Research on VFM quantitative evaluation of PPP project based on fuzzy real option method

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Abstract: Value-for-money evaluation can provide decision-making basis for the selection of public project implementation mode. As far as the current situation is concerned, there is a great controversy in the quantitative evaluation of value for money. This paper attempts to explore the option value ignored in the evaluation process of PPP projects by using the concept of triangular fuzzy number in real option B-S model and combining with the traditional quantitative evaluation model. Taking a tourism creative park project as an example, the uncertainty value range is calculated without completely deviating from the existing evaluation system, so as to provide a more comprehensive perspective for the quantitative evaluation of value for money.

1. Introduction
The PPP model of introducing private capital is very effective in alleviating the pressure of financial capital, improving the supply level of public services, and changing the functions of the government. In recent years, with the deepening of PPP model promotion, a series of problems exposed in the whole process indicate that China needs to further promote the standardization of PPP project decision-making process. Due to the late start of VFM evaluation in China, the research on the accuracy and effectiveness of the evaluation method is still lacking. In recent years, the lack of VFM evaluation in China has hindered the healthy development of PPP model in China[1]. At present, VFM evaluation system not only measures the feasibility of the project qualitatively and quantitatively, but also standardizes the evaluation procedures, which can promote the sound development of PPP model in China. Therefore, it is particularly important to build a suitable and feasible quantitative evaluation model[2].

2. VFM evaluation status
PPP project evaluation research is developing towards the direction of quantitative research. At present, although some progress has been made in quantitative evaluation, many researchers believe that the NPV method used in the quantitative evaluation is easy to cause the deviation of decision-making. Some researchers have pointed out that the calculation indexes of PSC are all based on certain assumptions, which are subjective and easy to lead to the calculation results of PSC values are not completely accurate and reliable[3]. In the process of VFM evaluation, there are too many restrictions, which are different from the actual situation, and the indicators are too subjective and single, so that the evaluation results are not convincing[4]. In recent years, researchers have also tried to establish a set of robust PSC computer system to improve the quantitative evaluation procedure from the determination of net present value and other aspects. Wang et al. (2010)[5]introduced the real option
value of the project to modify the NPV results. Hou Chenxi and Song Yongfa (2010)[6] proposed that real option method provides an effective theory and decision-making tool for judging the uncertain value of projects. Zhu Xiuli et al. (2011)[7] introduced the real option pricing formula to improve the calculation and evaluation of metro projects. The result is far greater than the value obtained by traditional NPV method. Martins J (2014)[8] proposed that real option theory can be introduced flexibly Express the implied value of the project.

Real option comes from financial option, as a decision-making tool and means[9], it has been mature in foreign countries. Compared with the traditional evaluation method which does not take this dynamic change into account, it can better reflect the real value of the project[10]. Based on the original method, this paper uses the real option method to calculate the new VFM, and analyzes the VFM quantitative evaluation process of PPP project again, in order to get more fair and reasonable results.

3. Traditional quantitative evaluation model based on PSC

The calculation of PSC value includes initial PSC0 (including net construction cost, net operation and maintenance cost), competitive neutral adjustment value, transferable risk cost and retention risk cost, as shown in the following formula.

\[
PSC = PSC_0 + CNV_a + R_t + R_r
\]

Among them, PSC is the comparative value of the public sector; PSC0 is the initial value (yuan); CNVa is the competitive neutral adjustment value (yuan); Rt is the transferable risk cost; Rr is the retained risk cost.

\[
PSC_0 = (C_1 - G) + (C_2 - B) + C_x
\]

Among them, C1 is the construction cost of the reference project (yuan); G is the capital income of the reference project (yuan); C2 is the operation and maintenance cost of the reference project (yuan); B is the third-party income; Cx is other costs of the reference project.

4. Quantitative evaluation model adjusted by fuzzy real option method

Fuzzy number is a method that can effectively express fuzzy data. If x is the domain, the mapping \( \mathbb{U} \) is given: \( X \rightarrow [0,1] \), \( X \rightarrow \mathbb{U}(x) \), then is called the fuzzy set on \( X \). \( \tilde{A} \) (can be remembered: \( \tilde{A} = (a^L, a^M, a^U) \)) represents a triangular fuzzy number. In the formula, \( a^L \leq a^M \leq a^U \), \( a^L \) and \( a^U \) represent the lower and upper limits respectively, which indicate the degree of blurring, and \( a^M \) is the median (the most likely value).

