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Selection of IT Personnel through Hybrid Multi-attribute AHP-FLP Approach

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Abstract*—The personnel evaluation and selection is an important problem that can considerably affect the future competitiveness and performance of an organization. This paper presents a comprehensive hierarchical structure for selecting and evaluating a right personnel and proposes a new approach called "Analytical Hierarchy Process Weighted Fuzzy Linear Programming Model (AHP-FLP)" for personnel selection based on multiple attributes or criteria. The weights of the various criteria, taken as local weights from a given judgment matrix, are calculated using Analytical Hierarchy Process (AHP) that are also considered as the weights of the fuzzy linear programming model. This new model is compared with the classical AHP method. The study concluded that the AHP-FLP method outperforms the AHP method for selection of personnel with respect to restricted selection criteria. An example demonstrates the feasibility of the presented framework. Drawing on a real case of an Indian company from IT industry, the approach has been used to analyze the selection criteria used in recruitment for different IT roles which differed significantly in professional skills required.

***Index Terms*— Analytic Hierarchy Process, Decision making, Fuzzy linear programming.**

I. INTRODUCTION

Personnel selection aims at recruiting individuals who match the qualifications required to perform a defined job in the best way. Increasing competition in global markets urges organizations to put more emphasis on personnel selection process. Such strategic decisions are made by utilizing rigorous and costly selection procedures which differ with respect to organizations. These procedures are usually designed keeping in mind the criteria or attributes for selection of personnel in different roles and at different levels in that organization. For example in an IT company, criteria such as information technology/ information system (IT/IS) skills, management knowledge, and knowledge of business processes in new recruits will vary according to the type of role being filled. For the entry level positions, more importance is attached to IT skills of an employee whereas for a higher management position, management knowledge or the knowledge of business processes plays an important part.

Decision on selection of a suitable employee is therefore a complex process involving multiple criteria. One class of approaches that deal with multi-criteria decision making problems includes techniques based on the well-known Analytic Hierarchy Process (AHP) which reduces complex decisions to a series of pair wise comparisons and synthesizes the results. AHP and its extensions have been utilized extensively in the selection of human resources. A detailed review of various applications of AHP in different settings is provided by [1]. Although the purpose of crisp AHP is to capture the expert's knowledge, the traditional AHP still may not reflect the human thinking style [2]. Uncertainty of the information along with inherent difficulties related to human knowledge make the decision making relating to employee selection highly complicated. The multiple criteria are consider at the same time, with various weights and thresholds, having the potential to reflect at a very satisfactory degree the vague preferences of the Decision makers. Assigning different weights to various criteria, a fuzzy multi-objective model enables the decision makers to consider the vagueness of information [3]. Therefore, AHP methodology integrated with the fuzzy multi-objective linear programming model has been adopted as an alternative to the conventional and singular methods of weight derivation in AHP.

This paper applies a hybrid method of employee selection, analytical hierarchy process weighted fuzzy linear model (AHP-FLP) to a well-known Indian company operating in IT industry. The novelty of the research lies in the application of the hybrid approach to a real case study. It is shown that the weights calculated by AHP-FLP approach are in line or better than the conventional AHP approach.

The remainder of the paper is organized as follows. Section 2 briefly discusses the methodologies of AHP and AHP-FLP. This is then followed by the application of AHP-FLP method to an IT industry case in section 3. Conclusions and managerial implications are in the final section.

II. METHODOLOGIES

A. The Analytic Hierarchy Process (AHP) methodology

Analytic Hierarchy Process (AHP) is widely used multi criteria decision making method introduced by [4] and it resolves decision making problems by structuring each problem into a hierarchy with different levels of criteria. The upper level of the hierarchy represents the overall goal, while the lower level consists of all possible alternatives. One or more intermediate levels embody the decision criteria and sub-criteria [5]. After breaking the complex multi-criteria decision problem into multiple hierarchical levels, decision makers have to compare each cluster in the same level in a pair wise fashion based on their own experience and knowledge. Since the comparisons are carried out through personal or subjective judgments, some degree of inconsistency may be occurred. To guarantee the judgments are consistent, the final operation called consistency verification is incorporated in order to measure the degree of consistency among the pair wise comparisons by computing the consistency ratio. If it is found that the consistency ratio exceeds the limit (i.e. if CR>0.1), the decision makers should review and revise the pair wise comparisons. Once all pair wise comparisons are carried out at every level, and are proved to be consistent, the judgments can then be synthesized to find out the priority ranking of each criterion and its attributes.

