Personnel selection fuzzy model

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Abstract

The paper presents a two-level personnel selection fuzzy model: short list and hiring decision. The model is an attempt to minimize subjective judgment in the process of distinguishing between an appropriate employee and an inappropriate employee for a job vacancy. The model comprises an analytic hierarchy process of three levels. The lowest level relates to the preliminary selection or shortlist procedure. Modifying multi-objective models of decision-making, the main decision elements are assumed as linguistic fuzzy variables. The problem is considered broad, since the worth values of the variables are calculated as expected values of the fuzzy variables. The second level relates to the hiring decision or selection of a final candidate for an employment opportunity. The selector assesses his/her own expectations of the short-listed job applicants. The expectations are treated by a probabilistic–possibilistic approach. The top level is the expected utility of hiring the successful candidate. Compared to the traditional way of selecting an appropriate short-listed job applicant this model minimizes individual judgment at both short-listed and hiring decision levels. The model is illustrated by a case study.

Keywords: personnel selection, analytic hierarchy process, multi-criteria fuzzy decision, fuzzy variables, membership function, probabilistic–possibilistic approach, confrontation ability

1. Introduction

Human resource management (HRM) is a process of managing people through recruitment and personnel selection, performance appraisal, reward systems, training and development (Pullin and Fastenau, 1998).

The selection process following the recruiting process should provide reliable and valid information about job applicants. The procedure to obtain such information usually involves several steps: completion of application form, initial interview, employment test, background investigation, preliminary selection, hiring decision. The initial interview is understood to be the main source of information about job applicants (Nankervis, Compton and McCarthy, 1993). The employment test provides a broader sampling of behavior. Contacting the previous employer of the job applicant usually provides background investigation. The preliminary selection is a decision-making process with elements that
are pro or contra the job applicant. The hiring decision is to accept or reject the short-listed applicant. In many organizations the use of summary forms and checklists to evaluate the preliminary selected or short-listed applicant follows the initial hiring decision.

The traditional hiring selection procedure uses a clinical or statistical methods approach. In the clinical approach decision-makers select upon their understanding of the job specifications and the individuals who have been successful in the preliminary selection. Job specifications include skill requirements, effort, responsibility, and job conditions. The procedure usually has personal biases and stereotypes ‘covered up by what appear to be rational basis for acceptance or rejection’. The statistical methods approach supports the hiring decision through the combination of test scores and the criterion of success for the applicant (Nankervis, Compton and McCarthy, 1993).

Both the preliminary selection and hiring selection procedures are crucial decision processes in personnel selection. However, they may be based on imprecise perceptions of a job applicant’s selector by relying on feeling, experience, emotion, appeal to other people’s understanding. In such situations people often act on their ‘gut feelings’ rather than strictly on a rational basis (Saaty, 1995). It is common sense that personnel selectors tend to include as many elements as possible in their decision-making process, without being able to clearly define which element has the greatest impact on the outcome of a decision. As a result, decisions could be made based on the persistence of some personnel selector or a personnel selector’s ability to persuade others to accept his or her ideas. Decisions chosen under such circumstances are defined as subjective judgment.

In order to avoid ‘gut feeling’ in a personnel selection decision-making procedure the analytic hierarchy process (AHP) has been introduced (Saaty, 1995; Lipovetsky, 1996; Labib, Williams and O’Connor, 1998; Iwamura and Lin, 1998). Combined with fuzzy logic numbers and multi-objective decision models it may help to avoid the problems of individual judgment (Liang and Wang, 1992; Pedrycz, 1996; Cheng, Young and Hwang, 1999, Chen and Chiou, 1999; Pal, 1999; Radojevic and Petrovic 1997).

The purpose of this paper is to provide an approach to minimizing subjective judgments in the crucial procedures of personnel selection: short-listed procedure and hiring decision procedure. In this respect, this paper is an attempt to create a multi-criteria fuzzy decision model based on AHP.

The paper is organized as follows. A theoretical foundation of the model formation is given in Section 2. The model is formulated in Section 3. A case study with numerical computation illustrates the modeling idea in Section 4. The paper ends with concluding remarks and directions for future work.

