Evaluation and Selection of Supplier in A Supply Chain Management using DEA-TOPSIS Methods Under Intuitionistic Fuzzy Environment

M.V. Madhuri, N. Ravi Shankar

Abstract: Selection of efficient supplier is essential in a Supply Chain Management. It increases product quality, reduces wastage and saves time. In recent past, many methods were used in supplier selection process. Selection of efficient supplier that suits the manufacturer criteria is needed. The proposed method comprises of two stages that integrates Data Envelopment Analysis (DEA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The efficiency of the given set of suppliers is evaluated using DEA method in the first stage that filters the given list of suppliers. While in the second stage, TOPSIS method is applied to select one of the efficient suppliers shortlisted in first stage. Integration of two methods reduces the selection time. Since the data provided and the criteria considered are vague and imprecise in nature, decision making is done in intuitionistic fuzzy environment. The proposed methodology is demonstrated with a numerical illustration.

Keywords: Decision making; Data Envelopment Analysis; TOPSIS, Intuitionistic fuzzy numbers; Supply Chain Management.

I. INTRODUCTION

Effective management of Supply Chain network of a manufacturing and distribution company plays a key role in a business organization as it integrates various activities beginning with the acquisition of raw material from supplier, manufacture the product and sale of the finished product to the customer through distribution centers. Main challenge of a business organization is to balance both customer satisfaction and profit. Purchase of the quality raw material from a reliable supplier increases the production quality, minimizes delivery time and inventory costs there by increasing customer satisfaction. Evaluation and choice of efficient supplier which meets the requirements of the manufacturer under various performance criteria brings significant benefits to the organization. De Boer et al [1] gives an analysis of diverse methods in supplier selection that includes problem definition, performance criteria, supplier qualifications and proposed new techniques and methods that are currently in use.

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Choosing a supplier is a decision-making activity that decides which alternative to choose from the given list of alternatives. Dickson [2] gives the survey of both firm and individual vendor selection practices and presented list of factors needed for the vendor evaluation. Chai. J et al [3] gave the detailed literature analysis of various decision-making methods in the choice of supplier and developed a procedural analysis model for the revised articles under the logical aspects of the problem, environment and approach.

DEA method was developed by Farrell and Michael James in 1957[4] and further extended by Charnes et al in 1978[5]. It is a linear programming technique that assesses relative efficiency of the given set of units using various inputs and outputs and the efficiency measure is obtained by dividing weighted sum of outputs by weighted sum of inputs as given by Friedman et al [6]. This method not only identifies efficient alternative but also sets benchmark for less performing alternatives while evaluating each alternative [7-9]. DEA method has its applications mainly in determining relative efficiency of various programs in educational institutions. A. Bessent and W. Bessent [10], assessed educational programs of a community college using DEA and suggested necessary steps for the improvement of existing programs and termination of inefficient programs. Tomkins and Green [11] did a study using DEA in the evaluation of efficiency of the departments in a UK university. J. Johnes and G. Johnes [12] in their study of various models to measure the technical efficiency in terms of research outputs of economic departments, provided guidelines for the efficiency score interpretations. While Sinuany-Stern et al [13] analysis on Ben-Gurion University's academic departments' relative efficiencies by considering the Operating costs and pay roll costs as input and grants, contact hours, and publications as outputs suggest that operating cost of few departments could be reduced. Their analysis also gave a conclusion that efficient departments can be revised as inefficient when the variables are changed or mixed. Puri et al [14] discussed DEA application to Bank sector considering labor and operating expenses as intuitionistic fuzzy numbers at branch level. DEA method can also be used as a tool for the selection of supplier. Toloo, Mehdi, and Soroosh Nalchigar [15] identified efficient suppliers using cardinal and ordinal data and used their method in prioritizing suppliers.