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Saaty[4] states that in many practical cases the pair wise judgments of decision makers will contain some degree of uncertainty. It is usually the case that the decision maker is certain about the ranking order of the comparison elements but uncertain about the precise numerical values of his judgments. The classical AHP attempts to overcome this problem by introducing a discrete linguistic set of comparison judgments. Instead of directly assigning numerical values to the comparison ratios, the decision maker chooses an appropriate linguistic phrase, best corresponding to his comparison preferences.

B. Analytical hierarchy process weighted fuzzy linear programming model (AHP-FLP)

For employee selection problems, the collected data does not behave crisply and they are typically fuzzy in nature. Bellman and Zadeh [6] suggested a fuzzy programming model for decision making in fuzzy environment. Later, this method was used by [7] to solve fuzzy multi-objective linear programming problems. In this subsection, the general fuzzy multi-objective model for employee selection is presented in the following manner [8,9] .

Find a vector $X=[x_1,x_2,...x_n]$ which maximizes the employee performance using objective function with for number of *m* criteria. An imprecise aspiration levels has been assigned to the objective by incorporating the objective function as a fuzzy constraint with a restriction (aspiration) level. The inequalities are defined softly if the requirement (resource) constants are defined imprecisely.

Find X

$$\tilde{Z}_k(X)=\sum_{i=1}^{n} c_{ki}\, x_i \underset{\sim}{\ge} Z_k^0 \qquad \forall k=1,,...m$$

Subject to

$$\sum_{i=1}^{n} a_{ri}\, x_i \le b_r$$

(P1)

c_{ki} , a_{ri} and b_r are crisp values. In this model, the sign $\sim$ indicates the fuzzy environment. $\underset{\sim}{\ge}$ denotes the fuzzified version of $\ge$ interpretation "essentially greater than or equal to" . Z_k^0 is the aspiration level that the decision maker wants to reach. Every objective function value $\tilde{Z}_k$, changes linearly from Z_k^* (minimum value of Z_k) to (maximum value of Z_k).

Based on linear membership function, maximization goals $\tilde{Z}_k$ are given as follows:

$$\mu_{Z_1}(X)=\begin{cases}1 & ;Z_1(X)\ge Z_k^0\\ \dfrac{Z_k^0-Z_1(X)}{Z_k^0-Z_k^*} & ;Z_k^*\le Z_1(X)<Z_k^0\\ 0 & ;Z_k(X)<Z_k^*\end{cases},k=1,2,...m$$

The model formulated in (P1) can be solved using weighted additive model which is widely used in vector –objective optimization problems, the basic concept is to use a single utility function to express the overall performance of decision maker draw out the relative importance of criteria [10]. In this approach, multiplying each membership function of fuzzy goals by their corresponding weights and then adding the results together to obtain a linear weighted utility function. The weighted additive model proposed by [11] is equivalent to solving the following crisp single objective programming model [12] :

Maximize $\sum_{k=1}^{m} w_k \alpha_k$

Subject to

$$\left.\begin{aligned}&\mu_{Z_k}(X)\ge\alpha_k\\&\alpha_k\in[0,1]\\&w_k\ge 0\end{aligned}\right\}\ \forall k=1,2,...m$$

$$\sum_{k=1}^{m} w_k=1;$$

$$x_i\ge 0 \quad \forall i=1,2,...n \qquad \text{(P2)}$$

Where w_k $and\, \mu_{Z_k}(X)$ represents the weighting coefficients that presents the relative importance among the fuzzy goals and membership function of objective function. The problem (P2) can be solved using standard mathematical programming approach.

Overall formulation of this model is summarized in the following stages of Fig.1.

