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Assessing the performance of suitable suppliers for an Indian manufacturing organization using fuzzy TOPSIS method based on SWOT analysis approach

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Abstract
The main aim of this study is assessing the potential suppliers for an Indian manufacturing organization by using multi criteria decision method. Supplier selection, assessment and prioritization are the important topics in modern supply chain management (SCM) for all manufacturing organization. In this situation the selection of perfect supplier is a big challenge for purchasing department. This paper presents an approach for assessing the performance of suitable suppliers and then ranking them. With the help of experience and expertise of 8 experts, authors could identify the criteria for supplier selection. Total 10 criteria selected for evaluating the 4 alternatives. In this research SWOT analysis approach is proposed as an analytical tool for determining the weight/relative importance of each criteria and fuzzy TOPSIS method is for ranking the alternatives. The results of proposed method indicate that second supplier (S2) is the best supplier that can be preferred for company.

Keywords: Supplier appraisal, fuzzy set theory, TOPSIS, SWOT analysis.

1. Introduction

Globalization of market is initiating the elevated competition for modern organizations. In this spirited world market the prospect survival of most companies, depends frequently on the enthusiasm of their personnel to companies. Suppliers play a significant role in supply chain management (SCM). Suppliers are needed for organizations to provide the essential goods, components, materials, and services at a right time and in effective manner to uphold an aggressive improvement [1]. Selecting the best set of suppliers is a very big challenging and significant subject. In the academic literature this crisis has understandably acknowledged for extensive attention. Literature has provided a lot key insights and models for the assessment and assortment of suppliers. Literatures shows many methods for suppliers selection like; Analytical Hierarchical Process, Fuzzy Goal Programming, Fuzzy Programming Model, Interpretive Structural Modeling, Unit Crowd Optimization and replication Optimization Approach. The fuzzy TOPSIS method based on SWOT analysis approach proposed to solve this problem.

Growing in complexity is making the quantitative approaches more popular and is considered to be efficient methods of selecting suppliers where as subjective approaches have acknowledged keeping away from use it frequently [2]. The performances of Employee or personnel such as competence, awareness, expertise, and other abilities play a vital role in the accomplishment of a society. The main goal of organizations is to seek more powerful ways of ranking of a set of supply chain partners/ personnel who have been evaluated in terms of unlike competencies. Price consideration has a broader sense nowadays; it includes the costs associated with the process of purchasing and over the purchased item's whole life in accumulation to the purchasing cost. Therefore quality, delivery, and cost considered as selection goals in addition to a probabilistic measure of crisis [3].

Selection of supplier is a tactical judgment in the course of supply chain management (SCM) and depends on the sourcing approach of the company. It helps for the optimization of supply chain and therefore raising the effectiveness of the supply chain. An inappropriate supplier assortment can create a huge confusion in entire supply chain. The supplier selection decision in a supply chain (SC) does not depend exclusively on cost or quality measures, but also on various criteria [4].

2. Related work

In present scenario's economy, outsourcing has become a standard rather than an exception, thus it is essential to recognize the suitable supplier to outsource. Suitable Supplier selection is a critical function performed by the purchasing subdivision. Selecting a suitable supplier is a multi-criterion problem; it includes the qualitative as well as quantitative factors. The company and its supplier formed a critical relationship and companies usually create a set for evaluation criteria to be used to evaluate possible sources [5]. Allocating orders to suppliers plays a vital role in managing the supply chain. The selection of qualified suppliers gives a different confidence to managers. Splitting orders between suppliers is essential that it may manipulate the efficiency of the whole supply chain [6].

Most of supplier ranking systems obtained their best solutions without taking into consideration operations management

approach of firm which is necessary for better management [7]. The method should also think about that decision makers might face some situations like time pressure, lack of proficiency in related issue, etc., throughout the assessment process [8]. Researchers used different types of MCDM methodologies for selecting the appropriate supplier for a company such as analytical hierarchy process (AHP), ANP, TOPSIS etc.

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method formed by Hwang and Yoon in 1981 [9]. It is based on the thought to that the choice should have the least coldness from the positive ideal solution (PIS) and the excessive from the negative-ideal solution (NIS). This method is used to choose the best option out of given more options [10-14]. Some researchers extended fuzzy TOPSIS method for providing further degree of freedom to symbolize the uncertainties and fuzziness of the real humanity [15].

