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INTUITIONISTIC FUZZY NUMBER BASED GROUP DECISION MAKING APPROACH FOR PERSONNEL SELECTION

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Abstract: The most appropriate personnel selection is a very important issue for an organization's success due to the increasing competition in global market. Traditionally, Saaty's consistency method is used to check the consistency of the experts' judgments in personnel selection problem and the inconsistency judgments can be sent to return to the experts for reevaluation, which is time consuming and sometimes undesired by experts, or can be extracted from decision making process. A perfect multiplicative consistent intuitionistic preference relation (IPR) will be repaired the inconsistent IPRs of the experts into a consistent one automatically. There is no paper about personnel selection using integrated intuitionistic fuzzy analytic hierarchy process method (IFAHP)-IFVIKOR (intuitionistic fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje) approach under group decision making with perfect multiplicative consistent IPR. This paper presents an integrated multi-criteria decision making method for personnel selection with perfect multiplicative consistent IPR under intuitionistic fuzzy environment. Priority value of criteria has been defined by utilizing IFAHP method and the most appropriate personnel among candidates has been found by utilizing intuitionistic fuzzy VIKOR. The application of personnel selection is conducted to illustrate the effectiveness of the proposed method in a logistic firm. The personel selection is realized according to a questionnaire responded by three experts in human resources management area. Five criteria for personel selection are defined through literature review and the judgments of expert team. K1 (self-confidence) is defined as the most important criteria for personnel selection of the specified logistic firm by using IFAHP. Alt_3 is defined as the most suitable personnel for the specified logistic firm by using IFVIKOR.

Keywords: Personnel selection, intuitionistic preference relation, fuzzy multi-criteria group decision making, intuitionistic fuzzy set

Personel Seçimi İçin Sezgisel Bulanık Sayı Temelli Grup Karar Verme Yaklaşımı

Öz: Küresel pazarda artan rekabetten dolayı en uygun personel seçimi bir organizasyonun başarısında çok önemli bir konudur. Saaty'nin tutarlılık metodu uzman görüşlerinin tutarlılığını kontrol etmek için kullanılır. Tutarsız görüşler yeniden değerlendirme için uzmanlara geri gönderilir. Bu çalışmada mükemmel çarpımsal tutarlı sezgisel tercih ilişkisi, tutarsız uzman görüşlerini otomatik olarak tutarlı hale getirmek için kullanılır. Sezgisel bulanık analitik hiyerarşi prosesi (SBAHP) ve SBVIKOR (sezgisel bulanık VlseKriterijumska Optimizacija I Kompromisno Resenje) yaklaşımı personel seçimi probleminde daha önce kullanılmamıştır. Bu makale sezgisel bulanık ortamda mükemmel çarpımsal tutarlı sezgisel tercih ilişkili personel seçimi için bütünleşik çok kriterli karar verme yaklaşımını sunmaktadır. Kriterlerin öncelik dereceleri SBAHP metodu kullanılarak belirlenmiş ve adaylar arasından en uygun personel SBVIKOR metodu kullanılarak belirlenmiştir. Personel seçimi uygulaması bir lojistik firmasında önerilen

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metodun etkinliğini göstermek için gerçekleştirilmiştir. İnsan kaynakları alanında uzman üç kişi tarafından bir anket yardımıyla personel seçimi yapılmıştır. Personel seçimi için uzman görüşleri ve literatürden yararlanılarak beş kriter belirlenmiştir. SBAHP yaklaşımı sonucunda K1 (kendine güven) kriteri lojistik firması için personel seçiminde en önemli kriter olarak belirlenmiştir. SBVIKOR yaklaşımı sonucunda lojistik firması için en uygun adayın alternatif 3 olduğu belirlenmiştir.

Anahtar Kelimeler: Personel seçimi, sezgisel tercih ilişkisi, bulanık çok kriterli grup karar verme, sezgisel bulanık küme

1. INTRODUCTION

Personnel selection, which is one of the most substantial practices of human resources management, is the process of selecting the best among the candidates applying for a determined vacancy in the firm so that the best candidate must have the qualifications required to perform the job in the best way (Zhang and Liu, 2011). It defines the input quality of personnel and thus plays an substantial role in personnel selection and recruitment (Dursun and Karsak, 2010). Many modern organizations deal with big challenges due to the growing competition in the global market. Skill, capability, knowledge and other abilities of their personnel affect importantly the performance of the organizations.

Gibney and Shang (2007) handled the analytical hierarchy process (AHP) in the personnel selection process. Lin (2010) developed an integrated analytic network process (ANP) and fuzzy data envelopment analysis (DEA) method as a decision support tool for personnel selection. Dursun and Karsak (2010) and Liu et al. (2015) described the fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) with 2-tuples, the VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) with interval 2-tuple linguistic variables for personnel selection, respectively. Zhang and Liu (2011) presented an intuitionistic fuzzy multi-criteria group decision making method based on a grey relational analysis for personnel selection. Baležentis et al. (2012) suggested fuzzy MULTIMOORA under group decision making for personnel selection. Yu et al. (2013) investigated a hesitant fuzzy group decision making method with some aggregation operators for personnel evaluation. Sang et al. (2015) presented Karnik–Mendel algorithm based fuzzy TOPSIS in personnel selection application. Ji et al. (2018) proposed to select the best personnel a projection based TODIM (An acronym in Portuguese of interactive and decision-making method named Tomada de decisao interativa e multicritévio) method by using multi-valued neutrosophic numbers. Karabasevic et al. (2016) considered SWARA (Step-wise Weight Assessment Ratio Analysis) and ARAS (Additive Ratio Assessment) methods under uncertainties for selection of candidate for the vacant position of a sales manager. Qin et al. (2016) developed some hesitant fuzzy aggregation operators based on Frank triangular norms and applied in human resource selection them. Aarushi (2016) presented an integrated AHP-TOPSIS approach in problem of personnel selection.

