Research on the performance measurement model of knowledge management based on Grey relational analysis

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Abstract

Performance measurement of knowledge management is a decision-making analysis project that involves multiple complex factors, levels and fuzzy uncertain information. On the basis of analysis of influence factors of knowledge management performance measurement, the study established an evaluation index system of enterprise knowledge management performance. Meanwhile, by combining grey relational analysis method and Euclidean distance measurement, a performance measurement model of knowledge measurement was established. Via standardization of different types of evaluation indexes of knowledge management performance, Euclidean distances of standardized evaluation indexes of knowledge management performance and the grey relational coefficients based on Euclidean distances were established respectively. Then the weighted grey correlations of evaluation indexes of knowledge management performance were obtained. In this way, evaluation analysis of enterprise knowledge management performance was realized. Finally, the model and algorithm was tested with a case study. The result proves that the method of combining grey relational analysis and Euclidean distance is efficient and has its application value in performance evaluation of knowledge management.

Keywords: knowledge management, performance measurement, Grey relational analysis, euclidean distance, model

1 Introduction

In the era of knowledge economy, knowledge has become key resource in economic growth, social development and enterprise development. Efficient knowledge management is important for an enterprise to acquire and maintain advantages in competition. Thus, knowledge management is increasingly important in enterprise management. As a key section in knowledge management, performance evaluation of knowledge management can evaluate the level and capacity of enterprise knowledge management performance in an effective, accurate and objective way. It is beneficial to the enterprise to control its knowledge management and development changes and can help with the evaluation of enterprise development. What's more, enterprise can find problems in knowledge management in the process of performance measurement of knowledge management and make plans to deal with these problems, which is an important way for the enterprise to evaluate its capacity of knowledge management [1-3]. Thus, finding the key influence factors in the improvement of performance and taking effective measures on time are of theoretical importance and engineering application value. Knowledge management combines multiple disciplines and methods. Enterprise managers improve the overall organizing efficiency of enterprise system, Reaction capacity of enterprise business operation, enterprise marketing competitiveness, innovation capacity in production, enterprise capital appreciation, etc. Thus, the performance measurement of enterprise knowledge management usually concentrates on these issues. By far, there have been some studies direct on this problem and have gained corresponding achievements [4-8]. However, different scholars and specialists have different perspectives in performance measurement of knowledge management. Thus, there are no unified evaluation indexes of knowledge management performance and elements in knowledge management cannot be reflected. Besides, some methods of performance measurement of knowledge management are not operable and performable enough. In a word, the current methods of performance measurement of knowledge management have some limitations. Thus, this study, based on existing studies and researches, tentatively puts forward a performance measurement model of knowledge management based on grey relational analysis [8-11]. Via a case study, the feasibility and operability of the model were tested.

2 The evaluation index system of performance measurement of enterprise knowledge management

2.1 PRINCIPLE OF THE CHOICE OF EVALUATION INDEXES OF PERFORMANCE MEASUREMENT OF KNOWLEDGE MANAGEMENT

There are complex dynamic factors of multiple levels and perspectives that influence the result of performance measurement of knowledge management, which make the design principle of choosing of the evaluation indexes of knowledge management performance in the evaluation index system of enterprise knowledge management performance. Whether the evaluation indexes of knowledge

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management performance is valid or not concerns the reliability and validity of the whole evaluation index system of knowledge management performance. There is no unified design principle in choosing evaluation indexes of knowledge management performance in the field of designation of evaluation system of knowledge management performance, and different scholars and specialists have different perspectives in principles to follow in the designation of evaluation indexes of knowledge management performance. The author of this paper deems that the choice of evaluation indexes of knowledge management performance should guarantee the objecttiveness, accurateness and effectiveness of the performance measurement result of knowledge management, and the performance measurement of knowledge management should be conducted from multiple perspectives and levels. Thus, in the establishment of evaluation indexes of knowledge management performance, the following principles should be followed:

1) Scientific: in choosing evaluation indexes of knowledge management performance, elements in enterprise knowledge management and the rationality of the overall structure of evaluation indexes should be considered in the first place. The indexes should analyse the condition of enterprise knowledge management from a scientific perspective. Thus, the reliability and representativeness of chosen evaluation indexes can be guaranteed.
2) Comprehensiveness: the evaluation index system of enterprise knowledge management should comprehensively reflect the overall condition of enterprise knowledge management system. It should be able to analyse the condition of knowledge management from different perspectives. Thus, the choice of evaluation indexes of knowledge management performance should consider factors in multiple aspects.
3) Integral: the evaluation index system of enterprise knowledge management is a complex decision-making system. Thus, the choice of evaluation index of knowledge management performance should keep the integral and internal relations among each element and avoid imperfect and omission of index element.
4) Objectiveness: the choice of evaluation indexes of knowledge management performance should avoid the influence of subjective factors to the greatest extent. Each evaluation index should be able to reflect the actual condition of enterprise knowledge management.
5) Consistency: different evaluation indexes of knowledge management performance should apply consistent standard in assignment.
6) Hierarchy: the levels of evaluation index system of knowledge management performance and the membership between each two levels should be clear.
7) Operability: the evaluation indexes of knowledge management performance should be operable enough so as to conduct quantitative or qualitative measurement.

2.2 ESTABLISHMENT OF EVALUATION INDEX SYSTEM OF ENTERPRISE KNOWLEDGE MANAGEMENT PERFORMANCE

Based on the above-mentioned design principles, an evaluation index system of knowledge management performance was established in this paper, as presented in Table 1. The evaluation index system contains five 1st level indexes, namely the capacity of information management, the marketing capacity, the level of knowledge stock, the maturity of learning organization and the transfer ability of knowledge using.

Table1 The evaluation index system of knowledge management performance

Objective level	1st level index	2nd level index
Evaluation index system of knowledge management performance U	The capacity of information management U_1	Information level of the enterprise u_{11} Information communication level among employees u_{12} Information communication level among departments u_{13} Information communication level between the enterprise and the customers u_{14} Information support level of cooperation in production u_{15}
	The marketing capacity U_2	Customer satisfaction u_{21} Customer profitability u_{22} Market retention rate u_{23} Market share u_{24} Quick reaction capacity in marketing u_{25}
	The level of knowledge stock U_3	The ratio of technical personnel u_{31} The holding quantity of technological achievements u_{32} The conservation rate of technical personnel u_{33} The average level of education of technical personnel u_{34}
	The maturity of learning organization U_4	The learning competence in external communication u_{41} The learning competence in internal training u_{42} The improvement level of incentive mechanism u_{43} The ability of the knowledge managers u_{44}
	The transfer ability of knowledge using U_5	The knowledge acquisition capacity u_{51} The knowledge innovation capacity u_{52} The knowledge transformation capacity u_{53} The knowledge learning capacity u_{54}

3 Performance measurement model of knowledge management based on grey relational analysis

3.1 THE SET OF EVALUATION PLANS AND THE SET OF EVALUATION INDEXES

Assume that there are *m* enterprises that conduct evaluation and analysis of knowledge management performance. Thus, the set of evaluation plans will be formed as $C=\{C_1,C_2,...,C_n\}$. In the set, C_i is the evaluation plan of knowledge management performance of one of those different enterprises? Meanwhile, based on the structure and content of Table 1, the set evaluation indexes of knowledge management performance *U* with multiple levels can be determined. In this model $U=\{U_1,U_2,U_3,U_4,U_5\}$ and $\underset{i\neq j}{\forall}(U_i\cap U_j)=O,1\le i,j\le 5$. In the set $U_1=\{u_{11},u_{12},u_{13},u_{14},u_{15}\}$, $U_2=\{u_{21},u_{22},u_{23},u_{24},u_{25}\}$, $U_3=\{u_{31},u_{32},u_{33},u_{34}\}$, $U_4=\{u_{41},u_{42},u_{43},u_{44}\}$, $U_5=\{u_{51},u_{52},u_{53},u_{54}\}$.

3.2 STANDARDIZATION OF EVALUATION INDEXES

According to the content of evaluation indexes of knowledge management performance, different evaluation indexes can have different types of value of information. On the one hand, some values of evaluation indexes are accurate, while those of others are fuzzy and uncertain. On the other hand, some evaluation indexes have positive effect for the level of enterprise knowledge management performance and are positive evaluation indexes, and some have negative effect for the level of enterprise knowledge management performance and are negative evaluation indexes. Thus, in order to conduct effectively the performance measurement of knowledge management, different types of evaluation indexes need to be unified and standardized.

