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Personnel Selection By Using Fuzzy Hybrid Multi Criteria Decision Making Methodology

Bulanık Hibrit Çok Kriterli Karar Verme Metodolojisi Kullanılarak Personel Seçimi Yapılması

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ÖZ

Personel seçim problemi işletmeler için oldukça önemli ve içerisinde birden fazla değerlendirme kriterini barındıran ve belirsizliğin olduğu çok kriterli karar verme problemidir. Çalışmada, Bulanık TOPSİS, Bulanık Gri ilişkisel analiz, Bulanık Waspas, Bulanık Aras yöntemleri kullanılarak çözüm amaçlı bir yaklaşım önerilmiştir. Personel seçiminde kullanılacak kriterlerin ağırlıkları bulanık SWARA yöntemiyle belirlenirken grup hiyerarşisi de değerlendirilmiştir. Önerilen yaklaşımın uygulanabilirliğini ve sonuçlarını göstermek için, üretim sektöründe faaliyet gösteren bir işletmenin depo sorumlusu seçme sürecine önerilen yaklaşım uygulanmıştır.

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ABSTRACT

Personnel selection problem is a multi criteria decision-making problem which is very important for businesses and includes multiple evaluation criteria and uncertainty. In this study, fuzzy TOPSIS, Fuzzy Gray relational analysis (GRA), Fuzzy WASPAS and Fuzzy Aras methods are proposed. The criterion weights of the personnel selection problem are determined by using fuzzy SWARA method and group hierarchy is also evaluated. In order to demonstrate the applicability and results of the proposed methodology, the proposed methodology has been applied to the process of selecting a warehouse supervisor for a business is in the production sector.

1. Introduction

Personnel selection is a problem that results in the evaluation of candidates using more than one conflicting qualitative and quantitative criterias. In order to make the right choice, it is necessary to determine the evaluation criterias appropriate to the position and to address the problem with the appropriate multi criteria decision making (MCDM) method. The process of personnel selection begins with the application forms collected and then completed by eliminating the candidates who do not meet the prerequisites determined for the position and then making decisions according to the interviews. Nowadays, interviews are conducted by a decision group. This group includes different experts. When making an accurate assessment, it is very important to consider the individual hierarchy of decision-makers within the decision group.

In this study, criterion weights were determined by using fuzzy SWARA method. The ranking was performed by using fuzzy TOPSIS, fuzzy gray relational analysis (GRA), fuzzy WASPAS, and fuzzy ARAS methods. Decision group hierarchy was also considered. The proposed approach was performed for the problem of selecting a warehouse manager and the most suitable candidate was determined.

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In the second part of the study, literature review is presented, methodology is discussed in the third part. The real life application is examined in the fourth part. Conclusions and recommendations are presented in the fifth part.

