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Research Article

Employee Performance Evaluation based on Relative Ratio Method

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Abstract: For the problem of employee performance evaluation model, in which the index evaluation values are linguistic variables, a multiple attribute decision making method named relative ratio method is proposed based on triangular fuzzy numbers. First, the linguistic variables are transferred into triangular fuzzy numbers and to obtain the criteria weight, the triangular fuzzy number decision matrix is firstly defused into a crisp number decision matrix. Then the variation coefficient method is used to determine the evaluation criteria weight. Finally, based on the concept of relative ratio method, relative approach degree is induced for sorting and merit of employees' performance. At the end of the study, an example is given to illustrate the feasibility and effectiveness of the proposed method.

Keywords: Coefficient of variance, employee performance evaluation, linguistic variable, relative ratio method, triangular fuzzy numbed

INTRODUCTION

With the economic globalization, market competition is more and more fierce, how to improve the enterprise performance and maintain a sustainable competitive advantage becomes the hot topic in enterprise (Gliddon, 2004). Claus and Briscoe (2009) pointed out that the employee performance to improve the enterprise performance and sustained competitiveness has very important influence, the performance appraisal is a very meaningful work. Research on performance appraisal problems have aroused the interest of many scholars at home and abroad and put forward a lot of evaluation methods. For example, methods based on data envelopment method (Ahn and Chang, 2004), the fuzzy clustering method (Lee *et al*., 2006), the BP neural network (Tian *et al*., 2012) and Support Vector Machine (SVM) method (Zhu, 2009) etc. These documents in employee performance evaluation has achieved good results, but in some staff performance evaluation indicators, such as communication and coordination ability, professional ethics can't accurately measure, but the fuzzy number or linguistic variables can overcome this shortcoming. Fuzzy approach has been used to evaluate many type of performances such as product and marketing, finance, education and more (Arbaiy and Suradi, 2007). Moon *et al*. (2007) proposed a methodology utilizing fuzzy set theory and electronic nominal group technology for multi-criteria assessment in the group decision-making of promotion screening. The study suggested that the methodology is a good method for a transparent and fair multi-criteria performance evaluation in military organizations. Ren (2009) proposed set pair analysis method are used to deal for the university library staff performance evaluation, which the evaluation values are depicted by triangular fuzzy numbers. Due to linguistic variables such as: good, average, poor, very good that can better depict policymakers' attitude on the evaluation indexes. Arbaiy and Suradi (2007) gave the corresponding relationship of linguistic variables with triangular fuzzy numbers. For the employee performance evaluation problem, this study put forward a new multiple attribute evaluation method based on the basic concept of relative ratio method.

PRELIMINARY KNOWLEDGE

Definition 1: A triple $\tilde{A}=[a,b,c]$ called triangular fuzzy number, if its membership function is defined as:

$$\mu_{\tilde{A}}(x)=\begin{cases}0, & x\le a\\ \frac{x-a}{b-a}, & a\le x\le b\\ \frac{c-x}{c-b}, & b\le x\le c\\ 0, & x\ge c\end{cases}$$

Definition 2: Let $\tilde{A}=(a_1,a_2,a_3)$ and $\tilde{B}=(b_1,b_2,b_3)$ are two any triangular fuzzy numbers, the operations of the two fuzzy numbers are express as follows:

$$\tilde{A}+\tilde{B}=(a_1+b_1,a_2+b_2,a_3+b_3)$$

$$k\tilde{A}=(ka_1,ka_2,ka_3),k\in R$$

Table 1: Linguistic variables and corresponding triangular fuzzy numbers for the for the ratings

Linguistic variable	Triangular fuzzy number
Very Poor (VP)	(0, 0, 1)
Poor (P)	(0, 1, 3)
Medium Poor (MP)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Medium Good (MG)	(5, 7, 9)
Good (G)	(7, 9, 10)
Very Good (VG)	(9, 10, 10)

Let $\tilde{A}=(a_1,a_2,a_3)$ and $\tilde{B}=(b_1,b_2,b_3)$ be two triangular fuzzy numbers. Then the vertex method is defined to calculate the distance between them as follows:

$$d(\tilde{A},\tilde{B})=\sqrt{\frac{1}{3}[(a_1-b_1)^2+(a_2-b_2)^2+(a_3-b_3)^2]}$$

It is an effective and simple method to calculate the distance between two triangular fuzzy numbers (Chen, 2000).