The literature review shows that the many researchers focused on personnel selection by employing fuzzy logic. Decision makers present their opinions by using linguistic terms to reduce time and information loss so they can simply express their assessments on the criteria with a defined linguistic term (Liu et al., 2015). A fuzzy set merely includes the membership degree, but disregards the indeterminacy and the non-membership degree in decision making process. In other words, the calculation results generally present only a membership degree but no result about non-membership and uncertainty are given. The membership degree of a fuzzy set is only single value so that this situation produces the loss of information and the lack of certainty. Because the decision makers generally have some vagueness in the preference evaluation of objects handled (Xu and Liao, 2014). The IFS overcomes the specified drawbacks so that it provides more flexibility and certainty for personnel selection problems. The IFS, which involves a membership degree, a non-membership degree and a hesitation degree, reflects the properties of affirmation, negation and hesitation of decision makers. IFS has been utilized in various problems such as supplier selection (Xu, 2007), agriculture management practices selection (Hernandez and Uddameri, 2010), personnel selection (Zhang and Liu, 2011), energy technology selection (Abdullah and Najib, 2016).

AHP and VIKOR methods were used for different applications in the literature. Sambasivan and Fei (2008) suggested the AHP to evaluate success criteria of application ISO 14001 in the electrical and electronics sector. Ayağ (2010) integrated the fuzzy AHP and simulation for software selection. Onar et al. (2014) recommended the interval type-2 fuzzy AHP to define the importance degrees of factors in strategic decision selection. Abdullah and Najib (2016) suggested the IFAHP in the sustainable energy planning decision-making problem. Xu and Liao (2014) investigated the global supplier development by using the intuitionistic fuzzy AHP (IFAHP). VIKOR has been used in various problems such as personnel selection (Çevikcan et al., 2009), supplier selection (You et al., 2015), failure mode and effects analysis (Liu et al., 2015), robot selection (Parameshwaran et al., 2015), project selection (Salehi, 2015), vehicle selection (Aydın and Kahraman, 2014), material selection (Liu et al., 2013). IFVIKOR has been utilized in few papers such as robot selection (Devi, 2011), and supplier selection (Wu and Geng, 2014a). Some authors considered the integration of two multi-criteria decision making approaches such as IFAHP-IFVIKOR (Efe et al., 2017), fuzzy AHP-fuzzy VIKOR (Yu et al., 2018; Awasthi et al., 2018), AHP-VIKOR (Prasad et al., 2016; Moghaddam et al., 2011). The defined papers can be prevented from the loss of information due to crisp number and type-1 fuzzy number utilization by using intuitionistic fuzzy numbers. Type-1 fuzzy numbers consider crisp membership degrees to express fuzzy numbers but intuitionistic fuzzy numbers handle a membership degree, a non-membership degree, and a hesitancy degree. Intuitionistic fuzzy numbers ensure us with additional information to describe the fuzziness and the uncertainty of the real life world. Efe et al. (2017) considered IFAHP-IFVIKOR method in risk evaluation area. This paper handles IFAHP-IFVIKOR method in personnel selection area.

Experts interact to obtain a group opinion in group decision making. Each individual expert might have special aims, judgments although they purpose to define the most suitable alternative. In group decision making environment, IFWA operator can be used to aggregate opinions of each decision maker in order to achieve a group decision. Saaty's consistency method is useful but cannot ameliorate or repair the inconsistency preference relations automatically so that the inconsistency preference relations can be sent to return to the decision maker for reevaluation or can be extracted from decision making process. The reevaluation process is time consuming and the decision makers do not sometimes desire to participate to this reevaluation process. Therefore, we will utilize the proposed method by Xu and Liao (2014) to check the consistency of an intuitionistic preference relation (IPR). This method will be repaired the inconsistent IPRs of the decision makers into a consistent one automatically. The literature lacks studies about personnel selection using integrated IFAHP-IFVIKOR approach under group decision making with perfect multiplicative consistent IPR. This approach decreases the ambiguity and the information loss in personnel selection problem. This paper aims to provide an integrated IFAHP-IFVIKOR methodology to determine the most convenient personnel among possible candidates for a logistic firm. The weights of criteria in proposed approach have been defined by using IFAHP method and the result of the presented integrated method for personnel selection has been determined by using IFVIKOR method. The results of the suggested method and other methods are compared to show the advantages of the integrated IFAHP-IFVIKOR methodology. The logistic firm wants to recruit personnel for a vacant position so the managers define the three experts in human resources management area. The personel selection is realized according to a questionnaire responded by three experts in human resources management area. Five criteria for personel selection are defined through literature review and the judgments of expert team. After initial elimination, five candidates have been remained for further evaluation. An expert team of E1, E2 and E3 presented their judgments about the candidates. The importance degrees of E1, E2, and E3 decision makers can be defined as (0.40, 0.35, 0.25), respectively. IFAHP is utilized to determine weights of criteria and then IFVIKOR is employed to rank personnel candidates based on criteria so that selection process is completed.

This paper consists of four sections. The proposed integrated IFAHP-IFVIKOR approach is given in Section two. Section three is related with illustrative implementation of the presented decision making method. The concluding remarks that have been acquired in the last section.

2. THE PROPOSED APPROACH

The related notations and variables in this paper are presented in Table 1. This paper considers the intuitionistic fuzzy number presented by Atanassov (1986). The judgments of the experts are combined by using IFWA (intuitionistic fuzzy weighted averaging) operator developed by Xu (2007).

