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By A.A.Khaled, Sanjoy Kumar Paul, Ripon Kumar Chakraborty, Md. Salahuddin Ayuby

Bangladesh University

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SELECTION OF SUPPLIERS THROUGH DIFFERENT MULTI-CRITERIA DECISION MAKING TECHNIQUES

Strictly as per the compliance and regulations of:

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I. Introduction

There has been an evolution in the role and structure of the purchasing function through the nineties. The purchasing function has gained great importance in the supply chain management due to factors such as globalization, increased value added in supply, and accelerated technological change. Supplier selection and evaluation is the process of finding the suppliers being able to provide the buyer with the right quality products and/or services at the right price, at the right quantities and at the right time. Evaluation and selection of suppliers is a typical multiple criteria decision making (MCDM) problem involving multiple criteria that can be both qualitative and quantitative. A key and perhaps the most important process of the purchasing function is the efficient selection of suppliers, objective of the supplier selection process is to reduce risk and maximize the total value for the buyer and it involves considering a series of strategic variables.The explicit consideration of multiple, conflicting objectives in a decision model has made the area of multiple criteria decision-making (MCDM) very challenging. Suppliers are considered the best intangible assets of any organization. Suppliers have varied strengths and weaknesses that require careful assessment before order placement. It can be argued that it is extremely difficult for any one supplier to excel in all dimensions of performance. Suppliers have to satisfy minimum overall performance standards, but one of the scheme's objectives is to improve these continually. So selection of suppliers is the most important decision problem in today's competitive business environment. Abratt (1986) analyzed the buying process and identifies and determines the relative importance of the factors influencing supplier selection. Avery (1999) identified factors affecting MRO supplier selection. Sharland et al. (2003) examined the impact of cycle time on supplier selection. Lin et al. (2005) identified the factors affecting the supply chain quality management. Gonzalez et al. (2004) looks at the variables and their relative importance in supplier selection from quality, cost and productivity perspectives. Humphreys et al. (2003) developed a decision support tool which should help companies to integrate environmental criteria into their supplier selection process. Yan and Wei (2002) used supplier selection criteria as an example to apply a proposed compromise weighting in a group decision making environment. Svensson (2004) investigated the models of supplier segmentation and supplier selection criteria. Kannan and Tan (2002) described an empirical study of the importance of supplier selection and assessment criteria of American manufacturing companies for items to be used in products already in production. Lee et al. (2001) proposes a methodology which identifies the managerial criteria using information derived from the supplier selection processes and makes use of them in the supplier management process. Pearson and Ellram (1995) examined and explore the differences in decision criteria used for supplier selection in small and large organizations. Verma and Pullman (1998) examined the differences in weights assigned to decision criteria in actual choice of suppliers and perceived importance of decision criteria before selecting the suppliers. Dulmin and Mininno (2003) given the financial importance and the multi-objective nature of supplier selection decision and an effort is made to highlight those aspects that are

About : Department of Industrial and Production Engineering
Bangladesh University of Engineering and Technology, Dhaka – 1000, Bangladesh,Corresponding email: sanjoy_ipe@yahoo.com

crucial to process qualitative and quantitative performance measures. In this paper, the contribution of a multi-criteria decision aid method (PROMETHEE/GAIA) to such problems is investigated, together with how to allow for a simultaneous change of the weights (importance of performance criteria), generating results that can be easily analyzed statistically, performing an innovative sensitivity analysis. In this paper, different multi-criteria making techniques have been discussed and compared to select the best suppliers.