2. Theoretical foundation of the model formation

A common belief among business academics and practitioners is that HRM should be based on justice principles, particularly in hiring. The justice principle is understood as the process of decision-making to be carried out with the minimal influence of subjective judgments. The hiring procedure is the first contact of a future employee with an organization. Recent research by Bowen, Gilliland and Folger (1999) has shown that the employee’s commitment to the organization is dependent on the employee’s treatment in the hiring process. If the employees are fairly treated during the selection period, they should be more committed to the organization.

Reviewing contemporary personnel selection literature it seems that the challenging task of a
complex decision-making process that distinguishes appropriate employees from inappropriate employees could be treated as multi-hierarchical models of decision-making.

The multi-hierarchical approach usually implies the analytic hierarchy procedure (AHP). The AHP is a process for identifying, understanding, and assessing the interactions of variables in the chosen decision. It is based on the principle of constructing hierarchies, setting priorities, and logical consistency (Saaty, 1995).

The principle of constructing hierarchies relates to breaking down reality into homogeneous levels and subdividing these levels into smaller ones. The principle of setting priorities is based on comparison of pairs of similar alternatives against certain criteria, ‘and to discriminate between both members of a pair by judging the intensity of their preference for one over the other’. The principle of logical consistency states that similar ideas are grouped according to homogeneity and relevance. The intensities of relations among such ideas based on particular criterion justify each other in some logical way.

The AHP is structures on several levels, of which level one comprises the expected utility. The lowest level comprises alternatives that would contribute to the expected utility ‘through their impact on the intermediate criteria’ in the intermediate level. According to Lipovetsky (1996), the AHP has widespread application in decision problems involving multiple criteria in systems of many levels. The priority of each alternative and criterion is represented by the weight. Accordingly ‘summing the priorities of every alternative with the weights of every criterion creates a priority for the highest level. It leads the overall priorities of alternatives on each successfully higher level as a linear combination of the sub priorities derived for the previous level. Such summing through the whole hierarchical structure produces a synthesized judgment for all alternatives under the stated goal’.

In Barzilai’s (1998) opinion Saaty’s AHP modeling is limited to linear value functions in the case of single-level hierarchies. Although normalized weight criteria and alternatives do not have to be linear in the input data, value function is always linear in its variables. It indicates the simplified approach to understanding any decision process presented through AHP.

The AHP decision models are the subject of the research of Sage (1977), Keeny and Raiffa (1981), Ahmad (1990), Seydal and Olsen (1990). Based on AHP approach Lai (1995) defines the personnel selection process as a multi-objective decision-making problem. To Iwamura and Lin (1998) the personnel selection process depends on the achievement of different criteria. Since the criteria are achievable only at the expense of alternatives that underpin each criterion, there is a need to establish a hierarchy of importance among alternatives so as to satisfy as many criteria as possible in the order specified. Labib, Williams and O’Connor (1998) suggest that in the personnel selection process one should

- break down a complex decision process into component criteria;
- arrange these criteria or variables into a hierarchic order;
- assign numerical values to subjective judgments on the relative importance of each variable;
- synthesize the judgments to determine the overall priorities of the variables.

Consequently, it implies that the analytic hierarchy process (AHP) supports the personnel selection decision process.

Human judgments as a part of personnel selection are vague and imprecise. Accordingly, they can be treated by fuzzy logic as linguistic variables (Sakawa, Nishizaki and Hitaka, 1999).

The application of fuzzy set theory in the decision-making process under multiple criteria has been
the subject of research over the last two decades (Carlsson and Fuller, 1996). The basic postulate behind this work is that many real-world problems, including personnel selection, have more to do with fuzziness than randomness as the major source of imprecision (Zimmerman, 1992). In such situations it is appropriate to handle uncertainty by fuzzy set theory (Kacprzyk and Yager, 1985).

Some research on the creation of analytic hierarchic decision models based on fuzzy logic has been undertaken recently (Cheng, Young and Hwang, 1999; Chen and Chiou, 1999; Pal, 1999; Radojevic and Petrovic, 1997; Pedrycz, 1996). It is mainly concentrated on the application of AHP and some attempts to avoid subjective judgment in processes that do not relate to personnel selection.

