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VENDOR SELECTION USING TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS) METHOD

Dinesh Singh[1], Dr. L.P. Singh[2]
[1]Research Scholar, Mechanical Engineering Department, SHIATS-Deemed University, Allahabad
E-mail: ram.dineshptpr@gmail.com[2], Asstt. Prof. Mechanical Engineering Department, SHIATS-Deemed University, Allahabad
E-mail: [1]psingh1976@gmail.com

Abstract

Supplier selection, in real situation, is affected by several qualitative and quantitative factors and is one of the most important activities of purchasing department. Since at the time of evaluating suppliers against the criteria or factors, decision makers (DMS) do not have precise, exact and complete information, supplier selection becomes more difficult. Here, we apply Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to evaluate and select the best supplier. Through this article, we compare TOPSIS with some other approaches and afterward demonstrate that the concept of TOPSIS is very important for ranking and selecting right supplier.

Keywords—TOPSIS, MADM, Supplier selection, Supplier selection problem, Supply chain management.

1. Introduction

In order to maintain a competitive position in the global market, organizations have to follow strategies to achieve shorter lead times, reduced costs and higher quality [1]. Therefore, suppliers play a key role in achieving corporate competitiveness, and as a result of this, selecting the right suppliers is a critical component of these new strategies [1]. Several conflicting quantitative and qualitative factors or criteria like cost, quality, delivery etc. affect supplier selection problem; therefore, it is a Multi-Attribute Decision Making (MADM) problem.

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 [2].

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).

2. Decision variables

As the competition among organizations has increased and customer demands have diversified in the global business environment, the manufacturing and logistics costs of the firms have been sharply increasing. One of the important issues among organizations is how to select good suppliers which can help in build up an efficient and profitable supply chain. Main criteria are identified which affect the vendor selection which are given below

a) Price of the goods or services

b) Lead time for delivery

c) Quality of the goods or service

d) Transportation Cost

e) Scope of the resources

f) Reputation of the supplier

g) Cultural barrier

h) Risk

i) Existing relationship

j) Additional value-added capability

The first four criteria – "price of the goods or services," "lead time for delivery," "quality of the goods or service," and "transportation cost" – are quantitative ones which can be optimized using multi-objective decision making methods. The other six criteria – "scope of the resources," "reputation of the supplier," "cultural barrier," "risk," existing relationship," and "additional value-added capability" – are non-quantitative criteria (qualitative criteria); rather, they are the attributes in the supply Chain problem and hence, can be optimized using multi-attribute decision making methods.

3. Steps in TOPSIS method

- Construct normalized decision matrix.
- Construct the weighted normalized decision matrix.
- Determine the ideal and negative ideal solutions.
- Calculate the separation measures for each alternative.
- Calculate the relative closeness to the ideal solution and then rank the preference order

Suppose we have m alternatives (options) and n attributes / criteria and we have the score of each option with respect to each criterion.

Let x_{ij} score of option i with respect to criterion j, we have a decision matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & . & . & x_{1m} \\ x_{21} & x_{22} & . & . & x_{2m} \\ . & . & . & . & . \\ . & . & . & . & . \\ x_{n1} & x_{n2} & . & . & x_{nm} \end{bmatrix} = (x_{ij}) \text{ m×n matrix.}$$

Let J be the set of benefit attributes or criteria (more is better)
Let J' be the set of negative attributes or criteria (less is better)

3.1 Normalized decision matrix

This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria. Normalize scores or data as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad \text{i=1, 2............m,} \quad \text{j= 1, 2.............n}$$

So we can get the normalized decision matrix *R*:

$$R = (r_{ij})n\times m = \begin{bmatrix} r_{11} & r_{12} & . & . & r_{1m} \\ r_{21} & r_{22} & . & . & r_{2m} \\ . & . & . & . & . \\ . & . & . & . & . \\ r_{n1} & r_{n2} & . & . & r_{nm} \end{bmatrix}$$

3.2 Weighted normalized decision matrix

Assume we have a set of weights for each criteria w_j for $j = 1,2 \ldots, n$.
Multiply each column of the normalized decision matrix by its associated weight.
An element of the new matrix is:

$$v_{ij}=w_j.r_{ij}$$

3.3 Ideal and negative ideal solutions

3.3.1 Ideal solution

$A^*=\{v_1^*,\ldots,v_n^*\}$,where:

$vj * = \{ \max((v_{ij}) \text{ if } j\in J; \ \min (v_{ij}) \text{ if } j\in J'\}$

3.3.2 Negative ideal solution

$A'=\{v_1',\ldots,v_n'\}$,where:

$v' = \{ \min (v_{ij}) \text{ if } j\in J \ ; \max (v_{ij}) \text{ if} \in J' \}$

3.4 Separation measures for each alternative

3.4.1 Separation from the ideal alternative is

$$s_i^* = \sqrt{\sum_j (v_j^* - v_{ij})^2}$$

3.4.2 Separation from the negative ideal alternative is

$$s_i' = \sqrt{\Sigma_j (v_j' - v_{ij})^2}$$

3.5 Relative closeness to the ideal solution C_I^*

$$c_i^* = s_i' / (s_i' + s_i^*), \quad 0 < c_i^* < 1$$

4. Case study

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. After forming decision making team, step 1 starts developing an updated pool of supplier selection criteria for the industry, as well as those criteria recommended by the experts. In this case study, the criteria are selected as shown in Table 1. 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.

4.1 Selecting criteria for supplier evaluation and weight

Table-1 Selecting criteria for supplier evaluation and Weight of criteria

Code	Criteria	Weight (%)
D1	Material quality	0.20
D2	On time delivery	0.08
D3	Ordering cost	0.07
D4	Product price	0.15
D5	Financial stability	0.10
D6	Delivery lead time	0.09
D7	Technical capability	0.07
D8	Transportation cost	0.05
D9	Rejection of defective product	0.08
D10	Production facilities and capacity	0.11

4.2 Decision matrix

Table-2 Supplier's information

Criteria Vendors	D1 (%)	D2 (%)	D3 (Rs)	D4 (Rs)	D5 (Grad)	D6 (Day)	D7 (%)	D8 (Rs)	D9 (%)	D10 (Grad)
A1	95	90	135	2800	5	12	46	650	.02	5
A2	94	96	150	3500	3	15	52	470	.03	4
A3	96	94	145	3000	6	14	38	550	.01	6
A4	90	91	140	3100	3	10	40	700	.02	7

4.3 Normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$

Criteria Vendor	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
A1	0.51	0.49	0.47	0.45	0.56	0.47	0.52	0.54	0.47	0.45
A2	*0.50*	0.52	0.53	0.56	0.34	0.58	0.59	0.39	0.71	0.36
A3	0.51	0.51	0.51	0.48	0.68	0.54	0.43	0.46	0.24	0.53
A4	0.48	0.49	0.49	0.50	0.34	0.39	0.45	0.58	0.47	0.62

4.4 Weighted normalized decision matrix

$$v_{ij} = w_j . r_{ij}$$

Criteria Vendor	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
A1	.1020	.0392	.0329	.0675	.0560	.0423	.0364	.0270	.0376	.0495
A2	.100	.0416	.0371	.0840	.0340	.0522	.0413	.0195	.0568	.0396
A3	.1020	.0408	.0357	.0720	.0680	.0486	.0301	.0230	.0192	.0583
A4	.0960	.0392	.0343	.0750	.0340	.0351	.0315	.0290	.0376	.0682

4.5 Determine the ideal and negative ideal solutions

4.5.1 Positive ideal solution:

A* = {.1020, .0416, .0371, .0840, .0680, .0522, .0413, .0290, .0568, .0396}

4.5.2 Negative ideal solution:

A' = {.0960, .0392, .0392, .0675, .0340, .0351, .0301, .0195, .0192, .0682}

4.6Calculate the separation measures for each alternative

4.6.1 The separation from the ideal alternative is:

Vendors	$s_i^{*}=\sqrt{\sum_j (v_j^{*} - v_{ij})^2}$
A1	.0320
A2	.0353
A3	.0462
A4	.0534

4.6.2 Similarly, the separation from the negative ideal alternative is:

Vendors	$s_i^{'}=\sqrt{\sum_j (v_j^{'} - v_{ij})^2}$
A1	.0367
A2	.0544
A3	.0388
A4	.0219

4.7 Relative closeness to the ideal solution c_i^{*}

Vendor	$c_i^{*}= s_i^{'}/(s_i^{'}+s_i^{*})$	Rank
A1	0.534	2
A2	0.606	1
A3	0.456	3
A4	0.290	4

Thus, vendor 2 has the best score amongst 4 vendors. Hence second vendor would be selected

5. Conclusion

For an 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 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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