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A FUZZY APPROACH TO PERSONNEL SELECTION

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Working Paper 44/99
November 1999

Abstract

This paper proposes a new approach to the evaluation of the suitability of job applicants. It attempts to help decision-makers minimise subjective value judgments and make more effective selection from the pool of applicants, under the various evaluation criteria. It has the potential to be an effective tool to be employed by those involved in personnel selection.

Keywords: personnel evaluation fuzzy sets; decision making and fuzzy suitability table.

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INTRODUCTION

Human Resource Management (HRM) is a process of managing people through personnel selection, performance appraisal, reward systems, training and development. A common belief among business academics and practitioners is that HRM should be based on justice principles, particularly in hiring, performance appraisal and rewarding. The justice principles are understood as the process of decision making to be carried out with the minimal influence of subjective judgments.

The hiring procedure is the first contact of a future employee with an organisation. Recent research has shown that the employee's commitment to the organisation is dependent on the employee's treatment in the hiring process [5]. If the employees are fairly treated during the selection period, they should be more committed to the organisation.

Reviewing the contemporary recruitment literature it seems that this challenging task of trying to distinguish "good" workers from "poor" workers with the aid of tests and other devices coincides with the early formulations of industrial psychology [3, p.2]. That is the principles of personnel selection have changed very little since Freyd published his guidelines in 1923 [11]. According to Guinon it is discouraging that "little of substance has been added or changed in the half century since then" [12, p. 782]. Blunt points that in practice, personnel selection is carried out less rigorously than it should be in many instances [4]. In addition research of both Brotherton [7] and Robertson [19] present convincing evidence that the selection process is very much based on subjective criteria, no matter of how great variability between organisations exists.

The exact evaluation of job applicants is a difficult process because of the complexity and multivalences of their skills. However, the fuzzy theory developed by Zadeh [22, 24] can be applied to improve the efficiency of assessments and reduce the subjective judgment.

According to Carlsson and Fullér, the application of fuzzy set theory in the decision making process under multiple criteria, when only incomplete or vague information is available, has been the subject of much research over the last two decades [9]. The basic postulate behind this work is that many real world problems have more to do with fuzziness than randomness as the major source of imprecision [28]. In such situations, it is more appropriate to handle uncertainty by fuzzy set theory than by probability theory [21].

In recent years, some research on the application of fuzzy set theory in HRM, mainly in the personnel placement domain, was undertaken [8, 15, 22]. Liang and Wang combined fuzzy set theory and weighted complete bipartite graphs to develop a polynomial time algorithm for solving personnel placement [15]. Yakoob and Kawata discussed workers' placement in an industrial environment using the concepts of triangular fuzzy numbers and linguistic variables [22]. "For the sake of clarity" they have used only the model values when multiplying triangular numbers, and their computation was overly based on the assumption that multiplication returns a piecewise linear membership function. However, multiplication produces a quadratic form of resulting fuzzy number [16, p. 138]. Cannavacciuolo etal. [8] arbitrarily suggested membership functions "that seem suitable" [8, p. 517] and did not provide the full algorithm which a decision maker can follow.

In this paper, the formulation of a new approach for recruiters' evaluation is presented. The proposed method has the advantage of being easily implemented in any spreadsheet by a decision maker, and thus overcoming the drawbacks of the one presented in [8].

This paper is organised as follows. The first section, provides a review of the background of fuzzy set theory. In Section two, application of fuzzy ideas to human resources staff selection is forwarded. In particular in instances in which a single skill per task is required a fuzzy suitability table is proposed. In Section three, the proposed method for a general, multi-skills per task scenario is extended. In the following section the proposed procedure is illustrated via a case study.

1. BACKGROUND OF THE FUZZY SET THEORY

The theory of fuzzy sets was proposed by Lotfi Zadeh in his seminal paper 1965 [23] as an approach to handling uncertainty and vagueness in decision making processes. Zadeh elaborated on such ideas in a 1975 article [23] and introduced the concept of linguistic variables. The classical (so-called crisp) theory allows an element either to be a member of a set or excluded from a set. In fuzzy sets, however, an element can be a partial member of a set; hence a fuzzy set is a class whose boundaries are not sharply defined.