DEA method evaluates supplier's efficiency and classify them into two categories as efficient or inefficient but cannot decide the best supplier that suits the manufacturer's criteria since all efficient suppliers are equally good. Hence the proposed method uses TOPSIS method in the second stage to select best supplier from the shortlisted set of suppliers. TOPSIS is a popular approach developed by Hwang and Yoon [16] that has application in the solution of MCDM problems and in supplier selection process due to its ability of choosing best supplier quickly. Chen et al [17] used the TOPSIS concept and developed methodology to solve supplier selection problem under fuzzy conditions. While Boran Faith Emre et al [18] used intuitionistic fuzzy average operator for the aggregation of individual opinions of decision makers for rating importance of criteria and alternatives in TOPSIS method and developed a supplier selection problem. Few researchers gave integrated DEA and Wang and Lu [19] concludes that rank reversal approach is often used in various MCDM tools whenever there is addition or removal of alternative. Lotfi, F. et al [20] used the outcomes of various ranking methods as criteria in TOPSIS method to compute score based on efficiencies. Chitnis, Asmita, and Omkarprasad S. Vaidya [21] provided tie breaking procedure using DEA& TOPSIS for computing performance efficiencies that addresses the issue of assigning unique ranking method taking example of data from Indian Bank. There were a variety of DEA ranking methods like cross efficiency [22], super efficiency [23], benchmarking [24] techniques. These ranking methods may not have same viewpoint. Preference of ranking method over others is critical as each method has its own weightage and viewpoint which are usually in conflict with each other which reflects in conflict model results. To solve this problem of conflict, instead of using ranking method on DEA the proposed method uses TOPSIS method in the second stage to enable the decision maker to choose the suitable supplier among the shortlisted suppliers.

Practical data available is qualitative that is linguistic and imprecise in nature in a group decision making process of a supplier selection. The expression of preferences and opinion of decision makers during evaluation and selection process cannot be quantified by exact numbers between 0 and 1 due to the lack of precise information. They are expressed as intuitionistic fuzzy numbers that has acceptance degree / membership value, rejection degree /non-membership value and hesitant values. Hence intuitionistic fuzzy numbers are more appropriate than fuzzy numbers in the supplier selection process.

The outline of the paper is organized as follows: Section II gives the preliminaries consisting of definitions of Intuitionistic fuzzy sets (IFS), Intuitionistic fuzzy number (IFN), Triangular intuitionistic fuzzy number and defuzzification of triangular intuitionistic fuzzy numbers using centroid of centroids [25]. Section III gives notations and methodology that measures efficiency score and select supplier in two stages using DEA -TOPSIS methods. Section IV gives the example that illustrates the model. Section V gives the conclusion.

II. PRELIMINARIES

Atanassov [26] introduced Intuitionistic fuzzy sets (IFS) and they are the addition to the fuzzy sets given by Zadeh [27]. This section includes some basic definitions of intuitionistic fuzzy sets (IFS) [26], intuitionistic fuzzy number (IFN), Triangular intuitionistic fuzzy numbers, their arithmetic operations and defuzzification of triangular and trapezoidal IFN [28].

A. Intuitionistic Fuzzy Set (IFS):

A subset A of a universal set X expressed as $A=\{(x,\mu_A(x),\upsilon_A(x))/x\in X\}$ is said to be Intuitionistic fuzzy set. Where $\mu_A(x):X\to[0,1]$, $\upsilon_A(x):X\to[0,1]$ represents degree of membership and non-membership values such that $\mu_A(x)+\upsilon_A(x)\le 1\,\forall x\in X$. Further, $\pi_A(x)=1-\mu_A(x)-\upsilon_A(x)\;\forall x\in X$is the degree if hesitant of *x*. $0\le\pi_A(x)\le 1$ and the Intuitionistic fuzzy set becomes a fuzzy set when $\pi_A(x)=0$.

B. Intuitionistic Fuzzy Number (IFN):

An Intuitionistic fuzzy set A is said to be an intuitionistic fuzzy number (IFN) [28] with membership and non-membership functions μ_A,υ_A when it satisfies the following.

(i) A is normal, i.e., $\exists x_0\in R$such that $\mu_A(x_0)=1$then $\upsilon_A(x_0)=0$.

(ii) A is convex for $\mu_A(x)$

i.e., $\mu_A(\lambda x_1+(1-\lambda)x_2)\ge min(\mu_A(x_1),\mu_A(x_2))$ $\forall x_1,x_2\in R,\lambda\in[0,1]$.

(iii) A is concave for $\upsilon_A(x)$ i.e.,

$\upsilon_A(\lambda x_1+(1-\lambda)x_2)\le max(\upsilon_A(x_1),\upsilon_A(x_2))$ $\forall x_1,x_2\in R,\lambda\in[0,1]$.