Table 1. The related notations and variables

μ_{ik}	The membership degree of the preference of i. criterion on k. criterion
v_{ik}	The non-membership degree of the preference of i. criterion on k. criterion
π_{ik}	The indeterminacy degree of the preference of i. criterion on k. criterion
σ	controlling parameter
τ	consistency threshold
p	number of iterations
ω_i	the weight of i. criterion
f_j^*	intuitionistic fuzzy positive ideal solution of j. criterion
f_j^-	intuitionistic fuzzy negative ideal solution of j. criterion
$\bar{d}_{ij}$	normalized intuitionistic fuzzy difference between j. criterion and i. criterion
S_i	maximum group utility of i. alternative
R_i	individual regret of i. alternative
Q_i	The degree of closeness of i. alternative

2.1. Intuitionistic Fuzzy Analytic Hierarchy Process Method

AHP developed by Saaty (1980) considers simultaneously qualitative and quantitative data. The IFAHP method develops Saaty's AHP by integrating with intuitionistic fuzzy set theory, which is characterized by a membership function, a non-membership function, and a hesitancy function, to make a decision in uncertain environment. IFAHP is used to define the importance degrees of criteria in a personnel selection problem in a vagueness environment. The consistency ratio (CR) of the pair-wise comparison matrix must be smaller than 0.1 before acquiring the priorities of the criteria. The preference relations may cause to misleading solutions without CR. Xu and Liao (2014) suggested an algorithm to establish a perfect multiplicative consistent IPR $\bar{R}=(\bar{r}_{ik})_{n\times n}$ as follows in Eqs. (1)-(7):

Step 1: For $k>i+1$, let $\bar{r}_{ik}=(\bar{\mu}_{ik},\bar{v}_{ik})$, where

$$\bar{\mu}_{ik}=\frac{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1}\mu_{it}\mu_{tk}}}{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1}\mu_{it}\mu_{tk}}+\sqrt[k-i-1]{\prod_{t=i+1}^{k-1}(1-\mu_{it})(1-\mu_{tk})}},k>i+1 \tag{1}$$

$$\bar{v}_{ik} = \frac{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} v_{it} v_{tk}}}{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} v_{it} v_{tk}} + \sqrt[k-i-1]{\prod_{t=i+1}^{k-1} (1-v_{it})(1-v_{tk})}}, k > i+1 \quad (2)$$

Step 2: For $k = i+1$, let $\bar{r}_{ik} = r_{ik}$.

Step 3: For $k < i+1$, let $\bar{r}_{ik} = (\bar{v}_{ki}, \bar{\mu}_{ki})$.

Step 4: It means that *R* is an acceptable multiplicative consistent IPR, if

$$d\left(R^{(p)}, \bar{R}\right) < \tau \quad (3)$$

where

$$d\left(R^{(p)}, \bar{R}\right) = \frac{1}{2(n-1)(n-2)} \sum_{i=1}^{n} \sum_{k=1}^{n} \left(\left| \bar{\mu}_{ik} - \mu_{ik}^{(p)} \right| + \left| \bar{v}_{ik} - v_{ik}^{(p)} \right| + \left| \bar{\pi}_{ik} - \pi_{ik}^{(p)} \right| \right) \quad (4)$$

and τ is the consistency threshold and *p* is the number of iterations.

Step 5: If $\tau > 0.1$, a new IPR must be determined as follows:

$$\tilde{\mu}_{ik} = \frac{\left(\mu_{ik}^{(p)}\right)^{1-\sigma} \left(\bar{\mu}_{ik}\right)^{\sigma}}{\left(\mu_{ik}^{(p)}\right)^{1-\sigma} \left(\bar{\mu}_{ik}\right)^{\sigma} + \left(1-\mu_{ik}^{(p)}\right)^{1-\sigma} \left(1-\bar{\mu}_{ik}\right)^{\sigma}}, \; i,k = 1,2...,n \quad (5)$$

$$\tilde{v}_{ik} = \frac{\left(v_{ik}^{(p)}\right)^{1-\sigma} \left(\bar{v}_{ik}\right)^{\sigma}}{\left(v_{ik}^{(p)}\right)^{1-\sigma} \left(\bar{v}_{ik}\right)^{\sigma} + \left(1-v_{ik}^{(p)}\right)^{1-\sigma} \left(1-\bar{v}_{ik}\right)^{\sigma}}, \; i,k = 1,2...,n \quad (6)$$

where σ is a controlling parameter that is determined by the decision maker.

The multiplicative consistent IPR can be ameliorated automatically by using these steps.

Xu and Liao (2014) presented a new method to obtain the weights of the criteria in IFS as follows:

$$\omega_i = \left(\frac{\sum_{k=1}^{n} \mu_{ik}}{\sum_{i=1}^{n} \sum_{k=1}^{n} (1-v_{ik})}, 1 - \frac{\sum_{k=1}^{n} (1-v_{ik})}{\sum_{i=1}^{n} \sum_{k=1}^{n} \mu_{ik}} \right), \; i = 1,2,...,n \quad (7)$$

2.2. Intuitionistic Fuzzy VIKOR Method

The VIKOR method was developed by Opricovic (1998) and Opricovic and Tzeng (2004) for MCDM problems. The VIKOR method deals with ranking and selecting of the alternatives, and defines a compromise solution, which is the closest to the ideal solution, for a complex problem so that the decision makers obtain a final decision. The IFVIKOR method, which integrates VIKOR method and IFS, is employed to rank the alternatives for a personnel selection problem in an uncertain environment in this paper. The IFVIKOR method can be presented as follows in Eqs. (8)-(15) (Chatterjee, 2013):

Step 1: Define the intuitionistic fuzzy positive ideal solution $f_j^* = \left(\mu_j^*, v_j^*\right)$ and the intuitionistic fuzzy negative ideal solution $f_j^- = \left(\mu_j^-, v_j^-\right)$ values of all criteria ratings, *j=1,2,…,n*

$$f_j^* = \begin{cases} \max_i r_{ij} & for\,benefit\,criteria \\ \min_i r_{ij} & for\,\cos t\,criteria \end{cases} \quad i = 1,2,...,m \tag{8}$$

$$f_j^- = \begin{cases} \min_i r_{ij} & for\,benefit\,criteria \\ \max_i r_{ij} & for\,\cos t\,criteria \end{cases} \quad i = 1,2,...,m \tag{9}$$