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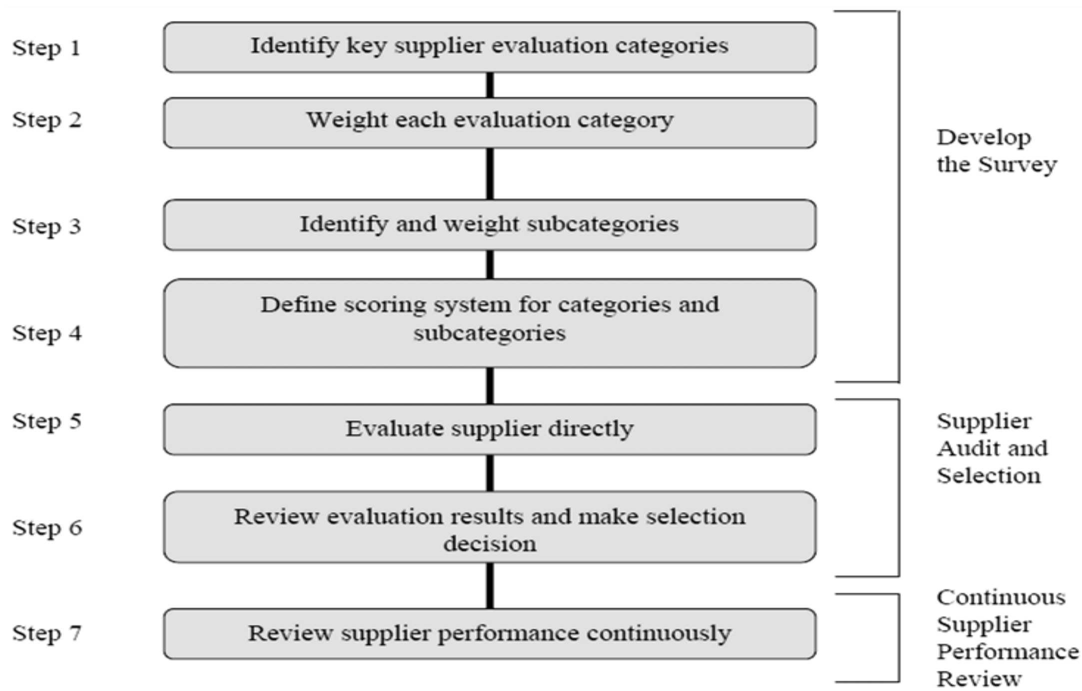

Fig. 1: Different steps for supplier evaluation process

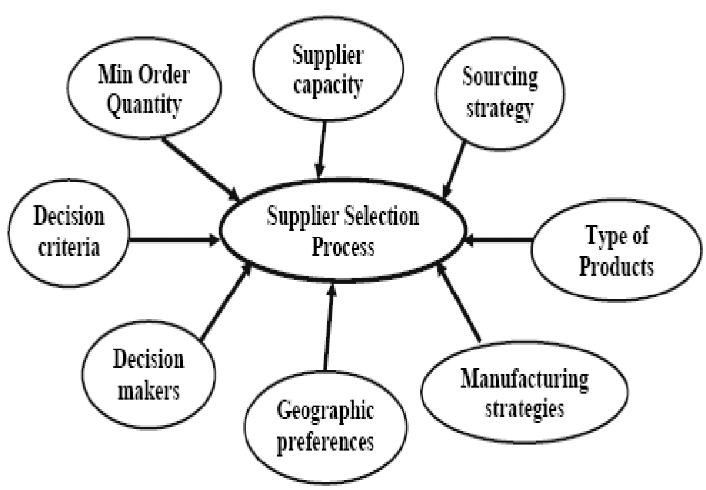

Fig. 2: Factors affecting supplier selection

There are some steps to evaluate and select suppliers. Figure 1 shows the different steps for evaluation of suppliers. To evaluate the suppliers, many factors are considered such as types of products, supplier capacity, supplier reliability etc. Figure 2 represents the different factors which affect the supplier selection process.

II. Different multi-criteria techniques

There are some multi-criteria techniques which are widely used to evaluate the suppliers. These techniques are:

- Linear weighted point
- Categorical method
- Analytical Hierarchical Process (AHP)
- A Fuzzy Approach for Supplier Evaluation & Selection
- Outranking methods
- Multi-Attribute Utility Technique (MAUT)
- Judgmental modeling
- Interpretive Structural Modeling

1) *Weighted Point Method*

The weighted point which consider attributes that are weighted by the buyer. The weight for each attribute is then multiplied by the performance score that is assigned. Finally, these products are totaled to determine final rating for each supplier. Typically this system is designed to utilize quantitative measurements. The advantages of the weighted point method include the ability for the organization to include numerous evaluation factors and assign them weights according to the organization's needs. The subjective factors on the evaluation are minimized. The major limitation of this approach is that it is difficult to effectively take qualitative evaluation criteria into consideration.

