IASET: Journal of Mechanical Engineering (IASET: JME)
ISSN(P): Applied; ISSN(E): Applied
Vol. 1, Issue 1, Jan - Jun 2016, 31-42

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

SUPPLIER SELECTION USING FUZZY-TOPSIS METHOD: A CASE STUDY IN A CEMENT INDUSTRY

S. M. ATIKUR RAHMAN[1] & SHOHANUZZAMAN SHOHAN[2]

[1]Department of Industrial Engineering and Management Khulna University of Engineering & Technology, Khulna, Bangladesh

[2]Department of Industrial Engineering and Management Khulna University of Engineering & Technology, Khulna, Bangladesh

ABSTRACT

A number of manufacturing firms in developing countries do not practice affordable, efficient and user friendly supplier selection tools because of its cost of an adequate planning and inappropriateness of application. If a systematic method is performed then it is possible to select the most suitable suppliers efficiently with respect to time, cost and quality. This study depicts an overview of the FUZZY-TOPSIS methods for multi-criteria decision making problem under uncertain environments. A qualitative and quantitative criterion comprises this supplier selection mode in this paper. This study also deals with optimum decision making for supplier selection and allocating order by applying the proposed method. This proposed method with triangular fuzzy numbers is utilized for dealing with uncertain and imprecise judgment of decision makers. A detailed step by step implementation method is proposed in this paper. At last a case study is made at Holcim Cement Bangladesh Ltd. Mongla Plant, Khulna.

KEYWORDS: Supplier Selection, Fuzzy Topsis Method, Triangular Fuzzy Method, Multi-Criteria Decision Making

INTRODUCTION

Today, the competition between corporations grows fast. In this highly competitive environment companies which design and manage their supply chains best will be more profitable and hence stronger.[1]**.** Decision making is one of the most important activities in business.

Managers need reliable and true forecasts for their decisions. Doing this they should consider scientific criteria. In general, a decision making problem is selecting the most appropriate alternative according to at least one goal or criteria from the alternatives cluster.[2] This decision making involves the right selection of the raw material supplier in the supply chain. The selection of a supplier for partnership is the most important step in creating a successful alliance. The selection of an appropriate supplier is an important factor affecting eventual buyer–supplier relationship. If the process is done correctly, a higher quality, longer lasting relationship is more attainable. [3]

A corporation which develops good relationships with its suppliers gain cost advantages through on-time and desired quality deliveries. Therefore supplier evaluation has a strategic importance for the corporations. [[1] Actually there is various processes for supplier selection and evaluation such as AHP, Fuzzy-AHP, ANP, TOPSIS, MCDM, Goal programming, Supply chain networking etc.

TOPSIS is an approach based on the TOPSIS technique (Technique for Order Preference by Similarity to Ideal

Solution) and the fuzzy set theory. The TOPSIS method is based on the concept that the optimum option has the least distance from the positive ideal solution. It is a linear weighting technique, which was first proposed, in its crisp version by Chen and Hwang, with reference to Hwang and Yoon. Since then, this method has been widely adopted to solve MCDM problems in many different fields. Because decision information is uncertain instead of certain in most environments, further extension for group decision making problems under fuzzy environment was published by Cheng ,known as Fuzzy TOPSIS. The selection of the third-party provider is a typical MCDM problem. In this method firstly we screen out providers that have not minimal qualifications by the selection criteria. Then closeness coefficient of contractors to each proposal will be computed by Fuzzy TOPSIS method and finally these coefficients as successful indicators for each provider will be fed in to a linear programming to select most profitable projects and providers with respect to the constraints.

LITERATURE REVIEW

Supplier selection is one of the critical activities for firms to gain competitive advantage and achieve the objectives of the whole supply chain. It is likely that the manufacturer allocates more than 60% of its total sales on purchased items, such as raw materials, parts, and components (Krajewsld & Ritzman,). Moreover, material cost is up to 70 % of finished good product cost (Ghodsypour & O’Brien,). Selecting the right suppliers and determining the appropriate orders from them can bring significant benefit in the reduction in purchasing cost, decrease in supplying risk and improved product quality. Therefore, by selecting appropriate supplier thoroughly, it can contribute success advantages to the manufacturing organization in confronting competitive environment (Liu & Hai,). There are various criteria to be considered when selecting the appropriate supplier. Dickson proposed 23 supplier selection criteria. But, it’s not permanently judged that all the criteria must be included into a final decision making because each firm has a different strategy in the supply chain in terms of the characteristics of the product. As remark, in the case study of this paper, the Dickson’s criteria will be the point to be adopted according to the preferences of the decision makers in the company.

