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Personnel Selection for Promotion using an Integrated Consistent Fuzzy Preference Relations - Fuzzy Analytic Hierarchy Process Methodology: A Real Case Study

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Abstract: Personnel selection is an important business process for companies. Training, experience information and personal characteristics are important qualities for employee to be recruited. The most accurate result of the personnel selection is obtained from the qualified personnel by determining the personnel who is most suitable for the job requirements. The basic idea of personnel selection is to choose the best candidate for a job. Personnel selection is crucial in human resources management. A solution to the Multi Criteria Decision Making (MCDM) problem is Personnel selection. The main goal of this paper is to find the best personnel using the integrated Consistent Fuzzy Preference Relations (CFPR) and Fuzzy Analytic Hierarchy Process (FAHP) methodology. CFPR is used to obtain the importance weight of personnel selection criteria (22 sub-criteria are categorized under 5 main criteria). Then, the importance weights of personnel selection criteria are integrated with a FAHP model to prioritize the personnel alternatives. For a case study in Turkey, the ranking of the alternatives (17) is calculated using the integrated CFPR-FAHP model, and the best personnel is selected for promotion. This methodology makes it easier for managers/human resources department to decide on recruitment and personnel promotion. The proposed methodology provides the consistent results owing to the integrated methods. The main contribution in this study is the reduction of judgments for a preference matrix using the proposed methodology. To the authors' knowledge, this study will be the first to integrate CFPR and FAHP methods for personnel selection.

Keywords: Personnel Selection, Multi Criteria Decision Making (MCDM), Consistent Fuzzy Preference Relations (CFPR), Fuzzy Analytic Hierarchy Process (FAHP).

1. Introduction

Human resources management (HRM) is the management of human in organizations. HRM is the process of employee recruitment, training and development, performance evaluation, rewarding, maintaining employee commitment, managing compensation. The main purpose of human resources management is to maximize the employees' performance in order to achieve optimal productivity and effectiveness.

One crucial factor in human resources management is personnel selection. Personnel selection (PS) determines the most suitable employee for the job or position in human resources management and these must meet the qualifications required for a job or a position. The advantages of personnel selection are decreasing the possibility of hiring "insufficient" employees and reducing the discrimination. So organizations don't have to spend time and pay training costs for the development of incorrectly positioned employees.

A valid personnel selection procedure based on job position must determine which main criteria or sub-criteria is to be the basis of assessment. Also this procedure must determine the importance weights of each criterion. Because their importance level are different from each other.

The selection or prioritization of alternatives for multiple criteria is called multi-criteria decision-making (MCDM) (Ozdemir, Basligil, 2016). In personnel selection process, MCDM methods can be applied. Some of these methods are Elimination and Choice Translating Reality English (ELECTRE), Grey Relational Analysis (GRA), Hamming Distance Method, Fuzzy Systems, their hybrids, etc.

In this paper, to select the best personnel for promotion in a firm according to the prioritized personnel selection criteria defined in (Ozdemir et al., 2017) is aimed. However, the best personnel alternative cannot be determined by CFPR method. So, the personnel selection problem is improved and two MCDM methods are integrated to select the best personnel, namely Consistent Fuzzy Preference Relations (CFPR) and Fuzzy Analytic Hierarchy Process (FAHP). Firstly the importance weights of the personnel selection criteria are determined using CFPR, then the personnel are prioritized according to these weights using FAHP methodology. This is the first study that integrates these methods in personnel selection area.

The rest of the paper is organized as follows: In section 2, the literature review is given. CFPR methodology and FAHP methodology are presented in Section 3 and Section 4, respectively. The problem definition and the integrated CFPR-FAHP methodology are described in Section 5. In Section 6, an application of integrated CFPR and FAHP methodology in personnel selection is shown. Besides, calculated results are given in this section. Finally, obtained results are considered in Section 7.

2. Literature Review

When the literature was examined, many MCDM studies related to personnel selection were found. Chen (Chen, 2000) proposed a vertex method to find the distance between fuzzy numbers and extended the TOPSIS procedure to the fuzzy environment for personnel selection. Lazarevic (Lazarevic, 2001) presented a two-level personnel selection fuzzy model to minimize subjective judgment in the process of distinguishing between an appropriate employee and an inappropriate employee for a job vacancy. Golec and Kahya (Golec, Kahya, 2007) used a fuzzy model for selecting and evaluating a right employee. Lin (Lin, 2010) combined Analytic Network Process (ANP) with fuzzy