Example: Assume that there are seven criteria that are being used to evaluate suppliers, quality, price, service production capacity, Engineering capacity, Business structure and delivery. These attributes were weighted with the relative importance considered by the buyer on a 0 (less important) to 1(most important) scale, as shown in Table 1. Further, assume that proposals from three suppliers are being considered (Supplier 1, Supplier 2, and Supplier 3). Table 1 presents the final results.

Table 1: Supplier Selection by weighted point method

Factors	Weight	Supplier-1	Supplier-2	Supplier-3
Quality	0.30	0.20	0.15	0.25
Delivery	0.10	0.15	0.20	0.12
Production Capacity	0.08	0.10	0.10	0.05
Service	0.15	0.15	0.05	0.10
Engineering Capacity	0.10	0.08	0.15	0.10
Business Structure	0.05	0.17	0.20	0.08
Price	0.22	0.15	0.15	0.30

After determining the final scores form the weighted values of different customer, the best supplier is selected. Table 2 shows the final score of different suppliers. According to the previous results from Table 2, the higher weight belongs to supplier 3, and is judged to be the best overall.

Table 2: Score and ranking of supplier by weighted point method

Supplier	Score	Rank
Supplier-1	0.155	2
Supplier-2	0.1385	3
Supplier-3	0.186	1

2) *Categorical Method*

The supplier selection of any manufacturing and service industries include consideration of critical, qualitative as well as quantities factors. The categorical method relies heavily on the experience and ability of the individual buyer (Timmerman, 1986). People in charge of purchasing, quality, production, and sales all express their opinions about the supplier's performance on the basis criteria which are important to them. These departments assign either a preferred, unsatisfactory, or neutral rating for each of the selected attributes for every contending supplier. At periodic evaluation meetings, the buyer discusses the rating with department members. The buyer then determines the supplier's overall scores. The primary advantage of the categorical approach is that it helps structure the evaluation process in a clear and systematic way. In the categorical method both subjective and objective factors are evaluated, converted to consistencies, dimensionless indices and then combined with the critical measure to yield the performance measure of a supplier. The eight-step procedures are given as follows.

1. Critical factors, objective factors, and subjective factors are defined

Critical factors

If a presence of a factor precludes a supplier from further consideration, regardless the other factor that might be exist, then the factor is known as critical factor. The critical factor either must or must not be present in a supplier for further consideration. For example if price is considered as critical factor, a supplier whose product price exceeds a certain level can be eliminated and not be considered further.

Objective factors

Objective factor are those which can be evaluated in monetary terms price of the purchased materials, its quality and cost of transportation from buyer sites.

Subjective factors

Subjective factor are those factors which are difficult to quantify but are important enough in the decision making process to warrant there consideration. Example: the prestige of supplier, their after sale service and flexibility.

2. Critical factor measures are evaluated

C_p= 1 if price of the materials, components, and services is less than or equal to the maximum price affordable and C_p =0 otherwise,

C_d= 1 if delivery of the materials, and services is within acceptable Interval of the planned due date and C_d = 0 otherwise,

C_q =1 if quality of the materials, components, and services meets the purchasing organizations standards and C_q = 0 otherwise.

Critical Factor Measure,

$$CFM = Cp \times Cd \times Cq$$

3. Objective factor measures are evaluated

C_{Pm} =Purchase price offered by the supplier

$C_{Pm} = C_p \times Q$

Where, C_p=Unit price of 1 unit of the product and Q=Economic order quantity

C_{Qm} =Quality cost associate with items purchased by the supplier.

$C_{Qm} = C_q \times Q \times P$

Where, C_q=Opportunity cost of 1 unit of manufactured product that does not meet the quality standard of the organization and P=Percentage defective.

C_{Dm}=Cost associated with delays in delivery if purchase is made from supplier.

$C_{Dm} = Q(C_s \times T^{+} + C_c \times T^{-})$

Where, C_s=Stock out cost per unit per day for late delivery.

C_T=Carrying cost per unit per day for early delivery.

T^+=Expected Lateness of order purchased (days)

T^-=Expected Earliness of order purchased (days)

C_{Tm} =Transportation cost of the purchased item.

$C_{Tm} = C_T \times W \times d$

Where, C_T=Cost of transportation per ton per mile.

W=Weight of the economic order quantity

d =Distance from the buyer to supplier in mile.