FUZZY TOPSIS

Technique for Order Performance by similarity to Ideal solution (TOPSIS), one of the most classical methods for solving MCDM problem, was first developed by Hwang and Yoon.[04] It is based on the principle that the chosen alternative should have the longest distance from the negative-ideal solution i.e. the solution that maximizes the cost criteria and minimizes the benefits criteria; and the shortest distance from the Positive-ideal solution i.e. the solution that maximizes the benefit criteria and minimizes the cost criteria. In classical TOPSIS the rating and weight of the criteria are known precisely. However, under many real situations crisp data are inadequate to model real life situation since human judgments are vague and cannot be estimated with exact numeric values. [04]To resolve the ambiguity frequently arising in information from human judgments fuzzy set theory has been incorporated in many MCDM methods including TOPSIS. In fuzzy TOPSIS all the ratings and weights are defined by means of linguistic variables. A number of fuzzy TOPSIS methods and applications have been developed in recent years. Chen and Hwang [05] first applied fuzzy numbers to establish fuzzy TOPSIS. Triantaphyllou and Lin [06] developed a fuzzy TOPSIS method in which relative closeness for each alternative is evaluated based on fuzzy arithmetic operations. Liang [07] proposed Fuzzy MCDM based on ideal and anti-ideal concepts. Chen [08] considered triangular fuzzy numbers and defined crisp Euclidean distance between two fuzzy numbers to extend the TOPSIS method to fuzzy GDM situations. Chu [09] and Chu and Lin [10] further improved the methodology. Proposed by Chen. [[08]Chen and Tsao [11] are to extend the TOPSIS method based on Interval-valued fuzzy sets in decision analysis. Jahanshahloo et al [14] and Chu and Lin [12] extended the fuzzy TOPSIS method based on alpha level sets with interval arithmetic. Chen and Lee [13] extended fuzzy TOPSIS based on type-2 fuzzy TOPSIS method in order to provide additional degree of freedom to represent the uncertainties and fuzziness of the real world.

Among the various shapes of fuzzy number, triangular fuzzy number (TFN) is the most popular one. TFN is a fuzzy number represented with three points as follows: $\tilde{A} = (l, m, u)$ which can be drawn in figure 1. This representation is interpreted as membership functions and holds the following conditions:

a) *l* to *m* is increasing function

b) *m* to *u* is decreasing function

c) $l \leq m \leq u$

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & for\ x < l\ ;\ x > u \\ \frac{x-l}{m-l} & for\ l \leq x \leq m \\ \frac{u-x}{u-m} & for\ m \leq x \leq u \end{cases}$$

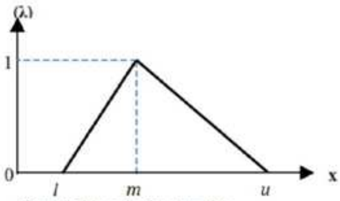

Figure 1. Triangular fuzzy number

METHODOLOGY

The TOPSIS (technique for order preference by similarity to an ideal solution was first developed by Hwang & Yoon. In this method two artificial alternatives are defined as positive-ideal and negative-ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria (Wang & Elhag,). In short, the positive ideal solution is the one which has the best level for all attributes considered, whereas the negative ideal solution is the one which has the worst attribute values. TOPSIS selects the alternative that is the closest to the positive ideal solution and farthest from negative ideal solution. The steps of fuzzy TOPSIS algorithm can be constructed in details as follows:

1. Generating feasible alternatives, determining the evaluation criteria, and setting a group of decision makers. Assume that there are m alternative, n evaluation criterion, and k decision maker.

