The Application of Factor Analysis in Construction Project Post-evaluation

Haiyan ZHANG

Civil Engineering College of Inner Mongolia University of Science and Technology
BaoTou City, Inner Mongolia Autonomous Region, China
e-mail: ztyzhy@126.com

Abstract—**Project after the authenticity of the evaluation results to a large extent depends on the rationality of the evaluation method, this article in view of the construction project post-evaluation of current method is a systematic research, and put forward the factor analysis method used in the construction project evaluation analysis, the use of dimension reduction multiple related indexes for the comprehensive factor, a few of them had nothing to do with each other to overcome the defects of the artificial weights are objective, authentic, only makes the comprehensive evaluation results. His electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.**

Keywords-construction project; post-evaluation; evaluation method; factor analysis

I. INTRODUCTION

Al The implementation of construction projects may involve many aspects of society, and therefore their success or failure depends on factors more aspects. These factors determine the success of the project must be determined through a comprehensive, objective, detailed analysis and evaluation will be. So late evaluation of the project is a very necessary part, through the evaluation can be informed of the specific circumstances of each factor to determine the success of the project. Ultimately lessons learned feedback to project decision-making, management and builders, for construction projects have been perfect, it is of great significance in improvements and construction projects to be built in the project decision-making.

In the evaluation process the project, select the essential evaluation methods, the availability of accurate and objective evaluation of the results after selecting evaluation methods played a decisive role.

II. ANALYSIS AND COMPARISON OF EXISTING METHODS OF EVALUATION

Current methods for post-project evaluation to comprehensive evaluation of the majority. Evaluation methods are commonly used: expert evaluation; operations research and other mathematical methods; economic analysis intelligent evaluation methods.

Expert assessment method currently mainly: scoring, Grading, weighted scoring method and Order Method and the like. Compared to other, the expert evaluation method is simple, practical, so in many fields have been widely used, but because of the method depends on the subjective judgment of the experts, therefore, are often subjective factors ingredients high phenomenon. Thus, before choosing this method of evaluation, we must consider carefully whether to use this method.

Economic evaluation method is a good one as previously prepared comprehensive economic indicators to evaluate different objects methods. So far, the frequent uses of economic evaluation are: given a formula or method of calculation of the integrated model of economic indicators. Advantages economic evaluation law meaning clear, not vague, it is possible to contribute to comparative studies of different objects. But the flaw is that the economic evaluation methods tend to apply to some specific formulas and models, which are often more difficult to complete, on the other hand, for those complex object systems, be given a uniform to a dimension (for example, the growth rate) model is very difficult, thereby greatly limiting the application of the method.

Other operations research and mathematical methods: application of mathematical methods of operations research, etc., requires the user to have a more profound knowledge of mathematics, otherwise it is difficult to complete. Currently Mathematics project evaluation commonly used are: multi-objective decision-making method, data envelopment analysis methods and models (Charnes A, et a1 [1], 1978; Wei right age [2], 1988; Wei right age, Sun DB and Xiao Zhijie [3], 1991), AHP (analytic hierarchy process, AHP) (Saaty [4], 1980; Liu Bao et al [5], 1984), fuzzy comprehensive evaluation method, mathematical statistics.

DEA is designed for the relative effectiveness of multiple-input and multiple-output decision-making unit of a comprehensive evaluation. The method can be regarded as a non-parametric method of economic evaluation is based on a set of observations about the input-output to determine the effective production frontier of their nature. Wei Quanling by pareto DEA validity and effective multi-objective programming problem solution (non-dominated solutions) conducted a comparative study found that overall the two are equivalent. Data envelopment analysis method has been advances in technology assessment, and evaluation of a number of areas returns to scale enterprise efficiency evaluation is widely applied. DEA has applications in many other fields, such as enterprise performance evaluation (and Amendment Chuan and Chen Xiaohong [6], 2005); based on DEA real estate performance of the listed companies (Liu Yongle Hu Yanjing and Zhangfang Jie [7], 2005); relative efficiency (Li Jin [8], 2001).

The basic principle of AHP is based on having a hierarchical structure of goals, sub-goals (criteria), Constraints and departments of the object to evaluate and use pairwise comparison method of determining judgment matrix, then the biggest feature judgment matrix root corresponding eigenvector coefficients as respective components. Finally, a comprehensive program of each respective weight (priority).

Fuzzy comprehensive evaluation method is a method to target those systems with fuzzy comprehensive evaluation of factors. The fuzzy comprehensive evaluation method can better solve the comprehensive evaluation in fuzzy (such as things between generic not clarity, evaluation experts acknowledge the fuzziness, etc.) on the knowledge, so has been very widely used in many fields.

