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Compared Evaluation of Vendor Selection Using Different Methods

K.B.G.Tilak, A.Venkata Vishnu, S.A. Mujeeb-Ur-Rehman
Department of Mechanical Engineering, NNRG, Hyderabad A.P. India

Abstract :In the era of highly competitive and global operating environment, it is the responsibility of the organization to focus all its activities to meet the never-ending demands of the knowledge able customers. Hence, holistic approaches from all the departments of the organization are required to achieve the objectives. One of the functions that attained a prominent 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 quality, 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 the help of linear weighing model technique is called the VIKOR method. This result is then compared with the results of the already existing traditional method called TOPSIS method, which is more reliable while going for a supplier selection.

Keywords - Supply Chain Management, Multi-Criterion Problem, VIKOR method, TOPSIS method, etc.

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, quality, delivery, etc.

(2) Supplier selection when there are some limitations in suppliers' capacity, quality, 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 quality 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 **technique is called the VIKOR method. This result is then compared with the results of the already existing traditional method called TOPSIS method, which is more reliable while going for a supplier selection.**

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.

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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

1.1. 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.

Alternatives:

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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.
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.
Conflict among attributes:
Since different attributes represent different dimensions of the alternatives, they may conflict with each other. For instance cost may conflict with profit, etc.
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.
Decision weights:
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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.
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
A1	a_{11}	a_{12}	a_{13}	………	a_{1N}
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}

Figure No. 1: Decision matrix

I. Methodology

1.1. VIKOR Method

The VIKOR method was developed to solve MCDM problems with conflicting and noncommensurable (different units) criteria. Assuming that compromising is acceptable for conflict resolution, the decision maker wants a solution that is the closest to the ideal. The alternatives are evaluated according to all established criteria. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria, and on proposing compromise solution (one or more).

The advantage of the VIKOR method, enabling to be applied in situations with multiple criteria. It follows from the use of the Lp metric in the compromising programming method. It can be described as follows:

$$L_{P,i} = \left\{ \sum_{j=1}^{n} \left[w_j \left(f_j^* - f_{ij} \right) / \left(f_j^* - f_j^- \right) \right]^p \right\}^{1/p}$$

where $1 \leq p \leq \infty$; $i = 1, 2, \ldots, m$.
W_j= weight criteria,
f_i^* = ideal solution points,
f_i^* = negative solution points,

The utility function of the VIKOR method is an aggregate of $L_{1,i}$ and $L_{\infty,i}$. $L_{1,i}$ is interpreted as 'concordance' and can provide decision makers with information about the maximum 'group utility' or 'majority'. Similarly, $L_{\infty,i}$ is interpreted as 'discordance' and provides decision makers with information about the minimum individual regret of the 'opponent'.

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information about the minimum individual regret of the 'opponent'.

Of the many MCDM tools, the VIKOR method has the following characteristics.

1. The best alternative determined by the VIKOR method is nearest to the ideal solution and farthest from the negative-ideal solution.
2. The best alternative according to the VIKOR method has the maximum group utility for decision makers and ensures the least regret.
3. The VIKOR method considers two weights in decision-making. One is that of the criteria, the other that of the maximum group utility.

The VIKOR method includes the following steps.

Step 1. Determine the normalized 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 f_{ij} is defined:

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

Step 2. Determine Ideal Solution (A^*) & Negative Solution (A^-)

Determine the ideal (nearest to the actual solution) and negative (farthest to the actual solution) ideal alternative. The ideal alternative and the negative ideal alternative, denoted as A^* and A^- respectively, are defined as:

$$A^* = \{(\max_i f_{ij} | j \in J),(\min_i f_{ij} | j \in J')|i=1,2,\ldots,m\}$$
$$= \{f_1^*, f_2^*,\ldots,f_j^*,\ldots,f_n^*\}$$
$$A^- = \{(\min_i f_{ij} | j \in J),(\max_i f_{ij} | j \in J')|i=1,2,\ldots,m\}$$
$$= \{f_1^-, f_2^-,\ldots,f_j^-,\ldots,f_n^-\}$$

Step 3. Calculate the utility measure(S_i) and the regret measure(R_i)

The utility measure and the regret measure for each alternative are given as

$$S_i = \sum_{j=1}^{n} w_j (f_i^* - f_{ij}) / (f_i^* - f_i^-)$$
$$R_i = \max_i \left[w_j (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right]$$

where Si and Ri represent the utility measure and the regret measure, respectively, and wj is the weight of the jth criterion.

Step 4. Calculate the VIKOR index.

The VIKOR index can be expressed as follows:

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*)$$

Where $S^* = \min_i S_i$, $S^- = \max_i S_i$,

$R^* = \min_i R_i$, $R^- \max_i R_i$

Step 5. Rank the order of preference

The alternative with the smallest VIKOR value is determined to be the best value.

1.1. 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.

$$R_i = \max_i \left[w_j (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right]$$

where Si and Ri represent the utility measure and the regret measure, respectively, and wj is the weight of the jth criterion.

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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

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:

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

Step 2. Weighting the Normalized Decision Matrix

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

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

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

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:

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

where J and J' are benefit and cost criteria respectively.
Step 4.separation of Aijfrom A^* (Si^*) & from A^- (S_i^-)
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

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

Step 5. Determine Relative Closeness (C_i^*) of A_{ij}w.r.t A
Calculate the relative distance c_i^* to the ideal alternative, defined as:

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

Step 6. Rank the alternatives
Rank the preference order.