2. Choosing the appropriate linguistic variables for the importance weight of the criteria ($\tilde{w}_j = l_{ij}, m_{ij}, u_{ij}$) and the linguistic rating for alternatives with respect to criteria ($\tilde{x}_{ij}$) as TFN.

3. Aggregate the weight of criteria to get the aggregated fuzzy weight $\tilde{w}_j$ of criterion C_j , and obtain the aggregated fuzzy rating $\tilde{x}_{ij}$ of alternative A_i under criterion C_j evaluated by expert.

$$\tilde{x}_{ij} = \frac{1}{k}[\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \dots\dots + \tilde{x}_{ij}^k] \qquad ; i=1,2,\dots\dots,m\ ;\ j=1,2,\dots.,n$$

$$\tilde{w}_j = \frac{1}{k}[\tilde{w}_j^1 + \tilde{w}_j^2 + ... + \tilde{w}_j^k] \qquad ; j=1,2,….,n$$

4. Construct the fuzzy decision matrix.

$$\tilde{D} = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{matrix} \qquad \tilde{W} = [\tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n];$$

i=1,2,……,m ; j=1,2,….,n

5. Normalize fuzzy decision matrix. The normalized fuzzy decision matrix denoted by $\tilde{R}$ is obtained by formula as follows:

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn} \text{ , i=1,2,……,m ; j=1,2,….,n}$$

The formula above can be calculated as details:

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{U_j^*}, \frac{m_{ij}}{U_j^*}, \frac{u_{ij}}{U_j^*} \right) \text{ Where, } U_j^* = \max u_{ij}$$

6. Construct the weighted normalized fuzzy decision matrix. In order to the different importance of each criterion, we can construct the weighted normalized fuzzy decision matrix as:

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n} \text{, i=1,2,……,m ; j=1,2,….,n}$$

Where, $\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j$, i=1,2,……,m ; j=1,2,….,n

7. Determine the fuzzy positive-ideal solution (FPIS) S^+ and fuzzy negative-ideal solution (FNIS) S^-. The calculation can be obtained as follows:

$$S^+ = (\tilde{v}_1^+, \tilde{v}_2^+, ..., \tilde{v}_n^+)$$

$$S^- = (\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-)$$

Where, $\tilde{v}_j^+ = \max\{v_{ij3}\}$ and $\tilde{v}_j^- = \min\{v_{ij1}\}$ since $\tilde{v}_j$ is weighted normalized TFNs

i=1,2,……,m ; j=1,2,….,n

8. Calculate the distance of each alternative from FPIS (d^+) and FNIS (d^-) . According to the vertex method, the distance between two triangular fuzzy numbers $A_1(l_1, m_1, u_1)$ and $A_2(l_2, m_2, u_2)$ is calculated as:

$$d(A_1, A_2) = \sqrt{\frac{1}{3}[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2]}$$

$$d_i^+ = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^+\right)$$

$$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right)$$

9. Calculate the closeness coefficient (CC_i) and rank the order of alternatives according to the coefficient. After we obtain the distance d^+ and d^-, we calculate the closeness coefficient of each alternative using the formula bellow:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

CASE STUDY

A reputed cement industry, Holcim Bangladesh LTD faced many problems in their supplier selection. They call for a tender and then they investigate their profile then call two or three supplier and trial their raw materials to produce cement but this causes their profit or success at late. For finding solution we proposed a model of supplier selection**.**The existing supplier selection process is given below:

Table 1: The Existing Supplier Selection Process

Step 1: Calling for Public Tender
Step 2: Initial screening, survey on factory and monitor actual status
Step 3: Interview of Executives of Supplier Company and negotiation with somebasic elements; such as cost, quality, and service level.
Step 4: Using materials for trial and error in production and through itseffectiveness
Step 5: Rate the topmost supplier and visit them again.
Step 6: Finally select the supplier

The purpose of the study to select right supplier for the cement industry by considering multi-criteria for decision making purpose and improve productivity the plant to meet the customer demand perfectly within due date.

