 43.75% because it has a history of the best performance in each criterion and sub criteria.

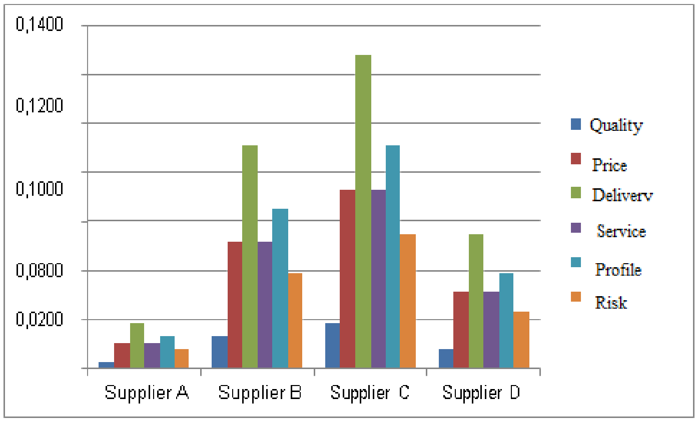

Figure 2. Diagram of Supplier Performance

6. Conclusion

Based on the results of the AHP and TOPSIS analysis, the company is recommended to select supplier C as the main supplier for the company as it gained a percentage of Performance to Quality of 1.82%, Performance to Price of 7.29%, Performance to Delivery of 12.76%, Performance to Service of 7.29%. Supplier C also had a percentage of company profile of 9.11% and risk of 5.47%.

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Biographies

Mochammad Chaeron is a staff in Industrial Engineering Department at the Universitas Pembangunan Nasional Veteran, Yogyakarta, Indonesia. He holds a Bachelor of Mechanical Engineering and Master of Industrial and Management Engineering. His research areas include automation of production and manufacturing processes.

Gunawan Madyono Putro is a staff in Industrial Engineering Department at the Universitas Pembangunan Nasional Veteran, Yogyakarta, Indonesia. He earned a Bachelor and Master in Industrial and Management Engineering. His research areas include manufacturing processes and quality.

Apriani Soepardi is an Associate Professor in Industrial Engineering Department at the Universitas Pembangunan Nasional Veteran, Yogyakarta, Indonesia. She earned a Doctoral Program in Mechanical Engineering. In 2017, Mrs.Soepardi was a Sandwich-Doctoral Program student in the Department of Management and Engineering, Division of Energy Systems, Linköping University, Sweden. She has published journals and conference papers. Her research areas include industrial energy efficiency, agile and sustainable manufacturing, and system modelling.