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Pratesh Jayaswal
Madhav Institute of Technology and Science, Gwalior (M.P), pratesh.jayaswal@gmail.com

M.K. Trivedi
Madhav Institute of Technology and Science, Gwalior (M.P), mk.trivedi@gmail.com

Lalit Kumar
Madhav Institute of Technology and Science, Gwalior (M.P), lalit_031024@yahoo.co.in

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Vendor Selection Methodology Based on Multi Criteria Decision Making

Pratesh Jayaswal[1], M.K.Trivedi[2] & Lalit Kumar[3]

Madhav Institute of Technology and Science, Gwalior (M.P) - 474005
E-mail : lalit_031024@yahoo.co.in

Abstract **-** Many analytical models have been developed for addressing the Vender selection for companies. There are a list of vendor for selecting materials. It is very difficult to select a genuine vendor. Since the selection of a vendor is influenced by several parameters which are in linguistic. Form also, 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.

Keywords **-** *Fuzzy sets, Decision matrix, Rank, Multiple criteria decision making, priority weight.*

I. INTRODUCTION

The vendor selection problem (VSP) is associated to decide how one vendor could be selected from a number of potential alternatives (Dickson 1966). Weber et al. (1998) believe that vendor selection decision entail the selection of individual vendor to employ, and the determination of order quantities to be placed with the selected ones. On the other hand, the cost of raw materials, component parts and services purchased from external vendors are significant for most manufacturing firms.

Vendor selection is one of the most critical activities for many companies. The selection of wrong vendor could be enough to upset the company's financial and operational position. The selection of an appropriate vendor 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 venders. The selection of appropriate vendors has been one of the most important function for a company. Which is an unstructured, complicated and multi-criteria decision problem over the past two decades? Many studies have pointed out that the key is to set effective evaluation criteria for the vendor selection problem (VSP). Earlier works on vendor selection identified. 10 criteria's (i.e. price, delivery, quality etc.) for evaluating and selecting appropriate vendors and deciding on the size of the order to be placed with each vendor. A vendor selection problem usually involves more than one centurion and criteria often conflict with each other. In multiple criteria decision making (MCDM), It is usually assumed that the criteria are independent. A considerable number of decision models have been developed based on the MCDM theory.

The multiple criterion decision issue focuses mainly on the identification of the evaluation criteria and on the determination of the perfect structure (i.e. weights) previous reached on the identification of evaluation criteria in vendor selection have usually focused on products, services, and purchase situations. However, there are often too many evaluation criteria in complex problems to determine whether these criteria are dependent on or independent to each other.

The process of selection of suitable maintenance alternative for manufacturing plant on the basis of quantitative & qualitative factors requires following sources.

- Selection of fuzzy numbers & their memberships functions.
- Defining the scale of preference.
- Averaging the fuzzy numbers as given by the experts in terms linguistics variables.
- Determination of fuzzy weights.
- Overall ranking of alternatives.

In this paper, the vendor selection by a multi criteria decision making method for these methods identified a criteria based on cost, quality, service etc. These criteria short out the suitable vendor by using the expert system there are consider fine experts E_1, E_2, E_3, E_4 & E_m these experts give the data in a logistics variable than find the weight of the criteria and find the rank. Than we find the suitable vendor for a material.

II. REVIEW OF PREVIOUS WORK

The VSP has been a focus area of research since the 1960s. This was based on a questionnaire sent to 273 purchasing agents, identified 23 different commonly used criteria from a list of 50 distinct factors for the VSP. Quality, delivery, performance history, warranties and claim policies, production facilities and capacity, price and technical capabilities were the most important of them. 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 environment. Other researchers also endorsed that various criteria must be considered in the VSPs. The criteria used may vary across different product categories and situations (Lehmann and O'Shaughnessy, 1982). Linear weighting methods are the most utilized Approach for vendor evaluation and selection problems. These models place a weight on each Vendor selection criterion and provide a total score for each vendor by summing up the vendor's performance on the criteria multiplied by these weights. Many researchers such as Timmerman (1986) endorsed using a weighted linear method of multiple criteria for the VSP. Gaballa (1974) is the first author who applied Mathematical programming to a supplier selection Problem in a real case. He used a mixed integer Programming (MIP) model to minimize the total discounted price of it misallocated to the suppliers. Anthony and Buffa (1977) and Pan (1989) also Developed a linear programming (LP) model for 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 practical case.