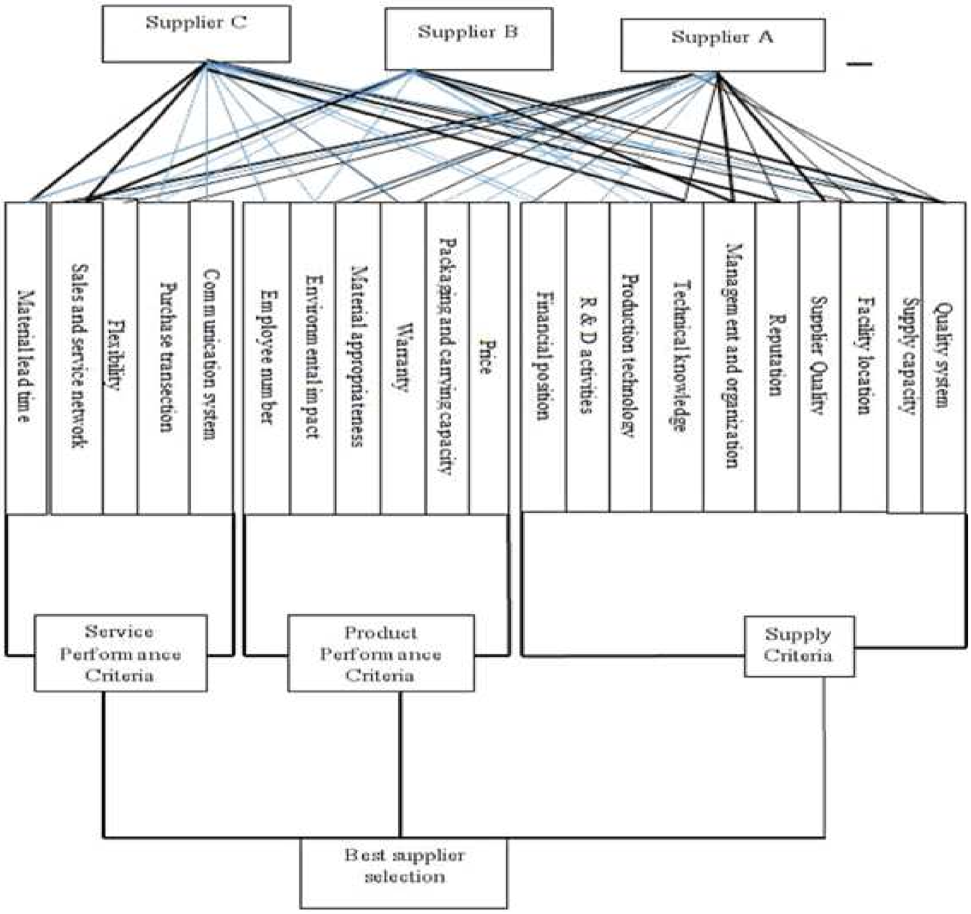

Figure 2: The Hierarchy of Structure (Achieved by AHP Statistical Analysis)

Step 1: Generating feasible alternatives, determining the evaluation criteria, and setting a group of decision makers. Based on the data collection, there are 3 alternatives, 21evaluation criteria, and 3 decision makers. The generation of criteria is adopted from the Dickson's criteria which are evaluated by decision makers to match between the preferences and literatures.

Step 2: choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic variables for ratings of alternatives with respect to criteria as TFN. The DMs choose linguistic variables for both the importance weight of the criteria and alternatives with respect to criteria in 7 scales because of ease to understand and apply.

Table 4.1: Linguistic Variables for the Importance Weight of the Criteria

Linguistic Variable	Corresponding Triangular Fuzzy Number
Very Low (VL)	(0, 0, 0.1)
Low (L)	(0, 0.1, 0.3)
Medium Low (ML)	(0.1 ,0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
Medium High (MH)	(0.5, 0.7, 0.9)
High (H)	(0.7, 0.9, 1.0)
Very High (VH)	(0.9, 1.0, 1.0)

Table 4.2: Linguistic Variables for the Ratings

Linguistic Variable	Corresponding Triangular Fuzzy Number
Very Poor(VP)	(0, 0, 1)
Poor (P)	(0, 1, 3)
Medium Poor (MP)	(1 ,3, 5)
Medium (M)	(3, 5, 7)
Medium Good(MG)	(5, 7, 9)
Good (G)	(7, 9, 10)
Very Good(VG)	(9, 10, 10)

