Application of Set Pair Analysis in the Performance Evaluation of Enterprise Managers

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Abstract: The performance of managers in enterprises has the characteristics of multi-layer and variability, etc. Thus it is important but difficult to make evaluations. Set pair analysis (SPA) is a new method to deal with the question of uncertainty. The performance evaluation model was established based on the theory of set pair analysis (SPA), and analytic hierarchy process (AHP) was applied to determine the weight of indexes. Finally, the paper applied the example to verify the effectiveness of the method. The results show that SPA has the advantages of clear concept and simple computation, and it provides a simple and suitable evaluation method for the performance assessment.

1. Introduction

Performance assessment is the basis and key link of human resource management. Market competition has put forward new requirements on enterprise human resource management. Implementation and improvement of performance assessment is an important guarantee to achieve strategic objectives and continue to upgrade themselves for enterprises. Managers in the enterprise have a pivotal role, they are the backbone of the enterprises, Managers can fully play its role or not, All of these will directly affect the development of enterprises. The establishment of a scientific and effective performance evaluation system is the the key to effective management of managers.

David thinks that personnel loss is directly linked to performance appraisal. If the employee's performance is not recognized, even high-performance employees will leave work and go to another enterprise[1]. Chinese and foreign scholars have done a lot of work on the performance evaluation method. Douglas proposes performance evaluation method of multi-directional feedback[2]. Funderburg thinks that 360-degree performance appraisal is conducive to the progress of employees, and can play a role in long-term incentive[3]. Overall, Enterprises can choose the performance evaluation methods include level evaluation, objective evaluation method, sequence comparison method, relative comparison method, group evaluation method, 360-degree performance appraisal method and so on. Currently, the research of domestic human resource performance evaluation is firstly to give a mark with the above methods, then use the fuzzy comprehensive evaluation. In this paper, set pair analysis (SPA) is applied to performance evaluation of managers.

2. Set pair analysis method

Set pair analysis (SPA) is a system analysis method to make a quantitative analysis for identical degree, different degree and contrary degree (IDC)[4]. The core idea is to analyze the characteristics of set pair and create the expressions of two sets about identical degree, different degree and contrary degree in the background of certain problems. IDC connection degree is usually determined by the following ideas, analyzing the characteristics of set pair H according to the needs of problem W, N properties are obtained. There are S properties shared by the two sets, the two sets are contrary in P properties, neither contrary nor identical in the rest of $F = N - S - P$ properties, that is, its nature is uncertain. S/N is the identical degree in problem W, referred to as identical degree, F/N is the

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different degree in problem W, referred to as different degree, P/N is the contrary degree in problem W, which is referred to as contrary degree[5].

The paper represents the connection degree with the formula $\mu = \frac{S}{N} + \frac{F}{N} i + \frac{P}{N} j$, i is the different degree coefficient, i∈[-1,1], j is the contrary degree coefficient, j≡-1[6].

$$\text{Let } \frac{S}{N} = a, \frac{F}{N} = b, \frac{P}{N} = c, \text{ then } \begin{matrix} \mu = a + bi + cj \\ a + b + c = 1 \end{matrix} \quad (1)$$

3. Performance evaluation model of managers

Performance assessment of enterprise managements is a process to evaluate the actual performance of each management based on certain evaluation criteria. Therefore, the evaluation criteria can be regarded as the set A, and the actual performance evaluation can be regarded as the set B. By comparing the set B and set A, the IDC connection degree can be found, then we can compare the performance of each of managers to distinguish between high and low performance. According to these ideas, this paper builds performance evaluation model of managers.

3.1. Establishment of Performance Evaluation Index System

The content of managers performance evaluation reflects the basic requirements of enterprise employees. It is basic and crucial to establish a scientific and reasonable index system for the objective performance assessment of managers. For the multi-layer and multi-variability of managers' performance, the content of performance measurement is also quite complex[7] [8]. The paper will evaluate the managers' performance from four areas including work attitude, work ability, knowledge level and work performance[9]. The evaluation system of managers' performance is shown in Table 1.

Table 1 evaluation index system of managers' performance

first grade indexes	second grade indexes
work attitude	dedication spirit
	organizational discipline
	positive initiative
work ability	communication ability
	creative ability
	adaptive ability
	expression ability
knowledge level	comprehensive knowledge
	professional knowledge
work performance	work quantity
	work quality
	work efficiency

3.2. Determining of Each Index Weight

The paper assumes that there are k first grade indexes*(k=1,2,..n)* in the evaluation index system, and there are s second grade indexes*(s=1,2,…m)* under them. Let the weight of first grade indexes be w_k , $\sum_{k=1}^{n} w_k = 1$, Let the weight of second grade indexes be w_{ks} , $\sum_{s=1}^{m} w_{ks} = 1$. The weights can be determined to use Delphi, AHP and other methods.