Step 2: Calculate the normalized intuitionistic fuzzy difference $\bar{d}_{ij}$ using Euclidean distance in Eqs. (10)-(12):

$$\bar{d}_{ij} = \frac{d\left(f_j^*, r_{ij}\right)}{d\left(f_j^*, f_j^-\right)} \tag{10}$$

$$d\left(f_j^*, r_{ij}\right) = \sqrt{\frac{1}{2}\left(\left(\mu_j^* - \mu_{ij}\right)^2 + \left(v_j^* - v_{ij}\right)^2 + \left(\pi_j^* - \pi_{ij}\right)^2\right)} \tag{11}$$

$$d\left(f_j^*, f_j^-\right) = \sqrt{\frac{1}{2}\left(\left(\mu_j^* - \mu_j^-\right)^2 + \left(v_j^* - v_j^-\right)^2 + \left(\pi_j^* - \pi_j^-\right)^2\right)} \tag{12}$$

Step 3: Calculate the values S_i and R_i and Q_i, i=1,2,…,m.

$$S_i = \sum_{j=1}^{n} w_j \times \bar{d}_{ij} \tag{13}$$

$$R_i = \max_j\left(w_j \times \bar{d}_{ij}\right) \tag{14}$$

$$Q_i = v\frac{d\left(S_i - S^*\right)}{d\left(S^- - S^*\right)} + \left(1 - v\right)\frac{d\left(R_i - R^*\right)}{d\left(R^- - R^*\right)} \tag{15}$$

where $S^* = \min_i S_i$, $S^- = \max_i S_i$, $R^* = \min_i R_i$, $R^- = \max_i R_i$, w_j is the weights of criteria and v is presented as a weight for the strategy of maximum group utility, whereas 1-v is the weight of the individual regret. The value of v is handled to 0.5 in this paper. The first part maximum group utility and the second part individual regret of Eq.(15) is calculated by using Eqs.(10)-(12).

Step 4: Rank the alternatives sorting by the values S, R and Q in decreasing order. The final result can be presented by three ranking lists.

2.3. IFAHP-IFVIKOR method

Figure 1 presents a systematic approach for personnel selection. This paper considers IFAHP-IFVIKOR approach to define the most suitable personnel. IFAHP is utilized to determine weights of criteria by using Eqs. (1)-(7) and then IFVIKOR is employed to rank personnel candidates based on criteria by using Eqs. (8)-(15) so that selection process is completed.

The preference relations of specialists' opinions are established to obtain priorities of criteria and to evaluate the ratings of the candidates by employing the linguistic scale, which is demonstrated in Table 2.

Table 2. Transformation between linguistic variables and IFNs

Linguistic variables	IFNs
Very high (VH)	(0.95,0.05,0.00)
High (H)	(0.75,0.15,0.10)
Medium (M)	(0.50,0.40,0.10)
Equal (E)	(0.50,0.50,0.00)
Low (L)	(0.25,0.65,0.10)
Very low (VL)	(0.05,0.95,0.00)

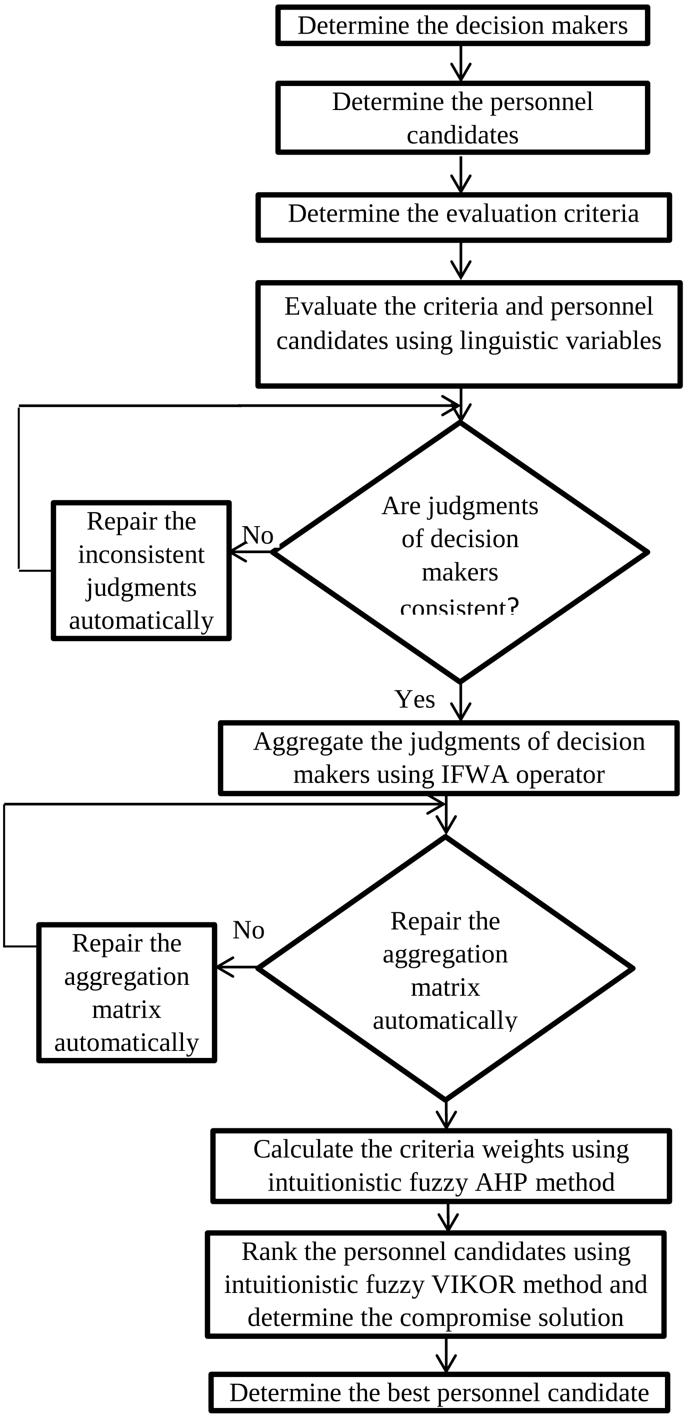

Figure. 1:
A systematic approach for personnel selection

3. NUMERICAL EXAMPLE FOR PERSONNEL SELECTION

3.1. Implementation

A real life application in a logistic firm is presented in order to show the efficiency of the proposed approach and the decision hierarchy process of the problem is presented in Figure 2. The logistic firm wants to recruit personnel for a vacant position performing the following tasks.