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. Also multi-criteria decision making (MCDM) Models have been applied for the VSP. Min (1994) Presented a MCDM method based on utility theory for supplier evaluation and Narasimhan (1983) and Barbarosoglu and Yazgac (1997) used the analytical hierarchy process (AHP) for selecting (rating) the vendors. Ghodsypour and O'Brien (1998) used an integrated AHP and LP model for the vendor selection and order allocation problem.

III. FUZZY NUMBERS AND THEIR MEMBERSHIP FUNCTIONS

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 membership 1.0. In modeling these problems, trapezoidal and triangular fuzzy numbers are generally adopted (Dubois and Prade, 1988; chen and Hwang, 1992). Membership function of an element represents a degree to which the element belongs to a set. Let A_i be a fuzzy number such that $\forall A_i \in R$ (set of real number and considered in the form of

$$A_i = (a, b, c, d); \qquad i = 1, \dots\dots\dots m$$

Where a<b<c<d is the scale of preference to be used by experts and m is the fuzzy numbers to be used in the analysis. The membership function for triangular and trapezoidal fuzzy number is shown in Figure – 1 & 2 and defined as $\mu_A(x)$:

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

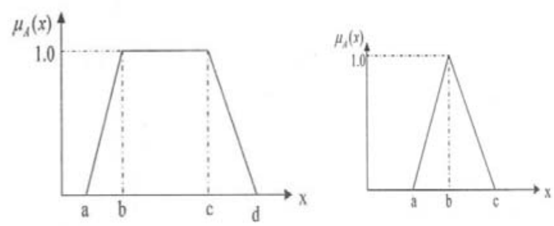

Fig. 1 (a) Trapezoidal membership function, (b)Triangular membership function

3.1 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 $[+, -, \times, \div]$ are expressed (Kaufmann and Gupta 1991) as.

$$A \oplus B = (a_1, b_1, c_1, d_1) \oplus (a_2, b_2, c_2, d_2)$$
$$= (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2)$$

$$A \ominus B = (a_1, b_1, c_1, d_1) \ominus (a_2, b_2, c_2, d_2)$$
$$= (a_1 - d_2, b_1 - c_2, c_1 - b_2, d_1 - a_2)$$

$$A \otimes B = (a_1, b_1, c_1, d_1) \otimes (a_2, b_2, c_2, d_2)$$
$$= (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2, d_1 \times d_2)$$

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

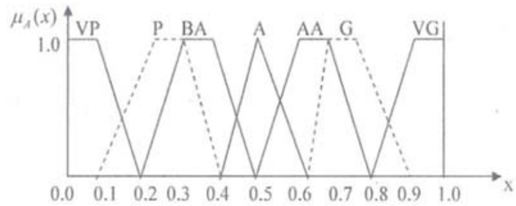

Fig. 2 : Graphical representation of fuzzy numbers for linguistic variables.

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

Table 1 shows the fuzzy numbers associated with the corresponding linguistic variables and the same is graphically represented in figure-3.

Table 1: Fuzzy numbers and corresponding linguistic variables

Linguistic Variable	Fuzzy Number
VG/VH (Very good/ Very high)	(0.8, 0.9, 1.0, 1.0)
G/H (Good/High)	(0.6, 0.7, 0.8, 0.9)
AA/AM (Above average/ Above medium)	(0.5, 0.6, 0.7, 0.8)
A/M (Average/ Medium)	(0.4, 0.5, 0.5, 0.6)
BA/BM(Below average/ Below Medium)	(0.2, 0.3, 0.4, 0.5)
P/L (Poor/Low)	(0.1, 0.2, 0.3, 0.4)
VP/VL (Very poor/Very low)	(0.0, 0.0, 0.1, 0.2)

Establishing weight for Decision Criteria:

Following are the steps.

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 aJik be the fuzzy number assigned to an alternative A_i by the experts (E_k) for the decision criterion, C_j, the average of fuzzy numbers is given as

$$A_{ij} = \frac{1}{p} \oplus \left(a^j{}_{i1} \oplus a^j{}_{i2} + \ldots + a^j{}_{ik}\right); \quad K = 1, 2, \ldots \ldots \ldots \ldots, P.$$

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 experts, 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 = $\{X_{ij}\}$ $\{W_j\}$
- 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.