Cheng, Young and Hwang (1999) developed a method for evaluating systems by AHP based on linguistic variable weight. The model was applied in military systems. They believe that AHP is to a certain extent applicable to present simple decision processes. However, if the decision process is a complex system with an unbalanced scale of judgment, ‘the subjective judgment, selection and preference of decision-makers influence the AHP method’. In order to avoid it, Cheng et al. suggest the use of fuzzy logic. They use the membership function to calculate the performance score, and ‘identify expectation of the decision-maker to avoid the constraint of system alternatives and subjective judgments of decision-makers’. They calculate the importance of relative weight through the centralization of dilation power of the weight value. Then they ‘select the minimal membership function of attribute under its alternatives, and rank all of the alternatives. The best alternative is the maximal membership function’.

Chen and Chiou (1999) use the fuzzy set theory to describe imprecise human subjective judgment in a process of credit rating. According to them the fuzzy integral is defined as ‘the maximal degree of agreement between the objective evidence and the associated degree of importance for various information sources’. It consists of both objective evidence supported by various evaluation criteria and the expected worth of subsets of these criteria. A fuzzy approach for rating business credit is presented in a tree-like hierarchical decision structure. A basic hierarchical structure is used to aggregate credit-rating information. The lower level nodes are presented with two variables, the degree of importance and the objective evidence of each lower criterion. Five linguistic weighing terms and their three inclination terms are used ‘to obtain loan officers’ assessment on the relative importance’ of each lower criterion in a basic hierarchical structure. Triangular fuzzy numbers describe subjective judgments. By using the fuzzy numbers Chen and Chiou made the final credit-rating results sensitive to changes of credit information.

Chen and Chiou’s approach, although applicable in credit rating, highlights that fuzzy logic is applicable in imprecise human subjective judgment. This seems to be important to confirm the usefulness in fuzzy logic to eliminate subjective judgment in decision processes in general.

The popularity of fuzzy logic in decision-making processes is spreading even to legal systems. Pal (1999) applies a model of case similarity assessment based on fuzzy proximity relations for legal decision-making processes.

Radojevic and Petrovic (1997) propose ‘fuzzy set theory and approximate reasoning as an appropriate framework to imitate human reasoning in expressing a preference structure’. Each criterion in the process of decision-making should be explained by linguistic variables.

Pedrycz (1996) argues that fuzzy models can be developed and studied at linguistic levels. As such they can include both numerical and fuzzy-set type quantities. The models can be presented in the form of an input–output model with three conceptual blocks: input interface, processing block, and output interface. Each of the blocks can be explained through neural networks and logic processors in
particular. The other way of presenting fuzzy models could be hierarchical fuzzy modeling. It highlights the possibility of selecting the most suitable fuzzy model that best fits the character of the provided data. The crucial point is to pay attention to the ‘transformation of the available information from its numerical level into the internal form acceptable by the processing unit’. Development of hierarchical fuzzy modeling could contribute to a general concept of ‘soft computing by adding an extra flexibility in processing heterogeneous information’.

Two approaches can be identified in the contemporary literature on fuzzy logic modeling as it relates to HRM personnel selection. The first approach comprises personnel evaluation in the entire process of appropriate job applicant selection (Liang and Wang, 1992; Cannavacciuolo et al., 1994). The second approach evaluates the workers’ suitability in an industrial environment (Yaakob and Kawata, 1999).

Liang and Wang (1992) evaluate personnel suitability and job vacation by implementing concepts of fuzzy set theory. The degree of matching between personnel and job is expressed by a fuzzy suitability index. The approach is an attempt to model the entire HRM selection. The model is divided into two levels. The first level determines the decision-maker’s evaluation criteria. The second level assigns ratings to different personnel under each evaluation criterion. Liang and Wang’s approach to optimal personnel placement does not distinguish between the short-listing step and hiring-decision step in selection procedure as the important part of HRM personnel selection function.

