International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)

Impact Factor: 5.164

IJESRT

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SUPPLIER SELECTION FOR MULTI CRITERIA DECISION MAKING PROBLEMS (MCDM) USING FUZZY ANALYTIC HIERARCHY PROCESS (F-AHP) AND TECHNIQUE FOR ORDER PERFORMANCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS) METHODS

Shweta Dubey[1], Josy George[2] & Pushkal Badoniya[3]
[1,2&3]Assistant Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology, Bhopal, M.P (India)

ABSTRACT
In the increasingly competitive world of business and industry, identifying the suppliers and managing the supply chain have become an important factor. Supplier selection problems usually consist of multiple criteria that contradict each other. However, multiple criteria decision-making (MCDM) analyses assume that these criteria are independent from each other. Many models have been developed for solution of MCDM problems. In this paper integration of fuzzy analytic hierarchy process (fuzzy-AHP) and technique for order performance by similarity to ideal solution (TOPSIS) is carried out to identify the most suitable supplier for manufacturing firm. A numerical example presented illustrates the different selection criteria to select the best supplier for manufacturing firm

KEYWORDS: Supplier Selection, Supply Chain Management, MCDM, Fuzzy AHP, TOPSIS.

1. INTRODUCTION
In today's complex world decision making has become more and tougher and can barely be solved by considering a single attribute or which can also be termed as criterion for a certain problem, so there comes the utility and the hallmark of MCDM methodologies in multi-objective problems where comparisons as well as ranking and selection can be done between the multiple attributes and multiple alternatives with the initial help of the decision makers. Decision-making can be treated as the cognitive process where choosing the best option among the alternatives is logical. It consists of a set of criteria and alternatives. Each criterion has a weighted value that can be obtained from decision-maker or expert group. After evaluating the weighted value of different criteria, the decision-making can be made.

The decision of supplier selection depends upon a various number of criteria. Mainly, cost is the foremost criteria considered while choosing a supplier, others such as product quality of the material, delivery time and service quality of the supplier also play a vital role while selecting a suitable supplier. To choose the best supplier is not easy for decision maker who always satisfies the entire requirements of the buyers. Supplier selection is a multi-criteria decision-making problem that includes both qualitative and quantitative factors, some of which conflict with each other. A multi-criteria decision-making technique helps the decision-makers (DMs) to evaluate a set of alternatives.

In this paper proposes an integrating fuzzy analytic hierarchy process (fuzzy-AHP). The F-AHP is used to determine the weight for each criterion, while TOPSIS method is used to obtain the final ranking for the attributes. A numerical example is used to illustrate the proposed method. The numerical results show that the proposed integrating method is feasible in solving MADM. The proposed method would make a great impact and significance for the practical implementation. Finally, this paper provides some commendations for future research directions.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

2. LITERATURE REVIEW

Deemed as a multi-criteria decision-making problem, the supplier selection process receives considerable attention in the literature. The multifaceted nature of the problem was first recognised by Dickson (1966), who examined the importance of supplier evaluation criteria. Therefore, the criteria most identified are quality, cost and delivery performance history. Several techniques and models are used to solve these kinds of problems. Many conflicting objectives characterise the problem of supplier selection. The maximisation of the purchase value, the minimisation of cost and delay in delivery and the maximisation of the profit are the most identified.
The decision making of selecting the best supplier, the firms can save material costs, quality and can increase other competitive advantage. This decision becomes complicated when it becomes multiple suppliers, multiple criteria, and imprecise parameters, and also the uncertainty and vagueness of the expert's opinion is the prevalent characteristic of the problem. Therefore, it uses a multi criteria decision making method namely Fuzzy AHP and this can be utilized as an approach for supplier selection problem.a fuzzy analytical hierarchy process-based methodology is used to select the best supplier firm providing the most customer satisfaction for the criteria determined.

From the above literature review, it is evident that supplier selection is clearly a multi-criteria decision-making problem. The next section will discuss about the methodology of the research study.

Fuzzy Analytic Hierarchy Process (F-AHP)

Fuzzy logic is used to make conclusions that are based on uncertain, imprecise, vague, ambiguous and missing value information. Fuzzy logic was first proposed by Zadeh, AHP was developed by Saaty and fuzzy AHP or F-AHP integrates the fuzzy logic with AHP in order to make the decision support system tolerant to imprecise and uncertain. AHP has been widely used to solve multiple criteria decision making (MCDM) problems. It assigns priorities to various decision criteria by performing pair wise comparison between alternatives. In a generic AHP model, first level denotes the goal; the criteria and sub-criteria (if any) are in the third and fourth levels respectively and the fourth level contains the alternatives.

