A fuzzy AHP approach to personnel selection problem

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ARTICLE INFO

Article history:
Received 10 August 2007
Received in revised form 7 May 2008
Accepted 11 September 2008
Available online 20 September 2008

Keywords:
Fuzzy AHP
Personnel selection
Yager's weighted goal method
Fuzzy decision support system

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.

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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
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, Α is a fuzzy subset of X such that for all x∈X. There is a number μX(x)∈[0,1] which is assigned to represent the membership of x to Α, and μX(x) is called the membership function of Α [24].

**Definition 2 (Fuzzy number).** A fuzzy number Α is a normal and convex fuzzy subset of X. Here, the ‘convex’ set implies that ∀x1∈X, x2∈X, ∀α∈[0,1], μX(αx1+(1−α)x2)≥min{μX(x1), μX(x2)} [24].

**Definition 3 (Triangular fuzzy number).** A triangular fuzzy number Α can be defined by a triplet (a, b, c). The membership function is defined as

\[ μX(x) = \begin{cases} 
\frac{x-a}{b-a} & a \leq x \leq b, \\
\frac{c-x}{c-b} & b \leq x \leq c, \\
0 & \text{otherwise}
\end{cases} \]

(1)

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

**Fuzzy number addition ⊕**

\[ (a_1, b_1, c_1) ⊕ (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2) \]

(2)

**Fuzzy number multiplication ⊗**

\[ (a_1, b_1, c_1) ⊗ (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \]

(3)

**Definition 4.** A linguistic variable is characterized by a quintuple (x, T(x), U, G, 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, M(x) which is fuzzy subset U [26].

**Definition 5.** Yager’s weighted goals method: let X = {x1, x2, ..., xn} l = 1,2,...,n be a set of alternatives, The goal is represented by fuzzy sets Gj. The importance weight of goal is expressed by wj j = 1,2,...,m. The attainment of goal by alternative is expressed by degree of membership μGj. The fuzzy set decision, D, as then intersection of all fuzzy goals, that is, μGj(xi) = min{μGj(xi)}, 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].

\[ \mu_{Gj}(xi) = (\mu_{Gj}(xi))^w_j \]

(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 fuzzy AHP numerical pair-wise comparison introduced by Saaty in the form of nine point 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 national weapon 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
pair of criteria. To determine relative weights, decision makers are asked to make pair-wise comparison using a \(1 \sim 9\) preference scale [19]. The pair-wise comparison data is organized in the form of fuzzy triangle numbers using Definition 3.

Step 2: If decision makers cannot utilize the preferences by the form of fuzzy triangle numbers, they can give preferences by linguistic terms, and use look-up tables for values, they can easily derive corresponding value of fuzzy numbers (Definition 4 and Fig. 4)

Step 3: After setting up the hierarchy and pair-wise comparisons of criteria of alternatives, it is necessary to calculate global value of priority of alternatives.

The procedure of all calculations steps will be given in Section 2.4.

2.3. Outline of the proposed FAHP approach

In this part, FAHP method is proposed as a tool for implementing multiple criteria personnel selection problem. In FAHP method, identification of hierarchy is the key factor in using AHP. In the AHP, a complex decision problem is structured as a hierarchy. AHP initially breaks a complex multi-criteria decision-making problem into a hierarchy of interrelated decision elements. With AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure similar to family tree. In order to determine the optimal personnel alternative, a four level hierarchical model is devised (Fig. 1). Fig. 2 shows the steps of proposed approach.

The first level is objective. In this study, objective is the determination of the most eligible person. The goal is divided into three main criteria, which are A: general factors pertaining to work, B: complementary factors pertaining to work, and C: individual factors. The third level of hierarchy includes alternatives.

2.3.1. Category one: general factors pertaining to work

General factors pertaining to work mainly include the knowledge base, skill and abilities of the individuals in organization. Management is increasingly aware that skilled employees who are committed to business goals are the company's most important assets. Therefore, these criteria are divided by 6 sub-criteria, namely A1: work experience, A2: level of foreign language, A3: undergraduate degree, A4: master degree, A5: analytical thinking of integrated systems, A6: basic computer skill.

