IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 22, Issue 11. Ser. VII (November 2020), PP 50-54
www.iosrjournals.org

Chemical Supplier Selection Using AHP and TOPSIS

Tusher Sarder[1], Mahabubur Rahman Khan[2]
[1]*University of Dhaka, Institute of Leather Engineering and Technology, Bangladesh*
[2] *University of Dhaka, Institute of Leather Engineering and Technology, Bangladesh*

Abstract:
The research comes at a time when the industries and people are increasingly facing various global challenges and leather related research is still inadequate, while economic, environmental and social-supply disciplines fall into three dimensions at the same time. In today's highly competitive environment, companies need to manage their supply chain more efficiently in order to stay competitive in the field of leather as in every sector. Chemical Supplier Selection, the process of determining the right supplier, capable of delivering the right quality products and services to the buyer at the right price, at the right time and at the right quantity, is one of the most important activities in operations management. In other words, supplier selection is a multi-criteria decision-making problem that involves both qualitative and quantitative factors. The aim of this study is to find the right chemical supplier in the leather industry using Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods. Here we have first calculated the weights of criteria by using AHP method and then we have ranked the chemical suppliers by using TOPSIS method. The results of this research can help managers in the leather industry to find the right chemical supplier.

***Key Word**: Chemical supplier; Leather Industry; AHP; TOPSIS.*

Date of Submission: 22-11-2020 Date of Acceptance: 07-12-2020

I. Introduction

Since the beginning of human history, leather products have served as a useful ingredient. In the tanning industry, raw skin is transformed into leather through multiple chemical and mechanical activities. Leather processing technology has evolved from enduring practice to industrial activity naturally [1]. Finding the right chemical suppliers to meet the needs and expectations of the company is one of the basic requirements for effective supply chain management for the leather industry. There is a special importance for retention and long-term survival of the company. Studies conducted in different leather industries sought to solve the problem of selecting suitable chemical suppliers using different criteria and methods. So, chemical suppliers are corporate pro competition plays a vital role in achieving this and as a result, choosing the right supplier is an important component of these new strategies. Several conflicting quantitative and qualitative factors or criteria, such as price, quality of chemicals, timely delivery, social responsibility, safety management benefits, risk consideration, etc., affect the choice of supplier. Therefore, it is a multi-criteria decision-making problem that involves both quantitative and qualitative factors, some of which conflict with each other. Choosing the right chemical supplier among the various suppliers is a complex issue for top management. In industries that deal with large-scale production they can cover about 70% of the product cost of raw materials and components [2]. In this situation, the purchasing department can play a key role in reducing costs. Supplier selection is one of the most important tasks in purchasing management. Using a suitable method for this purpose is a critical issue. Supplier selection is a Multiple Criteria Decision Making (MCDM) problem. Here we use the AHP method which is the most popular and widely used method for assigning weights to criteria with consistency check of experts, and TOPSIS method which is an effective method for finding the most efficient alternative. A stable and competitive supplier thus donates to one by improving the overall efficiency of one organization. The whole procedure is explained with the help of numerical examples and is ultimately determined according to the results of the rank of each supplier.

II. Literature Review

Supplier selection is the most important and prominent part of the purchasing function as it contributes to enhancing competitive strategy and global market share by reducing operational costs, offering high-quality products, enlarging total supply chain profit, and improving total supply chain performance. For globalization, customer expectations have increased; these expectations cannot be explained only by lower product cost, as they also involve quality, lead time, warranties, and many other criteria that make supplier selection a multi-criteria problem.

Dickson [3] is one of the early researchers on supplier selection. He identified 23 criteria based on questionnaires returned from 170 purchasing managers of companies in the United States and Canada. Weber et al. [4] then reviewed 74 relevant articles, published in 1966 to 1990, to provide a broad view of criteria and methods used in supplier selection. Simpson et al. [5] explore whether most companies across a broad area of industries in the United States had a formal process for supplier evaluation, and also identified key criteria by which suppliers were being assessed. The results indicated that almost half of the respondents had no formal method for assessing supplier performance since most companies still follow simple and subjective approaches for supplier selection.

Chemical is one of the most important elements in leather industry. Chemical is used in almost every step from raw leather to finished leather. So, the quality of finished leather is depended on the chemical. Thus the chemical supplier selection is an important task for purchasing department.

Chemical supplier selection criteria depend on various factors such as quality of chemicals, price, timely shipment, social responsibility etc. Table 1 shows the criteria for chemical supplier selection. These criteria are identified through detail literature review and industrial experts' opinion.

Table 1: Criteria for chemical supplier selection

Code	Criteria
C1	Quality of chemicals
C2	Price
C3	Timely shipment
C4	Social responsibility
C5	Safety management facility
C6	Risk management

In this research we select five suppliers (S1, S2, S3, S4, S5) for evaluation.