In F-AHP, linguistic variables represented by triangular fuzzy numbers are being utilized to perform pair-wise comparison among the criteria and alternatives themselves. This is achieved by constructing a fuzzy judgment matrix. Laarhoven and Pedcrycz were one of the first researchers to integrate fuzzy logic into AHP. They introduced the triangular membership function to be used in F-AHP for pair-wise comparison. Buckley introduced a new method to compute fuzzy weights and specifically utilized triangular membership functions. Other researchers introduced new methods to use triangular membership functions in pair-wise comparisons. This study utilizes the method described by Buckley and uses triangular fuzzy membership function to calculate relative weights of criteria as well as alternatives. Reason for using triangular membership function is that while interviewing the case company which is discussed in the next section, all the approximate values for each criterion as described by the purchasing staff was around a single value instead of any standard or a range of values.

Following are the steps to be performed:
Step 1: Comparing criteria and alternatives using linguistic variables shown in table 1.

Table 1: Linguistic Term & The Corresponding Triangular Fuzzy Numbers

Linguistic Variables	Saaty Value	Fuzzy Triangular Values
Equally Important	1	(1, 1, 1)
Slightly Important	3	(2, 3, 4)
Strongly Important	5	(4, 5, 6)
Very Strongly Important	7	(6, 7, 8)
Extremely Important	9	(9, 9, 9)

The intermittent values between two adjacent scales	2	(1, 2, 3)
	4	(3, 4, 5)
	6	(5, 6, 7)
	8	(7, 8, 9)

As we can see from table 1; the linguistic terms are mapped to triangular fuzzy numbers. Suppose if the expert suggests that "Criterion 1 (Cr_1) is strongly important than criterion 2 (Cr_2)", then it will take (4, 5, 6) fuzzy triangular value. On the other hand, while constructing pair-wise matrix, comparison of Cr_2 to Cr_1 will have fuzzy triangular value (1/6, 1/5, 1/4). The sample pair-wise comparison matrix "A" is shown is equation 1. Here d_{ij} indicates the comparison of i^{th} criterion with j^{th} criterion using fuzzy triangular values as mentioned in table 1. For the above example of Cr_1 is strongly important than Cr_2, d_{12} value represent this comparison and will have be equal to; d_{12} = (4, 5, 6).

$$D = \begin{bmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{n1} & \cdots & d_{nm} \end{bmatrix}$$

Step 2: The geometric mean of fuzzy comparison values is calculated for each criterion which is shown in equation l

$$r_i = \left(\prod_{j=1}^{n} d_{ij}\right),\ i = 1,\ 2 \ldots.,\ n$$

Step 3: Find the vector summation of each r_i. Then find the reciprocal of summation vector and replace the fuzzy triangular value to make it in an increasing order. Then find the fuzzy weight of each criterion i (w_i) by multiplying each r_i with this reverse vector.

$$Weight\ (w_i) = r_i \otimes (r_1 \oplus r_2 \oplus \ldots. \oplus r_n)^{-1} = (lw_i,\ mw_i,\ uw_i)$$

Operations on fuzzy numbers are defined as follows:

$$a_1 \oplus a_2 = (l_1 + l_2,\ m_1 + m_2, u_1 + u_2)$$

$$a_1 \otimes a_2 = (l_1 .\ l_2,\ m_1 .m_2, u_1 .\ u_2)$$

$$a_1^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right)$$

$$a_1^{\frac{1}{n}} = \left(l^{\frac{1}{n}}, m^{\frac{1}{n}}, u^{\frac{1}{n}}\right)$$

Step 4: In this step, the weights calculated, triangular fuzzy numbers (lw_i, mw_i, uw_i) are to convert them into crisp values, the centre of gravity method was applied:

$$M_i = \frac{(lw_i + mw_i + uw_i)}{3}$$

Step 5: Mi is a non-fuzzy member which needs to be normalized using equation 5.

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}$$

After finding the normalized weights of all the criteria and the alternatives, the score or rank of each alternative is calculated by multiplying each alternative weight with the related criteria. The alternative with the highest score is ranked 1st and can be selected by the decision maker. This methodology has been applied for supplier selection is a textile industry using a real case study which is discussed in the next section.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

A Multi-Criteria Decision Making (MCDM) technique helps the decision makers (DMs) to evaluate the best

alternatives. TOPSIS method is a most common technique of multi-Attribution Decision Making (MADM)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

models. "Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)" is a method of multi-criteria decision analysis and this method was introduced by Hwang and Yoon in 1981. TOPSIS logic is rational and understandable. It chooses the alternative which has the shortest geometric distance from the positive ideal solution and compares a set of alternatives by identifying weights for each criterion, normalizes the scores for each criterion and calculates the geometric distance between each alternative and the ideal alternative in order to give the best score for each criterion. TOPSIS method helps to choose the right suppliers with a various finite number of criteria.