The way that people think is inherently fuzzy. An approach for computation based on degree of truth rather than usual true or false is termed as fuzzy logic. Fuzzy logic includes various stages between the extreme values. Fuzzy set theory is used in decision making when due to uncertainty incomplete information is available. The huge donation of fuzzy set theory is its ability to represent vague information it uses linguistic conditions to represent decision maker preference [16].

SWOT technique is used to conduct a systematic assessment on each major issue and alternative and the outcome of the SWOT exercise is the key to the unbiased justification of tradeoffs in a balanced approach [16-17-18].

3. Preliminaries of Fuzzy Set Theory

Fuzzy logic is a method for computing based on "level of truth" in place of exactly "right or wrong" it bounded by limits from "0" to "1" as farthest belongings of truth but as well includes the various stages in between. Fuzzy set theory is used in decision making when due to uncertainty incomplete information is available. The great contribution of fuzzy set theory is its ability to represent indistinct information it uses linguistic terms to represent decision maker preference. For example, the probability that it will sunshine on Sunday can be represent in linguistic conditions as very high, high, low, etc. when many parameters cannot determine analytically and require expert's opinion then fuzzy set theory can be applied. For example, competency, equity, mobility, quality of service, etc [11]. Some related definitions and properties are studied from; [14-15].

Definition 1. A fuzzy set ã in a universe of dialogue X is characterized by a membership function $\mu_{\tilde{a}}(x)$ that maps each element x in X to a real number in the interval (0, 1). The function value $\mu_{\tilde{a}}(x)$ is known as the grade of relationship of x in ã. The closer the value of $\mu_{\tilde{a}}(x)$ to1, the higher the score of membership of x in ã.

Definition 2. A triangular fuzzy number is represented as a triplet $\tilde{a} = (a_1, a_2, a_3)$. Fig.1 shows a triangular fuzzy quantity ã. The membership function $\mu_{\tilde{a}}(x)$ of triangular fuzzy number ã is given by;

$$\mu_{\tilde{a}}(x) = \begin{cases} 0, x \leq a1 \\ \frac{x-a1}{a2-a1}, a1 \leq x \leq a2 \\ \frac{a3-x}{a3-a2}, a2 \leq x \leq a3 \\ 0, x > a3 \end{cases}$$

Where a_1, a_2, a_3 are real numbers and $a_1<a_2<a_3$. The value of x at a_2 gives the maximal grade of $\mu_{\tilde{a}}(x)$, i.e., $\mu_{\tilde{a}}(x) = 1$; it is the most probable value of the assessment records. The significance of x at a_1 provides the minimal grade of $\mu_{\tilde{a}}(x)$, i.e., $\mu_{\tilde{a}}(x) = 0$; it is the smallest value of data.

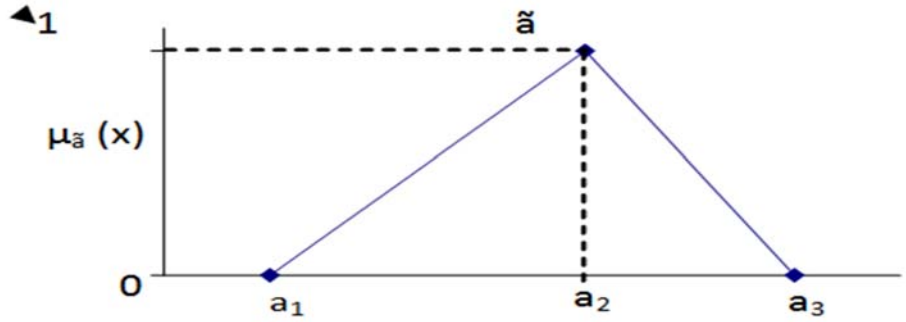

Fig 1: Triangular fuzzy number ã.

Constants a_1 and a_3 are the lower and upper boundaries of the existing area for the assessment data. These constants reveal the fuzziness of the assessment data. The narrower the period $[a_1, a_3]$, the lesser is the fuzziness of the assessment data.