III. Methodology

Analytical Hierarchy Process (AHP)

AHP is a well-known and widely used multi criteria decision-making method in industries that was initially proposed by Prof. Thomas L. Saaty. The steps of this method are given as follows:

Step 1: Forming a pairwise comparison matrix (G) and given the ratings based on the expert's opinions using linguistic scale it is shown in table 2.

$$G = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ g_{n1} & g_{n2} & \cdots & g_{nn} \end{bmatrix} \quad (1)$$

where n is the order of the matrix.

Step 2: Normalized the resulting matrix

$$G_1 = \begin{bmatrix} g'_{11} & g'_{12} & \cdots & g'_{1n} \\ g'_{21} & g'_{22} & \cdots & g'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ g'_{n1} & g'_{n2} & \cdots & g'_{nn} \end{bmatrix} \text{ and } g'_{ji} = \frac{g_{ij}}{\sum_{j=1}^{n} g_{ij}} \text{ for } j, i = 1, 2, \ldots, n \quad (2)$$

Step 3: Calculating the weights

$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}, \quad w_j = \frac{\sum_{j=1}^{n} g_{ji}}{n} \quad (3)$$

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a multi-criteria decision analysis method, which was originally developed by Ching-Lai Hwang and Yoon in 1981 with further developments by Yoon in 1987, and Hwang, Lai and Liu in 1993. It is a technique to evaluate the performance of alternatives through the similarity with the ideal solution. According to this technique, the best possible value will be closest to the positive-ideal solution and longest from negative-ideal solution [6]. The steps of this method are given as follows:

Step 1: Creating a decision matrix consisting of m alternatives and n criteria

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (4)$$

Step 2: Normalizing the decision matrix. The normalization of the decision matrix 'X' is computed below

$$\overline{X} = \begin{bmatrix} \overline{x}_{11} & \overline{x}_{12} & \cdots & \overline{x}_{1n} \\ \overline{x}_{21} & \overline{x}_{22} & \cdots & \overline{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \overline{x}_{m1} & \overline{x}_{m2} & \cdots & \overline{x}_{mn} \end{bmatrix}, \ \overline{x}_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (5)$$

Step 3: Calculating the weighted normalized matrix

$$V = (v_{ij})_{m\times n}, \ \ v_{ij} = \overline{x}_{ij} \times w_j, i = 1, 2, \cdots, m, \ \ j = 1, 2, \cdots, n. \qquad (6)$$

Step 4: Calculating the positive ideal solution (A^+) and the negative ideal solution (A^-)

$$A^+ = \{v_1^+, v_2^+, \cdots, v_n^+\} = \{(max_i v_{ij}, j \in P^+)(min_i v_{ij}, j \in P^-)\}, \ \ i = 1, 2, \cdots, m$$
$$A^- = \{v_1^-, v_2^-, \cdots, v_n^-\} = \{(min_i v_{ij}, j \in P^+)(max_i v_{ij}, j \in P^-)\}, \ \ i = 1, 2, \cdots, m$$

where P^+ is associated with 'beneficial' criteria and P^- is associated with 'non-beneficial' criteria.

Step 5: Calculating the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, \ \ i = 1, 2, \cdots, m \qquad (7)$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \ \ i = 1, 2, \cdots, m \qquad (8)$$

Step 6: Calculating the relative proximity to the ideal solution using the relative index

$$R_i = \frac{S_i^-}{S_i^+ + S_i^-}, \ \ i = 1, 2, \cdots, m \qquad (9)$$

Step 7: Ranking the best alternatives according to R_i in descending order.

Table 2: Linguistic scale for both AHP and TOPSIS

Degree of preference	Scale
Equal importance	1
Moderate importance of one factor over another	3
Strong or essential importance	5
Very strong importance	7
Extreme importance	9
Intermediate values	2, 4, 6, 8

IV. Case Application

The chemical supplier selection for leather industry is a crucial issue. In this study, five chemical suppliers have assessed based on six criteria. The data was collected from one case company located in Savar. The data for AHP is collected from one expert from the case companies and it is given in Table 3.

Table 3: Data for AHP analysis collected from one expert

Criteria	Code	C1	C2	C3	C4	C5	C6
Quality of chemicals	C1	1	4	6	9	7	6
Price	C2	1/4	1	2	5	4	5
Timely shipment	C3	1/6	1/2	1	3	3	4
Social responsibility	C4	1/9	1/5	1/3	1	5	3
Safety management facility	C5	1/7	1/4	1/3	1/5	1	2
Risk management	C6	1/6	1/5	1/4	1/3	1/2	1

Again, data for TOPSIS analysis to select best chemical supplier is given in Table 4.

Table 4: Data for TOPSIS analysis collected from one expert

Criteria / Suppliers	C1	C2	C3	C4	C5	C6
S1	2	8	9	8	4	9
S2	6	7	8	6	1	8
S3	1	6	1	4	9	7

S4	3	8	5	6	8	4
S5	8	7	2	2	9	5

V. Results and discussions

Using equations (1), (2), and (3), the weights of each criterion is examined. The final weight of each criterion is given in Table 5.