Cannavacciuolo et al. (1994) propose an interesting approach to personnel evaluation through the application of fuzzy logic. In their understanding, the fuzzy set theory helps to both highlight and to create an easy model for decision situations that are normally overlooked by traditional models in personnel evaluation. It also contributes to simplifying the translation from human reasoning into procedures. However, in the selection of an appropriate candidate for an employment opportunity Cannavacciuolo et al., similar to Laing and Wang, do not make use of short-listing selection or hiring-decision selection. Yaakob and Kawata (1999) created a fuzzy workers’ placement model based on individual and group evaluation. The model is the improved Cannavacciuolo et al. (1994) approach to personnel evaluation. Similar to Liang and Wang and Cannavacciuolo et al., the Yaakob and Kawata model does not cover the most important part of the HRM employee selection procedure.

The fuzzy decision models consider decision problems mainly through two approaches:

1. the solution search procedure that starts from the top-level solution to the lower level solutions. This is known as Stakelberg strategy (Wen and Bialas, 1986);
2. AHP solution search procedure for which the decision-makers at the lower level optimize their objective function, taking a goal or preference of the upper level into consideration (Lai, 1996).

Ahmad used the second approach to develop a decision model in the construction industry (Ahmad, 1999). He divided the decision process into deterministic implementation and probabilistic implementation. Deterministic implementation captures decision alternatives, information, and preferences of decision-making. It comprises a subjective evaluation while deciding. Accordingly, the decision process is a multi-criteria decision procedure based on a binary choice situation. The binary decision problem consists of a three-level hierarchy. The first level is an overall top-level objective formulated as an expected utility. The second level is a decision criteria, and the third level is decision alternatives. The same set of alternatives underpins each criterion. The importance of each criterion is assigned by an appropriate weight. Once the weights are assigned to all levels of the hierarchy, the weights along each branch are multiplied and the products are summed for each alternative. Then the alternatives are ranked. The alternative with the largest weight is designed as preferred.
According to Sage (1977) the worth assessment procedure comprises the:

- list of variables that influence upon criteria of the highest importance. The purposes are worth-independent;
- establishment of overall performance criteria and subdivision of each criterion into its lower constitute alternative;
- measurement of the degree of criteria satisfaction.

A probabilistic implementation of the decision process relates to the establishment of the probability assessment of risk attitudes in choosing the alternatives based on the maximization of expected utility.

The Ahmad (1990) and Sage (1977) approach to multi-criteria decision model comprises individual judgments in worth assessment of each alternative and each criterion. As such, it could be used as a theoretical foundation of the personnel selection fuzzy model (PSFM). If the worth assessment is replaced by a membership function which minimizes the influence of subjective judgment through multi-level process of decision-making, the PSFM could be established.

3. PSFM—personnel selection fuzzy model

The decision process of selecting appropriate employees from inappropriate employees could be divided into deterministic implementation and fuzzy logic implementation (see Figure 1). Deterministic implementation defines the expected utility
where: \( P \) is a simple probability measure on a decision alternative \( X \), \( u \) is a real-valued function on \( X \).

Decision alternative \( X \) is underpinned by attributes. Each attribute \( S_i \) is a linguistic fuzzy variable from which worth \( S_i^f \) and corresponding worth weight \( w_i^f \) are determined. Total worth \( S \) influences upon decision whether to short list:

\[
S = w_1 S_1 + w_2 S_2 + \ldots w_n S_n
\]

where

\[
w_1 + w_2 + \ldots + w_n = 1
\]

\[0 \leq S_i \leq 100, \quad i = 1, 2, \ldots n\]

Value \( S_i \) represents the influence of corresponding factor \( i \) into a final short-list decision. Worth weight \( w_i \) determines the degree of significance of the corresponding element compared to other elements. The degree of significance minimizes direct influence of a decision-maker to the whole selection procedure.

Each factor has a threshold worth that expresses the degree of desirability of the strength of the decisions. It is different from the minimum permitted value \( S \).