3.3. Composition of Evaluation Team

Team members include superiors, colleagues, subordinates and outside experts. Scoring method can be used in the performance evaluation and fuzzy evaluation method can also be used.

3.4. Establishment of Second Grade Indexes Coefficient Matrix with IDC

The paper assumes that there are r evaluated managers, Through this evaluation method to rate managers, we can get the coefficient matrix with IDC.

$$R_{pk} = \begin{bmatrix} a_{k1} & b_{k1} & c_{k1} \\ a_{k2} & b_{k2} & c_{k2} \\ . & . & . \\ . & . & . \\ a_{km} & b_{km} & c_{km} \end{bmatrix} \tag{2}$$

In above equation, R_{pk} is the assessment matrix of assessed person p when all the second grade indexes s are considered under a certain first grade indexes k . p is the individual of the evaluated managers, p=1,2,…r .

3.5. Expression of Connection Degree under First Grade Indexes

According to the weight of each index and coefficient matrix with IDC, we can create the connection degree of expression between the actual performance of managers and performance standards under a certain first grade indexes *k(k* = 1, ..., *n).*

$$\mu_{pk} = \begin{pmatrix} w_{k1} & w_{k2} & \dots & w_{ks} \end{pmatrix} \cdot \begin{bmatrix} a_{k1} & b_{k1} & c_{k1} \\ a_{k2} & b_{k2} & c_{k2} \\ . & . & . \\ . & . & . \\ a_{ks} & b_{ks\cdot} & c_{ks} \end{bmatrix} \cdot \begin{bmatrix} 1 \\ i \\ j \end{bmatrix}$$

$$= \sum_{s=1}^{m} w_{ks} \cdot a_{ks} + \left(\sum_{s=1}^{m} w_{ks} \cdot b_{ks} \right) i + \left(\sum_{s=1}^{m} w_{ks} \cdot c_{ks} \right) j \tag{3}$$

$$\text{Let } a_k = \sum_{s=1}^{m} w_{ks} \cdot a_{ks}, b_k = \sum_{s=1}^{m} w_{ks} \cdot b_{ks}, \; c_k = \sum_{s=1}^{m} w_{ks} \cdot c_{ks},$$

$$\text{then } \; \mu_{pk} = a_k + b_k i + c_k j . \tag{4}$$

3.6. Comprehensive Performance Assessment Model

We can get the coefficient matrix R_p with IDC under the comprehensive index based on the above calculated connection degree under the first grade indexes.

$$R_p = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ . & . & . \\ . & . & . \\ a_k & b_k & c_k \end{bmatrix} \tag{5}$$

According to *Rp* and w_k , Comprehensive performance assessment model can be got as follows:

$$\mu_p = \begin{pmatrix} w_1 & w_2 & \dots & w_s \end{pmatrix} \cdot \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ . & . & . \\ . & . & . \\ a_k & b_{k\cdot} & c_k \end{bmatrix} \cdot \begin{bmatrix} 1 \\ i \\ j \end{bmatrix}$$

$$= \sum_{k=1}^{n} w_k \cdot a_k + \left(\sum_{k=1}^{n} w_k \cdot b_k \right) i + \left(\sum_{k=1}^{n} w_k \cdot c_k \right) j \tag{6}$$

$$\text{Let } a_p = \sum_{k=1}^{n} w_k \cdot a_k,\ b_p = \sum_{k=1}^{n} w_k \cdot b_k,\ c_p = \sum_{k=1}^{n} w_k \cdot c_k,$$

$$\text{then} \quad \mu_p = a_p + b_p i + c_p j. \tag{7}$$

3.7. Performance Comparison and Analysis

The actual performance of each manager can be determined by comparing the size of each connection degree μp.