2.3.2. Category two: complementary factors pertaining to work

It must be considered that attitude, self-esteem, personal goal setting, intrinsic motivation, the ability to work with employees from other departments' facilities, abilities of the individuals in an organization, team-work, and flexibility play an important role in the whole capability of human performance. Therefore, second criterion is divided into six categories; B1: decision-making in designing and developing the systems (Decision-making), B2: be able to work in multi-disciplinary teams (working in teams), B3: effective time using, B4: a recognition of goal and open to new area technologies (Determination of goal), B5: ability to engage in long life learning and open to new area technologies (Long life learning), B6: being willingness and decisiveness to work in organization (Willingness).

2.3.3. Category three: individual work factors

Individuals' performance capability includes communication (written and oral), capacity analysis encompasses the core abilities, culture and personnel value, and appearance. Therefore, the third criterion is divided into five categories; C1: capacity analysis encompasses the core abilities (Core abilities), C2:
appearance including knowledge and skill (Appearance), C3: old enough to be able to adopt new techniques and modern tools (Age), C4: culture that comprises employees’ capabilities (Culture), C5: oral and written communication skill (Oral, written communication).

Finally, the fourth and last level consists of alternatives. Six alternatives that the manager wants to compare; those names are labeled as; P1, P2, P3, P4, P5, P6. AHP analysis can be given as follows.

### 2.4. Calculation steps of FAHP

**Step 1:** In order to determine the most adequate person, four levels of hierarchy are constructed (Fig. 1). According to the total goal requirement given in Fig. 1, the decision maker took a part in the evaluation, marked the result of pair-by-pair comparison of first degree of hierarchy. Triangular fuzzy numbers \((l, m, u)\) are used to indicate the relative strength of each pair of elements in the same hierarchy. By using triangular fuzzy numbers, via pair-wise comparison, fuzzy judgment matrix \(\tilde{A}(a_{ij})\) is constructed. Where \(a_{ij}^0 = 1, 3, 5, 7, 9\) or \(1^{-1}, 3^{-1}, 5^{-1}, 7^{-1}, 9^{-1}\), if \(i\) is not equal to \(j\). We perform fuzzy membership value by using \(\alpha\)-cut. \(\alpha\)-cut is known to corporate the experts or decision-makers confidence over his/her preferences or the judgments. It will yield an interval set of values from a fuzzy number. The lower limit and upper limit of the fuzzy numbers with respect to \(\alpha\)-cut were defined as follows by applying the Eq. (5), \(\tilde{a}_{ij} = [a_{ij} - \delta, a_{ij}, a_{ij} + \delta]\) is one of the elements of \(\tilde{A}\) is closed interval whose mid value is \(b_{ij}\). Then, \(b_{ij}\) is just one of the integers from one to nine which are used in the method of AHP. Let, \(b_{ij} - a_{ij} = c_{ij} - b_{ij} = \delta\), which is constant. When \(\delta\) is selected less than \(1/2\), \(b_{ij}\) is selected as the consecutive two-level scales’ midpoint and \(d\) is the cross over point of two triangle. If \(\mu(d)\) is equal to zero, it does not reflect the cognitive fuzziness completely. If \(\delta\) is set greater than one, the degree of fuzziness increases and the degree of confidence decreases. Zhu et al. [25] suggested that \(1/2 < \delta < 1\) is more suitable to reflect the fuzziness completely (Fig. 3).

\[
\tilde{a}_{ij} = [a_{ij} - \delta, a_{ij}, a_{ij} + \delta]
\]  
(5)

and,

\[
\tilde{a}_{ji} = \frac{1}{\tilde{a}_{ij}} = \left[ \frac{1}{a_{ij} + \delta}, \frac{1}{a_{ij}}, \frac{1}{a_{ij} - \delta} \right]
\]  
(6)

After all the elements of pair-wise comparison matrix of \(\tilde{A}\) are converted to fuzzy triangular numbers, geometric mean method is applied for these triangular fuzzy numbers to compute their priorities.

\[
m_i = \left( \prod_{j} \tilde{a}_{ij} \right)^{1/n} \quad i = 1, \ldots, n
\]

(7)

Since \(\tilde{a}_{ij}\) can be defined as \(a_{u1j}, a_{u2j}, a_{u3j}\)

\[
m_{u1} = \left( \prod_{i} a_{u1i} \right)^{1/n}
\]

\[
m_{u2} = \left( \prod_{i} a_{u2i} \right)^{1/n}
\]

\[
m_{u3} = \left( \prod_{i} a_{u3i} \right)^{1/n}
\]