Property 1- the main operations of two given triangular fuzzy number $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ are as follow;

(1) Adding two triangular fuzzy numbers/values
ã (+) $\tilde{b} = (a_1 + b_1, a_2 + b_2, a_3 + b_3)$, $a_1, b_1 \geq 0$

(2) Subtract two triangular fuzzy numbers/values
ã (-) $\tilde{b} = (a_1 - b_1, a_2 - b_2, a_3 - b_3)$, $a_1, b_1 \geq 0$

(3) Multiply two triangular fuzzy numbers/values
ã (x) $\tilde{b} = (a_1 * b_1, a_2 * b_2, a_3 * b_3)$, $a_1, b_1 \geq 0$

(4) Dividation of two triangular fuzzy numbers/values
$\frac{\tilde{a}}{\tilde{b}} = (\frac{a1}{b1}, \frac{a2}{b2}, \frac{a3}{b3})$, $a_1, b_1 \geq 0$

Property 2- operations of triangular fuzzy number $\tilde{a} = (a_1, a_2, a_3)$ with any real number k.

(1) Multiplication by k to triangular fuzzy number.
k (x) ã = (ka_1, ka_2, ka_3) $a_1, k \geq 0$

(2) Divide a triangular fuzzy number by k
$\frac{k}{\tilde{a}} = (\frac{k}{a1}, \frac{k}{a2}, \frac{k}{a3})$ $a_1, k \geq 0$

3.1. Linguistic Variables &Fuzzy Set Theory

In fuzzy set hypothesis, exchange scales are applied to transform the linguistic conditions into fuzzy numbers. In this research, we used a scale of 1–9 to rate the criteria and the attributes. Table 1 represents the linguistic variables and fuzziness applied for the attributes and Table 2 represents the linguistic variables and fuzziness used for the factors/criteria.

Table 1: Linguistic terms for alternative ratings on the basis of overall performance

Linguistic term	Membership function	Meaning
Very poor (VP)	[1, 1, 3]	Very poor preference.
Poor (P)	[1, 3, 5]	Poor preference.
Fair (F)	[3, 5, 7]	Average preference.
Good (G)	[5, 7, 9]	Good preference.
Very good (VG)	[7, 9, 9]	Very good preference.

Table 2: Linguistic terms for criteria ratings

Linguistic term	Membership function	Meaning
Very low	[1, 1, 3]	Minimum preference
Low	[1, 3, 5]	Fewer preference
Medium	[3, 5, 7]	Normal preference
High	[5, 7, 9]	High preference
Very high	[7, 9, 9]	Highest preference

3.2. Fuzzy Topsis Approach

TOPSIS method formed by Hwang and Yoon in 1981 **[9]**. It is based on the thought to that the choice should have the minimum distance from the ideal solution and the extreme from the negative-ideal solution. This method is used to choose the best option out of given more options [11-12-13-14-19].

Some researchers extended fuzzy TOPSIS method for providing further degree of freedom to symbolize the uncertainties and fuzziness of the real humanity **[15]**. The score and relative weight of the attributes in classical TOPSIS are recognized accurately. Though, in many real situations crispy data are insufficient to model real life condition since human being's thoughts are indistinct and cannot be predictable with exact numeric values [11].

3.2.1. Steps Used in Fuzzy TOPSIS Method

a) Assignment of ratings to the criteria and the alternatives. Let us Consider there are i possible candidates called A = {A 1, A 2, . . ., A i } which are to examine aligned with n criterion, C = {C 1, C 2, . ., C_n }. The criteria weights are denoted by w_j (j = 1, 2, . . ., m). The importance ratings of each decision maker DM_k (k = 1, 2, . ., K) for each alternative A_i (i = 1, 2, . ., n) with respect to criteria C_n (n= 1, 2, ., n) is then calculated.

b) Normalize the matrix by using formula applied in classical TOPSIS method in order to avoid complexity in calculation of fuzzy data.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right), \; c_j^* = \max_i c_{ij} \text{ (benefit criteria)} \qquad (1)$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}^-}{c_{ij}^*}, \frac{a_{ij}^-}{b_{ij}^*}, \frac{a_{ij}^-}{a_{ij}^*} \right) a_{ij}^- = \min_i a_{ij} \text{ (costcriteria)} \qquad (2)$$

Where $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ are the fundamentals of the beginning decision matrix.

c) Create the weighted normalized decision matrix.

