Published in Proceedings of the9th IFAC/IFIP/IFORS/IISE/INFORMS Conference Manufacturing Modelling, Management and Control MIM 2019, 28-30 August 2019, Berlin, Germany, which should be cited to refer to this work.
DOI A COMPLETER !!

Expert Selection for Humanitarian Projects Development: A group Decision Making approach with Incomplete Information Relations.

Abderrahmen Mediouni[1, 2✉]. Naoufel Cheikhrouhou[2]

[1] Geneva School of Economics and Management, GSEM - University of Geneva, 1211 Geneva 4, Switzerland (Tel: +41225463529; e-mail: mediouni.abderrahmen@hesge.ch).
[2]Geneva School of Business Administration, University of Applied Sciences Western Switzerland (HES-SO), 1227 Carouge, Switzerland (e-mail: naoufel.cheikhrouhou@hesge.ch)

Abstract: This paper proposes a methodology to select an expert for the development of humanitarian and social projects based on multi-criteria decision-making with incomplete information relations to add more objectivity to the recruitment process. The proposed approach starts with assessing the decision makers (DMs) by means of Fuzzy Analytic Hierarchy Process (AHP). Then, Analytic Network Process (ANP) is used to weigh the criteria in order to take into account the interdependencies between criteria. In the recruiting process, an expert could be unable to assess all criteria. Therefore, the incomplete preference relations is used when a DM is unable to express his judgment. At a later stage, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is addressed to rank the different candidates. The proposed methodology is applied to a situation where an extra DM evaluates four DMs, and six criteria are used to select one candidate among five. The obtained criteria weights and the final ranking of the candidates are analysed and compared to an approach where there is no lack of information in the decision maker's preferences.

Keywords: Expert selection, Multi-criteria decision-making, Incomplete preference relations, Fuzzy Analytic Hierarchy Process, Analytic Network Process, TOPSIS.

1. INTRODUCTION

Personnel selection is a common task for a decision maker (DM), where choosing the right candidate with the right attributes to match the job requirements is a key factor in the successful implementation of any given project. This also applies to the humanitarian field where projects are often characterized by complex working environments that, in fact, make the selection process even more difficult. Selecting experts for the development of humanitarian projects is generally based on the evaluation of several criteria such as work experience, education, motivation, among many others. In addition, improving the well-being of people and satisfying the unprecedented demand for health, food, and energy, just to mention a few, (Amadei and Sandekian 2010) implies that humanitarian projects cover various fields simultaneously. Hence, the expert selection criteria change from one project to another and since each DM involved in the selection process is specialized in a different field of expertise, judgments might vary from one DM to another. Therefore, the evaluation of criteria weights is not a simple task for sometimes it is challenging to decide, particularly where criteria are interdependent. Moreover, a DM who does not necessarily have the same weight within an organization is sometimes not able to express her/his preferences among two criteria. It is therefore essential to help decision makers refrain from emitting a judgment; all without negatively affecting the process of personnel selection. This paper presents a group multi-criteria decision making (MCDM) method that allows to consider the interdependences between some criteria along with granting decision makers a way to express their lack of judgment by means of incomplete preference relations. Thus, the consideration of incomplete information will add more objectivity and credibility to the process of recruiting humanitarian experts. The paper is structured as follows: Section 2 provides an overview of the state of the art about MCDM application in personnel selection. Section 3 develops the proposed methodology while Section 4 presents an application case of a real humanitarian project. The analysis of the results is presented in Section 5. Finally, Section 6 concludes the paper.

2. STATE OF THE ART

The general problem of selection decision is addressed by Zahedi (1987), where some or all the information are subjective. Liang and Wang (1992) proposes a substantial amount of information regarding the personnel selection problem and the techniques used to solve it. The personnel selection is a question of selecting the person who corresponds to the vacant position (Dursun and Karsak 2010), which is a process including subjectivity, validity, and criteria fixing (Canós and Liern 2008; Tavares 1994). This process is of great importance because the success of a project or the development of a company depends on the selected candidate. Some studies such as (Smith et al. 2002) and (Rouyendegh and Erkan 2013) discusses the staff selection problem using the opinion of a group of experts. Generally, a group of decision makers who are specialized in the field of the project or company's recruiters determine a number of criteria that allow to evaluate the candidates. Given that every decision maker has a different field of expertise, each one will tend to assign more weight to the criteria touching their domain and, their evaluation based on these criteria becomes more significant. Therefore, it is important to determine weights for the criteria as well as for the decision makers. Li and Chen (2011) study the peer review expert selection method in fund project review. They use XML (Extensible Markup Language) to describe expert knowledge and project knowledge. The results show that peer review expert selection can improve the matching accuracy (domain experts and projects).

