Computers & Industrial Engineering 59 (2010) 937–944

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Personnel selection using analytic network process and fuzzy data envelopment analysis approaches ☆

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ARTICLE INFO

Article history:
Received 17 March 2010
Received in revised form 25 June 2010
Accepted 5 September 2010
Available online 15 September 2010

Keywords:
Personnel selection
Analytic network process
Data envelopment analysis

ABSTRACT

This paper develops a decision support tool using an integrated analytic network process (ANP) and fuzzy data envelopment analysis (DEA) approach to effectively deal with the personnel selection problem drawn from an electric and machinery company in Taiwan. The current personnel selection procedure is a separate two-stage method. The administration practice shows that the separation between stages 1 and 2 reduces the administration quality and may incur both the top manager's displeasure and the decision-makers' depression. An illustrative example by a simulated application demonstrates the implementation of the proposed approach. This example demonstrates how this approach can avoid the main drawback of the current method, and more importantly, can deal with the personnel selection problem more convincingly and persuasively. This study supports the applications of ANP and fuzzy DEA as decision support tools in personnel selection.

1. Introduction

Human resources are one of the core competences for an organization to enhance its competitive advantage in a knowledge economy. Among the functions of human resource management, personnel selection significantly affects the character of employees and quality of administration, and hence it has attracted intensive attention and is an important topic for organizations. An effective personnel selection method should be able to assist the organization in selecting an appropriate person for a given job. Many studies have been conducted to help organizations make effective selection decisions. Further applications of effective techniques in the personnel selection field are still being developed. The personnel selection problem generally concerns with important and complex issues such as: (i) How to properly set the importance weights of criteria to reflect the situations in which not all personnel attributes/characteristics are equally important? (ii) How to use linguistic and/or numerical scales to evaluate the applicants under multiple criteria? (iii) How to aggregate the evaluation results and then rank the applicants? The inherent importance and complexity of the personnel selection problem require effective analytical methods to provide an operational/tactical decision framework.

The personnel selection problem drawn from an electric and machinery company in Taiwan is addressed in this study. A decision support tool using an integrated ANP and fuzzy DEA approach with three phases is developed to effectively deal with the current problem. The rest of this paper is organized as follows. Section 2 provides the relevant literature review. Section 3 describes the current method. In Section 4, the proposed approach is presented. Section 5 provides an illustrative example by a simulated application. Section 6 discusses the results. Finally, conclusions are given in Section 7.

2. Literature review

Researchers (e.g., Beckers & Bsat, 2002; Hough & Oswald, 2000; Liao, 2003; Robertson & Smith, 2001) have pointed out that many issues influence personnel selection practices, including change in personnel, change in work behavior, change in work, change in society, change of laws, advancements in information technology, and others. From a practical viewpoint of personnel selection, the rating biases are a common problem in the selection process (Arvey & Campion, 1982). Rothstein and Goffin (2006) argued that using personality measures appropriately may add value to personnel selection practices. Due to advancements in information technology, many studies have emphasized the development of decision support systems or expert systems to assist personnel selection (e.g., Hooper, Galvin, Kilmer, & Liebowitz, 1998; Mehrabad & Brojeny, 2007; Shih, Huang, & Shyur, 2005).

For the application of operation research related techniques in the personnel selection field, Chien and Chen (2008) proposed a data mining framework based on a decision tree and association rules to generate 30 meaningful rules for recruitment strategies. The personnel profile data and long-term work behavior records

☆ This manuscript was processed by Area Editor Imed Kacem.

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doi:10.1016/j.cie.2010.09.004

are collected to support this method. Kelemenis and Askounis (2010) developed a Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) based multi-criteria approach which incorporates the veto threshold for the ranking of the alternatives. In their approach, the ultimate decision criterion is not the similarity to the ideal solution but the distance of the alternatives from the veto set by the decision-makers. Dursun and Karsak (2010) argued that many individual attributes considered for personnel selection such as organizing ability, creativity, personality, and leadership exhibit vagueness and imprecision. Therefore, they developed a fuzzy multi-criteria decision-making algorithm, which uses the principles of fusion of fuzzy information, 2-tuple linguistic representation model and technique for order preference by similarity to the ideal solution, to tackle the assessment using both linguistic and numerical scales in a decision-making problem with multiple information sources. Gibney and Shang (2007) studied an application of the analytic hierarchy process (AHP) (Saaty, 1980) for the dean selection process of a business school. After the candidate finally selected by the Provost was different from the best one ranked by the search committee, the authors determined the reason for this difference, arguing that the root cause of the difference was a variation in emphasis on certain criteria. In fact, causing the differences in the evaluation results of the dean selection case are very likely to occur since AHP must satisfy the property of independence among the criteria in the decision-making process. Since dependence and feedback relationships will usually be generated among the criteria in actual practice, the analytic network process (ANP) (Saaty, 1996) is a more suitable technique for avoiding differences or errors in the evaluation results. In recent studies, many researchers have applied ANP to decision-making problems (e.g., Bernhard, Vacik, & Lexer, 2005; Chen, Lee, & Wu, 2008; Chung, Lee, Amy, & Pearn, 2005; Hsieh, Lin, & Lin, 2008; Jharkharia & Shankar, 2007). Regarding the characteristics of the AHP and ANP methods, a problem is decomposed into several levels to construct a hierarchy in the AHP scheme. The basic assumptions of AHP are that it can be used in functional independence of an upper part, or cluster, of the hierarchy from all its lower parts and from the criteria or items in each level (Lee & Kim, 2000). Saaty (1996) argued that many decision problems cannot be structured hierarchically because of the interaction and dependence of higher-level elements on a lower-level element. Then, he proposed the ANP method to deal with such problems. The ANP generalizes the AHP as a widely used technique by replacing a hierarchy with a network. With respect to the uses of AHP and ANP methods, Saaty suggested that AHP is used to solve the problem of independence on alternatives or criteria and ANP is used to deal with the problem of dependence among alternatives or criteria.