Membership and non-membership functions are defined as

$$\mu_A(x)=\begin{cases} f_A(x), a_1\le x<a_2\\ 1, a_2\le x<a_3\\ g_A(x), a_3\le x\le a_4\\ 0, otherwise\end{cases}$$

And

$$\upsilon_A(x)=\begin{cases} h_A(x), b_1\le x<b_2\\ 0, b_2\le x<b_3\\ k_A(x), b_3\le x\le b_4\\ 1, otherwise\end{cases}$$

Where $a_1,a_2,a_3,a_4,b_1,b_2,b_3,b_4\in R$ such that $b_1\le a_1\le b_2\le a_2\le a_3\le b_3\le a_4\le b_4$, and the functions $f_A(x)$ and $k_A(x)$ are increasing piecewise continuous in $[a_1,a_2)$ and $(b_3,b_4]$ respectively , while $g_A(x)$, $h_A(x)$ are decreasing piecewise continuous in $(a_3,a_4]$ and $(b_3,b_4]$ respectively.

C. Triangular Intuitionistic fuzzy number [28]

An IFN will be a triangular intuitionistic fuzzy number when membership and non-membership functions are given by

$$\mu_A(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, a_1 \le x < a_2 \\ 1, x = a_2 \\ \frac{x-a_3}{a_2-a_3}, a_2 < x < a_3 \\ 0, otherwise \end{cases}$$

and $$\upsilon_A(x) = \begin{cases} \frac{x-b_2}{b_1-b_2}, b_1 \le x < b_2 \\ 0, x = b_2 \\ \frac{x-b_3}{b_2-b_3}, b_2 < x < b_3 \\ 1, otherwise \end{cases}$$

D.Defuzzification of Intuitionistic fuzzy number

Ranking or defuzzification of triangular intuitionistic fuzzy number using centroid of centroids with membership and non-membership functions [25] is given by $R(A) = \left(\frac{(a_1+b_1)+14a_2+(a_4+b_4)}{18}\right)\left(\frac{4w_1+5w_2}{18}\right)$ where w_1, w_2 are the maximum values of membership and non-membership functions such that $0 < w_1, w_2 \le 1$.

III. EFFICIENCY MEASURE AND SELECTION OF SUPPLIERS

The proposed model integrates DEA and TOPSIS methods for the selection of suitable supplier. It is done in two stages. In stage 1, We measure the supplier's efficiency under various input and output criteria using DEA method and shortlist the efficient suppliers. In stage 2, using TOPSIS method the selection of supplier that best suits manufacturer requirement is done by the group of decision makers.

Stage 1

To check the efficiency score of the given set of suppliers.

DEA is a linear programming model that measures the relative efficiency of the suppliers using various inputs and outputs. The performance of supplier is calculated in terms of efficiency or productivity score which is the ratio of its weighted sum of outputs to the weighted sum of inputs with the constraint that maximum value of the score do not exceed 1. The suppliers with maximum efficiency score 1 are more efficient than those with efficiency score less than one.

Notations:

i - Suppliers
r - Outputs
s- Inputs
y_{si} – input variable
x_{ri} – output variable
u_r – output weightage
v_s – input weightage
e_i – efficiency score of i^{th} supplier

Mathematical model to evaluate supplier efficiency

Max $e_i = \sum_{r=1}^{n} u_r x_{ri}$

Subject to:

$$\sum_{r=1}^{n} u_r x_{ri} - \sum_{s=1}^{m} v_s y_{si} < 0, \forall i$$

$$\sum_{s=1}^{m} v_s y_{si} = 1$$

$$u_r, v_s > 0 \qquad (1)$$

Maximum efficiency of each supplier is calculated using inputs and outputs from the above model. The suppliers with efficiency score 1 are identified and checked for the compliance of the organization's requirements using TOPSIS method in stage 2.

Stage 2

TOPSIS method to choose the best supplier among the shortlisted set of suppliers from stage 1.