Data Envelopment Analysis (DEA) approach for solving personnel selection problem. Afshari et al. (Afshari et al., 2010) presented a MCDM methodology using ELECTRE for employee selection. Kelemenis and Askounis (Kelemenis , Askounis, 2010) used Fuzzy TOPSIS incorporating a new concept for the ranking of the alternatives to solve personnel selection problem. Rashidi et al. (Rashidi et al., 2011) proposed a fuzzy system for selecting a project manager. Their proposed fuzzy system is based on IF-THEN rules; a genetic algorithm improves the overall accuracy. Furthermore, they used a back-propagation neutral network method to train the system. Boran et al. (Boran et al., 2011) extended TOPSIS method to intuitionistic fuzzy environments to select appropriate personnel among candidates. Kabak et al. (Kabak, et al., 2012) used a combination of MCMD approaches to propose a fuzzy hybrid multicriteria decision making approach for sniper selection. Balezentis et al. (Baležentis et al., 2012) extended the fuzzy MULTIMOORA method which enables to aggregate subjective assessments of the decision-makers and offers an opportunity to perform more robust personnel selection procedures for linguistic reasoning under group decision making. Rouyendegh and Erkan (Rouyendegh, Erkan, 2012a) applied fuzzy ELECTRE methodology for academic staff selection. Roy and Misra (Roy, Misra, 2012) used an integrated Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Hierarchical Process (AHP) to select the best personnel from a number of alternatives. Yu et al. (Yu et al., 2013) investigated aggregation methods for personnel evaluation. Md Saad et al. (Md Saad et al., 2014) proposed a new approach which is based on Hamming distance method with subjective and objective weights (HDMSOW's) for personnel selection problem. Aggarwal (Aggarwal, 2014) defined a method using fuzzy multi-attribute decision making for personnel selection. Violeta and Turskis (Violeta, Turskis, 2014) developed an algorithm which integrates additive ratio assessment method with fuzzy numbers (ARAS-F), fuzzy weighted-product model and analytic hierarchy process (AHP) for group selection. Karabašević et al. (Karabašević et al., 2015) proposed an approach by using the SWARA and the MULTIMOORA methods for personnel selection.

CFPR methodology was less studied than other methodologies such as FAHP, FANP, ELECTRE, etc. Herrera-Viedma et al. (Herrera-Viedma et al., 2004) defined a new characterization method for constructing consistent fuzzy preference relations from a set of n−1 preference data. Their aim was to assure better consistency of the fuzzy preference relations provided by the decision makers by avoiding the inconsistent solutions in the decision making processes. Wang and Lin (Wang, Lin, 2006) proposed a more convenient and flexible method for constructing a consistent complete fuzzy preference relation in which decision makers can compare any row, column or diagonal. Wang and Chen (Wang, Chen, 2007) presented a consistent fuzzy preference relations method to select partners and they showed that their method provides rankings of partnership in making decision easily and practically. Wang and Lin (Wang, Chen, 2009) constructed a model to select merger strategies for banks by using the consistent fuzzy preference relation. Chen and Chao (Chen, Chao, 2012) proposed a simple method which uses consistent fuzzy preference relations (CFPR) for constructing the decision matrices in vendor selection. Lu and Yu (Lu, Yu, 2012) determined the assessment factors in software development project risk by using fuzzy MCDM and CFPR to assess the absolute and relative importance rates and determined priorities of these factors. Chang et al. (Chang et al., 2013) proposed a model for administrators to identify risk factors. They determined importance weights for risk factors by using consistent fuzzy preference relations. Jafarnejad et al. (Jafarnejad et al., 2014) proposed a comprehensive approach to risk management in supply chains. They used a CFPR method to determine the relative importance of each identified risk. Their results indicate that financial risks, demand risks and supply risks are the most important risks in the SMEs (small and medium enterprises) context. Chiu et al. (Chiu et al., 2016) proposed a mechanism to resolve the parameter setting issue for the manufacturing process using the screen printing technology. They applied the Delphi method and the consistent fuzzy preference relations method to determine the important parameters required during the manufacturing process. The uniformity of print thickness can be improved by their proposed method.

In the literature, AHP and other methodologies integrated with AHP had been studied extensively. Nassar et al. (Nassar et al., 2003) developed a computer tool for selection of appropriate building assemblies. Shapira and Goldenberg (Shapira, Goldenberg, 2005) proposed an AHP model for equipment selection. Bitarafan et al. (Bitarafan et al., 2012) evaluated the appropriate construction method by using AHP method. Buckley extended Saaty’s AHP. So, the people who evaluate can use fuzzy rates instead of exact rates (Hsieh et al., 2004).

FAHP was studied by many researchers in the literature (Laarhoven, Pedrycz, 1983; Buckley, 1985a; Boender et al., 1989; Chang, 1996; Ribeiro, 1996; Lootsma, 1997). Application areas of FAHP are decision making for new product development (Buyukozkan, Feyzioglu, 2004), flexible manufacturing systems (Chutima, Suwanfuji,1998), behavior-based safety management in production (Dagdeviren, Yüksel, 2008), selection of enterprise resource planning (ERP) systems (Cebeci, 2009), weapon selection (Dagdeviren et al., 2009), etc. For the evaluation and ranking of alternatives, FAHP can be applicable to MCDM approach (Kahraman et al., 2004; Mikhailov, Tsvetinov, 2004; Rodríguez et al., 2013). Cascales and Lamata (Cascales, Lamata, 2008) used FAHP approach in management maintenance processes. Alias et al. (Alias et al., 2009) proposed FAHP approach to find the appropriate use of water system. Zeng et al. (Zeng et al., 2007) proposed a risk assessment model by using fuzzy reasoning techniques and AHP method. Pan presented a FAHP approach for selecting a suitable bridge construction method (Pan, 2008) and for selecting an appropriate excavation construction method (Pan, 2009). Nieto-Morote and Ruz-Vila (Nieto-Morote, Ruz-Vila, 2011) proposed a fuzzy approach for construction project risk assessment. Kog and Yaman (Kog, Yaman, 2014) analyzed and classified academic studies which were studied between 1992 – 2013 for contractor selection problem. Taylan et al. (Taylan et al., 2014) used FAHP and fuzzy TOPSIS methods for construction projects selection. Andric and Lu (Andric, Lu, 2016)proposed a fuzzy logic-based method for risk assessment.

