Performance Appraisal Model for Human Resource based on Fuzzy Evaluation Method

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Abstract
Scientific human resources management plays an important role in business activities of enterprises, which enables enterprise employees comprehensive understanding of the situation and their staff composition, help enterprises to establish and improve the incentive and restraint mechanisms, rational and effective allocation of human resources, improve management level and overall competitiveness. This paper studies the current status of human resource management, compares the different theories and methods of human resources management, and considers the dynamic fuzzy point of the human resources management; lead the dynamic fuzzy logic theory into human resources management for study.

Keyword: Performance Appraisal, DFL, AHP, Human Resource, Membership

1. Introduction
Performance evaluation system in the company is an important basis for human resource management department to formulate human resource policy as well as carry out policy. It is an important mechanism for the company to perform control on implementation process of its strategic target and strategic system [1-2]. Without an effective performance management system, normal operation activities cannot be guaranteed to smoothly implement and strategic target cannot even be guaranteed to be finally realized. Regarding employees in the company, to perform a set of effective performance evaluation system can promote to improve overall talent quality in the company so as to further facilitate talent development strategy in the company and improve core competitiveness in the company[3-7].

In recent years, management thought and management philosophy on ERP (Enterprise Resource Planning) have been gradually introduced and some advanced new information technologies like ERP, CRM, SCM (Supply Chain Management) have been broadly applied in many large and medium-sized enterprises in China. These technological application and implementation will generate necessarily impact on each step of company operation [8-10]. However, so far, computer technology has hardly been applied to performance evaluation system in enterprise organization or enterprise employee staff in China and many companies are still restricted to manual evaluation and some companies are even perform in a formalistic manner. Nowadays, companies have universally carried out integration on ERP height information and human resource management is also to realize blending in it as one important part of ERP. However, traditional performance evaluation method either lacks objectivity or lacks science [11]. On the basis of this reason, combined with new performance evaluation system theory and evaluation method, the latest computer technology is utilized to develop a set of application on company’s performing models and system of performance evaluation to offer direction on company’s strategic development and employees’ development, which is a new research thinking.

Taken above reasons into account, on the basis of recent years’ research, this paper integrated with dynamic fuzzy logic (DFL), made use of computer technology, relied on human resource management system, set up a human resource evaluation model based on DFL and completed a modernized and intelligent employee staff performance evaluation system, which is of significance.

2. Preliminary

2.1. Related definitions of dynamic fuzzy logic

Definition 1: Assume there is a mapping on universe U:
\((\overline{A}, \overline{A}): (\overline{U}, \overline{U}) \rightarrow [0, 1] \times [\leftarrow, \rightarrow] (u, u) \mapsto (\overline{A(u)}, \overline{A(u)})\) is abbreviated as \((\overline{A}, \overline{A}) = \overline{A}\) or \(\overline{A}\), then \((\overline{A}, \overline{A})\) is the dynamic fuzzy sets (DFS) on \((\overline{U}, \overline{U})\). \((\overline{A(u)}, \overline{A(u)})\) is the membership degree of membership function to \((\overline{A}, \overline{A})\).

**Definition 2:** DF (Dynamic Fuzzy proposition) is a sentence with character of dynamic fuzzy, expressed by capital letters A, B, C… etc. For a DF proposition, it has no absolute truth or falsity, but its dynamic fuzzy true or false degree is rectifiable.

**Definition 3:** First-order dynamic fuzzy logic order function is some kind of relation between dynamic fuzzy predicate calculus and individuals, as described as \(f_1, f_2, f_3, \ldots\) etc. First-order dynamic fuzzy logic order function is individual function which has several vacancies.

When different vacancies are filled with different individual variables, they can become the name items of this dynamic fuzzy order function. Only when all the variables of an dynamic fuzzy order function are filled the resulting item can become a specific individual.

**Definition 4:** Dynamic fuzzy calculus formation can be defined as the follows.

- **DF formation variable is a formed formula;**
- **If \((\overline{x}, \overline{x})P\) is a formed formula, so is \((\overline{x}, \overline{x})P; ;**
- **If \((\overline{x}, \overline{x})P\) and \((\overline{y}, \overline{y})Q\) are formed formulas, then \((\overline{x}, \overline{x})P \lor (\overline{y}, \overline{y})Q\), \((\overline{x}, \overline{x})P \land (\overline{y}, \overline{y})Q\), \((\overline{x}, \overline{x})P \rightarrow (\overline{y}, \overline{y})Q\) and \((\overline{x}, \overline{x})P \leftrightarrow (\overline{y}, \overline{y})Q\) are all formed formulas;**
- **If and only if the results of above propositions are implemented limitedly, the proposition variable conjunctions and the strings of parenthesis symbol are also formed formulas.**

### 2.2. Calculation on indicator weight of performance appraisal based on AHP

AHP (analytic hierarchy process) method [12] is used to determine the weight of each indicator in performance appraisal. The procedures are:

1. The overall target of is determined by understanding of the system. Clear the range referred by planning and decisions. Gather related information widely;
2. Establish multi-hierarchy structure. According to difference in targets and functions, the system are divided into several hierarchical levels;
3. Determine the relation degree among neighbour elements in above hierarchical levels. By constructin comparison matrix and mathematical methods of matrixs, determine the weight sequence of related elements in the hierarchy. For elements in the same level, they are compared each other with rules of previous hierarchy, which are often judged by authoritative and representative experts [13].