Total threshold worth is

\[
S^* = w_1^* S_1^* + w_2^* S_2^* + \ldots w_n^* S_n^*
\]

Difference

\[
D = S - S^*
\]

is used for determination of decision power coefficient \( d \) to stress the justification of decision to short list, where

\[
d = k \quad \text{for} \quad 10(k - 1) < D \leq 10k, \quad k = 1, 2, \ldots 10
\]

\[
d = 0 \quad \text{for} \quad D < 0
\]

Coefficient \( d \) justifies a decision to short list.

Threshold worth \( S_i^* \) is assigned for each factor.

For example, a `financial background' attribute of a job applicant may be qualified as: extremely good, very good, good, satisfactory and bad (see Figure 2). For each of these qualifications the corresponding values of membership function \( \mu \) can be attached by the possible worth fuzzy variables \( S_i^f \).

The fuzzy variable \( S_i^f \) is expressed by pairs of values

\[
S_i^f = \{ S_i^1/\mu_i^1, S_i^2/\mu_i^2, \ldots S_i^k/\mu_i^k \}
\]

The expected value of variable \( S^e \) is by Zadeh's (1968) theory of probability of fuzzy events

\[
S^e = \frac{S_i^1*\mu_i^1 + S_i^2*\mu_i^2 + \ldots S_i^k*\mu_i^k}{\mu_i^1 + \mu_i^2 + \ldots + \mu_i^k}
\]
The fuzzy variables, which determine good financial background and bad financial background, are:

- **good financial background**: \( S_f^1 = (0/0.10, 20/0.20, 40/0.40, 60/0.70, 100/0.80) \)
- **bad financial background**: \( S_f^2 = (0/0.30, 20/0.40, 40/0.80, 60/1.00, 100/0.40) \).

The expected values for \( S_f^1 \) and \( S_f^2 \) are:

- for the **good financial background**
  \[
  S_f^1 = (0*0.10 + 20*0.20 + 40*0.40 + 60*0.70 + 80*1.0 + 100*0.80)/
  (0.10 + 0.20 + 0.40 + 0.70 + 1.00 + 0.80) = 64.55
  \]

- for the **bad financial background**
  \[
  S_f^2 = (0*0.30 + 20*0.40 + 40*0.80 + 60*1.0 + 80*1.0 + 100*0.40)/
  (0.30 + 0.40 + 0.80 + 1.00 + 0.40) = 48.28
  \]

Worth weights imply the significance of some alternatives or attributes, that are to be compared with satisfaction of the other alternatives or attributes. Since there are two hierarchical levels of criterion classification, the worth weights are determined at a higher level and then at a lower level, independently. The results obtained assign final values of worth weights. It is assumed that the attributes of an alternative or sub-alternative sets are worth-independent. Each lower-level attribute is
independent in the sense that the effect of double counting is eliminated. A pair of attributes is independent of a third attribute if a given level of the third attribute does not affect the value trade-off between the attributes of the pair. This is known as preferential independence, since it implies that the degree of preference over the levels of one alternative is not dependent on the levels of the other criteria (Keeny and Raiffa, 1981). The mutual preferential independence (pairwise) implies additivity.

Determination of worth weights at each level independently contributes to application of proper value-judgment principles.

The starting point is a level on which criteria are defined by a corresponding order determining the relative values of worth weights (see Table 2).

The first value of the first alternative, which is called ‘Lead the implementation of EVA (economic value added) drivers’, equals 1 (see Table 2). It is compared by the factor of significance with the second alternative, related to the ‘Provide financial analysis for development, maintenance and communication of the business plan’. The significant relation of these two criteria is established. If it is 1:1.2, then the relative values of worth weights are

\[ w_{1e}^{(1)} = 1, \quad w_{2e}^{(1)} = 1.200 \]

Then the values of the second and third alternatives are compared. Suppose they are 1:0.8. The relative value of the third alternative to ‘Team work’ is

\[ w_{3e}^{(1)} = 0.8 \times w_{2e}^{(1)} = 0.8 \times 1.2 = 0.960 \]

