International Journal of Hybrid Information Technology
Vol. 9, No.12 (2016), pp. 175-186
http://dx.doi.org/10.14257/ijhit.2016.9.12.16

Research on Indicator System of Construction Project Comprehensive Performance Management and Evaluation: Based On Combination Weight and TOPSIS

Tao Li [a] and Hao Liu [b,] *

School of Economics and Management, North China Electric Power University, Beijing 102206, People's Republic of China
[a]442508263@qq.com; [b]liuhao1989610@163.com

Abstract

Currently, the scope of the traditional indicator system for performance evaluation of construction project is much broader. But the indicators are mostly involved only in quality, schedule, and environmental goals of the project. In other words, it only focuses on considering the level of performance that only a few large projects in progress goals, without taking into account of the impact on the overall performance level caused by the employees involved in the project and project management level of internal management of the project, which cannot meet the requirements for performance evaluation. Therefore, this article, from the view of the traditional project performance evaluation, through the introduction of financial indicators, indicators of internal, learning and development indicators, suggests a new comprehensive performance evaluation index system for construction projects. Based on the newly-built comprehensive performance evaluation index system of construction project, the collected project data by the author of this paper will be processed and analyzed. According to the characteristics of the index system and data rules, together with the introduction of a combination of indicators of empowerment evaluation method and TOPSIS method, the three construction project performance level is evaluated comprehensively in order to verify the rationality and practicality of the proposed construction project of comprehensive performance rating system. The results of this research show that the proposed project overall level of performance evaluation method is feasible, and it can be employed to do more comprehensive performance evaluation of the construction project, which provides new ideas and reference for the comprehensive evaluation of the level of performance of construction projects.

Keywords: *comprehensive performance; evaluation methods; index system; combination weight; TOPSIS; index system*

1. Introduction

With the further expansion in the construction field, more and more enterprises are faced with the obvious problems of how to fully enhance the project performance management and, at the same time, make a reasonable and holistic evaluation on the project performance level, and other issues as well. Comprehensive performance evaluation of the project is not only the key to improving the overall management of the project, but also an important measure to improve the construction of their own level of performance. Traditional indicators of performance evaluation system involves mostly just in quality, schedule, and environmental goals of the project, that is to say, it only considers the level of performance that only a few large projects in progress goals, without taking into account of the impact on the overall performance level caused by the staff involved

ISSN: 1738-9968 IJHIT

in the project and project management level of internal management of the project, which cannot meet the requirements for the performance evaluation.

With the rapid development of performance evaluation theory and practice, the evaluation processes of enterprise performance and project performance have made great progress. The enterprise performance evaluation has gradually improved from former financial evaluation to comprehensive evaluation which focuses on both financial indicators and other enterprise indicators. The most representative comprehensive evaluation methods are balanced score card-BSC[1] and key performance indicators-KPI[2] Meanwhile, the project is improving the level of performance evaluation, the target range is not only involved in aspects of the project schedule, quality, safety, and environment, but also contribute to keep the project on business development point of view. E.K. Zavadskasn, *etc* [3]established project performance evaluation index system includes not only the traditional project performance indicators, also includeed project profitability, revenue management and other aspects. Wang Tingjing and Lai Changbing [4]established indicator system of project performance from the aspects of economic benefits, socioeconomic impact, operation, environment impact, but indicators related to project progress, its cost and quality were not included. Besides, the indicator system was improving towards project cost and employee attitude [5], which also exceeded the purpose scopes of traditional project performance evaluation.

In summary, current at the time of the evaluation of project performance evaluation index system constructed system compared with traditional indicators have great development, but the main index system to expand the company's financial and internal staff point of view, involving content still has some limitations. Therefore, this article is not only isolated from the traditional indicators of project performance evaluation system, but also the introduction of innovative financial indicators, indicators of internal processes, learning and development indicators, the establishment of a new comprehensive performance evaluation of the project to ensure project performance evaluation for comprehensive, reasonable. Then quantitative indicators and qualitative indicators of quantitative data collection process. According to the index system characteristics and data rules, select the calculation of each index combination weighting method Entropy Law and the characteristic value method based on the weight, and then select the ideal point method for comprehensive evaluation of the project. Finally, collecting three performance indicators in the construction project data to verify the scientific paper establishes the index system through examples, rationality, to provide a method of reference for a comprehensive evaluation of the level of performance of construction projects.