2. Literature Review

The studies related to the personnel selection problem were investigated. Dağdeviren (2007), Güngör et al. (2009) and Kabak and Kazançoğlu (2012) presented a solution methodology to the personnel selection problem by using fuzzy AHP. Adıgüzel (2009) and Ünal (2011) proposed analytical hierarchy process method to the personnel selection problem. Dağdeviren (2010) addressed the personnel selection problem. In this study, the weight of personnel selection criteria is calculated by using analytical network process method and determined the most suitable candidate by sorting with TOPSIS method. Kelemis and Askounis (2010) presented a solution approach based on TOPSIS method. Lin (2010) developed a decision support tool consists of analytical network process (ANP) and data envelopment analysis (DEA) methods for the personnel selection problem. Zhang and Liu (2011) discussed the personnel selection problem using fuzzy gray relational analysis method and presented a case demonstrating the applicability of the model. Baležentis et al. (2012) proposed a fuzzy multimoora based model for the personnel selection problem. Zolfani et al. (2012) presented a solution approach to the quality control manager selection problem based on AHP and gray-Copras methods. Yildiz and Deveci (2013) addressed fuzzy VIKOR method for personnel selection problem. Tepe and Görener (2014) proposed a solution to the personnel selection problem using analytical hierarchy process and MOORA methods. Sang et al. (2015) presented the solution methodology developed based on fuzzy TOPSIS, and Karnik-Mendel algorithm. Senger and Albayrak (2016) determined the weights of criteria of the personnel selection problem using AHP method and used GRA method for sorting alternatives. Değermenci and Ayvaz (2016) identified the most suitable personnel with fuzzy TOPSIS method. Akar and Çakır (2016) determined the weight of the criteria for personnel selection of the logistics company by using fuzzy AHP and determined the most suitable candidate by MOORA method. Karabasevic et al. (2016) presented SWARA and ARAS methods under uncertainty, and determined the most suitable candidate by evaluating the candidates for the position of sales manager. Alguliev et al. (2017) proposed fuzzy Vikor methodology based solution methodology for personnel selection problem. Kenger and Organ (2017) determined the weight of the criteria by appling entropy method for personnel selection problem and determined the most suitable candidate by ranking the candidates with ARAS method. Turskis et al. (2017) proposed a hybrid approach to staff selection. Personnel selection criteria were determined by conducting analytical hierarchy process method. They performed fuzzy ARAS and fuzzy EDAS methods and obtained the same ranking in both methods. Urosevic et al. (2017) solved the sales manager selection problem by using the SWARA and WASPAS methods. Dahooie et al. (2017) determined the criteria weights by using SWARA method and the most suitable candidate by using gray-ARAS method. Ulutas et al. (2018) solved the personnel selection problem of a production company by using fuzzy AHP and fuzzy GRA. Ilgaz (2018), İçigen and Çetin (2017), Koyuncu and Özcan (2014), Doğan and Önder (2014) determined the criteria weights by using AHP and identified the most suitable candidate by using TOPSIS method. Efe and Kurt (2018) examined selection problem with fuzzy AHP and fuzzy TOPSIS. Karabasevic et al. (2018) calculated the selection criteria weights in personnel selection problem with SWARA method. The most suitable candidate was determined by using EDAS method in the ranking of the candidates. Efe and Kurt (2018) evaluated the personnel selection problem for assembly line by using fuzzy TOPSIS method. Samanlioglu et al. (2018) determined the criteria weights with fuzzy AHP and fuzzy TOPSIS method for personnel selection problem. Özder et al. (2019) used AHP and PROMETHEE for researcher selection problem. Generators et al. (2019) used fuzzy Mutimoora for personnel selection problem in the aviation sector. They also discussed the same problem with AHP and TOPSIS method. Lightning et al. (2019) determined the most suitable candidate for the personnel selection problem in the aviation sector by appliying ARAS method.

In personnel selection problem, a research paper in the related literature determining the criteria weight by using fuzzy SWARA method considering group hierarchy and selecting the most suitable candidate by using fuzzy TOPSIS, fuzzy GRA, fuzzy ARAS, fuzzy WASPAS was not encountered.

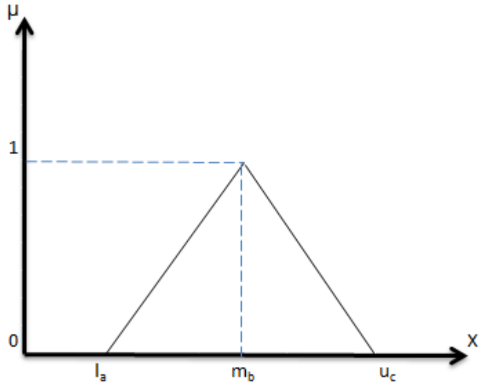
3. Methodology

3.1. Fuzzy Set Theory

The fuzzy set theory was introduced by Zadeh (1965). Fuzzy set theory was presented as a tool for modeling environments containing uncertainty information, such as the views of decision-makers. Decision-makers make assessments using linguistic expressions. Fuzzy set and membership functions are used to convert linguistic expression to the number. Fuzyy set $\tilde{A}$ of a universal set X is defined by a membership function $\mu_{\tilde{A}}(x)$, which assigns element x a real number in the interval [0,1]. Triangular fuzzy number is used in the study. The triangular fuzzy number is a fuzzy number which is defined by three points. Triangular fuzzy number is presented by triple (l_a, m_b, u_c) and a graphical representation is shown in Figure 1 (Deng, 1999: 217). This membership function is given in Equation (1) (Kahraman et al., 2004: 174). (l_a, m_b, u_c) denotes the smallest value, the most promising value and the largest value, respectively. This representation is interpreted under given conditions: l_a to m_b is an increasing function, m_b to u_c is a decreasing function, $l_a \leq m_b \leq u_c$ and outside of the domain is zero.