In the literature, FAHP was also used for personnel selection as an application area. Mikhailov (Mikhailov, 2002) proposed a fuzzy programming method for partnership selection. Huang et al. (Huang et al., 2004) proposed a fuzzy neural network approach in human resource selection system. Gungor et al. (Gungor et al., 2009) applied FAHP to evaluate the best adequate personnel in personnel selection system. Chen (Chen, 2009) proposed fuzzy multiple criteria model using FAHP in employee recruitment. Sun (Sun, 2010) constructed a performance evaluation model by using FAHP and fuzzy TOPSIS method. Rouyendegh and Erkan (Rouyendegh, Erkan, 2012b) investigated FAHP approach for academic staff selection.

When the literature was searched, any integrated CFPR-FAHP methodology was not found. This integration will therefore be demonstrated by a real case study in the area of personnel selection.

3. Consıstent Fuzzy Preference Relatıons (Cfpr)

Herrera-Viedma et al. (Herrera-Viedma et al., 2004) proposed CFPR which requires n-1 judgments for a preference matrix with n elements. The pairwise comparison is simplified and consistent results can be obtained by CFPR. Because, it reduces judgments. The relative importance of main-criteria and subcriteria is determined by CFPR mentioned in (Wang, Lin, 2009; Chang et al., 2013).

The steps of CFPR are as follows (Ozdemir et al., 2017; Jafarnejad et al., 2014)

Step-1: Determining main-criteria and subcriteria.

Step-2: Determining preference degrees. Pairwise comparions are obtained by linguistic scale in Table 1.

Step-3: Constructing pairwise comparison matrices of the criteria (C_i, $i = 1, \dots, n$) for a set of $n-1$ preference values provided by the evaluators.

Step-4: Transforming preference value $a_{ij} \in \left[\frac{1}{9}, 9\right]$ into $p_{ij} \in [0,1]$ through (1).

$$p_{ij} = \frac{1}{2}\left(1 + \log_9 a_{ij}\right) \quad (1)$$

Table 1. Linguistic scale (Jafarnejad et al., 2014)

Definition	Relative Importance
Equally important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Absolutely more important	9
Intermediate values	2, 4, 6, 8

Then, the remaining p_{ij}^k are calculated using (2), (3) and (4).

$$p_{ij} + p_{ji} = 1 \quad (2)$$

$$p_{ji} = \frac{j-i+1}{2} - p_{i(i+1)} - p_{i+1(i+2)} - \cdots - p_{j-1(j)} \quad (3)$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \quad (4)$$

This preference matrix can contain values included in the interval $[-a, 1+a]$ rather than in the interval $[0, 1]$. In this case, a transformation function can be used to preserve transitivity. This transformation can be done by (5).

$$f\left(p_{ij}\right) = \frac{p_{ij} + a}{1 + 2a} \quad (5)$$

In (5), a indicates the absolute value of the minimum in the preference matrix. Then, the fuzzy preference relation matrices of other evaluators are also calculated.

Step-5: Aggregating the fuzzy preference relation matrices to find the importance weights of the selection criteria. The transformed fuzzy preference value of the k^{th} evaluator for criteria i and criteria j is denoted by p_{ij}^k. The judgments of m evaluators are integrated by (6). m is used for the total number of evaluators.

$$p_{ij} = \frac{1}{m}\left(p_{ij}^1 + p_{ij}^2 + \cdots + p_{ij}^m\right), \quad k = 1,2, \dots, m \quad (6)$$

Step-6: Normalizing the aggregated fuzzy preference relation matrices. The normalized fuzzy preference relation matrix is obtained by (7). In (7), h_{ij} indicates the normalized fuzzy preference value of each criterion.

$$h_{ij} = \frac{p_{ij}}{\sum_{i=1}^{n} p_{ij}}, \quad i, j = 1,2, \dots, n \quad (7)$$

Step-7: Calculating the importance weight of each criterion by (8) for prioritization.

$$w = \frac{1}{n}\sum_{j=1}^{n} h_{ij} \tag{8}$$

4. Fuzzy Analytıc Hıerarchy Process (FAHP)

Pairwise comparisons are structured to assess the evaluators' preferences using triangular fuzzy numbers (a^l, a^m, a^u) as shown in Table 2 for FAHP.