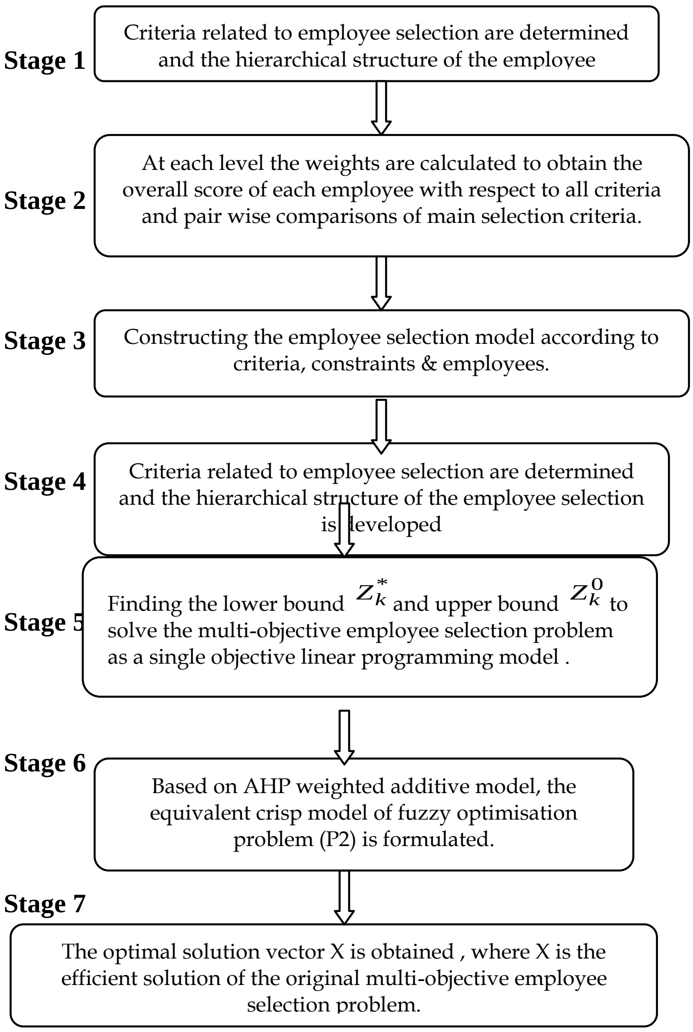

Fig.1. Stages of AHP-FLP model

III. APPLICATION OF THE AHP-FLP MODEL

The objective of this study is to develop a hybrid model, which will help to solve the employee selection problem of a major IT based Indian company (name has not been revealed due to confidentiality). Recruitment needs to be made at the entry level of two different professional roles in the company viz project manager and systems analyst.

A. Definition of IT employee selection criteria

The selection of criteria requires a thorough check on different aspects from each criteria and the requirement of the job. Criteria or attributes to be selected by the HR department was therefore based on extensive literature survey by the research wing of HR department.

From a resource-based view, the professional knowledge and skills of IT employees represent a part of the company's IT capability and has an effect on the company's competitiveness [13-14]. High quality employees will also help enhance the value, quality of service, and level of satisfaction with the enterprise information systems [15]. Noll and Wilkins [16], for example suggested that IT employees should possess the following critical skills: business knowledge, user support, advanced IS applications, programming, systems planning. Fink and Neumann17 in turn concluded after an extensive review of the literature that IT personnel should possess three capabilities: business capability, behavioral capability and technical capability. Gallivan et al.[18] also investigated the actual professional skills of IS employees between 1988 and 2003. The study found that companies were more willing to employ IT personnel if their professional capabilities matched the popular information technologies at the time. While many academics have made suggestions on the professional skills that IT employees should possess based on different perspectives, at the moment, the view put forth by [19] is probably one of the more popular today. They proposed that there are four critical knowledge/skills for IT professionals, namely: 1) Technical specialties knowledge/skills; 2) Technology management knowledge/skills; 3) Business functional knowledge/skills; and 4) Interpersonal and management knowledge/skills. Other researchers have studied their perspective (see ref. 20,21) and used it as the foundation for their own studies. This study has therefore opted to use the research perspective of Lee et al.19 as the operational definition for measuring the professional knowledge and skills of IT personnel during recruitment.

The hierarchical structure for the selection criteria required at different levels of the professional positions is given in the figure 2. Here A: project manager (entry level) B: system analyst (entry level) , E1: Employee1 , E2: Employee2 , E3: Employee 3.

B. Calculation of the weights of the criteria

First, the hierarchical structure of the employee selection has been identified based on the evaluations of experts from the company. They also indicated their degree of preference between and within the criteria at each level of the hierarchy in a pair wise form using Saaty's scales ranging from 1 – equally preferred to 9 – extremely preferred. Next step involves the weight calculation of each job at each level to obtain the overall score of each employee with respect to all 18 sub-criteria and pair wise comparisons of the main selection criteria. For example, for the recruitment at the entry level of project manager and system analyst position, three employees are judged on the basis of the selected attributes.

