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Supplier Selection by Using Multi Criteria Decision Making Methods

P.Murali[1], V. Diwakar Reddy[2], A. Naga Phaneendra[3]

Department of Mechanical Engineering, Sri Venkateswara University college of Engineering, Tirupati, India

Email – muralikrishna.781@gmail.com; phani.34suriya@gmail.com

Abstract— In the present study an efficient multi criteria decision making (MCDM) approach has been proposed for quality evaluation and performance appraisal in supplier selection. Supplier selection is a multi-criteria decision making problem influenced by multiple performance criteria.These criteria's/attributes may be both qualitative as well as quantitative .Qualitative criteria estimates are generally based on previous experience and expert opinion on a suitable conversion scale.This conversion is based on human judgment.Therefore predicted result may not be accurate always because the method does not explore real data.These are analyzed by TOPSIS(Technique for order preference similarity to ideal solution), PROMETHEE(Preference Ranking Organization Method for Enrichment Evaluations) etc. In solution of MCDM problems there should be a common trend is to convert quantitative criteria values into an equivalent single performance index called Multi attribute performance index. MCDM methods helps to choose the best alternatives where many criteria have come into existence ,the best one can be obtained by analyzing the different scope for the criteria, weights for the criteria.

Keywords— Supplier Selection, MCDM, Qualitative, Quantitative, Weights for the Criteria,Multi attribute performance index, TOPSIS,PROMETHEE.

INTRODUCTION

In any Industry decisions are being made from various criteria's, so the decision can be made by providing weights are obtain from expert groups. MCDM is pertaining to structure and solve decision and planning problems involving multiple criteria [1].The main objective of this survey is to support decision makers where there are huge choices exist for a problem to be solved. This survey on multi criteria decision understands the need of MCDM,many works have been proposed in determining the best optimal solution for a problem using different methods in it.

PROPOSED METHODOLOGIES

The proposed methodology for supplier selection problem, composed of TOPSIS method, consists of three Steps .They are as follows:
(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 deter-mined 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 deter-mined, using TOPSIS method in the third step.

TOPSIS METHOD

TOPSIS(Technique for order preference similarity to ideal solution) method was introduced for the first time by Yoon and Hwang and was appraised by surveyors and different operators. As large number of potential available vendors in the current marketing environment, a full ANP (Analytic Network Process) decision process becomes impractical in some cases [11]. To avoid an unreasonably large number of pair-wise comparisons, we choose TOPSIS as the ranking technique because of its concepts ease of use. A general TOPSIS process with six activities is listed below.

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

$$D = \begin{array}{c} \\ B_1 \\ \dots \\ B_n \end{array} \begin{array}{c} F_1 \quad F_2 \quad \dots \quad F_n \\ \begin{pmatrix} P_{11} & P_{12} & \dots & P_{1n} \\ \dots & \dots & \dots & \dots \\ P_{m1} & P_{m2} & \dots & P_{mn} \end{pmatrix} \end{array} \quad \text{--------------------------} \quad (1)$$

Where Bi 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.

STEP 2: Calculate the normalized decision matrix Q= [S_{ij}]. The normalized value $S_{ij}$is calculated as

$$S_{ij} = \frac{P_{ij}}{\sqrt{\sum_{j=1}^{n} {P_{ij}}^2}} \quad \textbf{i=1....n;j=1......m} \quad \textbf{------------------ (2)}$$

STEP 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:

$V_{ij}=W_{ij*}S_{ij,}$ J=1……n;i=1……….m; ------------ (3)

Where w_j represents the weight of the j^{th} attribute or criterion.

STEP 4: Determine the PIS (Positive Ideal Solution) and NIS (Negative Ideal Solution) respectively:

$V^+= (v_1^+ \dots\dots v_n^+) = ((\text{Max } v_{ij} \ {}_1 \ j \in J),(\text{Min } v_{ij} \ 1 \ j\in J1))$

$V^- =(v_1^- \dots\dots\dots v_n^-) = ((\text{Min } v_{ij} \ 1 \ j\in J),(\text{Max } v_{ij} \ 1 \ j \in J^1))$

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

STEP 5: Calculate the separation measures, using the m-dimensional Euclidean distance. The separation measureEi+ of each alternative from the PIS is given as:

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

Similarly, the separation measure $Ei-$ of each alternative from the NIS is as follows:

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

STEP 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:

$$H_i^{\ *} = \frac{\varepsilon_i^{\ -}}{\varepsilon_i^{\ +} + \varepsilon_i^{\ -}} \text{---------} \quad (6)$$

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

CASESTUDY

To apply this methodology, we have solved simulated numerical problem. Assume that the management of Lanco industry Srikalahasthi wants to choose their best suppliers. Based on proposed methodology, three 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, 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.