In this paper, the interdependency between the criteria is addressed by means of Analytic Network Process (ANP) coupled with incomplete preference relations. The method is based on the additive-consistency property whose mathematical formulation has been given by Tanino (1984). In terms of methodology, fuzzy approaches are always used for selection problems due to the need of incorporating imprecise judgment. Büyüközkan and Çifçi (2011) develop a novel approach based on fuzzy analytic network process within multi-person decision-making schema under incomplete preference relations. They illustrate their approach with a real-life problem of selecting sustainable suppliers. In addition, the personnel selection is a situation which deals with vagueness, subjectivity and imprecision. The use of fuzzy environment seems adapted to this feature. Mediouni et al. (2018) propose a hybrid evaluation methodology for expert selection based on fuzzy analytical hierarchy process for the evaluation of the decision maker weights coupled with technique for order preference by similarity to ideal solution to rank the alternatives. The results show that the approach allows a decrease in the uncertainty associated with decision-making. Huang et al. (2004) discuss the appointment of managers in companies through fuzzy neural network and propose a new model for evaluation of managerial talent. They recur to the simple additive weighting (SAW) and fuzzy analytic hierarchy process (FAHP) to let decision-makers adjust weighted values and obtain decisive results of each phase's scores. Petrovic-Lazarevic (2001) presents a two-level personnel selection fuzzy model: short list and hiring decision. The model attempts to minimize subjective judgement in the process of selecting the right employee for a job vacancy. It is based on an analytic hierarchy process (AHP) with three levels: the preliminary selection or short-list procedure, the hiring decision or selection of a final candidate for an employment opportunity and the expected utility of hiring the successful candidate.

Fuzzy sets theory and TOPSIS are also used in other domains that present similarities with the field of research in this paper. In particular, many studies deal with supplier selection problem that have some similarities with the personnel selection problem (Oliveira Neto et al. 2017; Falsini et al. 2012). Wang et al. (2009), for instance, propose a fuzzy hierarchical TOPSIS, which is not only well suited for evaluating fuzziness and uncertainty problems, but also provides more objective and accurate criterion weights while simultaneously avoiding the problem of Chen's Fuzzy TOPSIS (Chen 2000). They use their method in a practical supplier selection problem. Considering both tangible and intangible criteria, Liao and Kao (2011) propose integrated fuzzy techniques for TOPSIS and multi-choice goal programming (MCGP) approach to solve the supplier selection problem. Chaghooshi et al. (2016) suggest a VIKOR and DEMATEL (Decision Making Trial and Evaluation Laboratory) based hybrid fuzzy approach for the selection of a project manager for an Iranian food company. Park et al. (2011) extend the TOPSIS method to solve multiple attribute group decision-making (MAGDM) problems in interval-valued intuitionistic fuzzy environment. They illustrate their method with a problem of determining what kind of air-conditioning systems should be installed in a library. Chen (2000) extends the TOPSIS to fuzzy environment and is considered as a reference for it. Owing to vague concepts frequently represented in decision data, the crisp value are inadequate to model real-life situations. That is why he describes the rating of each alternative and the weight of each criterion by linguistic terms that can be expressed in triangular fuzzy numbers. He proposes a vertex method to calculate the distance between two triangular fuzzy numbers. He illustrates his method with an engineer hiring example in a software company. Huang et al. (2008) present a fuzzy analytic hierarchy process method for the selection of government sponsored technology development projects in Taiwan that can be viewed as a multiple-attribute decision.

As a conclusion, the used techniques are varied and diverse. Nevertheless, the proposed approach to consider incomplete information in group-based expert selection for the development of humanitarian projects constitutes a novel approach.

