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Research on Evaluating the Efficiency of the Project Financing of the Energy Service Company

Abstract The financing efficiency evaluation of the ESCO (Energy Service Company) is an important approach to improve the operation efficiency of existing building energy-saving projects. To scientifically and reasonably evaluate the financing efficiency of the ESCO, this paper puts forward a combination evaluation model based on the method set. Firstly, the method set is composed of different methods that meet the demand of statistical coherence, and KENALL-W coefficient test of concordance is used to check up the coherence of the ranking results of the different methods. Secondly, mean, Borda and Copeland are used separately for calculating the combination evaluation results and the circular combination method is used to ensure the coherence of evaluation results. Finally, the combination evaluation model is used to evaluate the 10 ESCO business project financing benefits, and the effectiveness of the models is verified accordingly.

Keywords: ESCO, project financing, financing efficiency, method set, combination evaluation

1 Introduction

According to a study, at least 1.5 trillion CNY (Zhan, He, & Liu, 2012) is used to achieve the 50% energy saving standards for the building energy conservation transformation, which shows that the implementation of energy saving renovation for existing buildings is necessary in China. However, the successful fund raising has become the key point of the project. Whether it is completed smoothly or not will affect the project. The contract energy management mechanism was introduced in China in 1998 (Shang & Li, 2013), and its main function is to build energy efficiency service enterprises. In the ESCO project finance system, the financing efficiency evaluation can reflect not only the current state of capital management in the enterprise, but also the trend, and constantly improve the financing management level of enterprises. Therefore, to scientifically and accurately evaluate the effectiveness of project financing, effectively monitor the financing management of ESCO enterprises, clear the key factors influencing the ESCO project financing, and take effective measures are important topics.

In the field of financing efficiency evaluation researches have achieved fruitful results (Chen & Li, 2004; Li, Chen, G., & Chen, B., 2013; Li & Xu, 2014; Wang, Huang, & Gao, 2009; Wang, Zhang, & Huang, 2009; Yu, Guo, & Zhu, 2011). However, having reviewed the existing literature, the authors found that a majority of scholars in the domain of the financing efficiency evaluation focused on a single evaluation method, such as fuzzy comprehensive evaluation method (Zhu & Pu, 2006), DEA evaluation method (Jia & Liu, 2014), principal component analysis (Xu & Li, 2010), gray evaluation method (Li & Wang, 2014), and matter-element analysis (Zhang & Guo, 2015). There is little information on the financing efficiency evaluation model based on method set. Due to the randomness of errors in the single evaluation method system, this paper, presents the results of the single evaluation prior to those of KENDALL-W Concord coefficient test and Spearman rank correlation coefficient test combined. Finally, the combination of ESCO project financing efficiency evaluation provides new thoughts.

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2 The efficiency evaluation index system of ESCO project financing

2.1 The principles of the efficiency evaluation index system of ESCO project financing

The efficiency evaluation index system of ESCO project

financing is complex, because so many influencing factors need to be accurately measured. Therefore, according to construction requirements and premises of the evaluation index system, three principles should be followed:

(1) Pertinence principle

ESCO financing has the features of both enterprise financing and project financing Compared with other corporate finance, it has the different financing channels and financing ways which involve project financing efficiency factors, and the interaction among different affecting factors. Based on formation factors and mechanisms of ESCO project financing structure, the authors select a scientific and reasonable efficiency evaluation method, and (prominent more evident) on the selected evaluation index of ESCO project finance.

(2) Comprehensive and systematic principle

The design of financing efficiency index system of ESCO project should be careful, objective, reasonable, and contains all the important influencing factors. A comprehensive evaluation index system can reflect the advantages and disadvantages of existing financing structure. To improve accuracy, the authors establish a multi-level index evaluation system. The three-level index method of ESCO project financing efficiency evaluation is applied, and each index system composed of one, two, and three-level index systems. The analytic hierarchy process is introduced to weight assignment in the index system, making the evaluation results more objective and accurate.