$$\tilde{v}_{ij} = \tilde{w}_j \cdot \tilde{r}_{ij}, \quad j=1,2,\ldots m \; i=1,2,\ldots n \qquad (3)$$

d) Determine the fuzzy ideal and fuzzy negative-ideal solutions.

$$A^+ = \{\tilde{v}_1^+, \tilde{v}_2^+, \ldots \tilde{v}_m^+\} \quad (4)$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_m^-\} \quad (5)$$

where $\tilde{v}_j^+ = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$, j=1,2,…m.

e) Calculate the separation measure for NIS and PIS.

$$S_i^+ = \sum_{j=1}^{m} s(\tilde{v}_{ij}, \tilde{v}_j^+) \; i=1,2,\ldots n \text{ – Ideal separation} \qquad (6)$$

$$S_i^- = \sum_{j=1}^{m} s(\tilde{v}_{ij}, \tilde{v}_j^-) \; i=1,2,\ldots n \text{ – Negative-ideal separation} \qquad (7)$$

Where $s(\tilde{v}_{ij}, \tilde{v}_j^+)$ and $s(\tilde{v}_{ij}, \tilde{v}_j^-)$ are distance measurements.

f) Calculate the closeness coefficient of alternatives.

$$c_i^* = \frac{S_i^-}{(S_i^+ + S_i^-)}, \; 0 < c_i^* < 1, \; i=1,2,\ldots, n \qquad (8)$$

g) Rank the preference order.

Alternatives can now be prioritized in the downward order of c_i^*. The alternatives prioritized by using these steps, the priority given according to the rank of alternatives. Higher the rank Higher the priority and lower the rank lower will be the priority, rank indicates the usefulness of alternatives.

3.2.2. Concept of "SWOT" analysis

Concept of SWOT analysis approach is a helpful tool for the scheduling, growth and judgment making and has extensively been applied as a means to methodically investigate an organization's interior and outdoor environments supervision **[14]**.

Strength- It is the powers available for achieving the goal effectively.

Weaknesses- These are the deficiencies in association that keep it from achieving its objectives.

Opportunity- It is a complimentary condition for organization.

Threats- These are unfavorable situation of organization that potentially harmful for its strategic planning.

Proper implementation of SWOT analysis gives strategic results that enable the organization to achieving the goal. Strength and weakness are intra organizational factors while opportunity and threats are inter organizational factors [14-17]. The description of intra and inter organizational factors is given in table 3.

Table 3: Intra and inter organizational factors

Intra organizational factors	
Strength (S)	**Weaknesses (W)**
□ Reliable sales personnel with good understanding	□ Delay in work finalizing.
□ Trust with personnel.	□ High rental costs.
□ No communication gap between employees.	□ No up to date with market trends.
□ Good strategic decisions	□ More inventory holding problems.
□ Good nature of higher authorities.	□ Issues of Cash flow
□ No leakage of important information.	□ No record management.
Inter organizational factors	
Opportunities (O)	**Threats (T)**
□ No alternative in market	□ Alternative producers in market.
□ Customer's loyalty	□ Competitors are following strategic advertisement.
□ Interest of sales department according to customer demand	□ Competitors opening business nearby.
□ Less expensive inputs.	□ Economic downturn whiles other people spending less.

Source: [14-17]

4. The decision hierarchy

Graphical illustration of the decision goal, the main objectives, i.e. attributes and the alternatives is known as decision hierarchy shown in Figure.2. And the procedure of methodology included the sequential steps to reaches the aim of paper. This procedure includes appropriate application of SWOT analysis, fuzzy set theory and Techniques for order preference by similarity to an ideal solution (TOPSIS) method.

