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A MULTI CRITERIA DECISION MAKING MODEL FOR SELECTION OF SUPPLIER USING PREFERENCE

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ABSTRACT

The aim of the present work is to propose a multi criteria decision making (MCDM) methodology for selection of appropriate supplier. The proposed methodology is based on Preference Selection Index (PSI) method. In the proposed method preference selection index value is calculated for every supplier alternatives and appropriate supplier is selected as best candidate for a given application whose preference selection index value is the highest. One case study of supplier selection problem is presented to demonstrate and validate the applicability of the proposed methodology.

Key words: *Multi Criteria Decision Making, Supplier Selection and Preference Selection Index Method.*

1. Introduction

Nowadays, purchasing department of the manufacturing industries is giving the huge importance to the selection of appropriate supplier for the given manufacturing environment. Supplier selection is one of the most important decision making problems which consider the number of conflict criteria to identify suppliers with the highest potential for meeting a firm's needs consistently and at an acceptable cost [1].

Thus, supplier selection problem is one of the most important decisions for manufacturing industries to make a good amount of profit and for a successful supply chain system in presence of multiple criteria because the cost of purchased raw materials or component parts or services dominates the final product cost by approximately 60% and if manufacturing organization does not receive the materials or services as per standards as it directly affects the final output the manufacturing industries [2] . In addition, Supplier selection is a multiple attribute decision-making (MCDM) problem which is affected by several conflicting selection criteria such as price, quality, flexibility and reliability of supplier, delivery time and goodwill of the supplier.

Hence to address this issue and to help the decision maker for selection of appropriate supplier using multi criteria decision making methodology many studies are reported in the past and a few recent researches are mentioned here. Ozcan and Ona [1] presented fuzzy AHP approach for supplier selection in a washing machine company. Chaterjee and Chaterjee[2] presented COPRAS-G method for ranking and selection of appropriate supplier for manufacturing environment. Liao and Kao [3] presented integrated fuzzy TOPSIS and multi-choice goal programming (MCGP) approach to solve the supplier selection problem. Wu and Liu [4] applied VIKOR and fuzzy TOPSIS method for selection of supplier. Chan and Chan [5] presented AHP model for selection of supplier for the fashion market. Sanayei et al [6] proposed a hierarchy MCDM model based on fuzzy sets theory and VIKOR method for supplier selection in the supply chain system. Kasirian et al [7] integrated AHP and ANP to select supplier. Montazer et al [8] presented ELECTRE III method for vendor selection. Chou and Chang [9] presented a fuzzy simple multi-attribute rating technique (SMART) for solving the vendor selection problem. Chou et al. [10] presented a fuzzy decision making approach to deal with the supplier selection problem in supply chain system. Rao [11] presented graph theory and matrix approach, and TOPSIS method for selection of supplier. Yang and Chen [12] presented combined analytical hierarchy process and grey relational analysis for selection of supplier. Bayazit [13] proposed an ANP model to tackle the supplier selection problem. Perçin [14] applied an integrated AHP–GP approach for supplier selection. Liu and Hai [15] presented a novel weighting procedure in place of AHP's paired comparison for selecting suppliers. Kumar et al [16] applied a fuzzy goal programming approach for vendor selection problem in a supply chain. Liu et al [17] proposed a simplified DEA model to evaluate the overall performances of suppliers. Ghodsypour and Brien [18] presented integrated the analytical hierarchy process

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and linear programming for choosing the best suppliers.

2. Objective of Research

Literature review reveals that previously, many MADM methods reported for the selection of supplier with assigning a relative importance between supplier selection attributes using AHP method. These all MADM methods may be give wrong selection when there is conflict between selection criteria to assign a relative importance or a huge number of selection criteria or a decision maker will inexperienced. Hence, in the present study simple and systematic supplier selection methodology based on preference selection index (PSI) method is presented for selection of appropriate supplier without assigning a relative importance between supplier selection criteria.