Step 3: Aggregate the weight of criteria to get the aggregated fuzzy weight of criterion, and obtain the aggregated fuzzy rating of alternative under criterion evaluated by expert Step 4, Construct the fuzzy decision matrix as shown in **Table-4.3**:

Table 4.3: Fuzzy Decision Matrix

Weight	A1	A2	A3
C1 (0.1, 0.3, 0.5)	(4, 6, 8)	(6, 8, 9.5)	(3, 5, 7)
C2 (0.3, 0.5, 0.7)	(3, 5, 7)	(2, 4, 6)	(4, 6, 8)
C3 (0.5, 0.7, 0.9)	(5, 7, 9)	(4, 6, 8)	(3, 5, 7)
C4 (0.7, 0.9, 1.0)	(2, 4, 6)	(3, 5, 7)	(5, 7, 9)
C5 (0.2, 0.4, 0.6)	(6, 8, 9.5)	(3, 5, 7)	(4, 6, 8)
C6 (0.3, 0.5, 0.7)	(5, 7, 8.5)	(4, 6, 8)	(4, 6, 8)
C7 (0.1, 0.3, 0.5)	(3, 5, 7)	(5, 7, 9)	(5, 7, 8.5)
C8 (0.4, 0.6, 0.8)	(4, 6, 7.5)	(4, 6, 8)	(2, 4, 6)
C9 (0.9, 1, 1)	(5, 7, 8.5)	(6, 8, 9.5)	(4, 6, 7.5)
C10 (0.9, 1, 1)	(4, 6, 8)	(5, 7, 9)	(7, 9, 10)
C11 (0.6, 0.8, 0.95)	(3, 5, 7)	(2, 4, 6)	(1, 3, 5)
C12 (0.5, 0.7, 0.9)	(6, 8, 9.5)	(4, 6, 8)	(3, 5, 7)
C13 (0.3, 0.5, 0.7)	(5, 7, 9)	(2, 4, 6)	(7, 9, 10)
C14 (0.2, 0.4, 0.6)	(3, 5, 7)	(7, 9, 10)	(4, 6, 8)
C15 (0.1, 0.3, 0.5)	(4, 6, 7.5)	(5, 7, 8.5)	(3, 5, 7)
C16 (0.6, 0.8, 0.95)	(5, 7, 9)	(2.5, 4, 6)	(3, 5, 7)
C17 (0.1, 0.3, 0.5)	(4, 6, 7.5)	(3, 5, 7)	(5, 7, 9)
C18 (0.1, 0.3, 0.5)	(3, 5, 7)	(5, 7, 9)	(4, 6, 7.5)
C19 (0.5, 0.7, 0.9)	(5, 7, 9)	(4, 6, 8)	(3, 5, 7)
C20 (0.2, 0.4, 0.6)	(6, 8, 9.5)	(4, 6, 8)	(5, 7, 9)
C21 (0.3, 0.5, 0.7)	(3, 5, 7)	(5, 7, 9)	(4, 6, 8)

Step 5: Construct a normalized fuzzy decision matrix as shown in **Table-4.4**. The normalization is to transform different scales and units among various criteria into common measurable units to allow comparisons across the criteria.

Table 4.4: Normalized Fuzzy Decision Matrix

	A1	A2	A3
C1	(0.42, 0.63, 0.84)	(0.63, 0.84, 1.0)	(0.32, 0.53, 0.74)
C2	(0.37, 0.63, 0.87)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1.0)
C3	(0.56, 0.78, 1.0)	(0.44, 0.67, 0.89)	(0.33, 0.56, 0.78)
C4	(0.22, 0.44, 0.67)	(0.33, 0.56, 0.78)	(0.56, 0.78, 1.0)
C5	(0.63, 0.84, 1.0)	(0.32, 0.53, 0.74)	(0.42, 0.63, 0.84)
C6	(0.58, 0.82, 1.0)	(0.47, 0.70, 0.94)	(0.47, 0.70, 0.94)
C7	(0.33, 0.56, 0.78)	(0.56, 0.78, 1.0)	(0.56, 0.78, 0.94)
C8	(0.5, 0.75, 0.94)	(0.5, 0.75, 1.0)	(0.25, 0.50, 0.75)
C9	(0.53, 0.74, 0.89)	(0.63, 0.84, 1.0)	(0.42, 0.63, 0.79)
C10	(0.4, 0.6, 0.8)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)