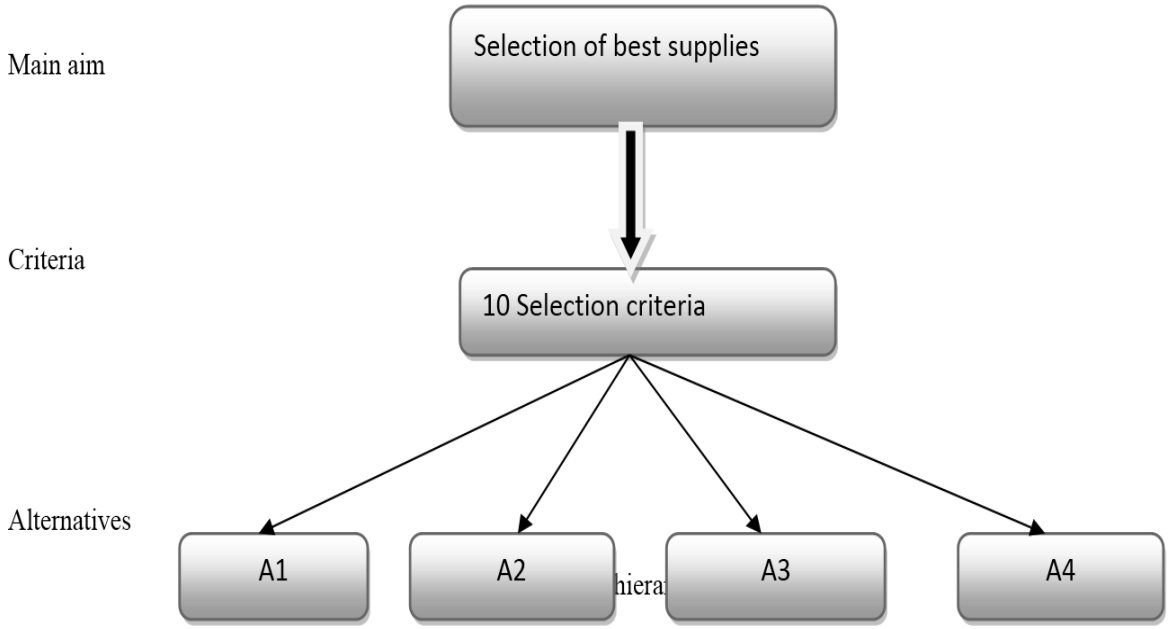

Fig 2: The decision hierarchy

4.1. The procedure followed in methodology for ranking the alternatives

- Identify the criteria by industrial and literature survey
- Identify the Scale used for attributes rating
- Identify the Alternatives
- Compute the aggregate weights of the Criteria using SWOT analysis
- Follow TOPSIS procedure with weights calculated using fuzzy values.
- Calculate negative and positive ideal solutions.
- Calculate separation measures for NIS & PIS.
- Rank the preference alternatives for priority.

5. Supplier selection using proposed methodology

In this research, decision makers were invited to inspection of four alternatives. Through the literature investigation and experts' opinions, the authors finally adopted 10 criteria. This research includes 10 evaluation criteria, such as logical thinking (C1), Qualification (C2), Work experience (C3), language known (C4), keenness (C5), punctuality (C6), Decision making (C7), teams work (C8), Age (C9), and interior ability (C10). In addition, there are four alternatives include: supplier (S1), (S2), (S3) and (S4). After the construction of the hierarchy the different priority weights of each criteria are determine using the SWOT analysis approach.

5.1. Determine the linguistic weighting of each criteria

Strengths, weaknesses, opportunities and threats (SWOT) analysis is a helpful tool for the forecast, growth and Trust building and has extensively been applied to methodically examine an organization's interior and exterior environments administration. In this research SWOT analysis applied to assign the relative importance to each criteria according to their positivity and negativity. Experts assigned the relative

importance to all ten criterions in qualitative manners according to the positive or negative impact of risk factor on activities of organization. The qualitative values of criterions such as flexibility, reliability etc has been provided in the linguistic form. This is so because the decision makers feel comfortable in providing a fuzzy measure than giving a crisp value. Even the values to the quantitative criterion, cost and implementation time, has been provided in form of fuzzy numbers. The strengths and opportunities of criteria can be known without separate calculation for weaknesses & threats and risks may understand in better way according to their positive and negative response. Strengths (S) and opportunities (O) are assumed as positive criteria and weaknesses (W) and threats (T) are categorized as negative criteria and in order to deal with uncertainty we integrate fuzzy logic in the planned methodology.

Procedure followed to assign the relative importance to each criterion:

- ✓ First each expert indicates the level of strengths, opportunities, weaknesses and threats of each criteria for company.
- ✓ Replace these levels by 9 point scale assumed with fuzzy values.
- ✓ Calculate aggregate weights for each criteria
- ✓ Use these aggregate values as criterion weights and further to evaluate the alternatives.

