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Implementation of TOPSIS Method for Multi Criteria Decision Making of Supplier Selection

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ABSTRACT

In this study an efficient multi criteria decision making (MCDM) approach has been used for quality appraisal and performance assessment in supplier selection. Supplier selection is a multi-criteria decision making problem predisposed by multiple performance measures. These 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). For solving 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.

Key words: Supplier Selection, MCDM, Qualitative, Quantitative, TOPSIS

INTRODUCTION

In any Industry decisions are being made from various criteria's, so the decision can be made by providing weights are obtained from expert groups. MCDM is pertaining to structure and solve decision and planning problems involving multiple criteria [1]. To analysis the cost the MOLP method and the Multi Criteria Decision making tools (MCDM) have been included in the paper of Sultana et.al (2016) to take the decision and to select the suppliers more accurately and makes a reflection on the effective suppliers selection criteria like supplier reliability, product quality and supplier experience etc. And also suggests on the most quantitative results on cost effective methods and supplier selection approaches [2]. The main objective of this survey is to support decision makers where there are huge choices exist for a problem to be solved. The 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. Kambiz Shahroudi and Hajar Rouydel et al took approaches in AHP/FAHP -TOPSIS and MOLP related problem in the year of 2012 1nd 2013 [3-4]. Yayla *et al* utilized the fuzzy TOPSIS method to select the most appropriate supplier of garment 'X' operating in Turkey. The ranking were determined by firm in terms of closeness index values: supplier 1, supplier 2 and supplier 3 [22]. Shahroudi *et al* applied TOPSIS to evaluate suppliers in supply chain cycle based on various variables and effective criteria [23]. Hüseyin *et al* performed a case study in a filter company to identify the best supplier considering four criteria- quality, cost, delivery time and institutionalization by applying the steps of fuzzy TOPSIS [24]. Singh *et al* applied Fuzzy TOPSIS for selection of suppliers in supply chain cycle in an automobile industry. They provided weights to each criterion. By using these weights every supplier were provided rank [25]. Das *et al* proposed an application of weighted type-2 fuzzy multi-attribute decision making method based TOPSIS on supplier selection in a risk oriented supply chain. Eight risks-evaluative attributes namely, Performance risk, Demand risk, Environmental risk, Process risk and Logistics risks were taken for selection among three supplier alternatives. The proposed method remarkably reduced the degree of computation required for constructing the average decision matrix and weighted decision matrix of attributes enhancing Lee and Chen' ranking value approach of trapezoidal interval type-2 fuzzy sets in selection of alternatives [26]. Zahar *et al* proposed fuzzy TOPSIS method and supporting software for the selection of appropriate artificial hip prosthesis suppliers in the Orthopaedic Clinic of Kragujevac Medical Center, Serbia. The proposed method dealt with the rating of both quantitative and qualitative criteria and selected a suitable supplier effectively. The relative importance of criteria was described by linguistic expressions which are modelled by fuzzy sets. These values were calculated by using method of average value. All uncertainties and imprecision were modelled by triangular fuzzy numbers [27]. Öztürk *et al* applied Fuzzy TOPSIS method for the performance evaluation and selection of an appropriate sustainable supplier of an energy company [28]. Haoran *et al* mainly focused on the conceptual, descriptive and simulation. They attempted to identify the factors which have impact on the distribution cost and the selection for better distributors in an agricultural enterprise in China based on quantitative method fuzzy TOPSIS [29].

METHODOLOGIES

The 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, to variables are recognize 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, weights are assigned 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 [13]. 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.

Step 2: Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as follows:

$$r_{ij} = x_{ij}\sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad \text{i =1, 2, ..., m and j = 1, 2, ..., n…………………} \qquad (1)$$

Step 3: Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as follows:

$$v_{ij} = r_{ij} \times w_j \quad \text{i =1, 2,..., m and j = 1, 2, ..., n.} \qquad (2)$$

where w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 4: Determine the ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,...,m\} \qquad (3)$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,...,m\} \qquad (4)$$

Step 5: Calculate the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2}, \; j = 1,2,...,m \qquad (5)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}, \; j = 1,2,...,m \qquad (6)$$

Step 6: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i with respect to A^* is defined as follows:

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1,2,...,m \qquad (7)$$

Step 7: Rank the preference order.