Definition 3: Owing to the fuzziness of the employee performance evaluation problem, the ratings of qualitative criteria are considered as linguistic variables, which is a variable whose values are linguistic terms (Chen, 2001). In this study, the linguistic variables are express in triangular fuzzy numbers as Table 1.

EMPLOYEE PERFORMANCE EVALUATION MODEL

Consider a department employee performance problem. Let $X=\{x_1,x_2,\cdots,x_m\}$ be possible alternatives (evaluate employees) set and $O=\{o_1,o_2,\cdots,o_n\}$ be the evaluation criteria set with which alternative performances are measured. $D=\{D_1,D_2,\cdots,D_s\}$ is expert set. Suppose the rating of alternative x_i ($i=1,2,\cdots,m$) on criteria o_j ($j=1,2,\cdots,n$) given by decision maker D_k ($k=1,2,\cdots,s$) is linguistic variable $\tilde{s}_{ij}^k$, which can be described by triangular fuzzy number $\tilde{a}_{ij}^k=(a_{ij}^k,b_{ij}^k,c_{ij}^k)$. Hence, the employee performance model is a multi-criteria group decision making problem can be concisely expressed in matrix format as follows:

$$\tilde{D}^k=(\tilde{a}_{ij}^k)_{m\times n}=\begin{array}{c} \\ x_1 \\ x_2 \\ \vdots \\ x_m \end{array}\begin{array}{c} \begin{array}{cccc} o_1 & o_2 & \cdots & o_n \end{array} \\ \begin{pmatrix} \tilde{a}_{11}^k & \tilde{a}_{12}^k & \cdots & \tilde{a}_{1n}^k \\ \tilde{a}_{21}^k & \tilde{a}_{22}^k & \cdots & \tilde{a}_{2n}^k \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{m1}^k & \tilde{a}_{m2}^k & \cdots & \tilde{a}_{mn}^k \end{pmatrix} \end{array}$$

where, $k=1,2,\cdots,s$ and $w=(w_1,w_2,...,w_n)$ is the criteria weight vector. Collect the criteria values of the fuzzy decision matrix $\tilde{D}^k=(\tilde{a}_{ij}^k)_{m\times n}$, $k=1,2,...,s$ into one decision matrix $\tilde{D}=(\tilde{a}_{ij})_{m\times n}$, where:

$$\tilde{a}_{ij}=\frac{1}{s}(\tilde{a}_{ij}^1+\tilde{a}_{ij}^2+\cdots+\tilde{a}_{ij}^s)$$

In general, criteria can be classified into two types: benefit attributes and cost attributes. In other words, the criteria set can be divided into two subsets: I_1 and I_2, where I_k (k = 1, 2) is the subset of benefit criteria set and cost criteria set, respectively.

The normalization method mentioned above is to preserve the property that the range of a normalized triangular fuzzy number $\tilde{r}_{ij}^k$ belongs to the closed interval [0, 1]. Hence, the fuzzy decision matrix $\tilde{D}=(\tilde{a}_{ij})_{m\times n}$ are transformed into the normalized fuzzy decision matrix $\tilde{R}=(\tilde{r}_{ij})_{m\times n}$, where $\tilde{r}_{ij}=(r_{ij}^l,r_{ij}^m,r_{ij}^u)$ obtained by the following formula (Xu, 2002):

$$\begin{cases} r_{ij}^L = a_{ij}^L \Big/ \sqrt{\sum_{i=1}^m (a_{ij}^U)^2} \\ r_{ij}^M = a_{ij}^M \Big/ \sqrt{\sum_{i=1}^m (a_{ij}^M)^2} \\ r_{ij}^U = a_{ij}^U \Big/ \sqrt{\sum_{i=1}^m (a_{ij}^L)^2} \\ i\in M,\ j\in I_1 \end{cases}$$

And:

$$\begin{cases} r_{ij}^L = (1/a_{ij}^U) \Big/ \sqrt{\sum_{i=1}^m (1/a_{ij}^L)^2} \\ r_{ij}^M = (1/a_{ij}^M) \Big/ \sqrt{\sum_{i=1}^m (1/a_{ij}^M)^2} \\ r_{ij}^U = (1/a_{ij}^U) \Big/ \sqrt{\sum_{i=1}^m (1/a_{ij}^U)^2} \\ i\in M,\ j\in I_2 \end{cases}$$

where $M=\{1, 2,\ldots, m\}$.