3. Supplier Selection Methodology

The proposed supplier selection methodology is based on the PSI method. The Preference selection index method was developed by Maniya and Bhatt [19,20,21] as multi criteria decision making tool. In the proposed methodology there is no need to assign a relative importance between supplier selection criteria. The main steps of Supplier selection methodology based on the PSI method are described below in details.

Step-1: *Define the supplier selection problem.*

In this step, define the application of supplier selection, identify the possible significant supplier selection attributes or criteria, and evaluate the potential supplier or alternative with respect to every supplier selection criteria for a given industrial application. Let, S = {S_i for i = 1,2,3,…m} be a set of supplier, C = {C_j for j =1,2,3,…,n } be a set of supplier selection criteria or attributes, and Q_{ij} is the performance (qualitative or quantitative performance) of alternative A_i when it examined with criteria C_j.

Step -2: *Formulate the decision matrix*.

The solving of any MADM problems begins with constructing decision matrix. The decision matrix contains all the performance or measures (Q_{ij}) of attributes are in quantitative form, i.e. numerical value (x_{ij}). If the performance measures of attributes are in qualitative form, i.e. linguistic term, then it is required to convert the linguistic terms into fuzzy number and linguistic terms converted to the crisp score using fuzzy conversion scale [22]. In the present study, 11-point scale proposed by Venkatasamy and Agrawal [23, 24] is adopted for converting linguistic terms into crisp value. A crisp values are shown in Table 1 to convert quantitative performance of attributes into qualitative performance. Finally, a supplier selection decision matrix will be represented as shown in Figure 1.

	C1	C2	C3	-----	Cn
S1	x_{11}	x_{12}	x_{13}	-----	x_{1n}
S2	x_{21}	x_{22}	x_{23}	-----	x_{2n}
S3	x_{31}	x_{32}	x_{33}	-----	x_{3n}
-----	-----	-----	-----	-----	-----
Sm	x_{m1}	x_{m2}	x_{m3}	-----	x_{mn}

Fig.1 Decision Matrix

Table 1: Crisp Value of Supplier Selection Criteria [22,23,24]

Linguistic terms of Supplier selection criteria	Crisp value of Supplier selection attribute
Exceptionally low	0.045
Extremely low	0.135
Very low	0.255
low	0.335
Below average	0.410
Average	0.500
Above average	0.590
High	0.665
Very high	0.745
Extremely high	0.865
Exceptionally high	0.955

Step -3: *Formulate normalized decision matrix*.

In any MADM methods, normalization procedure is required to transform performance rating with different measurement unit into a compatible unit. A normalized decision matrix is nothing but a normalized FMS selection attributes data are presented the tabular form as shown in Figure 2.

	C1	C2	C3	-----	Cn
S1	R_{11}	R_{12}	R_{13}	-----	R_{1n}
S2	R_{21}	R_{22}	R_{23}	-----	R_{2n}
S3	R_{31}	R_{32}	R_{33}	-----	R_{3n}
-----	-----	-----	-----	-----	-----
Sm	R_{m1}	R_{m2}	R_{m3}	-----	R_{mn}

Fig. 2 Normalized Decision Matrix

Where, $R_{ij} = \frac{x_{ij} - \min_j x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}$, (If the criteria are beneficial, i.e. profit) (1)

$$R_{ij} = \frac{\max\limits_{i} x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}$$, (If the criteria are non-beneficial, i.e. cost) (2)

Step-4: *Compute the Preference variation value (PV_j).*

Now, preference variation values every supplier selection criteria are computed using following equation. In addition, Preference variation value (PV_j) is not exactly variance which is used in the sample variance analogy.

$$PV_j = \sum_{i=1}^{n} \left[R_{ij} - \bar{R}_j \right]^2 \quad (3)$$

Where, $\bar{R}_j = \frac{1}{m} \sum_{i=1}^{m} R_{ij}, \forall i, j$

The deviation in the preference value is calculated because the value PV_j is not variance which is used to find standard deviation in the sample variance analogy. In this step the deviation in the preference value is computed for every supplier selection criteria using following equation:

$$\Phi_j = \left| 1 - PV_j \right| \quad (4)$$

Step-6: *Compute overall preference value (Ψ_j).*
In this step, the overall preference value (Ψ_j) is determined for every supplier selection criteria using following equation, so that $\sum_j \Psi_j = 1$.