4. Subjective factor weights are determined
   The subjective factor weight is a measure of the relative importance of the subjective factor in the selection of decision and is determine using the preference theory and AHP approach.
5. Supplier weight is determined
   To determine the supplier weight, the relative desirability of each supplier with respect to the each subjective factor is determined.
6. Subjective factor measures are evaluated
   Subjective factor measure (SFM) is obtained by the AHP approach.
7. Objective factor decision weight is determined
   Objective factor measure (OFM), Total cost of objective measure, $Cm = C_P + C_Q + C_D + C_t$
8. Supplier performance measures are calculated
   Supplier performance measure (SPM) $= CFM(X \times OFM + (1\text{-}X) \times SFM)$

Where X is the relative importance of objective factor in decision making

Some special characteristics of categorical method are:

- ✓ It is also inexpensive and requires a minimum of performance data.
- ✓ Vendors with composite high or low ratings are noted, and future supply decisions are influenced by them
- ✓ It is also inexpensive and requires a minimum of performance data
- ✓ It relies heavily on the experience and ability of the individual buyer

3) *A Fuzzy Approach For Supplier Evaluation & Selection*

During recent years, how to determine suitable suppliers in the supply chain has become a key strategic consideration. However, the nature of these decisions usually is complex and unstructured. In general, many quantitative and qualitative factors such as quality, price, and flexibility and delivery performance must be considered to determine suitable suppliers. In this method, linguistic values are used to assess the ratings and weights for these factors. These linguistic ratings can be expressed in trapezoidal or triangular fuzzy numbers. Since human judgments including preferences are often vague and cannot estimate his preference with an exact numerical value. A more realistic approach may be to use linguistic assessments instead of numerical values. In other words, the ratings and weights of the criteria in the problem are assessed by means of linguistic variables We can convert the decision matrix into a fuzzy decision matrix and construct a weighted-normalized fuzzy decision matrix once the decision-makers' fuzzy ratings have been pooled. The fuzzy positive ideal solution (FPIS) is defined and the fuzzy negative ideal solution (FNIS). And then, a vertex method is applied in this method to calculate the distance between two fuzzy ratings. Using the vertex method, we can calculate the distance of each alternative from FPIS and FNIS, respectively. Finally a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives. The higher value of closeness coefficient indicates that an alternative is closer to FPIS and farther from FN IS simultaneously. Linear trapezoidal membership functions are considered to be adequate for capturing the vagueness of these linguistic assessments. These linguistic variables can be expressed in positive trapezoidal fuzzy numbers, as in Figure 3 and Figure 4. The importance weight of each criterion can be by either directly assigning or indirectly using pair wise comparison. It is suggested in this paper that the decision-makers use the linguistic variables shown in Figure 5 to evaluate the importance of the criteria and the ratings of alternatives with respect to qualitative criteria.

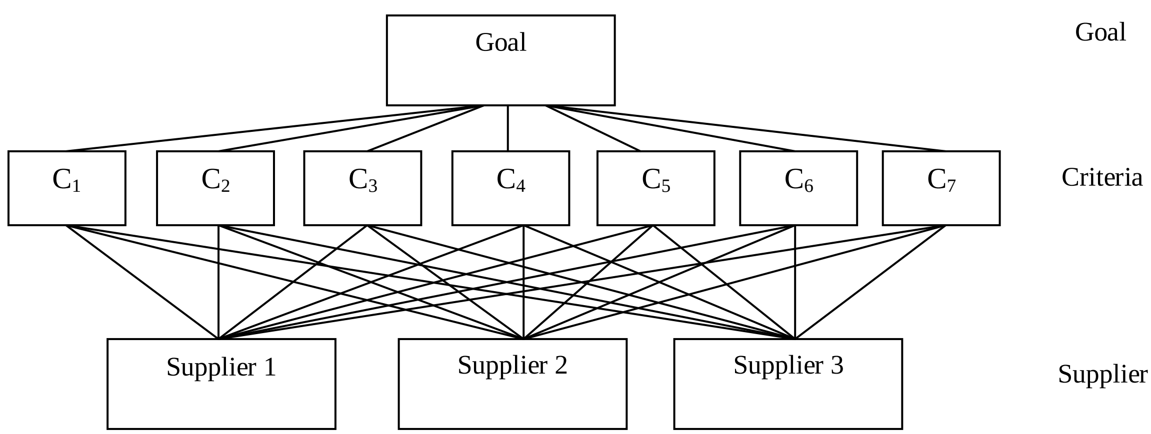

Fig.3: Relation of goal, factors and supplier in decision making

Factors are denoted as Quality (C_1), Delivery (C_2), Production Capacity (C_3), Service (C_4), Engineering Capability (C_5), Business Structure (C_6) and Price (C_7).