IV. CASE STUDY

The purposed methodology allows the experts to rank the suitable vendor reelection for a 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 baisi of linguistic manner, which corresponded to the real lie situations in a much better way for simplicity five experts E_1, $E_{2,}$, $E_{3,}$ $E_{4,}$ $E_{5\ in}$ vendor selection projects, were consulted to get the linguistic variables in terms of importance of each of the delusion criteria used to rank the F_2, vendor for eacherileria ($V_{1,}$ $V_{2,}$ V_3, $V_{4,}$ V_5).

Criteria's

1. Ordering cost(C_{11})
2. Transportation cost(C_{12})
3. Inventory cost(C_{13})
4. On time delivery(C_{14})
5. Order delivery time(C_{15})
6. Percentage waste items(C_{16})
7. Percentage of warranty claims(C_{17})
8. Average response time of each clamp(C_{18})
9. Flexibility in service(C_{19})
10. Financial position(C_{20})

Table -2 show the linhuistic variables assigned by the experts to each of the dicission criteria are define in the table -1

Table 2: Linguistic variables assigned by the experts

Criteria	*Expert*				
	E_1	*E_2*	*E_3*	*E_4*	*E_5*
C_{11}	*G*	*V*	*G*	*G*	*VG*
C_{12}	*G*	*G*	*G*	*VG*	*G*
C_{13}	*AA*	*G*	*G*	*VG*	*VG*
C_{14}	*AA*	*AA*	*A*	*A*	*A*
C_{15}	*A*	*A*	*AA*	*A*	*A*
C_{16}	*G*	*G*	*VG*	*G*	*A*
C_{17}	*AA*	*VG*	*A*	*AA*	*A*
C_{18}	*A*	*AA*	*AA*	*A*	*A*
C_{19}	*VG*	*G*	*VG*	*A*	*G*
C_{20}	*AA*	*AA*	*A*	*VG*	*A*

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

$$X_{C2} = \begin{bmatrix} (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) & (0.6,0.7,0.8,0.9) & (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) \\ (0.6,0.7,0.8,0.9) & (0.6,0.7,0.8,0.9) & (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) & (0.8,0.9,1.0,1.0) \\ (0.5,0.6,0.7,0.8) & (0.6,0.7,0.8,0.9) & (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) & (0.8,0.9,1.0,1.0) \\ (0.5,0.6,0.7,0.8) & (0.5,0.6,0.7,0.8) & (0.4,0.5,0.5,0.6) & (0.4,0.5,0.5,0.6) & (0.4,0.5,0.5,0.6) \\ (0.4,0.5,0.5,0.6) & (0.4,0.5,0.5,0.6) & (0.5,0.6,0.7,0.8) & (0.4,0.5,0.5,0.6) & (0.4,0.5,0.5,0.6) \\ (0.6,0.7,0.8,0.9) & (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) & (0.6,0.7,0.8,0.9) & (0.4,0.5,0.5,0.6) \\ (0.5,0.6,0.7,0.8) & (0.8,0.9,1.0,1.0) & (0.4,0.5,0.5,0.6) & (0.5,0.6,0.7,0.8) & (0.4,0.5,0.5,0.6) \\ (0.4,0.5,0.5,0.6) & (0.5,0.6,0.7,0.8) & (0.5,0.6,0.7,0.8) & (0.4,0.5,0.5,0.6) & (0.4,0.5,0.5,0.6) \\ (0.8,0.9,1.0,1.0) & (0.6,0.7,0.8,0.9) & (0.8,0.9,1.0,1.0) & (0.5,0.6,0.7,0.8) & (0.6,0.7,0.8,0.9) \\ (0.5,0.6,0.7,0.8) & (0.5,0.6,0.7,0.8) & (0.4,0.5,0.5,0.6) & (0.8,0.9,1.0,1.0) & (0.4,0.5,0.5,0.6) \end{bmatrix}$$