Step 1. Determine weightage of each decision maker

$$\lambda_k = \frac{\left[\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k+\upsilon_k}\right)\right]}{\sum_{k=1}^{l}\left[\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k+\upsilon_k}\right)\right]} \qquad (2)$$

Step 2. Construction of accumulated intuitionistic fuzzy decision matrix in decision maker's view. denoted by $R = (r_{ij})_{mxn}$

Where $r_{ij} = \left(\mu_{A_i}(x_j), \upsilon_{A_i}(x_j), \pi_{A_i}(x_j),\right)$

$$r_{ij} = \left[1 - \Pi_{k=1}^{l}\left(1-\mu_{ij}^{(k)}\right)^{\lambda_k}, \Pi_{k=1}^{l}\left(\upsilon_{ij}^{(k)}\right)^{\lambda_k}, \Pi_{k=1}^{l}\left(1 - \mu_{ij}^{(k)}\right)^{\lambda_k} - \Pi_{k=1}^{l}\left(\upsilon_{ij}^{(k)}\right)^{\lambda_k}\right] \qquad (3)$$

Step3. Decide the criteria weightage in decision maker's view on importance of grades.

Weight of each criteria j by k^{th} decision maker is given by

$$w_j^{(k)} = \left[1 - \prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right), \prod_{k=1}^{l}\left(\upsilon_j^{(k)}\right), \prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right) - \prod_{k=1}^{l}\left(\upsilon_j^{(k)}\right)\right] \qquad (4)$$

Step 4. Construction of accumulated weighted intuitionistic fuzzy decision matrix $R' = (r'_{ij})_{mxn}$

$$r'_{ij} = \left(\mu_{A_1w}(x_j), \upsilon_{A_1w}(x_j), \pi_{A_1w}(x_j)\right)$$

Where

$$\mu_{A_iw}(x_j) = \mu_{A_i}(x_j) * \mu_w(x_j)$$

$$\upsilon_{A_iw}(x_j) = \upsilon_{A_i}(x_j)\, \upsilon_w(x_j) - \upsilon_{A_i}(x_j) * \upsilon_w(x_j)$$

$$\pi_{A_iw}(x_j) = 1 - \upsilon_{A_i}(x_j) - \upsilon_w(x_j) - \mu_{A_i}(x_j) * \mu_w(x_j) + \upsilon_{A_i}(x_j) * \upsilon_w(x_j) \qquad (5)$$

Step 5. Determine intuitionistic fuzzy Optimistic and pessimistic solutions A+ and A-

The given set of criteria are characterized as Benefit criteria J_1, Cost criteria J_2 and intuitionistic optimistic and pessimistic solutions are obtained as follows.

$A^+ = (a_1^+, a_2^+, \dots a_n^+)$ and $A^- = (a_1^-, a_2^-, \dots a_n^-)$ where $a_j^+ = (\mu_j^+, \upsilon_j^+, \pi_j^+)$ and $a_j^- = (\mu_j^-, \upsilon_j^-, \pi_j^-)$

$$\mu_j^+ = \left(\left(\max_i \mu_{A_iW}(x_j)/j \in J_1\right), \left(\min_i \mu_{A_iW}(x_j)/j \in J_2\right)\right)$$

$$\upsilon_j^+ = \left(\left(\min_i \upsilon_{A_iW}(x_j)/j \in J_1\right), \left(\max_i \upsilon_{A_iW}(x_j)/j \in J_2\right)\right)$$

$$\pi_j^+ = 1 - \mu_j^+ - \pi_j^+$$

$$\mu_j^- = \left(\left(\min_i \mu_{A_iW}(x_j)/j \in J_1\right), \left(\max_i \mu_{A_iW}(x_j)/j \in J_2\right)\right)$$

$$\upsilon_j^- = \left(\left(\max_i \upsilon_{A_iW}(x_j)/j \in J_1\right), \left(\min_i \upsilon_{A_iW}(x_j)/j \in J_2\right)\right)$$

$$\pi_j^- = 1 - \mu_j^- - \pi_j^- \qquad (6)$$

Step 6. Calculation of separation measures

Positive and negative separation measures S+ and S- from respective intuitionistic optimistic and pessimistic solutions are calculated for each supplier using normalized Euclidean distance.

$$S^+ = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}\left[\left(\mu_{A_iW}(x_j) - \mu_j^+\right)^2 + \left(\upsilon_{A_iW}(x_j) - \upsilon_j^+\right)^2 + \left(\pi_{A_iW}(x_j) - \pi_j^+\right)^2\right]}$$

$$S^- = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}\left[\left(\mu_{A_iW}(x_j) - \mu_j^-\right)^2 + \left(\upsilon_{A_iW}(x_j) - \upsilon_j^-\right)^2 + \left(\pi_{A_iW}(x_j) - \pi_j^-\right)^2\right]}$$

$$(7)$$

$C_i^+ = \frac{S_i^-}{S_i^+ + S_i^-}$ where $0 \le C_i^+ \le 1$.

