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APPLICATION OF TOPSIS: A MULTIPLE CRITERIA DECISION MAKING APPROACH IN SUPPLIER SELECTION

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ABSTRACT

Selection of suppliers is not based on cost only. It involves many criteria. Techniques to deal with multi-criteria have been proposed by many researchers. This paper demonstrates the application of one of the multi-criteria decision making (MCDM) technique for supplier selection in a semi-conductor industry. TOPSIS, the MCDM approach, is very effective and gives better result. Future research areas for decision making have been suggested.

Keywords*: *Ideal Solution, MCDM, Supplier Selection, TOPSIS,

I. INTRODUCTION

Supplier selection has been an important aspect for any manufacturing firm as most of the components are to be outsourced to reduce cost. But, selection of supplier on the basis of cost is not the only purpose in real-world situation. There are many factors which needs to be considered while selection. So selection phase is a multi-criteria decision making (MCDM). There are many MCDM techniques in literature such as AHP, ANP, ELECTRE, TOPSIS, and PROMETHEE [1].Among these techniques, Technique for order preference by similarity to ideal solution (TOPSIS) method is simple and easy to perform in lesser time and calculation and stability is better (Application of MOORA) [2]. So this paper shows the application of TOPSIS method for a case study. TOPSIS, developed by Hwang and Yoon in 1981 [3], is used to rank the alternatives based on different criteria.TOPSIS method provides two artificial alternatives. One is “ideal best” and other is “ideal worst”. Based on these two alternatives, other alternatives are ranked. According to this technique, the best alternative would be the one that is closest to the positive-idealsolution and farthest from the negative-ideal solution. The positive-ideal solution is one thatmaximizes thebenefit criteria and minimizes the cost criteria. The negative-ideal solution maximizes the cost criteria andminimizes the benefit criteria. In summary, the positive-ideal solution iscomposed of all best values attainableof criteria, and the negative-ideal solution consists of all the worst values attainable of criteria[4].TOPSIS makes full use of attribute information, provides a cardinal ranking of alternatives, and does not require attribute preferences to be independent [5]. Steps for TOPSIS procedure have been shown in fig 1 [5 and 3]:

Step 1: Construct normalized decision matrix

$$r_{ij} = x_{ij}/\sqrt{(\Sigma x^2_{ij})} \quad \text{for} \quad i = 1, \ldots, m; \; j = 1, \ldots, n \quad (1)$$

where x_{ij} and r_{ij} are original and normalized score of decision matrix , respectively

Step 2: Construct the weighted normalized decision matrix

$$v_{ij} = w_j \, r_{ij} \qquad (2)$$

where w_j is the weight for j criterion

Step 3: Determine the positive ideal and negative ideal solutions.

$$A^* = \{ v_1^*, \ldots, v_n^* \}, \quad (3) \quad \text{Positive ideal solution}$$

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

$$A' = \{ v_1', \ldots, v_n' \}, \quad (4) \quad \text{Negative ideal solution}$$

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

Step 4: Calculate the separation measures for each alternative.

The separation from positive ideal alternative is:

$S_i^* = [\Sigma (v_i^* - v_{ij})^2]^{½} \; i = 1, \ldots, m(5)$

Similarly, the separation from the negative ideal alternative is:

$S'_i = [\Sigma (v_j' - v_{ij})^2]^{½} \quad i = 1, \ldots, m \, (6)$

Step 5: Calculate the relative closeness to the ideal solution C_i^*

$$C_i^* = S'_i / (S_i^* + S'_i) , \quad (7) \quad 0 < Ci^* < 1$$

Select the Alternative with C_i^* closest to 1.

Fig 1: Stepwise Procedure for Performing TOPSIS Methodology [5 and 3]

II. CASE STUDY

TOPSIS have been applied for a case of Taiwan's semiconductor industry for supplier selection as shown in table 1 [6]. Four dimensions were taken namely Delivery management capability (D), Quality management capability (Q), Price (P) and Service (S). Y.T. Lin et.al. 2010 [6] considered D, Q and S as value related dimension. They assumed price and value related dimension as independent. In their proposed model, ANP was used to derive the weightings based on these interrelationships among different factors for these 4 dimensions. Total 14 factors were considered under these 4 dimensions for selection of 5 different suppliers. The final ranking of all alternatives (the 5 qualified vendors) were calculated by synthesizing the scores of each alternative under the 4 (D, Q, S, P) dimensions and 14 criteria in the proposed model byY.T. Lin et.al [6]. In this paper, TOPSIS method has been applied for the case study. Table 2 represents the normalized decision matrix. According to the weights described by ANP method, table 3 shows weighted normalized matrix. After this, positive ideal solution (PIS) and negative ideal solution (NIS) have been calculated as follows:

Positive ideal solution, S^+ = (0.126, 0.109, 0.111, 0.087, 0.115, 0.079, 0.094, 0.057, 0.092, 0.093, 0.037)

Negative ideal solution, S^- = (0.872, 0.0752, 0.0585, 0.0731, 0.0862, 0.0572, 0.0736, 0.0394, 0.0564, 0.0574, 0.0287)

Positive ideal solution represents the maximum value for benefit criteria and minimum value for cost criteria. While, negative ideal solution shows minimum value for benefit criteria among given alternatives and maximum value for cost criteria.

