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A fuzzy AHP approach to personnel selection problem

Zülal Güngör [a,*], Gürkan Serhadlıoğlu [b], Saadettin Erhan Kesen [c]

[a] Gazi University, Faculty of Engineering and Architecture, Industrial Engineering Department, 06570 Maltepe-Ankara, Turkey
[b] Land forces headquarters, General plans and principles chairmanship 06100, Bakanliklar Ankara, Turkey
[c] Selcuk University, Faculty of Engineering and Architecture, Industrial Engineering Department, 42075 Campus-Konya, Turkey

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ABSTRACT

Due to the increasing competition of globalization and fast technological improvements, world markets demand companies to have quality and professional human resources. This can only be achieved by employing potentially adequate personnel. In this paper, we proposed a personnel selection system based on Fuzzy Analytic Hierarchy Process (FAHP). The FAHP is applied to evaluate the best adequate personnel dealing with the rating of both qualitative and quantitative criteria. The result obtained by FAHP is compared with results produced by Yager's weighted goals method. In addition to above-mentioned methods, a practical computer-based decision support system is introduced to provide more information and help manager make better decisions under fuzzy circumstances.

1. Introduction

In the global market, modern organizations face high levels of competition. In the wake of increasingly competitive world market the future survival of most companies, depends mostly on the dedication of their personnel to companies. Employee or personnel performances such as capability, knowledge, skill, and other abilities play an important role in the success of an organization. The main goal of organizations is to seek more powerful ways of ranking of a set employee or personnel who have been evaluated in terms of different competencies. Great deal of attention in literature was given for the selection of eligible and adequate person among alternative rivals and extensively conducted review can be found in Robertson and Smith [18]. The objective of a selection process depends mainly on assessing the differences among candidates and predicting the future performance. Latter is a challenging task since larger samples are required and other temporal changes may affect employees. Personality factors are generally described as emotional stability, extraversion, openness, agreeableness and conscientiousness Salgado [20]. Jessop [11] determined seven criteria from overview of job description: written communication, oral communication, planning, organizing ability, team player, decisiveness, and working independently. One of the techniques concerning the selection of personnel to fill new positions is to have interviews with related personnel. Robertson and Smith [18] and Cortina et al. [9] present notable ability and availability of interviews to predict the performance of the personnel in the job. The usages of different methods in some European countries are given in Dany and Torchy [10].

As in many decision problems, personnel selection problem is too complicated in real life; humans generally fail to make a good prediction for quantitative problems, whereas comparatively having a good guess in qualitative forecasting. In many situations, individuals mostly prefer to express their feelings with verbal expression. Fuzzy linguistic models permit the translation of verbal expressions into numerical ones. Thereby dealing quantitatively with imprecision in the expression of the importance of each criterion, some multi-criteria methods based on fuzzy relations are used. Fuzzy set theory has been proposed by Miller and Feinzing [16], Karsak [13] and Capaldo and Zollo [4] to rate the personnel selection problem. Fuzzy analytical approach has been applied by Mikhailov [15] to partnership selection problem. Minimally biased weight method has been applied by Jessop [11] in personnel selection. Chen and Cheng [6] proposed a Fuzzy Group Decision Support System (FGDSS) based on metric distance method to solve IS (Information System) in personnel selection problem.

In this type of multi-criteria analysis, AHP is suggested as a tool for implementing a multiple criteria performance scheme. Developed by Saaty [19], the AHP is a simple decision-making tool to cope with complex, unstructured and multi-attributed problems.

The most creative part of decision-making that has an important effect on the outcome is modeling the problem. Identification of the

* Corresponding author. Tel.: +90 312 271 7400; fax: +90 312 230 8434.
E-mail address: zulalg@gazi.edu.tr (Z. Güngör).

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decision hierarchy is the key factor in using AHP. AHP is essential for the formalization of a complex problem using a hierarchical structure and utilizes pair-wise comparisons. AHP has found wide range of applications in industry and other areas. Albayrak and Erensal [1] used AHP, which determines the global priority weights for different management alternatives to improve human performance. A good review is given by Vaidya and Kumar [21] about the applications of AHP. The conventional AHP cannot reflect the human thinking style yet. Therefore, FAHP was developed to solve the hierarchical fuzzy problems. In the FAHP, all calculations are carried out by fuzzy numbers.

In this paper, FAHP method is suggested to solve personnel selection problem using multi-criteria decision-making process. The organization of the paper is as follows: first, the review on fuzzy linguistic and FAHP will be given. Second, fuzzy analytical hierarchy process is constructed and computations are carried out. Then, Yager's weighted method is introduced and applied to the same problem for comparing the results of Yager [23,22]. In the subsequent section, we introduce and discuss a fuzzy decision support system to help the decision maker. The paper will be ended by the conclusion part.