The alpha-level set of \( \tilde{A} \) can be expressed as:

\[
[ (1-\alpha) a_1 + \alpha a_2, (1-\alpha) a_3 + \alpha a_2 ], \quad \alpha \in [0,1], \quad (\alpha \text{ is the level of confidence})
\]  

Among them:

\[
\tilde{A}_\alpha^L = (1-\alpha) a_1 + \alpha a_2
\]

\[
\tilde{A}_\alpha^U = (1-\alpha) a_3 + \alpha a_2
\]

When using the Black-Scholes option method, the formula is:

\[
V_{option} = E_t N(d_1) - Ke^{-r(T-t)} N(d_2)
\]

Among them:
\[ d_1 = \frac{\ln \left( \frac{E_t}{K} \right) + \left( r + \frac{\sigma^2}{2} \right)(T-t)}{\sigma \left( T-t \right)^{1/2}} \]

\[ d_2 = d_1 - \sigma \left( T-t \right)^{1/2} \]

\( E_t \) is the value of the project assets (present value); \( K \) is the option execution price; \( T \) is the maturity time; \( r \) is the risk-free interest rate; \( \sigma \) is the value volatility.

Because investors hold different views on the future situation, the real option theory can express this part of value when evaluating. Therefore, when the real option method is introduced to evaluate the value for money of PPP project, it is adjusted based on the traditional PSC evaluation system. The evaluation is expressed as \( \text{NPV} = \text{NPV}_0 + \text{Voption} \), where \( \text{NPV}_0 \) is the net present value of the project and \( \text{Voption} \) is the option value of the project.

The triangular fuzzy number processing for \( E, K, \sigma \) and other variable representations is as follows:

\[ \tilde{E} = (E_1, E_2, E_3) \quad \tilde{K} = (K_1, K_2, K_3) \quad \tilde{\sigma} = (\sigma_1, \sigma_2, \sigma_3) \]

\[ \tilde{E}_a = (E^L_a, E^U_a) \quad \tilde{K}_a = (K^L_a, K^U_a) \quad \tilde{\sigma}_a = (\sigma^L_a, \sigma^U_a) \]

According to the properties of triangular fuzzy numbers and the formula in the "B-S" model (2) the fuzzy option value formula can be expressed as:

\[ V_{\text{option}} = \tilde{E}_t N(\tilde{d}_1) - \tilde{K} e^{-rT} N(\tilde{d}_2) \] (3)

Among them:

\[ \tilde{d}_1 = \frac{\ln \left( \frac{\tilde{E}_t}{\tilde{K}} \right) + \left( r + \frac{\tilde{\sigma}^2}{2} \right)(T-t)}{\tilde{\sigma}(T-t)^{1/2}} \]

\[ \tilde{d}_2 = \tilde{d}_1 - \tilde{\sigma}(T-t)^{1/2} \]

Finally, the formula for calculating the value of real options based on triangular fuzzy numbers is:

\[ V_a = (V^L_a, V^U_a) = \left[ (E_t)^L_a N((d_1^L_a)^L_a - K^L_a e^{-(T-t)} N((d_2^L_a)^L_a), (E_t)^U_a N((d_1^U_a)^U_a - K^U_a e^{-(T-t)} N((d_2^U_a)^U_a) \right] \] (4)

Among them:

\[ d_1^L_a = \frac{\ln \left( \frac{(E_t)^L_a}{(K^U_a)^L_a} \right) + \left( r + \frac{\sigma^L_a}{2} \right)(T-t)}{\sigma^L_a(T-t)^{1/2}} \]

\[ d_1^U_a = \frac{\ln \left( \frac{(E_t)^U_a}{(K^L_a)^U_a} \right) + \left( r + \frac{\sigma^U_a}{2} \right)(T-t)}{\sigma^U_a(T-t)^{1/2}} \]

\[ d_2^L_a = \left( d_1^L_a - \sigma^L_a(T-t)^{1/2} \right)^U_a \]

\[ d_2^U_a = \left( d_1^U_a - \sigma^U_a(T-t)^{1/2} \right)^L_a \]
5. Example analysis

5.1. Project Overview Description:
Based on the actual situation and regional planning of the plot, this tourism project will create a “tourism+” innovation base and an immersive experience of the Tourism Culture Creative Design Park (CDP). The return source of the project company mainly includes tourism and industry user payment, as well as the feasibility gap subsidy of the government, of which the feasibility gap subsidies are paid by the government's general public budget. The estimated total investment is 1.15 billion yuan, the project capital is 350 million yuan, accounting for 30.43% of the total investment of the project. The government and social capital jointly contribute according to the shareholding ratio, and the remaining 69.57% are in the name of the project company established. Financing.

5.2. PSC value calculation (Discounted at a discount rate of 4.9%)

5.2.1. Construction cost Construction costs mainly include cash invested in the project, as well as physical assets and intangible assets such as fixed assets and land. The estimated total dynamic investment of the project is about 1.15 billion yuan, and the construction period is invested in three years. Therefore, the construction cost of the project is a total of 1.15 billion yuan, and the net present value is 1.046 2 billion yuan.

5.2.2 Capital gains Considering that the project does not generate revenue for activities such as transfer, lease or disposal of assets throughout its life cycle, the capital income of the project is zero.