(8)

For each of the alternatives or criterion, weights can be computed as follows:

\[
W_{r1} = \frac{m_{r1}}{\sum_{i} m_{ri}} \quad m_{r1}
\]

\[
W_{r2} = \frac{m_{r2}}{\sum_{i} m_{ri}} \quad m_{r2}
\]

\[
W_{r3} = \frac{m_{r3}}{\sum_{i} m_{ri}} \quad m_{r3}
\]

(9)

and then weight of criterion \(i\) can be written as

\[
\tilde{w}_i = \left( W_{r1}W_{r2}W_{r3} \right)
\]

(10)

**Step 2:** If decision maker cannot determine the importance of criterion with triangular fuzzy numbers, he/she can use linguistic variables. The decision makers use the linguistic variables to assess the importance of the criterion with respect to the goal and utilize the linguistic variables to appraise the rating alternatives with respect to each criterion.

Decision maker easily converts the linguistic variables to fuzzy numbers using Fig. 4 and Table 1

**Step 3:** The importance degree of each objective can be incorporated into the formulation using fuzzy priorities and rating of alternatives. The priority weight of each alternative can be obtained by multiplying the matrix of evaluation ratings by the vector of attribute weights and summing over all attributes.

\[
g(a_j, w_j) = \sum_{i} \tilde{w}_i \otimes \tilde{a}_{ij}
\]

(11)

### 2.5. Yager’s weighted goal method

FAHP uses a large number of fuzzy arithmetic operations to compute the score of performance. Such a large number of operations cause some loss of information and add loss of accuracy for decision-making. Yager’s weighted method does not require

![Membership functions of linguistic values for criteria rating.](Image)

**Fig. 4.** Membership functions of linguistic values for criteria rating.

<table>
<thead>
<tr>
<th>Table 1 Fuzzy numbers.</th>
<th>Fuzzy numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuzzy language</strong></td>
<td><strong>Fuzzy numbers</strong></td>
</tr>
<tr>
<td>VB</td>
<td>(1,1,2)</td>
</tr>
<tr>
<td>VP</td>
<td>(1,2,3)</td>
</tr>
<tr>
<td>P</td>
<td>(2,3,4)</td>
</tr>
<tr>
<td>F</td>
<td>(3,4,5)</td>
</tr>
<tr>
<td>G</td>
<td>(4,5,6)</td>
</tr>
<tr>
<td>VG</td>
<td>(5,6,7)</td>
</tr>
<tr>
<td>I</td>
<td>(6,7,7)</td>
</tr>
</tbody>
</table>
complex computation and Yager's weighted method is applied to the same problem. Solution procedure can be described as follows:

1. Establish membership value of each sub-criterion with respect to higher level of criteria.
2. Determine consistent weights, \( w_j \), for each alternative, by employing Saaty's eigenvector method. The resulting fuzzy sets are as follows:

\[
m_{y_j}(x_i) = m_{y_j}(x_i)w_j \quad (12)
\]

3. The intersection is determined as follows:

\[
m_{y_j}(x_i) = (m_{y_j}(x_i)w_j)_{x_i} = \min m_{y_j}(x_i) \quad (13)
\]

3. Illustrative example

As is explained in Section 2.2, we aim at selecting most appropriate person to fulfill the new position. We have three criteria namely general factors pertaining to work, complementary factors pertaining to work and individual factors. The first criterion, the second criterion and the third criterion are subdivided into six, six, and five criteria, respectively. Tables 2–5 demonstrate the relevant matrix related to first level of hierarchy, criterion A, criterion B, and criterion C, respectively.

### Table 2
Value of first hierarchy.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>1/2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>1/5</td>
<td>1/3</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 3
The evaluation matrix relevant to the A.

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
</tr>
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<td>A1</td>
<td>1</td>
<td>1/3</td>
<td>2</td>
<td>1/3</td>
<td>1/5</td>
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<td>1/2</td>
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<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
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<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>A6</td>
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<td>1/3</td>
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### Table 4
The evaluation matrix relevant to the B.

