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Research on portfolio evaluation of PPP water construction project considering project relevance

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Abstract. At present, for the benefit of project implementation, many PPP projects are not only to evaluate and manage a single project, but also to evaluate and manage a number of projects under the guidance of the whole strategic goal of the government. In this paper, a mathematical model of PPP project portfolio value for money evaluation is established by using the public sector reference standard method while considering the correlation between projects, and the value for money evaluation of multiple projects is carried out to realize the goal of PPP project portfolio evaluation. Taking a PPP water construction combination project as an example, conducting Value-for-money evaluation of the PPP project portfolio with the established evaluation model so as to verify the scientificity and practicability of the evaluation model.

1. Introduction

Water infrastructure, an important, irreplaceable and inseparable facility, is crucial for national economic and social development and improving the ecological environment [1]. In recent years, the national investment in water construction projects has gradually increased, and water construction projects have a vigorous development. Water affairs construction projects are characterized by large scale of investment, long construction period, more participating units and complex organizational relationships, and are also susceptible to the influence of force majeure events and factors such as natural environment[2-3]. Therefore, water construction projects have greater project risks. The characteristics of the PPP mode are in line with the water construction project, and many water construction projects have also adopted the PPP mode. The PPP model can not only reduce the financial pressure of the government to a great extent, but also provide investment opportunities for social capital. At the same time, it can appropriately transfer project risks to social capital and jointly bear the corresponding risks[4]. This article is to jointly manage multiple PPP water construction projects, mainly value-for-money evaluation. In the past, it was a value-for-money evaluation of a single project. This article is a combination of multiple PPP waterworks construction projects. Considering the relativity between the projects, the evaluation model of the value for money of the project portfolio is established, and the practicability and scientific nature of the evaluation model are verified by the actual cases, thus the water project portfolio can be applied to the PPP model.
2. The concept and connotation of PPP mode
PPP was first proposed by the British government in 1982. It generally refers to the agreement between the government and the private sector. The government authorizes the private sector to build public infrastructure projects, manage and operate them, and provide public services to the public[5]. PPP (public private partnership) is a partnership between government and social capital. Generally referred to as public-private partnership, there are broad and narrow senses. Broadly speaking, PPP is the various partnerships established by the public and private sectors to provide public goods and services. In a narrow sense, PPP refers to the way in which the public sector and the private sector jointly fund the establishment of a project company, thus providing public services for the society[6]. PPP mode is used as a public-private partnership model for infrastructure management and has obvious advantages compared with the traditional model. The PPP model can make the public and private sectors achieve mutual benefits and complementary advantages. First, clarify the respective responsibilities and obligations of the public and private sectors. The public sector ensures the quality and quality of public goods and services, undertakes operational responsibilities, routine project supervision and management, and procurement of raw materials. The private sector fulfills its project construction obligations and is responsible for raising project funds and providing designated public goods; Secondly, the PPP model is the contract system, which has the legal guarantee to attract the private capital participation in the public service domain, thus ensuring sufficient funds for public construction; Thirdly, the public sector can reduce the cost of production and maintenance, and relieve the government budget pressure and debt burden. It also opens the door for the private sector to enter the public sector, giving the private sector an additional choice in investment decisions. At present, PPP model is widely used in urban rail transit, water project construction, bridge construction and so on[7].

3. Correlation between the project portfolio
Many scholars at home and abroad have done a lot of research on the correlation between projects. Among them, Aaker and Tyebjee believe that there are three types of correlations between resource use overlap, technology and project effects among projects in the project portfolio[8]; On the basis of analyzing the correlation between projects, Stummer compares the income of the project portfolio under the consideration of the correlation between projects [9]; Robert also has his own views on the interaction between projects. He divides these influencing factors into roughly five categories, including resource interaction, technology interaction, income interaction, result interaction and other interaction [10]. Although there have been many studies on the correlation between projects, Verma believes that a large number of previous studies have not established effective mathematical models to analyze and evaluate the relationship between resources, benefits, and outcomes[11]. On the basis of this research, Fishburn and Lavalle established an effective quantitative mathematical model to deal with the correlation between the two projects, but only analyzed the relationship between resources and income. Moreover, the relational matrix method can only solve the correlation between two items, and it will encounter difficulties when solving the correlation of more than three items[12]. Domestic An hui Gang and Guo Peng analyzed the characteristics of the project and believed that there are three correlations among resources, technology and income[13].

Referring to the research of many scholars at home and abroad and the actual situation, this paper divides the correlation between projects into the following categories: resource-related, income-related, technology-related, logically related, and result-related. The specific analysis is as follows:

3.1. Resource related
Resource sharing among different projects is a common phenomenon in the project implementation process, because the resources of the enterprise are limited. When excessive resources are invested in a project, the resources of other projects will be squeezed and affect other projects implementation. Such as key equipment, manpower and other resources, When a project portfolio consumes these resources
or the cost is not equal to the sum of the resources or costs consumed by a single project, there is a resource correlation.