Then the results of judgement are expressed with rated value. The judgement matrix \(B\) is:

\[
B = \begin{bmatrix}
B_{11} & B_{12} & \ldots & B_{1n} \\
B_{21} & B_{22} & \ldots & B_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
B_{n1} & B_{n2} & \ldots & B_{nn}
\end{bmatrix}
\]

4. Calculate the combing weight of elements in the matrix, to system target. Determine the final target’s degree of elements in the bottom hierarchy by total ranking. The methods are explained as follows:

Matrix \(B\) is normalized as:

\[
B^*_{ij} = \frac{B_{ij}}{\sum_{k=1}^{n} B_{kj}}
\]

The elements of judgement \(B\) is summed by rows, that is

\[
562
\]
Calculate the relative weight \( W_i \)

\[
W_i = \frac{B_i}{\sum_{k=1}^{n} B_k}
\]  

(3)

In this way, relative weight of each indicator can be acquired.

3. Human resource evaluation model

3.1. Principle idea

In terms of performance testing system, the basic function is to store comment set of examiners and examinees to database and the weight of each index set will be offered according to company’s own features. By means of inference and calculations, examinees belonging to each evaluation rankings can be shown. From this, we can discover that the core of total measurement system is inference system design. According to examiners’ comment set, how can we select operation inference regulations? This must be considered in the whole systematic design and realization process.

On the basis of human resource evaluation system of DFL, input rule of comment set needs to be first established. Then, input rule of weight in each index set needs to be set up. And then, there should be appropriate inference mechanism of dynamic fuzzy logic. Finally, man-machine interface needs to be considered. Figure 1 shows the overall structure:

3.2. Modeling

Performance evaluation in company’s human resource is a multi-level and multi-factoring overall evaluation problem \([14-15]\) and each factor’s feature is different from each other. For example, it is difficult to perform analysis on classical mathematical approach to analyze quality, quantity and natural dynamic in the job. Therefore, this paper applied theory and method of dynamic fuzzy logic and comprehensive evaluation in tree form to set up comprehensive evaluation model of dynamic fuzzy in tree form to implement performance evaluation. The specific steps are shown as the followings:

Step 1: To set up tree root \( N_0 \), that is, the final evaluation result of evaluation objects.

Step 2: Towards each leaf node point \( N_i \) of trees, each index \( U=\{U_m, U_{m+1}, \ldots, U_n\} \) (\( m \leq i \leq n \)) from its reliable index set \( U_i \) set up a node point \( N_i \) to be acted as a sub node point \( N_i \). Then the weight \( w_{ij} \) of each side in trees can be determined and \( w_{ij} \) refers to index \( U_i \) contribution degree on \( U_i \) till leaf node point in tress can be acquired by direct evaluation.

Step 3: evaluation set of each leaf node point can be determined and evaluation set \( V_i \) refers to evaluators’ set made up of various kinds of total evaluation results on evaluation object. That is, \( V_i =\{V_{i1}, V_{i2}, \ldots, V_{in}\} \), \( V_{ij} \) refers to evaluation ranking \( j \) dynamic fuzzy membership degree.
Step 4: node point evaluation set of node point and evaluation set of side weight seeking for node point.

\[ V_i = \left[ W_{m}, W_{m+1}, \ldots, W_{n} \right] \]

\[ V_{ij} = \sum_{m=1}^{n} (w_{ij} \land v_{ij}) \]  

Then, \( V_i \) is performed normalization.

Step 5: According to step 4, the evaluation set of non-leaf node points can be gradually solved and evaluation of root node points can be finally solved. The result of it is the final evaluation result.

From this design process, we can discover that structural model method is provided and tree form structure of this model is determined. But, it needs to be more specific in analysis on tree form variety. According to different industries, profession, positions, tree form structural model can be correspondingly constructed.