Table 1. Selecting criteria for supplier evaluation and Weight

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

Step-1 developing decision matrix;

Table2. Supplier's information

Criteria Suppliers	1	2	3	4
D1 (%)	95	94	96	90
D2 (%)	90	96	94	91
D3 (₹)	135	150	145	140
D4 (₹)	2800	3500	3000	3100
D5 (Grad)	5	3	6	3
D6 (Day)	12	15	14	10
D7 (%)	46	52	38	40
D8 (₹)	650	470	550	700
D9 (%)	0.02	0.03	0.01	0.02
D10(Grad)	5	4	6	7

Step-2 Calculating the normalized decision matrix

$$S_{ij} = \frac{P_{ij}}{\sqrt{\sum P_{ij}^{\,2}}}$$

Table 3. Normalized decision matrix information of Suppliers

SupplierCriteria	1	2	3	4
D1	0.51	0.50	0.51	0.48
D2	0.49	0.52	0.51	0.49
D3	0.47	0.53	0.51	0.49
D4	0.45	0.56	0.48	0.50
D5	0.56	0.34	0.68	0.34
D6	0.47	0.58	0.54	0.39
D7	0.52	0.59	0.43	0.45
D8	0.54	0.39	0.46	0.58
D9	0.47	0.71	0.24	0.47
D10	0.45	0.36	0.53	0.62

Step-3 calculating the weighted normalized decision matrix;

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

Table 4. Weighted normalized decision matrix information of Suppliers

Criteria Supplier	1	2	3	4
D1	0.1020	0.1000	0.1020	0.0960
D2	0.0392	0.0416	0.0408	0.0392
D3	0.0329	0.0371	0.0357	0.0343
D4	0.0675	0.0840	0.0720	0.0750
D5	0.0560	0.0340	0.0680	0.0340
D6	0.0423	0.0522	0.0486	0.0351
D7	0.0364	0.0413	0.0301	0.0315
D8	0.270	0.0195	0.0230	0.0290
D9	0.0376	0.0568	0.0192	0.376
D10	0.0495	0.0396	0.0583	0.0682

Step-4 Determining the PIS (Positive Ideal Solution) and NIS (Negative Ideal Solution).

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

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

Step-5 Calculating separation measure $Ei+$Calculating separation measure $Ei-$

Table 5. Positive separation measure of Suppliers

Supplier	$E_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^{+})^2}$
1	0.0320
2	0.0353
3	0.0462
4	0.0534

Table 6. Negative separation measure of Suppliers

Supplier	$E_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^{-})^2}$
1	0.0367
2	0.0544
3	0.0388
4	0.0219

Step-6 Separation measures and the relative closeness coefficient;

RESULTS

Table 7. Relative Closeness Coefficient of Suppliers

Suppliers	Closeness Coefficient $H_i^* = \frac{\varepsilon_i^-}{\varepsilon_i^+ + \varepsilon_i^-}$	Rank
Supplier 1	0.534	2
Supplier 2	0.606	1
Supplier 3	0.456	3
Supplier 4	0.290	4

Therefore, 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.

PROMETHEE METHOD

STEP 1: Normalize the decision matrix using the following equation:

Rij= [Xij-min(Xij)] / [max(Xij)-min(Xij)]
(i=1,2,3……, j=1,2….m) -------- (7)
Where Xij is the performance measure of i^{th} alternative with respect to j^{th} criteria.

STEP 2: Calculate the evaluative difference of i^{th} alternative with respect to other alternative. This step involves the calculation of differences in criteria values between different alternative pairwise.

