Integration of Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for Supplier Selection

Josy George[1], Pushkal Badoniya[2], Haider Ali Naqvi[3]
[1]Assistant Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology, Bhopal, M.P (India)
[2,3]Assistant Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology Excellence, Bhopal, M.P (India)

Abstract- *Most decision-making problems can be considered as multiple criteria decision making (MCDM) problems and should be solved by different MCDM method. The main advantage of MCDM is that it can give managers many dimensions to consider related elements and evaluate all possible options under variable degrees. In the paper work multi criteria decision making (MCDM) methods are used such as SAW method and TOPSIS method. The Simple Additive Weighting (SAW) method is an easy-to-use technique. It can analyze cases based on the criteria used. The use of criteria values in this approach has an unlimited amount. The more criteria used, the higher the accuracy of the results obtained. The alternatives are ranked based on their relative closeness to the ideal solution. The TOPSIS technique is helpful for decision makers to structure the problems to be solved, conduct analyses, comparisons and ranking of the alternatives. To understand the hybridization a numerical example is solved with propose method.*

Keywords- Supplier Selection, Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Multiple Criteria Decision Making (MCDM)

I. 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 simple additive weighting – technique for order preference similar to ideal solution (SAW-TOPSIS). The SAW 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 recommendations for future research directions.

II. LITERATURE REVIEW

Selection of qualified supplier is a key success factor for an organization. The complexity and importance of the problemes, all for analytical methods rather than intuitive decisions. In literature, there are various methods regarding personnel selection. This paper considers a real application of personnel selection with using the opinion of expert by one of the decision- making model, it is called SAW method.

The right decision in placing employees in an appropriate position in a company will support the quality of management and will have an impact on improving the quality of human resources of the company. Such decision-making can be assisted by an approach through the Decision Support System (DSS) to improve accuracy in the employee placement process. The purpose of this paper is to compare the four methods of Multi Criteria Decision Making (MCDM), i.e., Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW), Analytic Hierarchy Process (AHP) and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) for the application of employee placement in accordance with predetermined criteria. The ranking results and the accuracy level obtained from each method are different depending on the different scaling and weighting processes in each method.

SAW Method

The SAW (Simple Additive Weighted) method was first introduced by Harsanyi in 1955. Because of simple procedure, SAW method has gotten popular, and widely been used in MCDM problems.

Step by step: SAW method:

- Normalizing decision matrix.
- Multiplying weight of criteria by normal value of each criteria of every alternatives.
- Sum up the values created in the last step and make the point of each alternatives.
- Choose the alternative that has the maximum point.

TOPSIS Method

TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon. TOPSIS is based on closest Euclidean distance to ideal point and longest distance to nadir point. DMs should specify cost and profit criterions when using TOPSIS for the MCDM problems. TOPSIS is a compensatory method that make trade-offs between poor and good resulted criterions.
Step by step: TOPSIS method:

- Normalizing decision matrix.
- Multiplying weight of criteria by normal value of each
- criterion of every alternative.
- Determining the ideal and nadir point for every criterion.
- Calculate the Euclidean distance from ideal and nadir alternative for each alternative.
- Calculate the relative closeness to ideal alternative.
- Elect the alternative with the highest relative closeness.

III. METHODOLOGY ADOPTED

Simple Additive Weighting (SAW) which is also known as weighted linear combination or scoring methods is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of The SAW method requires the process of normalizing the decision matrix to a scale comparable to all current alternative ratings [6]. This method is the most famous and most widely used method of dealing with Multiple Attribute Decision Making (MADM) situations. MADM itself is a method used to find the optimal alternative of some alternatives with certain criteria. The SAW method requires decision makers to assign weights to each attribute [7]. The total score for the alternative is obtained by summing all the results of the multiplication between the rating and the weight of each attribute. The rating of each attribute must be dimensionless; it has passed the previous matrix normalization process.