C11	(0.43, 0.72, 1.0)	(0.28, 0.57, 0.85)	(0.14, 0.43, 0.72)
C12	(0.63, 0.84, 1.0)	(0.42, 0.63, 0.84)	(0.32, 0.53, 0.73)
C13	(0.5, 0.7, 0.9)	(0.2,0.4, 0.6)	(0.7, 0.9, 1.0)
C14	(0.3, 0.5, 0.7)	(0.7, 0.9, 1.0)	(0.4, 0.6, 0.8)
C15	(0.47, 0.70, 0.88)	(0.59, 0.82, 1.0)	(0.35, 0.59, 0.82)
C16	(0.56, 0.78, 1.0)	(0.27, 0.44, 0.67)	(0.33, 0.56, 0.78)
C17	(0.44, 0.67, 0.83)	(0.33, 0.55, 0.78)	(0.56, 0.78, 1.0)
C18	(0.33, 0.56, 0.78)	(0.56, 0.78, 1.0)	(0.44, 0.67, 0.83)
C19	(0.56, 0.78, 1.0)	(0.44, 0.67, 0.89)	(0.33, 0.56, 0.78)
C20	(0.63, 0.84, 1.0)	(0.42, 0.63, 0.84)	(0.52, 0.73, 0.94)
C21	(0.33, 0.56, 0.78)	(0.56, 0.78, 1.0)	(0.44, 0.67, 0.89)

Step 6: Constructing the Weighted Normalized Fuzzy Decision Matrix as shown in Table-**4.5**.

Table 4.5: The Weighted Normalized Fuzzy Decision Matrix

	A1	A2	A3
C1	(0.042, 0.19, 0.42)	(0.063, 0.252, 0.50)	(0.032, 0.16, 0.37)
C2	(0.111, 0.32, 0.61)	(0.075, 0.25, 0.525)	(0.15, 0.375, 0.7)
C3	(0.28, 0.54, 0.9)	(0.22, 0.47, 0.80)	(0.165, 0.392, 0.702)
C4	(0.15, 0.40, 0.67)	(0.231, 0.504, 0.78)	(0.392, 0.702, 1.0)
C5	(0.13, 0.34, 0.6)	(0.064, 0.212, 0.444)	(0.084, 0.252, 0.504)
C6	(0.174, 0.41, 0.70)	(0.141, 0.35, 0.47)	(0.141, 0.35, 0.658)
C7	(0.033, 0.17, 0.39)	(0.056, 0.234, 0.50)	(0.056, 0.234, 0.47)
C8	(0.20, 0.45, 0.752)	(0.20, 0.45, 0.80)	(0.1, 0.3, 0.6)
C9	(0.477, 0.74, 0.89)	(0.567, 0.84, 1.0)	(0.378, 0.63, 0.79)
C10	(0.36, 0.6, 0.8)	(0.45, 0.7, 0.9)	(0.63, 0.9, 1.0)
C11	(0.26, 0.576, 0.95)	(0.168, 0.456, 0.80)	(0.084, 0.344, 0.684)
C12	(0.32, 0.588, 0.90)	(0.1, 0.441, 0.756)	(0.16, 0.371, 0.657)
C13	(0.15, 0.35, 0.63)	(0.06, 0.2, 0.42)	(0.21, 0.45, 0.70)
C14	(0.06, 0.20, 0.42)	(0.14, 0.36, 0.60)	(0.08, 0.24, 0.48)
C15	(0.047, 0.21, 0.44)	(0.059, 0.246, 0.50)	(0.035, 0.177, 0.41)
C16	(0.336, 0.624, 0.9)	(0.162, 0.352, 0.64)	(0.20, 0.45, 0.741)
C17	(0.044, 0.20, 0.42)	(0.033, 0.165, 0.39)	(0.056, 0.234, 0.50)
C18	(0.033, 0.168, 0.39)	(0.056, 0.234, 0.50)	(0.044, 0.201, 0.415)
C19	(0.23, 0.546, 0.9)	(0.22, 0.47, 0.80)	(0.165, 0.392, 0.702)
C20	(0.124, 0.336, 0.6)	(0.08, 0.252, 0.504)	(0.104, 0.292, 0.564)
C21	(0.10, 0.23, 0.546)	(0.168, 0.39, 0.70)	(0.132, 0.335, 0.623)

