An Evaluation Model to Human Factors in Information Systems based on Consistent Quantification of Index and Evaluation Equilibrating

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***Abstract*—In this paper, a comprehensive evaluation model to human factors is presented for information systems. The model can be used in the evaluation that the number of evaluation expert for every evaluated object or target is different. By introducing the concept of Gini coefficients, the coordinated and balance degree of evaluated targets can also be reflected in the evaluation. The proposed model can be widely used because it contains the process of different types of index such as quantitative, qualitative, cost and benefit targets. The reliability and universality are validated by experiment results.**

***Keywords*—human factors; evaluation model; index consistency; index equilibrium**

I. INTRODUCTION

Human factors play an essential role in the evaluation of effectiveness of information system. Due to the diversity of the composition, dynamism of the results and complexity of the representation, the human factors is different with the conventional system evaluation [1].

There are two prominent challenges existing in human factors evaluation. On the one hand [2], evaluation index contains the efficient index and cost type index in human factors evaluation which have been traditionally quantized respectively respectively, and this may affect the evaluation result after quantizing. On the other hand [3], human factors evaluation contains many evaluation indexs, and it may lead to the same result of the final evaluation, while the sub-index values are different. These two problems will cause the difference or error of evaluation result between actual circumstances and calculating result.

II. PERSONNEL EVALUATION MODEL AND METHOD

We denote the experts, the evaluation personnel and the index of evaluation by $E=\{E_1,E_2...E_r\}$, $X=\{x_1,x_2...x_m\}$, $p=\{p_1,p_2...p_n\}$ respectively. For any expert E_k (k= 1, 2, …, r;), $a_{ij}(k)$ means the value of evaluation personnel x_i about the index of evaluation p_j (i= 1, 2, …, m; j= 1, 2, …, n) . So evaluation matrix A(k) can be defined as

$$A(k)=(a_{ij}(k))_{m\times n}\quad, k=1, 2, \cdots, r \tag{1}$$

Due to the each of the human factors have its own index of evaluation. It is necessary to transform these data based on the same evaluation characteristics of the system.

A. *Index consistency quantitative treatment*

There are two kinds of evaluation index of human factors [4]. One is efficiency index which is known as positive indicator, such as ability; the other is cost type index which is known as reverse indicator, such as training expenses. Existing method to quantize the positive indicator and the reverse indicator may cause the deviation between the result of positive indicator and the result of reverse indicator in the same index system and greatly reduce the accuracy of comprehensive evaluation. Therefore, we need a method that can quantify the positive and inverse index uniformly.

To eliminate the influence of the quantizing to evaluation accuracy, the logarithmic type efficacy coefficient method is used in this paper to quantify index. The logarithmic type efficacy coefficient (called quantitative factor) is defined as

$$b_{ij}=\frac{\log_a a_{ij}-\log_a x_s}{\log_a x_h-\log_a x_s} \tag{2}$$

where a_{ij} , x_s and x_h represented the actual value, the refused value, and the design value, respectively. Different value of x_h has different meaning of quantitative factor: when x_h is the target value of system design, quantitative factor can reflect the gap of actual level and system design goal; when x_h is a reference value, quantitative factor can show the comparison of evaluation objects and the general object.

By applying the transform defined in (2), we obtain the normalized evaluation matrix B(k), which can be represented as:

$$B(k)=(b_{ij}(k))_{m\times n}\qquad k=1, 2,\dots r \tag{3}$$

The authority of the value degree is defined as $H=\{H_1,H_2,\cdots,H_r\}$, for any $H_k\in$ [0, 1] , (k=1,2,…r). In order to calculate the evaluation value of each expert, we defined the matrix $C=(c_{ij})_{m\times n}$,

$$c_{ij} = \sum_{k=1}^{r} \frac{H_k b_{ij}(k)}{\sum_{l=1}^{r} H_l} \quad (4)$$

(4) denotes the evaluation value of the people x_i about index evaluation p_j of all experts.