II. Case study

Initially the survey process is conducted in a retailer shop Baid Electronics, Hyderabad. It is one of the largest retailer outlets. Altogether three products that are sold in BAID ELECTRONICS are chosen.
They are
1. Business PC'S (Product 1)
2. Home PC'S. (Product 2)
3. Networking PC'S. (Product 3)

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

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

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

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

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

Step 6. Rank the alternatives
Rank the preference order.

III. Case study

Initially the survey process is conducted in a retailer shop Baid Electronics, Hyderabad. It is one of the largest retailer outlets. Altogether three products that are sold in BAID ELECTRONICS are chosen.
They are
4. Business PC'S (Product 1)
5. Home PC'S. (Product 2)
6. Networking PC'S. (Product 3)

Altogether six brands are chosen for these three products. These six brands supply all the three products. They are:
1. Zenith …………………. A1
2. HP ……………………. A2
3. Acer ………............. A3
4. IBM ………………….. A4
5. Compaq - Presario …… A5
6. Wipro …………………. A6

Criteria for selecting Supplier:

1) Timely delivery (**TD**)
2) Quality (**QY**)
3) Profit (**PR**)
4) Proactive service (**PS**)
5) Replacement of unmoved stock (**RS**)

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 VIKOR Method and TOPSIS Method the following results are drawn.

IV. Results & Discussion

PRODUCT 1 (BUSINESS PC'S)

Table No.1. Results for the product 1

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	3	1
2	A2	2	4
3	A3	4	5
4	A4	1	2
5	A5	6	6
6	A6	5	3

PRODUCT 2 (HOME PC'S)

Table No.2. Results for the product 2

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	5	3
2	A2	2	4
3	A3	3	5
4	A4	1	1
5	A5	6	6
6	A6	4	2

PRODUCT 3 (NETWORKING PC'S)

Table No.3. Results for the product 3

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	5	5

2	A2	1	1
3	A3	3	3
4	A4	2	2
5	A5	6	6
6	A6	4	4

PRODUCT 1 (BUSINESS PC'S) WITH LIMITED SUPPLIER

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	3	1
2	A2	2	4
3	A3	4	5
4	A4	1	2
5	A5	6	6
6	A6	5	3

PRODUCT 2 (HOME PC'S)

Table No.2. Results for the product 2

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	5	3
2	A2	2	4
3	A3	3	5
4	A4	1	1
5	A5	6	6
6	A6	4	2

PRODUCT 3 (NETWORKING PC'S)

Table No.3. Results for the product 3

S.NO	SUPPLIERS	VIKOR METHOD	TOPSIS METHOD
1	A1	5	5
2	A2	1	1
3	A3	3	3
4	A4	2	2
5	A5	6	6
6	A6	4	4

PRODUCT 1 (BUSINESS PC'S) WITH LIMITED SUPPLIER

Table No.4. Results for the product 1

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	1
2	A2	1	4
3	A3	4	2
4	A4	3	3

PRODUCT 2 (HOME PC'S) WITH LIMITED SUPPLIER

Table No.5. Results for the product 2

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	4
2	A2	4	1
3	A3	1	2
4	A4	3	3

PRODUCT 3 (NETWORKING PC'S) WITH LIMITED SUPPLIER

Table No.6. Results for the product 3

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	2
2	A2	4	4
3	A3	1	1
4	A4	3	3

From the results it is found out that,

- In case of PRODUCT 1, Table No.1, VIKOR method is giving supplier IBM (A4) is better compared to all. TOPSIS method is giving supplier zenith (A1) is better compared to all.

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	1
2	A2	1	4
3	A3	4	2
4	A4	3	3

PRODUCT 2 (HOME PC'S) WITH LIMITED SUPPLIER

Table No.5. Results for the product 2

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	4
2	A2	4	1
3	A3	1	2
4	A4	3	3

PRODUCT 3 (NETWORKING PC'S) WITH LIMITED SUPPLIER

Table No.6. Results for the product 3

S.NO	SUPPLIER	VIKOR METHOD	TOPSIS METHOD
1	A1	2	2
2	A2	4	4
3	A3	1	1
4	A4	3	3

From the results it is found out that,

- In case of PRODUCT 1, Table No.1, VIKOR method is giving supplier IBM (A4) is better compared to all. TOPSIS method is giving supplier zenith (A1) is better compared to all.
- In case of PRODUCT 2, Table No.2, best and worst alternatives suggested by two methods are same but remaining alternatives are different and the supplier IBM (A4) is better compared to all.
- In case of PRODUCT 3, Table No.3, best and worst alternatives suggested by two methods are same and the supplier HP (A2) is better compared to all.
- In case of PRODUCT 1, Table No.4, VIKOR method is giving supplier ACER (A2) is better compared to all. TOPSIS method is giving supplier zenith (A1) is better compared to all.
- In case of PRODUCT 2, Table No.5, VIKOR method is giving supplier COMPAQ (A3) is better compared to all. TOPSIS method is giving supplier ACER (A2) is better compared to all.
- In case of PRODUCT 3, Table No.6, best and worst alternatives suggested by two methods are same and the supplier COMPAQ (A3) is better compared to all.

V. 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.

This work proposed a unique approach called VIKOR Method for supplier selection by considering the concordance, discordance and maximum group utility. The VIKOR method for supplier selection presented in this research allows for comprehensive evaluation of supplier performance by estimating ideal, negative solution, utility and regret measures.

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. But VIKOR method overcomes these limitations. So we can rely on the results of VIKOR method.

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