An Entropy-Weight Based TOPSIS Approach for Supplier Selection

Josy George[1], Mukesh Sahu[2], Haider Ali Naqvi[3]

[1,2,3]Assistant Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology Excellence, Bhopal (M.P), India

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Abstract -
Supplier selection is one of the most critical issues to be dealt by manufacturing firms in today's competitive environment. It is a multi-criteria decision-making problem which involves both qualitative and quantitative factors. In order to select the best supplier, it is important to make a trade-off between these tangible and intangible factors which conflict with each other. The objective of this paper is to develop a methodology to evaluate suppliers in supply chain cycle based on Technique for Order Preference by Similarity to Ideal Solution method (TOPSIS) by entropy weight *concept. To understand this method a numerical example is proposed to illustrate the effectiveness of TOPSIS method.*

Key Words*: *TOPSIS Method, Entropy Weight, Supplier Selection, Multi-criteria decision making (MCDM)

1. INTRODUCTION

Organizations must work with several suppliers to continue its activities. Selection of the suppliers in a group of candidate firms is a difficult decision problem. In these circumstances, supplier selection is vital for the firms. Determining the best supplier is the key for success to the companies with respect to strategic sense.
The prime focus this paper is selection of supplier based on TOPSIS method, TOPSIS method was first developed by Hwang & Yoon and ranks the alternatives according to their distances from the positive ideal and the negative ideal solution, i.e. the best alternative has simultaneously the shortest distance from the ideal solution and the farthest distance from the negative ideal solution. The ideal solution is identified with a hypothetical alternative that has the best values for all considered criteria whereas the negative ideal solution is identified with a hypothetical alternative that has the worst criteria values. In practice, TOPSIS has been successfully applied to solve selection/evaluation problems with a finite number of alternatives because it is intuitive and easy to understand and implement.

The acronym TOPSIS stands for Technique for Order Preference by Similarity to the Ideal Solution. In general, the process for the TOPSIS algorithm starts with forming the decision matrix representing the satisfaction value of each criterion with each alternative. Next, the matrix is normalized with a desired normalizing scheme, and the values are multiplied by the criteria weights. Subsequently, the positive-ideal and negative-ideal solutions are calculated, and the distance of each alternative to these solutions is calculated with a distance measure.
Finally, 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.

2. LITERATURE REVIEW

Selection supplier is a strategic decision in the course of supply chain management. The selection of suppliers depends on the sourcing strategy of the buyer/manufacturer. It helps in optimizing the supply chain and thus increasing the efficiency of the supply chain. An incorrect supplier selection can drive the entire supply chain into confusion.

Selecting suppliers and service providers through competitive bid ding processes is a vital activity for most operating organizations and manufacturers. In today's competitive markets, companies have understood the importance of selecting proper suppliers who can supply their requirement with their desired quality and in a scheduled time. Therefore, businesses try to measure the performance of their suppliers to select the best supplier to gain supply chain surplus. Consequently, supplier selection is a key factor of the procurement process. Basically, selecting a proper supplier is considered as a non-trivial task. To achieve this goal, the majority of the decision makers empirically evaluate and select suppliers.

The Entropy method can be used not only to quantitatively estimate data quantity, but also to calculate objectively the relative weight of information. Entropy was originally intended to imply a physical phenomenon of numerator turbulence degree or the probability scale under a specified condition. If entropy values are lower, the numerator degrees are more proportional, implying as close to perfect entropy as possible. Conversely, if entropy values are higher, the numerator degrees have a more irregular inflection. Therefore, entropy weight method was introduced to obtain the relative weight of each attribute. Additionally, in information theory, entropy can be used to measure expected information content of a certain message.

3. ENTROPY WEIGHT BASED TOPSIS MODEL

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) 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 - I: 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 - II: 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 - III: Normalize the decision matrix by using formula.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$$

Step - IV: Compute ej value by using formula

$$e_j = -k \sum_{i=1}^{m} p_{ij} . \ln p_{ij}$$

Where

$$k = \frac{1}{\ln m}$$

Step - V: Compute d_j value by using formula

$$d_j = 1 - e_j$$

Step - VI: Calculate w_j value, which shows the weight of jth criteria, by using formula below. The sum of the weights of all criteria must be equal to 1.