In order to keep the generality of statement, assume that the value of enterprise *i* on performance evaluation index *j* is $V_{ij}=[v_{ij}^{\min},v_{ij}^{\max}]$, $v_{ij}^{\min}<v_{ij}^{\max}$.

If the evaluation index is a positive evaluation index, its standardized value $\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]$ of enterprise *i* on performance evaluation index *j* is:

$$\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]=\left[\frac{v_{ij}^{-\min}-\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{\max\limits_{1\le i\le m}(v_{ij}^{-\max})-\min\limits_{1\le i\le m}(v_{ij}^{-\min})},\frac{v_{ij}^{-\max}-\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{\max\limits_{1\le i\le m}(a_{ij})-\min\limits_{1\le i\le m}(a_{ij})}\right]. \quad (1)$$

If the evaluation index *j* is a negative evaluation index, its standardized value $\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]$ of enterprise *i* on performance evaluation index *j* is:

$$\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]=\left[\frac{\max(v_{ij}^{-\max})-v_{ij}^{-\min}}{\max\limits_{1\le i\le m}(v_{ij}^{-\max})-\min\limits_{1\le i\le m}(v_{ij}^{-\min})},\frac{\max(v_{ij}^{-\max})-v_{ij}^{-\max}}{\max\limits_{1\le i\le m}(a_{ij})-\min\limits_{1\le i\le m}(a_{ij})}\right]. \quad (2)$$

If the evaluation index *j* is a moderate evaluation index, its standardized value $\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]$ of enterprise *i* on performance evaluation index *j* is:

$$\bar{V}_{ij}=\left[v_{ij}^{-\min},v_{ij}^{-\max}\right]=\left[\frac{\frac{\max(v_{ij}^{-\max})+\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{2}-v_{ij}^{-\min}}{\frac{\max\limits_{1\le i\le m}(v_{ij}^{-\max})-\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{2}},\frac{\frac{\max(v_{ij}^{-\max})+\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{2}-v_{ij}^{-\max}}{\frac{\max\limits_{1\le i\le m}(v_{ij}^{-\max})-\min\limits_{1\le i\le m}(v_{ij}^{-\min})}{2}}\right]. \quad (3)$$

It can be observed that those standardized evaluation indexes of knowledge management performance all satisfy $0\le v_{ij}^{-\min}\le 1$, $0\le v_{ij}^{-\max}\le 1$. Then the differentiation among those evaluation indexes is removed and measure standard of all the evaluation indexes is unified, which is beneficial to the accuracy of performance measurement of knowledge management.

3.3 THE GREY RELATIONAL DEGREE OF PERFORMANCE MEASUREMENT OF ENTERPRISE KNOWLEDGE MANAGEMENT

Grey relational analysis is a decision-making analysis method that analyzes and determines the degree of influence between two systems by analyzing the reference sequence and comparing the proximity of the geometrical shape of sequences to judge the proximity of changing tendency based on the analysis of the geometrical proximity of the data sequence of the system. It measures the relational degree between systems or between factors based on the grey relational degree, and describes the relative changes of factors in the development of the system. In the development process of the system, if the consistency of change trends of two factors is high, the grey relational degree between the two factors is high; otherwise the grey relational degree between the two factors is low. The grey relational analysis analyzes the development trend of the system, so it does not require strictly the sample size and typical regulations of distribution. Thus, it can be widely applied. However, when grey relational analysis is conducted to fuzzy and uncertain values of evaluation indexes, the classical grey

relational analysis method needs to be improved. Thus, this study introduces Euclidean distance in analysis.