A linguistic variable is a variable whose values are expressed in linguistic terms .The concept of a linguistic variable is very useful in dealing with situations, which are too complex or not well defined to be reasonably described in conventional quantitative expressions. For example, ''weight'' is a linguistic variable whose values are very low (VL) , low (L), medium (M) , medium high (MH), high (H), very high (VH), etc. Fuzzy numbers can also represent these linguistic values. For example, the linguistic variable ''Medium High (MH)'' can be represented as (0.5 ; 0.6 ; 0.7 ; 0.8).The linguistic variable ''Very Good (VG)'' can be represented as (8,9,9, 10).[Figure 4 and Figure 5].

Step 1: Three decision-makers use the linguistic weighting variables shown in figure 5 to assess the importance of the criteria. The importance weights of the criteria determined by these three decision makers are shown in Table 3.

Step 2: Three decision-makers use the linguistic rating variables shown in Fig. 5 to evaluate the ratings of candidates with respect to each criterion. The ratings of the three candidates by the decision makers under the various criteria are shown in Table 4.

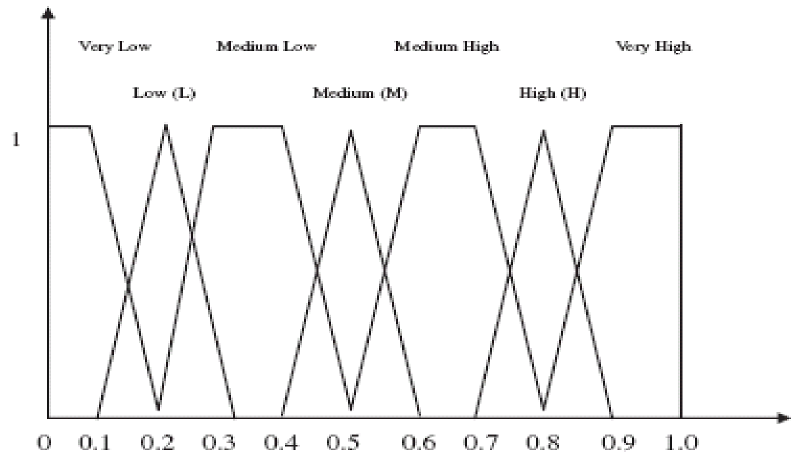

Fig 4: Linguistic variables for importance weight of each criterion

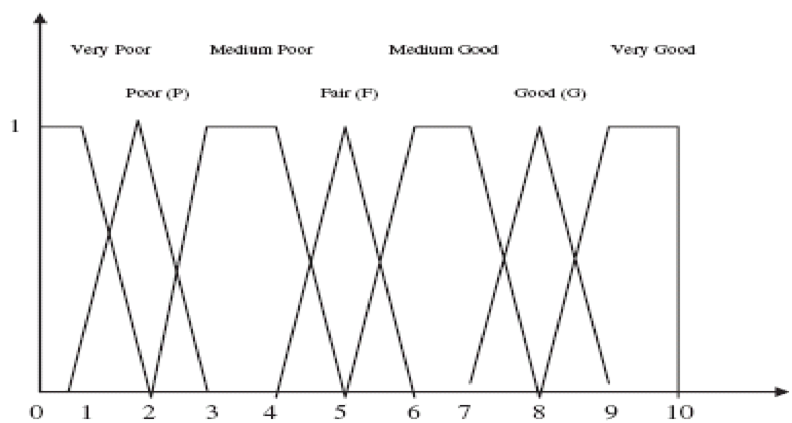

Fig 5: Linguistic variables for ratings

Step 3: Then the linguistic evaluations shown in Tables 3 and 4 are converted into trapezoidal fuzzy numbers to construct the fuzzy- decision matrix and determine the fuzzy weight of each criterion, as in Table 5.

Step 4: The normalized fuzzy-decision matrix is constructed as in Table 6.