Step 1: The structure of matrix

$$D = \begin{bmatrix} X_1 & \cdots & X_j \\ \vdots & \ddots & \vdots \\ X_{i1} & \cdots & X_{ij} \end{bmatrix}$$

Step 2: Calculate the Normalized the matrix D by using the following formula:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{J} {x_{ij}}^2}}$$

Step 3: Construct the weighted normalized decision matrix by multiplying:

$$V_{ij} = w_{ij}.r_{ij}$$

Step 4: Determine the positive ideal solution and negative ideal solution

$$A^* = \{(max\ v_{ij} |\ j\ \in J), (min\ v_{ij} |j\ \in J')\}$$
$$A^- = \{(min\ v_{ij} |\ j\ \in J), (max\ v_{ij} |j\ \in J')\}$$

Step 5: Calculate the separation measure

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}$$

Step 6: Calculate the relative closeness to the ideal Solution

$$C_i^* = {S_i^-}\Big/{S_i^* + S_i^-}\ , 0 \le C_i^* \le 1$$

Step 7: Calculate the total score and select the alternative closest to 1.

Numerical Example

In this section, to implement the methodology, we have solved simulated numerical example the management of a manufacturing company wants to choose their best suppliers based on proposed methodology.

A manufacturing firm wants to choose their best supplier for their hardware division. The evaluation is between ten suppliers, the evaluation objectives and choose the best of them. The evaluation group determines the value of each criterion which is based on the pointer scale. The selection criterions are Product Quality (PQ), Price (PR), Service Quality (SQ), and Delivery Time (DT).

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Implementation of Fuzzy AHP Weight Calculation of Criteria

Table 2: Pair Wise Comparisons of Alternatives

	PQ	PR	SQ	DT
PQ	(1,1,1)	(1/6,1/5,1/4)	(1,1,1)	(1/8,1/7,1/6)
PR	(4,5,6)	(1,1,1)	(4,5,6)	(4,5,6)
SQ	(1,1,1)	(1/6,1/5,1/4)	(1,1,1)	(2,3,4)
DT	(6,7,8)	(1/6,1/5,1/4)	(1/4,1/3,1/2)	(1,1,1)

Table 3: Fuzzy Geometric Mean, Fuzzy Weight, Avg. Weight & Normalized Weight

	Fuzzy Geometric Mean Value (ri)	Fuzzy Weight (wi)	Average Weight (Mi)	Normalized Weight (Ni)
PQ	(0.38, 0.41, 0.45)	(0.06, 0.08, 0.10)	0.0775	0.0752
PR	(2.83, 3.34, 3.83)	(0.45, 0.61, 0.82)	0.6274	0.6095
SQ	(0.76, 0.88, 1.00)	(0.12, 0.16, 0.21)	0.1653	0.1606
DT	(0.71, 0.83, 1.00)	(0.11, 0.15, 0.21)	0.1592	0.1547
Total	(4.68, 5.46, 6.29)		1.0294	1.0000
Inverse Value	(0.21, 0.18, 0.16)			
Increasing Value	(0.16, 0.18, 0.21)			

Implementation of TOPSIS for Supplier Ranking

Table 4: Decision Matrix

	PQ	PR	SQ	DT
Supplier 1	75	120	5	80
Supplier 2	88	212	4	74
Supplier 3	68	225	6	84
Supplier 4	56	180	5	66
Supplier 5	66	230	7	58
Supplier 6	81	130	3	94
Supplier 7	94	275	2	54
Supplier 8	86	195	3	62
Supplier 9	71	315	5	43
Supplier 10	79	380	9	87

Calculate the Normalized the matrix by using the mentioned formula in methodology section

Table 5:Normalized Matrix

	PQ	PR	SQ	DT
S 1	0.3073	0.1590	0.2993	0.3520
S2	0.3606	0.2809	0.2395	0.3256
S3	0.2786	0.2982	0.3592	0.3696
S4	0.2295	0.2385	0.2993	0.2904

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

S5	0.2704	0.3048	0.4191	0.2552
S6	0.3319	0.1723	0.1796	0.4135
S7	0.3852	0.3644	0.1197	0.2376
S8	0.3524	0.2584	0.1796	0.2728
S9	0.2909	0.4174	0.2993	0.1892
S10	0.3237	0.5036	0.5388	0.3828

From Table 5, the corresponding weights of the criterion are taken, then the normalized weight matrix is calculated.