Case Study

To apply this methodology, a simulated numerical problem has solved. Assume that the management of 'X' industry wants to choose their best suppliers. Based on proposed methodology, three steps are applied for assessment and selection of suppliers. In this part with application of these steps were dealt. 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(%)
C1	product price	0.16
C2	ordering cost	0.06
C3	logistics cost	0.05
C4	material quality	0.15
C5	responsiveness of product quality	0.06
C6	rejection of defective product	0.07
C7	flexibility in production	0.03
C8	manufacturing capability	0.09
C9	technological capability	0.06
C10	on time delivery service	0.07
C11	delivery lead time	0.05
C12	sharing of information	0.03
C13	financial capability	0.06
C14	financial stability	0.04
C15	work safety and labor health	0.02

Step-1 developing decision matrix

Table - 2 Suppliers Information

Criteria of Suppliers	No of suppliers			
	1	**2**	**3**	**4**
C1(BDT)	2324	2905	2490	2573
C2(BDT)	114.54	124.5	120.35	116.2
C3(BDT)	540	390	460	580
C4(%)	92	90	95	90
C5(%)	90	89	92	93
C6(%)	0.01	0.03	0.01	0.02
C7(Grad)	5	6	4	7
C8(Grad)	4	5	7	6
C9(%)	38	40	50	46
C10	96	91	95	90
C11(Day)	13	16	11	10
C12	6	7	5	4
C13	95	92	96	91
C14(Grad)	5	3	6	3
C15	82	84	80	75

Step-2 Calculating the normalized decision matrix

Table -3 Normalized Decision Matrix Information of Suppliers

Criteria of suppliers	**Suppliers**			
	1	**2**	**3**	**4**
C1(BDT)	0.450093	0.562617	0.482243	0.498318
C2(BDT)	0.481421	0.523284	0.505841	0.488398
C3(BDT)	0.542255	0.391629	0.461921	0.582422
C4(%)	0.501238	0.490341	0.517582	0.490341
C5(%)	0.494431	0.488937	0.505418	0.510912
C6(%)	0.258199	0.774597	0.258199	0.516398
C7(Grad)	0.445435	0.534522	0.356348	0.62361
C8(Grad)	0.356348	0.445435	0.62361	0.534522
C9(%)	0.434179	0.457031	0.571289	0.525586
C10(%)	0.515935	0.489064	0.510561	0.483689
C11(Day)	0.511478	0.629512	0.432789	0.393445
C12(%)	0.534522	0.62361	0.445435	0.356348
C13(%)	0.507898	0.491859	0.513244	0.486513
C14(Grad)	0.562544	0.337526	0.675053	0.337526
C15(%)	0.51046	0.52291	0.49801	0.466884

Step-3 calculating the weighted normalized decision matrix;

Table – 4 Weighted Normalized Decision Matrix Information of Suppliers

Criteria of suppliers	**Suppliers**			
	1	**2**	**3**	**4**
C1(BDT)	0.072015	0.090019	0.077159	0.079731
C2(BDT)	0.028885	0.031397	0.03035	0.029304
C3(BDT)	0.027113	0.019581	0.023096	0.029121
C4(%)	0.075186	0.073551	0.077637	0.073551
C5(%)	0.029666	0.029336	0.030325	0.030655
C6(%)	0.018074	0.054222	0.018074	0.036148
C7(Grad)	0.013363	0.016036	0.01069	0.018708
C8(Grad)	0.032071	0.040089	0.056125	0.048107
C9(%)	0.026051	0.027422	0.034277	0.031535
C10(%)	0.036115	0.034234	0.035739	0.033858
C11(Day)	0.025574	0.031476	0.021639	0.019672
C12(%)	0.016036	0.018708	0.013363	0.01069
C13(%)	0.030474	0.029512	0.030795	0.029191
C14(Grad)	0.022502	0.013501	0.027002	0.013501
C15(%)	0.010209	0.010458	0.00996	0.009338

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

Table -5 Determined PIS and NIS

A^*	A^-
0.072015	0.090019
0.028885	0.031397
0.019581	0.029121
0.077637	0.073551
0.030655	0.029336
0.054222	0.018074
0.018708	0.01069
0.056125	0.032071
0.034277	0.026051
0.036115	0.033858
0.019672	0.031476
0.018708	0.01069
0.030795	0.029191
0.027002	0.013501
0.010458	0.009338

Step-5 Calculating separation measure

Table – 6 Positive Separation Measure of Supplier

Suppliers	Si+
1	0.045908451
2	0.031415659
3	0.038011199
4	0.02865958

Table – 7 Negative Separation Measure of Supplier

Suppliers	Si-
1	0.022278118
2	0.039473976
3	0.034049411
4	0.030486913

Step-6 Separation measures and the relative closeness coefficient.

RESULTS

Table -8 Relative closeness Coefficient of suppliers

Suppliers	Pi	Rank
2	0.556837062	1
3	0.472510726	3
4	0.515447515	2

Therefore, the relative closeness coefficients are determined, and four suppliers are ranked. Obtained results have been mentioned in Table-8. Thus, supplier 2 has the best score amongst 4 suppliers.

CONCLUSION

For an Industry it is necessary to maintain the upright harmonization between organization and provider in terms of material quality, quantity, cost and time. By above exact treatment it is clear that the supplier selection for an Industry encompasses multiple criteria which show the significant role in selection of suppliers. It allows the decision makers to rank the candidate alternative more efficiently and easily. Solving a supplier selection problem and the results obtained can be valuable to the decision maker in framing the supplier selection strategies by exploring the present study with the use of TOPSIS methods.

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