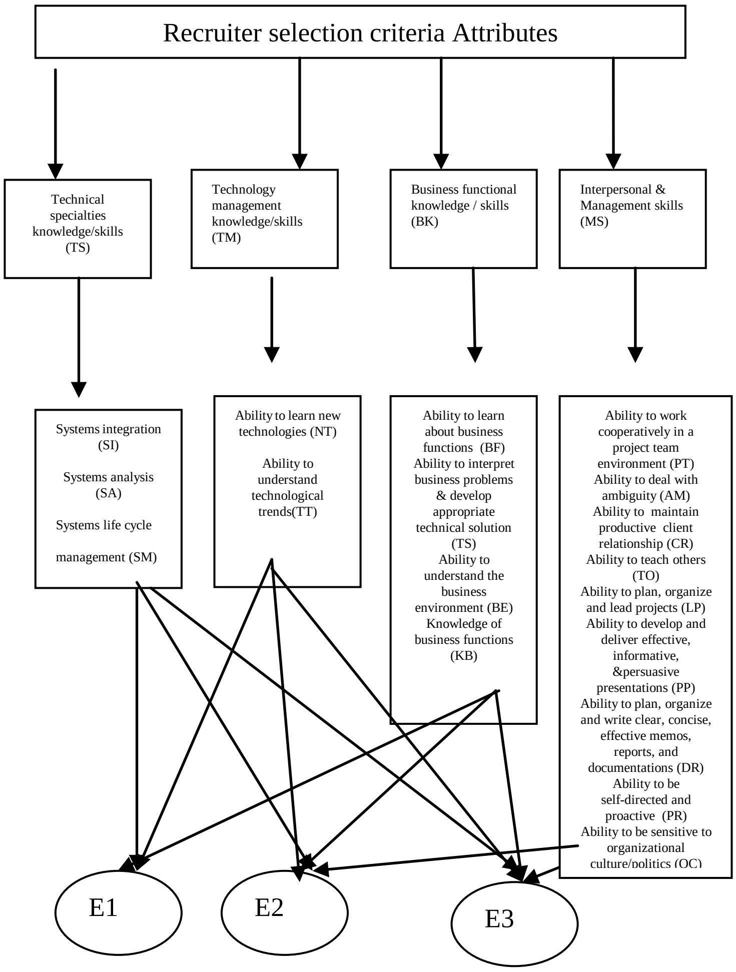

Table 1 and Table 2 presents the local weights of each of the three employees for the job of project manager and system analyst respectively at the entry level of recruitment with respect to main selection criteria viz . Technical specialties knowledge/skills, Technology management knowledge/skills, Business functional knowledge/skills and Interpersonal and management knowledge/skills. Each employee's local weight related to the respective selection criterion is taken as an objective function coefficient in multi-objective linear programming model. The detailed calculation of the local weights using AHP methodology for the post of project manager (entry level) and system analyst (entry level) is provided in the Appendix.

Table 1. Input data for employee selection for the entry level post of Project Manager

Employee	TS	TM	BK	MS
E1 (x_1)	0.238	0.34	.3343	0.3031
E2 (x_2)	.365	.315	.4193	0.3237
E3 (x_3)	0.369	0.34	.2718	0.3586

Table 2. Input data for employee selection for the entry level post of System Analyst

Employee	TS	TM	BK	MS
E1 (x1)	0.482	0.34	0.587	0.738

E2 (x2)	0.279	0.315	0.285	0.179
E3 (x3)	0.239	0.34	0.128	0.083

C. Constructing multi-objective linear programming models

This stage involves construction of multi-objective linear programming model as a single objective employee selection problem using each time only one objective. The multi-objective programming of our application presented as z_1 to z_4 (for four main criteria) . The multi-objective linear programming model corresponding to post A can be written as

$$\text{Maximize} \begin{Bmatrix} Z_1 = 0.238x_1 + 0.365x_2 + 0.369x_3 \\ Z_2 = 0.34x_1 + 0.315x_2 + 0.34x_3 \\ Z_3 = 0.3343x_1 + 0.4193x_2 + 0.2718x_3 \\ Z_4 = 0.30315x_1 + 0.3237x_2 + 0.3586x_3 \end{Bmatrix}$$

$$\text{Subject to} \quad x_1 + x_2 + x_3 = 1; \quad x_1, x_2, x_3 \geq 0 \qquad \text{(P3)}$$

Similarly for post B, multi-objective linear programming model can be written as

$$\text{Maximize} \begin{Bmatrix} Z_1 = 0.482x_1 + 0.279x_2 + 0.239x_3 \\ Z_2 = 0.34x_1 + 0.315x_2 + 0.34x_3 \\ Z_3 = 0.587x_1 + 0.285x_2 + 0.128x_3 \\ Z_4 = 0.738x_1 + 0.179x_2 + 0.083x_3 \end{Bmatrix}$$

$$\text{Subject to} \quad x_1 + x_2 + x_3 = 1; \quad x_1, x_2, x_3 \geq 0 \qquad \text{(P4)}$$

D. Constructing the bounds for each main criterion

The linear membership function is used for fuzzifying the objective functions and the constraints for the above problem. The data set values of the lower bounds (Z_k^*) and the upper bounds (Z_k^0) of the objective functions are provided below:

Table 3. Bounds of the objective functions

	Post A		Post B	
	Min	Max	Min	Max
Z_1---TS	0.238	0.369	0.239	0.482
Z_2---TM	0.315	0.34	0.315	0.34
Z_3---BK	0.2718	0.4193	0.128	0.587
Z_4---MS	0.30315	0.3586	0.738	0.083