Finally, mathematical statistics used for project evaluation including principal component analysis, factor analysis, cluster analysis, discriminant analysis and the like. The method in many areas, including environmental quality, comprehensive evaluation of economic benefits such as access to an extremely wide range of use, and time in the future, but also to more areas of infiltration, is a very practical method for project evaluation.

III. CHARACTERISTICS AND ADVANTAGE OF FACTOR ANALYSIS METHOD

Factor analysis is one of the methods of mathematical statistics, is an objective method of empowerment. The use of dimension reduction, multiple related index in the comprehensive factor, for a handful of unrelated to each other and be able to give the meaning of each factor to clear, at the same time according to the size of each factor variance contribution rate to determine the weight value, overcomes the defect of human weights, objective, authentic, only makes the comprehensive evaluation results. But using this approach requires to have linear correlation between the initial number of observations.

A. The Characteristics of the Factor Analysis Method

- Factor analysis can be a number of observations of quantitative indicators for scientific classification. After evaluation of construction project, the evaluation index of the identified the initial index as observation index, the current the project evaluation are generally based on the experience of evaluators and classifies the knowledge of human to get it at the next higher level of qualitative indicators. According to the resulting qualitative indicators to determine the weights of every index, then to the evaluation results, will affect the reliability and objectivity of evaluation results. If use factor analysis to these observation index qualitative classification need to use mathematical method to calculate the calculated results, so that the results are more accurate.
- Factor analysis objective empowerment approach. In the factor analysis method for each weighting method is based on the indexes relative to the size of the original variable information contribution

amount. The more, the greater the weighting to provide information. Set all the eigenvalues of the common factor lambda respectively 1, 2, lambda... Lambda m, according to the characteristic value contribution to the corresponding factors of the proportion of total extracted eigenvalue for rights. Namely the weight of each factor is (1):

$$\lambda m / \sum_{i=1}^{m} \lambda i \tag{1}$$

B. The Advantage of Factor Analysis Method

Construction project evaluation index is numerous, and most of the index and correlation between, therefore USES the factor analysis as a method for determining the weights of qualitative indicators, can simplify the analysis process, and can objectively give weight value, so it can ensure the reasonable accuracy of the evaluation results.

IV. FACTOR ANALYSIS APPLICATION CASES

Adopt the method of factor analysis to municipal heating co-generation project piping after comprehensive evaluation on the economic benefits after the operation of the project.

A. To Establish the Sample Observations

TABLE I. TABLE TYPE STYLES

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
Payback period (X1)	85	86	84	85	83	84	82	86	87	88
Total return on investment (X2)	93	95	91	92	89	90	87	91	92	93
Earnings before interest and tax (X3)	91	94	90	89	88	90	85	90	91	92
Capital interest rates (X4)	89	92	90	86	86	88	84	92	92	91
Financial net present value (X5)	90	91	92	89	85	88	85	94	97	90
Financial net present value rate (X6)	92	94	95	92	89	90	88	96	97	97
Financial internal rate of return (X7)	91	95	89	91	90	91	88	95	96	96
The loan payback period (by 8)	80	84	87	82	79	82	76	78	86	88
Asset-liability ratio (X9)	82	85	88	81	78	81	77	76	84	85

Selected indicators are time limit for a project schedule reasonable degree, investment payback period, the total investment yield, earnings before interest and tax, capital,

Gold interest rates and financial net present value, financial, financial internal rate of return, net present value rate loan payback period, the asset-liability ratio.

And then with the X1, X2, X3, X4, X5, X6, X7, by 8, X9 said. Invited ten related senior experts, according to the various factors of scores, expressed as a 0, scoring the results are shown in table 1.

On sample observation value is obtained by kmo and Bartlett sphere test sample correlation matrix

To solve the characteristic equation of the correlation coefficient matrix R, calculation for R W of characteristic vector and characteristic value of lambda.

TABLE II. CORRELATION MATRIX

	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.00	0.78	0.78	0.82	0.72	0.89	0.93	0.65	0.44
X2	0.78	1.00	0.94	0.73	0.55	0.65	0.68	0.60	0.62
X3	0.78	0.94	1.00	0.84	0.58	0.69	0.74	0.67	0.64
X4	0.82	0.73	0.84	1.00	0.85	0.89	0.83	0.59	0.49
X5	0.72	0.55	0.58	0.85	1.00	0.88	0.69	0.51	0.41
X6	0.89	0.65	0.69	0.89	0.88	1.00	0.79	0.70	0.54
X7	0.93	0.68	0.74	0.83	0.69	0.79	1.00	0.46	0.22
X8	0.65	0.60	0.67	0.59	0.51	0.70	0.46	1.00	0.91
X9	0.44	0.62	0.64	0.49	0.41	0.54	0.22	0.91	1.00

B. Determining Factor Number M

Results from table 3, according to the characteristic value is greater than 1, or carried out in accordance with the cumulative contribution rate of 85% for the principle factors. Current k factor accumulation of information the cumulative contribution rate exceeds 85%, the k factor index instead of the original index n. Through SPSS factor analysis of variance decomposition factor extraction conditions (see table 4), we can find that factor 1, and factor variance contribution rates of 2 were 54.25%, 31.88% and total 86.1% > 85%. So number for the two factors.