3.2. Income related
It refers to the fact that the selection of one item in a portfolio affects the returns of other items, so that the overall return of the portfolio may be greater or less than the sum of the individual items. The mutual effects of earnings can be generally divided into: mutual exclusion, synergy, and substitution.

3.3. Technology related
Technical relevance means that when a project in a project portfolio is carried out, the success rate of other projects increases. Therefore, the output and income of the project portfolio can be improved, but it is worth noting that in some project portfolios, there is a possibility that the impact of income between projects is negative, that is, the technical correlation may produce a negative increment of income.

3.4. Logically related
Logical correlation means that there may be logical dependence or exclusion in the implementation of each project, which can be divided into dependent and mutually exclusive types. Dependency refers to the fact that two projects have certain relevance or complementarity in technology, that is, the implementation of two projects can be carried out at the same time; mutual exclusion means that two projects have certain exclusion effects, when one project is implemented, another project will be excluded, that is, two projects cannot be implemented simultaneously.

3.5. Result related
The result correlation is one of the important interrelationships between projects. The result refers to the probability of success of a single project. The result correlation means that the implementation of one project will have an impact on the success probability of another project. The mutual influence of the results can be divided into two types. One is that the implementation of one project leads to an increase in the success rate of other projects, and the other is that the implementation of one project leads to a decrease in the success rate of other projects.

4. Establishing a value-for-money evaluation model for project portfolios considering project relevance
When a single PPP project conducts quantitative evaluation of value for money, it calculates the PSC value when the government adopts the traditional procurement method, and uses the LCC value in the PPP mode, to obtain the VFM value to evaluate whether the item is worth the value. When the project portfolio is value for money, because of the relativity between the projects, the method of directly evaluating the value of a single project will be biased. The calculation of the project component value evaluation is not only a simple addition of the sub-item calculation parameters, but also considers the project relevance. Then calculation parameters of the project portfolio should be revised to determine the correct and scientific correction coefficient and evaluate the value for money of the project portfolio.

4.1. Determination of PSC value correction coefficient
The PSC value is mainly composed of three parts: initial PSC, competitive neutral adjustment value, and risk-taking cost.

4.1.1. Determination of initial PSC value correction coefficient. The initial PSC value of the portfolio is recorded as NPV1 and the calculation model is:
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The cost of construction is the total investment of the project portfolio invested by the government or an investment company authorized to manage it. Operating costs include financing interest, material costs, staff salaries and benefits, power costs, and management fees. Because the project portfolio has the correlation of resources, the correct correction coefficient is determined when calculating the initial PSC value of the project portfolio, so that the calculation result is more accurate. The material cost, management fee, etc. consumed by the project portfolio will be reduced compared to the sum of individual projects. Assuming that both construction and operating costs are reduced by x%, the calculation model for the initial PSC value of the portfolio is modified to:

$$
\sum_{i=0}^{n} \left( \sum_{t=0}^{m} \left[ \left( \text{Construction cost} - \text{Capital gain} \right) + \left( \text{Operating cost - Third party revenue} \right) + \text{Other costs} \right] \right) \left( 1 + i \right)^{-t}
$$

4.1.2. Determination of the Correction Coefficient of Competitive Neutral Adjustment Value. The competitive neutral adjustment value of the project portfolio is recorded as NPV2, and the calculation model is:

$$
\sum_{j=0}^{m} \left\{ \sum_{i=1}^{n} \left( \text{VAT and its additional + Income tax} \right) \right\} \left( 1 + i \right)^{-j}
$$

Competitive neutral adjustments typically include land fees, administrative approval fees, income taxes, and other related taxes, as well as other reasonable expenses. Because the project portfolio has logical correlation, when calculating the competitive neutral adjustment of the project portfolio, the correct correction coefficient should be determined, and the related taxes and fees, such as the administrative examination and approval expenses consumed by the project portfolio, will be reduced compared with the sum of the individual projects. Assuming a y% reduction in VAT and surcharges and income taxes, the competitive neutral adjustment value calculation model for the portfolio is modified to:

$$
\sum_{j=0}^{m} \left\{ \sum_{i=1}^{n} \left( \text{VAT and its additional + Income tax} \right)(1 - y \%) \right\} \left( 1 + i \right)^{-j}
$$

4.1.3. Determination of the Correction Coefficient of Risk-bearing cost. The risk-bearing cost is recorded as NPV3 and the calculation model is:

$$
\sum_{i=0}^{n} \left\{ \sum_{t=2}^{m} \left( \text{Construction cost overrun risk} + \text{User related risk} + \text{Policy risk} + \text{Force majeure risk} \right) \right\} \left( 1 + i \right)^{-t}
$$

The risk-bearing costs mainly include construction cost overrun risk, user payment risk, policy risk, force majeure risk, etc. Because the project portfolio has revenue and technology related, the risk of force majeure of the project portfolio will increase, that is, the risk of risk taking increases. The correct correction factor should be determined. If the risk-bearing cost is increased by a%, the Risk-bearing cost calculation model of the portfolio is modified to:

$$
\sum_{i=0}^{n} \left\{ \sum_{t=2}^{m} \left( \text{Construction cost overrun risk} + \text{User related risk} + \text{Policy risk} + \text{Force majeure risk} \right)(1 + a \%) \right\} \left( 1 + i \right)^{-t}
$$

