International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.6, Nov-Dec. 2012 pp-4189-4194 ISSN: 2249-6645

A Fuzzy Logic Multi-Criteria Decision Approach for Vendor Selection Manufacturing System

Harish Kumar Sharma[1]
National Institute of Technology, Durgapur (WEST BENGAL) - 1713209

Abstract: *The success of an industry depends on optimization of product cost and for achieving above goal Internal selection should be efficient. In the present study an efficient Multi-Criteria Decision Making (MCDM) approach has been proposed for quality evaluation and performance appraisal in vendor selection. Vendor selection is a Multi-Criteria Decision Making (MCDM) problem influenced by several parameters which are in linguistic. Multiple.Performance criteria/attributes. These criteria attributes may be both qualitative as well as quantitative. Qualitative criteria estimates are generally based on previous experience and perfomanance maker's opinion on suitability. Therefore to quantity the linguistic variables fuzzy logic and set theory is used. The fuzzy set theory helps in vagueness of the system. a fuzzy decision approach is developed where are resourcing of vendors to select suitable vendor for materials is made MCDM method has been illustrated in this reporting through a case study*.

Keywords: *Vendor's selection Fuzzy sets, Decision matrix, Rank, Multiple criteria decision making, weight*

I. Introduction

Iron and steel industry is an important basic industry for any industrial economy providing the primary material for construction, automobile machinery and other industries. the importance of maintenance function has increased due to its role in keeping and improving the availability, product quality cost-effectiveness levels. Maintenance costs constitute an important part of the operating budget of manufacturing firms. Maintenance selection is one of the most critical activities for many industries. The selection of an appropriate maintenance may reduce the purchasing cost and also improve competitiveness.

It is impossible for a company to successfully produce, low-cost, high-quality products without satisfactory maintenance. The selection of appropriate maintenance has been one of the most important function for a industries. If the relationship between a supplier and manufacturing industries. Many studies have pointed out that key is to set effective evaluation criteria for the supplier selection

Vendor selection is a common problem for acquiring the necessary materials to support the output of organizations. The problem is to find and evaluate periodically the best or most suitable vendor for the organization based on various vendor. Due to the fact that the evaluation always involves conflicting performance criteria of vendors. The techniques of multiple criteria decision making (MCDM) are coherently derived to manage the problem (Shyur &Shih, 2006).Evaluating vendors many criteria including quantitative, such as cost, price as well as qualitative, a considerable number of decision models have been developed based on the MCDM theory.

To resolve the problem, this paper suggests evaluating vendor using a multiple levels multiple criteria decision making method under fuzzy logic method maintenance alternative for industries planning of the basis of quantitative and qualitative factors formula are clearly displayed. Classified to benefit and cost criteria has the larger the better, ratings of vendor and importance weights of all the criteria are assessed in linguistic values represented by fuzzy numbers.

- Selection of fuzzy number & their membership functions.
- Fuzzy logic of the scale function
- Averaging the fuzzy numbers as given by the performance makers in terms linguistics variables.
- Determinations of fuzzy normalize weight.
- Overall ranking of alternatives.
- Finally result of multi criteria decision making

In this paper the vendor selection by a MCDM for these logic method identified a criteria based on product, cost ,quality ,service etc. these criteria short out the vendor by using the performance makers P_1,P_2,P_3,P_4,P_5, and P_N these performance makers gives the data in a logistics variable weight of the criteria then we find the suitable vendor material

II. REVIEW OF PREVIOUS WORK

[1]The vendor selection a focus area of research since the 1966s.literature (Dickson,1966; Weber ,1991)several dimensions are mentioned that are important for the multiple vendor selectiondecision.nmaking,price,quality,delivery,performance,history,capacity,service Production facilities and technical capabilities etc. the problem is how to select vendor that perform optimally on the desired dimensions.[2] Weber et al.(1991) reviewed 74 vendor(supplier) selection articles from 1966 to 1991 and showed that more than 63% of them were in a multi criteria decision making. other researchers also endorsed using a weighted linear method of multiple for the VSP. Gaballa (1974) is the first author who applied mathematical programming to a vendor selection problem in a real case. He used a mixed integer programming .model to minimize the total discounted price of it misallocated to the VSP. Weber