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-l_a}{m_c-l_a} \; for \; l_a \leq x \leq m_b \\ \frac{x-u_c}{u_c-m_b} for \; m_b \leq x \leq u_c \\ 0 \; for \; x < \; l_a, x > u_c \end{cases} \quad (1)$$

Figure 1. Triangle Fuzzy Number m_b



$\tilde{X} = (a_1, a_2, a_3)$ and $\tilde{Y} = (b_1, b_2, b_3)$ two triangular fuzzy numbers and mathematical operations of these two fuzzy numbers (addition, subtraction, multiplication, division) are as follows (Kaufmann and Gupta, 1991):

$$\tilde{X}+\tilde{Y}=(a_1, a_2, a_3)+(b_1, b_2, b_3)= (a_1+b_1, a_2+b_2, a_3+b_3) \quad (2)$$

$$\tilde{X}-\tilde{Y}=(a_1, a_2, a_3)-(b_1, b_2, b_3)= (a_1-b_3, a_2-b_2, a_3-b_1) \quad (3)$$

$$\tilde{X} \text{ x } \tilde{Y}=(a_1, a_2, a_3)x(b_1, b_2, b_3)= (a_1 b_1,\ a_2 b_2,\ a_3 b_3,) \quad (4)$$

$$\tilde{X}/\tilde{Y}=(a_1, a_2, a_3)/(b_1, b_2, b_3)= (a_1/b_3, a_2/b_2, a_3/b_1) \quad (5)$$

The distance between $\tilde{X} = (a_1, a_2, a_3)$ and $\tilde{Y} = (b_1, b_2, b_3)$ is defined as follows (Merigó and Casanovas, 2011: 107):

$$d(\tilde{X},\tilde{Y})= \sqrt{\frac{1}{3}\left[(a_1-b_1)^2+(a_2-b_2)^2+(a_3-b_3)^2\right]} \quad (6)$$

Fuzzy numbers can be converted to real numbers in this way (Merigó and Casanovas, 2011: 111):

$$\text{Real}(\widetilde{A}) = \frac{l_a+2m_b+u_c}{4} \quad (7)$$

3.2. Definition of Linguistic Variables

It is important to identify appropriate linguistic terms to determine the criterion weights, the criterion values for alternatives, and the group hierarchy. Table 1, Table 2 and Table 3 present the linguistic terms.

Table 1. Linguistic Variables Used in Determining Criterion Weights

Linguistic Variables	Fuzzy Number
Very Low (VL)	(0, 0.1, 0.2)
Low (L)	(0.1, 0.2, 0.3)
Medium Low (ML)	(0.2, 0.35, 0.5)
Medium (M)	(0.4, 0.5, 0.6)
Medium High (MH)	(0.5, 0.65, 0.8)
High (H)	(0.7, 0.8, 0.9)
Very High (VH)	(0.8, 0.9, 1)

Table 2. Linguistic Variable To Evaluate Performance of Candidates

Linguistic Variables	Fuzzy Number
Very poor (VP)	(0, 1, 2)
Poor (P)	(1, 2, 3)
Medium Poor (MP)	(2, 3.5, 5)
Fair (F)	(4, 5, 6)
Medium Good (MG)	(5, 6.5, 8)
Good (G)	(7, 8, 9)
Very Good (VG)	(8, 9, 10)

Table 3. Linguistic Variable To Evaluate Group Hierarchy

Linguistic Variables	Fuzzy Number
Equally important (EI)	(1, 1, 1)
Moderately less important (MLI)	(2/3, 1, 3/2)
Less important (LI)	(2/5, 1/2, 2/3)
Very less important (VLI)	(2/7, 1/3, 2/5)
Much less important (MLI)	(2/9, 1/4, 2/7)

3.3. Aggregated Fuzzy Matrix

Suppose that *i* is the candidate, *j* is the evaluation criterion and *k* is the decision-maker. Decision-makers determine the level of significance of the evaluation criterion considering the linguistic terms of Table1. Table 2 presents the linguistic variables for decision matrix. It's formed by each decision maker and it's presented in Equation (8). The decision matrix of each decision maker is aggregated by Equation (9) (Awasthi et al., 2011: 101).