(3) Scientific principles

A scientific ESCO project financing efficiency evaluation index system is the basis of accurate and reasonable evaluation results. The scientific performance of evaluation activity depends on the science of index methods, standards, and procedures. In the evaluation process, scientific principles mainly refer to the index evaluation system, which can combine theory and practice, the content and the calculation formula of standardization and indicators.

2.2 The efficiency evaluation index system of ESCO project financing

To evaluate the financing efficiency of the ESCO project objectively and fairly, the first thing is to establish a scientific and reasonable system. Therefore, having summarized the ESCO operation rules of project financing, this paper reviewed research results of the CSSCI and core journals of Peking University scholar's related research results, and build the efficiency evaluation index system of ESCO project finance. As shown in Table 1.

Table 1

The Efficiency Evaluation Index System of ESCO Project Financing

	Level indicators	The secondary indicators
The efficiency evaluation index system of ESCO project financing	Project characteristics A_1	Project size A_{11}
		Project cycle A_{12}
	The cost of financing A_2	Cost of debt A_{21}
		Equity cost of capital A_{22}
		Bank borrowing costs A_{23}
		Keep the cost of capital A_{24}
	Financing risk A_3	Customer no-show risk A_{31}
		The risk of leverage A_{32}
		Project failure risk A_{33}
	Debt paying ability A_4	Asset-liability ratioA_{41}
		Sinking BeiFuLv A_{42}
		Interest BeiFuLv A_{43}
	Profitability A_5	The total investment yields A_{51}
		Internal rate of return A_{52}
		Capital of net profit margin A_{53}

3 The combination evaluation model of building ESCO enterprise project financing efficiency

3.1 An overview of the combination evaluation model based on method sets

The combination evaluation refers to a variety of single evaluation and sorting methods, and the single evaluation results are combined (Wang, 1998). Chen and Li (2004) assure that combination evaluation method for evaluating the consistency problem is obtain complementary and combined results from these single methods. Based on the set of ESCO project financing benefit combination evaluation model, this paper introduces five types of single evaluation methods, such as the fuzzy comprehensive evaluation method, the DEA evaluation method, principal component analysis method, gray evaluation method, and matter-element analysis method. The combination evaluation model is shown in *Figure 1*.

The combination evaluation method mainly includes four steps: First of all, ESCO project financing benefits are evaluated by using 5 types of evaluation methods separately, and the ranking results of each evaluation method are obtained; Secondly, the KENDAL-W is used to examine the consistency coefficient; Thirdly, the score is evaluated by a combination of different models, and the combination evaluation results are calculated; Lastly, according to the structure of Spearman rank correlation coefficient combination evaluation test, the final evaluation results are obtained.