and Current (1993) developed a multi objective MIP for vendor selection and order allocation among the selected vendors .they applied the proposed model in a proposed model in a practical case.[3] Buffa and Jackson (1983) and Sharma et al. (1989), respectively, used linear and non-linear mixed-integer goal programming (GP) for price, service level, delivery and quality goals. Failure base maintenance (FBM) is performed when a failure or breakdown occurs, no action is taken to detect the onset of or to present failure. The maintenance related costs are usually high, but it may be considered cost effective in certain cases.[4] fuzzy multi agent system is proposed for ta-chung chu,Rangnath varma (2011),developed to depict the relationship among parent criteria and their sub-criteria and criteria and the weight of all criteria,[5] amit karami and zhiling Gua We demonstrate that the fuzzy logic approach provides a robust analysis for vendor selection, [6]eleonona botani ,Antonio Rizzi (2007) An adapted multi –criteria approach to suppliers and products selection An application oriented to lead-time reduction. An extensive case study is presented to show the practical application of the methodology

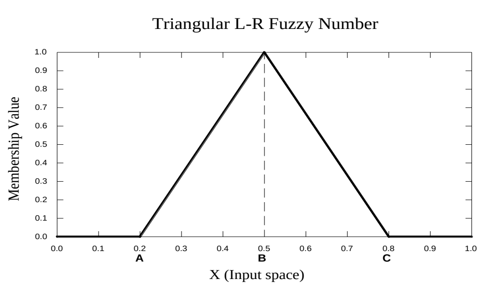
III. METHOD OF SOLUTION

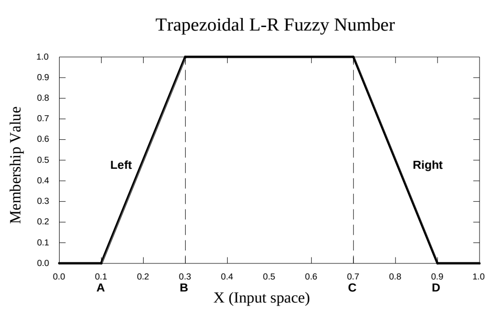
2.1 **Fuzzy sets**

A fuzzy set A can denoted by Ai = **{(x, f_A(x)) |x U}, where** U is universe of discourse, x is an element in U, A is a fuzzy set in $f_A(x)$ is the membership function of A x (Kaufmann & gupta, 1991) the larger $f_A(x)$, the stronger the grade of membership for x in A

2.2 Fuzzy **numbers**

A real fuzzy number A is described as any fuzzy subset of the real line R with membership function f_A which possesses the following properties (Dubois & Prade, 1978





A fuzzy number is defined as a continuous fuzzy set that contains convexity with one distinct peak and normality with at least one element with degree of

$$\mu_A(x)=\begin{cases}\dfrac{(x-a)}{(b-a)} a\le x\le b\\ \dfrac{(c-x)}{(c-a)} b\le x\le c\\ 0\end{cases} \quad \mu_A(x)=\begin{cases}\dfrac{(x-a)}{(b-a)} a\le x\le b\\ 1 b\le x\le c\\ \dfrac{(x-d)}{(c-d)} c\le x\le d\\ 0\end{cases}$$

(a) f_A is a continuous mapping from R to [0, 1];
(b) $f_A(x) = 0, \forall x \in (-\infty, a]$
(c) f_A is strictly increase on [a, b];
(d) f_A (x) = 1, x e [b, c];
(e) f_A is strictly decreasing on [c, d];(f) $f_A(x) = 0, \forall x \in [d,\infty)$;
Where a, b, c and d are real numbers. We may let a -1, or a=b, or b=c or c=d or d= +1

IV. OPERATIONS ON FUZZY NUMBERS

Let A=(a_1,b_1,c_1,d_1) and B= (a_2,b_2,c_2,d_2) are two trapezoidal fuzzy numbers. Then the operations [+,-,×,÷] are expressed (Kaufmann and Gupta 1991) as.

Let

$$\begin{aligned}A+B&=(a_1,\ b_1,\ c_1,\ d_1)+(a_2,\ b_2,\ c_2,\ d_2)\\ &=(a_1+a_2,\ b_1+b_2,\ c_1+c_2,\ d_1+d_2)\end{aligned}$$

$$\begin{aligned}A-B&=(a_1,\ b_1,\ c_1,\ d_1)-(a_2,\ b_2,\ c_2,\ d_2)\\ &=(a_1-d_2,\ c_1-b_2,\ c_1-b_2, d_1-a_2)\end{aligned}$$

$$\begin{aligned}A\times B&=(a_1,\ b_1,\ c_1,\ d_1)\times(a_2,\ b_2,\ c_2,\ d_2)\\ &=(a_1\times a_2,\ b_1\times b_2,\ c_1\times c_2,\ d_1\times d_2)\end{aligned}$$

$$\begin{aligned}\frac{A}{B}&=\frac{(a_1.\ b_1,\ c_1,\ d_1)}{(a_2,\ b_2,\ c_2,\ d_2)}\\ &=\left(\frac{a_1}{d_2},\frac{b_1}{c_2},\frac{c_1}{b_2},\frac{d_1}{a_2}\right)\end{aligned}$$