STEP 3: Calculate preference function, P_j (i, i')
P_j (i, i') =0 if R_{ij}<=Ri'j
P_j (i, i')= (Rij-Ri'j) if Rij >Ri'j

STEP 4: The aggregate preference function taking in to accountthe criteria weight.
Aggregate preference function,
m m
Π(i,i')= [Σ W_j * P_j (i ,i')] / Σ W_j --------------- (8)
j=1 j=1
Where W_j is the relative importance (weight) of j^{th} criteria

STEP 5: Determine the leaving and entering outranking flows as follows:
Leaving or positive flow for i^{th} alternative
n
ϕ+ (i) = 1/n-1 Σ Π(i,i') (i is not equal to i')
i'=1 ---------------------------- (9)
Entering or negative flow for i^{th} alternative
n
ϕ- (i)= 1/n-1 Σ Π(i,i') (i is not equal to i')
i'=1 ----------------------- (10)
Where n is the number of alternatives.

Here each alternative faces (n-1) other alternatives. The leavingflow express how much an alternative dominates the other alternative,while the entering flow denotes how much an alternative's dominated by other alternatives. Based on these outrankingflows, the PROMETHEE-1 method provide a partial preorderof the alternatives, whereas the PROMETHEE-2 method give the complete pre order by using the net flow, though it losses much information of preference relations.

Calculate the net outranking flow for each alternative.

$\phi(i) = \phi^{+}(i) - \phi^{-}(i)$-------------------------- (11)

Determine the ranking of all the considered alternatives depending on the values of ϕ (i). The higher value of ϕ (i), the better is alternative.Thus the best alternative is the one having the highest ϕ (i) value.

CASE STUDY

As a case study, the supplier selection problem in a Lanco IndustrySrikalahasthi has been studied.The attributes for supplier selection are cost (Rs), insertion loss(db), volume (cc), and Weight (kg). The targeted values of eachcriterion correspond to the elements of reference data series for comparison [9]. The target to minimize cost, achieve high insertionloss and less volume, less weight. For cost, volume and weightlower the better criteria (LB) and for insertion loss higher thebetter criteria (HB) have been selected.

Table 8.Objective data for supplier selection problem

Supplier Criteria	Cost (Rs)	Insertion Loss(db)	Volume (cc)	Weight (Kg)
Supplier 1	0.590	0.745	0.500	0.500
Supplier 2	0.745	0.665	0.745	0.745
Supplier 3	0.590	0.745	0.590	0.665
Supplier 4	0.590	0.665	0.590	0.590

Table 9. Normalized decision matrix

Supplier Criteria	Cost (Rs)	Insertion Loss(db)	Volume (cc)	Weight (kg)
Supplier 1	0	1	0	0
Supplier 2	1	0	1	1
Supplier 3	0	1	0.3673	0.6734
Supplier 4	0	0	0.3673	0.6734

Table 10. Preference functions for all the pairs of alternative

Suppliers pair Criteria	Cost (Rs)	Insertion Loss(db)	Volume (cc)	Weight (Kg)
(1,2)	0	1	0	0
(1,3)	0	0	0	0
(1,4)	0	1	0	0
(2,1)	1	0	1	1
(2,3)	1	0	0.6327	0.3266
(2,4)	1	0	0.6327	0.6327
(3,1)	0	0	0.3627	0.6734
(3,2)	0	1	0	0
(3,4)	0	0	0	0.3061
(4,1)	0	0	0.3673	0.3673
(4,2)	0	0	0	0
(4,3)	0	0	0	0

Table 11. Aggregate preference function

Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Supplier 1	-	0.300	0	0.300
Supplier 2	0.700	-	0.57859	0.61074
Supplier 3	0.1214	0.300	-	0.03214
Supplier 4	0.08926	0	0	-

Table 12. Leaving and Entering flows for different supplier

Suppliers	Leaving Flow	Entering Flow
Supplier 1	0.200	0.30355
Supplier 2	0.62978	0.2000
Supplier 3	0.15118	0.19286
Supplier 4	0.02975	0.31429

RESULTS

Table 13. Net Outranking Flow values for different supplier

Suppliers	Net out Ranking Flow	Supplier Ranking
Supplier 1	0.1036	3
Supplier 2	0.4298	1
Supplier 3	0.0417	4
Supplier 4	0.2846	2

Therefore, Net out Ranking Flow for different Suppliers are determined, and four Suppliers are ranked. Thus Supplier 2 has best score amongst 4 Suppliers.

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. It allows the decision makers to rank the candidate alternative more efficiently and easily. The present study explores the use of PROMETHEE and TOPSIS methods in solving a supplier selection problem and the results obtained can be valuable to the decision maker in framing the supplier selection strategies.

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