The index of evaluation matrix P has different weight to the evaluation value of people's comprehensive quality. The matrix W can be used to describe the difference:

$$W = \{w_1, w_2, \cdots, w_n\}$$

where $w_j > 0$ and $\sum_{j=1}^{n} w_j = 1$. Many algorithms have been proposed to obtain the matrix W such as AHP and Delphi.

B. *Index of the equalization*

Human factors contain many evaluation indexes in practical evaluation, and it may lead to the same result of the final evaluation, while the sub-index values are different, which will deteriorate the evaluation conclusion [5]. In order to evaluat the quality of people more comprehensively, inspired by Gini coefficient in economics, the equilibrium coefficient (EC) is introduced in this paper to measure the distribution of the comprehensive evaluation value. In Fig. 1, lines with ring,square, stars and triangle denote respectively the distribution of the different types of indicators, the line with ring distribution is the most balanced, then square, stars, followed by the worst triangle.

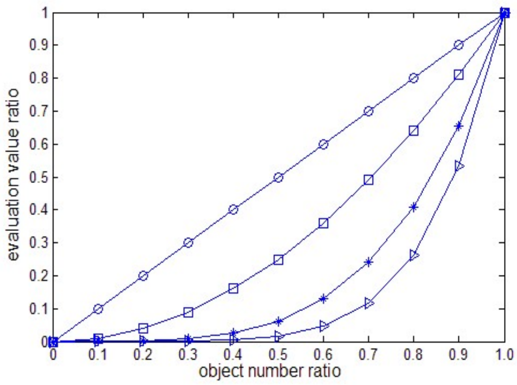

Figure 1. Equilibrium factor

We can obtain EC by step as follows：

Step 1: assume that v_{i1} , v_{i2} ,…, v_{in} is the ascending arrangement of the index evaluation value c_{i1} , c_{i2} ,… c_{in} ;

Step2: no more than the sum of the v_{il} evaluation value of the total evaluation value of the proportion of the sum defined as

$$E_l^i = \frac{1}{\sum_{k=1}^{n} v_{ik}} \sum_{j=1}^{l} v_{ij} \quad \text{i=1,2,…m, l=1,2,…n} \quad (5)$$

Step 3: no more than the value of the v_{il} index number accounts for the proportion of the total number of the index defined as

$$F_l^i = \frac{l}{n} \text{,l=1,2,…n, i=1,2,…m} \quad (6)$$

The relaship between E_l^i and F_l^i as shown in Fig. 1. E_l^i is the transverse axis, F_l^i is the longitudinal axis.

Step 4：the EC is obtained as

$$g = \frac{1}{n} + \frac{1}{n} \frac{2}{\sum_{j=1}^{n} v_{ij}} \sum_{k=1}^{n-1} (n-k) v_{ik} \quad (7)$$

By using the EC, we process the human factors of evaluation as follows:

The weighted comprehensive formular defined as

$$z = \alpha g_i \sum_{j=1}^{n} (w_j c_{ij}) + (1-\alpha) \max_j \{(w_j c_{ij})\} \quad \text{i=1,2,…,m} \quad (8)$$

where α is the adjustable parameter and $0 \le \alpha \le 1$. If the comprehensive quality of experts is emphasized, a larger α should be chosen, while if we pay more attention to personnel in some way ability, the parameter α should set for a smaller coefficient.

III. MAIN STEPS OF PROPOSED ALGORITHM

Based on the above analysis, the proposed algorithm is summarized as follows:

Step 1: initializing the evaluation object set X, the experts set E and the evaluation index P;

Step 2: According to the index of the evaluation, experts give the evaluation respectively. Then we acquire the evaluation matrix A(k);

Step 3：normalizing the evaluation matrix to get matrix B(k);

Step 4：given the expert authority H;

Step 5：according to the formula (4) calculation matrix C;

Step 6：calculating equilibrium degree coefficient g;

Step 7：calculating overall rating value Z.

The above model basically has the following features:

1. By the consistency index quantitative methods, the asymmetry problem of evaluation index quantitative is solved effectively;

2. Adapt to the evaluation given by different number of experts.

3. Introduced in the quantitative operator, the evaluation conclusion can reflect the degrees of coordinated and balanced, which make the evaluation more comprehensive.