Table-3 Normalized weights of criterion

Criteria	Average Fuzzy Score				Defuzz ified value	normalized weight
C_{11}	0.68	0.78	0.88	0.94	0.820	0.25
C_{12}	0.64	0.74	0.84	0.92	0.785	0.239
C_{13}	0.66	0.76	0.86	0.92	0.800	0.243
C_{14}	0.42	0.52	0.54	0.64	0.530	0.161
C_{15}	0.44	0.54	0.58	0.68	0.560	0.170
C_{16}	0.60	0.70	0.78	0.86	0.735	0.224
C_{17}	0.52	0.62	0.68	0.76	0.645	0.196
C_{18}	0.44	0.54	0.58	0.68	0.560	0.171
C_{19}	0.64	0.74	0.82	0.88	0.770	0.234
C_{20}	0.52	0.62	0.68	0.76	0.645	0.196

Rating of alternatives (venders) on criterion (Xij) Suitability of vanders against each criteria are to be rated and linguistic variables are assigned by the experts to the vanders table-4 are define in table-1 the linguistic variables are converted into fuzzy numbers.

Table 4: Linguistics variables for alternatives.

Crit eria	Ven dors	Experts				
		E_1	E_2	E_3	E_4	E_5
C_{11}	V_1	G	G	G	VG	G
	V_2	VG	G	VG	G	VG
	V_3	A	AA	A	A	A
	V_4	A	A	A	AA	AA
	V_5	AA	A	A	A	A
C_{12}	V1	VG	VG	G	G	VG
	V2	G	G	G	VG	G
	V3	G	VG	G	G	G
	V4	G	G	AA	G	VG
	V5	G	G	G	G	G
C_{13}	V1	VG	G	VG	VG	G
	V2	G	VG	VG	G	G
	V3	G	AA	G	AA	G
	V4	A	A	A	A	AA
	V5	G	G	G	AA	AA
C_{14}	V1	VG	G	VG	VG	G
	V2	G	AA	AA	G	G
	V3	A	A	A	A	AA
	V4	G	VG	G	G	AA
	V5	G	G	G	G	AA
C_{15}	V1	G	G	G	G	VG
	V2	A	G	G	A	AA
	V3	G	G	VG	G	G
	V4	VG	VG	VG	G	G
	V5	VG	G	G	VG	G
C_{16}	V1	VG	VG	G	VG	G
	V2	A	A	P	P	A
	V3	A	A	P	A	A

Criteria	Vendors	Experts				
		E_1	E_2	E_3	E_4	E_5
	V4	VG	VG	G	G	VG
	V5	VG	G	VG	VG	VG
C_{17}	V1	G	VG	VG	G	G
	V2	P	A	A	P	P
	V3	P	A	A	A	P
	V4	G	VG	G	VG	VG
	V5	VG	VG	VG	VG	G
C_{18}	V1	G	G	G	VG	G
	V2	A	AA	G	G	G
	V3	G	G	G	VG	AA
	V4	VG	VG	VG	VG	G
	V5	VG	G	G	VG	VG
C_{19}	V1	VG	VG	VG	G	G
	V2	A	G	G	AA	A
	V3	A	G	AA	AA	AA
	V4	AA	A	A	AA	A
	V5	AA	AA	G	A	A
C_{20}	V1	G	G	G	VG	G
	V2	AA	AA	G	AA	G
	V3	AA	AA	AA	A	A
	V4	VG	VG	VG	G	G
	V5	VG	VG	G	G	VG