Table 5: Final weight of each criterion obtained from AHP analysis.

Criteria	Code	C1	C2	C3	C4	C5	C6	Weight
Quality of chemicals	C1	1	4	6	9	7	6	0.50049
Price	C2	1/4	1	2	5	4	5	0.21035
Timely shipment	C3	1/6	1/2	1	3	3	4	0.13161
Social responsibility	C4	1/9	1/5	1/3	1	5	3	0.07599
Safety management facility	C5	1/7	1/4	1/3	1/5	1	2	0.04495
Risk management	C6	1/6	1/5	1/4	1/3	1/2	1	0.03661

MaxiEigen=6.61690475, RI=1.24, CI=0.12338095, CR=0.099501<0.1

It is clearly shown that criteria ‘Quality of chemicals (C1)’ received the highest weight and criteria ‘Risk management (C6)’ received the lowest weight in the AHP analysis.

Finally, the comparison matrix among criteria and suppliers are constructed based on expert feedback and given in Table 4. Using equations (5), (6), (7), (8), and (9), the final ranking of supplier is established. The final ranking of suppliers is given in Table 6.

Table 6: Final ranking of suppliers

Suppliers	Euclidean distance	relative closeness	R_i	Ranking
S1	0.1037	0.2816	0.2692	4
S2	0.2462	0.0987	0.7139	2
S3	0.0270	0.3395	0.0738	5
S4	0.1098	0.2384	0.3153	3
S5	0.3294	0.0803	0.8040	1

Based on the AHP-TOPSIS analysis, it is clear that supplier S5 received the top position in the analysis that means this supplier (S5) is able to fulfill the identified criteria. Therefore, case company may select the supplier S5 for getting the better quality.

VI. Conclusion

For recognizing the most influential criteria and supplier in leather industry this paper proposed a hybrid MCDM method like AHP-TOPSIS [7-10]. AHP is used to define the weights based on the pairwise comparison matrix with the other factors. From the priority of weights, we identified the most influential supplier selection criteria. TOPSIS is used to determine critical alternative in the leather industry based on closeness coefficient. ‘Supplier S5’ is the important alternative in the case company. Managers in case company may use our results to select the best supplier. The recommendations for future research are deliberated as follows-execution of same study in other industries like fireworks, petrochemical, paper etc.

References

[1]. Sundar, V.J., Raghavarao, J., Muralidharan, C., & Mandal, A.B., “Recovery and utilization of chromium- tanned proteinous wastes of leather making: A review”, Critical Reviews in Environmental Science and Technology, Vol: 41(22), pp: 2048–2075, 2011.
[2]. Rajhaans, Prof. Dr. (Mrs.) N. R., Barshikar, Shantanu, ‘Supplier Selection in Manufacturing Industry Using Topsis’, *Research Gate*, March 2015.
[3]. Dickson GW. An analysis of vendor selection systems and decisions. J Purch 1966; 2:5-17.
[4]. Weber CA, Current JR, Benton WC. Vendor selection Criteria ad methods. Eur J Oper Res 1991; 50:2-18.
[5]. Simpson PM, Siguaw JA, White SC. Measuring the performance of suppliers: an analysis of evaluation processes. J Supply Chain Manag 2002; 38:29-41.
[6]. Hwang, C.L., Yoon, K., 1981. Multi Attribute Decision Making. Springer, New York.

[7]. Joshi, R., Banwet, D.K. and Shankar, R., 2011. A Delphi-AHP-TOPSIS based benchmarking framework for performance improvement of a cold chain. *Expert Systems with Applications*, *38*(8), pp.10170-10182.
[8]. Tavana, M. and Hatami-Marbini, A., 2011. A group AHP-TOPSIS framework for human spaceflight mission planning at NASA. *Expert Systems with Applications*, *38*(11), pp.13588-13603.
[9]. Prakash, C. and Barua, M.K., 2015. Integration of AHP-TOPSIS method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment. *Journal of Manufacturing Systems*, *37*, pp.599-615.
[10]. Majumdar, A., Sarkar, B. and Majumdar, P.K., 2005. Determination of quality value of cotton fiber using hybrid AHP-TOPSIS method of multi-criteria decision-making. *Journal of the Textile Institute*, *96*(5), pp.303-309.
[11]. Panitas S., Kawinpob S., Thanawath N., Weerapat S., Sirawadee A., "Supplier selection towards uncertain and unavailable information an extension of topsis method"- Operations Research Perspectives, 2018, pages 69-79, Elsevier.
[12]. Kamalakannan R., Ramesh C., Shummugasundaram M., Sivakumar P., Mohamed A., "Evaluation and selection of suppliers using topsis", 2020, Elsevier.

Tusher Sarder, et. al. "Chemical Supplier Selection Using AHP and TOPSIS." *IOSR Journal of Business and Management (IOSR-JBM)*, 22(11), 2020, pp. 50-54.