

A Fuzzy Multiple Criteria Decision Making Model in Employee Recruitment

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Summary

This study is intended to improve the lack of recruitment processes as well as reduce individual senses of supervisory level by fuzzy logic and Analytic Hierarchy Process methods. This study tries to identify appropriate personality traits and key professional skills through the information statistics and analysis of Analytic Hierarchy Process in order to expect the recruitment process be more reasonable based on the fuzzy multiple criteria decision making model to achieve the goal of merit-based selection. The results showed that the fuzzy multiple criteria model constructed in this study could indeed solve the shortcomings in existing enterprises' recruitment, and provide more information for decision-making reference.

Key words:

AHP, fuzzy logic, multiple criteria, decision making, employee recruitment

1. Introduction

Human resources are important assets of enterprises, and competition in the enterprise has become a competition for talent. Most enterprise managers are hoping to find appropriate candidates. It means that employee recruitment has become one of the most important and indispensable activities [1]. However, it is a very expensive activity which requires a large number of cost and time. Enterprises' demand should not be considered unilaterally as well as candidates' individual needs and expectations should also be taken into account in order to avoid recruiting unsuitable personnel and low effectiveness. Therefore, how to design the approach becomes a prerequisite for a company to recruit qualified and suitable employees [2].

If a set of personnel database is integrated and equipped to assist the recruitment, most problems can be solved, including: how to attract talents to enter the business, the unification of the recruitment processes, strengthening service quality, preservation, management and backup of biographical data [3]. Therefore, the productivity of human resource unit can be improved as well as its

strategic role and status can be strengthened. It would not only allow enterprises being easy to understand the human resource context, facilitating control and scheduling, but also allow them realizing job vacancies to recruit and train new employees [4].

Today's information services industry is highly knowledge-intensive, which embraces a wide range. With the advances in science and technology improvement, one can say that its applications cover all the industries. The professional threshold is no longer limited to information personnel. It is more and more common to cooperate with professional talents in other areas. In order to grasp and organize personnel as well as to identify the appropriate staff, employee recruitment will contribute to the operation and development of enterprises [5].

This study is focused on the recruitment of mid-level supervisory staff for information industry. It is intended to improve the lack of recruitment processes as well as reduce individual senses of supervisory level by fuzzy logic and Analytic Hierarchy Process methods. This study tries to identify appropriate personality traits and key professional skills through the information statistics and analysis of Analytic Hierarchy Process in order to expect the recruitment process be more reasonable based on the fuzzy multiple criteria decision making model to achieve the goal of merit-based selection.

2. Literature Review

2.1 Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process, a multi-objective decision-making method, was developed by Saaty in 1971 [6]. It is mainly used in the uncertainty of decision-making issues with many assessment criteria. The interactive hierarchies are intended to make effective decision-making for complex issues or uncertainty in risk, or to search for consistency when determining divergence. After constant application, modification and validation, the entire theory of AHP was completed in 1980. The theory is simple and

Manuscript received July 5, 2009

Manuscript revised July 20, 2009

easy to operate. It can capture the majority of experts and policy makers' opinions at the same time, which is very practical in practice [7].

Application of AHP method to deal with complex issues can be broadly divided into the following six steps:

(1) Problem definition

The system of problem should be maximized to cover all the possible factors. At the same time, the planning group should be established to define the scope of the problem.

(2) Construction of hierarchy

Members in the planning group identify the criteria and Sub-criteria of action affecting the problem, as well as the nature of alternatives and alternative programs with brainstorming; secondly, report this preliminary structure to decision-makers or decision-making groups for amendment; then, the planning group or members in decision-making group check all the elements affecting the problem, determining the Binary Relation between them; if the decision is made by the planning group, it is required to report to decision-makers or decision-making group; finally, construct the hierarchy of the whole problem with Interpretive Structural Modeling or Hierarchical Structural Analysis.

(3) Questionnaire design and survey

Elements of each hierarchy should be compared in pairs taking one element in the previous hierarchy as a benchmark. Therefore, each paired comparison needs a questionnaire design, decision-makers or members in decision-making group fill out the 1-9 scale. The questionnaire has to clearly describe the questions for each paired comparison with detailed notes.