Table 2. Relationship between fuzzy numbers

High/low Levels		Fuzzy
Label	**Linguistic Terms**	**Numbers**
E	Just equal	(1,1,1)
SL	Slightly Low	(1,1,3)
M	Middle	(1,3,5)
SH	Slightly High	(3,5,7)
H	High	(5,7,9)
VH	Very High	(7,9,9)

In (9), the $m \times n$ fuzzy matrix can be seen. The element a_{mn} represents the comparison of the row element m with column element n. If $\tilde{A}$ is a pairwise comparison matrix (9), it is assumed that the reciprocal, and the reciprocal value, i.e. $1/a_{mn}$ is assigned to the element a_{mn} (Tuzkaya, Onut, 2008; Tuzkaya et al., 2010; Ozdemir , Ozdemir, 2017):

$$\tilde{A} = \begin{bmatrix} (1,1,1) & \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ \vdots & \ddots & \vdots \\ (1/a_{1n}^u, 1/a_{1n}^m, 1/a_{1n}^l) & \cdots & (1,1,1) \end{bmatrix} \tag{9}$$

The fuzzy set theory was introduced to deal with uncertainness by (Zadeh Ozdemir, Ozdemir, 2017). An important contribution of fuzzy set theory is its ability to represent ambiguous data. A triangular fuzzy number is defined as (l, m, u) where $(l \leq m \leq u)$.

Steps of FAHP are as follows (Hsieh et al., 2004; Ozdemir, Ozdemir, 2017; Kaya, Kahraman, 2011):

Step-1: Determining alternatives, main-criteria and subcriteria.
Step-2: Creating the hierarchy including aim, main-criteria, subcriteria, and alternatives.
Step-3: Evaluating the relative importance of the criteria using pairwise comparisons and assigning linguistic terms to the pairwise comparisons by evaluators with fuzzy numbers.

$$\tilde{A} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & \cdots & 1 \end{bmatrix} \tag{10}$$

Step-4: Defining the fuzzy geometric mean and fuzzy weight of each criteria.

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in}\right)^{1/n} \tag{11}$$

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \ldots \oplus \tilde{r}_n)^{-1} \tag{12}$$

In (10-12), $\tilde{a}_{in}$ is the fuzzy comparison value of criteria i to criteria n, $\tilde{r}_i$ is the geometric mean of fuzzy comparison value of criteria i to each criteria and $\widetilde{w}_i$ is the fuzzy weight of the i^{th} criteria.
Step-5: Defuzzifying and normalizing the fuzzy weights.

5. Problem Defınıtıon and Proposed Methodology

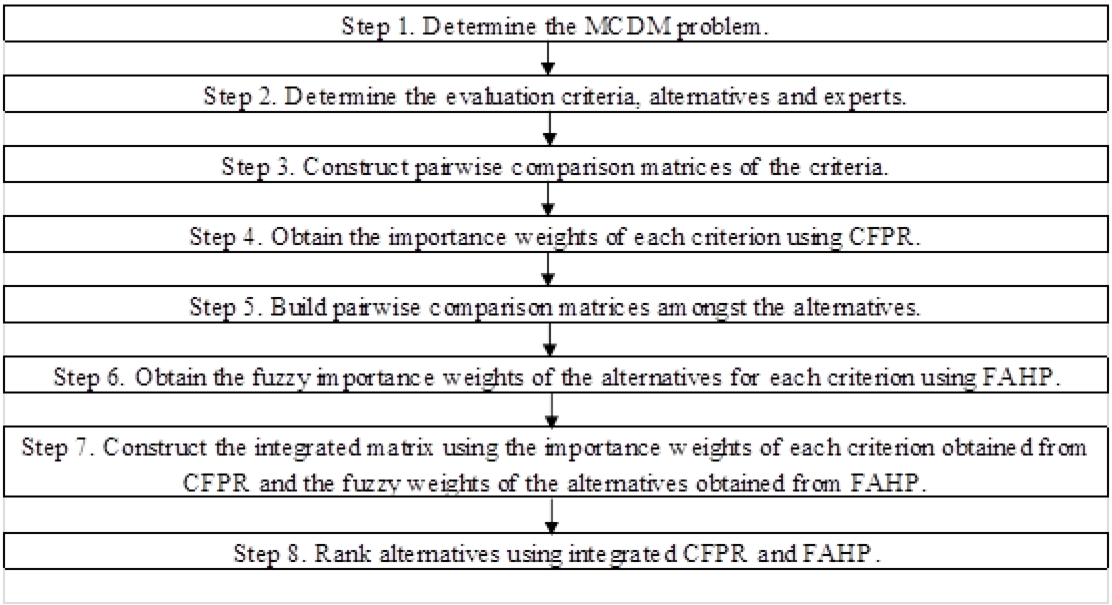
In this section, an integrated CFPR-FAHP method for personnel selection is studied. The proposed model uses the CFPR to calculate the importance weights of personnel selection criteria (Ozdemir et al., 2017). Then, the obtained criteria are integrated with the FAHP to prioritize alternatives. The main steps of the integrated CFPR-FAHP are shown in Figure 1.

In this paper, personnel selection problem for a firm in Istanbul, Turkey was chosen and an integrated CFPR-FAHP methodology was used. The firm wants to promote one of the engineers for a chiefengineer position. Table 3 shows the decision criteria for this personnel selection problem.

6. Applicatıon: A Real Case Study

In this paper, personnel selection criteria are studied and prioritizing the personnel using integrated MCDM methodologies, CFPR and FAHP are aimed. The proposed model uses the CFPR to calculate the importance weights of personnel selection criteria (Ozdemir et al., 2017). Then, the obtained criteria are integrated with the FAHP to prioritize the alternatives.