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n}(1 - e_j)}$$

Step - VII: Construct the weighted normalized decision matrix by multiplying:

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

Step - VIII: 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 - IX: 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 - X: Calculate the relative closeness to the ideal Solution

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

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

4. 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 1: Quantitative information

Selection Criteria → / Alternatives ↓	C1	C2	C3	C4	C5
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

Table 2: 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

4.1 CALCULATIONS

Step 1: The structure of matrix

Table 3 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

Step 2: Calculate the Normalized the matrix by using the mentioned formula in methodology section.

Table 4: 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

Step 3: Normalize the decision matrix by using the mentioned formula in methodology section.

Table 5 Proportional Matrix 1

SC → / A ↓	C1	C2	C3	C4	C5
Supplier 1	0.28	0.22	0.30	0.26	0.38
Supplier 2	0.26	0.25	0.30	0.34	0.33
Supplier 3	0.25	0.24	0.23	0.19	0.07
Supplier 4	0.22	0.27	0.16	0.19	0.20

Step 4: Compute ej value by using formula by using the mentioned formula in methodology section.

Table 6 Proportional Matrix 2

SC → / A ↓	C1	C2	C3	C4	C5
Supplier 1	0.28	0.22	0.30	0.26	0.38
Supplier 2	0.26	0.25	0.30	0.34	0.33
Supplier 3	0.25	0.24	0.23	0.19	0.07
Supplier 4	0.22	0.27	0.16	0.19	0.20
$\sum_{i=1}^{n} (p_{ij}.lnp_{ij})$	-1.38	-1.38	-1.35	-1.35	-1.24
-k	-0.72	-0.72	-0.72	-0.72	-0.72
e_j	0.99	0.99	0.97	0.97	0.89

Step 5 & 6: Compute d_j value by using formula and calculate w_j value.

Table 7 Weight Calculation

e_j	**e_1**	**e_2**	**e_3**	**e_4**	**e_5**
	0.99	0.99	0.97	0.97	0.89
$d_j = 1 - e_j$	0.10	0.10	0.30	0.30	0.11
$w_j = \frac{1 - e_j}{\sum_{j=i}^{n} 1 - e_j}$	0.11	0.11	0.33	0.33	0.12
Weight	**w_1**	**w_2**	**w_3**	**w_4**	**w_5**

Step 7: Construct the weighted normalized decision matrix.

Table 8: Weight Normalized Matrix

SC → A ↓	C1	C2	C3	C4	C5
Supplier 1	0.06	0.05	0.19	0.17	0.08
Supplier 2	0.06	0.06	0.19	0.22	0.07
Supplier 3	0.05	0.05	0.15	0.12	0.02
Supplier 4	0.05	0.06	0.16	0.12	0.04

Step 8: Determine the positive ideal solution and negative ideal solution.

Table 9 Positive and Negative Ideal Solution

A^*	0.05	0.05	0.19	0.22	0.02
A^-	0.06	0.06	0.15	0.12	0.08

Step 9: Calculate the separation measure for suppliers.

Table 10 Separation Measure for suppliers

	Supplier 1	Supplier 2	Supplier 3	Supplier 4
S+	0.079	0.052	0.108	0.107
S-	0.065	0.015	0.062	0.042

Step 10: Calculate the relative closeness to the ideal Solution.

Table 11 Relative Closeness Coefficient

Alternatives ↓	S^*	S^-	S^*+S^-	$C^* = S^-/(S^*+S^-)$
Supplier 1	0.079	0.065	0.144	0.45
Supplier 2	0.052	0.147	0.667	0.22
Supplier 3	0.180	0.062	0.170	0.36
Supplier 4	0.107	0.042	0.149	0.28

Step 10: Supplier ranking according to preferences.

Table 12 Alternatives Ranking

Alternatives	TOPSIS Index	Rank
Supplier 1	0.451	1
Supplier 2	0.220	4
Supplier 3	0.365	2
Supplier 4	0.282	3

5. RESULT AND CONCLUSIONS

In this study, Entropy weight based TOPSIS method for decision making to tackle multi criteria decision making problem affected by uncertainty and taking into account the preferences of the decision maker is applied. This method allows in finding the best alternative by given criteria and characteristics. Entropy weight is used in TOPSIS analysis which is used for making the right decision for the organization. Results from Entropy and TOPSIS analysis are objective and accurate. The ranking of the alternatives in order are S1 > S3 > S4 > S2. Results indicate that S1 is the best alternative with C^* *value* of 0.451wherein S1 which is the best alternative.

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