Table 6:Normalized Weight Matrix

	PQ	PR	SQ	DT
S 1	0.0231	0.0969	0.0481	0.0544
S 2	0.0271	0.1712	0.0385	0.0504
S 3	0.0210	0.1817	0.0577	0.0572
S 4	0.0173	0.1454	0.0481	0.0449
S 5	0.0203	0.1858	0.0673	0.0395
S 6	0.0250	0.1050	0.0288	0.0640
S 7	0.0290	0.2221	0.0192	0.0368
S 8	0.0265	0.1575	0.0288	0.0422
S 9	0.0219	0.2544	0.0481	0.0293
S 10	0.0243	0.3069	0.0865	0.0592

Determine the positive ideal solution and negative ideal solution, the separation measure and the relative closeness to the ideal Solution

Table 7: Positive and Negative Ideal Solution

A+	0.0290	0.0969	0.0865	0.0640
A-	0.0173	0.3069	0.0192	0.0293

Table 8:Relative Closeness Coefficient & Ranking

	S+	S-	C*	Rank
S 1	0.0401	0.2135	0.8421	1
S 2	0.0896	0.1390	0.6082	5
S 3	0.0902	0.1340	0.5976	6
S 4	0.0658	0.1648	0.7147	3
S 5	0.0945	0.1308	0.5804	7
S 6	0.0584	0.2053	0.7785	2
S 7	0.1447	0.0859	0.3726	8
S 8	0.0865	0.1506	0.6352	4
S 9	0.1660	0.0601	0.2658	9
S 10	0.2101	0.0740	0.2605	10

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

3. RESULT AND CONCLUSIONS

Evaluation of alternative suppliers, ranking and selection of the most appropriate involves consideration of numerous and conflicting criteria. Application of different multicriteria decision making methods to the problem of supplier selection helps to make a more objective and reliable decisions. In the formulation and solving procedure of supplier selection problems multi-criteria decision-making methods often involve active participation of decision makers. This is particularly related to formulation of criteria relative importance as well as to analysis, ranking and selection of the final solution, i.e. best alternative.

In this paper, the calculation algorithm is done properly and the results were reached within the framework of the objectives set for the supplier. In this study supplier 1 was the most suitable supplier for further procurement process.

REFERENCES

[1] F. Allag, R. Zegadi, S. Bouharati, L. Tedjar, and I. Bouharati, “Dynamic of air pollution and its effect on newborns: Analysis using fuzzy logic inference system,” Wulfenia Journal, pp. 18–25, 2013.
[2] S. M. A. Burney, S. M. Ali, and M. S. Khan, “A Novel High Order Fuzzy Time Series Forecasting Method with Higher Accuracy Rate,” International Journal of Computer Science and Network Security, vol 18, no 5, pp. 13–40, 2018.
[3] M. Khan, A. Manzoor, K. Rohail, S. M. Ali, A. Iftikhar, and M. Alam, “Soft computing applications in education management—A review,” in Innovative Research and Development (ICIRD), 2018 IEEE International Conference on, 2018, pp. 1–4.
[4] Iftikhar, S. Musa, M. Alam, M. M. Su’ud, and S. M. Ali, “Application of Soft Computing Techniques in Global Software Development: state-of-the-art Review,” International Journal of Engineering & Technology, vol. 7, no. 4.15, pp. 304–310, 2018.
[5] T. L. Saaty, “Decision making with the analytic hierarchy process,” International journal of services sciences, vol. 1, no. 1, pp. 83–98, 2008.
[6] O. S. Vaidya and S. Kumar, “Analytic hierarchy process: An overview of applications,” European Journal of operational research, vol. 169, no. 1, pp. 1–29, 2006.
[7] P. Ishtiaq, S. A. Khan, and M. Haq, “A multi-criteria decision-making approach to rank supplier selection criteria for hospital waste management: A case from Pakistan,” Waste Management & Research, vol. 36, no. 4, pp. 386–394, Apr. 2018.
[8] O. Kilincci and S. A. Onal, “Fuzzy AHP approach for supplier selection in a washing machine company,” Expert systems with Applications, vol. 38, no. 8, pp. 9656–9664, 2011.
[9] F. Dweiri, S. A. Khan, and A. Almulla, “A multi-criteria decision support system to rank sustainable desalination plant location criteria,” Desalination, vol. 444, pp. 26–34, Oct. 2018.
[10] Ghodsypour, S. a. (1998). "A Decision Support System for Supplier Selection Using an Integrated Analytic Hierarchy Process and Linear Programming". International Journal of Production Economics, Vol.56-57(20),199-212.