<table>
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<tr>
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<th>B4</th>
<th>B5</th>
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<td>2</td>
</tr>
<tr>
<td>B2</td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>1/3</td>
<td>1/2</td>
<td>1</td>
</tr>
<tr>
<td>B3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1/2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>B5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1/3</td>
<td>1</td>
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<td>1</td>
<td>1/2</td>
<td>1/3</td>
<td>1/5</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 5
The evaluation matrix relevant to the C.

<table>
<thead>
<tr>
<th></th>
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<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
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<td>5</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
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<td>C2</td>
<td>1/5</td>
<td>1</td>
<td>1/3</td>
<td>1/3</td>
<td>1</td>
</tr>
<tr>
<td>C3</td>
<td>1/7</td>
<td>1</td>
<td>1</td>
<td>1/5</td>
<td>1/5</td>
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</tr>
</tbody>
</table>

These crisp values are converted to the fuzzy triangular numbers using Eqs. (5) and (6).

Six alternative persons who are willing to capture the position to compete with each other. Table 6 shows the linguistic evaluation related to each criterion. After getting fuzzy triangular numbers, we use Eqs. (7) and (8) to compute their priorities (geometric mean method). For each criterion or alternative, the weights can be calculated using Eq. (9). Fuzzy weights are defuzzified by using Eq. (10) to get the crisp weight values.

Linguistic definitions in Table 6 are converted to fuzzy triangular numbers by using Table 1. For FAHP Eq. (11) is used to calculate scores of each alternative. For Yager’s weighted method, Eqs. (12) and (13).

4. Experimental results

In order to demonstrate the usability of Yager’s weighted method, two methods are compared with each other under different \( \alpha \)-cut levels. For \( \alpha \)-cut levels, 0.6, 0.7, 0.8, 0.9, values are used and score values of for each of six alternatives both FAHP and Yager’s weighted methods are shown in Table 7. Both methods are programmed and coded in Visual Basic 6.0 programming. The comparison of these two models under different \( \alpha \)-cut levels can be considered as a decision support (DS) model since it guides decision makers to make a decision about which alternative is the best for after being run.

If Table 7 is examined elaborately, it can be shown that P3 is the best choice for all \( \delta \) values both FAHP and Yager’s weighted approach. Both of the methods are not sensitive for \( \delta \) values.
because ranking is not changing even if score values are changing. This proves the strength of the two methods. P5 is the second best alternative for both of the methods. P2 and P1 are the two worst choice for fulfilling the position. For Yager’s method P4, P6 and P1 have the same scores for all the δ values. For FAHP P4, P6, and P1 are placed third, fourth and fifth rank, respectively.

As a result two proposed methods nearly generate the same solution and they can be substituted for each other. The trivial differences result from the fact that summation operations in FAHP increase the fuzziness inside it. But Yager’s weighted method requires less computational time and complexity, it can be preferred as a tool for helping decision maker.

5. Conclusions

In this age of increased competitive markets, the notion of the personnel selection problem has an enormous interest. Decision makers face rising and complex environments today, and also decision makers are often uncertain in assigning the evaluation scores in crisp value. Therefore, in this paper, we tried to design a multi-criteria decision-making model based on fuzzy set theory to select the most adequate person. Unlike other decision methods, the proposed model can adaptively find a suitable person for the job. For making uniform consensus of the decision makers, we converted all pair-wise comparisons into triangular fuzzy numbers to adjust fuzzy rating and fuzzy attribute weight, and used fuzzy operators to get to select the best alternative. We also proposed Yager’s weighted method, and compared the results with FAHP method.

Finally, observing all these results, FAHP approach and Yager’s weighted method propose the same alternative (P3) as the best choice. They came from different theoretical backgrounds and relate differently to the discipline of multi-criteria decision-making. Because data needed for FAHP and Yager’s weighted method approach are different, we do not necessarily expect to have same result for the same personnel selection problem. But, in comparing the ranking derived by using FAHP methods and Yager’s weighted method, the best alternative is (P3), and ranking of alternatives by each method is very close to each other. This indicates that when the decision maker is consistent with himself in determining the data of each method independently, the ranking results will be necessarily the same. Results obtained in fuzzy sets Yager’s weighted method also show that there is a good consistency between two methods. If methods are compared in terms of amount of computations, Yager’s weighted method requires less complex computational operations.

For the future research, the authors suggest the other multi-criteria approaches such as ELECTRE III and fuzzy outranking methods to be used and to be compared in justification of the personnel selection problem.

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