*Carry out payroll operations for blue collar and white collar roles
*Updating of responsibilities according to legislative changes
*Carry out the personnel entry and exit procedures
*Preparation of reports and notice indemnity calculations and related reports
*Follow-up of employee permits in line with legal regulations and company procedures
*Carry out foreign employee work permit procedures
*Preparing monthly points
*Supporting recruitment process
*Carry out orientation process for new comers

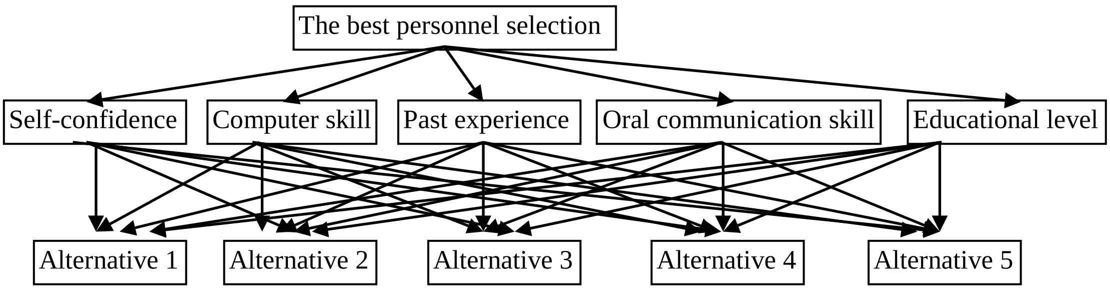

Figure 2:
The decision hierarchy process of the problem

The personel selection is realized according to a questionnaire responded by three experts in human resources management area. The managers define the three experts with minimum 5 years of experience in human resources management area. These experts are external consultant (E1), human resources management experts (E2 and E3). After initial elimination, five candidates have been remained for further evaluation. An expert team of E1, E2 and E3 presented their judgments about the candidates by using Table 2. Five criteria were defined through literature review and the expert team so that these criteria are self-confidence (K_1), computer skill (K_2), past experience (K_3), oral communication skill (K_4), and educational level (K_5). Self confidence and past experience are achieved by Dursun and Karsak (2010). Computer skill is obtained by Karabasevic et al. (2016). Oral communication skill and educational level is taken by Baležentis et al. (2012). These criteria are necessary to perform the above tasks according to the three experts. The importance degree of decision makers are assigned in order to show their differences in the group decision making problem so that the importance degrees of E1, E2, and E3 decision makers can be defined as (0.40, 0.35, 0.25), respectively. IFAHP is utilized to determine weights of criteria and then IFVIKOR is employed to rank personnel candidates based on criteria so that selection process is completed.

The three experts construct the preference relations of criteria as showing in Tables 3-5. Table 3 handles the preference relations of criteria according to expert 1.

Table 3. Preference relation of criteria for expert 1

	K_1	K_2	K_3	K_4	K_5
K_1	(0.5,0.5,0)	(0.4,0.5,0.1)	(0.15,0.75,0.1)	(0.15,0.75,0.1)	(0.4,0.5,0.1)
K_2	(0.5,0.4,0.1)	(0.5,0.5,0)	(0.4,0.5,0.1)	(0.4,0.5,0.1)	(0.5,0.4,0.1)
K_3	(0.75,0.15,0.1)	(0.5,0.4,0.1)	(0.5,0.5,0)	(0.5,0.4,0.1)	(0.75,0.15,0.1)
K_4	(0.75,0.15,0.1)	(0.5,0.4,0.1)	(0.4,0.5,0.1)	(0.5,0.5,0)	(0.75,0.15,0.1)
K_5	(0.5,0.4,0.1)	(0.4,0.5,0.1)	(0.15,0.75,0.1)	(0.15,0.75,0.1)	(0.5,0.5,0)

Table 4 handles the preference relations of criteria according to expert 2.

Table 4. Preference relation of criteria for expert 2

	K_1	K_2	K_3	K_4	K_5
K_1	(0.5,0.5,0)	(0.95,0.05,0)	(0.4,0.5,0.1)	(0.25,0.65,0.1)	(0.25,0.65,0.1)
K_2	(0.05,0.95,0)	(0.5,0.5,0)	(0.4,0.5,0.1)	(0.05,0.95,0)	(0.25,0.65,0.1)
K_3	(0.5,0.4,0.1)	(0.5,0.4,0.1)	(0.5,0.5,0)	(0.75,0.15,0.1)	(0.95,0.05,0)
K_4	(0.65,0.25,0.1)	(0.95,0.05,0)	(0.15,0.75,0.1)	(0.5,0.5,0)	(0.25,0.65,0.1)
K_5	(0.65,0.25,0.1)	(0.65,0.25,0.1)	(0.05,0.95,0)	(0.65,0.25,0.1)	(0.5,0.5,0)

Table 5 handles the preference relations of criteria according to expert 3.

