Efficiency Assessment on the Incremental and Stock PPP Projects—Based on AHP-Fuzzy Comprehensive Method under "Multiple Participation"

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Abstract. The development of the incremental PPP projects and the stock PPP projects are uneven and there are very few successful cases of the stock PPP projects. To explore the reason, we built the evaluation indicator system according to the different demands of different participants of PPP firstly, then adjusted the indicators system according to the characteristics of the increment and stock projects. That is an indicators system based on multiple participation. Lastly, used the AHP-fuzzy comprehensive evaluation method to evaluate the chosen cases and found the efficiency of the stock PPP project lower than the incremental one. The reason is that the lack of support policy and the incomplete of laws cause the risk and the management of stock project higher.

Introduction

Recent years, PPP is popular for its positive reinforcement to public utilities and infrastructure. By the end of 2016, 11260 projects were involved in the national PPP projects pool with total 1350million RMB investment. 1351 projects with 220million RMB investment were in construction. The landing rate of PPP projects was 31.6%. Most of the projects in the pool were incremental projects instead of stock ones. Why did this happen? Was the efficiency of PPP model used in incremental projects higher? It needs more deep research. The existing study of evaluation on PPP projects focused on three things. (1) The evaluation on the project participation. Zhang Haisong (2016) built a long-term social evaluation system for agricultural development from social influence, social adaptability, fairness and government performance [1]; Geng Huamin (2015) improved the financial evaluation method of sewage treatment project from the financial angle of the project[2]; Wang Bingchun (2016) found the best portfolio of loans and equity by building a project risk quantification model and a game model of between bank and project company[3]. (2) The assessment of the PPP project. Different projects have different characteristics which needs to formulate a corresponding evaluation. Du Jing, etc. (2016) analyzed the VFM of urban rail traffic by combination the basic indicators and guidance indicators[4]; Feng Xuedong, etc. (2016) assured the investment risk of the PPP project of endowment Real Estate according to the building, operating and macro environment[5]. Zhao Xinbo (2009) built a performance evaluation system on a special type from the PPP project’s economics, efficiency, resulting and fairness [6]. (3) The research on the assessment method. Yuan Jingfeng, etc. (2009) built PPP index system using key
performance index from project’s features, projects’ course, financing environment, innovation and study and participation [7]. Fan Zhiqing, etc. (2010) built a BOT social comprehensive performance model for highway based on the fuzzy matter element method [8].

The current research neglects the "multiple participation" characteristics of PPP projects and the difference between incremental project and stock project. The contribution of the study is that: 1) establish an index system from the angle of "multiple participation"; 2) divide PPP projects into incremental and stock project instead of classify them by industry type; 3) use the AHP-fuzzy comprehensive method which is the combination of qualitative and quantitative and is suitable to evaluate the index difficult to quantify.

The Structure of Index System under "Multiple Participation"

The Participants’ Needs Analysis

PPP project is a complex system which involves many stakeholders such as governments, inhabitants, the investors, suppliers, operators, contractor, banks and other financial institutions and collateral in the course of designing, financing, building, operating and maintenance. They can be divided three main interests: local government, social investors and the public. The main aims of local government is to relieve the fiscal pressure, transfer risk by PPP and increase the supply and quantity of infrastructure at the same time. The purpose of social investors is gaining investment earnings within the scope of the risk. The public’s quest is to enjoy higher quality service and improve the quality of life by paying a reasonable fee. A successful PPP project should satisfy all the interests. If the regulation of local government is absent, the quality of the product will be inferior or the price of the product will be too high. The result is that the customer will reduce or give up the consumption, which means PPP project fails. If the regulation of local government is too strictly, it will reduce the investment motivation of the social investors. The result is the PPP project will be half-assed and the inhabitants’ welfare will be influenced. So it's necessary to consider these factors when evaluate the efficiency of the PPP project.

The Establishment of Indicators System under "Multiple Participation"

The characteristic of the PPP is the public and the private in partnership which means there are benefits distribution and risk sharing among them. The economic and risky is obvious. The main investment area of PPP projects are public utilities and infrastructure, which require the PPP project should be adapting to the local economic development and sustainable. So adaptive indicators economic indicators, risk indicators and sustainability indicators are chosen as level one indicators. Further, we refine the indicators based on the demands of different participants of PPP projects and build the secondary indicators.

1) Adaptive indicators. It measures the PPP project is adaptive to the local economic development and policy or not. Concretely, it shows the demands of local government, social investors and the public. If the investment of a PPP project is more than the local governments' financial ability or its financial demands is difficult to be satisfied, which will not relieve the debt pressure on local governments. Otherwise it will bring fiscal distress to local government and reduce the earnings of investors. In order to increase the investment earning, the investors may be lower the quality of the project or increase the price of the
utilities which reduce public welfare. So the match of PPP with the local government's financial power, local economic development, financial environment and inhabitants' price accepted is chosen as secondary indicators. They reflect the needs of local government, the need of social investor and the needs of inhabitants differently.