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1j} & \cdots & \tilde{x}_{1n} \\ \cdots & & & & \cdots \\ \tilde{x}_{i1} & & \tilde{x}_{ij} & & \tilde{x}_{in} \\ \cdots & & & & \cdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mj} & \cdots & \tilde{x}_{mn} \end{bmatrix} ;i=1,2,..,m\ j=1,2,.n \quad (8)$$

$$a_{ij} = \min_k\{a_{ijk}\} \quad b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ijk} \quad c_{ij} = \max_k \quad (9)$$

$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ expresses an aggregated fuzzy number. After performing the integration procedure, the normalized integrated decision matrix should be calculated. Normalization method makes different scale alternatives non-measurable (0,1) to provide value between (Fenton and

Wang, 2006: 431). The integrated fuzzy decision matrix $\tilde{R} = [\tilde{r}_{ij}]_{mxn}$ is normalized as follows:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j}\right), c_j = \max_i\{c_{ij}\} \text{ maximization criteria}$$

$$\tilde{r}_{ij} = \left(\frac{c_j - c_{ij}}{c_j}, \frac{c_j - b_{ij}}{c_j}, \frac{c_j - a_{ij}}{c_j}\right), c_j = \min_i\{c_{ij}\}$$

minimization criteria (10)

The same aggregation and normalization methods were applied in all methods in order to compare the results obtained from all the methods used in this study.

3.4. Group Hierarchy and Fuzzy Criteria Weight Determination

A model has been developed for the situation where there is a difference in hierarchy among the individuals in the group decision. The group hierarchy usually occurs in real life problems. Hierarchy may change over time or may vary according to the business problem being addressed. In this study, the hierarchy is determined by using fuzzy SWARA method. The hierarchy is integrated into the criterion weighting phase and criterion weights are determined for each decision-maker. This value is weighted by using group hierarchy values. Then the final criteria weights are obtained by integrating the results of the decision makers.

SWARA was introduced in 2010 by Keršuliene, Zavadskas and Turskis. SWARA is one of the multi-criteria decision-making methods used by experts in complex problems where multiple decision-making factors exist (Mavi et al., 2017: 2405). SWARA obtains the criterion weights by taking into account the importance levels of the criteria used. SWARA steps are given (Keršuliene et al., 2010: 247):

First, the evaluation criteria are determined and the criterias are sorted by decreasing importance levels. In the second step, criteria significance levels are calculated. Each criterion is compared with the previous criterion starting from the second criterion and the relative significance (s_j) is obtained. In the third step, coefficient values (k_j) are calculated as indicated in Equation (11). In the fourth step, the significance vector (q_j) is found with the help of Equation (12). In the last step, criterion weights (w_j) are obtained by using Equation (13).

$$k_j = \begin{cases} \tilde{1} & j = 1 \\ s_j + \tilde{1} & j > 1 \end{cases} \quad (11)$$

$$\tilde{q}_j = \begin{cases} \tilde{1} & j = 1 \\ \frac{x_{j-1}}{k_j} & j > 1 \end{cases} \quad (12)$$

$$w_j = \frac{\tilde{q}_j}{\sum_{k=1}^{n} \tilde{q}_k} \quad (13)$$

3.4.1. Fuzzy TOPSIS

Hwang and Yoon (1981) developed TOPSIS method. This method is based on that the best alternative is the farthest alternative to the negative ideal solution and the closest to the positive ideal solution. It is one of the most preferred multi-criteria decision making methods in the literature. Fuzzy TOPSIS method steps are as follows (Celik et al., 2009: 4550). The fuzzy decision matrix is converted to the normalized fuzzy decision matrix by Equation (10). The fuzzy criterion weights ($\tilde{w}_j$) are multiplied by the normalized fuzzy decision matrix ($\tilde{R}$) and the weighted normalized fuzzy decision matrix ($\tilde{V}$) is obtained.