After this, distance of all alternative with respect to PIS and NIS has been calculated as shown in table 4. Any alternative showing the least distance from the PIS and farthest from NIS is considered the best solution among the given alternatives.

From table 4, closeness coefficient (CC) for alternatives can be calculated as shown in table 5. Alternative having highest value for alterative will be considered as best suppliers. Ranking of all the suppliers can be calculated by CC values. Ranking for price dimension was same as for value related dimension. So TOPSIS method validates the result of the case study and is very effective to be used for such case studies.

In TOPSIS method, there is no rank reversal. In this method, ideal best and worst solution is found and according to that, judgement of better alternative could be done. This TOPSIS method can be used as hybrid of ANP and TOPSIS, where ANP gives weightage of multi-criteria and TOPSIS gives ranking of alternatives based on these criteria.

Table 1: Decision matrix having weights by using ANP and scores of all alternatives [6]

Value related dimension (V)	Weights by using ANP	A	B	C	D	E
Delivery management capability (D)						
Accuracy of delivered contents (D1)	0.126	9.083	7.833	7.167	6.333	6.417
On time delivery (D2)	0.109	9.167	8	7.25	6.333	6.583
Delivery adjustment flexibility (D3)	0.111	9	7	6.583	4.75	5.167
Quality management capability (Q)						
Correctness of testing data (Q1)	0.087	8.917	8.417	7.75	7.667	7.5
Quality abnormal rate (Q2)	0.115	8	7.25	6.5	6.333	6
Capability to prevent repeated error (Q3)	0.079	8.167	6.75	6.583	5.917	6.083
Error judgment rate (Q4)	0.094	8.083	7	6.917	6.333	6.333
Integrated service capability (S)						
Response time for customers' request (S1)	0.057	8.917	7.583	7.333	6.167	6.25
Efficiency of engineering support (S2)	0.092	8.833	7.167	7	5.417	6.167
Fulfilling customers' special requests (S3)	0.093	9.167	7	7.167	5.667	5.917
Customer information service platform (S4)	0.037	9	8.083	7.667	7	7
Price (P)						
Testing price (P1)	0.422	7.833	7.583	7.667	4.417	4.583
Compensation rate for broken wafers (P2)	0.336	8.5	7.75	7.833	6.083	6.333
Acceptance criteria (P3)	0.242	8.75	8.333	8	6.333	6.75

Table 2: Normalized decision matrix

	A	B	C	D	E
D1	1	0.8623	0.789	0.6972	0.7064
D2	1	0.8726	0.7908	0.6908	0.7181
D3	1	0.7777	0.7314	0.5277	0.5741
Q1	1	0.9439	0.8691	0.8598	0.841
Q2	1	0.9062	0.8125	0.7916	0.75
Q3	1	0.8264	0.806	0.7245	0.7448
Q4	1	0.866	0.8557	0.7834	0.7834
S1	1	0.8503	0.8223	0.6916	0.7009
S2	1	0.8113	0.7924	0.6132	0.6981
S3	1	0.7636	0.7818	0.6181	0.6454
S4	1	0.8981	0.8518	0.7777	0.7777

Table 3: Weighted normalized decision matrix

	A	B	C	D	E
D1	0.126	0.1086	0.0994	0.0878	0.089
D2	0.109	0.0951	0.0861	0.0752	0.0782
D3	0.111	0.0863	0.0811	0.0585	0.0637
Q1	0.087	0.0821	0.0756	0.0748	0.0731
Q2	0.115	0.1042	0.0934	0.091	0.0862
Q3	0.079	0.0652	0.0636	0.0572	0.0588
Q4	0.094	0.0814	0.0804	0.0736	0.0736
S1	0.057	0.0484	0.0468	0.0394	0.0399
S2	0.092	0.0746	0.0729	0.0564	0.0642
S3	0.093	0.071	0.0727	0.0574	0.06
S4	0.037	0.0332	0.0315	0.0287	0.0287

Table 4: Distance from positive and negative ideal solutio

	DPIS	DNIS
A	0	0.1008
B	0.0497	0.0524
C	0.06368	0.038449
D	0.0994	0.005092
E	0.0928	0.01038

Table 5: Closeness coefficient displaying ranking of alternatives

	Closeness Coefficient (CC)	Rank
A	1	1
B	0.51322	2
C	0.376	3
D	0.048	5
E	0.1006	4

III. CONCLUSION AND FUTURE SCOPE

From table 5, supplier A was found to be the best supplier among all 5 suppliers. The ranking of suppliers was supplier A, B C E and D in descending order. The ranking is same as in the proposed methodology by Y.T. Lin et.al [6]. But TOPSIS method is easy to use and gives accurate result. Also it gives us the distance from the ideal best and worst solution. This distance evaluates suppliers and gives them opportunities to improve in the worst criteria. Also TOPSIS is efficient and there is no rank reversal and inclusion of any other supplier doesn't change the ranking. In future, TOPSIS can be used with fuzzy set theory to include linguistic terms of decision making. Also TOPSIS method can be used with other methodology for getting a hybrid model for a particular problem. Computation becomes difficult for decision maker when number of criteria increases. So, there is a need for such a technique which will make the solution easier even for many criteria's.

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