Three evaluators from academia and the firm were chosen for personnel selection problem. Five main-criteria and 22 subcriteria were determined according to their opinion (Ozdemir et al., 2017). 17 alternatives were determined by the views of the managers. Table 3 shows the decision criteria for this personnel selection problem. The importance weight of main-criteria and subcriteria based on Table 1 were determined by all experts. The pairwise comparison matrices for the main-criteria and subcriteria (M1) were constructed with the help of the evaluator 1 indicated in Table 4 and Table 5, respectively.



Step 1. Determine the MCDM problem.

Step 2. Determine the evaluation criteria, alternatives and experts.

Step 3. Construct pairwise comparison matrices of the criteria.

Step 4. Obtain the importance weights of each criterion using CFPR.

Step 5. Build pairwise comparison matrices amongst the alternatives.

Step 6. Obtain the fuzzy importance weights of the alternatives for each criterion using FAHP.

Step 7. Construct the integrated matrix using the importance weights of each criterion obtained from CFPR and the fuzzy weights of the alternatives obtained from FAHP.

Step 8. Rank alternatives using integrated CFPR and FAHP.

Table 3. Decision Criteria (Ozdemir et al., 2017).

Main-Criteria		**Subcriteria**	
M1	ACTIVITY	S11	Productive Activity
		S12	Auxiliary Activity
		S13	Inefficient Activity
M2	FEE	S21	Fee Paid
		S22	Payable Fee
		S23	Requested Fee
M3	EDUCATION	S31	Education Status
		S32	Foreign Languages
		S33	Certificates
		S34	Job Experience
		S35	Technology Usage
		S36	Lifelong Learning
M4	INTERNAL FACTORS	S41	Self-Confidence
		S42	Take Initiative
		S43	Analytic Thinking

		S44	Leadership
		S45	Productivity
		S46	Decision Making / Problem Solving
M5	BUSINESS FACTORS	S51	Compatible with the Team / Communication
		S52	Teamwork Skills
		S53	Finishing Work on Time
		S54	Business Discipline

Table 4. Pairwise comparison matrix of evaluator 1 for main-criteria.

	M1	M2	M3	M4	M5
M1	1	5			
M2		1	0.33		
M3			1	0.50	
M4				1	3
M5					1

Table 5. Pairwise comparison matrix of evaluator 1 for subcriteria.

	S11	S12	S13
S11	1	5	
S12		1	3
S13			1

After that, the remaining p_{ij}^{k} for each criteria were obtained by using (1), (2), (3) and (4) (Table 6, 7).

Table 6. Transformed fuzzy preference values of evaluator 1 for main-criteria.

	M1	M2	M3	M4	M5
M1	0.500	0.866	0.616	0.459	0.709
M2	0.134	0.500	0.250	0.092	0.342
M3	0.384	0.750	0.500	0.342	0.592
M4	0.541	0.908	0.658	0.500	0.750
M5	0.291	0.658	0.408	0.250	0.500

Table 7. Transformed fuzzy preference values of evaluator 1 for subcriteria.

	S11	S12	S13
S11	0.500	0.866	1.116
S12	0.134	0.500	0.750
S13	-0.116	0.250	0.500

Transformation of preference values for main-criteria and subcriteria was done by (5) (Table 8, 9).

Table 8. Preference values transformed by transformation function for main-criteria.

	M1	M2	M3	M4	M5
M1	0.500	0.809	0.598	0.465	0.676
M2	0.191	0.500	0.289	0.156	0.367

M3	0.402	0.711	0.500	0.367	0.578
M4	0.535	0.844	0.633	0.500	0.711
M5	0.324	0.633	0.422	0.289	0.500

Table 9. Preference values transformed by transformation function for subcriteria.

	S11	**S12**	**S13**
S11	0.500	0.797	1.000
S12	0.203	0.500	0.703
S13	0.000	0.297	0.500

Then, the fuzzy preference relation matrices of other 2 evaluators were also calculated with the same procedure. Table 10 and Table 11 show the aggregated pairwise comparison matrices obtained by (6) for main-criteria and subcriteria, respectively.

Table 10. Aggregated pairwise comparison matrix of 3 evaluators for main-criteria.

	M1	**M2**	**M3**	**M4**	**M5**
M1	1.500	2.444	2.260	1.742	2.676
M2	0.556	1.500	1.316	0.798	1.732
M3	0.740	1.684	1.500	0.982	1.916
M4	1.258	2.202	2.018	1.500	2.434
M5	0.324	1.268	1.084	0.566	1.500

Table 11. Aggregated pairwise comparison matrix of 3 evaluators for subcriteria.

	S11	**S12**	**S13**
S11	1.500	1.727	2.000
S12	1.273	1.500	1.773
S13	1.000	1.227	1.500

The normalized fuzzy preference relation matrices are calculated by (7) for main and sub-criteria (Table 12, 13).

Table 12. Normalized matrix for main-criteria.

