Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 10 (23): 3068-3075, 2010
ISSN 1812-5654

Personnel Selection using ELECTRE

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Abstract: Selecting personnel are an important problem, yet often difficult task. It is complicated because of more than one dimension. This study considers a real application of personnel selection with using the opinion of experts by one of the group decision making model, it is called ELECTRE method. This study has applied seven criteria that they are qualitative and positive for selecting the best one amongst five personnel and also ranking them. The personnel that were in the same grade in ELECTRE method were identified and were re-ranked by using AHP method. We have also used from five expert's opinion. Finally the introduced method is used in a case study.

Key words: Human resource management, personnel selection, multi-criteria decision making, elimination et choice translating reality (ELECTRE), Analytical Hierarchy Process (AHP)

INTRODUCTION

Personnel selection is the process of choosing individuals who match the qualifications required to perform a defined job in the best way. It determines the input quality of personnel and plays a important role in human resource management. Increasing competition in global markets urges organizations to put more emphasis on personnel selection process. Important issues such as changes in organizations, work, society, regulations and marketing have an influence on personnel selection and recruiting. Organizations differ with respect to the procedures and budgets for recruiting, selecting and orienting people (Karsak, 2001). Some firms make a strategic decision to choose the best candidate by utilizing rigorous and costly selection procedures, while others decide to fill positions quickly and inexpensively based only on the information stated on the application forms. Nonetheless, the growing importance attached to personnel selection process has paved the way for analytical decision making approaches.

Organizations today are making abundant changes internally to cope with a highly turbulent external environment. Frequent reorganizing, downsizing, rightsizing, hierarchical flattening, teaming and outsourcing shape the selection process; which is influenced by the fact that many people are experiencing major difficulties in their attempts to adapt to the uncertainties of career life (Brousseau *et al*., 1996). In general, human resource practices and climate have considerable impact on how the shock of downsizing ultimately translates to organizational performance (Trevor and Nyberg, 2008).

Many studies have reported a positive association between various human resources practices and objective and perceptual measures of selecting human resources, some authors have expressed concern that results may be biased because of methodological problems (Kulik *et al*., 2007; Le *et al*., 2007). Traditional methods for selection of human resources are mostly based on statistical analyses of test scores that are treated as accurate reflections of reality. Modern approaches, however, recognize that selection is a complex process that involves a significant amount of vagueness and subjectivity (Kulik *et al*., 2007).

In general, personnel selection, depending on the firm's specific targets, the availability of means and the individual preferences of the Decision Makers (DMs), is a highly complex problem. The multi-criteria nature of the problem makes Multi-Criteria Decision Making (MCDM) methods and cope with this, given that they consider many criteria at the same time, with various weights and thresholds, having the potential to reflect at a very satisfactory degree the vague-most of the times-preferences of the DMs. In this study, ELECTRE method is suggested to solve personnel selection problem using multi-criteria decision-making process.

In most of the situations where a decision must be taken, it is rare for the DM to have in mind a single clear criterion (Figueira *et al*., 2005). Such situations, where a single-criterion approach falls short, refer to as MCDM problems. Many terminologies have been proposed for

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the categorization of MCDM problems. The dominant terms are the one of Multi-Criteria Decision Analysis (MCDA) or Multi-Attribute Decision Making (MADM), for problems in which the DM must choose from a finite number of explicitly available alternatives characterized by a set of multiple attributes (or criteria) and the one of Multi-Objective Mathematical Programming (MOMP) or Multi-Objective Decision Making (MODM) that deal with decision problems characterized by multiple and conflicting objective functions that are to be optimized over a feasible set of decisions. Here, the alternatives are not explicitly known a priori (Figueira *et al*., 2005). In what follows, the main categories of MCDM are presented.

One class of approaches that deal with subjectivity includes techniques based on the well-known Analytic Hierarchy Process (AHP) which reduces complex decisions to a series of pair wise comparisons and synthesizes the results. AHP and its extensions have been utilized extensively in the selection of human resources. Typical applications include the ones presented by Lai (1995), Iwamura and Lin (1998) and Labib *et al*. (1998). Albayrak and Erensal (2004) used AHP, which determines the global priority weights for different management alternatives, to improve human resource performance outcomes. A detailed review of various applications of AHP in different settings is provided by Vaidya and Kumar (2006). Lai (1995) describes the employee selection process as a multi-objective decision-making problem. Iwamura and Lin (1998) explain that the employee selection process requires the accomplishment and aggregation of different factors. Labib *et al*. (1998) suggested an employee selection process that uses the AHP and has four stages.