E. Finding fuzzy multi-objective model

The fuzzy multi-objective formulation for the post A can be written as :

Find X

So as to satisfy

$$\text{Maximize} \quad \tilde{Z}_1 = 0.238x_1 + 0.365x_2 + 0.369x_3 \underset{\sim}{\geq} Z_1^0$$

$$\text{Maximize} \quad \tilde{Z}_2 = 0.34x_1 + 0.315x_2 + 0.34x_3 \underset{\sim}{\geq} Z_2^0$$

$$\text{Maximize} \quad \tilde{Z}_3 = 0.3343x_1 + 0.4193x_2 + 0.2718x_3 \underset{\sim}{\geq} Z_3^0$$

$$\text{Maximize} \quad \tilde{Z}_4 = 0.30315x_1 + 0.3237x_2 + 0.3586x_3 \underset{\sim}{\geq} Z_4^0$$

Subject to

$$x_1 + x_2 + x_3 = 1; \quad x_1, x_2, x_3 \geq 0 \qquad \text{(P5)}$$

Similarly for post B , fuzzy multi-objective formulation can be written as

Find X

So as to satisfy

$$\text{Maximize} \quad \tilde{Z}_1 = 0.482x_1 + 0.279x_2 + 0.239x_3 \underset{\sim}{\geq} Z_1^0$$

$$\text{Maximize} \quad \tilde{Z}_2 = 0.34x_1 + 0.315x_2 + 0.34x_3 \underset{\sim}{\geq} Z_2^0$$

$$\text{Maximize} \quad \tilde{Z}_3 = 0.3587x_1 + 0.285x_2 + 0.128x_3 \underset{\sim}{\geq} Z_3^0$$

$$\text{Maximize} \quad \tilde{Z}_4 = 0.738x_1 + 0.179x_2 + 0.083x_3 \underset{\sim}{\geq} Z_4^0$$

$$\text{Subject to} \quad x_1 + x_2 + x_3 = 1; \quad x_1, x_2, x_3 \geq 0 \qquad \text{(P6)}$$

In this stage the membership functions of the four objective functions (Z1, Z2, Z3, Z4) are provided by which to maximize the performance of employees related to each of the four main criteria. To exemplify, the performance assessment criteria to show the membership function of Z_1, Z_2, Z_3, Z_4 for the post A are as follows:

$$\mu_{Z_1}(X) = \begin{Bmatrix} 1 & ; Z_1(X) \geq 0.369 \\ \dfrac{0.369 - Z_1(X)}{0.369 - 0.238} & ; 0.238 < Z_1(X) < 0.369 \\ 0 & ; Z_1(X) \leq 0.238 \end{Bmatrix}$$

$$\mu_{Z_2}(X) = \begin{Bmatrix} 1 & ; Z_2(X) \geq 0.34 \\ \dfrac{0.34 - Z_2(X)}{0.34 - 0.315} & ; 0.315 < Z_2(X) < 0.34 \\ 0 & ; Z_2(X) \leq 0.315 \end{Bmatrix}$$

$$\mu_{Z_3}(X) = \begin{Bmatrix} 1 & ; Z_3(X) \geq 0.4193 \\ \dfrac{0.4193 - Z_3(X)}{0.4193 - 0.2718} & ; 0.2718 < Z_3(X) < 0.4193 \\ 0 & ; Z_3(X) \leq 0.2718 \end{Bmatrix}$$

$$\mu_{Z_4}(X) = \begin{Bmatrix} 1 & ; Z_4(X) \geq 0.3586 \\ \dfrac{0.3586 - Z_4(X)}{0.3586 - 0.3031} & ; 0.3031 < Z_4(X) < 0.3586 \\ 0 & ; Z_4(X) \leq 0.3031 \end{Bmatrix}$$

Similarly for post B , membership functions can be defined as

$$\mu_{Z_1}(X) = \begin{Bmatrix} 1 & ; Z_1(X) \geq 0.482 \\ \dfrac{0.482 - Z_1(X)}{0.482 - 0.239} & ; 0.239 < Z_1(X) < 0.482 \\ 0 & ; Z_1(X) \leq 0.239 \end{Bmatrix}$$

$$\mu_{Z_2}(X) = \begin{Bmatrix} 1 & ; Z_2(X) \geq 0.34 \\ \dfrac{0.34 - Z_2(X)}{0.34 - 0.315} & ; 0.315 < Z_2(X) < 0.34 \\ 0 & ; Z_2(X) \leq 0.315 \end{Bmatrix}$$

$$\mu_{Z_3}(X) = \begin{Bmatrix} 1 & ; Z_3(X) \geq 0.587 \\ \dfrac{0.587 - Z_3(X)}{0.587 - 0.128} & ; 0.128 < Z_3(X) < 0.587 \\ 0 & ; Z_3(X) \leq 0.128 \end{Bmatrix}$$

$$\mu_{Z_4}(X) = \begin{Bmatrix} 1 & ; Z_4(X) \geq 0.738 \\ \dfrac{0.738 - Z_4(X)}{0.738 - 0.083} & ; 0.083 < Z_4(X) < 0.738 \\ 0 & ; Z_4(X) \leq 0.083 \end{Bmatrix}$$