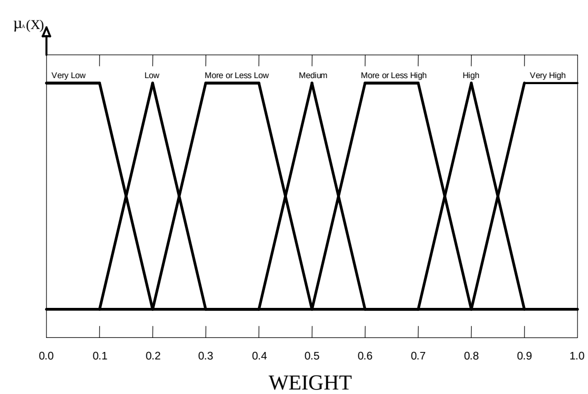


Fig. 2: Graphical representation of fuzzy numbers for linguistic variables.

For the selection of location, seven fuzzy numbers are taken to describe the level of performance on decision criteria, to avoid difficulties for an performance makers in distinguishing subjectively between more than seven alternatives Salty (1977)

Table 1 shows the fuzzy numbers associated with the corresponding linguistic variables and the same is graphically represented in figure3.

Table 1: Fuzzy numbers and corresponding linguistic variables

Linguistic Variable	Fuzzy Number
VL (Very low)	(0.0, 0.0, 0.1, 0.2)
L (low)	(0.1, 0.2, 0.3, 0.4)
ML/LL (more or less low)	(0.2, 0.3, 0.4, 0.5)
M (Medium)	(0.4, 0.5, 0.5, 0.6)
MH/LH (more or less high)	(0.5, 0.6, 0.7, 0.8)
H(High)	(0.6, 0.7, 0.8, 0.9)
VH (Very high)	(0.8, 0.9, 1.0, 1.0)

Step – 1:

The linguistic variables assigned by the experts for each criteria is translated into fuzzy numbers and the same is represented in the matrix (Fuzzy Decision Matrix).

Step – 2:

Let A^{j}_{ar} be the fuzzy number assigned to an vendor A_I by the Perfomanance makers (P_k) for the decision criterion.

C_j, the average of fuzzy numbers is given as

$$A_{ij} = \frac{1}{p} \otimes \left(a^{j}_{i1} \oplus a^{j}_{i2} + \ldots\ldots + a^{j}_{ik} \right); k$$

=1,2………….p.

The average fuzzy score matrix for each criteria is obtained.

Step – 3:

The crisp score (Defuzzified values) for each criteria is obtained. Defuzzification of fuzzy numbers is an operation that produces a non fuzzy crisp value. Defuzzified value is given by the following equation (Kaufman and Gupta, 1991).

Trapezoidal fuzzy number

$$E = \frac{(a+b+c+d)}{4}$$

Triangular fuzzy number

$$E = \frac{(a+2b+c)}{4}$$

Step – 4:

The normalized weight for each criteria (C_i) is obtained as W_j, Where J=1, 2… n. The normalized weight for each criterion is obtained by dividing the Defuzzified scores of each criterion by the total of all the criteria.

Rating of Suitable Locations:

In similar way as procedure adopted for the calculation of weight criteria, the rating of suitable location is derived as:

- Locations suitable on each of the criteria are to be rated in the linguistic variables by the performance makers, which is converted into fuzzy numbers and the same is represented in the matrix form (Fuzzy Decision Matrix).
- The average fuzzy score matrix for each locations are obtained.
- The crisp score (Defuzzified value) for each location are obtained and same is represented in the matrix form as X_{ij}, where i= 1,2 , m and J= 1,2, , n. Where, m is the number of locations, n is the number of criteria.
- Total aggregated score for locations against each criteria is obtained as

TS = {X_{ij}} {W_j}

$$TS = \begin{bmatrix} v_{11}v_{12}\ldots v_{1j}\ldots v_{1m} \\ v_{21}v_{22}\ldots v_{2j}\ldots v_{2m} \\ \vdots\vdots \\ v_{i1}v_{i2}\cdots v_{ij}\cdots v_{im} \\ \vdots\vdots \\ v_{n1}v_{n2}\cdots v_{nj}\cdots v_{nm} \end{bmatrix} \otimes \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_j \\ \vdots \\ w_n \end{bmatrix} = (v \times w)^t$$

On the basis of the total score obtained for each location against decision criteria, overall scores are obtained, using simple average method, which provide final ranking of locations.