3. PROPOSED METHODOLOGY

3.1 Criteria

The objective of this paper is to develop an MCDM approach to select an expert for the development of a humanitarian project for the benefit of a non-governmental organisation with incomplete information relations. A preliminary study lead to define six criteria, the same criteria used in (Mediouni et al. 2018), serving to evaluate the candidates during the selection process and can be modified to better correspond to every situation: Work experience which covers the previously accomplished jobs (C1); Education related to the accumulated knowledge through educational level and diplomas (C2); Satisfaction with past projects which can be evaluated through the opinion of the past employers of the candidate(C3); Motivation which provide answer to questions like "why does a person apply for a specific project" in order to take into account further humanitarian commitment of the candidate(C4); Compensation which is an important criteria due to the limited budget of humanitarian projects (C5), and Capacity of integration related to the expert ability to transmit ideas and managing projects in different cultural and social environments (C6).

3.2 Fuzzy AHP for decision makers' weights

The committee in charge of the personnel selection procedure is composed of four decision makers plus an additional one, who is in charge of the pair-wise comparison of the four others. This extra DM knows all the others and can assess each one's importance and expertise level by making a pairwise comparison on a linguistic scale basis. The linguistic assessments are then converted into triangular fuzzy numbers for Fuzzy AHP evaluation. The used procedure is illustrated by Kara and Cheikhrouhou (2014).

3.3 ANP for criteria weights with incomplete information

3.3.1 Incomplete information

The evaluation of a criterion compared with another one or the influence of a criterion on another one is not always an easy task. It is sometimes difficult for a decision maker to assess a comparison between criteria. In such situation, to the approach allows the DM not to emit a judgment, which may lead to a lack of information in the comparison between the criteria. The incomplete preference relations allow completing the missing information. The comparison of the criteria is difficult to quantify. This operation is realized by means of linguistic variables associated with fuzzy numbers (Table 1).

Table 1 - Linguistic variables for the evaluation of the criteria with corresponding fuzzy numbers

Linguistic variables	Fuzzy scale
Very high importance or influence (VH)	(0.75, 1, 1)
High importance or influence (H)	(0.5, 0.75, 1)
Medium importance or influence (M)	(0.25, 0.5, 0.75)
Low importance or influence (L)	(0, 0.25, 0.5)
Very low importance or influence (VL)	(0, 0, 0.25)

Each decision maker defines the importance of each criterion in his own table. Then, all tables are combined by means of a weighted average since the weights of the DMs have been calculated in the previous step. The decision makers have the possibility not to fill a comparison value using the character "?". The incomplete table is filled with linguistic variables using Table 1.

Then the values are defuzzified and the lower triangular part of the matrix is completed using the same procedure in Herrera-Viedma et al. (2007). The next step consists of determining the missing values using an iterative procedure as follows:

1/ Define the set of values that can be estimated. The subset of missing values that can be estimated in step h of the procedure is denoted by EMV_h (estimated missing values) and defined as follows:

$$\mathrm{EMV_h} = \left\{(i,k) \in \mathrm{MV} \setminus \bigcup_{l=0}^{h-1} \mathrm{EMV_l} \mid i \neq k \wedge \exists j \in \{\mathrm{H_{ik}^{h1}} \cup \mathrm{H_{ik}^{h2}} \cup \mathrm{H_{ik}^{h3}}\}\right\} \quad (1)$$

With

$$\mathrm{H_{ik}^{h1}} = \left\{ j \mid (i,j),(j,k) \in \left\{\mathrm{EV} \bigcup_{l=0}^{h-1} \mathrm{EMV_l}\right\}\right\} \quad (2)$$

$$\mathrm{H_{ik}^{h2}} = \left\{ j \mid (j,i),(j,k) \in \left\{\mathrm{EV} \bigcup_{l=0}^{h-1} \mathrm{EMV_l}\right\}\right\} \quad (3)$$

$$\mathrm{H_{ik}^{h3}} = \left\{ j \mid (i,j),(k,j) \in \left\{\mathrm{EV} \bigcup_{l=0}^{h-1} \mathrm{EMV_l}\right\}\right\} \quad (4)$$

And $EMV_0=\emptyset$ (by definition). The aim is to reach $EMV_{maxIter}=\emptyset$ with $maxIter>0$. That means that all the missing values have been estimated. EV is the set of pairs of alternatives for which the DM provides preference values and $H_{ik}^{h1}, H_{ik}^{h2}, H_{ik}^{h3}$ are the sets of intermediate alternative x_j $(j\neq i,k)$ that can be used to estimate the preference value p_{ik} $(i\neq k)$ using (6)-(8).