<u>Process of SAW consist of these steps:</u>

- Construct a pair-wise comparison matrix (n x n) for criteria with respect to objective by using Saaty's 1-9 scale of pair-wise comparisons shown in Table 2.1. In other words, it is used to compare each criterion

Table 1: The Fundamental Scale for Pairwise Comparisons

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice

9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6 and 8 can be used to express intermediate value		

- For each comparison, we will decide which of the two criteria is most important, and then assign a score to show how much more important it is.
- Compute each element of the comparison matrix by its column total and calculate the priority vector by finding the row averages.
- Weighted sum matrix is found by multiplying the pair-wise comparison matrix and priority vector.
- Dividing all the elements of the weighted sum matrix by their respective priority vector element.
- Compute the average of this value to obtain max
- Find the consistency Index, CI, as follows:
  CI = (λ_{max} – n)/(n-1) Where n is the matrix size.

  Calculate the consistency ratio, CR, as follows:

Table 2: Random Index Table

N	1	2	3	4	5
RCI	0	0	0.58	0.9	1.12
N	6	7	8	9	10
RCI	1.24	1.32	1.41	1.45	1.51

CR = CI/RI

Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in Table 2. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), this method was first suggested by Hwang and Yoon (1981) in accordance with the idea of ranking the choices based on their approximation to the ideal solution and their distance from the worst solution. The ideal choice is the one which minimizes the costs and maximizes the benefits and the negative choice is the one which maximizes the costs and minimizes the benefits. Among the advantages of this method are the facts that it possesses robust and vigorous logic, the mathematical calculations are really simple, and considers the best and the worst solutions while it has the ability to compare a high number of choices.

The steps for the TOPSIS analysis are as follows:

Step 1: The structure of matrix

D =

	X_1	X_2	…	X_j
A_1	X_{11}	X_{12}	…	X_{1j}
A_2	X_{21}	X_{22}	…	X_{2j}
.	.	.	…	.
.	.	.	…	.
A_i	X_{i1}	X_{i2}	…	X_{ij}

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

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

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.

IV. ILLUSTRATIVE EXAMPLE

For a company that wants select its supplier, suppose the following criteria and characteristics as the most important items to focus: Price (C1), Project Completion Time (C2), Work Quality (C3), Amount of equipment (C4), Distance(C5).

After consideration following decision matrix is obtained:

Table 3: Quantitative information

Selection Criteria →	**C1**	**C2**	**C3**	**C4**	**C5**

Alternatives ↓					
Supplier 1	80	12	Very Good	Good	260
Supplier 2	75	14	Very Good	Very Good	230
Supplier 3	72	13	Good	Sufficient	50
Supplier 4	65	15	Sufficient	Sufficient	140

By using five criteria mentioned above, the weights of criteria have been computed by using comparison matrix. Meanwhile, data was gathered from expert's opinion with questionnaire in sector of manufacturing. The company is using scale values of 1-5 as shown in table 4.

Table 4: Criterion Relationship Matrix

	C1	C2	C3	C4	C5
C1	1	2	2	4	2
C2	0.50	1	1	3	2
C3	0.50	1.00	1	2	2
C4	0.25	0.33	0.50	1	0.50
C5	0.50	0.50	0.50	2.00	1

Implementing SAW method for finding out the weight of the criterion.

Table 5: Weights of criteria by Comparison matrix

	C1	C2	C3	C4	C5	Sum	Weight
C1	0.29	0.29	0.31	0.31	0.22	1.41	0.28
C2	0.29	0.29	0.31	0.31	0.22	1.41	0.28
C3	0.14	0.14	0.15	0.15	0.22	0.82	0.16
C4	0.14	0.14	0.15	0.15	0.22	0.82	0.16
C5	0.14	0.14	0.08	0.08	0.11	0.55	0.11

Test of consistency

Let the pair-wise comparison matrix be denoted M1 and principal vector be denoted M2.

Then define M3 = M1*M2; and M4 =M3/M2. λmax = average of the elements of M4.

Consistency index (CI) = (λmax - N) / (N - 1)

Consistency Ratio (CR) = CI/RCI corresponding to N.