$$\tilde{V} = [\tilde{V}_{ij}]_{mxn} \quad (14)$$

$$\tilde{V}_{ij} = \tilde{r}_{ij} \; X \; \tilde{w}_j \quad (15)$$

The largest normalized value equals the positive ideal solution ($\tilde{A}^+$), and the smallest normalized value equals the negative ideal solution ($\tilde{A}^-$) (Sun, 2010: 7748).

$$\tilde{A}^+ = \{\tilde{v}_1^+, \tilde{v}_2^+, \dots\dots, \tilde{v}_n^+\} \quad (16)$$

$$\tilde{A}^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \dots\dots, \tilde{v}_n^-\} \quad (17)$$

where

$\tilde{v}_j^+$=(1,1,1) and $\tilde{v}_j^-$=(0,0,0), j=1,2,…,n. (18)

The distance of each candidate to the positive ideal solution (d^+) and the negative ideal solution (d^-) is calculated.

$$d_i^+ = \sum_{j=1}^{n} d\left(v_{ij}, v_j^+\right) \quad (19)$$

$$d_i^- = \sum_{j=1}^{n} d\left(v_{ij}, v_j^-\right) \quad (20)$$

where d represents the distance between two triangular fuzyy numbers and is calculated by using Equation (21).

$$d(\tilde{X}, \tilde{Y}) = \sqrt{\frac{1}{3}\left[\begin{matrix}(a_1 - b_1)^2 + (a_2 - b_2)^2 \\ +(a_3 - b_3)^2\end{matrix}\right]} \quad (21)$$

where $\tilde{X}$ =(a_1, b_1, c_1) and $\tilde{Y}$=(a_2, b_2, c_2) are two triangular numbers. Using these distance values, the proximity index (CI) of each candidate is calculated by Equation (22). The proximity index is between 0 and 1. The candidate with the highest affinity value is determined as the best candidate (Dagdeviren et al., 2009: 8145).

Proximity index (CI) = (d_i^-) / $((d_i^-) + d_i^+)$ (22)

3.4.2. Fuzzy Gray Relational Analysis

Gray relational analysis method was first introduced by Dong (1982). It aims to show the degree of similarities and differences between the ideal solution and the alternatives. The method is generally preferred in the absence of precise, clear information. Fuzzy GRA method is used in cases of uncertainty (Liu et al., 2015; Li and Zhao, 2016). The steps of the method are given (Kuo et al., 2008: 81; Kuo and Liang, 2011: 1306). After the decision matrix is formed, the integrated matrix is obtained by utilizing Equation (9). The normalized decision matrix is formed by using Equation (10). The reference set is determined by using Equation (23).

$$\tilde{R}_0 = [\tilde{r}_{01}, \tilde{r}_{02}, \dots\dots, \tilde{r}_{0n}]$$

$$where \; \tilde{r}_{0j} = \max\left(\tilde{r}_{ij}\right) j = 1,2.., n \quad (23)$$

The distance (δ_{ij}) of each alternative to the reference set is calculated by using Equation (24). Gray relationship coefficient is defined in Equation (25) (Lin et al., 2002: 273).

$$\delta_{ij} = \left|\tilde{r}_{0i} - \tilde{r}_{ij}\right| \quad (24)$$

$$\varphi_{ij} = \frac{\delta_{min} + \rho\delta_{max}}{\delta_{ij} + \rho\delta_{max}}, \delta_{max} = \max(\delta_{ij}), \delta_{min} = \min(\delta_{ij}), \rho\epsilon[0,1] \quad (25)$$

The fuzzy criterion weights convert to real number by applying Equation (7) and then these are divided by the sum of real numbers. The sum of criterion weights is equal to one. Equation 26 is used to calculate the degree of the gray relationship. Alternatives are ranked according to the gray relational degree and the alternative with the highest value is the best alternative (Wang et al., 2013: 102).

