SUPPLIER SELECTION BY TECHNIQUE OF ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS) METHOD FOR AUTOMOTIVE INDUSTRY

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Abstract

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer demand. The supply chain includes not only the buyer and suppliers, but also transporters, warehouses, retailers and even customers themselves. In supply chain supplier selection process determine the suitable suppliers who provide the right quality products at the right price, at the right time and in the right quantities to the buyer. The aim of this paper is developing a methodology for selection of suppliers in supply chain cycle in an automobile industry. For supplier selection different important criteria are taking in account. These criteria have different weights by different experts. Using these weights provide rank to every supplier with the help of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS Method).

Key words: Supply chain management, Multi criteria decision making, Supplier selection problem, Topsis method.

Introduction

Supply Chain Management and its demands on the firms in the value chain have led to the operational integration of suppliers within the supply chain [1]. Selecting an appropriate supplier (or vendor) among different suppliers is a critical issue for top management. In industries that are concerned with large scale production the raw materials and component parts can equal up to 70% product cost. In such circumstances the purchasing department can play a key role in cost reduction, and supplier selection is one of the most important functions of purchasing management [4]. Therefore, using an appropriate method for this purpose is a crucial issue; supplier selection has been shown to be a multiple criteria decision making (MCDM) problem [5]. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was first developed by Yoon and Hwang. In supply chains; Co-ordination between a manufacturer and suppliers is typically a difficult and important link in the channel of distribution. Once a supplier becomes part of a well managed and established supply chain, this relationship will have a lasting effect on the competitiveness of the entire supply chain. Because of this, supplier selection problem has become one of the most important issues for establishing an effective supply chain system. Besides, selection of suppliers is a complicated process by the facts that numerous criteria must be considered in the decision making process [7].

Supplier selection process is one of the most significant variables, which has a direct impact on the performance of an organization. As the organization becomes more and more dependent on their suppliers, the direct and indirect consequences of poor decision making will become more critical. The nature of this decision is usually complex and unstructured. On the other hand, supplier selection decision-making problem involves trade-offs among multiple criteria that involve both quantitative and qualitative factors, which may also be conflicting. In this paper, with the help of going over expertise of experts and their relevant specialized literature, we can recognize variables and effective criteria in supplier selection, with regards to this point that, considering all criteria for supplier selection is impossible, the main and important criteria have been extracted by expert judgment. Thereafter, we will evaluate and determine weight of each supplier and finally, by implementing TOPSIS method, the rank of each supplier is determined. TOPSIS has been a favorable technique for solving multi criteria problems. This is mainly for two reasons, 1) its concept is reasonable and easy to understand, and 2) in comparison with other MCDM methods, like AHP, it requires less computational efforts, and therefore can be applied easily. TOPSIS is based on the concept that the optimal alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS). TOPSIS method are powerful decision making processes which help people to set priorities on parameters that are to be considered by reducing complex decision to a series of one-to-one comparisons, thereby synthesizing the result [2].

Proposed Methodology

The proposed methodology for supplier selection problem, composed of TOPSIS method, consists of three Steps [3]:

(1) Identify the criteria to be used in the model;
(2) Weigh the criteria by using expert views;
(3) Evaluation of alternatives with TOPSIS and determination of the final rank.

In the first Step, with the help of going over expertise of experts and their relevant specialized literature, we try to recognize variables and effective criteria in supplier selection and the criteria which will be used in their evaluation is extracted. Thereafter, list of qualified suppliers are determined and. In the last stage of the first step, the decision criteria are approved by decision-making team. After the approval of decision criteria, we assigned weights on them by organizing experts' sessions in the second step. In the last stage of this step, calculated weights of the criteria are approved by decision making team. Finally, ranks are determined, using TOPSIS method in the third step. Schematic diagram of the proposed model for weapon selection is provided in Figure 1.