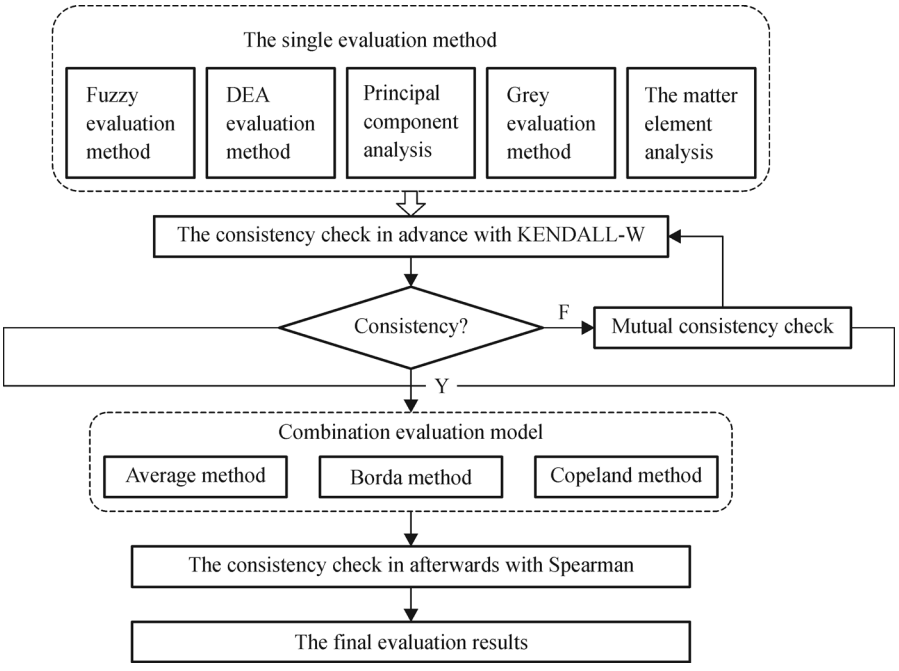

Figure 1. The combination evaluation model based on the set method.

3.2 Evaluation model based on method set combination

Step1: The single evaluation of ESCO project financing efficiency.

ESCO project financing benefits are evaluated by using 5 types of evaluation methods, and the ranking results of each evaluation method are obtained.

Step 2: The consistency coefficient is examined in KENDAL-W.

If the sorted results pass the consistency check, it proves that the single evaluation methods have consistency, go to step 4. If not, then go to step 3.

The consistency check of KENDALL-W is to eliminate conflicts of single evaluation method. Assume evaluating the evaluation object by m methods, and the value of the sorting results are showed in Table 2.

Table 2

Individual Evaluation Scheme Evaluation Results Sorting

Object	Method 1	Method 2	…	Method m
Object 1	y_{11}	y_{12}	…	y_{1m}
Object 2	y_{21}	y_{22}	…	y_{2m}
Object n	y_{n1}	y_{n2}	…	y_{nm}

y_{ij} expressed the i evaluation object under the j kinds of evaluation sorting. $1<y_{ij}\leqslant n$ $(i = 1,2,...,n,j = 1,2,...,m)$. The inspection is mainly examines the method whether the review object evaluation results are consistent or not. It shows the actual sample data meet with the differences among the biggest meet by Concorde coefficient W indicator.

(1) The null hypothesis and alternative hypothesis

where H_0: The result is not consistent. H_1: The result is consistent.

(2) Constructs statistic

$$\chi^2 = m(n-1)W \tag{1}$$

$$W = \frac{12\sum_{i=1}^{n} r_i^2 - 3m^2n(n+1)^2}{m^2n\ (\ n^2-1)} r_i = \sum_{j=1}^{m} y_{ij} \tag{2}$$

where m is the number of evaluation methods, n is the number of evaluation objects, r is the sum of the level of evaluation objects, χ^2 approximately obey the degrees of freedom for n-1 card square distribution.

(3) Statistical analysis

For a given significant level $\alpha, \chi^2 = m(n-1)W$ is subject to $\chi^2_{\alpha/2}(n-1)$, when $\chi^2 > \chi^2_{\alpha/2}(n-1)$, the authors assure that the evaluation method is consistent.

Step 3: Mutual consistency check.

If the sorted results are not consistent, the authors will make a consistent method from a variety of methods for two consistency checks. And then based on the sample data, the evaluation results and characteristics of the method are analyzed, and the selection method of the objective, realistic should be chosen and then return to step 2.

Step 4: Combination evaluation model

Every single evaluation method should be standardized,

and be chosen respectively. The authors use the arithmetic mean method, the Borda combination evaluation method, and Copeland combination evaluation method to calculate the benefit evaluation results of ESCO project financing. And obtain the combination evaluation results.