F. Developing AHP-FLP model

The weights (wk) associated with kth objective are taken from the pair wise comparison of the main selection criteria using AHP which are provided in the table 14 and table 15 for post A and post B respectively of appendix. It can be noted from the table that the total weights are equal to 1. Based on the AHP-weighted additive model (P3), the crisp single objective programming model, equivalent to the defined fuzzy model (P5) above, can be stated as follows:

Maximize $0.09\alpha_1 + 0.16\alpha_2 + 0.41\alpha_3 + 0.34\alpha_4$

Subject to

$$\alpha_1 \le \frac{0.369-(0.238x_1+0.365x_2+0.369x_3)}{0.369-0.238}$$

$$\alpha_2 \le \frac{0.34-(0.34x_1+0.315x_2+0.34x_3)}{0.34-0.315}$$

$$\alpha_3 \le \frac{0.4193-(0.3343x_1+0.4193x_2+0.2718x_3)}{0.4193-0.2718}$$

$$\alpha_4 \le \frac{0.3586-(0.30315x_1+0.3237x_2+0.3586x_3)}{0.3586-0.3031}$$

$$\alpha_1,\alpha_2,\alpha_3,\alpha_4 \in [0,1]$$

$$x_1 \ge 0, x_2 \ge 0, x_3 \ge 0, x_4 \ge 0$$

(P7)

Similarly the crisp single objective programming model, equivalent to the defined fuzzy model (P6) above, can be stated as follows

Maximize $0.09\alpha_1 + 0.18\alpha_2 + 0.4\alpha_3 + 0.32\alpha_4$

Subject to

$$\alpha_1 \le \frac{0.482-(0.482x_1+0.279x_2+0.239x_3)}{0.482-0.239}$$

$$\alpha_2 \le \frac{0.34-(0.34x_1+0.315x_2+0.34x_3)}{0.34-0.315}$$

$$\alpha_3 \le \frac{0.3587-(0.3587x_1+0.285x_2+0.128x_3)}{0.3587-0.128}$$

$$\alpha_4 \le \frac{0.738-(0.738x_1+0.179x_2+0.083x_3)}{0.738-0.083}$$

$$\alpha_1,\alpha_2,\alpha_3,\alpha_4 \in [0,1]$$

$$x_1 \ge 0, x_2 \ge 0, x_3 \ge 0, x_4 \ge 0$$

(P8)

G. Solving the AHP-FLP model

Problem (P7) and (P8) were solved using optimization software LINGO version 10. The optimal solution is obtained as follows.

For post A

X1=1; X2=0 ; X3=0 suggesting that employee E1 is the best choice according to decision maker's preferences .

Objectives (Zk) and membership function values $\mu_{Z_k}(X)$ are obtained as follows:

Z1 =0.238, Z2 =0.34, Z3 =0.3343, Z4 =0.30105

$\mu_{Z_1}(X)$ = 1, $\mu_{Z_2}(X)$ =0, $\mu_{Z_3}(X)$ =0.6, $\mu_{Z_4}(X)$ =0.99.

Membership values represents that the achievement levels of Z1 and Z4 are more than Z3 and Z2 . In other words, the achievement level of the objective functions corresponds with the priority of the employee selection criteria (based on decision maker preferences) indicating that employee 1 i.e. E1 is selected as the best employee for the post of project manager (post A)at entry level .

For post B

X_1=0; X_2=0 ; X_3=1 suggesting that employee E3 is the best choice according to decision maker's preferences .

Objectives (Zk) and membership function values are obtained as follows:

Z_1 =0.239, Z_2 =0.34, Z_3 =0.128, Z_4 =0.083

$\mu_{Z_1}(X)$ = 1, $\mu_{Z_2}(X)$ =0, $\mu_{Z_3}(X)$=1, $\mu_{Z_4}(X)$ =1.

The achievement level of the objective functions corresponds with the priority of the employee selection criteria (based on decision maker preferences) indicating that employee 3 i.e. E3 is selected as the best employee for the post of system analyst (Post B) at entry level.