Assume that all the evaluation indexes of knowledge management performances have been standardized, and the standardized indexes are all positive indexes. Thus, the optimal evaluation index sequence V^* of the set of evaluation indexes of knowledge management performance can be established as:

$$V^* = \left(\bar{V}_1^*, \bar{V}_2^*, ..., \bar{V}_n^*\right) = \left(\left[v_1^{-\min*}, v_1^{-\max*}\right], \left[v_2^{-\min*}, v_2^{-\max*}\right], ..., \left[v_n^{-\min*}, v_n^{-\max*}\right]\right). \quad (4)$$

In the sequence:

$$\bar{V}_j^* = [\max_{1\le i\le m}(v_{ij}^{-\min}), \max_{1\le i\le m}(v_{ij}^{-\max})]. \quad (5)$$

Thus, the Euclidean distance $D_{ij}(\bar{V}_{ij} \to \bar{V}_j^*)$ of the enterprise i on the evaluation index of knowledge management performance j and the ideal optimal sequence of evaluation indexes V^* is:

$$D_{ij}\left(\bar{V}_{ij} \to \bar{V}_j^*\right) = \frac{\left[\left|v_{ij}^{-\min} - \max_{1\le i\le m}\left(v_{ij}^{-\min}\right)\right|^2 + \left|v_{ij}^{-\max} - \max_{1\le i\le m}\left(v_{ij}^{-\max}\right)\right|^2\right]^{\frac{1}{2}}}{\sqrt{2}}. \quad (6)$$

According to the relative theories of grey relational analysis method, the relational coefficient ξ_{ij} of enterprise i on the evaluation index of knowledge management performance j and the ideal optimal evaluation index sequence V^* is:

$$\xi_{ij} = \frac{\min\limits_{1\le i\le m}\min\limits_{1\le i\le n} D_{ij}(\bar{V}_{ij} \to \bar{V}_j^*) + \rho \max\limits_{1\le i\le m}\max\limits_{1\le i\le n} D_{ij}(\bar{V}_{ij} \to \bar{V}_j^*)}{D_{ij}(\bar{V}_{ij} \to \bar{V}_j^*) + \rho \max\limits_{1\le i\le m}\max\limits_{1\le i\le n} D_{ij}(\bar{V}_{ij} \to \bar{V}_j^*)}, \quad (7)$$

where $i = 1, 2, ..., m$; $j = 1, 2, ..., n$; ρ is the resolution ratio and $\rho \in (0,1)$. Generally, $\rho = 0.5$.

Considering the weights w_{ij}^2 of different 2nd level evaluation indexes are different, the weighted grey relational degree φ_i^2 of enterprise i on the 2nd level evaluation index on knowledge management performance is:

$$\varphi_i^2 = \sum_{j=1}^{n^2}(w_{ij}^2 \xi_{ij}). \quad (8)$$

Combining the weights w_{ij}^1 of the 1st level of evaluation indexes, the weighted grey relational degree ψ_i of enterprise i on the evaluation index set of knowledge management performance is:

$$\psi_i = \sum_{j=1}^{n^1}(w_{ij}^1 \varphi_i^2). \quad (9)$$

Thus, according to the principle of selecting the closest in the analysis of grey relational analysis with multiple attributes based on grey relational degree of comprehensive weight, if:

$$\psi_i = \max\{\psi_1, \psi_2, \cdots, \psi_m\}. \quad (10)$$

The level of knowledge management performance of the enterprise i is the closest to the level of knowledge management performance correspondent to the ideal optimal evaluation index sequence.

3.4 REALIZATION OF THE MODEL AND ALGORITHM OF PERFORMANCE MEASUREMENT OF KNOWLEDGE MANAGEMENT BASED ON GREY RELATIONAL ANALYSIS METHOD

Based on what mentioned above, the algorithm implementation of performance measurement model of knowledge management based on grey relational analysis method can be described as below:

Step 1: Determine the basic principles in choosing evaluation indexes of enterprise knowledge management performance directing at the complex dynamic influence factors of multiple levels and aspects in the process of enterprise knowledge management.

Step 2: Establish the evaluation index system of knowledge management performance under the guidance of principles of choosing evaluation indexes, and form evaluation plan and evaluation index set of knowledge management performance based on this evaluation index system.

Step 3: Determine the types of evaluation indexes in the above-mentioned evaluation index set, and obtain the values of evaluation indexes of knowledge management performance plans of different enterprises.

Step 4: Standardize positive indexes, negative indexes and moderate indexes respectively according to Equations (1)-(3) and unify the measure standard of each type of evaluation indexes.