Table 5. Preference relation of criteria for expert 3

	K_1	K_2	K_3	K_4	K_5
K_1	(0.5,0.5,0)	(0.75,0.15,0.1)	(0.05,0.95,0)	(0.5,0.4,0.1)	(0.4,0.5,0.1)
K_2	(0.15,0.75,0.1)	(0.5,0.5,0)	(0.05,0.95,0)	(0.75,0.15,0.1)	(0.4,0.5,0.1)
K_3	(0.95,0.05,0)	(0.95,0.05,0)	(0.5,0.5,0)	(0.95,0.05,0)	(0.75,0.15,0.1)
K_4	(0.4,0.5,0.1)	(0.15,0.75,0.1)	(0.05,0.95,0)	(0.5,0.5,0)	(0.4,0.5,0.1)
K_5	(0.5,0.4,0.1)	(0.5,0.4,0.1)	(0.15,0.75,0.1)	(0.5,0.4,0.1)	(0.5,0.5,0)

The judgments of each expert can be checked in terms of consistency of the IPR and can be repaired the inconsistent IPRs of the experts into a consistent one automatically. A perfect multiplicative consistent IPR $\bar{R}=(\bar{r}_{ik})_{n\times n}$ can be established for expert 1. Firstly, it is determined the modified IPR $\bar{R}=(\bar{r}_{ik})_{n\times n}$ and it is shown in Table 6.

Table 6. Transformed preference relation of criteria for expert 1

	K_1	K_2	K_3	K_4	K_5
K_1	(0.500,0.500,0.000)	(0.400,0.500,0.100)	(0.308,0.500,0.192)	(0.219,0.586,0.195)	(0.364,0.364,0.272)
K_2	(0.500,0.400,0.100)	(0.500,0.500,0.000)	(0.400,0.500,0.100)	(0.400,0.400,0.200)	(0.667,0.150,0.183)
K_3	(0.500,0.308,0.192)	(0.500,0.400,0.100)	(0.500,0.500,0.000)	(0.500,0.400,0.100)	(0.750,0.105,0.145)
K_4	(0.586,0.219,0.195)	(0.400,0.400,0.200)	(0.400,0.500,0.100)	(0.500,0.500,0.000)	(0.750,0.150,0.100)
K_5	(0.364,0.364,0.272)	(0.150,0.667,0.183)	(0.105,0.750,0.145)	(0.150,0.750,0.100)	(0.500,0.500,0.000)

Here, we indicate $\bar{r}_{15}$ as an example:

$$\bar{\mu}_{15}=\frac{\sqrt[3]{\mu_{12}\mu_{25}\mu_{13}\mu_{35}\mu_{14}\mu_{45}}}{\sqrt[3]{\mu_{12}\mu_{25}\mu_{13}\mu_{35}\mu_{14}\mu_{45}}+\sqrt[3]{(1-\mu_{12})(1-\mu_{25})(1-\mu_{13})(1-\mu_{35})(1-\mu_{14})(1-\mu_{45})}}$$

$$=\frac{\sqrt[3]{0.4\times 0.5\times 0.15\times 0.75\times 0.15\times 0.75}}{\sqrt[3]{0.4\times 0.5\times 0.15\times 0.75\times 0.15\times 0.75}+\sqrt[3]{0.6\times 0.5\times 0.85\times 0.25\times 0.85\times 0.25}}=0.364$$

$$\bar{v}_{15}=\frac{\sqrt[3]{v_{12}v_{25}v_{13}v_{35}v_{14}v_{45}}}{\sqrt[3]{v_{12}v_{25}v_{13}v_{35}v_{14}v_{45}}+\sqrt[3]{(1-v_{12})(1-v_{25})(1-v_{13})(1-v_{35})(1-v_{14})(1-v_{45})}}$$
$$=\frac{\sqrt[3]{0.5\times0.4\times0.75\times0.15\times0.75\times0.15}}{\sqrt[3]{0.5\times0.4\times0.75\times0.15\times0.75\times0.15}+\sqrt[3]{0.5\times0.6\times0.25\times0.85\times0.25\times0.85}}=0.364$$

The deviation $d\left(R^{(p)},\bar{R}\right)$ between $R^{(p)}$ and $\bar{R}$ is calculated and the consistency of IPR is determined as $d\left(R^{(0)},\bar{R}\right)=0.1636>0.1$ which means the unacceptable consistency so that it needs to repair by using Eqs. (5)-(6) automatically. When σ is 0.8 here, the fused IPR $R^{(1)}$ can be indicated in Table 7.

Table 7. Acceptable consistent preference relation of criteria for expert 1

	K_1	K_2	K_3	K_4	K_5
K_1	(0.500,0.500,0.000)	(0.400,0.500,0.100)	(0.270,0.555,0.175)	(0.203,0.622,0.175)	(0.371,0.390,0.239)
K_2	(0.500,0.400,0.100)	(0.500,0.500,0.000)	(0.400,0.500,0.100)	(0.400,0.420,0.180)	(0.635,0.187,0.178)
K_3	(0.555,0.270,0.175)	(0.500,0.400,0.100)	(0.500,0.500,0.000)	(0.500,0.400,0.100)	(0.750,0.113,0.137)
K_4	(0.622,0.203,0.175)	(0.420,0.400,0.180)	(0.400,0.500,0.100)	(0.500,0.500,0.000)	(0.750,0.150,0.100)
K_5	(0.390,0.371,0.239)	(0.187,0.635,0.178)	(0.113,0.750,0.137)	(0.150,0.750,0.100)	(0.500,0.500,0.000)

The consistency of IPR is determined as $d\left(R^{(1)},\bar{R}\right)=0.0314<0.1$ which means the acceptable consistency. The consistency checking can be defined by using same process for the other IPR of criteria according to other experts.

IFWA operator can be utilized to aggregate the judgments of experts based on importance degree of experts and their IPRs. The judgments of all experts are combined into unique group opinion to aggregate the IPRs. The consistency checking of the combined IPR is done and it is determined as the unacceptable consistency so that it needs to repair by using Eqs. (5)-(6). After repairing process, the perfect multiplicative consistent IPR is defined and shown in Table 8. It is not shown here how Eqs. (7) and (8) are calculated due to its complexity. But IFWA operator is shown when the judgments of the three experts are aggregated for the five personnel candidates based on the five criteria.