H. Comparing the AHP and AHP-FLP results

Table 4 shows the overall scores of each employee applying for the post of project manager (entry level) using AHP & AHP-FLP. Refer to table 14 of Appendix, employee E2 was identified to be the most suitable employee for the job using the crisp AHP approach under no restrictions. In this approach criteria BK & MS (local weights 0.41 and 0.34 resp.) were identified as most important criteria whereas the criteria TS & TM were identified as least important criteria. When AHP-FLP approach is applied, Employee E1 is identified to be the most suitable employee with criteria BK & MS as most important criteria. Similarly for the post of system analyst, employee E1 was identified to be the best employee using conventional AHP approach whereas using AHP-FLP approach employee E3 is the best employee. Also criteria TS, BK & MS were considered more important. The finding that Employee 1 has been identified as the most suitable employee for post A and employee E3 for post B under AHP-FLP approach also tends to confirm the views of HR managers in our case, supporting our argument that AHP-FLP approach is somewhat superior to AHP approach.

Table 4. Comparing the AHP and AHP-FLP results for Project Manager (Entry level)

Employee	AHP approach	AHP-FLP approach
E1	0.295	**1.000**
E2	**0.3458**	0.000
E3	0.301544	0.000

Table5. Comparing the AHP and AHP-FLP results for System Analyst (Entry level)

Employee	AHP approach	AHP-FLP approach
E1	**0.57554**	0.000
E2	0.25309	0.000
E3	0.16047	**1.000**

IV. COMPARISONS AND FUTURE DIRECTIONS

Personnel selection decisions are made today in increasingly complex environments where the theory of fuzzy decision making can be of significant use.

In this study, the integration of AHP methodology with the fuzzy multi-objective linear programming model has been employed as an alternative to the conventional AHP method. Drawing on a real industry case, this study concludes that AHP-FLP approach outperforms AHP method for personnel selection with respect to restricted selection criteria. These findings also indicate that the weights of employee selection criteria calculated by AHP-FLP model are in line with the actual personnel selection decision of the company.

The novelty of this research lies in the application of a hybrid approach to a real industry case – AHP-FLP method for IT personnel selection, where none or little has been done on this subject. Despite the mentioned advantages of the proposed approach for the personnel selection problem, this research can also be extended by incorporating additional selection criteria or deleting some of the criteria depending on the needs of the company. The case problem considers entry level positions for two different roles in the IT company. In the similar manner it can be generalize for middle as well as senior level positions. Other IT positions such as Database administrator, Programmer or Systems engineer can also be considered along with the inter comparison at different levels. Different alternative methodologies such as fuzzy analytic network process, fuzzy TOPSIS and fuzzy ELECTRE can also be implemented to solve personnel selection problems. Finally, adding more alternative employees may serve another avenue for future research, though it may increase computational difficulties.

V. APPENDIX

Table 6a: Inter comparison of sub criteria with respect to main criteria (TS & TM) for Post A (Level 3 analysis)

TS					TM			
	SI	SA	SM	Eigen vector		NT	TT	Eigen vector
SI	1	1/3	1/2	0.163	NT	1	1/3	0.25
SA	3	1	2	0.54	TT	3	1	0.75
SM	2	1/2	1	0.3				
CR: .008					CR : 0			

Table 6b: Inter comparison of sub criteria with respect to main criteria (BK) for Post A (Level 3 analysis)

BK					
	BF	TS	BE	KB	Eigen vector
BF	1	1	1/2	1/2	0.149
TS	1	1	1/3	1/4	0.115
BE	2	3	1	3	0.457
KB	2	4	1/3	1	0.28
CR : .089					

Table 6c: Inter comparison of sub criteria with respect to main criteria (MS) for Post A (Level 3 analysis)

	PT	CE	CR	TO	LP	PP	DR	PR	OC	Eigen vector
PT	1	1	1	1	1	1	1	2	1	0.108
AM	1	1	1	2	1	2	3	2	1	0.147
CR	1	1	1	3/2	3/2	7/2	7/2	4	3	0.189
TO	1	1/2	2/3	1	3	2	3	3	3/2	0.151
LP	1	1	2/3	1/3	1	3/2	5/2	5/2	3	0.122
PP	1	1/2	2/7	1/2	2/3	1	5/2	3/2	4	0.102
DR	1	1/3	2/7	1/3	2/5	2/5	1	2	3/2	0.063
PR	½	1/2	1/4	1/3	2/3	2/3	1/2	1	1	0.050
OC	1	1	1/3	2/3	1/4	1/4	2/3	1	1	0.066
CR : .0622										

Table 7a : Inter comparison of sub criteria with respect to main criteria (TS & TM) for Post B (Level 3 analysis)