Finally, the third alternative and fourth alternative are compared, relating to ‘Develop business model to support business plan’. Let it be: 1:1.20. The relative value of the fourth alternative is

\[ w_{4e}^{(1)} = 1.2 \times w_{3e}^{(1)} = 1.2 \times 0.96 = 1.152 \]

Normalized relative weights of the starting point level, are

\[ w_1^{(1)} + w_2^{(1)} + w_i^{(1)} + w_n^{(1)} = 1 \quad (9) \]
### Table 2
Preliminary selection for the senior economic and financial analyst employment opportunity

<table>
<thead>
<tr>
<th>Decision alternative</th>
<th>Pairwise component</th>
<th>Relative weight</th>
<th>Normalized weight</th>
<th>Attributes</th>
<th>Pairwise component</th>
<th>Relative weight</th>
<th>Normalized weight</th>
<th>Overall normal weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>I XI</td>
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</tr>
<tr>
<td>1 Lead the implementation of EVA drivers</td>
<td>wi(1)</td>
<td>1.000</td>
<td>0.2319</td>
<td>j SI</td>
<td>wij</td>
<td>1.00</td>
<td>1.00</td>
<td>0.179</td>
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<tr>
<td></td>
<td>2 Key drivers</td>
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<td></td>
<td>3 Facilitation</td>
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<td>4 Training</td>
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<td></td>
<td>5 Coaching skills</td>
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<td>6 Reliable</td>
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<tr>
<td>Sum</td>
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</tr>
<tr>
<td>2 Provide financial analysis for development, maintenance and communication of the business plan</td>
<td>1.200</td>
<td>0.2783</td>
<td>j SI</td>
<td>wij</td>
<td>1.00</td>
<td>1.00</td>
<td>0.6667</td>
<td>wi*</td>
</tr>
<tr>
<td></td>
<td>2 Business planning background</td>
<td>0.5</td>
<td>0.50</td>
<td>0.3333</td>
<td>0.0928</td>
<td>62</td>
<td>50</td>
<td>5.75</td>
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<tr>
<td>Sum</td>
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<td></td>
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<tr>
<td>3 Team work</td>
<td>0.80</td>
<td>0.960</td>
<td>0.2226</td>
<td>j SI</td>
<td>wij</td>
<td>1.00</td>
<td>1.00</td>
<td>0.4545</td>
</tr>
<tr>
<td></td>
<td>2 Ability to work in different business units</td>
<td>1.2</td>
<td>1.20</td>
<td>0.5455</td>
<td>0.1214</td>
<td>65</td>
<td>44</td>
<td>7.89</td>
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<tr>
<td>Sum</td>
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<tr>
<td>4 Develop business model to support business plan</td>
<td>1.20</td>
<td>0.2672</td>
<td>j SI</td>
<td>wij</td>
<td>1.00</td>
<td>0.2226</td>
<td>0.126</td>
<td>wi*</td>
</tr>
<tr>
<td></td>
<td>2 Strategic thinking</td>
<td>0.7</td>
<td>1.00</td>
<td>0.397</td>
<td>0.1061</td>
<td>40</td>
<td>65</td>
<td>4.24</td>
</tr>
<tr>
<td></td>
<td>3 Computer excel skills</td>
<td>1.2</td>
<td>0.8400</td>
<td>0.477</td>
<td>0.1273</td>
<td>74</td>
<td>60</td>
<td>9.42</td>
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<tr>
<td>Sum</td>
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</tbody>
</table>

Note: Bold numbers are calculated numbers, D equals 18.47, d equals 2
where
\[ w_{i}^{(1)} = w_{i}^{e(1)}/\sum w_{i}^{e(1)} \]  

In the case study example provided
\[ \sum w_{i}^{e(1)} = 1.000 + 1.200 + 0.960 + 1.152 = 4.312 \]
\[ w_{1}^{(1)} = 0.2319, \ w_{2}^{(1)} = 0.2783, \ w_{3}^{(1)} = 0.2226, \ w_{4}^{(1)} = 0.2672 \]

For each set of attributes, the relative weights are determined. That is, after normalization, the relative weights \( w_{ij} \) are defined, where \( i \) is ordinal number of criteria of the starting point level, \( j \) is ordinal number of attributes of the corresponding group. The final worth weights of alternatives and attributes are
\[ w_{k} = w_{i}^{(1)} + w_{ij}^{(1)} \]  

\( S \) and \( S^* \) are determined by equations (2) and (4) respectively. The difference \( D \), by equation (5) indicates whether to short-list or not.