2. Establishment of Indicator System and Collection of Indicators Data

2.1. Establishing Indicator System

In order to ensure the objectivity and reasonableness of project performance evaluation, this paper establishes indicator system from the aspects of enterprise performance and project performance, in which enterprise performance indicators are from common indicator systems of enterprise performance evaluation[4], and project performance indicators are from some project under construction[6]. To ensure the comprehensiveness and simplicity, expert consultation and multivariate statistical methods are applied to simply the redundant indicators and indicators that correlate little with evaluation purpose, and the indicator system after reduction is shown in Table 2-1.

Table 2-1. Indicator System of Construction Project Performance Evaluation

First class	Second class	Third class
Indicator system of construction project performance evaluation (O)	finance (A_1)	income satisfaction of staff (B_{11})
		capital utilization (B_{12})
	internal process (A_2)	administration innovation(B_{21})
		management quality (B_{22})
	learning and development (A_3)	staffs learning attitude (B_{31})
		perfect degree of incentive mechanism(B_{32})
	construction(A_4)	timeliness of material, equipment and construction units (B_{41})
		completion of construction schedule plan(B_{42})
		complete construction data(B_{43})
	cost(A_5)	budget and final accounts deviation rate (B_{51})
		reduction rate of project cost (B_{52})
	technique(A_6)	contract compliance rate(B_{61})
		resolution rate of technical problem (B_{62})
	quality(A_7)	passing rate of project quality (B_{71})
		The quality qualification rate of raw materials and equipment (B_{72})
	environment(A_8)	environmental protection input (B_{81})
		environmental assessment level (B_{82})

2.2. Collecting Indicators Data

Based on the indicator system established above, quantitative data of three projects numbered project 1, project 2, project 3 (hereinafter referred to as P1, P2, P3) is collected, which mainly come from relevant departments materials. As to qualitative indicators, expert scoring is applied to rank them and then quantify them. The higher score, the higher performance level for the same indicator. Then, the indicators raw data can be seen in Table 2-2.

Table 2-2. Raw Data of Performance Evaluation Indicators

indicators	units	P1	P2	P3
B_{11}	%	76	87	84
B_{12}	%	31	40	26
B_{21}	point	3.8	4.3	3.2
B_{22}	point	3.1	3.4	4.2
B_{31}	point	2.1	3.3	4.0
B_{32}	point	3.8	4.2	3.6
B_{41}	%	90	87	72
B_{42}	%	81	89	76

B_{43}	%	87	85	79
B_{51}	%	18	9	16
B_{52}	%	75	86	88
B_{61}	%	80	91	84
B_{62}	%	90	95	87
B_{71}	%	95	92	90
B_{72}	%	93	97	85
B_{81}	million RMB	1.24	0.97	1.35
B_{82}	0-1	0.72	0.88	0.90

3. Models and Methods

3.1. Processing of Indicators Data

(1) Unification method

According to the indicator system established in this paper, the indicators including income satisfaction of staff, capital utilization, administration innovation, management quality, staffs' learning attitude, perfect degree of incentive mechanism, timeliness of material, equipment and construction units, completion of construction schedule plan, complete construction data, reduction rate of project cost, contract compliance rate, resolution rate of technical problem, passing rate of project quality, the quality qualification rate of raw materials and equipment, environmental assessment level are benefit indicators; budget and final accounts deviation rate, environmental protection input cost indicators.

Cost indicators are transferred into benefit indicators in this paper. The transfer formula is shown as $x^*=M-x$, where M is the set upper bound of x.

(2) Non-dimensional method

When evaluating the project performance level, different dimensions of different indicators makes it hard for the comprehensive evaluation [7]. Then, non-dimensional method is applied to unify the indicators dimensions, where efficacy coefficient is introduced in this paper [8]. The formula of efficacy coefficient is shown below:

$$x_{ij}^* = c + \frac{x_{ij} - m_j}{M_j - m_j} \times d$$

Where, M_j, m_j respectively represent maximum and minimum values of each indicator; c and d are known constants, which make the numbers for transformation translate and zoom. The c and d are respectively valued 60 and 40 in this paper.

3.2. Eigenvalue Method

Eigenvalue method is used for determining indicators weights by establishing evaluation matrixes and comparing evaluation indicators. Firstly, evaluation matrix A is established, and the eigenvector of matrix A can be calculated by the following formula $(A-\lambda E)x=0$, where λ is the root of equation $|A-\lambda E|=0$, and then the indicators weights sequencing can be obtained. The eigenvector corresponding to the maximum eigenvalue of matrix A is the weight vector wanted. However, this method needs examining consistency. Consistency indicator CI can be calculated with the following formula $CI = (\lambda_{\max} - m) / (m-1)$, where *m* represents the matrix order. The average random consistency *RI* meets demands of the Table 3-1.