2/ Complete the missing values. Here the aim is to maintain a maximum of consistency between the estimated values and the ones given by the DM. This task is done via Tanino's additive transitivity property (Tanino 1984):

$$a_{ij} = a_{ik} + a_{kj} - 0.5 \quad \forall i,j,k \in \{1,2,\dots,n\} \quad (5)$$

Equation (5) can be used to calculate the value of a preference degree using other preference degree. Indeed, the preference value a_{ij} $(i\neq j)$ can be estimated using an intermediate alternative x_k in three different ways.

1) From $a_{ij} = a_{ik} + a_{kj} - 0.5$, we obtain the estimated value cp_{ij}^{k1}

$$cp_{ij}^{k1} = a_{ik} + a_{kj} - 0.5 \quad (6)$$

2) From $a_{kj} = a_{ki} + a_{ij} - 0.5$, we obtain the estimated value cp_{ij}^{k2}

$$cp_{ij}^{k2} = a_{kj} - a_{ki} + 0.5 \quad (7)$$

3) From $a_{ik} = a_{ij} + a_{jk} - 0.5$, we obtain the estimated value cp_{ij}^{k3}

$$cp_{ij}^{k3} = a_{ik} - a_{jk} + 0.5 \quad (8)$$

3/ Check the consistency level. In this case, the subsets EV_i will be needed. It corresponds to the preference values known for the alternative x_i. For each alternative, the completeness level CP_i is defined as follows:

$$\mathrm{CP_i} = \frac{\#\mathrm{EV_i}}{2(n-1)} \quad (9)$$

Where $\#EV_i$ corresponds to the number of values known for x_i and n is the number of alternatives. It is associated with the error εp_{ij}.

$$\varepsilon p_{ij} = \frac{2}{3} \cdot \frac{\varepsilon p_{ij}^1 + \varepsilon p_{ij}^2 + \varepsilon p_{ij}^3}{\kappa} \quad (10)$$

With

$$\varepsilon p_{ij}^l = \begin{cases} \dfrac{\sum_{j \in H_{ij}^l} \left| cp_{ij}^{kl} - p_{ij} \right|}{\# H_{ij}^l}, & \text{if } (\# H_{ij}^l \neq 0); l \in \{1,2,3\} \\ 0, & \text{otherwise} \end{cases} \quad (12)$$

And

$$\kappa = \begin{cases} 3, & \text{if } (\#H_{ij}^1 \neq 0) \wedge (\#H_{ij}^2 \neq 0) \wedge (\#H_{ij}^3 \neq 0) \\ 2, & \text{if } (\#H_{ij}^t \neq 0) \wedge ((\#H_{ij}^v \neq 0) \wedge (\#H_{ij}^w \neq 0)) \\ & t, v, w \in \{1, 2, 3, \} t \neq v \neq w \\ 1, & \text{otherwise} \end{cases} \quad (13)$$

The parameter α_{ij} is defined as:

$$\alpha_{ij} = 1 - \frac{\#EV_i + \#EV_j - \#(EV_i \cap EV_j)}{4(n-1) - 2} \quad (14)$$

With all these parameters we can calculate the consistency level CL_{ij}, associated with a preference value a_{ij}, $(i,j) \in EV$ that is defined as a linear combination of its associated error εp_{ij} and the average of the completeness values associated to the two alternatives involved in the preference degree CP_i and CP_j.

$$CL_{ij} = (1 - \alpha_{ij}) \cdot (1 - \varepsilon p_{ij}) + \alpha_{ij} \cdot \frac{CP_i + CP_j}{2}, \quad \alpha_{ij} \in [0, 1] \quad (15)$$

CL_{ij} should not be less than 0.5 to conclude that a_{ij} is consistent. If a_{ij} is not consistent and $\varepsilon p_{ij} \neq 0$, then preferences should be revised by DM. If a_{ij} is not consistent and $\varepsilon p_{ij} = 0$, then known preferences should be increased.

3.3.2 ANP for criteria weights

In the majority of multi-criteria decision-making problems, the criteria are supposed to be independent which considerably simplifies the situation. In reality, many criteria are interdependent especially in the case of personnel selection. The use of ANP allows taking into account the influence of the criteria on each other.