With consideration a discrete universe of discourse X with cardinality n, $X = \{x_1, x_2, \ldots, x_n\}$. A fuzzy set A in X can be represented as a set of ordered pairs of a generic element $x \in X$ and its grade of membership

$$A = \{(x_1, \mu_A(x_1)), (x_2, \mu_A(x_2)), \ldots, (x_n, \mu_A(x_n))\}$$

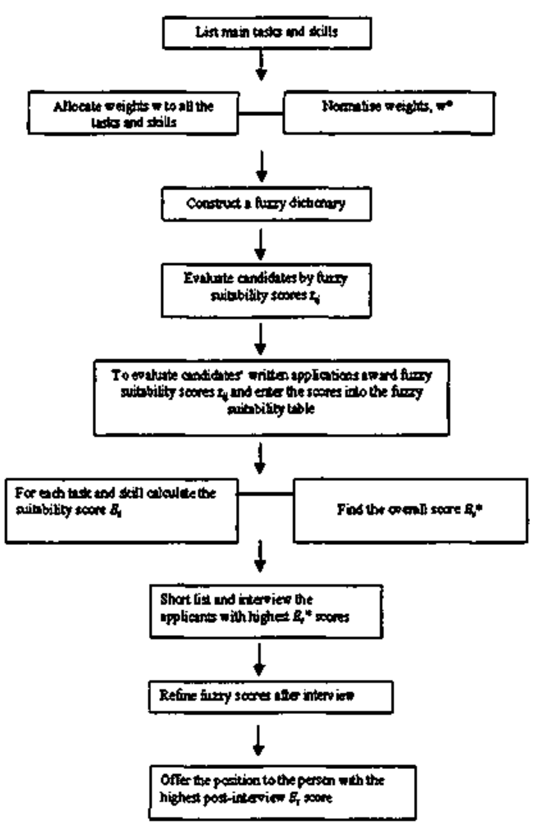
where μ_A is the membership (characteristic) function of the fuzzy set A. It maps the elements of X to the unit interval, μ_A: $X \rightarrow [0, 1]$ and therefore denotes a degree of membership of x in A. The larger the μ_A, the stronger the belonging degree of x in A. For convenience only elements of X with nonzero grades of membership in the fuzzy set (thus we will list only the support of the corresponding fuzzy set) are enumerated. Clearly, a fuzzy set is a generalisation of a crisp set whose membership function takes on only two values $\{0, 1\}$.

2. A NEW APPROACH FOR PERSONNEL SELECTION USING FUZZY SETS

In this section, the use fuzzy ideas to develop a rational and objective selection procedure considering all relevant criteria along with their importance is discussed.

Suppose that the job analysis has identified main tasks entailed in a job and determined the essential and desirable skills that are required to be performed. The decision-makers are responsible for assessing the suitability of L candidates under each of the N criteria.

The stepwise flow of the proposed method depicted in Figure 1 is presented as follows.



Step 1: List distinct main tasks and allocate weights (importance), w_i, to each of the tasks. Obtain the normalised weights w^*_i.

Step 2: For each task determine a skill to facilitate the task.

Step 3: Each skill is treated as a linguistic variable and descriptive adjectives are assigned, corresponding to the attainment of the company objectives. During this linguistic translation, a "dictionary" of descriptive adjectives is created. Assume five suitability levels (fuzzy linguistic hedges): very high (VH); High (H); Average (A); Low (L) and Very Low (VL), where the rating scales of a candidate's suitability are shown in Table 1.

Table 1. **A Fuzzy Dictionary**: Suitability levels and corresponding degrees of suitability

Linguistic value	Degree of suitability
Very high (VH)	0.81-1.00 (81%-100%)
High (H)	0.61-0.80 (61%-80%)
Average (A)	0.41-0.60 (41%-60%)
Low (L)	0.21-0.40 (21%-40%)
Very low (VL)	0.00-0.20 (0%-19%)

To evaluate the applicants' skills it is necessary to map fuzzy intervals into crisp numbers. To achieve this, let X be a set descriptive adjectives in the universe of discourse (j = 1, 2,...,5) and define a mapping function, M

$$M: X \rightarrow [0, 1]$$

that maps a suitability level to the highest degree of the corresponding suitability level. From Table 1 we can obtain the unique values of the mapping function

$$M(\text{Very high}) = 1.00$$
$$M(\text{High}) = 0.80$$
$$M(\text{Average}) = 0.60 \quad (1)$$
$$M(\text{Low}) = 0.40$$
$$M(\text{Very Low}) = 0.20$$

Step 4: Using the dictionary, it is possible to construct a fuzzy suitability table (FST) that lists all the skills, corresponding weights and the ranked fuzzy attributes. First, a simple case for each of the N tasks where there is only one required skill is discussed. Followed by an extension of this approach a general fuzzy suitability table (GFST) is proposed. Table 2 exemplifies the layout of a FST. In the first and second columns, all the tasks prescribed in the job's description and corresponding weights are listed, respectively. The bottom cell on the right of the table displays the overall "crisp" mark awarded to the applicant.