	M1	**M2**	**M3**	**M4**	**M5**
M1	0.343	0.269	0.276	0.312	0.261
M2	0.127	0.165	0.161	0.143	0.169
M3	0.169	0.185	0.183	0.176	0.187
M4	0.287	0.242	0.247	0.268	0.237
M5	0.074	0.139	0.133	0.101	0.146

Table 13. Normalized matrix for subcriteria.

	S11	**S12**	**S13**
S11	0.398	0.388	0.379
S12	0.337	0.337	0.336
S13	0.265	0.276	0.284

Finally, the importance weights of main-criteria and subcriteria were calculated by (8). (Table 14, 15).

Table 14. Importance weights of main-criteria.

M1	**M2**	**M3**	**M4**	**M5**
0.292	0.153	0.180	0.256	0.119

Table 15. Importance weights of subcriteria.

S11	**S12**	**S13**
0.388	0.337	0.275

Table 16 shows the importance weights and the ranking for each subcriteria.

Table 16. Importance weights of subcriteria.

Main-criteria	**Weight**	**Subcriteria**	**Local-weight**	**Global-weight**	**Rank**
M1	0.292	S11	0.388	0.113	1
		S12	0.337	0.098	2
		S13	0.275	0.080	3
M2	0.153	S21	0.288	0.044	8
		S22	0.346	0.053	6
		S23	0.366	0.056	5
M3	0.180	S31	0.197	0.035	13
		S32	0.208	0.037	12
		S33	0.116	0.021	21
		S34	0.183	0.033	16
		S35	0.138	0.025	19
		S36	0.158	0.028	18
M4	0.256	S41	0.096	0.025	20
		S42	0.167	0.043	10
		S43	0.234	0.060	4
		S44	0.155	0.040	11
		S45	0.167	0.043	9
		S46	0.181	0.046	7
M5	0.119	S51	0.287	0.034	15
		S52	0.289	0.034	14
		S53	0.148	0.018	22
		S54	0.276	0.033	17

The ranking of main-criteria and subcriteria are found as “M1>M4>M3>M2>M5” and “S11>S12>S13>S43>S23>S22>S46>S21>S45>S42>S44>S32>S31>S52>S51>S34>S54>S36>S35 >S41>S33>S53” in Table 16.

Table 17 shows the pairwise comparison of alternatives with respect to subcriteria (S11) for one evaluator using FAHP. After that, the geometric mean of fuzzy comparison value of subcriteria (S11) are calculated in Table 18. The weighted normalized fuzzy decision matrix is also calculated by FAHP methodology. The respected results can be seen in Table 19.

Same calculation procedure is done for each subcriteria and for each evaluator. The importance weight of main-criteria and subcriteria (Table 14 and Table 15) and the weighted normalized fuzzy decision matrix for all evaluators are integrated as partly shown in Table 20. Fuzzy importance weight for alternatives are calculated by using integrated CFPR-FAHP methodology in Table 21.

Table 17. The pairwise comparison of alternatives with respect to subcriteria S11.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_10	A_11	A_12	A_13	A_14	A_15	A_16	A_17
A_1	(1,1,1)	(3,5,7)	(1,1,3)	(1,1,3)	(1,3,5)	(1,1,3)	(1,3,5)	(3,5,7)	(0.14,0.2,0.33)	(0.2,0.33,1)	(0.33,1,1)	(1,1,3)	(1,1,3)	(1,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,3)
A_2	(0.14,0.2,0.33)	(1,1,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,3,5)	(1,1,3)	(1,3,5)	(0.2,0.33,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(1,3,5)
A_3	(0.33,1,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(1,1,3)	(0.14,0.2,0.33)	(0.2,0.33,1)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(1,1,3)	(1,3,5)	(1,3,5)
A_4	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(0.2,0.33,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)
A_5	(0.2,0.33,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,3,5)	(1,1,3)	(0.14,0.2,0.33)	(0.2,0.33,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)
A_6	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)	(1,3,5)	(1,3,5)	(0.2,0.33,1)	(0.2,0.33,1)	(1,3,5)	(1,1,3)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(1,3,5)
A_7	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(1,1,1)	(1,1,3)	(0.14,0.2,0.33)	(0.2,0.33,1)	(1,1,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)
A_8	(0.14,0.2,0.33)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)
A_9	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,1,1)	(1,3,5)	(3,5,7)	(1,1,3)	(1,3,5)	(1,3,5)	(1,1,3)	(1,3,5)	(3,5,7)
A_10	(1,3,5)	(0.33,1,1)	(1,3,5)	(0.33,1,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(0.2,0.33,1)	(1,1,1)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(1,3,5)
A_11	(1,1,3)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(1,1,1)	(0.33,1,1)	(0.14,0.2,0.33)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)
A_12	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,3,5)	(1,1,3)
A_13	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)
A_14	(1,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,1,3)	(1,1,3)
A_15	(1,3,5)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(1,1,1)	(1,1,3)	(1,1,3)
A_16	(1,1,3)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(0.2,0.33,1)	(0.33,1,1)	(0.20,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(1,1,1)	(1,1,3)
A_17	(0.33,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.2,0.33,1)	(0.33,1,1)	(0.2,0.33,1)	(0.14,0.2,0.33)	(0.2,0.33,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(0.33,1,1)	(1,1,1)

Table 18. The geometric mean of fuzzy comparison value of subcriteria (S11).