(4) Consistency testing

According to survey results, establish pairwise comparison matrix, get the Eigen-values and eigenvectors with a calculator or computer, and then test the consistency. If the consistency of matrix does not meet the requirements, it shows inconsistencies in decision-makers to determine, for that reason, planners should explain it clearly to decision-makers.

(5) Hierarchy consistency testing

If the consistency in each pairwise comparison matrix is consistent with the requirements, it is necessary to test the consistency of the whole hierarchy. If it does not meet the requirements, it means the correlations between elements have problems, which should be analyzed again.

(6) The choice of alternative

If the whole hierarchy passes the consistency testing, the priority vector of alternative can be obtained. If there is only one decision-maker, it is only required to calculate the priority level of alternative; if there is a decision-making group, it is required to calculate the alternatives for each decision-making member. Finally the weighted integrated comment is obtained with weighted average method, which is used to determine the priority of alternatives [6][7].

2.2 Fuzzy Analytic Hierarchy Process (FAHP)

Since AHP cannot overcome the ambiguity in decision-making, Laarhoved & Pedrycz (1983) evolved Saaty's traditional AHP, and developed it into FAHP, they substituted triangular fuzzy numbers directly into the pairwise comparison matrix, so as to deal with the ambiguity in criteria measuring and decision-making [8].

The traditional AHP had some shortcomings in its application. It was unable to cope with the subjective, vague and imprecise properties in people's decision-making. Buckley (1985) modified Saaty's AHP paired comparison values, and then he used trapezoidal fuzzy numbers to express the relative important criteria, and then obtained fuzzy weights with geometric mean [9].

In assessing customers' demand for service quality, usually traditional ways are not easy to express. But in fuzzy theory, the "linguistic variable" is used to overcome this barrier to express customers' importance. "Linguistic variable" refers to the variable is natural or artificial word or phrase, which is primarily used to deal with complex or ill-defined circumstances. Traditional way of AHP assessment takes researcher's vague ideas as a specific value to output, thus neglecting the characteristics of inter-numerical and linguistic "plausibility". In order to make up for the inadequacy of traditional methods, the calculation of fuzzy theory is used to express the meaning of linguistic variable. As FAHP uses fuzzy concept, there will not have overall disparity due to researcher's preferences for certain factors, which is far more objective than the traditional AHP [10].

3. Research Methodology

3.1 Design the expert questionnaire

The first step of the research methodology in this study is to design the expert questionnaire. After referring to relevant literatures and interviews with business experts, the questionnaire is classified into two parts: one is personal traits, such as "ability traits, personality traits,

motivation traits", the other is management skills, such as "technical skills, interpersonal skills, conceptual skills".

The effectiveness of the questionnaire is tested with a validity check. The content of the questionnaire is adjusted according to pre-test results, and at last the final questionnaire is defined by the fuzzy theory. After recovering all expert questionnaires, the dimensions of information are reduced with factor analysis, supplemented by the concepts of fuzzy logic method, the values, maximum value and geometric mean of importance are identified. Because the geometric mean can present all the experts' opinions best, it is used as the basis to set the threshold value. The factors above the threshold value are selected and retained, that is, it is intended to select the influencing factors with higher importance.

3.2 Construct AHP framework

(1) Construct the hierarchy framework

This study used AHP to break down complicated decision-making issues into several specific items. Generally, the framework of AHP can be divided into Tri-Tiered, the first Tier is Goal, which can be regarded as the ultimate goal of selection; the second Tier is Aspects / Objectives, which are the objectives to be achieved based on the Goal; the third Tier is sub-Criteria [6].

The purpose of the framework is to systematize the complexity of the problem. Through the decomposition in different hierarchies, decision-making problems and objectives are clearer. Individual hierarchy can be grouped to get different combinations, the elements or criteria affecting the system are grouped into a number of hierarchies, interaction and impact of the whole system should be a consideration. Therefore, when constructing the framework there are two issues to be solved: one is how to establish the hierarchical relationship, and two is how to assess the impact of properties in each hierarchy. The hierarchy structure is started from the overall goal, and then spread up to aspects and objectives, after that, the relevant criteria or attributes are defined.