Based on the written candidate's application and the fuzzy dictionary, the decision-makers award fuzzy scores, $z_{ij} \in [0, 1]$, for each of the skills within a given task. An example of the evaluation of a candidate's suitability for a task T_i and skill S_i is illustrated in Table 3. The suitability level of the candidate with respect to the task T1 is evaluated as 30% average, 70% high, and 10% very high. The corresponding fuzzy set for this task can is represented as

$$F(T_i) = \{(\text{Very Low}, 0), (\text{Low}, 0), (\text{Average}, 0.3), (\text{High}, 0.7), (\text{Very high}, 0.1)\}$$

Step 5: The candidate's suitability score, E_i, for the task T_i can now be calculated by the following formula

$$E_i = \frac{\sum_{j=1}^{5} z_{ij} M(x_j)}{\sum_{j=1}^{5} z_{ij}} w_i^* \tag{2}$$

where z_{ij} is the fuzzy score for the j-th suitability level (j =1....5) and i-th task, $M(x_j)$ is the resulting value of the mapping function, and w^*_i the normalised score for the particular task. Since the function E is normalised, its domain is [0, 1]. It is obvious that the larger values of E_i reflect the higher suitability level of the candidate for a particular task.

The evaluation of the candidate's grade for the example is shown in Table 3. From formulae (1) the values of the M function are: M(Average) = 0.60, M(High) = 0.80, and M(Very high) =1. By applying formula (2)

$$E_i = \frac{(0.3*0.60 + 0.7*0.80 + 0.1*1)}{0.3 + 0.7 + 0.1} * 0.2 = 0.763 * 0.2 = 0.153$$

The unweighted score, 0.763, indicates that the degree of the candidate's suitability for the task is 76.3%.

Step 6: The overall suitability score can be obtained by summing E_i values over all tasks.

$$E^* = \sum_{i=1}^{N} E_i = \sum_{i=1}^{N} \left(\frac{\sum_{j=1}^{5} z_{ij} M(x_j)}{\sum_{j=1}^{5} z_{ij}} * w_i^* \right) \tag{3}$$

Table 2. A fuzzy suitability table (single skill per task)

Task No.	Skill	Relative weight	Normalised weight	Applicant's suitability level					Degree of suitability
				Very Low	Low	Average	High	Very high	
T_1	S_1	w_1	w^*_1	z_{11}	z_{12}	z_{13}	z_{14}	z_{15}	
...	...	...	...	...	...	...	...	...	
T_i	S_i	w_i	w^*_i	z_{i1}	z_{i2}	z_{i3}	z_{i4}	z_{i5}	
...	...	...	...	...	...	...	...	...	
T_N	S_N	w_N	w^*_N	z_{N1}	z_{N2}	z_{N3}	z_{N4}	z_{N5}	
Total:									

Step 7: Select for interview small number of candidates with the highest E^* scores.

Step 8: After interview, refine fuzzy scores, or introduce new ones since some skills can be assessed only at the interview (eg. communication skills, potential for being a self-starter, ambition in line with anticipated job progression.).

Step 9: Finally, select the candidate with the highest post-interview E^* grade.

Table 3. An example of a fuzzy suitability table (single skill per task)

Task No.	Skill	Relative weight	Normalised weight	Applicant's suitability level					Degree of suitability
				Very Low	Low	Average	High	Very high	
...	...	...	...	...	...	...	...	...	
T_i	S_i	1.6	0.2	0	0	0.3	0.7	0.1	
...	...	...	...	...	...	...	...	...	
Total:		8							

3. A GENERALISED, MULTI-SKILLS PER TASKS, FUZZY SUITABILITY APPROACH

In this section, the method presented in the previous section is generalised to a more realistic multi-skills per tasks scenario.

Step 1: Same as the single-skill per task case.

Step 2: Within each task, list skills to accomplish the task and allocate relative weights to each of the skills; normalise the weights.

Step 3: Same as the single-skill per task case.