The other contemporary methods in the employee evaluation and selection are artificial intelligence techniques that are the fuzzy sets and neural networks. In contrast to conventional sets where a given value v is either included or not included in a set A, in fuzzy set theory each value is associated with a certain grade of membership in set A. This grade is expressed by a membership function that reflects the degree to which it can be argued that value v is included in A. Examples of such approaches can be found by Laing and Wang (1992), Yaakob and Kawata (1999), Lovrich (2000) and Wang *et al*. (2006). Lazarevic (2001) introduced a two-level fuzzy model for minimizing subjective judgment in the process of identifying the right person for a position. And Royes *et al*. (2003) proposed a combination of fuzzy sets and multicriteria tools for employee selection. In a similar approach, Golec and Kahya (2007) proposed a hierarchical structure and use a fuzzy model that has two levels: evaluation and selection. The first level employs a heuristic algorithm which evaluates candidates according to measure indicators whereas the second level selects the candidate using a fuzzy rule-based approach.

Some studies focused on proposed Expert Systems (ESs) or decision support systems to assist personnel selection. Wabalickis (1988) studied the capability of ES and pointed out that it has the potential to assist with tasks for selecting new employees, matching people with jobs, training new and old employees and so on. Later, a working ES named EXPER (Suh *et al*., 1993) was developed to assist managers in making job placement decisions, where employees were evaluated with respect to test scores, performance ratings, aptitude scores and so on and then were matched with specific jobs within an organization. Brunsson *et al*. (1998) developed and tested a rule-based ES, BOARDEX, to perform the Yes/No vote to screen officer personnel records in the first phase of board procedure. Experiment on a mock officer personnel records showed that BOARDEX was successful at selecting the records. Drigas *et al*. (2004) presented an expert system using neuro-fuzzy techniques that investigate a corporate database of unemployed and enterprises profile data for evaluation of the unemployed at certain job position. This study uses a sugeno type neuro fuzzy inferences system for matching an unemployed with a job position. Huang and Chen (2005) proposed a data mining framework based on decision tree and association rules to generate the useful rules for personnel selection. The useful rules were extracted from the relationships between personnel profile data and their work behaviors. Finally, 30 meaningful rules were chosen to develop the recruitment strategies.

MATERIALS AND METHODS

Multi-Criteria Decision-Making (MCDM) is one of the most widely used decision methodologies in the sciences, business, government and engineering worlds. MCDM methods can help to improve the quality of decisions by making the decision-making process more explicit, rational and efficient (Wanga and Triantaphylloub, 2008). Some applications of MCDM in engineering include the use on flexible manufacturing systems (Wabalickis, 1988), layout design (Cambron and Evans, 1991), integrated manufacturing systems (Putrus, 1990) and the evaluation of technology investment decisions (Boucher and Mcstravic, 1991).

Many methods have been proposed to analyze the data of a decision matrix and rank the alternatives. Often time's different MCDM methods may yield different answers to exactly the same problem (Triantaphyllou, 2000) and also some of the methods use additive formulas to compute the final priorities of the alternatives.

The ELECTRE evaluation method is widely recognized for high-performance policy analysis involving both qualitative and quantitative criteria. However, a critical advantage of this evaluation method is its capacity to point the exact needs of a decision maker and suggest an appropriate evaluation approach. The discordance indices of modified ELECTRE evaluation method are used to explain the significance of modified evaluation standards (Huang and Chen, 2005).

The ELECTRE method is a well known method, especially in Europe too. It has been widely used in civil and environmental engineering (Hobbs and Meier, 2000). Applications include the assessment of complex civil engineering projects, selection of highway designs, site selection for the disposal of nuclear waste, water resources planning (Anand Raj, 1995) and waste water (Rogers *et al*., 1999) or solid waste management (Hokkanen and Salminen, 1997) etc.

ELECTRE was conceived by Roy (1991) in response to deficiencies of existing decision making solution methods. ELECTRE is more than just a solution method; it is a Philosophy of decision aid the philosophy is discussed at length by Roy (1991). However, for this study we specifically concentrate on what is referred to as ELECTRE. ELECTRE has evolved through a number of versions (I, II, II, IV, V, IS, A); all are based on the same fundamental concepts but are operationally somewhat different (Huang and Chen, 2005).