4. Case study

4.1. Model cases based on software developers

During performance evaluation on software developers, including achievement assessment which also contains completion time, completion condition and completion quality and ability test which is also divided into technical skills, personal quality and teamwork spirit. Completion quality is made up of coding standards, BUG numbers and client’s satisfactory degree. Technical skills are commonly determined by professional knowledge skill, working efficiency, creative ability and learning ability. Personal quality is reflected by understanding ability, problem solution ability, communication ability and initiatives. Teamwork spirit is made up of discipline sense, ownership sense and cooperation quality. From this, based on the method from above chapter, the model can be set up as the followings:

Node point 0 refers to final result of performance evaluation. Node point 1 refers to achievement assessment. Node point 2 refers to ability test. Node point 4 refers to completion condition. Node point 5 refers to completion time. Node point 6 refers to technical ability. Node point 7 refers to personal quality. Node point 8 refers to teamwork spirit. Node point 9 refers to coding standard. Node point a refers to BUG numbers, node point b refers to client’s satisfactory degree, node point c refers to professional knowledge skill, node point d refers to working efficiency, node point e refers to creative ability, node point f refers to learning ability, node point g refers to understanding ability, node point h refers to problem solution ability, node point i refers to communication skill, node point j refers to initiative, node point k refers to discipline sense, node point l refers to ownership sense and node point m refers to cooperation quality.

![Performance appraisal model for software developers](image-url)
4.2. Determination of edge weight

Towards constructed model, the weight of tree’s edge can be acquired through research and statistics and it is shown as the followings:

\[
\begin{align*}
[w_{01} & w_{02}] = [(0.4, 0.4) (0.35, 0.35)] \\
[w_{13} w_{14} w_{15}] &= [(0.35, 0.35) (0.25, 0.25) (0.25, 0.25)] \\
[w_{26} w_{27} w_{28}] &= [(0.4, 0.4) (0.25, 0.25) (0.3, 0.3)] \\
[w_{39} w_{3a} w_{3b}] &= [(0.25, 0.25) (0.4, 0.4) (0.4, 0.4)] \\
[w_{6c} w_{6d} w_{6f}] &= [(0.3, 0.3) (0.3, 0.3) (0.3, 0.3) (0.2, 0.2)] \\
[w_{ik} w_{ij} w_{im}] &= [(0.3, 0.3) (0.25, 0.25) (0.4, 0.4)]
\end{align*}
\]

4.3. Evaluation set of the leaf node points

Towards each evaluative target project, we can provide corresponding evaluation set \(U=\{\text{excellent, good, qualified, needing to be improved, unqualified}\}\). According to given score to determine its range of level. Then the number of votes statistics for class \(j\) of item \(i\) can be acquired. If the total amount of people to attend the evaluation is \(Y\), then the membership \(V_{ij}=x_{ij}/Y\), \(i\in\{4,5,9, a, b, c, d, e, f, g, h, i, j, k, l, m\}, j\in\{1,5\}\).

Assume the comment set of the leaf nodes are:

1) Data in first group

\[
\begin{align*}
V_{14} &= [(0.3, 0.3) (0.3, 0.3) (0.2, 0.2) (0.2, 0.2) (0, 0)] \\
V_{15} &= [(0.3, 0.3) (0.3, 0.3) (0.3, 0.3) (0.1, 0.1) (0, 0)] \\
V_{16} &= [(0.4, 0.4) (0.3, 0.3) (0.2, 0.2) (0.1, 0.1) (0, 0)] \\
V_{17} &= [(0.3, 0.3) (0.5, 0.5) (0.2, 0.2) (0, 0) (0, 0)] \\
\cdots \\
V_{1k} &= [(0.35, 0.35) (0.4, 0.4) (0.25, 0.25) (0, 0) (0, 0)] \\
V_{1l} &= [(0.2, 0.2) (0.3, 0.3) (0.5, 0.5) (0, 0) (0, 0)] \\
V_{1m} &= [(0.3, 0.3) (0.4, 0.4) (0.3, 0.3) (0, 0) (0, 0)]
\end{align*}
\]

2) Data in first group

\[
\begin{align*}
V_{24} &= [(0.3, 0.3) (0.4, 0.4) (0.2, 0.2) (0.1, 0.1) (0, 0)] \\
V_{25} &= [(0.4, 0.4) (0.3, 0.3) (0.3, 0.3) (0, 0) (0, 0)] \\
V_{26} &= [(0.4, 0.4) (0.3, 0.3) (0.3, 0.3) (0, 0) (0, 0)] \\
\cdots \\
V_{2k} &= [(0.3, 0.3) (0.4, 0.4) (0.3, 0.3) (0, 0) (0, 0)] \\
V_{2l} &= [(0.3, 0.3) (0.3, 0.3) (0.4, 0.4) (0, 0) (0, 0)] \\
V_{2m} &= [(0.25, 0.25) (0.4, 0.4) (0.35, 0.35) (0, 0) (0, 0)]
\end{align*}
\]