Step 4: The layout of the generalised fuzzy suitability table (GFST) is given in Table 4. In the first three columns all the tasks required for a job, along with the relative and normalised weights, are revealed. In the column four for each of the tasks, prescribed tasks are listed. Relative and normalised skill weights are displayed in following two columns. The overall skill weights, computed as a product of corresponding normalised task weight and normalised skill weight, are shown in column seven. Assume, that the decision-maker can evaluate the suitability of each candidate's skill using the same classification of linguistic descriptors as in the previous section.

Step 5: The candidate's fuzzy suitability score, E_{ik}, for the skill S_{ik} within task T_k, can be obtained from the formula presented below

$$E_{ik} = \frac{\sum_{j=1}^{5} z_{ikj} M(x_j)}{\sum_{j=1}^{5} z_{ikj}} w^{*}_{ik} \qquad (4)$$

Formula 4 is a natural extension of formula 2: z_{ikj} is a fuzzy score for the i-th task ($1 \leq i \leq N$), k-th skill ($1 \leq k \leq t_i$) and j-th suitability level ($1 \leq j \leq 5$), and w^{*}_{ik} overall normalised score for the skill S_k within the task T_i. The function $M(x_j)$ has the same meaning as in the single skill per task case. The resulting values of this calculation are located in the second-last column to the right.

Step 6: The overall suitability score, E_i, for the task T_i can be evaluated by summing all the E_{ik} values for the task

$$E^{*}_{i} = \sum_{k=1}^{t_i} E_{ik} \qquad (5)$$

where t_i is the number of required skills per task. Finally, the total fuzzy suitability score for a candidate, E^*, is the sum of evaluated scores for all tasks

$$E^{*} = \sum_{i=1}^{N} E^{*}_{i}$$

Steps 7-9 are the same as in the previous section.

4. CASE STUDY

To demonstrate the effectiveness of the method that has been proposed in this paper, the following case study is considered

The job vacancy is: *Senior economic and financial analyst* for the corporate unit of the ABC Telephone Company. Tasks, determined through the job vacancy perspective, are summarised as follows:

1. Provide financial analysis to use for development, maintenance and communication of the business plan

2. Team work

3. Create business model to support a business plan

Decision criteria, or *skills*, for each *task* are itemised as follows

1. Provide financial analysis for the development, maintenance and communication of the business plan

   1.1 Financial background
   1.2 Business planning background

2. Team work

   2.1 Ability to work as a member of a team with minimum supervision
   2.2 Ability to work in different business units
   2.3 High communication skills

3. Create business model to support business plan

   3.1 Economic-Mathematical background
   3.2 Strategic thinking
   3.3 High level of general computer literacy
   3.4 Strong conceptual and analytical skills

Assume that after the interview, decision-makers evaluate a candidate's suitability using generalised fuzzy table as shown in Table 5.

The suitability level of the candidate with respect to the skill 1.1, "Financial background", within the task "Provide financial analysis" is evaluated as 40% low, 80% average, and 10% high. The corresponding fuzzy set for this skill is represented as

F(Financial background) = {(Low, 0.4), (Average, 0.8), (High, 0.1)}

By applying formula (4) we can see that the suitability score for this skill is

$$E_{11} = \frac{0.4 * M(Low) + 0.8 * M(Average) + 0.1 * M(High)}{0.4 + 0.8 + 0.1} * 0.2$$
$$= \frac{0.4 * 0.4 + 0.8 * 0.6 + 0.1 * 0.8}{0.4 + 0.8 + 0.1} * 0.2 = 0.111$$

Likewise, the score for the second skill, "Business planning" within this task was evaluated at 0.191, thus yielding 0.302 as the total suitability score for the task. The computed total "crisp" score for this applicant is shown in the bottom-right of the GFST. It indicates that the degree of the candidate's suitability for the job is 68.8%.

5. CONCLUSION

A new method has been proposed for evaluating the overall suitability of job applicants, using fuzzy logic. By expertly choosing weights for skills and tasks in advance of evaluation of applications, the fuzzy method achieves a rational basis for assessment.

Subjective value judgments in the recruitment and selection processes are avoided using the HRM fuzzy logic model. The method could be further developed including other factors than those that strictly influence the HRM decision making process.