Two separated phases are designed in order to address the research methodology, the stages are shown in Fig. 1 and are presented as follows:

- **Phase 1:** The first phase of this study is designed in order to select and consider suitable criteria and personnel in one of a sector of Telecommunication's Company respectively. The way of data collection that is applied for this phase is questionnaire. By using Comparison Matrix with one part of collected data that have been prepared by experts, the weights of criteria will be computed. After computing weights

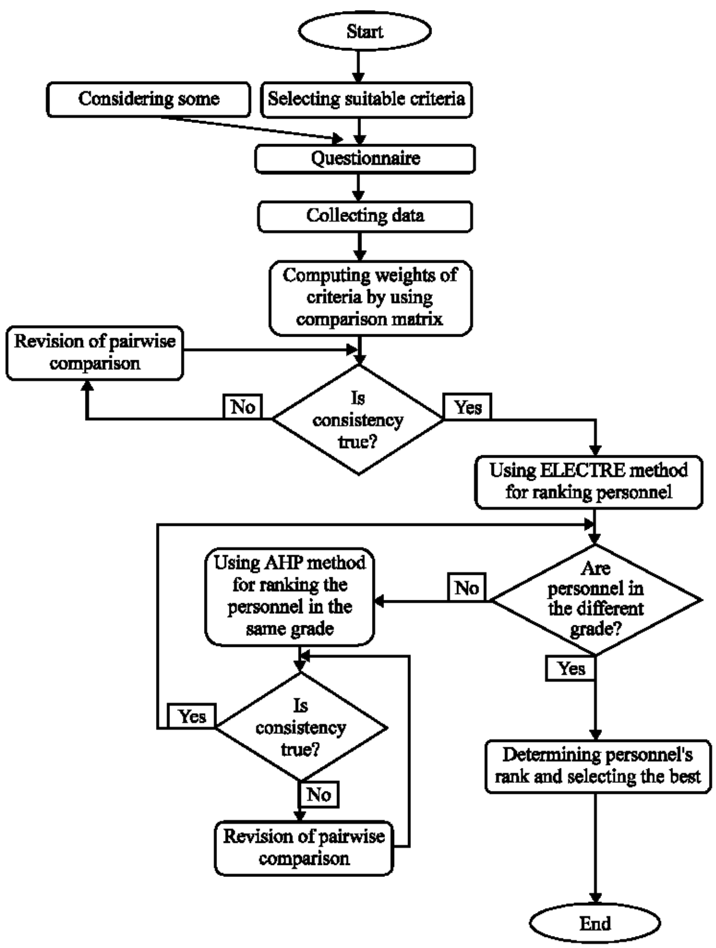

Fig. 1: Research framework

of criteria, specifying of Consistency will be executed too. If the Consistency is less than 0.1, then we use ELECTRE method for pre-ranking personnel. This phase is especially important because it provides the knowledge platform and pre-selecting personnel for next phase

- **Phase 2:** The applied methodology for this phase is based on output of previous phase and the method used is AHP. In this phase, after identifying the level of personnel, we apply AHP method when at least one of personnel's grades was placed in the same with another. In this way, specifying of Consistency will be executed too. In both of phases, if Consistency of data is less than 0.1, revision of pairwise comparison must be done. At the end of this phase, all of personnel which had been considered will be sorted in different level

After specifying relative criteria and also considering five people as alternatives, computing the weights of criteria were started by using comparison matrix.

Data was gathered from five expert's point of view in one of sector in Telecommunication Company. Following steps will be shown the way of solving an application problem in ELECTRE method and finally with AHP method it will rank the result of ELECTRE that some personnel were in the same level.

Steps of ELECTRE method: Asgharpour (2008):

- **Step 1:** Calculate the normalized decision matrix

$$N_{ij} = \frac{R_{ij}}{\sqrt{\sum_{i=1}^{m} R_{ij}^2}} \quad i = 1, 2... m; j = 1, 2...n,$$

- **Step 2:** Calculate the weighted normalized decision matrix

$$V_{ij} = N_{ij} \times W_{ij}$$

We assumed that W is a diagonal matrix (n×n) which values of its main diameter are W and the rest values are zero.

$$W = \begin{bmatrix} w_1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & w_2 & 0 & \cdots & 0 & 0 \\ 0 & 0 & w_3 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 0 & w_n \end{bmatrix}$$

- **Step 3:** Determine the concordance and discordance set

$$S_{kl} = \{J \mid N_{kj} \ge N_{lj}\}; \quad (k,l = 1, 2, 3,...m; k \ne l)$$

When this condition is true then we put 1 in its place otherwise we put 0.

