Evaluation of Supplier Selection by using Topsis Methodology- A Case Study

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Abstract— Today's global operating environment, it is the conscientiousness of the organization to focus all its activities to meet the never-ending demands of the knowledge able customers. Hence, proper approaches from all the departments of the organization are required to achieve the objectives. One of the functions that attained a well-known place in the organizations these days is the supply chain management and a vital sub-function of this includes the supplier selection, which helps in achieving a low cost high Fuel Efficiency, on-time delivery of the products. The present work basically concentrates on this vital area of supplier selection which is a multi-criterion problem including both the qualitative and quantitative factors. The problem is dealt with the help of a case-study, where in many alternatives of selecting a supplier is done with TOPSIS Method, which is more reliable while going for a supplier selection.

Key words: Supply Chain Management, Multi-Criterion Problem, TOPSIS Method

I. INTRODUCTION

In most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70%. In such circumstances the purchasing department can play a key role in cost reduction, and supplier selection is one of the important functions of purchasing management. Several factors affect a supplier's performance. Hence it is a multi-criteria problem and it is necessary to make a tradeoff between conflicting tangible and intangible factors to find the best suppliers.

Basically there are two kinds of supplier selection problem:

1) Supplier selection when there is no constraint. In other words, all suppliers can satisfy the buyer's requirements of demand, Fuel Efficiency, delivery, etc.
2) Supplier selection when there are some limitations in suppliers' capacity, Fuel Efficiency, etc. In other words, no one supplier can satisfy the buyer's total requirements and the buyer needs to purchase some part of his/her demand from one supplier and the other part from another supplier to compensate for the shortage of capacity or low Fuel Efficiency of the first supplier.

In the first kind of supplier selection, one supplier can satisfy all the buyer's needs (Single Sourcing) and the management needs to make only one decision, which supplier is the best, whereas in the second type of supplier selection, as no supplier can satisfy all the buyer's requirements, more than one supplier has to be selected (Multiple Sourcing). In these circumstances management needs to make two decisions: which suppliers are the best, and how much should be purchased from each selected supplier?

Supplier selection process begins with the realization of the need for a new supplier; determination and formulation of decision criteria; pre-qualification (initial screening and drawing up a shortlist of potential suppliers from a large list); final supplier selection; and the monitoring of the suppliers selected (i.e. continuous evaluation and assessment).

It is generally agreed in the literature that the following makes the supplier selection decision-making process difficult and/or complicated

- Multiple criteria – both qualitative and quantitative
- Conflicts amongst criteria – conflicting objectives of the criteria
- Involvement of many alternatives – due to fierce competition
- Internal and external constraints imposed on the buying process

A. Multi- Criteria Decision Making

Multi- Criteria Decision Making is the most well-known branch of decision-making. It is a branch of a general class of Operations Research (or OR) models, which deal with decision problems under the presence of a number of decision criteria. According to many authors [2, 9, 13] MCDM is divided into Multi-Objective Decision Making (or MODM) and Multi-Attribute Decision Making (or MADM).

MODM studies decision problems in which the decision space is continuous. A typical example is mathematical programming problems with multiple objective functions. The first reference to this problem, also known as the "vector-maximum" problem. On the other hand, MCDM concentrates on problems with discrete decision spaces. In these problems the set of decision alternatives has been predetermined. Although MCDM methods may be widely diverse, many of them have certain aspects in common.

B. Alternatives:

Alternatives represent the different choices of action available to the decision maker. Usually, the set of alternatives is assumed to be finite, ranging from several to hundreds. They are supposed to be screened, prioritized and eventually ranked.

C. Multiple Attributes:

Each MCDM problem is associated with multiple attributes. Attributes are also referred to as "goals" or "decision criteria". Attributes represent the different dimensions from which the alternatives can be viewed.

1) Conflict among attributes:

Since different attributes represent different dimensions of the alternatives, they may conflict with each other. For instance cost may conflict with Power, etc.

D. Incommensurable Units:

Different attributes may be associated with different units of measure. For instance, in the case of buying a used car, the attributes "cost" and "mileage" may be measured in terms of dollars and thousands of miles, respectively. It is this nature of having to consider different units, which makes MCDM to be intrinsically hard to solve.

E. Decision Weights:

Most of the MCDM methods require that the attributes be assigned weights of importance. Usually, these weights are normalized to add up to one.