$$\gamma_i = \sum_{j=1}^{n} w_j\, \varphi_{ij}, \quad i = 1,2,..,m \quad (26)$$

3.4.3. Fuzzy ARAS

Zavadskas and Turskis introduced Aras method in 2010. The method is effective and ease of use. The method can be applied to different MCDM problems. In Aras method, the alternative value is compared with the optimal value. Aras method can be adapted and modeled by fuzzy logic and gray theory (Ömürbek et al., 2017; Zavadskas et al., 2010). The four steps of the method are as follows (Zavadskas and Turskis, 2010: 3). In the second step, the decision matrix is normalized with the help of Equation (10). In the third step, the weighted normalized decision matrix is obtained by multiplying the criterion weights with the normalized decision matrix. In the fourth step, the optimal function value of each alternative is calculated with the help of Equation (27).

$$S_i = \sum_{j=1}^{n} \tilde{x}_{ij},\ i=1,2,\ldots\ldots m$$

S_i: *The ith alternative optimal functional value* (27)

The optimal function value with the highest value (S_0) is the most effective alternative. The utility value (K_i) of each alternative is calculated as presented in Equation 15 by the ratio of the optimal function value (S_i), optimal value (S_0).

$$K_i = \frac{S_i}{S_0}, i = 1,2,\ldots,m \quad (28)$$

The K_i benefit values obtained by equation (28) are between [0,1]. These values are listed from top to bottom and the alternative with the largest value is the most suitable alternative (Turskis and Zavadskas, 2010: 427).

3.4.4. Fuzzy WASPAS

The WASPAS method is described by Zavadskas et al. (2012). It is developed by combining the methods of the weighted total model (WSM) and the weighted product model (WPM). The method aims to achieve high consistency in estimation by optimizing the weighted integrated function (Lashgari et al., 2014: 735).

The method steps are as follows (Zavadskas et al., 2013: 108; Zavadskas et al., 2015: 15927): Decision matrix is constructed and the integrated decision matrix is obtained by using Equation (9). The decision matrix is normalized using Equation (10). The relative significance values of each alternative are determined according to the weighted total model (Q_i) and weighted product model (P_i) (Turskis et al., 2015: 119). In the last step, the total relative values of the alternatives (K_i) are calculated as indicated in Equation (29). The coefficient (λ) is between zero and one. The alternative with the highest significance level is identified as the best alternative.

$$K_i = \lambda\, Q_i + (1 - \lambda)\, P_i \quad (29)$$

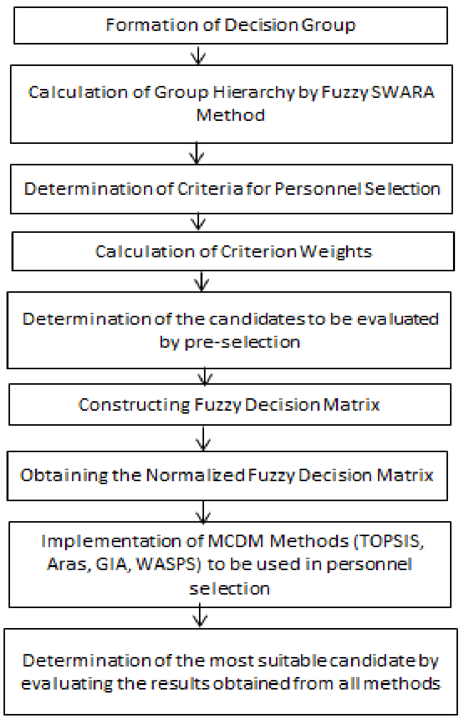
4. Experimental Study

To depict the application of the proposed methodology, a case study in production sector is presented. In this study, fifteen candidates who applied for the position of warehouse expert were examined. The proposed multi-criteria decision-making model process steps are presented in Figure 2.

Step 1: In the first stage, decision group is determined by the business manager. The decision group consists of human resource manager, purchasing manager and production planning manager. Decision makers will be called KV1-KV2-KV3 respectively.

Step 2: The hierarchy in the group decision is determined by using the fuzzy SWARA method. The linguistic variables are depicted in Table 3 and the managers use these linguistic variables to evaluate the importance level of decision group members. First, decision-makers are ranked in descending order according to their importance. Table 4 presents the ranking in the first column. s_j values are obtained by the evaluation of the business manager. The results are given in the third column in Table 4. Then, k_j, q_j and w_j are calculated by using Equation (11), Equation (12), Equation (13), respectively.