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_10	A_11	A_12	A_13	A_14	A_15	A_16	A_17
l	0.738	0.811	0.713	0.727	0.590	0.564	0.503	0.472	1.474	0.799	0.534	0.463	0.434	0.421	0.406	0.338	0.291
m	1.099	1.257	1.178	0.937	0.853	1.138	0.702	0.799	2.960	1.789	0.799	0.937	0.879	0.824	0.937	0.679	0.658
u	2.099	2.774	2.366	2.238	1.900	2.142	1.474	1.565	4.823	3.129	1.474	1.424	1.295	1.214	1.251	1.138	0.937

Table 19. The weighted normalized fuzzy decision matrix of subcriteria (S11).

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_10	A_11	A_12	A_13	A_14	A_15	A_16	A_17
l	0.022	0.024	0.021	0.022	0.018	0.017	0.015	0.014	0.044	0.024	0.016	0.014	0.013	0.013	0.012	0.010	0.009
m	0.060	0.068	0.064	0.051	0.046	0.062	0.038	0.043	0.161	0.097	0.043	0.051	0.048	0.045	0.051	0.037	0.036
u	0.204	0.270	0.230	0.218	0.185	0.208	0.143	0.152	0.469	0.304	0.143	0.139	0.126	0.118	0.122	0.111	0.091

Table 20. A part of integrated fuzzy weight matrix.

		Weight of M	Weight of S	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_10	A_11	A_12	A_13	A_14	A_15	A_16	A_17
M1-S11	**l**	0.292	0.388	0.023	0.026	0.023	0.022	0.019	0.017	0.015	0.014	0.048	0.025	0.017	0.014	0.013	0.012	0.012	0.010	0.008
	m	0.292	0.388	0.069	0.074	0.072	0.053	0.051	0.058	0.040	0.044	0.157	0.092	0.048	0.049	0.042	0.045	0.042	0.035	0.028
	u	0.292	0.388	0.212	0.259	0.242	0.220	0.187	0.183	0.136	0.140	0.459	0.291	0.145	0.138	0.119	0.114	0.109	0.108	0.081
M1-S12	**l**	0.292	0.337	0.022	0.025	0.031	0.022	0.021	0.020	0.016	0.017	0.039	0.016	0.014	0.012	0.012	0.011	0.010	0.009	0.008
	m	0.292	0.337	0.047	0.065	0.093	0.062	0.086	0.061	0.046	0.048	0.149	0.057	0.057	0.043	0.043	0.041	0.040	0.033	0.030
	u	0.292	0.337	0.214	0.269	0.333	0.219	0.259	0.199	0.183	0.155	0.447	0.158	0.156	0.135	0.120	0.117	0.113	0.103	0.085
M1-S13	**l**	0.292	0.275	0.028	0.028	0.025	0.022	0.022	0.024	0.021	0.017	0.036	0.015	0.014	0.012	0.013	0.012	0.010	0.009	0.009
	m	0.292	0.275	0.061	0.103	0.072	0.058	0.055	0.073	0.059	0.057	0.134	0.046	0.050	0.040	0.046	0.043	0.034	0.037	0.033
	u	0.292	0.275	0.259	0.324	0.262	0.206	0.198	0.210	0.185	0.177	0.405	0.148	0.140	0.119	0.126	0.121	0.097	0.095	0.083
M2-S21	**l**	0.153	0.288	0.034	0.041	0.033	0.024	0.022	0.022	0.021	0.016	0.033	0.016	0.016	0.014	0.011	0.010	0.010	0.009	0.008
	m	0.153	0.288	0.074	0.107	0.081	0.078	0.067	0.063	0.065	0.047	0.103	0.047	0.051	0.042	0.041	0.033	0.036	0.035	0.030
	u	0.153	0.288	0.284	0.314	0.255	0.233	0.197	0.195	0.176	0.146	0.341	0.130	0.136	0.112	0.097	0.082	0.082	0.080	0.070
M2-S22	**l**	0.153	0.346	0.027	0.027	0.023	0.029	0.024	0.021	0.018	0.016	0.034	0.014	0.013	0.012	0.012	0.010	0.010	0.008	0.008
	m	0.153	0.346	0.065	0.101	0.072	0.090	0.070	0.059	0.057	0.073	0.108	0.043	0.049	0.039	0.043	0.036	0.036	0.030	0.029
	u	0.153	0.346	0.269	0.338	0.250	0.288	0.232	0.203	0.184	0.195	0.339	0.156	0.160	0.132	0.128	0.109	0.095	0.084	0.080
M2-S23	**l**	0.153	0.366	0.026	0.025	0.024	0.022	0.020	0.019	0.017	0.016	0.037	0.015	0.013	0.012	0.012	0.011	0.010	0.009	0.008
	m	0.153	0.366	0.074	0.081	0.087	0.088	0.069	0.055	0.057	0.051	0.116	0.047	0.047	0.044	0.051	0.038	0.033	0.033	0.027
	u	0.153	0.366	0.293	0.290	0.304	0.283	0.226	0.212	0.195	0.174	0.408	0.165	0.153	0.146	0.147	0.126	0.110	0.100	0.089
M3-S31	**l**	0.180	0.197	0.009	0.019	0.012	0.020	0.019	0.023	0.023	0.013	0.035	0.013	0.019	0.012	0.015	0.015	0.012	0.014	0.011
	m	0.180	0.197	0.024	0.058	0.042	0.065	0.073	0.070	0.091	0.043	0.119	0.042	0.068	0.046	0.052	0.064	0.042	0.058	0.043
	u	0.180	0.197	0.125	0.253	0.147	0.234	0.247	0.269	0.294	0.162	0.425	0.167	0.238	0.151	0.180	0.187	0.144	0.179	0.135
M3-S32	**l**	0.180	0.208	0.022	0.024	0.029	0.021	0.021	0.019	0.016	0.017	0.037	0.016	0.015	0.013	0.012	0.012	0.011	0.009	0.008
	m	0.180	0.208	0.044	0.069	0.080	0.055	0.090	0.055	0.048	0.053	0.144	0.058	0.058	0.048	0.044	0.047	0.042	0.035	0.030
	u	0.180	0.208	0.215	0.266	0.320	0.217	0.268	0.199	0.186	0.166	0.436	0.168	0.163	0.139	0.130	0.141	0.118	0.107	0.092
M3-S33	**l**	0.180	0.116	0.009	0.018	0.014	0.020	0.020	0.022	0.021	0.013	0.034	0.015	0.018	0.011	0.015	0.015	0.012	0.014	0.011
	m	0.180	0.116	0.026	0.056	0.044	0.060	0.082	0.072	0.080	0.044	0.120	0.047	0.067	0.046	0.052	0.064	0.042	0.054	0.044
	u	0.180	0.116	0.129	0.241	0.166	0.227	0.270	0.272	0.271	0.163	0.415	0.180	0.240	0.149	0.181	0.178	0.134	0.168	0.142