IV. APPLICATIONS

We validated the effectiveness of our evaluation model by experiment of a job vacancy in an enterprise [6]. We assume that there are the three experts $E=\{E_1E_2E_3\}$ evaluating four staff candidates $X=\{x_1x_2x_3x_4\}$ for 5 personnel evaluation index of items $p=\{p_1,p_2...p_5\}$. The three experts form their evaluation matrix:

$$A(1)=\begin{bmatrix}85&79&90&88&67\\90&85&90&80&65\\85&85&88&85&62\\88&80&90&88&69\end{bmatrix}$$

$$A(2)=\begin{bmatrix}87&79&90&89&66\\90&83&91&79&64\\85&88&89&86&61\\91&81&90&88&69\end{bmatrix}$$

$$A(3)=\begin{bmatrix}82&80&92&88&65\\77&81&89&82&70\\79&90&90&85&69\\84&85&91&88&70\end{bmatrix}$$

After the normalized, the evaluation matrices can be rewritten as:

$$B(1)=\begin{bmatrix}0&0&0.175&0.427&0.091\\0.351&0.310&0.175&0&0.185\\0&0.310&0&0.271&0.332\\0.213&0.053&0.175&0.427&0\end{bmatrix}$$

$$B(2)=\begin{bmatrix}0.143&0&0.095&0.5056&0.138\\0.351&0.209&0.190&0&0.233\\0&0.457&0&0.360&0.382\\0.419&0.599&0.095&0.457&0\end{bmatrix}$$

$$B(3)=\begin{bmatrix}0.240&0&0.284&0.355&0.220\\0&0.055&0&0&0.220\\0.098&0.527&0.095&0.181&0.042\\0.332&0.271&0.190&0.355&0\end{bmatrix}$$

We choose the authority matrix $H=(H_1,H_2,H_3)=(0.6,1.0,0.8)$, according to the formula (4) to calculate matrix C

$$C=\begin{bmatrix}0.159&0&0.231&0.536&0.187\\0.293&0.239&0.152&0&0.319\\0.041&0.540&0.040&0.338&0.510\\0.402&0.385&0.192&0.516&0\end{bmatrix}$$

Assume weight coefficient W is

$W=(W_1,W_2,...W_5)=(0.1,0.1,0.3,0.2,0.2)$

Then according to the traditional method we can obtain the comprehensive weighted evaluation:

$$Z^*=WC^T=(0.225,0.209,0.319,0.319)$$

Then we note the evaluating result of X3 and X4 is same, so we can not tell which one is better. Now we using the model proposed in this paper to evaluating. Firstly, we generated the quantitative factor as follows:

$$g=(g_1,g_2,...,g_4)=(0.589,0.690,0.690,0.600)$$

Then comprehensive weighted evaluation can be calculated by

$$z=(z_1,z_2,...,z_4)=(0.133,0.144,0.191,0.212)$$

Fig. 2 shows that evaluation value of x3 is 0.212, and the evaluation value of x4 is 0.191, so x3 is more suitable than x4 for this job.

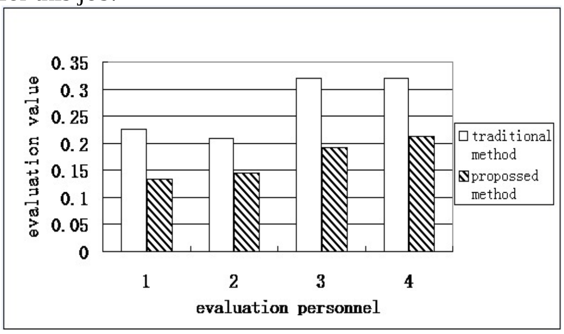

Figure 2. Comprehensive evaluation contrast diagram

V. CONCLUSION

For the key problems of personnel evaluation, the article gives specific algorithms and simulation using examples. The results show that the algorithm can effectively solve the problem of the personnel evaluation indicators consistency. At the same time, the introduction of the equilibrium coefficient (EC) can solve the unbalanced distribution of indicators, to improve the accuracy of the evaluation.

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