2) Economic indicators. It measures the social investors' economic benefits. The feasibility of the total cost, the extent of the funding maturity and investment yield are chosen as the secondary indicators.

3) Risk indicators. It measures the risk of the PPP project, including the uncertainty and the sharing appropriation of the risk. Specifically, the project phase ahead of schedule, the length of investment payback, the extent of the local government's commitment to the project and the reasonability of the risk sharing are chosen as the secondary indicators. They represent the needs of all the interests.

4) Sustainability indicators. It measures the effect of the PPP project, including the economic sustainable, social sustainable and environment sustainable. Local government debt compensation, resident welfare improvement, resource utilization, environmental satisfaction and public satisfaction are chosen as secondary indicators. They embody the interests of local government and the public.

The Adjustment of Index System Based on the Incremental and Stock Projects

The Adjustment and Determination of Index System

The projects can be classified as incremental projects and stock projects. An incremental project is also called new project. It is built for satisfying the new requirement of the public and the economic development. A stock project is known as an extension project. It is built on the original assets and resources in order to form new production facilities or expand the original production (service) scale or change the original operating mechanism and structure for increasing the quantity and quality of the production (service). So the indicators system are adjusted by the characteristics of the two type projects.

1) The differences in policy and laws create differences in adaptive and the economy. There are more effective tax incentives, fiscal subsidies and the law and rules for incremental projects because they are highly valued by local government. It's easier for incremental projects other than stock projects to be adaptable with local environment. So the extent the local authorities valued and tax incentives are added to the adaptive indicators as secondary indicators.

2) The difference in assets creates differences in complexity and economic. Complexity refers to the complexity of project management, the complexity of refinancing and the complexity of asset transfer. It's a critical indicator in level one added in the indicators system for there are huge difference in incremental projects and stock projects in this indicator. To stock project, it should determine the scope of the project, address the placement of the original staff, conduct a valuation assessment even the restructuring when the project is implemented. The transfer of assets involved the issue of tax. It's more complexity for stock project. But for incremental projects there are no cash inflow in the initial period and they need more investment on factory address, supplies, human resources, technology, plant and equipment is huge.

3) The differences in payback period cause differences in risk. The payback of incremental project is longer than stock project which increase the uncertainty.
Stock projects also face the uncertainty caused by the law and policy issues. So the risk sharing rationality and payback are added into the risk indicators. Additionally, stock project's compensation for local government debt is higher than incremental projects for the former can make the stock of local government debt re-operating. So the compensation for local government debt joins the sustainability indicators.

Finally, 5 level one indicators and 21 secondary indicators are determined considering "multiple participation" and the difference between incremental projects and stock projects.

**The Determination and Rating of Evaluation Factors**

According the indicators system, build the evaluation factors collection.

\[ U = \{u_1, u_2, u_3, u_4, u_5\} = \{\text{adaptativing, economic, risk, compexity, sustainability}\} \]

\[ u_i = \{u_{i1}, u_{i2}, ..., u_{ij}\}, \quad i = 1, 2, 3, 4, 5 \]

\[ u_{ij} \] is the different evaluation factors collection, \( u_{ij} \) is the indicators of the evaluation factors collection, that is secondary indicators.

Evaluation rating collection \( V \) is the description collection of the assessment object. It is judged and rated by the judge based on the facts and cognitive level. According to the literature and experts' opinion, the evaluation rating collection is

\[ V = \{\text{excellent, good, usually, worse}\} = \{\text{rate1, rate2, rate3, rate4}\} = \{100, 75, 50, 25\} \]

**The Weight of Index Determined by Layer Analysis**

1) The weight determination of level one indicators

Using the 1-9 gauge, the comparison matrix \( A \) is built through the comparison by several experts on the importance of indicators.

\[
A = \begin{bmatrix}
1 & \frac{1}{3} & \frac{1}{2} & 2 & 2 \\
\frac{3}{2} & 1 & 2 & 4 & 3 \\
2 & \frac{1}{2} & 1 & 3 & 2 \\
\frac{1}{2} & \frac{1}{4} & \frac{1}{3} & 1 & \frac{1}{2} \\
\frac{1}{2} & \frac{1}{3} & \frac{1}{2} & 2 & 1
\end{bmatrix}
\]

After calculation, get the largest feature \( \lambda = 5.0916 \) of matrix \( A \), the consistent indicators \( CI = \lambda - n/(n-1) = 0.0229 \), and the average random consistent indicators \( RI = 1.12 \). Then we get the random consistent ratio \( CR = CI/RI = 0.0204 < 0.1 \). That means matrix \( A \) is a satisfactory consistency with weight and coefficients are reasonably allocated. Matrix \( A \) goes through a consistent test. Then get weight vector \( \omega = (0.2353, 0.3529, 0.2353, 0.0588, 0.1176) \).