Step 5: Weighted normalized fuzzy- decision matrix is constructed as in Table 7

Table 3: Evaluation at level 1 for fuzzy approach

Criteria	Decision maker (D)		
	D_1	D_2	D_3
C_1	VH	VH	VH
C_2	MH	MH	MH
C_3	MH	H	H
C_4	MH	MH	MH
C_5	H	H	H
C_6	MH	H	MH
C_7	VH	VH	VH

Step 6: FPIS-Fuzzy positive ideal solution (A*) and FNIS-Fuzzy negative ideal solution (A-) is determined.

A*=(1,1,1,1) (0.8,0.8,0.8) (0.81,0.81,0.81,0.81) (0.8,0.8,0.8,0.8) (0.9,0.9,0.9,0.9)(0.9,0.9,0.9,0.9) (1,1,1,1)

A=(0.4,0.4,0.4,0.4)(0.25,0.25,0.25,0.25)(0.25,0.25,0.25,0.25)(0.25,0.25,0.25,0.25)(0.35,0.35,0.35,0.35) (0.25,0.25,0.25,0.25) (0.4,0.4,0.4,0.4)

Table 4: Evaluation at level 2 for fuzzy approach

Criteria	Supplier	D_1	D_2	D_3
C_1	A_1	MG	MG	MG
	A_2	G	MG	MG
	A_3	VG	VG	VG
C_2	A_1	MG	MG	G
	A_2	VG	VG	VG
	A_3	MG	MG	MG
C_3	A_1	MG	MG	MG
	A_2	G	G	G
	A_3	MG	MG	G
C_4	A_1	VG	VG	G
	A_2	MG	MG	MG
	A_3	MG	G	MG
C_5	A_1	MG	MG	Mg
	A_2	VG	VG	VG
	A_3	MG	MG	G
C_6	A_1	MG	MG	G
	A_2	G	G	G
	A_3	MG	MG	MG
C_7	A_1	MG	MG	MG
	A_2	G	G	G
	A_3	VG	VG	VG

Table 5: Fuzzy Decision matrix for fuzzy approach

Criteria	A_1	A_2	A_3	Weights
C_1	(5,6,7,8)	(5,6.7,7.3,9)	(8,9,10,10)	(0.8,0.9,1.0,1.0)
C_2	(5,6.7,7.3,9)	(8,9,10,10)	(5,6,7,8)	(0.5,0.6,0.7,0.8)
C_3	(5,6,7,8)	(7,8,8,9)	(5,6.7,7.3,9)	(0.5,0.73,0.77,0.9)
C_4	(7,8.7,9.3,10)	(5,6,7,8)	(5,6.7,7.3,9)	(0.5,0.6,0.7,0.8)
C_5	(5,6,7,8)	(8,9,10,10)	(5,6.7,7.3,9)	(0.7,0.8,0.8,0.9)
C_6	(5,6.7,7.39)	(8,9,10,10)	(5,6,7,8)	(0.5,0.67,0.73,0.9)
C_7	(5,6,7,8)	(7,8,8,9)	(8,9,10,10)	(0.8,0.9,1.0,1.0)

Step 7: The distance of each supplier from FPIS and FNIS with respect to each criterion are calculated, respectively from tables 8 and 9.

Sample calculation

A*=(1,1,1,1)(0.8,0.8,0.8)(0.81,0.81,0.81,0.81)(0.8,0.8,0.8,0.8)(0.9,0.9,0.9,0.9)(0.9,0.9,0.9,0.9)(1,1,1,1)d(A_1,A*)= ½√{(1-0.4)²+(1-0.54)²+(1-0.7)²+(1-0.8)²}=0.42

Step 8: d^*_i and d^-_i and closeness coefficient offive possible suppliers are calculated, which is shown in Table 10.

Step 9: Suppliers are selected from the closeness coefficient. The approval status for closeness coefficient is shown in Table 11.