Step 5: Construct the optimal evaluation index sequence of evaluation index set of knowledge management performance with Equations (4) and (5).

Step 6: Obtain the Euclidean distance between the plan of knowledge management performance and the ideal optimal evaluation index sequence with Equation (6).

Step 7: Obtain the grey relational coefficient between the plan of knowledge management performance and the ideal optimal evaluation index sequence with Equation (7).

Step 8: consider the weights of different levels of evaluation indexes of knowledge management performance and obtain the comprehensive weighted grey relational degree with Equations (8) and (9).

Step 9: According to the value of comprehensive weighted grey relational degree obtains the optimal plan of knowledge management performance with Equation (10).

4 Verification of the model and the algorithm

This paper set the evaluation and analysis of knowledge management performance of three enterprises in the economic and technological development zone of the new city zone of a provincial capital as the object for the case study, in order to prove the algorithm feasible and practicable. The set of analysis object of performance measurement of knowledge management is $C=\{C_1,C_2,C_3\}$. C_1, C_2 and C_3 respectively stand for the three enterprises. The weight values were obtained from specialists in domain design with comprehensive understanding of the mechanism of the three enterprises. They combined the investigation and analysis of the relative materials of the three enterprises, their own knowledge, experience and personal preference and analysed the weights of the 1st level indexes and the 2nd level indexes of the above-mentioned evaluation index system of knowledge management performance with comprehensive judgment approach. The corresponding weighted values are presented in Table 2. Meanwhile, via investigation, statistics and analysis, the information of the knowledge management performance of the three enterprises was obtained, as also presented in Table 2.

If a table is too long to fit onto one page, the table number and headings should be repeated on the next page before the table is continued.

Alternatively, the table can be spread over two consecutive pages (first on even-numbered, then on odd-numbered page).

For a wide table you can use 1-column section (Table 1), for a small standard table 2-column section is used (Table 2).

Table 2 Information of evaluation index of knowledge management performance

1st level index	Weight	2nd level index	Weight	Information of evaluation index		
				Enterprise 1	Enterprise 2	Enterprise 3
The capacity of information management U_1	0.21	Information level of the enterprise u_{11}	0.21	0.83–0.85	0.80–0.83	0.67–0.70
		Information communication level among employees u_{12}	0.19	0.68–0.73	0.75–0.80	0.78–0.83
		Information communication level among departments u_{13}	0.22	0.75–0.78	0.75–0.80	0.75–0.78
		Information communication level between the enterprise and the customers u_{14}	0.18	0.80–0.85	0.75–0.80	0.75–0.80
		Information support level of cooperation in production u_{15}	0.20	0.76–0.80	0.70–0.74	0.67–0.70
The marketing capacity U_2	0.15	Customer satisfaction u_{21}	0.18	0.80–0.85	0.60–0.65	0.80–0.85
		Customer profitability u_{22}	0.17	1.35	2.32	0.98
		Market retention rate u_{23}	0.20	85–90	80–85	85–90
		Market share u_{24}	0.25	0.016–0.018	0.013–0.015	0.012–0.015
		Quick reaction capacity in marketing u_{25}	0.20	0.60–0.70	0.75–0.85	0.65–0.75
The level of knowledge stock U_3	0.19	The ratio of technical personnel u_{31}	0.20	0.73	0.58	0.69
		The holding quantity of technological achievements u_{32}	0.30	15	22	18
		The conservation rate of technical personnel u_{33}	0.28	0.75–0.80	0.85–0.90	0.75–0.80
		The average level of education of technical personnel u_{34}	0.22	1.34	1.50	2.01
The maturity of learning organization U_4	0.22	The learning competence in external communication u_{41}	0.25	2.50–2.80	1.60–1.80	2.00–2.20
		The learning competence in internal training u_{42}	0.25	20.00–25.00	12.00–14.00	16.00–18.00
		The improvement level of incentive mechanism u_{43}	0.26	0.77–0.80	0.68–0.75	0.54–0.60
		The ability of the knowledge managers u_{44}	0.24	0.80–0.85	0.75–0.80	0.70–0.75
The transfer ability of knowledge using U_5	0.23	The knowledge acquisition capacity u_{51}	0.30	90–95	80–85	85–90
		The knowledge innovation capacity u_{52}	0.25	80–85	85–90	85–90
		The knowledge transformation capacity u_{53}	0.25	80–85	70–75	80–85
		The knowledge learning capacity u_{54}	0.20	70–75	80–85	80–85

Based on the type of evaluation indexes, applying the method of standardization of evaluation index in the paper, the standardized information of different evaluation indexes can be obtained. The values are presented in Table 3.