2) The weight determination of secondary indicators

Use the above method to form the comparative matrix of the secondary indicator. Calculate the maximum features and consistent ratio and test the consistent. Then, get the single factor of weight vector:

\[
B_1 = \begin{bmatrix}
1 & 2 & 1 & \frac{1}{2} & \frac{1}{3} \\
\frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{3} & \frac{1}{4} \\
1 & 2 & 1 & \frac{1}{2} & \frac{1}{2} \\
2 & 3 & 2 & 1 & \frac{1}{2} \\
3 & 4 & 2 & 2 & 1
\end{bmatrix}
\]

\[
B_2 = \begin{bmatrix}
1 & 3 & 4 & \frac{1}{2} \\
\frac{1}{3} & 1 & 2 & \frac{1}{3} \\
\frac{1}{4} & \frac{1}{2} & 1 & \frac{1}{3} \\
2 & 3 & 3 & 1
\end{bmatrix}
\]

\[
B_3 = \begin{bmatrix}
1 & 4 & 2 & 2 \\
\frac{1}{4} & 1 & \frac{1}{3} & \frac{1}{3} \\
\frac{1}{2} & 3 & 1 & 1 \\
\frac{1}{2} & 3 & 1 & 1
\end{bmatrix}
\]

\[
B_4 = \begin{bmatrix}
1 & 3 & 2 \\
\frac{1}{3} & 1 & \frac{1}{2} \\
\frac{1}{2} & 2 & 1
\end{bmatrix}
\]
After calculation, we get single factor weight vector of the adaptive indicator $\omega_1 = (0.1290, 0.0968, 0.1935, 0.1935, 0.3871)$, single factor weight vector of economic indicators $\omega_2 = (0.2308, 0.1538, 0.1538, 0.4615)$, single factor weight vector of risk indicators $\omega_3 = (0.4615, 0.0769, 0.2308, 0.2308)$, single factor weight vector of complexity indicators $\omega_4 = (0.5714, 0.1429, 0.2857)$, and single factor weight vector of sustainability indicators $\omega_5 = (0.2000, 0.2000, 0.2000, 0.2000, 0.2000)$.

Case Study

In order to compare the efficiency of the incremental project and stock project, we test the chosen two cases' efficiency using the indicators system by the method of AHP-fuzzy comprehensive evaluation.

Project Profile

Case 1. Incremental PPP project----XXX power plant (A project)

The total investment of a project was 61.6 million dollars. The cooperate form was BOT and the ratio of debt to capital was 3:1. The sponsor invested 15.4 million dollars in the company and the percentage was 25%. The rest money came from the syndicated loan made up 19 banks. One part of the loans (about 31.2 million dollars) were insured by export credit insurance. Other than that, there was no guarantee. The franchise period of A was 18 years, and the construction period was 33 months. The operation period was 3 month and 15 years. Local government supply policies and incentives, including franchise, purchasing electricity promise, political risk compensation, tax breaks and land support measures. The project company took the risk of construction, operation, technology and finance; and local government took the political and legal risk. The force majeure risk was shared by them. These were full written in the terms of grant. But the risk of financing, legal change and power rationing were not well designed which caused the project delayed three months than planned.

Case 2. Stock PPP project---XXX Sewage treatment project (B project)

The background was that the effectiveness of the existing sewage treatment was not enough to meet national standards. It's necessary to remodel and expanded the city sewage treatment. The form of cooperation was ROT (rebuild-operate-transfer). W company won the bidding and started a project company with local government. The total investment was 29.567 million RMB. 65% funding is debt and 35% funding was capital. Local government invested in the stock which was 49% of the equity. W company invested in cash which was 51% of the equity.

The franchise period of the project was 25 years including 1 year construction period. The procurement process was strict and the forward preparation was in place. But there was no preferential treatment for the value-added tax and land deed produced in the course of transfer assets.

Project Evaluation and Analysis

Using AHP-fuzzy comprehensive method under multiple participation evaluates project A.
Evaluate the adaptive of project A's factor with local economic development by experts, the matching with local governments' fiscal withstand ability satisfaction of financing demands, the extent of local authorities, the price acceptance, the result is that: $R_{11}^A = (0.0, 0.1, 0.5, 0.4)$; $R_{12}^A = (0.0, 0.2, 0.3, 0.5)$; $R_{13}^A = (0.5, 0.4, 0.1, 0.0)$; $R_{14}^A = (0.7, 0.2, 0.1, 0.0)$; $R_{15}^A = (0.4, 0.5, 0.1, 0.0)$, then get the fuzzy matrix of adaptive indicators.