Table 6: Normalized Fuzzy Decision matrix for fuzzy approach

Criteria	A_1	A_2	A_3
C_1	(0.5,0.6,0.7,0.8)	(0.5,0.67,0.73,0.9)	(0.8,0.9,1.0,1.0)
C_2	(0.5,0.67,0.73,0.9)	(0.8,0.9,1,1)	(0.5,0.6,0.7,0.8)
C_3	(0.5,0.6,0.7,0.8)	(0.7,0.8,0.8,0.9)	(0.5,0.67,0.73,0.9)
C_4	(0.7,0.87,0.93,1)	(0.5,0.6,0.7,0.8)	(0.5,0.67,0.73,0.9)
C_5	(0.5,0.6,0.7,0.8)	(0.8,0.9,1.0,1.0)	(0.5,0.67,0.73,0.9)
C_6	(0.5,0.67,0.73,0.9)	(0.8,0.9,1.0,1.0)	(0.5,0.6,0.7,0.8)
C_7	(0.5,0.6,0.7,0.8)	(0.7,0.8,0.8,0.9)	(0.8,0.9,1.0,1.0)

Table 7: Weighted normalized Fuzzy decision matrix for fuzzy approach

Criteria	A_1	A_2	A_3
C_1	(0.4,0.54,0.7,0.8)	(0.4,0.60.73,0.9)	(0.64,0.81,1.0,1.0)
C_2	(0.25,0.4,0.51,0.72)	(0.4,0.54,0.7,0.8)	(0.25,0.36,0.49,0.64)
C_3	(0.25,0.44,0.54,0.72)	(0.35,0.58,0.62,0.81)	(0.25,0.49,0.56,0.81)
C_4	(0.35,0.52,0.65,0.8)	(0.25,0.36,0.49,0.64)	(0.25,0.4,0.51,0.72)
C_5	(0.35,0.48,0.56,0.72)	(0.56,0.72,0.8,0.9)	(0.35,0.54,0.58,0.81)
C_6	(0.25,0.45,0.53,0.81)	(0.4,0.60.73,0.9)	(0.25,0.4,0.51,0.72)
C_7	(0.4,0.54,0.7,0.8)	(0.56,0.72,0.8,0.9)	(0.64,0.81,1.0,1.0)

Table 8: Distance between $A_{i\ (1,2,3)}$ and A* for fuzzy approach

Distance	C_1	C_2	C_3	C_4	C_5	C_6	C_7
$d(A_1, A^*)$	0.42	0.37	0.36	0.27	0.4	0.44	0.42
$d(A_2, A^*)$	0.39	0.24	0.27	0.39	0.2	0.30	0.28
$d(A_3, A^*)$	0.2	0.39	0.35	0.37	0.37	0.46	0.2

Table 9: Distance between $A^*_{i\ (1,2,3)}$ and $A^-_{i\ (1,2,3)}$ for fuzzy approach

Distance	C_1	C_2	C_3	C_4	C_5	C_6	C_7
$d(A_1, A^*)$	0.26	0.28	0.29	0.37	0.22	0.33	0.26
$d(A_2, A^*)$	0.32	0.39	0.38	0.24	0.41	0.47	0.37
$d(A_3, A^*)$	0.49	0.24	0.34	0.28	0.27	0.28	0.49

Table 10: Computation of d^*_i, d^-_i, Closeness coefficient CCi for fuzzy approach

Supplier	d^*_i	d^-_i	$d^*_i + d^-_i$	$CC = d^-_i / (d^*_i + d^-_i)$
A_1	2.68	2.01	4.69	0.43
A_2	2.07	2.58	4.65	0.56
A_3	2.34	2.39	4.73	0.51

Table 11: Approval Status for Closeness Coefficient (CC_i) for fuzzy approach

Closeness coefficient (CCi)	Assessment status
CCi ϵ [0,0.2]	Do not recommend
CCi ϵ [0.2,0.4]	Recommend with high risk
CCi ϵ [0.4,0.6]	Recommend with low risk
CCi ϵ [0.6,0.8]	Approved
CCi ϵ [0.8,1.0]	Approved and preferred

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Here for all suppliers the closeness co-efficient is between 0.4-0.6 which means the suppliers are recommended with low risk. Since $CC_2 > CC_3 > CC_1$, so supplier A_2 is selected. Sequence of preference is $A_2 > A_3 > A_1$.