(2) Establish pairwise comparison matrix

Pairwise comparison is carried out aiming at the elements in a certain hierarchy, so as to get the importance. The assessment scale of AHP has five items, that is, Equally Important; Slightly Important; Important; Very Important; Absolutely Important, with 1, 3, 5, 7, 9 measurement values. There are another four items with 2, 4, 6, 8 measurement values. Pairwise comparison matrix is established according to the results of the comparison with various elements, as shown in Figure 1 [7]:

$$A = [a_{ij}] = \begin{matrix} & \begin{matrix} A_1 & A_2 & \Lambda & A_n \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{matrix} & \begin{bmatrix} W_1/W_1 & W_2/W_1 & \Lambda & W_n/W_1 \\ W_2/W_2 & W_2/W_2 & \Lambda & W_n/W_2 \\ \vdots & \vdots & \ddots & \vdots \\ W_n/W_n & W_n/W_n & \Lambda & W_n/W_n \end{bmatrix} \end{matrix} = \begin{bmatrix} 1 & a_{12} & \Lambda & a_{1n} \\ 1/a_{12} & 1 & \Lambda & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \Lambda & 1 \end{bmatrix}$$

Fig. 1 Pairwise comparison matrix

where a_{ij} is the importance difference that element i is more important than element j.

$$a_{ji} = 1/a_{ij}, \quad i=1,2,\dots,n, \quad j=1,2,\dots,n$$

(3) Determine the weight of overall hierarchy

Weight determined by AHP is calculated by decision-makers based on paired comparative information constructed, so as to show that the importance difference between two assessment criteria. For example, there are N projects to be selected, decision-makers should establish paired comparative data, and further deduce the relative importance of criteria in the conditions with different consistency. Saaty used scaling ratio to derive the main eigenvector of pairwise comparison matrix, and then identifying the relative weights among criteria in the framework. Basically AHP scale includes five items: that is, Equally Important; Slightly Important; Important; Very Important; Absolutely Important with 1, 3, 5, 7, 9 measurement values; another four items are with 2, 4, 6, 8 measurement values. The significance of scale is represented in Table 1 [6][7].

Table 1: Definition and description of AHP scale

Scale	Definition	Descriptions
1	Equally Important	Two comparison projects' contribution levels have equal importance
3	Slightly Important	Experience and decision prefer a particular project slightly
5	Important	Experience and decision prefer a particular project
7	Very Important	Actually showing a very strong tendency of the preference on a particular project
9	Absolutely Important	Sufficient evidence to confirm there is a preference on a particular project absolutely
2,4,6,8	Intermediate value between adjacent scales	When intermediate value is needed

3.3 Comprehensive assessment of fuzzy multiple criteria decision-making model

Since Zadeh (1965) proposed the fuzzy theory [11], Bellman and Zadeh (1970) explored the decision-making methods under fuzzy environment [12]. They made fuzzy theory have a considerable theoretical basis in the study of uncertainty or subjective understanding issues. When fuzzy multiple criteria decision making theory and FAHP are introduced into the activities of personnel recruitment, the decision-making methods more complying with decision-makers' thinking are used, and the framework of a decision support system is constructed. The traditional multiple criteria analysis did not directly use the concept or method of fuzzy to solve the problem of inaccurate. So this study used it to construct a fuzzy selection model to address the ambiguity in staff recruitment.

(1) Fuzzy Number

Fuzzy number is a Fuzzy Subset of Real Number, and it represents an expansion of the confidence interval. According to Dubois and Prade's (1978) definition [13], fuzzy number means a Fuzzy Set and its membership function is $\mu_A(x): R \rightarrow [0,1]$ (in which, x refers to the score of assessment item), the function has following characteristics:

1. $\mu_A(x)$: refers to the continuous mapping from definitional domain R to $[0,1]$ space;
2. $\mu_A(x)$: a Convex fuzzy subset Mapping;
3. $\mu_A(x)$: Normalization of a fuzzy subset, that is, there is a number x_0 that makes $\mu_A(x_0)=1$;

If a number meets the above conditions, it is referred to as the fuzzy number. Operation about triangular fuzzy number $\mu_A(x)=(L,M,U)$ is shown in Equation (1) [13]:

$$\mu_A(x) = \begin{cases} (x-L)/(M-L) & L \leq x \leq M \\ (U-x)/(U-M) & M \leq x \leq U \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

According to the characteristics and expansion principle of triangular fuzzy function stipulated by Zadeh (1965), the algebraic operation of $\mu_{A1}(x)=(L_1, M_1, U_1)$ and $\mu_{A2}(x)=(L_2, M_2, U_2)$ is as follows [11][14]:

1. Addition of fuzzy numbers
 $(L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1 + L_2, M_1 + M_2, U_1 + U_2)$ (2)
2. Multiplication of fuzzy numbers

$$(L_1, M_1, U_1) \odot (L_2, M_2, U_2) = (L_1 L_2, M_1 M_2, U_1 U_2) \quad (3)$$

For any real number k:

$$k \odot \mu_A(x) = k \odot (L, M, U) = (kL, kM, kU) \quad (4)$$

(5)

3. Subtraction of fuzzy numbers

$$(L_1, M_1, U_1) \ominus (L_2, M_2, U_2) = (L_1 - U_2, M_1 - M_2, U_1 - L_2) \quad (5)$$

(6)

4. Division of fuzzy numbers

$$(L_1, M_1, U_1) \oslash (L_2, M_2, U_2) = (L_1/U_2, M_1/M_2, U_1/L_2) \quad (6)$$

(7)

(2) Linguistic Variable

For the complex situations, it is difficult to express reasonable with traditional quantified methods. Therefore, it is necessary to use linguistic variable. Linguistic variable refers to the variable represented by a word or phrase naturally or linguistically. It can be divided into several appropriate and effective linguistic scales, such as "Very good", "Good", "Fair", "Poor", "Very poor", so people can choose the most appropriate to describe when assessing, Figure 2 shows the graph for membership function of linguistic variables in five levels. After that, through the pre-designed fuzzy numbers represented by a variety of linguistic scales, all people's actual feelings on assessing projects are deduced [15].

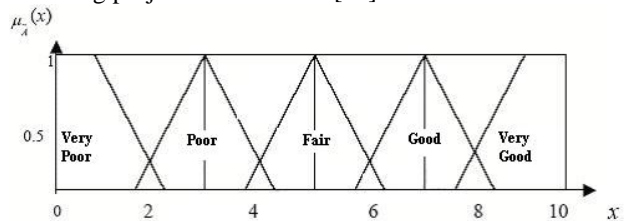


Fig. 2 Graph for membership function of linguistic variables in five levels

4. Conclusions

When recruiting, it is necessary to consider how to take into account a variety of levels and objectives, which is an important issue. Generally speaking, common tools and methods is the multiple criteria decision analysis method, therefore, this study was aimed to develop a set of recruitment model with fuzzy multiple criteria as a reference for decision-making. First of all, a questionnaire survey was conducted in decision-makers, management and professionals in information industry, and then assessment criteria were collated and selected supplemented by reference literature. After that, the weight of key factor was decided based on AHP, and through the fuzzy multiple criteria algorithm: this algorithm is based on triangular fuzzy number and linguistic variable, which is used to assess the "importance" and "satisfactory level" of criteria. Finally,

based on the comprehensive assessment integrated by each hierarchy, participants' scores were calculated as the basis for recruitment. Through this decision-making construction model, it is expected to make the recruitment process more fair and reasonable, so as to achieve the goal of merit-based selection.

This study established a set of fuzzy multiple criteria recruitment model, which improved the inadequacy of existing literature. In general, when deciding different assessing attributes according to objectives, this study applied fuzzy logic method to divide recruitment model into two levels, one is personal traits, such as "ability traits, personality traits, and motivation traits", the other is management skills, such as "technical skills, interpersonal skills, and conceptual skills". So the assessment objectives and criteria were decided through the above-mentioned two, and then AHP was used to compare them in pairs to obtain the weights of the criteria. In order to address the ambiguity in assessing data, fuzzy multiple criteria algorithm was used. Finally, participants' scores were calculated based on the integrated comprehensive assessment, which was the reference for recruitment. The results showed that the fuzzy multiple criteria model constructed in this study could indeed solve the shortcomings in existing enterprises' recruitment, and provide more information for decision-making reference.

The systematization and effectiveness of AHP and fuzzy multiple criteria algorithms were obvious: they could carry out systematic analysis on complex issues with hierarchical way, and then simplified the issues, increasing the effectiveness of problem evaluation. And through the comprehensive assessment of fuzzy multiple criteria decision-making model, specific numerical results were displayed, so that analysts could make the decision clearly. The results of this study will provide effective method and strategy for business recruitment. This study combined with the practice and theorem, verifying the use of theoretical models, so as to facilitate future inferences and follow-up research.

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