Saaty (1996) conceptually expressed the hierarchy and network structures as Fig. 1. The following super-matrix representation of the hierarchy shown in Fig. 1a is given by him:

$$W_h = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & 0 & 0 \\ 0 & W_{32} & I \end{bmatrix}$$

In the super-matrix W_h, W_{21} is a vector that represents the impact of the goal on the criteria and W_{32} is a matrix which represents the impact of the criteria on each of the alternatives. The identity matrix I is used to show that each element depends only on itself. This is a necessary aspect of a hierarchy when viewed within the context of the super-matrix. The zero entries correspond to those elements having no influence (Yuksel & Dagdeviren, 2007). If the criteria are dependent among themselves, the hierarchy is replaced by the network shown in Fig. 1b. The interdependency is expressed by the presence of matrix W_{22} in the $(2,2)$ entry of super-matrix, which yields W_n as follows (Saaty, 1996):

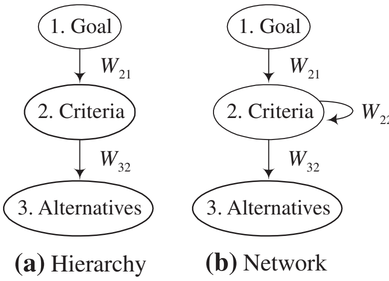

Fig. 1. Hierarchy and network structures (Saaty, 1996).

$$W_n = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{bmatrix}$$

Any zero entry in the super-matrix W_n can be replaced by a matrix if there is an interrelationship of the elements within a cluster or between two clusters (Yuksel & Dagdeviren, 2007).

In addition to interdependences among multiple criteria, personnel selection problems also involve decision-making in uncertain and vague situations, which requires an appropriate approach, such as fuzzy method, to deal with them. To obtain the final ranking values of candidates, Liang and Wang (1994) developed a fuzzy method to combine subjective assessments from interviews and objective assessments from tests. In their rating scheme, triangular fuzzy numbers (TFNs) were used to quantify the linguistic assessments of criteria weights and ratings. Yaakob and Kawata (1999) also used a fuzzy method to deal with workers' placement problem, and relationships among workers were included in the workers' assignment to make an adequate decision.

From the viewpoint of an employer, all applicants can be viewed as homogenous units. The evaluation results as well as ranking of applicants are substantially based on their relative performance. Thereby, data envelopment analysis (DEA) (Charnes, Cooper, & Rhodes, 1978) is a suitable technique for assessing the performance of applicants. DEA is a non-statistical and non-parametric technique for evaluating the relative efficiencies of a set of homogenous decision-making units (DMUs) that use multiple inputs to produce multiple outputs. Conceptually, the efficiency score of a DMU is measured by using the ratio of its weighted sum of outputs to its weighted sum of inputs. One of the characteristics of DEA is that each DMU determines a set of weights so as to reflect its best efficiency relative to all others. However, to prevent unfavorable factors from being ignored in the evaluation by setting a weight of zero to them, Charnes, Cooper, and Rhodes (1979) claimed that all weights should be greater than a small non-Archimedean number. In addition to this traditional way of assigning weights, the idea for weight restriction has been used in the relevant studies. One of the weight restriction methods is assurance region (AR) (e.g., Kao & Hung, 2008; Sun, 2004). Through the ARs obtained by prior information, DEA models can handle the cases in which the weights are subjected to predetermined relationship. When management is concerned with the degree to which the goals are met, then by setting the inputs of each DMU as one to neglect the difference and influence of inputs, the measurement result obtained is referred to as relative effectiveness (Chang, Hwang, & Cheng, 1995; Kao, Hwang, & Sueyoshi, 2003).

In conventional DEA, input and output data are treated as exact values on a ratio scale. In recent years, many researchers have developed DEA models to tackle the uncertain situations where some of the input or output data are not known exactly. Imprecise data can be expressed as fuzzy numbers, rank order data or bounded intervals.