After determination of a short-list, the second level of the PSFM model should be defined. This is a process of selecting the final candidate for the employment opportunity. For the given alternative \( X_i \) a resulting membership function \( \mu(t) \) can be derived. This function is dependent on a possibility of providing the selected candidate in time \( t \). Following Zadeh’s probabilistic–possibilistic approach (1978) the function \( F^*(t) \) for the alternative \( X_i \) can be formulated
\[ F^*(t) = \frac{1}{\alpha_n} \int_{0}^{t} f^*(t) \, dt \]  
\[ f^*(t) = f(t)\mu(t), \quad \alpha_n = \int_{0}^{t} f^*(t) \, dt \]  
\[ f(t) = \frac{1}{\sigma \sqrt{2\pi}} \exp[-(t-t_e)^2/2\sigma^2] \]  

where: \( t_e \) is expected time to effectively join the company; \( \sigma \) is standard deviation to effectively join the company.

The alternative \( X_i \) for the attribute \( S_i \) for the time \( t \) is assumed to be a fuzzy event with the probability of occurrence \( F^*(t) \). \( \alpha_n \) is a normalizing factor (Prascevic and Petrovic-Lazarevic, 1997).

Expected time \( t_{e}^* \) of providing alternative \( X_i \) as a fuzzy event is
\[ t_{e}^* = \int_{0}^{t} f^*(t) \, dt \]  

\( t_{e}^* \) is possible and probable expected time of providing alternative \( X_i \) (Prascevic and Petrovic-Lazarevic, 1996).

The selector can access his/her own expectations of the attribute \( S_i \), such as confrontation ability \( \phi(t) \), for the short-listed candidate, based on the available information.

For the probabilistic approach expected confrontation ability \( \phi \) for the candidate \( i \) is
\[ \phi_e^* = \int_0^\infty f(t)\phi(t) \, dt \] (16)

In a similar way, expected confrontation ability \( \phi \) for the probabilistic–possibilistic approach may be derived by the following formula

\[ \phi_e^* = \int_0^\infty f^*(t)\phi(t) \, dt \] (17)

In addition to these characteristic values, the following coefficients should be calculated

- expected time coefficient
  \[ k_t = \frac{t_e^*}{t_e} \] (18)

- expected confrontation abilities coefficient
  \[ k_c = \frac{\phi_e^*}{\phi_e} \] (19)

The candidate will be selected with a minimum \( \phi_e^* \) and values of \( k_t, k_c \) and normalizing factor \( \alpha_n \) which are close to 1.

If these values, especially \( \alpha_n \) are different from 1 then there is a difference between the candidate’s possibility and probability to start a new job. Therefore the candidate who has a minimal value of the confrontation abilities \( \phi_e \)

\[ \phi_n = \min \phi_e^* k_t k_c / \alpha_n \] (20)

will be selected.

To test the applicability of the model to its conception (Borenstein, 1998) the PFSM was verified in the selection process of a telecommunications industry company. Since the HRM issues are sensitive the verification is implied and presented in the form of a case study.

4. Case study

The employment opportunity is: Senior economic and financial analyst for the corporate unit of an ABC telephone company. The overall objective of the company is a share growth of 10%. Lower-level objectives, or decision alternatives, determined through the job vacancy perspective are:

1. to lead the implementation of economic value added (EVA) drivers;
2. to provide financial analysis to use for development, maintenance, and communication of the business plan;
3. to instigate team work;
4. to create a business model to support a business plan.