Figure 2. Personnel Selection Process



Step 3: After determining the group hierarchy, the criterion to be used in personnel selection is determined. Computer knowledge, work experience, foreign language skills, education, personal characteristics and general interview evaluation are the criteria to be used in personnel selection. These six criteria are shown in order of KR1-KR6.

Step 4: The criteria weights are determined in this step. Using linguistic expressions in Table 1, decision-makers evaluate personnel selection criterions. Table 5 shows the criterion evaluations of decision-makers. The criterion weights are weighted using group hierarchy and the integration criterion (Equation 9) is applied to obtain final criterion weights as follows.

$$\widetilde{W} = [(0.09, 0.27, 0.55), (0.08, 0.20, 0.37), (0.06, 0.15, 0.31), (0.06, 0.27, 0.55), (0.04, 0.16, 0.37), (0.06, 0.28, 0.61)]$$

Step 5: The candidates to be evaluated are determined. A prerequisite examination is conducted and the candidates who meet the requirements are identified. Six candidates meet the requirements are considered. Candidates will be shown as A1-A6 respectively. The decision group make interviews with candidates.

Step 6: Fuzzy decision matrix is constructed. Table 6 presents the evaluations of decision makers. Fuzzy decision matrices of decision makers are integrated using equation (9) and fuzzy decision matrix was obtained in accordance with the equation (8) and presented in Table 7.

Step 7: Normalized fuzzy decision matrix is generated. The normalized fuzzy decision matrix presented in Table 8 is obtained by applying the normalization procedure specified in Equation (10) to the fuzzy decision matrix presented in Table 7. The normalization procedure specified in Equation (10) is adapted to the fuzzy decision matrix presented in Table 7. The normalized fuzzy decision matrix presented in Table 8 is obtained.

Step 8: The final values and rankings obtained as a result of MCDM methods presented in the third section are presented in Table 9.

Step 9: In this study, four different hybrid MCDM methods are discussed in fuzzy environment. The sequence is as follows: Alternative 5> Alternative 2> Alternative 3> Alternative 4> Alternative 1> Alternative 6 and the most suitable candidate is the fifth candidate.

Table 4. Group Hierarchy

Decision Makers			s_j			k_j			q_j			w_j	
KV1	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	0.50	0.55	0.61
KV3	MLI	0.7	1.0	1.5	1.7	2.0	2.5	0.4	0.5	0.6	0.20	0.27	0.36
KV2	LI	0.4	0.5	0.7	1.4	1.5	1.7	0.1	0.2	0.3	0.12	0.18	0.26

Table 5. Criteria Evaluation of Decision makers

Decision makers	KR1	KR2	KR3	KR4	KR5	KR6
KV1	High	Medium	Medium Low	High	Medium	Very High
KV2	High	Medium High	Medium	Very High	Medium Low	High
KV3	Very High	High	Medium High	Medium High	Medium High	Medium High

Table 6. Evaluation of Candidates by Decision makers

Decision makers	Alternatives	KR1	KR2	KR3	KR4	KR5	KR6
KV1	Alternative 1	F	VP	MP	MG	G	MG
	Alternative 2	G	F	F	F	F	G
	Alternative 3	G	VG	MP	F	G	G
	Alternative 4	MP	VP	F	G	G	F
	Alternative 5	VG	VG	F	VG	G	VG
	Alternative 6	VP	VP	P	F	F	F
KV2	Alternative 1	MG	P	P	F	F	F
	Alternative 2	VG	MG	MG	MG	MG	G
	Alternative 3	F	G	F	F	G	G
	Alternative 4	F	P	MG	F	F	F
	Alternative 5	G	G	MG	G	G	G
	Alternative 6	P	P	P	MP	MP	MP
KV3	Alternative 1	MP	MP	MP	F	MP	MP
	Alternative 2	G	G	G	G	G	G
	Alternative 3	MG	G	MG	MG	G	G
	Alternative 4	F	MP	G	MG	F	F
	Alternative 5	VG	G	G	MG	G	G
	Alternative 6	MP	P	MP	P	MP	MP