We will also apply for discordance set as followed:

$$D_{kl} = \{J \mid N_{kj} < N_{lj}\}; \quad (k,l = 1, 2, 3,...m; k \ne l)$$

It is obvious that S_{kl} and D_{kl} are opposite then places of 0 belong to.

- **Step 4:** Calculate the concordance matrix

$$I_{kl} = \sum_{j \in S_{k,l}} W_j; \quad \sum_{j=1}^{n} W_j = 1$$

In this matrix (I) is {k,l = 1,2,3...m, k≠1}, so each element of matrix includes sum of element(s) W, that they depend to S_{kl}.

Therefore, each elements of S_{kl} will be between: $0 \le Ik,l \le 1$.

- **Step 5:** Calculate the discordance matrix

During computing matrix of NI, it is necessary that {k,l = 1,2,3...m, k≠1}, so each elements of matrix will be computed as follow:

$$NI_{k,l} = \frac{\max|V_{kj} - V_{lj}|}{\max|V_{kj} - V_{lj}|}; \quad j \in D_{k,l}, j \in J$$

in nominator and denominator respectively

- **Step 6:** Determine the concordance dominance matrix

Dimension of matrix F and matrix I (in step 4) are the same but for finding matrix F, it is needed to compute threshold amount ($\bar{I}$) as follow:

$$\bar{I} = \sum_{k=1}^{m} \sum_{l=1}^{m} \frac{I_{k,l}}{m(m-1)}$$

(m is dimension of matrix).

Matrix F can be calculated by using matrix I if each corresponding elements of matrix I, are divided to $\bar{I}$ (Threshold amount of this step).

$$f_{kl} = 1 \xrightarrow{if} I_{kl} \ge \bar{I},$$

$$f_{kl} = 0 \xrightarrow{if} I_{kl} < \bar{I}$$

The above inequalities mean that if each element of matrix I, is greater than or equal to $\bar{I}$, then 1 would be set in matrix F (corresponding element).

- **Step 7:** Determine the discordance dominance matrix.So we calculate matrix of G

$$\bar{NI} = \sum_{k=1}^{m}\sum_{l=1}^{m}\frac{NI_{k,l}}{m(m-1)}, \text{ (m is dimension of matrix)}$$

Matrix G can be calculated by using matrix NI, if each corresponding elements of matrix NI, are divided to $\bar{NI}$ (Threshold amount of this step).

$$g_{kl} = 1 \xrightarrow{if} NI_{kl} \geq \bar{NI}$$

$$g_{kl} = 0 \xrightarrow{if} NI_{kl} < \bar{NI}$$

Also, the above inequalities mean that if each element of matrix NI, is less than or equal to $\bar{NI}$, then 1 would be set in matrix G (corresponding element).

- **Step 8:** Determine the aggregate dominance matrix

We also compute matrix H. P is means personnel.

$$h_{k,l} = f_{k,l}.g_{k,l}$$

So, matrix H is performed by multiplying corresponding elements of F and G.

- **Step 9:** Eliminate the less favorable alternative and rank them

Finally, we must scan the columns of matrix H, each column that has the least amount of number 1 should be chosen as the best one.

Analytic Hierarchy Process (AHP) is widely used multi criteria decision making method introduced by Satty (1980) and it resolves decision making problems by structuring each problem into a hierarchy with different levels of criteria. In other word, AHP structures a decision problem into a hierarchy and evaluate multi criteria tangible and intangible factors systematically. AHP also has been applied in numerous fields (Forman and Gass, 2001; Vargas, 1990; Zahedi, 1986) including many software selection decisions. The AHP method involves four steps to solve a decision problem (Zahedi, 1986; Lin and Yang, 1996; Tam and Tummala, 2001):

Steps of AHP method:

- **Step 1:** Structuring the decision problem

Structure the hierarchy from the top (goal) through the intermediate levels (criteria, sub-sequent levels depend on) to the lowest level which usually contains the list of alternatives.