For locating the Best Non fuzzy Performance value (BNP) process of defuzzification is used and shown in table 4. Table 4 shows the relative weight of criteria, which obtained by using SWOT analysis approach. The weights for each criterion are: C1 (5.208), C2 (4.833), C3 (4.521), C4 (3.729), C5 (3.750), C6 (5.000), C7 (4.688), C8 (3.979), C9 (5.104) and C10 (4.479). The results of fuzzy TOPSIS shows the first two important factors for selecting person are C1 (5.208) and C9 (5.104). Moreover, the less important factor is C4 (3.729).

Table 4: Relative importance of criteria determine with the help of swot analysis

Criteria	Fuzzy weight	BNP
Logical thinking (C1)	[3.4,5.3,6.9]	5.208
Qualification (C2)	[3.0,4.9,6.6]	4.833
Work experience (C3)	[2.9,4.4,6.3]	4.521
Language known (C4)	[1.9,3.6,5.6]	3.729
Keenness (C5)	[2.1,3.6,5.5]	3.750
Punctuality (C6)	[3.3,5.0,6.7]	5.000
Decision making (C7)	[2.9,4.8,6.4]	4.688
Teams work (C8)	[2.4,3.9,5.7]	3.979
Age (C9)	[3.2,5.2,6.9]	5.104
Interior ability (C10)	[2.6,4.5,6.4]	4.479

5.2. Aggregate Fuzzy Rating Of Alternatives

The aggregate ratings for the four alternatives with respect to the 10 criteria are computed. The aggregate fuzzy decision matrix for the alternatives is presented in Table 5.

Table 5: Aggregate fuzzy decision matrix

	A1	A2	A3	A4
C1	[1,5.5,9]	[1,4,9]	[1,5.25,9]	[1,5,9]
C2	[1,4.5,9]	[1,4.3,9]	[1,4.39,9]	[1,4,9]
C3	[3,5.8,9]	[3,6.3,9]	[1,4.8,9]	[1,6,9]
C4	[1,5.3,9]	[1,5,9]	[1,4.5,9]	[1,5,9]
C5	[1,2.5,7]	[1,3,9]	[1,2.1,9]	[1,2,5]
C6	[3,6.3,9]	[1,5.5,9]	[1,5.8,9]	[1,6,9]
C7	[3,5.8,9]	[3,6,9]	[3,6,9]	[3,6,9]
C8	[1,5,9]	[1,6.3,9]	[1,5.3,9]	[1,6,9]
C9	[1,4,9]	[1,4.5,9]	[1,4,9]	[1,3.8,9]
C10	[1,4.3,9]	[1,4,9]	[1,5.3,9]	[1,4.8,9]

In the next step, we perform normalization of the fuzzy decision matrix of alternatives using Eq. 1 and weighted normalized fuzzy decision matrix is calculated using Eq. 2 As shown in table 6 &7.

Table 6: Normalized decision matrix

	A1	A2	A3	A4
C1	[0.11, 0.44, 1]	[0.11, 0.58,1]	[0.11, 0.53,1]	[0.11, 0.56, 1]
C2	[0.11, 0.47, 1]	[0.11, 0.47,1]	[0.11, 0.44, 1]	[0.11, 0.44, 1]
C3	[0.33, 0.69, 1]	[0.11, 0.53,1]	[0.11, 0.64, 1]	[0.33, 0.69, 1]
C4	[0.11, 0.2, 1]	[0.11, 0.22,1]	[0.11, 0.22, 1]	[0.11, 0.2, 1]
C5	[0.14, 0.43,1.29]	[0.2, 0.43,1.8]	[0.2, 0.4, 1]	[0.11, 0.28, 0.56]
C6	[0.11, 0.61,1]	[0.11, 0.64,1]	[0.11, 0.61, 1]	[0.11, 0.61, 1]
C7	[0.33, 0.67,1]	[0.33, 0.67,1]	[0.33, 0.67, 1]	[0.33, 0.64, 1]
C8	[0.11, 0.69,1]	[0.11, 0.69,1]	[0.11, 0.67, 1]	[0.11, 0.61, 1]
C9	[0.11, 0.5,1]	[0.11, 0.44,1]	[0.11, 0.42, 1]	[0.11, 0.5, 1]
C10	[0.11, 0.44,1]	[0.11, 0.581]	[0.11, 0.53, 1]	[0.11, 0.5, 1]