Table 8. Preference relation of criteria for the combining result of three experts

	K_1	K_2	K_3	K_4	K_5
K_1	(0.500,0.500,0.000)	(0.798,0.165,0.037)	(0.644,0.238,0.118)	(0.757,0.132,0.111)	(0.681,0.146,0.173)
K_2	(0.186,0.770,0.044)	(0.500,0.500,0.000)	(0.327,0.587,0.086)	(0.601,0.251,0.148)	(0.555,0.220,0.225)
K_3	(0.274,0.593,0.133)	(0.615,0.308,0.077)	(0.500,0.500,0.000)	(0.779,0.169,0.052)	(0.802,0.098,0.100)
K_4	(0.138,0.743,0.119)	(0.252,0.600,0.149)	(0.181,0.761,0.058)	(0.087,0.913,0.000)	(0.543,0.339,0.118)
K_5	(0.147,0.677,0.176)	(0.230,0.545,0.224)	(0.100,0.796,0.104)	(0.361,0.522,0.118)	(0.087,0.913,0.000)

The weights of criteria of the perfect multiplicative consistent IPR are obtained by using Eq.(7) as follows:

$\omega_1 = (0.2597, 0.6412),\ \omega_2 = (0.1666, 0.7489), \omega_3 = (0.2282, 0.6870),\ \omega_4 = (0.0923, 0.8455), \omega_5 = (0.0711, 0.8547)$

It is acquired $S(\omega_1) = -0.3815,\ S(\omega_2) = -0.5823,\ S(\omega_3) = -0.4588,\ S(\omega_4) = -0.7532,\ S(\omega_5) = -0.7837$ by using score function. The ranking of criteria is $K_1 > K_3 > K_2 > K_4 > K_5$, since $S(\omega_1) > S(\omega_3) > S(\omega_2) > S(\omega_4) > S(\omega_5)$ so that K_1 is the most important criteria for personnel selection of the specified logistic firm.

IFVIKOR method is proposed to evaluate the personnel candidates under an intuitionistic fuzzy environment. Three experts utilize the linguistic rating variables indicated in Table 2 to determine the rating of personnel candidates based on each criteria. The rating of the five personnel candidates based on the five criteria by the three experts are presented in Table 9.

Table 9. Evaluation data for alternatives

	E1					E2					E3				
	K_1	K_2	K_3	K_4	K_5	K_1	K_2	K_3	K_4	K_5	K_1	K_2	K_3	K_4	K_5
Alt_1	H	M	H	H	M	VH	M	H	L	VL	VH	VL	VL	M	M
Alt_2	M	VL	L	M	M	H	VL	VH	M	L	M	H	H	H	M
Alt_3	L	L	L	H	M	VH	L	VL	H	M	H	VH	VH	H	VH
Alt_4	M	M	M	L	M	H	L	VL	M	H	H	M	M	M	M
Alt_5	M	L	M	M	L	VH	M	L	VL	H	H	VL	H	H	M

The linguistic evaluations indicated in Table 9 are converted into intuitionistic fuzzy numbers by using Table 2. The group decision of the three experts based on their importance is obtained with using IFWA operator and the aggregated intuitionistic fuzzy rating of personnel candidates under the five criteria is shown in Table 10.

Table 10. Evaluation data for alternatives for the combining result of three experts

	K_1	K_2	K_3	K_4	K_5
Alt_1	(0.905,0.078,0.018)	(0.413,0.497,0.090)	(0.651,0.238,0.111)	(0.563,0.320,0.116)	(0.374,0.541,0.085)
Alt_2	(0.608,0.284,0.109)	(0.320,0.599,0.082)	(0.779,0.184,0.037)	(0.580,0.313,0.107)	(0.424,0.474,0.102)
Alt_3	(0.779,0.184,0.037)	(0.619,0.342,0.039)	(0.586,0.391,0.023)	(0.750,0.150,0.100)	(0.719,0.238,0.043)
Alt_4	(0.670,0.222,0.108)	(0.424,0.474,0.102)	(0.374,0.541,0.085)	(0.412,0.486,0.102)	(0.608,0.284,0.109)
Alt_5	(0.812,0.151,0.037)	(0.310,0.603,0.087)	(0.515,0.371,0.114)	(0.474,0.424,0.103)	(0.539,0.345,0.117)

IFWA operator is shown for K_1 based A_1 as an example. As it can be seen in Table 9, the judgments of experts are presented H, VH, and VH linguistic terms for K_1 based Alt_1, respectively. IFNs of H and VH from Table 2 are (0.75, 0.15, 0.10) and (0.95, 0.05, 0.00), respectively. The importance degrees of E1, E2, and E3 decision makers are (0.40, 0.35, 0.25), respectively. As it can be seen in Table 10, $\mu_{C_1-A_1}$ (membership degree of the aggregated K_1 based Alt_1) and $v_{C_1-\mathrm{Alt}_1}$ (non-membership degree of the aggregated K_1 based Alt_1) are 0.905 and 0.078, respectively.

$$\mu_{C_1-\mathrm{Alt}_1} = 1 - \left((1-0.75)^{0.40}\right) \times \left((1-0.95)^{0.35}\right) \times \left((1-0.95)^{0.25}\right) = 0.905$$

$$v_{C_1-\mathrm{Alt}_1} = \left(0.15^{0.40}\right) \times \left(0.05^{0.35}\right) \times \left(0.05^{0.25}\right) = 0.078$$

The best f_j^* and the worst f_j^- values of all criteria are defined by using Eqs. (8)-(9) as follows:

$f_1^* = (0.9048, 0.0776),\ f_2^* = (0.6189, 0.3423), f_3^* = (0.7791, 0.1836),\ f_4^* = (0.7500, 0.1500), f_5^* = (0.7188, 0.2378)$

$f_1^- = (0.6077, 0.2838),\ f_2^- = (0.3096, 0.6030), f_3^- = (0.3741, 0.5414),\ f_4^- = (0.4120, 0.4857), f_5^- = (0.3741, 0.5414)$

The values of S, R, and Q are computed by using Eqs. (10)-(15) for the five personnel candidates and are presented in Table 11.