(1) Arithmetic average method

We assume that r_{ik} (I = 1, 2,...,n, k = 1, 2,...,n) is the row of y_i under the first k method, and the rank of each method sequence transforms the count by sorting grading method, that is, the first get n score, the k get n-$k+1$ score., then take the average, and then calculate the average score of different. The computation formula is as follows:

$$\overline{R_i} = \frac{1}{m}\sum_{k=1}^{m} R_{ik} \tag{3}$$

According to the average reordering, if two solutions are the same, then the variance is calculated and compared. The minimum variance is the best.

$$\sigma^2 = \sqrt{\frac{1}{m}\sum_{k=1}^{m}\left(R_{ik} - \overline{R_i}\right)^2} \tag{4}$$

(2) Combination evaluation model of Borda

The Borda combination evaluation method is a method of the minority subordinating to the majority. If evaluation thought the y_i is more than y_j,then $y_i > y_j$. If evaluation thought the y_i is equal y_j,then $y_i = y_j$. The Borda matrix is defined as $B = \{b_{ij}\}_{n\times n}$.

$$b_{ij} = \begin{cases} 1 & y_i > y_j \\ 0 & else \end{cases} \tag{5}$$

We define the total score of y_j as b_i, then $b_i = \sum_{i=1}^{n} b_{ij}$. According to the score height to sorting, if $b_i = b_j$, then the authors calculate the variance, and then compare the variance, the minimum variance is the best.

(3) Copeland method

The Copeland method is improved method on the basis of the Borda method, and it considers not only the "better," but also the distinction between "equal" and "less,"

$$c_i = \begin{cases} 1 & y_i > y_j \\ 0 & else \\ -1 & y_i < y_j \end{cases} \tag{6}$$

We define the total score of y_j as c_i,then $c_i = \sum_{i=1}^{n} c_{ij}$, according to the score height to sorting, if $c_i = c_j$, then the authors calculate the variance, and then compare the variance, the minimum variance is the best.

Step 5: The consistency post-check with Spearman

The consistency post-check with Spearman mainly use the Spearman rank correlation coefficient to test the ranking results of combination evaluation method of income and the interrelation between the original sorting results.

$$\rho_{jk} = 1 - \frac{6\sum_{i=1}^{n}\left(x_{ik} - x_{ij}\right)^2}{n\left(n^2-1\right)} \tag{7}$$

where x_{ik} is the original method, x_{ij} is the sorting result specification values under combination evaluation. n is the number of objects, and ρ_{jk} is the rank correlation coefficient. The authors will make inspections on the basis of the rank correlation coefficient of Spearman.

(1) The sorting combination evaluation results can be converted to value. The sorting results are shown in Table 3.

Table 3

Combination Evaluation Results Sorting

Object	Combination 1	Combination 2	…	Combination m
Object 1	x_{11}	x_{12}	…	x_{1m}
Object 2	x_{21}	x_{22}	…	x_{2m}
Object n	x_{n1}	x_{n2}	…	x_{nm}

(2) The null hypothesis and alternative hypothesis

H_0: The composed method has nothing to do with the original evaluation method.

H_1: The combination methods are relates to the original evaluation method.

(3) Constructing statistics

$$t_k = \rho_k\sqrt{\frac{n-2}{1-\rho_k^2}}\ (\mathrm{k} = 1,2.....\mathrm{p})\ \rho_k = \frac{1}{m}\sum_{j=1}^{m}\rho_{jk} \tag{8}$$

where t_k obeys the T distribution of $\mathrm{n}-2$ in freedom degrees. ρ_k is the average correlation degree.

Step 6: The final evaluation results

According to the rank correlation coefficient of Spearman, the most appropriate combination evaluation method is selected to get the result of the final evaluation results. The main idea of the combination evaluation method is to avoid inadequacy of the single evaluation method and to employ the advantages of combination evaluation method. The authors choose t_k as a best combination method of the largest group, which is most close to the original method, and the result is the final evaluation result.

4 The empirical analysis

This paper selects the 10 ESCO from Tianjin to verify the validity of the combination evaluation method, and then the project financing efficiency is evaluated.