Table 7: Weighted normalized decision matrix

	A1	A2	A3	A4
C1	[0.38, 2.36, 6.90]	[0.38, 3.09, 6.90]	[0.38, 2.80, 6.90]	[0.38, 2.94, 6.90]
C2	[0.33, 2.31, 6.60]	[0.33, 2.31, 6.60]	[0.33, 2.18, 6.60]	[0.33, 2.18, 6.60]
C3	[0.97, 3.06, 6.30]	[0.32, 2.32, 6.30]	[0.32, 2.81, 6.30]	[0.97, 3.06, 6.30]
C4	[0.21, 0.72, 5.60]	[0.21, 0.80, 5.60]	[0.21, 0.80, 5.60]	[0.21, 0.72, 5.60]
C5	[0.30, 1.54, 7.07]	[0.42, 1.53, 9.90]	[0.42,1.44, 5.50]	[0.23, 1.00, 3.06]
C6	[0.37, 3.06, 6.70]	[0.37, 3.19, 6.70]	[0.37, 3.06, 6.70]	[0.37, 3.06, 6.70]
C7	[0.97, 3.20, 3.40]	[0.97, 3.20, 6.40]	[0.97, 3.20, 6.40]	[0.97, 3.07, 6.40]
C8	[0.27, 2.71, 5.70]	[0.27, 2.28, 5.70]	[0.27, 2.60, 5.70]	[0.27, 2.38, 5.70]
C9	[0.36, 2.60, 6.90]	[0.36, 2.31, 6.90]	[0.36, 2.17, 6.90]	[0.36, 2.60, 6.90]
C10	[0.29, 2.00, 6.40]	[0.29, 2.63, 6.40]	[0.29, 2.38, 6.40]	[0.29, 2.25, 6.40]

Then, the fuzzy positive ideal solution (A^+) and the fuzzy negative ideal solutions (A^-) are computed using Eq. (4) and (5) for the four alternatives, results are mentioned in table 8.

Table 8: Negative ideal solution (NIS) and positive ideal solution (PIS)

Criteria	NIS	PIS
C1	[0.4, 2.4, 6.9]	[0.4, 3.1, 6.9]
C2	[0.3, 2.2, 6.6]	[0.3, 2.3, 6.6]
C3	[0.3, 2.3, 6.3]	[1, 3.1, 6.3]
C4	[0.2, 0.7, 5.6]	[0.2, 0.8, 5.6]
C5	[0.2, 1, 3.1]	[0.4, 1.5, 9.9]
C6	[0.4, 3.1, 6.7]	[0.4, 3.2, 6.7]
C7	[1, 3.1, 6.4]	[1, 3.2, 6.4]
C8	[0.3, 2.3, 5.7]	[0.3, 2.7, 5.7]
C9	[0.4, 2.2, 6.9]	[0.4, 2.6, 6.9]
C10	[0.3, 2, 6.4]	[0.3, 2.6, 6.4]

5.2.1. Calculate the separation measure for NIS and PIS. Likewise we compute the separation of each alternative from the fuzzy positive ideal matrix (A^+) and fuzzy negative ideal matrix (A^-) using Eq. (6) and (7), here S^- shows the separation for negative ideal solution and S^+ indicates the separation for positive ideal solution as Shown in table 9.

Table 9: The separation measure for NIS and PIS

Alternatives	A1	A2	A3	A4
S^-	[4.2603]	[6.9078]	[2.6089]	[1.281]
S^+	[2.996]	[1.1121]	[4.4986]	[6.8924]

Now the method is applied to find the closeness coefficients ($\mathbf{C_i^*}$) for all alternatives. $\mathbf{C_i^*}$indicates the order of preference of selected alternatives, higher value of $\mathbf{C_i^*}$ shows the more preferable relative performance. Using (Eq. (8)), we compute the closeness coefficient ($\mathbf{C_i^*}$) of the five alternatives. Closeness coefficient indicates the weight for preference of alternatives as shown in table 10.