Step 7: Determine the fuzzy positive-ideal solution S^+ (FPIS) and fuzzy negative-ideal solution S^- (FNIS) as follows:

Table 4.6: Fuzzy Positive Ideal Solution S+ (FPIS) and Fuzzy Negative Ideal Solution S- (FNIS) as Follows

	S^+	S^-
C1	(0.5, 0.5, 0.5)	(0.032, 0.032, 0.032)
C2	(0.7, 0.7, 0.7)	(0.075, 0.075, 0.075)
C3	(0.9, 0.9, 0.9)	(0.165, 0.165, 0.165)
C4	(0.78, 0.78, 0.78)	(0.15, 0.15, 0.15)
C5	(0.6, 0.6, 0.6)	(0.064, 0.064, 0.064)
C6	(0.7, 0.7, 0.7)	(0.141, 0.141, 0.141)
C7	(0.5, 0.5, 0.5)	(0.033, 0.033, 0.033)
C8	(0.8, 0.8, 0.8)	(0.1, 0.1, 0.1)
C9	(0.89, 0.89, 0.89)	(0.378, 0.378, 0.378)
C10	(1.0, 1.0, 1.0)	(0.36, 0.36, 0.36)
C11	(0.95, 0.95, 0.95)	(0.084, 0.084, 0.084)
C12	(0.9, 0.9, 0.9)	(0.1, 0.1, 0.1)

C13	(0.7, 0.7, 0.7)	(0.06, 0.06, 0.06)
C14	(0.6, 0.6, 0.6)	(0.06, 0.06, 0.06)
C15	(0.5, 0.5, 0.5)	(0.035, 0.035, 0.035)
C16	(0.9, 0.9, 0.9)	(0.162, 0.162, 0.162)
C17	(0.5, 0.5, 0.5)	(0.033, 0.033, 0.033)
C18	(0.5, 0.5, 0.5)	(0.033, 0.033, 0.033)
C19	(0.9, 0.9, 0.9)	(0.165, 0.165, 0.165)
C20	(0.6, 0.6, 0.6)	(0.08, 0.08, 0.08)
C21	(0.7, 0.7, 0.7)	(0.1, 0.1, 0.1)

Step 8: Calculate the distance of each alternative from FPIS (d+) and FNIS (d-) with respect to each criterion as shown in **Table-4.6** and then distance between them in **Table-4.7**.

Table 4.7: Distance between FPIS, FNIS and Alternative Rating

	FPIS			FNIS		
	A1	**A2**	**A3**	**A1**	**A2**	**A3**
C1	0.322627	0.290099	0.342308	0.241942	0.299101	0.208669
C2	0.408012	0.455979	0.368838	0.340365	0.278762	0.402596
C3	0.413924	0.468081	0.52836	0.480997	0.407952	0.3366
C4	0.429496	0.354766	0.45425	0.333117	0.419832	0.349174
C5	0.310108	0.392503	0.363582	0.350156	0.235446	0.276492
C6	0.346783	0.40327	0.381552	0.358669	0.225035	0.321958
C7	0.336199	0.298827	0.299328	0.22077	0.293836	0.278028
C8	0.401997	0.40104	0.509902	0.431124	0.455522	0.310913
C9	0.253686	0.199105	0.336523	0.36651	0.460452	0.278836
C10	0.450777	0.366288	0.221284	0.289367	0.372066	0.50797
C11	0.453128	0.541005	0.629272	0.583951	0.468365	0.377536
C12	0.380239	0.538955	0.543596	0.555741	0.426856	0.3593
C13	0.37855	0.495984	0.317595	0.372872	0.22301	0.441286
C14	0.401663	0.299555	0.371663	0.22301	0.359629	0.264071
C15	0.350623	0.293824	0.330985	0.236921	0.29514	0.231509
C16	0.362524	0.551528	0.489142	0.512629	0.296976	0.374
C17	0.318505	0.337843	0.298827	0.243433	0.219752	0.293836
C18	0.336855	0.298827	0.318623	0.220359	0.293836	0.241018
C19	0.437499	0.468081	0.52836	0.479448	0.407952	0.3366
C20	0.314257	0.365477	0.337726	0.335595	0.264172	0.305383
C21	0.448931	0.355492	0.392334	0.268214	0.386749	0.331551