Table 3-1. Average Random Consistency RI

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

The random consistency rate *CR* can be calculated with formula $CR = CI / RI$. When *CR* is lower than 0.10, the judgment matrix has satisfied consistency; or the judgment matrix need adjusting, until it has satisfied consistency.

3.3. Entropy Weight Method

Entropy weight method is used to determine the indicators weights based on information load of each indicator [9]. Here establishes matrix R= $(x_{ij})_{m*n}$, in which x_{ij} represents the *i*th indicator attribute corresponding to *j*th item. The detailed procedure of the entropy weight method is given below:

(1) Contribution degree

$$p_{ij} = x_{ij} / \sum_{i=1}^{n} x_{ij}$$

Where, p_{ij} represents the contribution degree of the *j*th item corresponding to *i*th indicator attribute.

(2) Entropy

Entropy e_i is the total contribution of all the items to *i*th indicator:

$$e_i = -k \sum_{j=1}^{n} p_{ij} Inp_{ij}$$

Where, constant *k* can be calculated by formula $k = 1/Inn$.

(3)Difference coefficient

g_i represents contribution difference of each item corresponding to the *i*th indicator.

$$g_i = 1 - e_i$$

(4)Indicators weights

The entropy weight of the *j*th indicator can be obtained by the following formula:

$$w_i = \frac{g_i}{\sum_{i=1}^{m} g_i}$$

3.4. Combination Weight Method

In order to avoid the influence of experts' subjective preferences in subjective weight, and uncontrolled weighting result in objective weight, the combination weight is applied to determine the indicators weights[10]. The weight vector by eigenvalue method is shown as $w' = \left(w_1', w_2', \cdots, w_n'\right)^T$, and the weight vector by entropy weight method is shown as $w'' = \left(w_1'', w_2'', \cdots, w_n''\right)^T$. Then the combination weight of each indicator can be calculated with the following formula:

$$w = k_1 * w' + k_2 * w''$$

Where, $k_1 + k_2 = 1$ and k_1, k_2>0.

3.5. TOPSIS

TOPSIS is originated in discrimination problems of multivariate statistical analysis [11]. The detailed procedures of TOPSIS are shown below:

(1)Standard decision matrix

Based on the indicators data after processing in Table 5-1, the standard decision matrix T=(t_{ij})$_{m*n}$ can be established.

(2) Weighted decision matrix

Based on the indicators combination weight vector $W=(w_1, w_2, ..., w_m)$, the weighted decision matrix can be obtained by the following formula:

$$X = WT = \begin{bmatrix} w_1t_{11} & w_2t_{12} & \dots & w_nt_{1n} \\ w_1t_{21} & w_2t_{22} & \dots & w_nt_{2n} \\ \dots & \dots & \dots & \dots \\ w_1t_{m1} & w_2t_{m2} & \dots & w_nt_{mn} \end{bmatrix}$$

Where, w_j is the weight of the jth indicator and $\sum_{j=1}^{n} w_j = 1$.

(3)Positive and negative ideal points

In the weighted decision matrix, the positive ideal point x^+ is a vector composed of maximum number of each column; the negative ideal point x^- is a vector composed of minimum number of each column, that is, x^+ and x^- meet the requirements below:

$$x^+ = (x_1^+, x_2^+, ..., x_m^+), x_j^+ = \max\{x_{ij}\}, j = 1, 2, ..., m$$

$$x^- = (x_1^-, x_2^-, ..., x_m^-), x_j^- = \min\{x_{ij}\}, j = 1, 2, ..., m$$

(4)Distances with positive and negative ideal solutions

The n-dimension Euclidean distances between evaluated object and positive, negative ideal points are shown by y_i^+ and y_i^-, which are calculated with the following formulas:

$$y_i^+ = \sqrt{\sum_{j=1}^{m}(x_{ij} - x_j^+)}, \quad i = 1, 2, ..., n$$

$$y_i^- = \sqrt{\sum_{j=1}^{m}(x_{ij} - x_j^-)}, \quad i = 1, 2, ..., n$$

(5) Similarities with positive ideal point

Similarities with positive ideal point can be obtained by the following formula:

$$C_i = \frac{y_i^-}{y_i^+ + y_i^-}$$

It is obvious that the larger C_i is, the longer distance between evaluated object and negative ideal solution and shorter distance between evaluated object and positive ideal solutions are. Then, rank the similarities of all the objects and select the best evaluated object.