- **Step 2:** Creating pair wise comparison matrix

After constructing AHP model, the priorities should be done. Weights are assigned to each criterion and sub criterion. These weights are assigned through a process of pair wise comparison. In pair wise comparison, each objective is compared at a peer level in terms of importance. In this time, a set of pair-wise comparison matrices (size n×n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1 is constructed. The pairwise comparisons are done in terms of which element dominates the other.

- **Step 3:** Determining normalized weights

So, by using each pairwise comparison Matrices, weight of each row was computed by matrix of W.

- **Step 4:** Synthesize the priorities

The final step is to synthesize the solution for the decision problem in order to obtain the set of priorities for alternatives. After computing the weight of alternatives in respect to sub criteria and then sub criteria in respect to criteria and also criteria in respect to goal from step 3 (in the level immediately above), they are aggregated to produce composite weights which used to evaluate decision alternatives.

If each comparison matrix was filled randomly, it will be shown by the Consistency Ratio. The Consistency Ratio (CR) is an indicator which mathematically approximates level of pairwise comparisons. It work as a function of maximum Eigen value and size of the matrix (Consistency Index), which is then compared to similar values if the pairwise comparison had been merely random (Random Index). The consistency of a comparison is totally acceptable for pragmatic purposes if it is not greater than 0.1 (Satty, 1980).

Table 1: Determining the weights of criteria by comparison matrix

Criteria	C1	C2	C3	C4	C5	C6	C7	Weights
C1	1.00	2.00	2.00	4.00	3.00	2.00	3.00	0.264
C2	0.50	1.00	2.00	3.00	3.00	4.00	3.00	0.234
C3	0.50	0.50	1.00	0.33	2.00	0.20	0.50	0.075
C4	0.25	0.33	3.00	1.00	3.00	0.50	2.00	0.117
C5	0.33	0.33	0.50	0.33	1.00	0.33	0.50	0.053
C6	0.50	0.25	5.00	2.00	3.00	1.00	3.00	0.175
C7	0.33	0.33	2.00	0.50	2.00	0.33	1.00	0.082

W= {0.264, 0.234, 0.075, 0.117, 0.053, 0.175, 0.082}

Table 2: The normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
P1	0.388514	0.670478	0.316228	0.262613	0.225018	0.280056	0.180334
P2	0.388514	0.383131	0.632456	0.525226	0.450035	0.420084	0.631169
P3	0.6799	0.574696	0.421637	0.262613	0.562544	0.70014	0.270501
P4	0.291386	0.191565	0.527046	0.393919	0.337526	0.280056	0.450835
P5	0.388514	0.191565	0.210819	0.656532	0.562544	0.420084	0.541002

Table 3: The weighted normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
P1	0.102568	0.156892	0.023717	0.030726	0.011926	0.04901	0.014787
P2	0.102568	0.089653	0.047434	0.061451	0.023852	0.073515	0.051756
P3	0.179494	0.134479	0.031623	0.030726	0.029815	0.122525	0.022181
P4	0.076926	0.044826	0.039528	0.046089	0.017889	0.04901	0.036968
P5	0.102568	0.044826	0.015811	0.076814	0.029815	0.073515	0.044362

Table 4: Stages of concordance and discordance set

	J=1	J=2	J=3	J=4	J=5	J=6	J=7		
S1,2	1	1	-	-	-	-	-	D1,2	3,4,5,6,7
S1,3	-	1	-	1	-	-	-	D1,3	1,3,5,6,7
S1,4	1	1	-	-	-	1	-	D1,4	3,4,5,7
S1,5	1	1	1	-	-	-	-	D1,5	4,5,6,7
	J=1	J=2	J=3	J=4	J=5	J=6	J=7		
S2,1	1	-	1	1	1	1	1	D2,1	2
S2,3	-	-	1	1	-	-	1	D2,3	1,2,5,6
S2,4	1	1	1	1	1	1	1	D2,4	0
S2,5	1	1	1	-	-	1	1	D2,5	4,5
	J=1	J=2	J=3	J=4	J=5	J=6	J=7		
S3,1	1	-	1	1	1	1	1	D3,1	2
S3,2	1	1	-	-	1	1	-	D3,2	3,4,7
S3,4	1	1	-	-	1	1	-	D3,4	3,4,7
S3,5	1	1	1	-	1	1	-	D3,5	4,7
	J=1	J=2	J=3	J=4	J=5	J=6	J=7		
S4,1	-	-	1	1	1	1	1	D4,1	1,2
S4,2	-	-	-	-	-	-	-	D4,2	1,2,3,4,5,6,7
S4,3	-	-	1	1	-	-	1	D4,3	1,2,5,6
S4,5	-	1	1	-	-	-	-	D4,5	1,4,5,6,7
	J=1	J=2	J=3	J=4	J=5	J=6	J=7		
S5,1	1	-	-	1	1	1	1	D5,1	2,3
S5,2	1	-	-	1	1	1	-	D5,2	2,3,7
S5,3	-	-	-	1	1	-	1	D5,3	1,2,3,6
S5,4	1	1	-	1	1	1	1	D5,4	3