Table 21. Fuzzy importance weight matrix for alternatives.

	A_1	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**	**A_10**	**A_11**	**A_12**	**A_13**	**A_14**	**A_15**	**A_16**	**A_17**
l	0.019	0.021	0.019	0.019	0.017	0.017	0.015	0.013	0.034	0.015	0.013	0.011	0.011	0.010	0.009	0.009	0.008
m	0.050	0.064	0.063	0.060	0.059	0.052	0.049	0.043	0.120	0.055	0.045	0.040	0.041	0.039	0.034	0.034	0.028
u	0.197	0.245	0.224	0.214	0.201	0.186	0.171	0.143	0.379	0.180	0.147	0.127	0.122	0.115	0.102	0.102	0.086

Table 22. Results of the application using integrated CFPR-FAHP.

	A_1	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**	**A_10**	**A_11**	**A_12**	**A_13**	**A_14**	**A_15**	**A_16**	**A_17**
Weights	0.089	0.110	0.102	0.098	0.092	0.085	0.078	0.066	0.178	0.083	0.069	0.059	0.058	0.055	0.049	0.048	0.041
Normalized Values	6.54%	8.07%	7.50%	7.19%	6.80%	6.24%	5.76%	4.88%	13.08%	6.12%	5.05%	4.37%	4.26%	4.02%	3.57%	3.55%	2.98%

The results of the proposed methodology are shown sequentially in Table 22. The personnel ranking is obtained as "A_9>A_2>A_3>A_4>A_5>A_1>A_6>A_10>A_7>A_11>A_8>A_12>A_13>A_14>A_15>A_16>A_17" according to the results shown in Table 22.

When these results are examined, it is straightforward to say that the selection of Personnel A_9 is the most appropriate result, followed by the others.

7. Conclusion

Personnel selection is a very important process in today's business environment. CFPR method can determine which criteria is the best for employee. According to these criteria, employees can develop themselves. Furthermore, managers and human resources department can also evaluate employees by these criteria. Two MCDM methods are integrated to determine the best personnel, namely Consistent Fuzzy Preference Relations (CFPR) and Fuzzy Analytic Hierarchy Process (FAHP). Firstly the importance weights of the personnel selection criteria are determined using CFPR, then the personnel are prioritized according to these weights using FAHP methodology.

At the end of the evaluation process, the ranking of main-criteria is obtained as "M1>M4>M3>M2>M5 (Activity>Internal Factors>Education>Fee>Business Factors)"; the global ranking of subcriteria is obtained as "S11>S12>S13>S43>S23 (Productive Activity>Auxiliary Activity>Inefficient Activity>Analytic Thinking>Requested Fee)". The ranking of the personnel is found as "A_9>A_2>A_3>A_4>A_5" followed by the others.

The proposed methodology provides the consistent results with the existing methods in the literature. The general limitation of using the FAHP methodology instead of the integrated methodology is the costly information required from evaluators (approximately 3000 pairwise comparisons for one evaluator). The main contribution in this study is the reduction of pairwise comparisons for a preference matrix using the integrated CFPR-FAHP methodology. Namely, this methodology accelerates the decision process. The limitations of the proposed methodology are the evaluator's preferences including uncertainty and the need for multiple evaluators to make decisions.

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