Relative ratio method for employee performance evaluation: In this section, we will give the calculation steps of the relative ratio method for the employee performance evaluation as follows:

Step 1: Calculate the normal performance decision matrix $\tilde{R}=(\tilde{r}_{ij})_{m\times n}$

Step 2: Calculate the positive and negative ideal solution:

The positive ideal solution is defined as $R^* = (r_1^*, r_2^*, \ldots, r_n^*)$, where $r_j^* = [1,1,1]$

And the negative ideal solution is defined as $R^- = (r_1^-, r_2^-, \ldots, r_n^-)$, where $r_j^- = [0,0,0]$

Step 3: Calculating the criteria weight vector by the following step:

- The final performance decision $\tilde{R} = (\tilde{r}_{ij})_{m\times n}$ is firstly defused into a crisp number decision matrix $G = (g_{ij})_{m\times n}$ by the centroid defuzzification method given as follows (Yager, 1981):

$$g_{ij} = \frac{1}{3}(r_{ij}^l + r_{ij}^m + r_{ij}^u)$$

- The coefficient of variation method proposed by Men and Liang (2005) and the calculation formula is:

$$w_j = \frac{\delta_j}{\sum_{j=1}^{n}\delta_j}, j = 1,2,\ldots,n$$

where $\delta_j = \frac{s_j}{\bar{x}_j}$, $\bar{x}_j = \frac{1}{m}\sum_{i=1}^{m} x_{ij}$ and

$$s_j = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(x_{ij} - \bar{x}_j)^2}$$

Obviously, $w_j \geq 0, \sum_{j=1}^{n} w_j = 1, j = 1,2,\ldots,n$.

Step 4: Calculate the distance measure of alternative x_i with the positive and negative ideal solution, as:

$$d(x_i, x^*) = \sqrt{\sum_{j=1}^{n} w_j d(\tilde{r}_{ij}, r_j^*)},$$

And:

$$d(x_i, x^-) = \sqrt{\sum_{j=1}^{n} w_j d(r_{ij}, r_j^-)}$$

Step 5: Calculate the relative ratio of the alternative: Set:

$$d(x^-) = \max_{1\leq i\leq m}\{d(x_i, x^-),$$
$$d(x^+) = \min_{1\leq i\leq m}\{d(x_i, x^*)$$

The relative ratio of the *i*-th alternative employee defined as:

$$\xi_i = \frac{d(R_i, R^-)}{d(R^-)} - \frac{d(R_i, R^*)}{d(R^+)}, i = 1,2,\ldots,m$$

Easy to prove that the relative ratio $\xi_i \leq 0$, which reflects the *i*-th object close to being the ideal alternative and away from negative ideal vector extent greater, indicating that the alternative *i* and the positive ideal vector objects relative distance is smaller, while the negative ideal vector larger relative distance.

Step 6: Rank the alternatives. Ranking order of the alternatives *xj*(*j* = 1, 2, …, m) can be generated according to the increasing order of the relative ratio ξ_i.

A PARACTICAL EXAMPLE

Set a certain university to investigate four employees x_1, x_2, x_3, x_4 of the administrative department of work performance, the evaluation index selection, service attitude o_1, initiative o_2, work coordination ability o_3 and sense of responsibility o_4, these four criteria are all benefit index. Hired three decision maker to evaluate these four employees, criteria value are given by linguistic variables given in Table 2.