IV. NUMERICAL EXAMPLE.

Following section illustrates an example as application of the proposed model.

Example:

In a supply chain network, a manufacturing company requires best quality raw materials to manufacture the product. Five suppliers are available whose efficiency is evaluated, and one supplier that best suits the company's requirements is selected under given set of criteria by a team of experts called decision makers. It is done in two stages. In stage 1, using DEA method we check the efficiency of each supplier based on 0-1 scale and eliminate the inefficient suppliers from the list. The shortlisted suppliers are the then assessed using TOPSIS method and selected under most suitable criteria by a team of three decision makers in Stage2.These criteria include C_1-Quality, C_2-Environmental criteria, C_3-Just in time management, C_4- social criteria and C_5- commercial criteria. The data available is linguistic and more imprecise in nature hence represented in intuitionistic fuzzy numbers.

Stage 1

DEA method to find the efficiency of the given set of suppliers

The de- fuzzified crisp inputs and outputs of the DEA are as follows and their weights are given in Tables I and II respectively.

Input variables	Output variables
y_1 - Quality of the system	x_1 – Quality
y_2 - Carbon credits	x_2 - Environmental criteria
y_3 - Delivery time of the material	x_3 - Just in time management
y_4 - Equal opportunity to gender and no child labor	x_4 - social criteria
y_5 - price of the material	x_5 - commercial criteria

Using the inputs and outputs from Tables I & II in the above model, maximum efficiency of all the 5 suppliers are calculated and their scores are recorded in Table III.

Table I

	y_1	y_2	y_3	y_4	y_5
S_1	0.71	1.04	0.75	0.88	0
S_2	1.13	1.04	1.13	1.08	1.26
S_3	1.01	1.04	0.87	1.03	0.73
S_4	0.81	0.84	1.04	0.96	1.26
S_5	0.86	0.82	0.82	0.95	0.96

Weights of Input Variables

Table II

	x_1	x_2	x_3	x_4	x_5
S_1	0.69	0.89	0.39	0	0.32
S_2	0.99	1.35	1.16	1.21	0.95
S_3	1.24	1.57	1.41	2.42	1.27
S_4	1.22	1.21	0.77	2.42	1.27
S_5	0.42	0.89	1.03	0	0.85

Weights of Output Variables

Table III

e_1	1
e_2	0.86
e_3	1
e_4	1
e_5	0.93

Efficiency core of Supplier e_i

From Table III we can see that the suppliers S_1, S_3 and S_4 have efficiency sore 1. These suppliers are checked for the required criteria of the manufacturer taking the outputs of the DEA as the required criteria testing by TOPSIS method in stage 2.

Stage 2

Step 1. Weights of the decision makers calculated using Table IV and equation (2) are shown in table V

Table IV

Linguistic terms	IFNs
Crucial (CR)	(0.85,0.10)
Significant (SF)	(0.60,0.35)
Standard (SD)	(0.5,0.5)
Depraved (DP)	(0.35,0.60)
Deplorable (D)	(0.10,0.85)

Linguistic Terms Rating Decision Makers

Table V

	DM_1	DM_2	DM_3
Linguistic terms	Crucial (CR)	Standard (SD)	Significant (SF)
Weights	0.434	0.242	0.256

Weights of the Decision maker

Step 2. Accumulated intuitionistic fuzzy decision matrix using equation (3) $R = (r_{ij})_{mxn}$ represented in Table VI.