So get the evaluation vector of adaptive indicators:

$$C_{11}^A = \omega_1 \times R_{11}^A \times (0.3870, 0.3419, 0.1709, 0.1000)$$

In the same way, we also get the evaluation vectors of others:

$$C_{12}^A = \omega_2 \times R_{12}^A = (0.4846, 0.3692, 0.1154, 0.0308)$$

$$C_{13}^A = \omega_3 \times R_{13}^A = (0.2923, 0.3077, 0.2077, 0.1923)$$

$$C_{14}^A = \omega_4 \times R_{14}^A = (0.5286, 0.2857, 0.1429, 0.0429)$$

$$C_{15}^A = \omega_5 \times R_{15}^A = (0.3600, 0.2800, 0.2200, 0.1400)$$

$C_1^A$, $C_2^A$, $C_3^A$, $C_4^A$, $C_5^A$ means the evaluation vector of economic, risk, complexity, sustainability.

Then we get general evaluation matrix $R^A$ by $C_1^A$, $C_2^A$, $C_3^A$, $C_4^A$, $C_5^A$.

$$R^A = \begin{bmatrix}
0.3870 & 0.3419 & 0.1709 & 0.1000 \\
0.4846 & 0.3692 & 0.1154 & 0.0308 \\
0.2923 & 0.3077 & 0.2077 & 0.1923 \\
0.5286 & 0.2857 & 0.1429 & 0.0429 \\
0.3600 & 0.2800 & 0.2200 & 0.1400
\end{bmatrix}$$

The final evaluation vector is $c^A = \omega \times R^A = (0.4074, 0.3329, 0.1641, 0.0986)$, after normalization $c^A = (0.4062, 0.3319, 0.1636, 0.0983)$. So the final score of A project is

$$Q_A = c^A \times Y = (0.4062, 0.3319, 0.1636, 0.0983) \times \begin{bmatrix}
100 \\
75 \\
50 \\
25
\end{bmatrix} = 76.1500$$

$$Q_B = c^B \times Y = (0.2485, 0.2875, 0.2842, 0.1797) \times \begin{bmatrix}
100 \\
75 \\
50 \\
25
\end{bmatrix} = 65.1150$$

$Q_A > Q_B$ that means project A is more suited to PPP model compared with project B. The reasons are as follows:

(1) The incremental project A gained more government support. The score weight of government values' indicator $u_{14}$ was $R_{14}^A = (0.7, 0.2, 0.1, 0.0)$ and the weight of high score $(\geq 75$ score$)$ was 0.9. Otherwise, the score weight of project B was $R_{14}^B = (0.2, 0.2, 0.4, 0.2)$ and the weight of high score was 0.4. Obviously, project A was more valued by local government.

(2) The risk of the incremental project A was easier to be recognized and controlled, and the risk sharing was more fair. Project B had more potential risks.
The score weight of the risk sharing fairness $u_{31}$ was $R_{31}^{u} = (0.2, 0.2, 0.3, 0.3)$ and the score weight was 0.4 which was less than the score weight 0.8 of project B $R_{31}^{A} = (0.4, 0.4, 0.1, 0.1)$. The reason is that there was land and asset transferring in the construction of project B which increased the risk of project B.

(3) The calculation of economic benefit and the project management was easier for project A. The asset transfer of project B was more complex and the score weight of the complexity of asset transfer $u_{43}$ was $R_{43}^{B} = (0.0, 0.1, 0.2, 0.7)$. The weight of high score was 0.1 less than 0.7 of the score weight of project A $R_{43}^{A} = (0.4, 0.3, 0.2, 0.1)$.

Conclusions

The "multiple participation" indicators evaluation of PPP was built and adjusted by the characteristics of incremental projects and stock projects. Then, we evaluate and test the two cases by the AHP-Fuzzy comprehensive method and find out that the efficiency of incremental project is better than stock project. The reason is that the lack of policy and the incomplete of laws cause the risk and the management cost of stock project higher. In order to rebuild or expand the stock project through PPP, the followings are suggested. Firstly, give a positive guide to the expansion of the stock project in PPP and encourage local governments to increase policy incentives and supports which compensate the inefficiency of the stock project. Secondly, to further refine the laws and regulations and lower the uncertainty of the stock project. For example, local government introduces new policies to regulate the transfer way of land tenure and specify the types of tax paid after the transfer of assets to reduce the uncertainty concerns both sides. Thirdly, accumulate experience in practice to summarize a set of the economic benefit calculation for the stock project. Finally, build the typical cases pool of the demonstration project to reward the excellent stock PPP project and encourage the innovation of the stock PPP project.

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References