4.2. Determination of LCC value correction factor

The LCC value includes the present value of various financial expenditures such as equity investment, operating subsidies and risk-taking during the whole life cycle of the PPP project. The calculation model for the portfolio LCC is:
Government equity expenditure refers to the project capital invested by the government in proportion to the equity investment in the PPP model. The operating subsidy is to cover the project expenditure through the government payment method during the franchise period, and to ensure that the social capital obtains a reasonable return. The cost of self-retaining risk refers to the financial or expenditure responsibility caused by the government taking risks during the operation period of the PPP project. Because the portfolio has income and result correlation, the equity expenditure and government expenditure of the portfolio will be less than the sum of the single projects. The force majeure risk of the project portfolio, that is, the cost of self-retaining risk will increase compared with the sum of the single projects. Therefore, the correct correction coefficient should be determined, assuming that both equity expenditure and government operating subsidy are reduced p%, and the cost of risk taking increases by q%. Then the calculation model of the LCC is modified to:

\[ \sum_{i=0}^{m} \left\{ \sum_{z=1}^{n} \left[ (\text{Government equity expenditure} + \text{Operational subsidy}) (1 - p\%) - \text{Capital gain} \right] - \text{Third party revenue} + (\text{Risk of self retention}) (1 + q\%) \right\} (1 + i^z) \]

5. Case calculation

5.1. Case introduction

5.1.1. project name. A country water construction PPP project.

5.1.2. Project Description. The project consists of five sub-items, namely:
Sub-item 1: A county water plant
Sub-item 2: Upgrade and renovation project of a county sewage treatment plant
Sub-item 3: Water Supply Hub Project
Sub-item 4: A county reservoir project
Sub-item 5: A county ecological water system project

5.1.3. Project Introduction. The parameters of each subproject of the project portfolio are shown in the following table:

|                      | Subproject 1 | Subproject 1 | Subproject 1 | Subproject 1 | Subproject 1 |
|----------------------|--------------|--------------|--------------|--------------|--------------|
| Construction cost    | 25627        | 3173         | 33516        | 27717        | 31648        |
| Operating cost       | 330793       | 19343        | 948429       | 32456        | 36542        |
| Capital gain         | 0            | 0            | 0            | 0            | 0            |
| Third party revenue  | 196020       | 0            | 932060       | 0            | 0            |
| Competitive          | neutral      | 866          | 10844        | 4416         | 6489         |
| adjustment value     |              |              |              |              |              |
| Risk cost            | 7448         | 266          | 12161        | 4522         | 7151         |
5.2. Drawing of cash flow statement

When calculating the PSC value when the government adopts the traditional procurement method, first calculate the net present value of construction cost, operating cost, third-party income, competitive neutral adjustment value, and risk-bearing cost in the whole life cycle, which can be drawn according to the data in the table. The project portfolio uses the cash flow statement in the traditional mode and the PPP mode. In Figure 1 and Figure 2, the cash flow statements are presented when the traditional mode and the PPP mode are respectively adopted by government:

![Figure 1. Cash flow statement for the entire life cycle when the government adopts the traditional model](image-url)
5.3. Case calculation

According to the data in the table and discount rate of 3%, and combined with the cash flow statement and the actual situation of the project portfolio, according to the discount rate of 3%, based on the above discussion of the correction coefficient of the calculation model, in this paper, the initial PSC value, the competitive neutral adjustment value, the risk-bearing cost, and the correction coefficient of the LCC value calculation model are determined as 5%. According to the calculation model, the calculation results are as follows:

After calculation, the initial PSC value of the project life cycle under the government's traditional model is: \( NPV_1 = 232,627 \)

Competitive neutral adjustment value in PPP mode: \( NPV_2 = 16,538 \)

Net present value of total risk exposure during the franchise period: \( NPV_3 = 19,140 \)

According to the above analysis and calculation, the government adopts the traditional model, the PSC value of the total net present value of government expenditures during the entire franchise period.

\[ PSC\ Value = NPV_1 + NPV_2 + NPV_3 = 268,305 \]

In PPP mode, the total net present value of government expenditures during the entire franchise period. PPP Value = 232,366

5.4. Value for money evaluation conclusion

Value for money = PSC Value - PPP Value = 35,939

Value for money index = \( \frac{PSC\ Value - PPP\ Value}{PSC\ Value} \times 100\% = 13.4\% \)

By comparison, the PPP value measured by the government in the PPP mode is lower than the PSC value under traditional purchase mode. It can be seen from this that the project portfolio adopts the PPP model, which not only effectively alleviates fiscal pressure, and improves resource utilization efficiency, but also does not impose an bring extra on the government. Therefore, the project meets the requirements of value for money (VFM), and it is suitable to operate in PPP mode.

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