$$\Psi_j = \frac{\Phi_j}{\sum_{j=1}^{m} \Phi_j} \quad (5)$$

Step-7: *Obtain preference selection index (I_i).*

Now, preference selection index (I_i) is computed for every supplier alternative using following equation:

$$I_i = \sum_{j=1}^{m} (R_{ij} \times \Psi_j) \quad (6)$$

Step-9: *Select the appropriate* supplier *for the given application.*

Now, Supplier alternatives are ranked according to the value of preference selection index (I_i) in descending or ascending order. Supplier is ranked/selected first whose preference selection index (I_i) is the highest and Supplier is ranked/selected last whose preference selection index (I_i) is the lowest and so on. Finally, the supplier will be selected for a given application whose preference selection index value is the highest or ranked first.

4. Case Study

One example of supplier selection problem is considered from the literature to validate the proposed supplier selection methodology and this considered example was solved by Liu et al [17], previously using data envelopment analysis for agricultural and construction equipment manufacturing firm. The detail steps of supplier selection methodology based on the PSI method are described in detail to demonstrate the case study as below.

Step -1: The objective of this case study is to select an appropriate supplier for the given industrial application. In the present study, we considered the 18 various suppliers and 5 supplier selection criteria same of Liu et al [17]. These all suppliers' performance is evaluated with every supplier selection criteria and its performance measures are shown in Table 2.

Step-

Table 2: Data of Supplier Selection Example

Supplier	Supplier selection criteria				
	C1	C2	C3	C4	C5
S1	100	100	90	249	2
S2	100	99.79	80	643	13
S3	100	100	90	714	3
S4	100	100	90	1809	3
S5	100	99.83	90	238	24
S6	100	96.59	90	241	28
S7	100	100	85	1404	1
S8	100	100	97	984	24
S9	100	99.91	90	641	11
S10	100	97.54	100	588	53
S11	100	99.95	95	241	10
S12	100	99.85	98	567	7
S13	100	99.97	90	567	19
S14	100	91.89	90	967	12
S15	80	99.99	95	635	33
S16	100	100	95	795	2
S17	80	99.99	95	689	34
S18	100	99.36	85	913	9

C1:Price ; C2: Quality; C3: Delivery Performance; C4: Distance; and C5: Supply Variety

Step-2: In this example all the supplier selection criteria are in the form of quantitative value. Hence, decision matrix for the supplier selection example is the same as of Table 2.

Step-3: In this step, a normalized decision matrix is formulated. In the present study there are 5 supplier selection criteria, out of these five selection criteria; C1

and C4 are considered as non beneficial criteria, and C2, C3 and C5 are considered as beneficial criteria.
Finally, the supplier selection criteria are normalized using equation (1) and equation (2). A normalized decision matrix of supplier selection criteria is represented in the tabular format as shown in Table 3.

Step-4: A preference variation value between values of supplier selection criteria are computed using equation (3), and its values are: PV_{C1} = 1.7778, PV_{C2} = 1.0779, PV_{C3} = 1.0707, PV_{C4} = 0.1446, and PV_{C5} = 1.2700.

Step-5: The deviation in a preference value is computed for every supplier selection criteria using equation (4), and its values are: Φ_{C1} = 0.7778, Φ_{C2} = 0.0779, Φ_{C3} = 0.0707, Φ_{C4} = 0.1446, and Φ_{C5} = 0.2700.

Step-6: In this step, the overall preference value *(Ψj)* is determined for every supplier selection criteria using equation (6), and its values are: Ψ_{C1} = 0.5800, Ψ_{C2} = 0.0581, Ψ_{C3} = 0.0527, ΨC4 = 0.1078, and Ψ_{C5} = 0.2013.