F. Decision Matrix:

An MCDM problem can be easily expressed in matrix format. A decision matrix A is an (M × N) matrix in which element a_{ij} indicates the performance of alternative *Ai* when it is evaluated in terms of decision criterion *Cj*, (for *i* = 1,2,3,..., *M*, and *j* = 1,2,3,..., *N*). It is also assumed that the decision maker has determined the weights of relative performance of the decision criteria (denoted as *Wj*, for *j* = 1, 2, 3, ..., *N*).

Alt	Criteria				
	C1	C2	C3	………	CN
POLO	$POLO_1$	$POLO_2$	$POLO_3$	………	$POLO_N$
A2	a_{21}	a_{22}	a_{23}	………	a_{2N}
A3	a_{31}	a_{32}	a_{33}	………	a_{3N}
:	:	:	:	:	:
AM	a_{M1}	a_{M2}	a_{M3}	………	a_{MN}

Table 1: Decision Matrix

II. METHODOLOGY

A. TOPSIS Method

TOPSIS (the Technique for Order Preference by Similarity to Ideal Solution) was developed by Hwang and Yoon (1981) as an alternative to the ELECTRE method. The basic concept of this method is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in a geometrical sense.

TOPSIS assumes that each attribute has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to locate the ideal and negative-ideal solutions. The Euclidean distance approach is used to evaluate the relative closeness of alternatives to the ideal solution. Thus, the preference order of alternatives is yielded through comparing these relative distances.

The TOPSIS Method includes the following steps

1) Step 1: Normalizing the Decision Matrix

Determine the normalized decision matrix (i.e. the matrix with suppliers' scores on the various criteria. Let x_{ij} be the numerical score of alternative *i* on criterion *j*. The corresponding normalized value r_{ij} is defined:

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

2) Step 2: Weighting the Normalized Decision Matrix

Determine the weighted normalized decision matrix. The weighted normalized value v_{ij} is defined as follows:

$$v_{ij} = w_j r_{ij},\ i = 1,2,\ldots,m;\ j = 1,2,\ldots,n$$

Where w_{ij} is the weight attached to criterion *j*.

3) Step 3: Determine Ideal Solution (A) & Negative Solution (A-)*

Determine the ideal and negative ideal alternative. The ideal alternative and the negative ideal alternative, denoted as A^* and A^- respectively, are defined as:

$$A^* = \{(\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J') \mid i = 1,2,\ldots,m\}$$
$$= \{v_1^*, v_2^*, \ldots, v_j^*, \ldots, v_n^*\}$$
$$A^- = \{(\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J') \mid i = 1,2,\ldots,m\}$$
$$= \{v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-\}$$

Where J and J' are benefit and cost criteria respectively.

4) Step 4: Separation of Aijfrom A (Si*) & from A- (Si-)*

In this step the distance s_i^+ between alternative *i* and A^* is determined, as well as the distance s_i^- between alternative *i* and A^-. In TOPSIS, the n-dimensional Euclidean distance is used to calculate these distances, hence

$$s_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, \; i = 1,2,\ldots,m$$

and

$$s_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \; i = 1,2,\ldots,m$$

5) Step 5: Determine Relative Closeness (Ci) of Aij w.r.t A*

Calculate the relative distance c_i^* to the ideal alternative, defined as:

$$c_i^* = \frac{s_i^-}{s_i^- + s_i^*}, \; 0 < c_i^* < 1, i = 1,2,\ldots,m$$

6) Step 6: Rank the alternatives

Rank the preference order.

III. CASE STUDY

In this project we have taken five different brands products to do the market analysis by using Technique of Order Preference by Similarity to Ideal Solution (TOPSIS) method.

A. Products:

- Volkswagen Polo C1
- Hyundai i20 C2
- Ford Figo C3
- Maruthi Suzuki Swift C4
- Tata Indica Vista C5

B. Criteria

- Cost
- Fuel Efficiency
- Power
- Features
- Service and Maintenance
- There are three modules in evaluating suppliers
  1) Weighting the criteria
  2) Constructing the decision matrix
  3) Solving the decision matrix using selected methodologies

Based on the evaluating modules by applying the TOPSIS Method the following results are drawn.