4. Results

4.1. Indicators Data Processing

When conducting unification of indicators data, M_{51} and M_{81} are respectively valued 1.40 million and 100%. Then based on the unification result, the efficacy coefficient method is applied to unify the indicators dimensions. The processing result is shown in Table 4-1.

Table 4-1. Processing Result of Indicators Data

indicators	unification			non-dimensions		
	P1	P2	P3	P1	P2	P3
B_{11}	76	87	84	60	100	89.0909
B_{12}	31	40	26	74.2857	100	60
B_{21}	3.8	4.3	3.2	81.8182	100	60
B_{22}	3.1	3.4	4.2	60	70.9091	100
B_{31}	2.1	3.3	4	60	85.2632	100
B_{32}	3.8	4.2	3.6	73.3333	100	60
B_{41}	90	87	72	100	93.3333	60
B_{42}	81	89	76	75.3846	100	60
B_{43}	87	85	79	100	90	60
B_{51}	82	91	84	60	100	68.8889
B_{52}	75	86	88	60	93.8462	100
B_{61}	80	91	84	60	100	74.5455
B_{62}	90	95	87	75	100	60
B_{71}	95	92	90	100	76	60
B_{72}	93	97	85	86.6667	100	60
B_{81}	0.16	0.43	0.05	71.5790	100	60
B_{82}	0.72	0.88	0.9	60	95.5556	100

4.2 Determining the Indicators Weights

(1) Indicators weights by eigenvalue method

According to the eigenvalue method, the indicators scores tables of relative importance and weighting result are shown from Table 4-2 to Table 4-10. And the weight of each indicator relative to the first class indicator is calculated, as Table 4-11 shows.

Table 4-2. Indicator Weights of Layer O-A

O-A	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	weight
A_1	1	1.5	0.8	0.8	0.5	0.4	0.6	0.8	0.0902
A_2	0.6667	1	0.7	0.6	0.4	0.5	0.8	0.9	0.0813
A_3	1.25	1.4286	1	1.25	1	1.5	2	1.25	0.1585
A_4	1.25	1.6667	0.8	1	0.8	1.25	1.5	0.5	0.1249
A_5	2	2.5	1	1.25	1	1.5	1.25	1	0.1653
A_6	2.5	2	0.6667	0.8	0.6667	1	0.8	0.5	0.1164
A_7	1.6667	1.25	0.5	0.6667	0.8	1.25	1	0.8	0.1129
A_8	1.25	1.1111	0.8	2	1	2	1.25	1	0.1505

The maximum eigenvalue λ_{max} of judgment matrix is 8.2641, the value of Consistency indicator *CI* 0.0377, the value of random consistency *RI* 0.0267, and the matrix has satisfied consistency.

Table 4-3. Indicators Weights of Layer A1-B

A_1	B_{11}	B_{12}	weight	λ_{max}	test
B_{11}	1	0.8	0.4444	2	CI=0; satisfied
B_{12}	1.25	1	0.5556		

Table 4-4. Indicators Weights of Layer A2-B

A_2	B_{21}	B_{22}	weight	λ_{max}	test
B_{21}	1	0.85	0.4595	2	CI=0;
B_{22}	1.1764	1	0.5405		satisfied

Table 4-5. Indicators Weights of Layer A3-B

A_3	B_{31}	B_{32}	weight	λ_{max}	Test
B_{31}	1	1.2	0.5455	2	CI=0;
B_{32}	0.8333	1	0.4545		satisfied

Table 4-6 Indicators Weights of Layer A4-B

A_4	B_{41}	B_{42}	B_{43}	weight	λ_{max}	test
B_{41}	1	1.5	2	0.4568		CI=0.0051;
B_{42}	0.6667	1	1.8	0.3366	3.0101	CR=0.0871;
B_{43}	0.5	0.5556	1	0.2067		satisfied

Table 4-7. Indicators Weights of Layer A5-B

A_5	B_{51}	B_{52}	weight	λ_{max}	test
B_{51}	1	0.7	0.4118	2	CI=0;
B_{52}	1.4286	1	0.5882		satisfied

Table 4-8. Indicators Weights of Layer A6-B

A_6	B_{61}	B_{62}	weight	λ_{max}	test
B_{61}	1	1.2931	0.5639	2	CI=0;
B_{62}	0.7733	1	0.4361		satisfied