V. CASE STUDY

Steel industries purposed methodology allows the experts to rank the suitable vendor reelection for a magnum steel limited Gwalior (India) companies on the basis of different decision criteria in a more realistic manner. The advantage of fuzzy set theory facilitates the assessment to be made on the basic of linguistic manner, which corresponded to the real lie situations in a much better way for simplicity five perfomanance makers E1, E_2,, E_3, E_4, E_5 vendor selection projects, were consulted to get the linguistic variables in terms of importance of each of the delusion criteria used to rank the vendor for each criteria's (V_1, V_2, V_3, V_4, V_5).

1. material cost(C_1)
2. Semi –Raw material cost (C_2)

3. Transportation cost (C_3)
4. Inventory and storage cost (C_4)
5. Production Process cost (C_5)
6. On time delivery (C_6)
7. Percentage waste items (C_7)
8. Flexibility in service (C_8)
9. Financial position (C_9)
10. Inspection (quality control) (C_{10})

Table. 2 show the linguistic variables assigned by the Perfomanance makers to each of the decision criteria are define in the table -1

Table 3: Linguistic variables assigned by the Perfomanance maker's

Criteria	**perfomanance maker's**				
	E_1	**E_2**	**E_3**	**E_4**	**E_5**
C_1	H	M	H	H	VH
C_2	H	H	H	VH	H
C_3	MH	H	H	VH	VH
C_4	MH	MH	M	M	M
C_5	M	M	MH	M	M
C_6	H	H	VH	H	M
C_7	MH	VH	M	MH	M
C_8	M	MH	MH	M	M
C_9	VH	H	VH	M	H
C_{10}	MH	MH	M	VH	M

The average fuzzy scores, defuzzified values and normalized weight of criteria are obtained and given in table 3

Table 3: Normalized weight of criteria

criteria	Parameter of average fuzzy scores				Defuzzified Value	Normalized weight
C_1	0.6 70	0.7 67	0.8 70	0.89 0	0.80 0	0.250
C_2	0.4 70	0.5 67	0.6 70	0.72 0	0.60 6	0.190
C_3	0.6 70	0.7 68	0.8 70	0.92 0	0.80 7	0.253
C_4	0.5 30	0.6 33	0.7 30	0.78 0	0.66 9	0.209
C_5	0.6 70	0.7 67	0.8 70	0.93 0	0.80 9	0.253
C_6	0.5 60	0.6 34	0.7 20	0.80 0	0.67 8	0.211
C_7	0.2 00	0.3 00	0.4 00	0.50 0	0.35 0	0.110
C_8	0.5 41	0.6 20	0.7 20	0.83 1	0.67 8	0.211
C_9	0.4 22	0.5 80	0.6 42	0.72 0	0.59 1	0.184
C_{10}	0.4 70	0.5 67	0.6 70	0.72 0	0.60 7	0.190

Rating of alternatives (venders) on criterion ($X_i^{\,j}$) Suitability of venders against each criteria are to be rated and linguistic variables are assigned by the experts to the venders table-3 are define in table-1 the linguistic variables are converted into fuzzy numbers

Table 5: Linguistics variables for alternatives

C_1	V_1	M	L	M	L	M
	V_2	H	M	VH	H	M
	V_3	VH	M	M	VH	VH
	V_4	VH	VH	H	VH	VH
	V_5	H	H	M	H	H
C_2	V_1	VH	VH	VH	VH	VH
	V_2	H	H	H	VL	L
	V_3	H	VH	VH	VH	VH
	V_4	M	M	VH	H	VH
	V_5	VH	VH	M	H	H
C_3	V_1	L	M	M	M	M
	V_2	L	M	H	M	H
	V_3	H	VH	H	H	VH
	V_4	VH	H	H	H	VH
	V_5	M	VH	H	VH	H
C_4	V_1	VH	VH	M	H	H
	V_2	VL	M	M	H	VH
	V_3	VH	VH	H	H	M
	V_4	M	H	H	VH	M
	V_5	VH	H	M	VH	VH
C_5	V_1	M	H	M	L	M
	V_2	H	L	VL	L	M
	V_3	M	M	VL	H	H
	V_4	H	VH	M	M	H