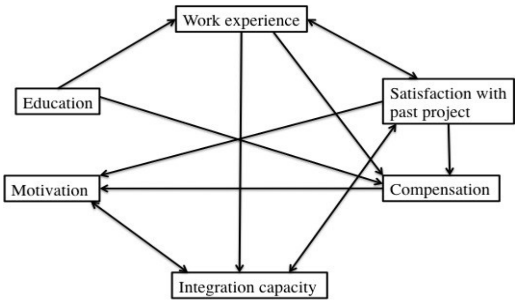

Fig. 1. Schema of the interdependence of the criteria.

A pairwise comparison between the criteria to obtain relative weight estimation. The comparison is made by means of linguistic variables (Table 1). The aim is to define the importance of a criterion compared with another in the process of personnel selection. To allow the DM to express a lack of opinion and apply the process of incomplete information, the steps of subsection 3.3.1 have to be used in order to calculate the weight vector W21 that represents the impact of goal on the criteria (having completed all the missing information).

$$W21 = \begin{pmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{pmatrix} \quad (16)$$

With

$$W_i = \frac{\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}}, \quad i \in \{1, 2, \dots, n\} \quad (17)$$

Finally, the determination of the matrix W22 representing the impact of the interdependences among criteria. An interdependence table for every criterion according to Fig. 1 is made, here again, the different steps of the incomplete information procedure are used. Once all the missing values have been found, we can then calculate a vector for each interdependence table that will form the *nxn* matrix W22.

$$W22 = [V_1 \quad V_2 \quad \dots \quad V_n] \quad (18)$$

With

$$V_i = \begin{pmatrix} D_1 \\ \vdots \\ D_m \end{pmatrix}, \quad i \in \{1, 2, \dots, m\} \quad (19)$$

With D_i=0 for the criteria that don't have any influence on a specific criterion. Otherwise, D_i are calculated using logarithmic least square method:

$$D_i = \frac{\left(\prod_{j=1}^{m} a_{ij}\right)^{1/m}}{\sum_{i=1}^{m} \left(\prod_{j=1}^{m} a_{ij}\right)^{1/m}}, \quad i \in \{1, 2, \dots, m\} \quad (20)$$

To have the final criteria weights, a simple matrix multiplication between W22 and W21 is made.

3.4 TOPSIS

After weighting the decision makers and the criteria, the TOPSIS phase is used to rank the candidates. The TOPSIS procedure is similar to Kara and Cheikhrouhou (2014).

4. APPLICATION of EXPERT SELECTION FOR HUMANITARIAN PROJECTS

A decision maker who knows all the other four DMs can assess the weights and the importance of the DMs with respect to the humanitarian project needs. Their task is to evaluate five candidates who apply for the position. The comparison is made by means of linguistic variables. These variables are converted into fuzzy numbers and then a fuzzy AHP evaluation is made. Table 2 shows the weights of the decision makers.

Table 2 - Weights of the decision makers

DM1	DM2	DM3	DM4
0.36	0.449	0.015	0.176

Every evaluation emitted by a DM corresponds to a number that represents the preference's degree of a criterion compared to another one. Thanks to the incomplete information relations, it is possible to estimate one or several missing values by means of the other values corresponding to the judgments emitted by the DM. To be able to complete the missing information, the DM has to complete at least one entire row or column of the table of evaluation by means of linguistic variables. For the interdependence tables, a pairwise comparison between the criteria is made to obtain relative weight estimation. The aim is to define the importance of a criterion compared with another in the process of personnel selection. The final criteria weights are shown in Table 3.

Table 3 - Weights of the criteria

Work experience	0.187
Education	0.141
Satisfaction with past projects	0.286
Motivation	0.077
Compensation	0.000
Integration capacity	0.142

After weighting the decision makers and the criteria, the TOPSIS phase starts to determine which candidate is best suited for the position according to the relative closeness to the ideal solution (Table 4).

Table 4 - Results of the TOPSIS procedure and ranking of the candidates

	D*	D-	CC*	Ranking
Candidate 1	0.091	0.108	0.544	3
Candidate 2	0.066	0.124	0.652	2
Candidate 3	0.045	0.115	0.720	1
Candidate 4	0.104	0.063	0.377	4
Candidate 5	0.102	0.059	0.365	5

5. DISCUSSION

To analyse the validity and the pertinence of the proposed method and its application, the results are compared to the outcomes of the work in (Mediouni et al. 2018), shown in table 5 and table 6, where a similar approach for the same illustrative example is developed. The difference is that in this paper the ANP for the weights of the criteria is used along with the incomplete information procedure. It is decided to compare the results of the calculations of the weights of the criteria because it is the only part of the procedure that is different. The final result is logically altered under the influence of this difference.