Table 3 The standardized value of evaluation indexes of knowledge management performance

2nd level index	Information of evaluation index		
	Enterprise 1	**Enterprise 2**	**Enterprise 3**
Information level of the enterprise u_{11}	0.976–1.000	0.941–0.976	0.788–0.824
Information communication level among employees u_{12}	0.819–0.880	0.904–0.964	0.940–1.000
Information communication level among departments u_{13}	0.938–0.975	0. 938–1.000	0.938–0.975
Information communication level between the enterprise and the customers u_{14}	0.941–1.000	0.882–0. 941	0.882–0.941
Information support level of cooperation in production u_{15}	0.950–1.000	0.875–0.925	0.838–0.875
Customer satisfaction u_{21}	0.941–1.000	0.706–0.765	0.941–1.000
Customer profitability u_{22}	0.582	1.000	0.422
Market retention rate u_{23}	0.944–1.000	0.889–0.944	0.944–1.000
Market share u_{24}	0.889–1.000	0.722–0.833	0.667–0.833
Quick reaction capacity in marketing u_{25}	0.706–0.824	0.882–1.000	0.765–0.882
The ratio of technical personnel u_{31}	1.000	0.795	0.945
The holding quantity of technological achievements u_{32}	0.682	1.000	0.818
The conservation rate of technical personnel u_{33}	0.833–0.889	0.944–1.000	0.833–0.889
The average level of education of technical personnel u_{34}	0.667	0.746	1.000
The learning competence in external communication u_{41}	0.893–1.000	0.571–0.643	0.714–0.786
The learning competence in internal training u_{42}	0.800–1.000	0.480–0.560	0.640–0.720
The improvement level of incentive mechanism u_{43}	0.963–1.000	0.850–0.938	0.675–0.750
The ability of the knowledge managers u_{44}	0.941–1.000	0.882–0.941	0.823–0.882
The knowledge acquisition capacity u_{51}	0.947–1.000	0.842–0.895	0.895–0.947
The knowledge innovation capacity u_{52}	0.889–0.944	0.944–1.000	0.944–1.000
The knowledge transformation capacity u_{53}	0.941–1.000	0.824–0.882	0.941–1.000
The knowledge learning capacity u_{54}	0.824–0.882	0.941–1.000	0.941–1.000

By applying the calculation formula of Euclidean distance in the paper, the matrix of Euclidean distance of performance measurement of knowledge management can be obtained:

$$\mathbf{D}=\begin{bmatrix}0.000 & 0.030 & 0.182\\ 0.170 & 0.051 & 0.000\\ 0.018 & 0.000 & 0.018\\ 0.000 & 0.059 & 0.059\\ 0.000 & 0.075 & 0.119\\ 0.000 & 0.235 & 0.000\\ 0.418 & 0.000 & 0.578\\ 0.000 & 0.056 & 0.000\\ 0.000 & 0.167 & 0.279\\ 0.176 & 0.000 & 0.166\\ 0.000 & 0.205 & 0.055\\ 0.318 & 0.000 & 0.182\\ 0.111 & 0.000 & 0.111\\ 0.333 & 0.254 & 0.000\\ 0.000 & 0.340 & 0.197\\ 0.000 & 0.385 & 0.228\\ 0.000 & 0.091 & 0.230\\ 0.000 & 0.059 & 0.118\\ 0.000 & 0.105 & 0.053\\ 0.056 & 0.000 & 0.000\\ 0.000 & 0.118 & 0.000\\ 0.118 & 0.000 & 0.000\end{bmatrix}_{22x3}$$