Table 4-9. Indicators Weights of Layer A7-B

A_7	B_{71}	B_{72}	weight	λ_{max}	test
B_{71}	1	0.86	0.4624	2	CI=0;
B_{72}	1.1627	1	0.5376		satisfied

Table 4-10. Indicators Weights of Layer A8-B

A_8	B_{81}	B_{82}	weight	λ_{max}	test
B_{81}	1	0.6667	0.4000	2	CI=0;
B_{82}	1.5	1	0.6000		satisfied

Table 4-11. Indicators Weights Corresponding To the First Class

first class	second class	third class
Indicator system of construction project performance evaluation (O)	(A_1) 0.0902	(B_{11}) 0.0401
		(B_{12}) 0.0501
	(A_2) 0.0813	(B_{21}) 0.0374
		(B_{22}) 0.0439
	(A_3) 0.1585	(B_{31}) 0.0865
		(B_{32}) 0.0720
	(A_4) 0.1249	(B_{41}) 0.0571
		(B_{42}) 0.0420
		(B_{43}) 0.0258
	(A_5) 0.1653	(B_{51}) 0.0681
		(B_{52}) 0.0972

	(A_6) 0.1164	(B_{61}) 0.0656
		(B_{62}) 0.0508
	(A_7) 0.1129	(B_{71}) 0.0522
		(B_{72}) 0.0607
	(A_8) 0.1505	(B_{81}) 0.0602
		(B_{82}) 0.0903

(2) Indicators weights by entropy weight method

Based on the indicator system and indicator data from three projects, the entropy weight method is applied to determine indicators weights, as the Table 4-12 shows.

Table 4-12. Indicators Weights by Entropy Weight Method

indicators	P1	P2	P3	e_i	g_i	w_i
B_{11}	60	100	80	0.9803	0.0197	0.0570
B_{12}	74.2857	100	60	0.9798	0.0202	0.0585
B_{21}	100	80	60	0.9809	0.0191	0.0553
B_{22}	80	100	60	0.9786	0.0214	0.0619
B_{31}	60	86.6667	100	0.9808	0.0192	0.0556
B_{32}	80	100	60	0.9795	0.0205	0.0593
B_{41}	100	93.3333	60	0.9794	0.0206	0.0598
B_{42}	75.3846	100	60	0.9801	0.0199	0.0577
B_{43}	100	90	60	0.9802	0.0198	0.0575
B_{51}	60	100	68.8889	0.9777	0.0223	0.0646
B_{52}	60	80	100	0.9792	0.0208	0.0603
B_{61}	60	100	74.5455	0.9799	0.0201	0.0583
B_{62}	75	100	60	0.9800	0.0200	0.0580
B_{71}	100	76	60	0.9802	0.0198	0.0573
B_{72}	80	100	60	0.9807	0.0193	0.0560
B_{81}	71.5790	100	60	0.9789	0.0211	0.0611
B_{82}	60	80	100	0.9787	0.0213	0.0618

(3) Indicators combination weights

The weights of subjective and objective weight methods for the combination weight are calculated by lagrange algorithm, and the result is shown in Table 4-13.

Table 4-13. Indicators Combination Weight

indicators	weight	indicators	weight	indicators	weight	indicators	weight
B_{11}	0.0422	B_{32}	0.0704	B_{52}	0.0926	B_{81}	0.0603
B_{12}	0.0511	B_{41}	0.0574	B_{61}	0.0647	B_{82}	0.0867
B_{21}	0.0396	B_{42}	0.0440	B_{62}	0.0517		
B_{22}	0.0461	B_{43}	0.0298	B_{71}	0.0528		
B_{31}	0.0826	B_{51}	0.0677	B_{72}	0.0601		

4.3. The result of TOPSIS

Weighted judgment matrix can be calculated by the indicators data after processing and indicators combination weights, as the Table 4-14 shows.