Table 5 - Weights of the criteria when full information is available (Mediouni et al. 2018)

C1	C2	C3	C4	C5	C6
0.251	0.077	0.264	0.237	0.000	0.171

Table 6 – Final candidate ranking when full information is available (Mediouni et al. 2018)

Candidates	Ranking
Candidate 1	2
Candidate 2	3
Candidate 3	1
Candidate 4	5
Candidate 5	4

There is a significant difference in the Motivation (0.077 vs 0.237) and Education criteria (0.141 vs 0.077). This can be explained by the fact of interdependence between criteria in this study. On the other hand, a different scale of linguistic variables is used. In the proposed method, the fuzzy numbers corresponding to the linguistic variables are included between zero and one, which is not the case in (Mediouni et al. 2018). Furthermore, in this study a criterion with a weak (i.e. low in our approach) influence has a bigger weight than with an equal influence. In our study, it is the opposite, a criterion with a low influence has a lower weight than if it has an equal influence. The values of the used fuzzy numbers have a direct influence on the weights of the criteria that explain the difference for both aforementioned criteria. These differences influence the final result. The best candidate, i.e. candidate 3, is the same in both studies but candidate 1 and candidate 2 are inverted. Candidate 4 and candidate 5 are also inverted in the final ranking. This difference is explained by the fact that the criteria do not have the same weight in both studies, which impacts the ranking of the candidates. It can be concluded that the use of incomplete information leads to almost the same results in terms of the best candidate and is thus a useful procedure.

6. CONCLUSION

This study proposes a novel fuzzy multi-criteria decision-making approach for the selection of experts for humanitarian development projects. First, the proposed methodology attributes a weight to every DM by means of fuzzy AHP and uses the ANP to weight the criteria and, finally, TOPSIS is applied for the ranking of the candidates. To fit the necessity of humanitarian field, six criteria are considered: Integration capacity, Compensation, Motivation, Satisfaction with past projects, Education and Work experience. The major contribution of this paper is the use of incomplete preference relations to tackle the fact that the DMs are not always able to express their preference between two criteria because they can come across an ambiguous situation or simply because they may not have the required competence to decide which criterion is more important. The integration of such procedure can easily increase the efficiency in terms of objectivity and repeatability of the personnel selection and therefore provide the decision makers with a tool allowing them to treat equally all the candidates. The real case application shows that 'Satisfaction with past projects' and 'Motivation' are the most weighted criteria in the selection of experts. In fact, those two criteria could lead to a fulfilment of a project objective before deadline, or beyond the target values which meets the requirement of humanitarian projects characterized by critical environments, where the implemented activities need to meet short and long-term goals. As demonstrated through the application, the candidate 3 fits the most in comparison with the others. In order to validate the approach, a comparison is conducted between the results and the outcomes of the case study illustrated by the authors in their previous work where there is no lack of information in the DM's preferences. The comparison shows that the criteria with the highest weight and the final ranking remains the same i.e. candidate 3 is associated with the highest rank.

To the best of author's knowledge, the approach to use fuzzy AHP, incomplete information, ANP and TOPSIS for the ranking in the selection of experts for humanitarian projects development constitutes a novel approach. Therefore, potential future research can consist of combining the proposed methodology with multi-objective mathematical models in order to increase the efficiency in the expert selection process.

REFERENCES

Amadei, Bernard, and Robyn Sandekian. (2010). Model of integrating humanitarian development into engineering education. *Journal of Professional Issues in Engineering Education and Practice* 136 (2): 84–92.

Bali, Özkan, Serkan Gümüş, and Metin Dağdeviren. (2013). A group MADM method for personnel selection problem using delphi technique based on intuitionistic fuzzy sets. *Journal of Military and Information Science* 1 (1): 13.

Büyüközkan, Gülçin, and Gizem Çifçi. (2011). A novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information. *Computers in Industry* 62 (2): 164–74.

Canós, L., and V. Liern. (2008). Soft computing-based aggregation methods for human resource management. *European Journal of Operational Research* 189 (3): 669–81.

Chen, Chen-Tung. (2000). Extensions of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets and Systems* 114 (1): 1–9.