Step-7: A preference selection index (I_i) is computed for every supplier alternative using equation (7), and it's computed values are: I_{S1} = 0.1954, I_{S2} = 0.1831, I_{S3} = 0.1673, I_{S4} = 0.0922, I_{S5} = 0.2801, I_{S6} = 0.2721, I_{S7} = 0.0991, I_{S8} = 0.2485, I_{S9} = 0.2027, I_{S10} = 0.3783, I_{S11} = 0.2397, I_{S12} = 0.2129, I_{S13} = 0.2392, I_{S14} = 0.1267, I_{S15} = 0.8820, I_{S16} = 0.1711, I_{S17} = 0.8822, I_{S18} = 0.1591.

Step-8: Finally, the preference selection index values show that the right or first choice of the most appropriate supplier is S17 and last choice is supplier S4 because of a preference selection index value of supplier S17 is the highest and for supplier S4 is the lowest.

Table 3: Normalized Decision Matrix for Supplier Selection Example

Supplier	Supplier selection criteria				
	C1	C2	C3	C4	C5
S1	0.0000	1.0000	0.5000	0.9930	0.0192
S2	0.0000	0.9741	0.0000	0.7422	0.2308
S3	0.0000	1.0000	0.5000	0.6970	0.0385
S4	0.0000	1.0000	0.5000	0.0000	0.0385
S5	0.0000	0.9790	0.5000	1.0000	0.4423
S6	0.0000	0.5795	0.5000	0.9981	0.5192
S7	0.0000	1.0000	0.2500	0.2578	0.0000
S8	0.0000	1.0000	0.8500	0.5251	0.4423
S9	0.0000	0.9889	0.500	0.7435	0.1923
S10	0.0000	0.6967	1.0000	0.7772	1.0000
S11	0.0000	0.9938	0.7500	0.9981	0.1731
S12	0.0000	0.9815	0.9000	0.7906	0.1154
S13	0.0000	0.9963	0.5000	0.7906	0.3462
S14	0.0000	0.0000	0.5000	0.536	0.2115
S15	1.0000	0.9988	0.7500	0.7473	0.6154
S16	0.0000	1.0000	0.7500	0.6454	0.0192
S17	1.0000	0.9988	0.7500	0.7129	0.6346
S18	0.0000	0.9211	0.2500	0.5703	0.1538

4.1 Result Comparison

The ranking order obtained and selection of appropriate supplier is compared with the published result to validate the applicability of the proposed method for selection of supplier. Result comparison shown in the Table 4.

Table 4: Result Comparison

Supplier	Proposed method	VIKOR –G Method at *v* = 0.5 [2]	TOPSIS method[11]
S1	11	9	12
S2	12	17	11
S3	14	11	15
S4	18	12	17
S5	4	15	5
S6	5	16	4
S7	17	13	18
S8	6	4	6
S9	10	10	10
S10	3	7	1
S11	7	5	8
S12	9	3	9
S13	8	8	7
S14	16	18	14
S15	2	2	3
S16	13	6	13
S17	1	1	2
S18	15	14	16

The result shown in Table 4 clearly reveals that Supplier S17 is the best or appropriate supplier for a given application. In addition, the results obtained using proposed method is parallel with the published results. Moreover Chaterjee and Chaterjee [2] already proved that supplier 17 is superior to supplier 10 with respect to attributes price and quality and these two are the most important attributes as per the weights assigned using AHP method with TOPSIS method by Rao [11]. Furthermore Liu et al [17] also suggested that supplier alternatives 17, 1, 10, 12, 15 are the only efficient suppliers hence supplier 17 suggested as the first choice by the proposed method is justified.

5. Conclusion

The results obtained using the proposed supplier selection methodology based on the PSI method reveals an outstanding correlation with those obtained by the past researchers, which specifically prove the applicability of the proposed method methods while solving the complex supplier selection problems without considering a relative importance between selection criteria. The proposed method can also be used for any type of multi attribute decision-making problem with considering any number of alternatives and any number of quantitative and qualitative criteria.

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