Table 7. Fuzzy Decision Matrix

Alternative/ Criteria	KR1			KR2			KR3			KR4			KR5			KR6		
Alternative1	2	5	8	0	2.2	5	1	3	5	4	5.5	8	2	5.5	9	2	5	8
Alternative2	7	8.3	10	4	6.5	9	4	6.5	9	4	6.5	9	4	6.5	9	7	8	9
Alternative3	4	6.5	9	7	8.3	10	2	5	8	4	5.5	8	7	8	9	7	8	9
Alternative4	2	4.5	6	0	2.2	5	4	6.5	9	4	6.5	9	4	6	9	4	5	6
Alternative5	7	8.7	10	7	8.3	10	4	6.5	9	5	7.8	10	7	8	9	7	8.3	10
Alternative6	0	2.2	5	0	1.7	3	1	2.5	5	1	3.5	6	2	4	6	2	4	6

Table 8. Normalized Fuzzy Decision Matrix

Alternative/ Criteria	KR1			KR2			KR3			KR4			KR5			KR6		
Alternative1	0.20	0.50	0.80	0.00	0.22	0.50	0.11	0.33	0.56	0.40	0.55	0.80	0.22	0.61	1.00	0.20	0.50	080
Alternative2	0.70	0.83	1.00	0.40	0.65	0.90	0.44	0.72	1.00	0.40	0.65	0.90	0.44	0.72	1.00	0.70	0.80	0.90
Alternative3	0.40	0.65	0.90	0.70	0.83	1.00	0.22	0.56	0.89	0.40	0.55	0.80	0.78	0.89	1.00	0.70	0.80	0.90
Alternative4	0.20	0.45	0.60	0.00	0.22	0.50	0.44	0.72	1.00	0.40	0.65	0.90	0.44	0.67	1.00	0.40	0.50	0.60
Alternative5	0.70	0.87	1.00	0.70	0.83	1.00	0.44	0.72	1.00	0.50	0.78	1.00	0.78	0.89	1.00	0.70	0.83	1.00
Alternative6	0.00	0.22	0.50	0.00	0.17	0.30	0.11	0.28	0.56	0.10	0.35	0.60	0.22	0.44	0.67	0.20	0.40	0.60

Table 9. Multi Criteria Decision Making Method Result Values and Rankings

Methods	FUZZY SWARA+ FUZZY TOPSIS		FUZZY SWARA+ FUZZY GRA		FUZZY SWARA+ FUZZY ARAS		FUZZY SWARA+ FUZZY WASPAS	
Alternative	Proximity index	Ranking	Gray relationship degree	Ranking	Utility Value	Ranking	Importance value	Ranking
Alternative1	0.378	5	0.431	5	0.626	5	0.538	5
Alternative2	0.468	2	0.773	2	0.943	2	0.738	2
Alternative3	0.455	3	0.738	3	0.917	3	0.708	3
Alternative4	0.380	4	0.535	4	0.686	4	0.553	4
Alternative5	0.494	1	0.989	1	1.000	1	0.799	1
Alternative6	0.284	6	0.346	6	0.474	6	0.376	6

5. Results

Personnel selection is a decision making process under multiple decision makers and decision makers use linguistic terms to express their opinions and multiple factors are used in personnel selection. This process aims to make a more objective evaluation by using MCDM methods.

This study proposed a fuzzy hybrid solution approach for solving personnel selection problem. Fuzzy SWARA was used to calculate criterion weights considering the group hierarchy. It was decided to apply more than one MCDM methods to validate and compare the results of discussing MCDM methods, since different rankings can be obtained in each of the MCDM methods. Fuzzy TOPSIS, fuzzy gray relational analysis, fuzzy WASPAS, fuzzy Aras methods were used to sort the alternatives. The most appropriate personnel selection was realized by integrating the results obtained from different multi criteria decision making methods. The proposed approach was adapted to the personnel selection problem for a production company. The same sequence was obtained from all methods. This means that the result is consistent, feasible and the multi-criteria decision making methods discussed in this study are suitable methods for the personnel selection problem.

In this study, the fuzzy SWARA approach was applied to weight the criteria considering group hierarchy. Fuzzy TOPSIS, fuzzy Gray relational analysis, fuzzy WASPAS, fuzzy Aras methods were used to rank the candidates. The final ranking was obtained by evaluating the results of more than one method and a real life problem was discussed. In the future studies, the hybrid solution approach can be applied to different type of decision making problems.

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