Dursun, Mehtap, and E. Ertugrul Karsak. (2010). A fuzzy MCDM approach for personnel selection. *Expert Systems with Applications* 37 (6): 4324–30.

Falsini, Diego, Federico Fondi, and Massimilliano M. Schiraldi. (2012). A logistics provider evaluation and selection methodology based on AHP, DEA and linear programming integration. *International Journal of Production Research* 50(17): 4822-4829.

Haifeng Li, and Ning Chen. (2011). Peer review expert selection method research based on knowledge set theory. In *2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC)*, 2248–51. Deng Feng, China: IEEE.

Herrera-Viedma, Enrique, Francisco Chiclana, Francisco Herrera, and Sergio Alonso. (2007). Group decision-making model with incomplete fuzzy preference relations based on additive consistency. *IEEE Transactions on Systems, Man and Cybernetics, Part B (Cybernetics)* 37 (1): 176–89.

Huang, Chi-Cheng, Pin-Yu Chu, and Yu-Hsiu Chiang. (2008). A fuzzy AHP application in government-sponsored R&D project selection. *Omega* 36 (6): 1038–52.

Jafarnejad Chaghooshi, Ahmad, Alireza Arab, and Seyyed Jalaladdin Hosseini Dehshiri. (2016). A fuzzy hybrid approach for project manager selection. *Decision Science Letters*, 447–60.

Kara, Selin Soner, and Naoufel Cheikhrouhou. (2014). A multi criteria group decision making approach for collaborative software selection problem. *Journal of Intelligent & Fuzzy Systems* 1: 37–47.

Liang, Gin-Shuh, and Mao-Jiun J. Wang. (1992). Personnel placement in a fuzzy environment. *Computers & Operations Research* 19 (2): 107–21.

Liang-Chih Huang, Kuo-Shu Huang, Hsiu-Ping Huang, and Bih-Shiaw Jaw. (2004). Applying fuzzy neural network in human resource selection system. In *IEEE Annual Meeting of the Fuzzy Information, 2004. Processing NAFIPS '04.*, 169-174 Vol.1. Banff, Alta., Canada: IEEE.

Liao, Chin-Nung, and Hsing-Pei Kao. (2011). An integrated fuzzy TOPSIS and MCGP approach to supplier selection in supply chain management. *Expert Systems with Applications* 38 (9): 10803–11.

Mediouni, Abderrahmen, Nicolas Zufferey, Nachiappan Subramanian, and Naoufel Cheikhrouhou. (2018). Fit between humanitarian professionals and project requirements: hybrid group decision procedure to reduce uncertainty in decision-making. *Annals of Operations Research* (2): 1–26.

Oliveira Neto, Geraldo Cardoso de, Julio Cezar de Oliveira, and André Felipe Henriques Librantz. (2017). Selection of logistic service providers for the transportation of refrigerated goods. *Production Planning &Control* 28(10): 813-828.

Park, Jin Han, Il Young Park, Young Chel Kwun, and Xuegong Tan. (2011). Extension of the TOPSIS method for decision making problems under interval-valued intuitionistic fuzzy environment. *Applied Mathematical Modelling* 35 (5): 2544–56.

Petrovic-Lazarevic, Sonja. (2001). Personnel selection fuzzy model. *International Transactions in Operational Research* 8 (1): 89–105.

Rouyendegh, Babak Daneshvar, and Turan Erman Erkan. (2013). An application of the fuzzy ELECTRE method for academic staff selection. *Human Factors and Ergonomics in Manufacturing & Service Industries* 23 (2): 107–15.

Smith, L Douglas, Robert M Nauss, Robert J Banis, and Ronald Beck. (2002). Staffing geographically distributed service facilities with itinerant personnel. *Operations Research*, 19.

Tanino, Tetsuzo. (1984). Fuzzy preference orderings in group decision making. *Fuzzy Sets and Systems* 12 (2): 117–31.

Tavares, L. Valadares. (1994). The strategic development of human resources: the challenge of OR. *International Transactions in Operational Research* 1 (4): 463–77.

Wang, Jia-Wen, Ching-Hsue Cheng, and Kun-Cheng Huang. (2009). Fuzzy hierarchical TOPSIS for supplier selection. *Applied Soft Computing* 9 (1): 377–86.

Zahedi, Fatemeh. (1987). Qualitative programming for selection decisions. *Computers & Operations Research* 14 (5): 395–407.