Table 4-14. Weighted Judgment Matrix

indicators	weighted judgment matrix		
B_{11}	2.5325	4.2209	3.7604
B_{12}	3.7996	5.1148	3.0689
B_{21}	3.2428	3.9634	2.3780
B_{22}	2.7688	3.2722	4.6146
B_{31}	4.9586	7.0465	8.2644
B_{32}	5.1638	7.0415	4.2249
B_{41}	5.7437	5.3608	3.4462
B_{42}	3.3139	4.3959	2.6376
B_{43}	2.9756	2.6781	1.7854
B_{51}	4.0598	6.7663	4.6612
B_{52}	5.5557	8.6897	9.2595
B_{61}	3.8813	6.4689	4.8223
B_{62}	3.8774	5.1699	3.1019
B_{71}	5.2836	4.0156	3.1702
B_{72}	5.2098	6.0113	3.6068
B_{81}	4.3171	6.0312	3.6187
B_{82}	5.2046	8.2888	8.6743

The positive and negative ideal points can be determined by the table above:

X^+=(4.2209,5.1148,3.9634,4.6146,8.2644,7.0415,5.7437,4.3959,2.9756,6.7663, 9.2595,6.4689, 5.1699, 5.2836, 6.0113, 6.0312, 8.6743)

X^-=(2.5325, 3.0689,2.3780,2.7688,4.9586, 4.2249, 3.4462,2.6376,1.7854, 4.0598, 5.5557, 3.8813, 3.1019, 3.1702, 3.6068, 3.6187, 5.2046)

Then, distances with positive, negative ideal points, the similarities with positive ideal point and the sequence of the three projects are shown in Table 4-15.

Table 4-15. The Result of TOPSIS

items	y^+	y^-	C_i	sequence
P1	69.1607	17.4411	0.2014	3
P2	5.6019	79.5978	0.9342	1
P3	52.119	42.8471	0.4512	2

According to the table above, the score of P2 is the highest. And by the methods applied in this paper, the performance levels of three projects are evaluated, in which P2 ranks first, P3 second, P1 third.

5. Conclusions

This paper takes the drawback that the project performance has great influence on enterprise performance into consideration, through the introduction of financial indicators, indicators of internal processes, learning and development indicators, to build a new comprehensive performance evaluation index system for construction projects. Based on this, performance indicators data of construction project is collected and then further processed, which lays the foundation for determining indicators weights. At last, TOPSIS is applied to comprehensively evaluate the projects performance levels. With living examples, the indicator system, combination weight method and comprehensive evaluation method are verified feasible. Judging from the raw data, the comprehensive performance condition of P2 is better, while the evaluation result of P2 ranks the first, consistent with the reality. Therefore, the evaluation methods introduced in this paper will provide reference for project performance evaluation. However, the relative importance of indicators in eigenvalue method is from experts scoring, which is inevitably subjective. So how to reduce the experts' subjective influence to the minimum and ensure a reasonable, real evaluation result still need further research.

References

[1] Herman and Aggis, "Performance management", Beijing: China Renmin University Press, **(2008)**.
[2] Y.H. Fu and Y.L. Xu, "Performance management (Second Edition)", Shanghai: Fudan University Press, **(2008)**.
[3] E.K. Zavadskasn, T. Vilutiene and Z. Turskis, "Multi-criteria analysis of Projects' performance in construction", Archives of Civil and Mechanical Engineering, **(2014)**, pp. 114-121.
[4] T.J. Wang and Y.B. Lai, "Study on the Performance Evaluation Index System of the Highway Construction Project", Highway traffic science and Technology (Technology Edition), no. 09, **(2008)**, 186-191.
[5] C. Ngacho and D. Das, "A performance evaluation framework of development projects: An empirical study of Constituency Development Fund construction projects in Kenya", International Journal of Project Management, vol. 32, no. 3, **(2008)**, pp. 492-507.
[6] Y.H. Sun and H. Luo, "Performance Appraisal Quantitative Management", Beijing: People's Posts and Telecommunications Press, **(2008)**, pp. 524-526.
[7] H.T. Wen and C.P. Ren, "A New Study of Non-measurement in Evaluation of Enterprise's Performance", On Economic Problems, no. 6, **(2011)**, pp. 61-65.
[8] H.B. Lv, "The Efficacy Coefficient Method in the Evaluation of Enterprise Performance", Inner Mongolia Science Technology and Economy, no. 9, **(2009)**, pp. 69-71.
[9] W.J. Qu and X.Y. Fang, "Assessment of black-start modes based on entropy value method and principal component analysis", Power System Protection and Control, vol. 42, no. , **(2014)**8, pp. 22-27.
[10] G.X. Song and D.L. Yang, "Combination weighting approach based on the decision-maker's preference and consistency of weighting methods", Systems Engineering and Electronics, vol. 26, no. 9, **(2004)**, pp. 1226-1230.
[11] X.X. Luo and S.H. Peng, "Research on the Vendor Evaluation and Selection Based on AHP and TOPSIS in Green Supply Chain", Soft science, vol. 25, no. 2, **(2011)**, pp. 53-56.