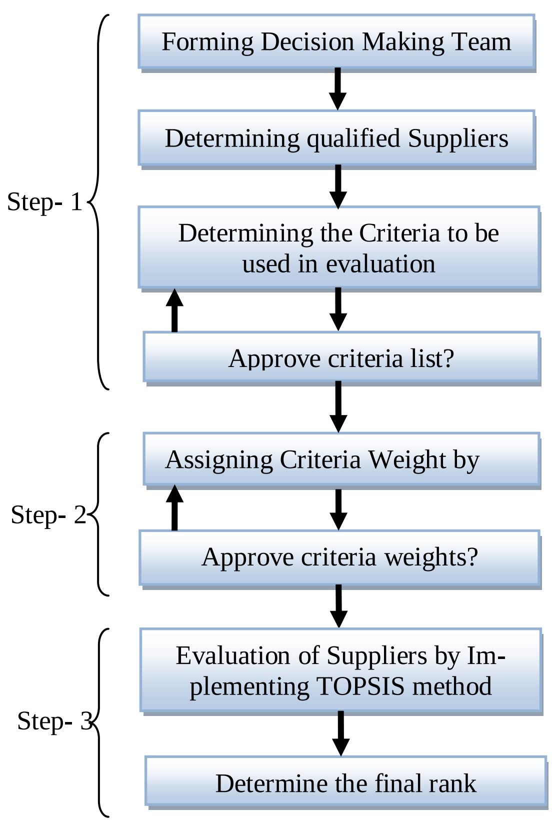

Figure1. Schematic diagram of the proposed methodology

Topsis Methods

TOPSIS method was introduced for the first time by Yoon and Hwang and was appraised by surveyors and different operators [3]. As large number of potential available vendors in the current marketing environment, a full ANP decision process becomes impractical in some cases. To avoid an unreasonably large number of pair-wise comparisons, we choose TOPSIS as the ranking technique because of its concept's ease of use. Also, ANP is adopted simply for the acquisition of the weights of criteria. First, a general TOPSIS process with six activities is listed below [2]:

ACTIVITY: 1) Establish a decision matrix for the ranking. The structure of the matrix can be expressed as follows:

$$\mathbf{D} = \begin{matrix} & \mathbf{F_1} & \mathbf{F_2} & \cdots & \mathbf{F_n} \\ \mathbf{B_1} \\ \cdots \\ \mathbf{B_n} \end{matrix} \begin{bmatrix} \mathbf{P_{11}} & \mathbf{P_{12}} & \cdots & \mathbf{P_{1n}} \\ \cdots & \cdots & \cdots & \cdots \\ \mathbf{P_{m1}} & \mathbf{P_{m2}} & \cdots & \mathbf{P_{mn}} \end{bmatrix} \qquad (1)$$

Where B_i denotes the alternatives i, i = 1...,m; F_j represents j^{th} attribute or criterion, j = 1...,n, related to i^{th} alternative; P_{ij} is a crisp value indicating the performance rating of each alternative B_i with respect to each criterion F_j.

ACTIVITY 2) Calculate the normalized decision matrix Q= $[S_{ij}]$. The normalized value s_{ij} is calculated as;

$$\mathbf{S_{ij}} = \frac{\mathbf{P_{ij}}}{\sqrt{\sum_{j=1}^{n} \mathbf{P_{ij}^2}}} \qquad i= 1\ldots..n;\ j= 1\ldots\ldots m \qquad (2)$$

ACTIVITY 3) Calculate the weighted normalized decision matrix by multiplying the normalized decision matrix by its associated weights. The weighted normalized value v_{ij} is calculated as:

$$V_{ij}= W_{ij}.S_{ij}\ , \qquad j= 1\ldots\ldots.n;\ i= 1\ldots\ldots\ldots m; \qquad (3)$$

Where w_j represents the weight of the jth attribute or criterion.

ACTIVITY 4) Determine the PIS and NIS, respectively:

$$\mathbf{V^{+}= \{v_1^{+}\ldots\ldots v_n^{+}\}}$$

$$\mathbf{= \{(Max\ vij\ \mid\ j \in J), (Min\ vij\ \mid\ j\ \in\ J')\}}$$

$$\mathbf{V^{-} = \{v_1^{-}\ \ldots\ldots\ v_n^{-}\}}$$

$$\mathbf{= \{(Min\ vij\ \mid\ j \in J), (Max\ vij\ \mid\ j\ \in\ J')\}}$$

Where J is associated with the positive criteria and J' is associated with the negative criteria.

ACTIVITY 5) Calculate the separation measures, using the m-dimensional Euclidean distance. The separation measure E_i^+ of each alternative from the PIS is given as:

$$\mathbf{E_i^+} = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2} \quad , i = 1……m \qquad (4)$$

Similarly, the separation measure E_i^- of each alternative from the NIS is as follows:

$$\mathbf{E_i^-} = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \quad , i = 1……m \qquad (5)$$

ACTIVITY 6) Calculate the relative closeness to the idea solution and rank the alternatives in descending order. The relative closeness of the alternative Ai with respect to PIS V+ can be expressed as:

$$\mathbf{H_i^*} = \frac{E_i^-}{E_i^+ + E_i^-} \qquad (6)$$

Where the index value of H_i* lies between 0 and 1. The larger the index value, the better the performance of the alternatives.

Numerical Problem

To apply this methodology, we have solved simulated numerical problem. Assume that the management of an Automobile industry wants to choose their best suppliers. Based on proposed methodology, 3 steps are applied for assessment and selection of suppliers. In this part we deal with application of these steps [3].