Attributes are listed below

1. Lead the implementation of EVA drivers
   1.1 Value-based management background
   1.2 Key drivers
1.3 Facilitation
1.4 Training
1.5 Coaching skills
1.6 Reliability
2. Provide financial analysis for development, maintenance, and communication of the business plan
   2.1 Financial background
   2.2 Business planning background
3. Instigate a team work
   3.1 Team player
   3.2 Ability to work in different business units
4. Create a business model to support a business plan
   4.1 Economic-mathematical background
   4.2 Strategic thinking
   4.3 Computer excel skills

The values of relative weights are given in Table 1. The indicator of justification of being short-listed $D$, by equation (5) is

$$D = 68.78 - 50.30 = 18.47$$

and by equation (6)

$$d = 2$$

Therefore, there is a significant justification of the decision to short-list. The candidates with the

- financial background attribute, and
- decision alternative: Provide financial analysis to use for development, maintenance, and communication of the business plan

should be given priority in the process of selection of the final candidate for the vacancy.

Two candidates have been short-listed.

According to a created computer program (Prascevic and Petrovic-Lazarevic, 1992), input data are: number of short-listed candidates, expected time $t_e$, standard deviation $\sigma$, values of membership function $\mu(t)$ and confrontation abilities $\phi(t)$ for every short-listed candidate. A time interval is selected $[t_e - \sigma_1, t_e + \sigma_1]$ and divided into 18 sub-intervals for numerical calculations of all characteristic values.

The expected time for Candidate One to effectively join the ABC company is

- $t_e = 200$ days
- standard deviation to effectively join ABC company $\sigma = 60$ days
- normalizing factor $\alpha_n = 0.6751$
- $t_e^* = 222.2$ days
- $k_t = 1.111$
- $k_e = 1.007$
- expected confrontation ability, $\phi_e = 554.98$
- possibly expected confrontation ability $\phi_e^* = 558.72$
- valid confrontation ability $\phi_n = 925.73$ (see Table 3a).
The expected time for Candidate Two to effectively join the ABC Company is 

- $t_e = 210$ days 
- standard deviation to effectively join ABC company $\sigma = 57$ days 
- normalizing factor $\alpha_n = 0.5207$ 
- $t_e^* = 210.0$ days 
- $k_t = 1.129$ 
- $k_c = 1.005$ 

- expected confrontation ability, $\phi_e = 557.23$ 
- possibly expected confrontation ability $\phi_e^* = 560.23$ 
- valid confrontation ability $\phi_n = 1221.44$ (see Table 3b).

According to the results, the expected possible confrontation abilities are similar for both candidates. Candidate Two has 

- $\alpha_n$ which is less favourable 
- a bigger difference between the possibility and probability of providing the purpose $i$ for the attribute
Ai in the time $t$, and

- much bigger value $\phi_n$

than Candidate One.

Hence the recruiter has to select Candidate One.

### 5. Conclusion

A common belief among business academics and practitioners is that HRM should be based on justice principles in hiring employees. The justice principle argues that the personnel-selection decision process should be carried out with minimal influence of subjective judgment. In order to avoid individual value judgment in the selection process’s stages of preliminary selection and hiring decision it is proposed to implement the PSFM.

The proposed PSFM uses the AHP as a basis for selecting the appropriate candidate for an employment opportunity. Similar to other AHP-based decision models such as Cheng, Young and Hwang (1999), Chen and Chiou (1999), Ahmad (1990), Sage (1977) that are not applied in HRM, the
PSFM lower-level decisions influence the higher-level decisions. In an effort to avoid the influence of subjective judgment, the lower level is underpinned by linguistic fuzzy variables. Worth and corresponding worth weight explain each linguistic fuzzy variable. Since the worth of a linguistic variable represents the influence of this variable into a preliminary selection level, in order to overcome the possible subjective judgment the pairwise component is introduced. With the normalized weight and explained procedure the justice principle remains in personnel selection procedure. Furthermore, the second level of PSFM presents a filter to short-listed candidates for an employment opportunity. Being based on standard statistical procedure common to HRM, but highlighting additional important criteria for selection, it is relevant of eliminating bias.

The model is based on a computer program that can be easily adapted to any specified personnel selection problem.

PSFM could be further developed towards inclusion of other aspects of managing people through the application of neurofuzzy logic to a wide cross-section of HRM processes.

References