4.4. Data analysis

According to form, comment set and weight of the tree, we use the method described as above.
When the first group of data is normalized:

\[
V_1 = \begin{bmatrix}
(0.4,0.4) & (0.3,0.3) & (0.2,0.2) & (0.1,0.1) & (0,0) \\
(0.3,0.3) & (0.5,0.5) & (0.2,0.2) & (0,0) & (0,0) \\
(0.4,0.4) & (0.4,0.4) & (0.3,0.3) & (0.1,0.1) & (0,0)
\end{bmatrix}
\]

Normalized,

\[
V_1 = \begin{bmatrix}
\frac{1}{3} & \frac{1}{3} & \frac{1}{4} & \frac{1}{12} & \frac{1}{12} \\
\frac{3}{4} & \frac{3}{4} & \frac{1}{4} & \frac{1}{12} & \frac{1}{12} \\
\frac{4}{3} & \frac{4}{3} & \frac{1}{4} & \frac{1}{12} & \frac{1}{12}
\end{bmatrix}
\]

Similarly the data of other group can be acquired after normalization.

\[
V_6 = \begin{bmatrix}
(0.25,0.25) & (0.3,0.3) & (0.15,0.15) & (0,0) \\
(0.3,0.3) & (0.3,0.3) & (0.1,0.1) & (0,0) \\
(0.3,0.3) & (0.3,0.3) & (0.1,0.1) & (0,0)
\end{bmatrix}
\]

\[
V_7 = \begin{bmatrix}
\frac{2}{7} & \frac{2}{7} & \frac{2}{7} & \frac{1}{7} & \frac{1}{7} \\
\frac{2}{7} & \frac{2}{7} & \frac{2}{7} & \frac{1}{7} & \frac{1}{7} \\
\frac{2}{7} & \frac{2}{7} & \frac{2}{7} & \frac{1}{7} & \frac{1}{7}
\end{bmatrix}
\]

Until the final normalized group data is acquired.

\[
V_8 = \begin{bmatrix}
\frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67} \\
\frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67} \\
\frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67} & \frac{20}{67}
\end{bmatrix}
\]

Normalized,

\[
V_8 = \begin{bmatrix}
\frac{70}{249} & \frac{70}{249} & \frac{70}{249} & \frac{70}{249} & \frac{70}{249} \\
\frac{70}{249} & \frac{70}{249} & \frac{70}{249} & \frac{70}{249} & \frac{70}{249} \\
\frac{42}{249} & \frac{42}{249} & \frac{42}{249} & \frac{42}{249} & \frac{42}{249}
\end{bmatrix}
\]

The data of second group are normalized as follows,

\[
V_3 = \begin{bmatrix}
\frac{8}{21} & \frac{8}{21} & \frac{5}{21} & \frac{5}{21} & \frac{2}{19} & \frac{2}{19} \\
\frac{6}{19} & \frac{6}{19} & \frac{5}{19} & \frac{5}{19} & \frac{2}{19} & \frac{2}{19}
\end{bmatrix}
\]

\[
V_4 = \begin{bmatrix}
\frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7} \\
\frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7} & \frac{3}{7}
\end{bmatrix}
\]
\[ V_{2_0} = \left[ (0.4, 0.4) (0.35, 0.35) \right] \]

\[ = \left[ \left( \frac{7}{21}, \frac{7}{21} \right) \left( \frac{5}{21}, \frac{5}{21} \right) \left( \frac{2}{21}, \frac{2}{21} \right) \left( 0, 0 \right) \right] \]

Normalized,

\[ V_{2_0} = \left( \frac{7}{23}, \frac{7}{23} \right) \left( \frac{6}{23}, \frac{6}{23} \right) \left( \frac{3}{23}, \frac{3}{23} \right) \left( 0, 0 \right) \]

According to \( V_{1_0} \) and \( V_{2_0} \), the DFL degree which is beyond good of the first member is

\[ \frac{70}{249} + \frac{70}{249} + \frac{70}{249} = \left( \frac{140}{249}, \frac{140}{249} \right) \approx \left( 0.562, 0.562 \right) \].

The same DFL degree for the second member is

\[ \frac{7}{23} + \frac{7}{23} + \frac{7}{23} + \frac{7}{23} = \left( \frac{14}{23}, \frac{14}{23} \right) \approx \left( 0.609, 0.609 \right) \].

The DFL degree of excellence is bigger than the first member. So we can conclude that both of them are excellent members and the performance of the second member is better than that of the first member.

5. Conclusion

Due to the multi-reasoning, multi-dimensional and dynamic feature of evaluation in the performance management for enterprise, the evaluation model for human resource is established based on DFL. We have designed the total structure of model and proposed the method for assessment. The addition and multiplication in matrix are replaced by LOR and XOR in DFL, which are used as operators for performance evaluation. At last the effectiveness of the improved algorithm is verified with case study.

6. References