Table 5: Average fuzzy scores and dufezzified scores

Criteria	Vendors	Average Fuzzy Scores				Defuzzied score
C_{11}	V1	0.64	0.74	0.84	0.92	0.785
	V2	0.72	0.82	0.92	0.96	0.855
	V3	0.42	0.52	0.54	0.64	0.53
	V4	0.44	0.54	0.58	0.68	0.56
	V5	0.42	0.52	0.54	0.64	0.53
C_{12}	V1	0.72	0.82	0.92	0.96	0.855
	V2	0.64	0.74	0.84	0.92	0.785
	V3	0.58	0.68	0.78	0.88	0.73
	V4	0.62	0.72	0.82	0.9	0.765
	V5	0.6	0.7	0.8	0.9	0.75
C_{13}	V1	0.72	0.82	0.92	0.96	0.855
	V2	0.68	0.78	0.88	0.94	0.82
	V3	0.56	0.66	0.76	0.86	0.71
	V4	0.42	0.52	0.54	0.64	0.53
	V5	0.56	0.66	0.76	0.86	0.71
C_{14}	V1	0.72	0.82	0.92	0.96	0.855
	V2	0.56	0.66	0.76	0.86	0.71
	V3	0.42	0.52	0.54	0.64	0.53
	V4	0.62	0.72	0.82	0.9	0.765
	V5	0.58	0.68	0.78	0.88	0.73
C_{15}	V1	0.64	0.74	0.84	0.92	0.785
	V2	0.5	0.6	0.66	0.76	0.63
	V3	0.64	0.74	0.84	0.92	0.785
	V4	0.72	0.82	0.92	0.96	0.855
	V5	0.68	0.78	0.88	0.94	0.82
C_{16}	V1	0.72	0.82	0.92	0.96	0.855
	V2	0.28	0.38	0.42	0.52	0.4
	V3	0.34	0.44	0.46	0.56	0.45
	V4	0.72	0.82	0.92	0.96	0.855
	V5	0.76	0.86	0.96	0.98	0.89
C_{17}	V1	0.68	0.78	0.88	0.94	0.82
	V2	0.32	0.42	0.5	0.6	0.46
	V3	0.3	0.4	0.46	0.56	0.43
	V4	0.72	0.82	0.92	0.96	0.855
	V5	0.76	0.86	0.96	0.98	0.89
C_{18}	V1	0.64	0.74	0.84	0.92	0.785
	V2	0.54	0.64	0.72	0.82	0.68
	V3	0.62	0.72	0.82	0.9	0.765
	V4	0.7	0.8	0.9	0.94	0.835
	V5	0.7	0.72	0.86	0.92	0.8
C_{19}	V1	0.72	0.82	0.92	0.96	0.855
	V2	0.5	0.6	0.66	0.76	0.63
	V3	0.5	0.6	0.68	0.78	0.64
	V4	0.44	0.54	0.58	0.68	0.56
	V5	0.48	0.58	0.64	0.74	0.61
C_{20}	V1	0.64	0.74	0.84	0.92	0.785
	V2	0.54	0.64	0.74	0.84	0.69
	V3	0.46	0.56	0.62	0.72	0.59
	V4	0.72	0.82	0.92	0.96	0.855
	V5	0.68	0.78	0.88	0.94	0.82

TS = [Xij][Wj]

	V1	V2	V3	V4	V5	Wj
C11	0.785	0.855	0.53	0.56	0.53	0.25
C12	0.855	0.785	0.51	0.612	0.75	0.239
TS=C13	0.855	0.82	0.71	0.53	0.71	0.243
C14	0.855	0.71	0.53	0.765	0.73	0.161
C15	0.785	0.63	0.785	0.855	0.82	0.171
C16	0.855	0.4	0.45	0.855	0.89	0.224
C17	0.82	0.46	0.43	0.855	0.89	0.196
C18	0.785	0.68	0.765	0.835	0.8	0.17
C19	0.855	0.63	0.64	0.56	0.61	0.234
C20	0.785	0.69	0.59	0.855	0.82	0.197

Total scores for vender (V1) on criteria is obtained as-(0.785*0.250)+(0.885*0.239)+(0.885*0.243)+(0.885*0.161)+(0.785*0.171)+(0.885*0.224)+(0.820*0.196)+(0.785*0.170)+(0.855*0.234)+(0.785*0.197)=1.72

Similarly, total scors for vanders (V2), (V3),(V4),(V5) are obtained and provided in table-6

In the selection of suitable vandor for any company , initial investement, qualitative criteria each has equal weightage. Hance the final scores and ranking of vanders are given in table-6.

Table 6: Final scores and ranging of vanders.

Vendors	V1	V2	V3	V4	V5
Final Scores	1.72	1.401	1.227	1.484	1.556
Rank	1	4	5	3	2

V. RESULTS AND DISCUSSION

With the fuzzy multi criteria decision approach, the order od ranking of vandors for the companys are as V1> V5>V4>V2>V3. The rsult show V1 is the best location for the company. Since, a fuzzylogic system in corporates the linguistic variables more practically and also helps in eliminating the imprecision and vagueness of the system. The traditional methods may not fully reflect a style of human thinking, because the experts usually feel more confident to give fuzzy judgments rather then crisp judgenents.

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