TS					TM			
	SI	SA	SM	Eigen vector		NT	TT	Eigen vector
SI	1	5	6	0.723	NT	1	1/3	0.25
SA	1/5	1	2	0.174	TT	3	1	0.75
SM	1/6	1/2	1	0.103				
CR: .0374					CR : 0			

Table 7b: Inter comparison of sub criteria with respect to main criteria (BK) for Post B (Level 3 analysis)

BK					
	BF	TS	BE	KB	Eigen vector
BF	1	1/5	1/6	1/3	0.063
TS	5	1	1/2	3	0.309
BE	6	2	1	4	0.492
KB	3	1/3	1/4	1	0.136
CR : .0367					

Table 7c : Inter comparison of sub criteria with respect to main criteria (BS) for Post B (Level 3 analysis)

MS					
	PT	CE	PP	DR	Eigen vector
PT	1	1/4	1/4	1/6	0.062
AM	4	1	1/3	1/3	0.165
CR : .0944					
PP	4	3	1	1/3	0.27
DR	6	3	3	1	0.503
CR : .0944					

Table 8: Local weights of employees with respect to each criteria for post A

Sub-criteria	weights	E1	E2	E3
SI	0.16	0.256	0.344	0.410
SA	0.54	0.2	0.35	0.45
SM	0.3	0.3	0.4	0.2
NT	0.50	0.33	0.33	0.33
TT	0.50	0.35	0.3	0.35
BF	0.15	0.15	0.65	0.2
TS	0.1	0.35	0.45	0.2
BE	0.46	0.33	0.33	0.33
KB	0.28	0.25	0.5	0.25
Sub-criteria	**weights**	**E1**	**E2**	**E3**
PT	0.11	0.25	0.3	0.45
AM	0.15	0.215	0.345	0.335
CR	0.19	0.15	0.65	0.2
TO	0.15	0.55	0.15	0.3
LP	0.12	0.15	0.25	0.6
PP	0.10	0.6	0.1	0.3
DR	0.06	0.3	0.2	0.5
PR	0.05	0.25	0.35	0.4
OC	0.07	0.34	0.33	0.33

Table 10: Employee versus main criteria for post A (level 2 analysis)

	TS	TM	BK	MS
E1	0.238	0.34	.3343	0.30305
E2	.365	.315	.4193	0.3237
E3	0.369	0.34	.2718	0.3586

Table 11: Employee versus main criteria for post B (level 2 analysis)

	TS	TM	BK	MS
E1	0.482	0.34	0.587	0.738
E2	0.279	.315	0.285	0.179
E3	0.239	0.34	0.128	0.083

Table 12: Comparison of main criteria for the post A (level 1 Analysis)

	TS	TM	BK	MS	Eigen values
TS	1	1/2	1/3	1/4	0.09
TM	2	1	1/2	1/3	0.16
BK	3	2	1	2	0.41
MS	4	3	1/2	1	0.34
CR : 0.07					

Table 13 : Comparison of main criteria for the post B (level 1 Analysis)

	TS	TM	BK	MS	Eigen values
TS	1	1/2	1/3	1/3	0.09
TM	2	1	1/2	1/3	0.18
BK	3	2	1	2	0.40
MS	3	3	1/2	1	0.32
CR : 0.07					

Table 9 : Table 9: Local weights of employees with respect to each criteria post B

Sub-criteria	weights	E1	E2	E3
SI	0.723	0.633	0.260	0.106
SA	0.174	0.082	0.343	0.575
SM	0.103	0.1	0.3	0.6
NT	0.50	0.33	0.33	0.33
TT	0.50	0.35	0.3	0.35
BF	0.063	0.11	0.309	0.581
TS	0.309	0.685	0.221	0.093
Sub-criteria	**weights**	**E1**	**E2**	**E3**
BE	0.492	0.685	0.221	0.093
KB	0.136	0.230	0.648	0.122
PT	0.062	0.665	0.231	0.104
AM	0.165	0.724	0.193	0.083
PP	0.27	0.79	0.133	0.077
DR	0.503	0.724	0.193	0.083

Table 14 : Comparison of employees for the post A (entry level)

	TS	TM	BK	MS	Final weights Project manager
	0.09	0.16	0.41	0.34	
E1	0.238	0.34	.3343	0.30305	0.295
E2	**.365**	**.315**	**.4193**	**0.3237**	**0.3458**
E3	0.369	0.34	.2718	0.3586	0.301544

Table 15: Comparison of employees for the post B (entry level)

	TS	TM	BK	MS	Final weights System analyst
	0.09	0.18	0.4	0.32	
E1	**0.482**	**0.34**	**0.587**	**0.738**	**0.57554**
E2	0.279	0.315	0.285	0.179	0.25309
E3	0.239	0.34	0.128	0.083	0.16047

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