After forming decision making team, step 1 starts developing an updated pool of supplier selection criteria for the industry, using those accepted criteria given in the literature, as well as those criteria recommended by the experts. In this numerical example, the criteria are selected as shown in Table 1. Although, the criteria considered in supplier evaluation are condition-industry specific. Selection of criteria is totally industry specific and based on each case and the criteria are changed and replaced. Opinions of decision makers on criteria were aggregated and weights of all criteria have been calculated by organizing the expert meeting. Its results have Assuming 4 suppliers are included in the evaluation process, information of each of suppliers has been mentioned in Table 2. After normalizing information and considering weight of criteria in them, negative and positive separation measures, based on normalized Euclidean distance for each supplier is calculated and then final weight of each supplier is calculated [3].

Table 1. **Selecting criteria for supplier evaluation and Weight of criteria**

Code	Criteria	Weight (%)
D_1	(Material Quality)	0.20
D_2	(On time delivery)	0.08
D_3	(Ordering cost)	0.07
D_4	(Product price)	0.15
D_5	(Financial stability)	0.10
D_6	(Delivery lead time)	0.09
D_7	(Technical Capability)	0.07
D_8	(Transportation cost)	0.05
D_9	(Rejection of defective product)	0.08
D_{10}	(Production facilities and capacity)	0.11

Step-1 Developing decision matrix;

Table-2 Supplier's information

Criteria → Suppliers ↓	1	2	3	4
D_1 (%)	95	94	96	90
D_2 (%)	90	96	94	91
D_3 (□)	135	150	145	140
D_4 (□)	2800	3500	3000	3100
D_5 (Grad)	5	3	6	3
D_6 (Day)	12	15	14	10
D_7 (%)	46	52	38	40
D_8 (□)	650	470	550	700
D_9 (%)	.02	.03	.01	.02
D_{10} (Grad)	5	4	6	7

Step-2 Calculating the normalized decision matrix

$$S_{ij} = P_{ij} / \sqrt{\sum (P^2_{ij})}$$

Table-3

Criteria → Supplier ↓	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
1	0.51	0.49	0.47	0.45	0.56	0.47	0.52	0.54	0.47	0.45
2	0.50	0.52	0.53	0.56	0.34	0.58	0.59	0.39	0.71	0.36
3	0.51	0.51	0.51	0.48	0.68	0.54	0.43	0.46	0.24	0.53

4	0.48	0.49	0.49	0.50	0.34	0.39	0.45	0.58	0.47	0.62

Step-3 Calculating the weighted normalized decision matrix;

$$\mathbf{V_{ij}} = W_{ij}.\ S_{ij}$$

Table-4

Criteria → Supplier ↓	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
1	.1020	.0392	.0329	.0675	.0560	.0423	.0364	.0270	.0376	.0495
2	.1000	.0416	.0371	.0840	.0340	.0522	.0413	.0195	.0568	.0396
3	.1020	.0408	.0357	.0720	.0680	.0486	.0301	.0230	.0192	.0583
4	.0960	.0392	.0343	.0750	.0340	.0351	.0315	.0290	.0376	.0682

Step-4 Determining the PIS and NIS.

V^+ = {.1020, .0416, .0371, .0840, .0680, .0522, .0413, .0290, .0568, .0396}

V^- = {.0960, .0392, .0329, .0675, .0340, .0351, .0301, .0195, .0192, .0682}

Step-5 Calculating separation measure E_i^+

Table-5

Supplier	$\mathbf{E^+ = [\sum(V_j^+ - V_{ij})^2]^{1/2}}$
1	.0320
2	.0353
3	.0462
4	.0534

Calculating separation measure E_i^-

Table-6

Supplier	$\mathbf{E^- = [\sum(V_j^- - V_{ij})^2]^{1/2}}$
1	.0367
2	.0544
3	.0388
4	.0219

Step-6 Separation measures and the relative closeness coefficient;

Table-7

Suppliers	Closeness Coefficient $H_i^* = E^-/(E^- + E^+)$	Rank
Supplier 1	0.534	2
Supplier 2	0.606	1
Supplier 3	0.456	3
Supplier 4	0.290	4

Thereafter, the relative closeness coefficients are determined, and four suppliers are ranked. Obtained results have been mentioned in Table-7. Thus, supplier 2 has the best score amongst 4 suppliers.

Conclusion

For an automobile industry it is necessary to maintain the good coordination between management and supplier in terms of material quality, quantity, cost, and time By above mathematical treatment it is clear that the supplier selection for an automobile industry involves multiple criteria which show the important role in selection of suppliers. Technique for Order Preference by Similarity to Ideal Solution is a simple and understandable method for selecting a suitable supplier. Using this method we select the different alternatives according to the importance of different criteria. Thus, TOPSIS method used for different multi-criteria decision problems in a suitable manner.

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