4. Model application

In order to verify the utility of performance evaluation model, the paper will evaluate the performance of six managers of a certain enterprise of Harbin in china. The value for each second grade index will use the fuzzy value between 0 and 1: 0 indicates very poor, 0.25 indicates relatively poor, 0.5 indicates general, 0.75 indicates relatively good, 1 indicates very good. Evaluation indicators and data are shown in table 2 as follows:

Table 2 performance evaluation data

number	work attitude			work ability				knowledge level		work performance		
	dedication spirit	organizational discipline	positive initiative	communication ability	creative ability	adaptive ability	expression ability	comprehensive knowledge	professional knowledge	work quantity	work quality	work efficiency
1	0.75	0.75	1.00	0.75	0.25	0.50	0.75	0.75	1.00	0.75	0.75	0.50
2	1.00	0.75	1.00	1.00	0.75	0.75	0.75	0.75	0.75	1.00	0.75	0.75
3	0.75	0.50	0.75	1.00	0.50	0.75	1.00	0.75	1.00	0.75	0.25	0.50
4	0.50	0.75	0.75	0.75	0.25	0.75	1.00	1.00	0.50	0.25	0.50	0.75
5	0.50	0.75	0.50	0.75	0.75	1.00	0.50	0.50	0.50	0.50	0.50	0.50
6	0.75	1.00	0.25	0.75	0.50	0.75	0.50	0.50	0.75	0.75	1.00	0.75

4.1. Determining of Each Index Weight

The weight of each index is gived here by the analytic hierarchy process (AHP) and shown in table 3 as follows:

Table 3 index weight

first grade indexes	weight	second grade indexes	weight
work attitude	0.1	dedication spirit	0.4
		organizational discipline	0.2
		positive initiative	0.4
work ability	0.3	communication ability	0.2
		creative ability	0.4
		adaptive ability	0.2
		expression ability	0.2
knowledge level	0.2	comprehensive knowledge	0.4
		professional knowledge	0.6
work performance	0.4	work quantity	0.2
		work quality	0.4
		work efficiency	0.4

4.2. Establishment of Coefficient Matrix with IDC

In the first grade indexes of performance evaluation, work attitude indicates good and bad connection, namely, the identical and contrary connection, the connection degree for work attitude is expressed with the form of a + cj. Work ability indicates the connection to have the ability and possibly have the ability, and its connection degree uses the form of a+bi. Knowledge level refers to the current level and indicates the connection between master and no master, therefore, the connection degree uses the form of a+cj. Work performance indicates the connection of good and

bad performance, and the connection degree can be used in the form of a + cj.

In this paper, the "very good" (corresponding to a value of 1) is taken as the reference standard. According to the data in table 2, the coefficient matrix with IDC can be constructed.

Here, first grade indexes k = 1,2,3,4, when k = 1, the second grade indexes s = 1,2,3, when k = 2, s = 1,2,3,4, when k = 3, s = 1,2, when k = 4, s = 1,2,3. According to the formula (2),

the coefficient matrix can be obtained for the first manager under the first grade indexes as follows.

$$R_{11}=\begin{bmatrix}0.75 & 0 & 0.25\\ 0.75 & 0 & 0.25\\ 1 & 0 & 0\end{bmatrix},\ R_{12}=\begin{bmatrix}0.75 & 0.25 & 0\\ 0.25 & 0.75 & 0\\ 0.5 & 0.5 & 0\\ 0.75 & 0.25 & 0\end{bmatrix},$$

$$R_{13}=\begin{bmatrix}0.75 & 0 & 0.25\\ 1 & 0 & 0\end{bmatrix},\ R_{14}=\begin{bmatrix}0.75 & 0 & 0.25\\ 0.75 & 0 & 0.25\\ 0.5 & 0 & 0.5\end{bmatrix},$$

$$\mu_{11}=\begin{pmatrix}0.4 & 0.2 & 0.4\end{pmatrix}\cdot\begin{bmatrix}0.75 & 0 & 0.25\\ 0.75 & 0 & 0.25\\ 1 & 0 & 0\end{bmatrix}\cdot\begin{bmatrix}1\\ i\\ j\end{bmatrix}$$

$$=0.85+0i+0.15j.$$

Similarly,

$\mu_{12}=0.5+0.5i+0j$, $\mu_{13}=0.9+0i+0.1j$, $\mu_{14}=0.5+0.5i+0j$,

$$R_1=\begin{bmatrix}0.85 & 0 & 0.15\\ 0.5 & 0.5 & 0\\ 0.9 & 0 & 0.1\\ 0.65 & 0 & 0.35\end{bmatrix}$$