Where RCI = Random Consistency Index and N = Numbers of elements.

$$M1 = \begin{bmatrix} 1.00 & 1.00 & 2.00 & 2.00 & 2.00 \\ 1.00 & 1.00 & 2.00 & 2.00 & 2.00 \\ 0.50 & 0.50 & 1.00 & 1.00 & 2.00 \\ 0.50 & 0.50 & 1.00 & 1.00 & 2.00 \\ 0.50 & 0.50 & 0.50 & 0.50 & 1.00 \end{bmatrix} \quad M2 = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.16 \\ 0.16 \\ 0.11 \end{bmatrix}$$

$$M3 = \begin{bmatrix} 1.44 \\ 1.44 \\ 0.83 \\ 0.83 \\ 0.56 \end{bmatrix} \quad M4 = \begin{bmatrix} 5.10 \\ 5.10 \\ 5.08 \\ 5.08 \\ 5.04 \end{bmatrix}$$

Consistency index (CI) = (λmax - N) / (N - 1)
= (5.08-5) / (5-1)
= 0.02

Consistency Ratio (CR) = CI/RCI (Reference Table 2)
=0.02/1.12
=0.018 < 0.10

The consistency Rate calculated was 0.018 that is less than 0.1, indicating sufficient consistency. The calculated weights are satisfactory.

Now the second section of the solution where the TOPSIS Method is implemented.

Table 6: Decision matrix

Selection Criteria → / **Alternatives ↓**	**C1**	**C2**	**C3**	**C4**	**C5**
Supplier 1	80	12	9	7	260
Supplier 2	75	14	9	9	230
Supplier 3	72	13	7	5	50
Supplier 4	65	15	5	5	140

The structure of matrix:

Table 7 Criterion Parametric values

Selection Criteria → / **Alternatives ↓**	**C1**	**C2**	**C3**	**C4**	**C5**
Supplier 1	80	12	9	7	260
Supplier 2	75	14	9	9	230

Supplier 3	72	13	7	5	50
Supplier 4	65	15	5	5	140
$\sum_{i=1}^{m} x_{ij}$	292	54	30	26	680
$\sqrt{\sum_{i=1}^{m} x_{ij}^2}$	146.4	27.09	15.36	13.41	377.62

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

Table 8: Normalized Matrix

SC → **A ↓**	**C1**	**C2**	**C3**	**C4**	**C5**
Supplier 1	0.55	0.44	0.58	0.52	0.68
Supplier 2	0.51	0.51	0.58	0.67	0.60
Supplier 3	0.49	0.47	0.45	0.37	0.13
Supplier 4	0.44	0.55	0.32	0.37	0.37

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

Table 9: Normalized Weight Matrix

SC → **A ↓**	**C1**	**C2**	**C3**	**C4**	**C5**
Supplier 1	0.15	0.12	0.09	0.08	0.07
Supplier 2	0.14	0.14	0.09	0.11	0.07
Supplier 3	0.14	0.13	0.07	0.06	0.01
Supplier 4	0.12	0.15	0.05	0.06	0.04

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

Table 10: Positive and Negative Ideal Solution

A^*	0.12	0.12	0.09	0.11	0.01
A^-	0.14	0.15	0.05	0.06	0.07

Table 11: Separation measure, relative closeness coefficient and ranking

Suppliers	**S_i^***	**S_i^-**	**C_i^***	**Rank**
Supplier 1	0.01	0.00	0.41	**3**
Supplier 2	0.00	0.00	0.56	**1**
Supplier 3	0.00	0.00	0.54	**2**
Supplier 4	0.01	0.00	0.15	**4**

V. CONCLUSION

The present study explores that the integration of SAW method and TOPSIS methods in solving a supplier selection problem and the results obtained can be valuable to the decision maker in framing the supplier selection strategies. For calculating the weight of the criterion, SAW method implemented the further calculations based on TOPSIS. The best ranked suppliers Supplier2 have advantage over the alternatives according to criterions. Thus, this integration methods can be successfully employed by the decision makers for the process of supplier selection

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