Table 4.8: The Distance of Each Alternative d^+ and d^-

	d^+	d^-
A1	7.86	7.44
A2	8.17	7.09
A3	8.36	6.83

Step 9: calculating the closeness coefficient (CCi) and rank the order of alternatives according to the coefficient. The result is shown in **Table-4.9:**

Table 4.9: Rank of Alternatives According and its Closeness Co-Efficient

	CC_i	Rank
A1	0.48	1
A2	0.46	2
A3	0.44	3

From the above table it is seen that closeness co-efficient of supplier A is greater than supplier B and C. Hence supplier A is best suited for that purpose in the cement industry and is selected.

RESULTS & DISCUSSIONS

In this process of supplier selection, actually there are some existing process at every industry and the author try to improve the existing process of cement industry which is given below through a flow chart table in the cement industry at Mongla plant.

The proposed supplier selection model as shown in **Table 5.1** eradicates the drawbacks of the conventional supplier selection process. The process starts by determining the key supplier selection and evaluating indicators. Then, sufficient data is collected against these indicators. The proposed selection process ends by validating the results and thus selecting the best supplier in an authentic and standard way. This selection process considers significant evaluating indicators and each contributes to determine the best supplier.

Table 5.1: The Proposed Supplier Selection Process

Step 1	Calling for Public Tender
Step 2	Determination of key supplier selecting and evaluation indicators
Step 3	By using TOPSIS,AHP,Fuzzy-AHP method, computing weighted
	value of each suppliers
Step 4	Validation result and finally selecting the best supplier

Table 5.2: Calculated Data

No.	Fuzzy-TOPSIS (Closeness Coefficient)
Supplier A	0.48
Supplier B	0.46
Supplier C	0.44

By using a common set of criteria or attributes, supplier selection is a broad comparison to identify the best supplier with the highest potential needs and at a reasonable price that meets firm’s requirements consistently. Actually the selection of the best supplier not only reduces purchasing cost but also improves corporate competitiveness in modern comprehensive business sector. Hence, supplier selection is one of most important challenge in multi-criteria decision making process. In this process, supplier selection has been done using TOPSIS . TOPSIS method is used for those 21 sub-attributes for the determination of closeness coefficient of each alternative supplier. In this process the TOPSIS calculations are done using MS-Excel . Here programming software is used to avoid hand-made error. Various information on suppliers such as delivery date, certification of the organization, quality system of the supplier can be collected from the database of ERP .This can reduce time consuming effort in the supplier selection process.

CONCLUSIONS

The purpose of this selection process is to improve the existing supplier selection process of any industry basically the author follow a Cement Industry for the supplier selection purpose. Actually from the start of industrial evaluation the industry select their supplier through a normal process that is why there are so many troubles in the industry in long run and which has a negative impact on the firms profit or productivity. Now-a-days Supplier selection, which includes multi criteria and multiple conflicting objectives, can be defined as the process of finding the right suppliers with the right quality at the right price, at the right time, and in the right quantities.

It is noted that, manufacturers spend more than 60% of its total sales on purchased items . In addition, their purchases of goods and services constitute up to 70% of product cost . Therefore, selecting the right supplier significantly reduces purchasing costs, improves competitiveness in the market and enhances end user satisfaction. Since this selection process mainly involves the evaluation of different criteria and various supplier attributes, it can be considered as a multiple criteria decision making (MCDM) problem . Based on several criteria and alternatives to be considered, various decision making methods have been proposed to provide a solution to this problem. Hence the author take such a beneficiary decision ofsupplier selection using multi-criteria decision making in the real industrial world.

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