4) Analytic Hierarchy Process (Ahp)

The Analytic Hierarchy Process (AHP) is systematic approach for selecting suppliers. People deal with complex decisions -rather than prescribing a "correct" decision", the AHP helps people to determine one. Based on mathematics and human psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. Analytical Hierarchical Process (AHP), is a decision-making method for prioritizing alternatives when multiple criteria must be considered and allows the decision maker to structure complex problems in the form of a hierarchy, or a set of integrated levels. Generally, the hierarchy has at least three levels: the goal, the criteria, and the alternatives. For the supplier selection problem, the goal is to select the best overall supplier. The criteria can be quality, price, service, delivery, etc. The alternatives are the different proposals supplied by the suppliers. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques. In the final step of the process, numerical priorities are derived for each of the decision alternatives. Since these numbers represent the alternatives' relative ability to achieve the decision goal, they allow a straight forward consideration of the various courses of action.A hierarchy is a system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements. Human organizations are often structured as hierarchies, where the hierarchical system is used for assigning responsibilities, exercising leadership, and facilitating communication. When we approach a complex decision problem, we can use a hierarchy to integrate large amounts of information into our understanding of the situation. As we build this information structure, we form a better and better picture of the problem as a whole.

Example: Assume that there are seven criteria that are being used to evaluate suppliers, quality, price, service and delivery, capacity, business capacity, structure. Further, assume that proposals from four suppliers are being considered (supplier 1 (S1), supplier 2 (S2), supplier 3 (S3) and supplier 4). Figure 3 shows the structure of this hierarchy. Preference weight values for different level of importance are shown in Table 12.

Table 12: Level of preference weight for AHP

Level of importance/ preference weights	Definition	Explanation
1	Equally Preferred	Two activities contribute equally to the objective
3	Moderately	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly or essentially favor one activity over another
7	Noticeable dominance	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest degree possible of affirmation
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above
Reciprocals	Reciprocals for inverse comparison	

For example, if a buyer believes that quality is moderately more important than delivery, then this judgment is represented by preference weight 3. Judgments are required for all the criterion comparisons, and for all the alternative comparisons for each criterion. This information is usually provided by the buyer. The buyer must now develop a set of pair wise comparisons to define the relative importance of the criteria to complete the following matrix. The data in the matrix can be used to generate a good estimate of the criteria weights. The weights provide a measure of the relative importance of each criterion. This process is summarized in the following steps, and shown in the Table 13.

Table 13: Evaluation at level 1 for AHP

Attributes	Quality	Delivery	Production Capacity	Service	Engineering Capacity	Business structure	Price	Geometric Mean (b)	Normalized weight
Quality	1	3	3	2	1	4	1/3	1.5746	0.1961
Delivery	1/3	1	3	3	1	3	1	1.3687	0.170
Prod. Capacity	1/3	1/3	1	1/3	1/2	1	1/3	0.4834	0.06
Service	1/2	1/3	3	1	1/3	1	½	0.7011	0.0873
Capacity	1	1	2	3	1	2	1/5	1.1332	0.1411
Business structure	1/4	1/3	1	1	1/2	1	1/3	0.5428	0.067
Price	3	1	3	2	5	3	1	2.225	0.277
Sum	6.42	7	16	12.33	9.333	15	3.7	8.0288	

After evaluation for different attribute factors final composite weight for different supplier is obtained. The final composite weight for different suppliers is shown in Table 14.

Here Composite weight: $(0.196\times06+0.170\times0.263+0.060\times0.163+\ldots\ldots+0.277\times0.167) = 0.3452$

From the result from Table 14, Supplier 3 is the most suitable due to having highest composite weight.

Table 14: Final Evaluation for Analytic Hierarchy Process (AHP)

Alternatives	Attributes & their Weights							Composite weight	Rank
	Quality	Delivery	Production Capacity	Service	Engineering Capacity	Business Structure	Price		
	0.196	0.170	0.06	0.087	0.141	0.067	0.277		
Supplier 1	0.60	0.263	0.163	0.221	0.637	0.223	0.167	0.3425	2
Supplier 2	0.20	0.4	0.297	0.460	0.105	0.39	0.33	0.298	3
Supplier 3	0.20	0.337	0.540	0.319	0.258	0.38	0.5	0.357	

III. Conclusions

Here in the paper from the numerical analysis of different data and human judgment the similar result for AHP and Linear weighted method has found. But different result is obtained from Fuzzy analysis. Actually each process has some advantages and short comings. An organization has to decide which process is suitable for its structure depending on the different factors and performance of suppliers to achieve the ultimate goal.

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