Table VI

	C_1	C_2	C_3	C_4	C_5
S_1	(0.759,0.122,0.119)	(0.537,0.420,0.043)	(0.660, 0.420,0.240)	(0.678, 0.195, 0.127)	(0.629, 0.282, 0.089)
S_3	(0.433,0.524,0.043)	(0.829,0.061,0.109)	(0.725, 0.159, 0.116)	(0.727, 0.156, 0.116)	(0.656, 0.237,0.106)
S4	(0.798,0.086,0.116)	(0.476,0.524,0)	(0.674,0.223,0.102)	(0.499,0.420,0.081)	(0.671,0.202,0.127)

Accumulated intuitionistic fuzzy decision matrix

Step3. Weights of the criteria are calculated by equation (4) using Tables VII & VIII and given in Table IX.

Table VII

Exceptional (E)	(0.9, 0)
Decent(D)	(0.8, 0.10)
Moderate(M)	(0.7, 0.2)
Bad (B)	(0.5, 0.5)
Very bad (VB)	(0.3, 0.5)

Importance of criteria in Linguistic term

Table VIII

SUPPLIERS	CRITERIA	DM_1	DM_2	DM_3
S_1	C_1 C_2 C_3 C_4 C_5	E E D M D	D E M M E	E D E M E
S_3	C_1 C_2 C_3 C_4 C_5	E G E D B	M B E D E	D E E M E
S_4	C_1 C_2 C_3 C_4 C_5	D M E E D	D E E D B	D D E M M

Importance of Criteria for each supplier

Table IX

Criteria	Weights
C1	(0.7269, 0.1652, 0.1079)
C2	(0.8831, 0, 0.11695)
C3	(05119, 0.280813, 0.2073)
C4	(0.6888, 0.2088, 0.1024)
C5	(0.8617, 0, 0.1383)

Weights of Criteria

Step 4. Table X represents Accumulated weighted intuitionistic fuzzy decision matrix

$$R' = (r'_{ij})_{mxn},\ r'_{ij} = \left(\mu_{A_1 w}(x_j), v_{A_1 w}(x_j), \pi_{A_1 w}(x_j)\right)$$

Table X

	C_1	C_2	C_3	C_4	C_5
S_1	(0.552,0.267,0.181)	(0.474,0.420,0.106)	(0.338,0.583,0.080)	(0.467,0.363,0.170)	(0.542,0.282,0.176)
S_3	(0.315,0.603,0.083)	(0.732,0.061,0.206)	(0.371,0.396,0.234)	(0.501,0.333,0.166)	(0.566,0.238,0.197)
S_4	(0.580,0.237,0.183)	(0.420,0.524,0.056)	(0.345,0.441,0.214)	(0.344,0.541,0.116)	(0.578,0.202,0.220)

Accumulated Weighted Intuitionistic Fuzzy Decision Matrix

Step 5. Intuitionistic fuzzy optimistic and pessimistic solutions A^+ and A^- are calculated using equations (6).

The given set of criteria are divided into two sets Benefit criteria $J_1 = \{C_1, C_2, C_3, C_4\}$, cost criteria $J_2=\{C_5\}$ and intuitionistic positive and negative ideal solutions are obtained.

A^+={(0.5802,0.2367,0.1830),(0.7324,0.0613,0.2063),(0.3710,0.3955,0.2335),(0.501,0.3326,0.1664),(0.5419,0.2821,0.1759)}

A^-={(0.3146,0.6027,0.0827),(0.4202,0.5241,0.0556),(0.3377,0.5828,0.0795),(0.3435,0.5410,0.1155),(0.5784,0.2017,0.2199)}.

Step 6. Separation measures S^+ and S^- from respective intuitionistic fuzzy optimistic and pessimistic solutions are calculated using equations (7). The relative closeness coefficients are determined.

Table XI

Suppliers	S^+	S^-	C_i^+
S_1	0.164050702	0.159446717	0.492884047
S_3	0.147510706	0.21610865	**0.594326585**
S_4	0.204467624	0.158942149	0.437363441

Separation measures and closeness coefficients

From Table XI we can conclude that supplier S_3 has the highest closeness coefficient and best suits the manufacturer's requirement hence selected for the supply of raw material.

V. CONCLUSION

Integration of DEA and TOPSIS methods improves the quality and reduces the production time, and production cost of the company. The proposed method is effective when selection is to be done from a large set of suppliers with minimum time. It also helps to choose the supplier that best suits the organization's requirements.

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