TABLE III. CHARACTERISTIC VALUE AND VARIANCE CONTRIBUTION TO THE TABLE

	The initial eigenvalue			Extraction of sum of squares loaded			Rotate the sum of squares loaded		
ingredients	Total	Percentage of variance	The cumulative percentage	Total	Percentage of variance	The cumulative percentage	Total	Percentage of variance	The cumulative percentage
1	6.54	72.68	72.68	6.54	72.68	72.68	4.88	54.25	54.25
2	1.21	13.44	86.13	1.21	13.44	86.13	2.87	31.88	86.13
3	0.65	7.24	93.37						
4	0.34	3.83	97.20						
5	0.15	1.64	98.84						
6	0.07	0.80	99.64						
7	0.02	0.22	99.86						
8	0.01	0.14	100.00						
9	0.00	0.00	100.00						

C. Factor Interpretation

TABLE IV. FACTOR LOAD MATRIX AFTER ROTATION

		Composition 1	Composition 2	Item Factor weight (%)
variance %		54.25	31.88	
Financial earning ability	Payback period of investment (X1)	0.89	0.34	62.99%
	Total return on investment (X2)	0.64	0.58	
	ebit (X3)	0.69	0.59	
	Financial net present value (X5)	0.82	0.23	
	Financial net present value ratio (X6)	0.85	0.40	
	Financial internal rate of return (X7)	0.94	0.11	
Project solvency	Loan repayment period (X8)	0.35	0.88	37.01%
	Asset liability ratio (X9)	0.15	0.98	

From Figure 1 and table 4, factor 1 in the originalvariablex1, X2, X3, x4, X5, X6, and X7 on a larger load, respectively, 0.89, 0.64, 0.69, 0.88, 0.82, 0.85, and 0.94. Reflects the financial profitability, can be named as financial profitability. Factor 2 in the original variable x9, X8 on a larger load, respectively, 0.88, 0.98. Reflects the ability to repay the situation, so it can be named Project solvency.

According to the implementation of the project economic benefit post evaluation of the two factors index weight shows, financial profitability for the maximum weight (Table 4) that project financial profitability are the main factors of the post evaluation of the economic benefits of the project. And then the ability to pay off the project.
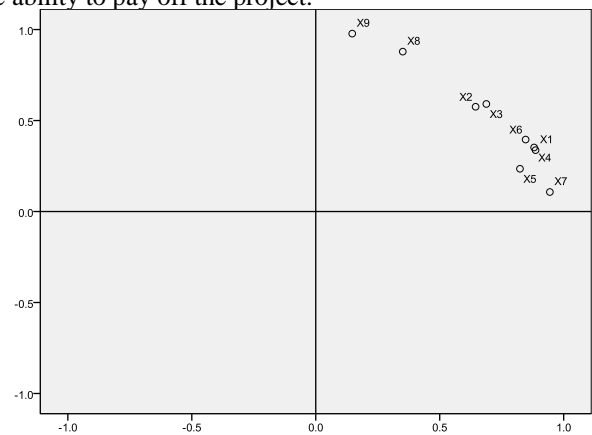

Figure 1. Composition in the rotating space

D.   Factor Score Model

- F1=0.038X1+0.086X2+0.022X3-0.033X4-0.056X5+0.141X6+0.138X7+0.086X8+0.068X9
- F2=0.022X1+0.153X2-0.029X3-0.012X4-0.093X5+0.052X6+0.025X7+0.166X8+0.018X9
- Comprehensive factor score model: F= (54.25/86.13) F1 + (31.88/86.13) F2=0.63F1+0.37F2

V. CONCLUSION

After the project evaluation, process and evaluation of complex content, many methods of evaluation, which is more appropriate, is the decisive factor to determine the true degree of evaluation results. In this paper, a systematic analysis of some of the commonly used evaluation methods, and compared to determine the factor based on the analysis of the post evaluation is more reasonable. However, because of the initial variables adopted by factor analysis, it is concluded that the subjective factors are inevitable in the quantitative analysis, and the objectivity of the evaluation results is inevitable. Therefore, how to avoid the subjective factors in factor analysis, or a direction in the future research.

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