	V_5	H	M	H	M	VH
C6	V_1	VH	H	VL	H	M
	V_2	VH	H	M	M	H
	V_3	L	VL	M	VL	L
	V_4	L	L	L	H	H
	V_5	VH	H	H	H	VH
C7	V_1	VL	M	L	VL	L
	V_2	VL	M	M	M	H
	V_3	M	M	VL	VL	L
	V_4	H	H	L	L	VL
	V_5	H	VH	VH	M	M
C8	V_1	VH	M	L	H	H
	V_2	VL	VL	L	M	M
	V_3	H	M	H	H	H
	V_4	L	M	H	M	H
	V_5	M	M	H	H	H
C9	V_1	L	M	L	L	L
	V_2	H	M	H	M	L
	V_3	L	M	VH	H	M
	V_4	M	VL	L	L	L
	V_5	H	H	M	M	VL
C10	V_1	H	VL	L	VL	VL
	V_2	L	H	H	H	M
	V_3	L	L	VL	VL	VL
	V_4	M	L	VL	M	VL
	V_5	M	L	VL	M	H

Table 6: Average fuzzy scores and Defuzzified scores

criteria	Vendor	Average Fuzzy scores				Defuzzied score
C1	V_1	0.670	0.767	0.870	0.890	0.799
	V_2	0.470	0.567	0.670	0.710	0.605
	V_3	0.670	0.767	0.870	0.880	0.797
	V_4	0.530	0.633	0.730	0.800	0.674
	V_5	0.670	0.767	0.870	0.900	0.802
C_2	V_1	0.530	0.633	0.730	0.820	0.679
	V_2	0.200	0.300	0.400	0.500	0.350
	V_3	0.730	0.833	0.930	0.980	0.869
	V_4	0.670	0.767	0.870	0.910	0.805
	V_5	0.600	0.700	0.800	0.900	0.750
C3	V_1	0.530	0.633	0.730	0.850	0.686
	V_2	0.480	0.530	0.633	0.730	0.593
	V_3	0.470	0.567	0.670	0.720	0.607
	V_4	0.330	0.433	0.530	0.450	0.436
	V_5	0.400	0.500	0.600	0.700	0.550
C4	V_1	0.733	0.830	0.930	0.980	0.868
	V_2	0.267	0.370	0.470	0.520	0.407
	V_3	0.400	0.500	0.600	0.700	0.550
	V_4	0.400	0.500	0.600	0.700	0.550
	V_5	0.533	0.630	0.730	0.801	0.494
C_5	V_1	0.200	0.300	0.400	0.500	0.350
	V_2	0.730	0.833	0.930	0.980	0.856
	V_3	0.670	0.767	0.870	0.920	0.807
	V_4	0.470	0.470	0.567	0.720	0.557
	V_5	0.530	0.633	0.730	0.820	0.679
C6	V_1	0.470	0.567	0.670	0.720	0.607
	V_2	0.470	0.567	0.670	0.700	0.602
	V_3	0.130	0.233	0.330	0.460	0.289
	V_4	0.530	0.630	0.730	0.820	0.678
	V_5	0.470	0.570	0.670	0.720	0.608
C7	V_1	0.730	0.830	0.930	0.950	0.860
	V_2	0.530	0.630	0.730	0.820	0.678
	V_3	0.400	0.500	0.600	0.700	0.550
	V_4	0.330	0.430	0.500	0.670	0.483
	V_5	0.530	0.630	0.730	0.820	0.678
C8	V_1	0.470	0.570	0.670	0.720	0.608
	V_2	0.730	0.830	0.930	0.980	0.868
	V_3	0.670	0.767	0.870	0.890	0.800
	V_4	0.470	0.470	0.567	0.620	0.532
	V_5	0.530	0.633	0.730	0.820	0.679
C9	V_1	0.470	0.567	0.670	0.720	0.606
	V_2	0.470	0.567	0.670	0.720	0.607
	V_3	0.130	0.233	0.330	0.460	0.289
	V_4	0.530	0.630	0.730	0.820	0.678
	V_5	0.470	0.570	0.670	0.720	0.608
C10	V_1	0.730	0.830	0.930	0.960	0.863
	V_2	0.530	0.630	0.730	0.830	0.680
	V_3	0.400	0.500	0.600	0.700	0.550
	V_4	0.330	0.430	0.500	0.640	0.476
	V_5	0.530	0.630	0.730	0.820	0.678
	V_4	0.467	0.567	0.667	0.767	0.617
	V_5	333	0.433	0.530	0.620	0.479