Numeric example: In Feb. 2009, by using seven criteria, one sector of Telecommunication Company in Khorasan-Iran, must be chosen one of the five people which have passed the exam. Here are criteria that have been mentioned above.

C1 = Ability to work in different business units
C2 = Past experience
C3 = Team player
C4 = Fluency in a foreign language
C5 = Strategic thinking
C6 = Oral communication skills
C7 = Computer skills

Calculating the weights of criteria has been computed by using comparison matrix. Meanwhile, data was gathered from five expert's point of view in one of sector in Telecommunication Company as shown in Table 1. For solving this kind of problem, First of all by calculating the normalized matrix in Table 2, we will prepare the matrix for weighted normalized matrix (Table 3) by applying $V_{ij} = N_{ij} \times W_{ij}$. After that, for computing concordance and discordance matrix in Table 5 and 6, respectively, we must calculate concordance and discordance set as shown Table 4. We will also compute concordance (Table 7) and discordance (Table 8) dominance matrix, by using Table 5 and 6 respectively. Finally, the result will be extract from Table 9.

Table 5: Concordance matrix

-	0.498	0.351	0.673	0.573
0.766	-	0.274	1.000	0.830
0.766	0.551	-	0.726	0.626
0.502	0.000	0.274	-	0.309
0.691	0.609	0.252	0.925	-

Table 6: Discordance matrix

-	1	0.931791	0.6	0.873755
0.637368	-	0.646325	0	0.291252
0.228008	0.858561	-	0.429281	0.937715
1	0.4	0.877161	-	0.548352
1	0.880404	0.8	0.660303	-

Table 7: Concordance dominance matrix

1	0	0	1	0
1	1	0	1	1
1	0	1	1	1
0	0	0	1	0
1	1	0	1	1

Table 8: Discordance dominance matrix

1	0	0	1	0
1	1	1	1	1
1	0	1	1	0
0	1	0	1	1
0	0	0	1	1

Table 9: Aggregate dominance matrix

	P1	P2	P3	P4	P5
P1	1	0	0	1	0
P2	1	1	0	1	1
P3	1	0	1	1	0
P4	0	0	0	1	0
P5	0	0	0	1	1

And finally, we can eliminate the less favorable alternative and rank them. In ELECTRE method, the best personnel will be P3 and P2 (in equal value) and they were followed by P5, P1 and P4. By using AHP, we solve this problem and determined that P3 will be preferred to P2. So, the result is: P3>>P2>>P5>>P1>>P4

In many times ELECTRE method cannot sort alternatives in different rank, so in this method, authors have applied from hybrid ELECTRE with AHP methods in order to solve this kind of problems. This methodology for personnel selection has not been seen in previous findings so far.

CONCLUSIONS

In this study, we presented a MCDM methodology for selecting employees to cover organizational positions. The method was applied using data from a real case in the Telecommunication sector of Iran. To increase the efficiency and ease-of-use of the proposed model, simple software such as MS Excel can be used. Evaluation of the candidates on the basis of the criteria only will be sufficient for the future applications of the model and implementation of this evaluation via simple software will speed up the process.

The limitation of this article is that ELECTRE ignores the fuzziness of executives' judgment during the decision-making process. Besides, some criteria could have a qualitative structure or have an uncertain structure which cannot be measured precisely. In such cases, fuzzy numbers can be used to obtain the evaluation matrix and the proposed model can be enlarged by using fuzzy numbers. For the future research, the authors suggest the other multicriteria approaches such as ELECTRE III and fuzzy outranking methods to be used and to be compared in justification of the personnel selection problem.

Finally, ELECTRE may be employed to address several human resource issues other than the selection process. Typical applications include the evaluation of training and development programmes and the assessment of individual employees or work groups. The method may also be applied in other business problems, not directly related to human resources. Examples of such applications include project selection and supplier selection in a supply chain.

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