The matrix of grey relational coefficient of 2nd level indexes of performance measurement of knowledge management can be obtained based on the matrix of Euclidean distance:

$$\mathbf{H}=\begin{bmatrix}1.000 & 0.906 & 0.614\\ 0.630 & 0.850 & 1.000\\ 0.941 & 1.000 & 0.941\\ 1.000 & 0.830 & 0.830\\ 1.000 & 0.794 & 0.708\\ 1.000 & 0.552 & 1.000\\ 0.409 & 1.000 & 0.333\\ 1.000 & 0.838 & 1.000\\ 1.000 & 0.634 & 0.509\\ 0.622 & 1.000 & 0.635\\ 1.000 & 0.637 & 0.840\\ 0.476 & 1.000 & 0.614\\ 0.723 & 1.000 & 0.723\\ 0.465 & 0.532 & 1.000\\ 1.000 & 0.459 & 0.595\\ 1.000 & 0.429 & 0.559\\ 1.000 & 0.761 & 0.557\\ 1.000 & 0.830 & 0.710\\ 1.000 & 0.734 & 0.845\\ 0.838 & 1.000 & 1.000\\ 1.000 & 0.710 & 1.000\\ 0.710 & 1.000 & 1.000\end{bmatrix}_{22x3}$$

The sequence of comprehensive weighted grey relational degree can be obtained via considering comprehensively the weight of 1st level evaluation indexes and 2nd level evaluation indexes. According to the principle of selecting the closest of the comprehensive weight grey relational degree, the knowledge management performance of Enterprise 1 is the optimal in the three, which consists with the actual condition.

5 Conclusion

Directing at the problems in the process of performance measurement of knowledge management, this paper puts forward a performance measurement model of knowledge management based on grey relational analysis. By establishing evaluation index system of knowledge management performance, standardization of different types of evaluation indexes is realized and an improved grey relational coefficient calculation model of evaluation indexes of knowledge management performance based on Euclidean distance is put forward. Thus, the weighted grey relational degree of performance measurement of knowledge management can be obtained, and evaluation and analysis of the knowledge management performance can be realized. Then by a case study, this model proves feasible and practicable, and can provide decision basis to the guidance of knowledge management development, which can help to improve the level of knowledge management and strengthen the competitiveness of the enterprise. What's more, it can also verify the regulations in studies of knowledge management and find new problems in knowledge management of enterprise, which is beneficial to the development of the discipline of enterprise knowledge management.

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References

[1] Hult G T M, Ketchen D J, Cavusgil S T, Calantone R J 2006 Knowledge as a strategic resource in supply chains *Journal of Operations Management* 24 458-75
[2] Lee K C, Lee S, Kang I W 2005 KMPI: measuring knowledge management performance *Information and Management* 42 469-82
[3] Wang J, Guan J 2002 The application of composite DEA method in measuring the performance of knowledge management of enterprises Studies in Science of Science 20(1) 84-8
[4] Fairchild A M 2002 Knowledge management metrics via a balanced scorecard methodology *Proceedings of the 35th Hawaii International Conference on System Science* USA 2002
[5] Li S, Chang Li, Zou S 2001 Grey relational assessment of know ledge stocks of enterprises *Science Research Management* 22(3) 73-8 *(in Chinese)*
[6] Zhu Q H, Zhang G 2003 Appraisal model of enterprises know ledge management based on artificial neural network *Science of Science and Management of S&T* (8) 32-4.
[7] Tseng S-M 2009Knowledge management performance measure index *Expert systems with Applications* (34) 734-45
[8] Wang T, Yang A, Bu L 2013 Mechanism scheme design based on multi-attribute extension gray relevant optimized decision-making model *Systems Engineering – Theory & Practice* 33(9) 2321-9 *(in Chinese)*
[9] Liu S, Fang Z, Yang Y, et al 2012 General grey numbers and its operations *Grey Systems: Theory and Application* 2012 2(3) 4-15
[10] Xiao X P, Wen J H, Xie M 2010 Grey relational analysis and forecast of demand for scrap steel *The Journal of Grey System* 22(1) 73-80
[11] Xie N M, Liu S F 2009 Research on evaluations of several grey relational models adapt to grey relational axioms *Journal of Systems Engineering and Electronics* 20(2) 304-9

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