(1) ESCO is evaluated by the fuzzy comprehensive evaluation method, the DEA evaluation method, principal component analysis method, gray evaluation method, and matter-element analysis method separately, which is shown in Table 4:

(2) The consistency coefficient is examined in KENDAL-W.

According to the *formula (1), (2)*, the authors calculate the concord coefficient W and χ^2. where $m = 5$, $n = 10$, the authors can get the result: $W = 0.977$ and $\chi^2 = 43.965$, we take a significant level as $\alpha = 0.05$, and get $\chi^2_{\alpha/2}(9) = 19.023$, then $\chi^2 > \chi^2_{\alpha/2}(9)$, it shows that the five types of single evaluation methods are consistent.

(3) The combination evaluation.

The project financing efficiency results are combined by the arithmetic mean value method, Borda combination evaluation method, and Copeland combination evaluation method, which is shown in Table 5:

(4) The consistency post-check with Spearman

According to the evaluation method of sorting, sorted value and combination evaluation values can be calculated. The values of t should be calculated, and the computer program SPSS (Statistical Package for Social Science) version 17.0 is used to help analyze the data, getting $t_1 = 25.7036$, $t_2 = t_3 = 18.093$. The experimental results show that there is a relationship between the single evaluation method and the combination method. Because of $t_1 > t_2 = t_3$, it is difficult for transportation and treatment in scale, so the t_1 is selected for the evaluation of the final results.

(5) The result analysis

Firstly, from the result analysis of the five types of single evaluation methods it can be concluded that the different approaches of evaluation have different operation mechanisms, and the evaluation results will show certain differences. Take the four companies for example, the results of Fuzzy comprehensive evaluation, DEA evaluation, principal component analysis and gray evaluation are on the 7th, but the results of matter-element analysis evaluation are on the 6th.The existence of the evaluation difference is due to the characteristics of the method itself and to the influence of subjective factors. But it is consistent to test the sorting by the KENDALL-W.

Secondly, the composite evaluation results of the three types of combination evaluation models are good and consistent.

5 Conclusions

The efficiency evaluation of ESCO project financing is an important way to improve the existing building energy-saving renovation projects, and is an essential approach to enhance financing management level of the ESCO enterprises. Based on the fuzzy comprehensive evaluation method, the DEA evaluation method, principal component analysis method, gray evaluation method, and matter-element analysis method, a combination evaluation model

Table 4

Single Evaluation Results

Project	Fuzzy		DEA		PCA		Gray		Matter element	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1	73.5	8	1.375	8	8.28	8	0.157	8	0.033	8
2	84.6	3	2.417	4	13.34	3	0.278	3	0.094	3
3	78.7	6	1.533	5	10.15	6	0.209	6	0.034	7
4	75.3	7	1.378	7	8.36	7	0.187	7	0.041	6
5	89.5	1	3.031	1	15.46	1	0.335	1	0.153	2
6	82.4	4	2.825	3	13.01	4	0.256	4	0.074	4
7	69.1	9	1.298	9	5.32	9	0.098	9	0.024	9
8	85.7	2	2.919	2	14.37	2	0.306	2	0.358	1
9	63.2	10	1.105	10	4.48	10	0.051	10	0.018	10
10	79.3	5	1.427	6	12.89	5	0.218	5	0.067	5

Table 5

Combination Evaluation Results

Combination evaluation	1	2	3	4	5	6	7	8	9	10
Arithmetic mean	8	3	6	7	1	4	9	2	10	5
Borda	8	3	7	6	1	4	9	2	10	5
Copeland	8	3	7	6	1	4	9	2	10	5

of efficiency evaluation of ESCO project financing in Tianjin has been constructed. The combination evaluation model eliminates the inadequacy of one single assessing method, improves the accuracy of the final evaluation results, and produces more comprehensive and objective results. But how to dynamically evaluate the project financing efficiency of ESCO is the new direction for future research.

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