Table 4. A generalised fuzzy suitability table (multi-skilled task)

Task	Task weight	Norm. Weight	Skill	Skill weight	Norm. weight	Overall skill weight	Applicant's suitability level					Degree of skill suitability	Degree of task suitability
							Very Low	Low	Average	High	Very high	E^*_{ik}	E^*_i
			S_1	w_1	w^*_1	w^*_{11}	z_{111}	z_{112}	z_{113}	z_{114}	z_{115}	E_{11}	
			...	...	...	...	...	...	...	...	...	...	
T_1	W_{T_1}	$w^*_{T_1}$	S_k	w_k	w^*_k	w^{**}_{1k}	z_{1k1}	z_{1k2}	z_{1k3}	z_{1k4}	z_{1k5}	E_{1k}	E^*_1
			...	...	...	...	...	...	...	...	...	...	
			S_{t_1}	w_{t_1}	$w^*_{t_1}$	$w^{**}_{1t_1}$	z_{1t_11}	z_{1t_12}	z_{1t_13}	z_{1t_14}	z_{1t_15}	E_{1t_1}	
...	...	...	...	...	...	...	...	...	...	...	...	...	...
			S_1	w_1	w^*_1	w^*_{i1}	z_{i11}	z_{i12}	z_{i13}	z_{i14}	z_{i14}	E_{i1}	
			...	...	...	...	...	...	...	...	...	...	
T_i	w_{T_i}	$w^*_{T_i}$	S_k	w_k	w^*_k	w^{**}_{ik}	z_{ik1}	z_{ik2}	z_{ik3}	z_{ik4}	z_{ik5}	E_{ik}	E^*_i
			...	...	...	...	...	...	...	...	...	...	
			S_{t_i}	w_{t_i}	$w^*_{t_i}$	$w^{**}_{it_i}$	z_{it_i1}	z_{it_i2}	z_{it_i3}	z_{it_i4}	z_{it_i5}	E_{it_1}	
...	...	...	...	...	...	...	...	...	...	...	...	...	...
			S_1	w_1	w^*_1	w^*_{N1}	z_{N11}	z_{N12}	z_{N13}	z_{N14}	z_{N15}	E_{N1}	
			...	...	...	...	...	...	...	...	...	...	
T_N	W_{T_N}	$w^*_{T_N}$	S_k	w_k	w^*_k	w^{**}_{Nk}	z_{Nk1}	z_{Nk2}	z_{Nk3}	z_{Nk4}	z_{Nk5}	E_{Nk}	E^*_N
			...	...	...	...	...	...	...	...	...	...	
			S_{t_N}	w_{t_N}	$w^*_{t_N}$	$w^{**}_{Nt_N}$	z_{Nt_N1}	z_{Nt_N2}	z_{Nt_N3}	z_{Nt_N4}	z_{Nt_N5}	E_{Nt_1}	
Total													

Table 5. Generalised fuzzy suitability table for the senior economic and financial analyst

Task	Task weight	Norm. weight	Skill	Skill weight	Norm. weight	Overall skill weight	Applicant's suitability level					Degree of skill suitability	Degree of task suitability
							Very Low	Low	Average	High	Very high	E^*_{ik}	E^*_i
1. Provide financial analysis for development, maintenance and communication of the business plan	3.00	0.500	1.1 Financial background	1.00	0.400	0.200	0	0.4	0.8	0.1	0	0.111	0.302
			1.2 Business planning background	1.50	0.600	0.300	0	0.1	0.7	0.3	0	0.191	
			Total:	2.50	1.000	0.500							
2. Team work	1.00	0.167	2.1 Ability to work as a member of a team	1.20	0.353	0.059	0	0	0	0.9	0.5	0.051	0.122
			2.2 Ability to work in different business units	1.00	0.294	0.049	0	0	0.1	0.8	0.3	0.041	
			2.3 High communication skills	1.20	0.353	0.059	0.1	0.5	0.8	0	0	0.030	
			Total:	3.40	1.000	0.167							
3. Create business model to support business plan	2.00	0.333	3.1 Economic-Mathematical background	1.30	0.276	0.092	0	0	0	0.2	0.9	0.089	0.264
			3.2 Strategic thinking	1.40	0.298	0.099	0	0	0.8	0.6	0	0.068	
			3.3 General computer literacy	1.00	0.213	0.071	0	0	0	0.3	0.8	0.067	
			3.4 Strong conceptual and analytical skills	1.00	0.213	0.071	0	0.5	0.8	0.3	0	0.041	
			Total:	4.70	1.000	0.333							
Total	6.00	1.000											0.688

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