The total scores for each vendor can be calculated matrix as follows

$$TS = \begin{array}{c c} & \begin{array}{ccccc} V_1 & V_2 & V_3 & V_4 & V_5 \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \\ C_8 \\ C_9 \\ C_{10} \end{array} & \begin{bmatrix} 0.800 & 0.605 & 0.797 & 0.674 & 0.802 \\ 0.679 & 0.350 & 0.869 & 0.805 & 0.750 \\ 0.686 & 0.593 & 0.607 & 0.436 & 0.550 \\ 0.868 & 0.407 & 0.550 & 0.550 & 0.494 \\ 0.350 & 0.856 & 0.807 & 0.557 & 0.679 \\ 0.607 & 0.602 & 0.289 & 0.678 & 0.608 \\ 0.860 & 0.678 & 0.550 & 0.483 & 0.678 \\ 0.608 & 0.808 & 0.800 & 0.532 & 0.629 \\ 0.606 & 0.607 & 0.289 & 0.678 & 0.608 \\ 0.863 & 0.680 & 0.550 & 0.476 & 0.678 \end{bmatrix} \end{array} \otimes \begin{array}{c} W_j \\ \begin{bmatrix} 0.250 \\ 0.190 \\ 0.253 \\ 0.209 \\ 0.254 \\ 0.213 \\ 0.110 \\ 0.212 \\ 0.185 \\ 0.190 \end{bmatrix} \end{array}$$

Total scores for vender **(V1)** on criteria is obtained as-
$(0.800\times0.250)+(0.679\times0.190)+(0.686\times0.253)+(0.868\times0.209)+(0.350\times0.254)+(0.607\times0.213)+(0.860\times0.110)+(0.608\times0.212)+(0.606\times0.185)+(0.863\times0.190)= 1.4035$
Similarly, total scores for venders **(V2), (V3),(V4),(V5)**are obtained and provided in table-7In the selection of suitable vendor for any company , initial investment, qualitative criteria each has equal weight age. Hence the final scores and ranking of venders are given in table.6

Table 7: Final scores and ranging of venders.

Vendors	**V1**	**V2**	**V3**	**V4**	**V5**
Final Scores	1.4035	1.2859	1.29900	1.2489	1.3353
Rank	1	4	3	5	2

VI. RESULTS CONCLUSION

This paper, presented the fuzzy multi criteria decision approach, the order odd ranking of vendor's for the company's are as **V1>V5>V3>V2>V4.** The result show V1 is the best location for the company. Has been highlighted to solve multi-criteria decision making problems through a case study of vendor selection. The Study demonstrates the effectiveness of the said MCDM techniques in solving such a vendor selection problem.

VII. ACKNOWLEDGEMENT

Authors would like to thank to Vimal steel corporation ltd., for providing data's to create decision criteria & also thank to Perfomanance maker's for providing linguistic variables to apply fuzzy multi criteria decision approach for selecting the best vendor for a companies.

REFERENCES

[1] Alexios-patapios kontis and vassilionvyagotis, supplier Selection problem multi-criteria approaches based on DEA,international Scientific Advances in Management & Applied Economics, vol1.1,no.2,207-219(2011)
[2] Shyur &Shih, 2006.Evaluating vendors many criteria Including quantitative, as well as qualitative, a considerable Number of decision making European Journal of Operation Research, Vol.50, 5-10(2009)
[3] Kaufmann, A.,& Gupta, M.M, Introduction to Fuzzy Arithmetic theory & application, Van No strand Reinhold, Newyork.vol.1; 5-18 (1991)
[4] Dickson, Weber, Multi objective linear model for Vendor Selection criteria and methods, European Journal of Operational Research, Vol.50, 2-18(1991)
[5] Buffa and Jackson and Sharma, Multi decision making used linear and non-linear programming, Total Quality Environmental Management Vol.3 (4); 521-530(1994)
[6] Tu-chung Chu, Rangnath varma, Evaluating suppliers via a multiple criteria decision making method under fuzzy Enviroment, nternationalJournalofcomputers&Industrial Engineering vol, 62; 653-660(2012)
[7] Swanson's., 2001.Linking maintenance strategies To performance. International Journal of Production Economics70, 237-244. (2001)
[8] Shyur &Shih, 2006.Evaluating vendors many criteria Including quantitative, as well as qualitative, a considerable Number of decision making European Journal of Operational Research,Vol.50,5-10(2009)