2. Preliminaries

2.1. Fuzzy sets and Fuzzy Numbers

Definition 1 ((Fuzzy set)).
Let X be a universe of discourse, $\tilde{A}$ is a fuzzy subset of X such that for all $x \in X$. There is a number $\mu_{\tilde{A}}(x) \in [0,1]$ which is assigned to represent the membership of x to $\tilde{A}$, and $\mu_{\tilde{A}}(x)$ is called the membership function of $\tilde{A}$ [24].

Definition 2 ((Fuzzy number)).
A fuzzy number $\tilde{A}$ is a normal and convex fuzzy subset of X. Here, the 'convex' set implies that

$$\forall x_1 \in X, \quad x_2 \in X, \quad \forall \alpha \in [0,1],$$

$$\mu_{\tilde{A}}(ax_1 + (1-a)x_2) \geq \min(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)) \text{ [24]}$$

Definition 3 ((Triangular fuzzy number)).
A triangular fuzzy number $\tilde{A}$ can be defined by a triplet (a, b, c). The membership function is defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-a}{b-a}, & a \leq x \leq b, \\ \dfrac{c-x}{c-b}, & b \leq x \leq c, \\ 0, & \text{otherwise}. \end{cases} \tag{1}$$

The addition, multiplication, subtraction and division operations of the triangular fuzzy numbers are expressed below [14].

Fuzzy number addition $\oplus$

$$(a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2) \tag{2}$$

Fuzzy number multiplication $\otimes$

$$(a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \text{ [26]} \tag{3}$$

Definition 4. A linguistic variable is characterized by a quintuple $(x, T(x), U, G, \tilde{M})$. x is the name of value. U is the universe of discourse, which is associated with the base variable u. $T(x)$ denotes the term set of x, that is, the set of the name of linguistic value of x, with each value being a fuzzy variable generically denoted by x and ranging over U. G is the syntactic rule for generating the name X, of values of x. A particular X, that is name generated by G, is called term. M is semantic rule for associating with each X its meaning, $\tilde{M}(x)$ which is fuzzy subset U [26].

Definition 5. Yager's weighted goals method: let $X = \{x_1, x_2 \ldots x_n\}$ $i = 1,2,\ldots n$, be a set of alternatives, The goal is represented by fuzzy sets G_j. The importance weight of goal is expressed by w_j $j = 1,2,\ldots,m$. The attainment of goal by alternative is expressed by degree of membership μ_{gj}. The fuzzy set decision, D, as then intersection of all fuzzy goals, that is, $\mu_D(x_i) = \min\{\mu_{gj}(x_i)\}$, Yager allows for different importance of the goals and expresses this by exponentially weighting of the membership function of the goals. Importance of weights is determined by AHP method [22].

$$\mu_{gj}(x_i) = (\mu_{gj}(x_i))^{wj} \tag{4}$$

Cheng et al. [7] proposed a new method for evaluating weapon systems by AHP with fuzzy variable based on Yager's weighted goal method.

2.2. Fuzzy AHP

FAHP method is a systematic approach to the alternative selection and justification problem by using the concepts of fuzzy set theory and hierarchical structure analysis. The decision maker can specify preferences in the form of natural language or numerical value about the importance of each performance attribute. The system combines these preferences using FAHP with existing data. In the FAHP method, the pair-wise comparisons in the judgment matrix are fuzzy numbers and use fuzzy arithmetic and fuzzy aggregation operators, the procedure calculates a sequence of weight vectors that will be used to choose main attribute. In some situations, the decision maker can specify preferences in the form of AHP numerical pair-wise comparison introduced by Saaty in the form of nine point of scale of importance between two elements. Triangular fuzzy numbers were introduced into the conventional AHP in order to enhance the degree of judgment of decision maker. The central value of a fuzzy number is the corresponding real crisp value. The spread of the number is the estimation from the real crisp number (Definition 3). If decision maker cannot specify their preferences by numerical values, he/she can also specify preferences in the form of natural language expressions about the importance of each performance attribute. Decision maker also utilizes fuzzy language to construct the look-up table for values, and derives its corresponding value to the fuzzy numbers. In the FAHP procedure, by using fuzzy arithmetic's and aggregation operator, the procedure calculates a sequence of weight vectors that will be used to combine the scores on each attribute. There are many FAHP methods proposed by various authors. The earliest work in FAHP appears in refs. [17]. Chang [5] used triangular fuzzy membership value for pair-wise comparison. Ching [8] proposed a new FAHP algorithm for evaluating naval tactical missile systems. More detailed FAHP literature review can be found in refs. [3,12]. Ayağ and Özdemir [2] also used the FAHP method to evaluate machine tool alternatives with quantitative variables B/C ratio.

In the following, first, the outlines of the analysis method on FAHP are given and then the method is applied to a personnel selection problem. For easy computing, we summarize the algorithm for evaluating personnel selection problem by FAHP.

Step 1: The first step of FAHP consists of developing a hierarchical structure of the assessment problem. After developing the performance hierarchy, decision makers have to determine the relative weights of each criterion. In the AHP, weights are determined using pair-wise comparison between each