C. Acquired Decision Matrix &Standardization of Decision Matrix

Description	C1	C2	C3	C4	C5	
Cost	3.95	4.35	3.25	3.95	4.35	8.92
Fuel efficiency	3.2	3.75	2.7	3.85	4.15	7.97
Power	3.5	4.1	3.4	4.1	3.45	8.32
Features	3.85	4.65	3.6	3.6	3.35	8.57
Service and maintenance	3.65	3.75	1.75	3.85	4.7	8.20

Table 2: Acquired Decision Matrix &Standardization of Decision Matrix

1) Step1: Resultant Standardized Decision Matrix is

Description	**C1**	**C2**	**C3**	**C4**	**C5**
Cost	0.44	0.48	0.36	0.44	0.48

Fuel efficiency	0.40	0.47	0.34	0.48	0.52
Power	0.42	0.49	0.40	0.49	0.41
Features	0.44	0.54	0.42	0.42	0.39
Service and maintenance	0.44	0.45	0.21	0.46	0.57

Table 3: Resultant Standardized Decision Matrix

2) *Step 2: Construction of Weighted Standardized Decision Matrix*

Criteria	C1	C2	C3	C4	C5
Cost	2	4	5	4	5
Fuel efficiency	3	4	4	4	4
Power	3	4	4	4	3
Features	3	5	5	3	3
Service and maintenance	4	4	3	4	4

Table 4: Construction of Weighted Standardized Decision Matrix

a) Expert Review by Broadway

Weighted Standardized Value = Attributes Weight *Standardized Value

Weighted Standardized Matrix is

Description	C1	C2	C3	C4	C5
Cost	0.84	1.87	1.72	1.7	2.3
Fuel efficiency	1.12	1.72	1.24	1.77	1.90
Power	1.29	2.0	1.66	2.0	0.12
Features	1.3	2.65	2.05	1.22	1.19
Service and maintenance	1.67	1.72	0.61	1.77	2.16

Table 5: Weighted standardized matrix is

3) *Step 3: Determine the Ideal Solution and Negative Ideal Solution*

A set of maximum values for each criteria is ideal solution

Description	POLO	I20	FIGO	SWIFT	VISTA	Max. value (row)	Min. value (row)
Cost	0.84	1.87	1.72	1.7	2.3	2.3	0.84
Fuel efficiency	1.12	1.72	1.24	1.77	1.90	1.90	1.12
Power	1.29	2.0	1.66	2.0	0.12	2.0	0.12
Features	1.3	2.65	2.05	1.22	1.19	2.65	1.19
Service and maintenance	1.67	1.72	0.61	1.77	2.16	2.16	0.61

Table 6: maximum values for each criteria

Ideal solution = {2.3,1.90,2.0,2.65,2.16}

Negative ideal solution= {0.84,1.12,0.12,1.19,0.61}

4) *Step 4: Determine Separation from Ideal Solution .Si**

Description	C1	C2	C3	C4	C5
Cost	2.13	0.18	0.33	0.36	0
Fuel efficiency	0.6	0.03	0.43	0.01	0
Power	0.5	0	0.11	0	3.53
Features	1.82	0	0.36	2.04	2.13
Service and maintenance	0.24	0.19	2.4	0.15	0
s_i^*	2.3	0.63	1.90	1.6	2.37

Table 7: Determine Separation from Ideal Solution

5) *Step 5: Determine Separation from Negative Ideal Solution S_i'*

Description	C1	C2	C3	C4	C5
Cost	0	1.06	0.77	0.73	2.13
Fuel efficiency	0	0.36	0.01	0.42	0.60
Power	1.36	3.53	2.37	3.53	0
Features	0.01	2.13	0.73	0.0	0
Service and maintenance	1.12	1.23	0	1.34	2.4
S_i'	1.57	2.88	1.96	2.45	2.26

Table 8: Determine Separation from Negative Ideal Solution

6) *Step 6: Determine Relative Closeness To Ideal Solution,*

Criteria	POLO	I20	FIGO	SWIFT	VISTA
S_i*	2.3	0.63	1.90	1.6	2.37
S_i'	1.57	2.88	1.96	2.45	2.26
S_i*+S_i'	3.87	3.51	3.86	4.05	4.63
S_i'/(S_i*+S_i')	0.40	0.82	0.50	0.60	0.48

Table 9: Determine Relative Closeness To Ideal Solution

According to results obtained I20 is the best followed by VISTA, SWIFT, POLO and FIGO

IV. CONCLUSION

Supplier selection is one of the most important processes in supply chain and must be systematically considered from the decision makers. For this reason, researchers evaluate supplier selection for many years in a large framework consisting of various techniques from the experimental to the analytical ones and its successful applications were performed in numerous sectors.

A statistical data was used to exemplify the performance of three methods. TOPSIS method is not considering the relative distances from the ideal and negative ideal solution.

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