Similarly,

$$R_2=\begin{bmatrix}0.95 & 0 & 0.05\\ 0.8 & 0.2 & 0\\ 0.75 & 0 & 0.25\\ 0.8 & 0 & 0.2\end{bmatrix},R_3=\begin{bmatrix}0.7 & 0 & 0.3\\ 0.75 & 0.25 & 0\\ 0.9 & 0 & 0.1\\ 0.45 & 0 & 0.55\end{bmatrix},$$

$$R_4=\begin{bmatrix}0.65 & 0 & 0.35\\ 0.6 & 0.4 & 0\\ 0.7 & 0 & 0.3\\ 0.55 & 0 & 0.45\end{bmatrix},R_5=\begin{bmatrix}0.55 & 0 & 0.45\\ 0.75 & 0.25 & 0\\ 0.5 & 0 & 0.5\\ 0.5 & 0 & 0.5\end{bmatrix},$$

$$R_6=\begin{bmatrix}0.6 & 0 & 0.4\\ 0.6 & 0.4 & 0\\ 0.65 & 0 & 0.35\\ 0.85 & 0 & 0.15\end{bmatrix}$$

4.3. Calculation of the Connection Degree of Comprehensive Indexes

$$\mu_1=\begin{pmatrix}0.1 & 0.3 & 0.2 & 0.4\end{pmatrix}\cdot\begin{bmatrix}0.85 & 0 & 0.15\\ 0.5 & 0.5 & 0\\ 0.9 & 0 & 0.1\\ 0.65 & 0 & 0.35\end{bmatrix}\cdot\begin{bmatrix}1\\ i\\ j\end{bmatrix}$$

$$=0.675+0.15i+0.175j$$

Similarly,

$\mu_2=0.805+0.06i+0.135j$,

$\mu_3 = 0.655 + 0.075i + 0.27j$,

$\mu_4 = 0.605 + 0.12i + 0.275j$,

$\mu_5 = 0.58 + 0.075i + 0.345j$,

$\mu_6 = 0.71 + 0.12i + 0.17j$.

4.4. Analysis of the Results

Since performance appraisal is the evaluation of the current behavior which has taken place, and uncertain factors are possible in future, such as creative ability which could be improved at work in future and so on. Therefore, the different degree coefficient i is assigned to 0, j ≡ -1, the six managers of connection degree can be obtained by calculating:

$\mu_1 = 0.50$, $\mu_2 = 0.67$, $\mu_3 = 0.385$, $\mu_4 = 0.33$, $\mu_5 = 0.235$, $\mu_6 = 0.54$. So, the performance order of six managers is as follows: No.2> No. 6> No. 1> No. 3> No. 4> No. 5.

5. Conclusions

As a new theory and method of uncertainty, compared with the traditional evaluation methods, set pair analysis(SPA) is not only rigorous in the theory of evaluation model, accurate and reliable in evaluation results, but also is relatively simple in the calculation, has broaden the research approach in the field of performance evaluation of enterprises' managers, provides a clear and simple mathematical model for the performance evaluation.

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References

[1] David G Allen and Rodger W Griffeth, "Job performance and turn-over:A review and integrative multi-route model," Human Resource Management Review, vol. 9, pp. 525–528, April 2006.

[2] Douglas H Flint, "The role of organization justice in multi-sourceperformance appraisal:Theory-based applications and directions for research," Human Resource Management Review, vol. 9, no. 1, pp. 10–14, 2005.

[3] Funderburg S A and Levy P E. "The influence of individual and cont-extual variables on 360-degree feedback system attitudes," Group and Organization Management, vol. 22, no. 2, pp. 210–215,2009.

[4] Zheng Wen-zhe and Yu Fen, "Construction of the Model of Performance Evaluation forMiddle-level Managers in Enterprise," Journal of Dalian University of Technology (Social Sciences), vol. 30, no. 3, pp. 44-47, 2009.

[5] He Jin-ping, Shi Yu-qun and Qi Wen-qiang, "A computational method of attribute measure based on set pair analysis," Engineering Journal of Wuhan University, vol. 43, no. 4, pp. 230-234, 2010.

[6] Wang Wen-sheng and Jin Ju-liang, "Risk Degree Assessment of Natural Disaster Based on Set Pair Analysis Method," Journal of Sichuan University(Engineering Science Edition), vol. 37, no. 6, pp. 9-12, 2009.

[7] Yang Jun-jie and Zhou Jian-zhong, "Uncertain multi-attribute decision making methods based on set pair analysis," Control and Decision, vol. 46, no. 12, pp. 105-108, 2012.

[8] Zhe Bing, Wang Wen-sheng and Wang Hong-fang, “Probe on Variation Uncertainty Coefficient i in Set Pair Analysis,” Journal of Sichuan University(Engineering Science Edition), vol. 29, no. 1, pp. 8-12, 2012.

[9] Meng Xian-meng and Hu He-ping, “Application of set pair analysis model based on entropy weight to comprehensive evaluation of water quality,” Journal of Hydraulic Engineering, vol. 37, no. 3, pp. 4-9, 2009.