Table 11. The values of S, R and Q for alternatives

	Alt_1	Alt_2	Alt_3	Alt_4	Alt_5
S	(0.272,0.582,0.146)	(0.444,0.391,0.165)	(0.236,0.674,0.090)	(0.514,0.330,0.156)	(0.424,0.417,0.159)
R	(0.111,0.830,0.059)	(0.260,0.641,0.099)	(0.127,0.822,0.051)	(0.228,0.687,0.085)	(0.167,0.749,0.084)
Q	0.128	0.902	0.040	0.883	0.573

S and R are determined as IFNs and the five personnel candidates are ranked by using score function. Since values of S and R are IFNs, value of Q is calculated by using Eqs. (10)-(12) and Eq. (15). The ranking of the five personnel candidates by values of S, R, and Q in decreasing order is indicated in Table 12. The personnel candidate Alt_3 is obviously the best candidate for the logistic firm according to value of Q and should be recruited by the logistic firm. The ranking will be followed by personnel candidates Alt_1, Alt_5, Alt_4, Alt_2.

Table 12. The ranking of alternatives by S, R and Q

	Alt_1	Alt_2	Alt_3	Alt_4	Alt_5
S	2	4	1	5	3
R	1	5	2	4	3
Q	2	5	1	4	3

3.2. Comparisons and discussion

The fuzzy VIKOR, fuzzy TOPSIS, IFAHP- intuitionistic fuzzy grey relational analysis (IFGRA), and IFAHP methods are considered in order to illustrate the effectiveness of the proposed method. Table 13 presents the ranking results of the five personnel candidates as acquired utilizing these methods.

Table 13. The ranking of alternatives by different methods

	Alt_1	Alt_2	Alt_3	Alt_4	Alt_5
IFAHP	2	3	1	5	4
IFAHP-IFGRA	1	4	2	5	3
FTOPSIS	1	3	2	5	4
FVIKOR	1	5	4	3	2
IFAHP-IFVIKOR	2	5	1	4	3

Based on the ranking results in Table 13, the advantages of the proposed approach according to the other methods can be summarized as follows:

The results of the FTOPSIS and the IFAHP-IFGRA are almost same. The grey relational grades and the closeness coefficient of personnel candidates are very close in IFAHP-IFGRA, FTOPSIS, respectively. TOPSIS method simultaneously deals to find the shortest distance from positive ideal solution and the farthest from negative ideal solution. The closeness coefficients of five personnel candidates are very close in fuzzy TOPSIS so that the closeness coefficients of the first and second personnel candidates are 0.127 and 0.123, respectively. GRA method provides to measure the grey relational grade between an alternative and the reference sequence and then the best alternative is selected according to the grey relational grades. The grey relational grades of the first and second personnel candidates are (0.472, 0.374, 0.154) and (0.461, 0.378, 0.161), respectively. VIKOR method considers the minimum individual regret and the maximum group utility and presents the compromise solution using the parameter v. The most appropriate candidate acquired from the proposed method and IFAHP method is the same and alternative 3. The most appropriate candidate of the other methods is remarkably different and alternative 1. IFVIKOR ensures a good solution due to take into account the non-membership degree and hesitation degree. The parameters in GRA and VIKOR methods play key role in the ranking orders of personnel candidates. The values of the compromise solutions in IFVIKOR aren't satisfied by the acceptable advantage condition so that it can be thought infeasible solution. But IFVIKOR can be found this result due to take into account the non-membership degree and hesitation degree. Efe et al. (2017) tested on risk evaluation problem the consistency of the IFAHP-IFVIKOR.

4. CONCLUSION

Selecting the most convenient personnel is very vital for an organization's performance in growing competitive environment. This paper provides an integrated IFAHP-IFVIKOR for personnel selection under group decision making with perfect multiplicative consistent IPR. The inconsistency preference relations can be sent to return to the decision maker for reevaluation or can be extracted from decision making process but the reevaluation process is time consuming and the decision makers do not sometimes desire to participate to this reevaluation process. This paper utilized the presented a perfect multiplicative consistent IPR by Xu and Liao (2014) to overcome these challenges. All judgments of experts are characterized based on linguistic variables by intuitionistic fuzzy numbers, which deals with uncertainty. IFWA operator is used to aggregate individual opinions of experts into a group opinion. IFAHP is utilized to determine the weights of criteria. IFVIKOR method is proposed to evaluate the personnel candidates based on the five criteria under an intuitionistic fuzzy environment. The suggested model is implemented within a logistic firm and shows that it can be efficiently utilized in personnel selection problem.

An integrated MCDM method with intuitionistic fuzzy set has big chance of success for personnel selection problem since it also handles uncertain judgments of experts. In future papers, this integrated approach can be utilized for dealing with vagueness under intuitionistic fuzzy environment in different applications such as risk assessment, software selection, and supplier selection.

The proposed integrated approach has the following advantages:

- It can decreased information loss and uncertainty in decision making process effectively due to utilization of IFS in fuzzy environment.
- It is fast method because a perfect multiplicative consistent IPR will be repaired the inconsistent IPRs of the experts into a consistent one automatically. The inconsistency judgments are not sent to reassessment to the experts.
- The importance degrees of criteria in personnel selection process are considered in linguistic terms instead of crisp terms. The decision makers can present their judgments more easily.

In future study, it can be focused on interval type 2 fuzzy number based MCDM method for personnel selection problem.

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