To sort the five alternatives' performance using the proposed method, the steps are given as follows:

Step 1: The normal performance decision matrix $\tilde{R} = (\tilde{r}_{ij})_{m\times n}$ is calculated as:

$$\tilde{R} = \begin{bmatrix} [0.3033, 0.4779, 0.7466] & [0.3007, 0.4612, 0.6758] \\ [0.3033, 0.4779, 0.7742] & [0.3007, 0.4612, 0.7009] \\ [0.3033, 0.4779, 0.7466] & [0.3007, 0.4612, 0.7009] \\ [0.3746, 0.5610, 0.8295] & [0.4775, 0.6016, 0.7509] \end{bmatrix} \rightarrow \begin{bmatrix} [0.4817, 0.6016, 0.7509] & [0.3051, 0.4583, 0.6692] \\ [0.3033, 0.4612, 0.6758] & [0.2333, 0.3786, 0.5948] \\ [0.3033, 0.4612, 0.7009] & [0.4845, 0.5977, 0.7435] \\ [0.3033, 0.4612, 0.6758] & [0.3769, 0.5380, 0.7435] \end{bmatrix}$$

Step 2: The ideal solution and negative ideal solution are respectively given as:

Table 2: The rating of the four employees by decision makers under all criteria

Criteria	Employee	Decision makers D_1	D_2	D_3
O_1	x_1	*F*	*G*	*G*
	x_2	*MG*	*MG*	*G*
	x_3	*G*	*G*	*F*
	x_4	*G*	*G*	*G*
O_2	x_1	*G*	*F*	*G*
	x_2	*MG*	*G*	*MG*
	x_3	*MG*	*MG*	*G*
	x_4	*VG*	*VG*	*VG*
O_3	x_1	*VG*	*VG*	*VG*
	x_2	*G*	*G*	*F*
	x_3	*MG*	*G*	*MG*
	x_4	*G*	*F*	*G*
O_4	x_1	*G*	*G*	*F*
	x_2	*F*	*F*	*G*
	x_3	*VG*	*VG*	*VG*
	x_4	*G*	*G*	*G*

$$R^* = (r_1^*, r_2^*, r_3^*, r_4^*) = ([1,1,1],[1,1,1],[1,1,1],[1,1,1])$$

$$R^- = (r_1^-, r_2^-, r_3^-, r_4^-) = ([0,0,0],[0,0,0],[0,0,0],[0,0,0])$$

Step 3: Calculate the criteria vector:

- Calculate the crisp number decision matrix $G = (g_{ij})_{m\times n}$:

$$G = \begin{bmatrix} 0.5093 & 0.4792 & 0.6114 & 0.4775 \\ 0.5185 & 0.4876 & 0.4801 & 0.4022 \\ 0.5093 & 0.4876 & 0.4885 & 0.6086 \\ 0.5884 & 0.6100 & 0.4801 & 0.5528 \end{bmatrix}$$

- Then the weight vector can be obtained by coefficient of variation method:

$$w = (0.1435, 0.2505, 0.2557, 0.3503)$$

Step 4: Calculate the distance measure:

$$d(x_1, x^*) = 0.7750, d(x_2, x^*) = 0.9577,$$
$$d(x_3, x^*) = 0.7297, d(x_4, x^*) = 0.6707$$

and

$$d(x_1, x^-) = 0.8754, d(x_2, x^-) = 0.7189,$$
$$d(x_3, x^-) = 0.9295, d(x_4, x^-) = 0.9926$$

Then we have $d(x^-) = 0.9926, d(x^*) = 0.6707$.

Step 5: The relative ratio of the *i*-th alternative employee defined as:

$$\xi_1 = -0.2736, \xi_2 = -0.7036,$$
$$\xi_3 = -0.1515, \ \xi_4 = 0$$

Step 6: Obviously, $\xi_2 < \xi_1 < \xi_3 < \xi_4$, then the employees performance order is $x_2 < x_1 < x_3 < x_4$.

CONCLUSION

This study is focus on employee performance evaluation problems; the use of triangular fuzzy number multi-attribute decision-making model is established. In this study, the variation coefficient method is adopted to determine the weight of each evaluation index, the use of digital information itself reflects the objective to determine the index weight, overcome the subjective weight in performance appraisal of artificial and uncertainty. In this study, the proposed method is simple, in line with the actual situation, the algorithm is easy to use Matlab and Excel software for modular operation, each department can use the method in the performance evaluation of employees.

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