Table 10: Closeness coefficient (C_i^*) of the alternatives

Alternatives	CL_i	Rank
Supplier 1	[0.5871]	2
Supplier 2	[0.8613]	1
Supplier 3	[0.3671]	3
Supplier 4	[0.1567]	4

Order of Closeness of alternatives for preference:
(Supplier 2) > (Supplier1) > (Supplier3) > (Supplier4)

6. Results

After using the data according to the decision makers for analysis, the proposed methodology (SWOT integrated Fuzzy TOPSIS approach) put forward alternative second (supplier 2) as the best choice and supplier 1 as the second choice, supplier 3and supplier 4 are the third and fourth option for an Indian manufacturing company which can give a better service to improve the output of organization. It is also found from the study that selected best supplier can be helpful for mitigating the bullwhip effect, and hence there will be no individual ownership in chain and the coordination will become strong that establishes the healthy environment. The relative importance for criteria and alternatives calculated using SWOT analysis and fuzzy TOPSIS method are shown in fig 3 and fig 4.

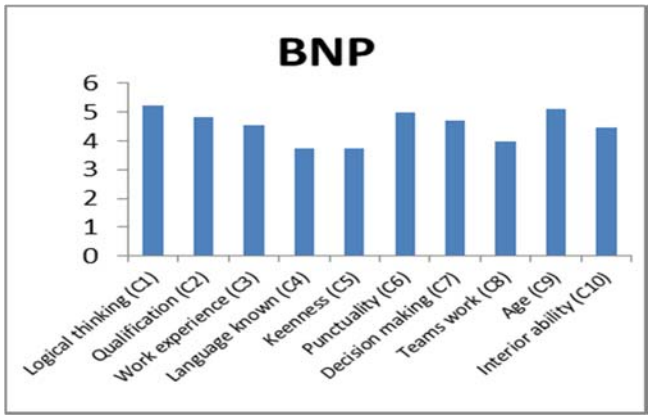

Fig 3: Relative importance of criteria

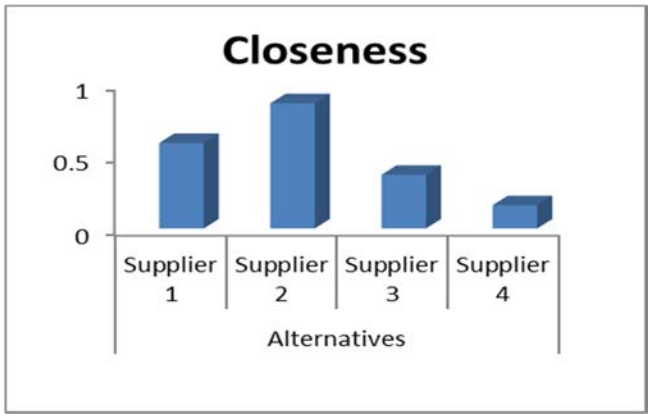

Fig 4: Relative importance of alternatives

On the basis of integration of SC channel, academic scholars and commercial groups found that a set of good suppliers can assist the supply chain partners to keep the costs downstairs and improving customer service for SCM. The goal of SCM is meeting the needs of consumers by supplying the exact product at the exact position and time. Therefore the firms have to develop a good relationship with his personnel (supplier). The suppliers require better understanding the customers' necessity for new products. This is a serious issue; suppliers need to be sure of the liability and position of their supply chain associates. And this shows importance of supplier's position within supply management.

7. Conclusion

In today's competitive markets, the concept of the supplier selection problem has a massive concern. The goal of SCM is meeting the needs of customers by supplying the right product at the right place, time and price. Therefore the firms have to develop the strategies for selecting suitable suppliers so that they can meet these all requirements. Before selecting any personnel of chain some criteria must be setup, on the basis of which someone can be examined. The suppliers necessitate enhanced perceptive the customers' necessity for new products. This is a serious issue; suppliers need to be sure of the liability and position of their supply chain associates. This shows importance of supplier's position within supply management.

In this paper, we tried to intend a MCDM model based on fuzzy set theory to select the most adequate supplier. Unlike additional methodologies, the used method can adaptively find a appropriate option for the company. The research examined the available alternatives by analyzing the data found from single Indian manufacturing group. The future research can be use the data from different organizations to get finest results. Since, our research mainly focused on production and composed information primarily from various departments within the company, future research might also include information from suppliers as well as buyers to get the better accurate results for supply chain.

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