5.2.3. Operation and maintenance costs It mainly includes the materials, equipment, labor and other costs required for operation and maintenance of the project throughout its life cycle, as well as management fees, sales expenses, and other expenses. The current operating cost is estimated to be 181.481 7 million yuan.

5.2.4. Third party income The third-party income is the project income that can be charged to users, including rental income, property and management service income, parking facilities and other ancillary facilities service income, and e-commerce platform service income. The present value of the project is 686.795 5 million yuan.

5.2.5. Present value of competitive neutral adjustment value The competitive neutral adjustment value is competitive advantage of the project cost allocated by the government compared with the social capital when the traditional investment mode is adopted. The project is a feasibility gap subsidy project. The competitive neutral adjustment value mainly considers the impact of taxes and fees. It is estimated that the current value of competitive neutral adjustment is 92.116 4 million yuan.

5.2.6 Project risk total value present value The project risk cost can be divided into transferable risk, shareable risk and non-transferable shareable risk according to the actual situation. This paper uses the classification proportional method to measure the current value of the risk is 47.914 8 million yuan. After analysis, the PSC value is the sum of the above three items, so the PSC value = 680.918 million yuan.

5.3. Calculating the PPP value

5.3.1. The value of equity investment The capital of the project is 115 million yuan, which will be invested by the shareholders in their respective shareholding proportion according to the construction needs during the construction period. The project company raised funds of 350 million yuan, accounting for 30.43% of the total investment. The government invested 70 million yuan, accounting for 20% of the equity. According to the financial analysis hypothesis, the static equity expenditure
responsibility of the project is 70 million yuan, and the present value of equity expenditure responsibility is 63.682 2 million yuan.

5.3.2. value of operating subsidy The expenditure of operation subsidy needs to be determined according to the total investment of the project construction, the reasonable profit and operation cost of the project, and finally calculated according to different payment modes. The project follow the basic principle of "low profit with guaranteed principal". According to the project implementation plan, the total operating subsidy expenditure is 776.337 3 million yuan, and the net present value is 453.849 7 million yuan.

5.3.3. Occurrence value of risk bearing expenditure PPP risk expenditure cost is the government shared risk cost and non transferable risk cost of all risk costs when calculating PSC value. After calculation, the PPP risk bearing cost of the project is 12.855 4 million yuan.

5.3.4. Supporting investment The supporting investment of the project includes: the government is responsible for the temporary land, access road, water, electricity and other infrastructure needed during the project construction, as well as the investment involved in the operation and maintenance period. The supporting investment of the project is calculated according to 0.1% of the total investment of the project. Therefore, the current value of the supporting investment expenditure of the project is 115 000 yuan.

5.3.5 PPP value results Based on the above analysis, the PPP present value calculation result is 530.052 million yuan.

5.4. Evaluation conclusion According to the above analysis, the PSC value of this project is 680.901 8 million yuan, the PPP value is 53 050.23 yuan, VFM value = PSC value - PPP value = 150.415 7 million yuan.

6. Determination and fuzzification of real option model parameters

6.1. The value of the underlying asset E The value of the underlying asset of the financial option reflected in the real option can be understood as the sum of the present value of the future cash flow of the project. The value of the underlying asset in this article is the net present value of the total cost of the project during the franchise. According to the overall calculation form, E = 541 million yuan was obtained. The fluctuation of cash flow during this period is mainly affected by policy risks and market risks. The upper limit of the value of the underlying asset is about 15% higher and the lower limit is about 8%. Therefore, construct the fuzzy number of the underlying asset value E = (4.98, 5.41, 6.22).

6.2. Option holding time T In the evaluation of value for money, the holding time of equity can be adjusted according to each stage. This article mainly evaluates VFM during the project identification stage, so T = 18.

6.3. Exercise price of option K The exercise price of the option is the sum of the discounted value of the estimated total expenditure, that is, the present value of the actual cost of the government's investment in PPP projects is 518 million. Its fluctuation range is up and down 5%, so the fuzzy number of the exercise price X of the option = (4.92, 5.18, 5.44).

6.4. Volatility of project value σ From a statistical point of view, volatility is a measure of the uncertainty of project value. That is to say, the greater the volatility, the greater the value of options. Cultural and tourism projects are still in
the development stage, lacking relevant historical record data. In the study, some experts suggest that the annual volatility can be 15% - 25% in the real option model, but according to the characteristics of the tourism project industry, the greater complexity and uncertainty lead to the greater volatility of income, so the project value volatility is adjusted to 20% - 30%, and the fuzzy number of $\sigma$ is constructed $\sigma = (0.20, 0.25, 0.30)$.

6.5. risk free interest rate

In the B-S Option Pricing Model, the long-term treasury bond interest rate can be used as the risk-free interest rate, and the five-year treasury bond interest rate of 2018 (compound interest rate) can be selected as the risk-free rate of return, so the risk-free rate of return here is $r = 4.27\%$. $\alpha$ is the representative parameter to realize the grasp degree of the total value of the project, which depends on various factors affecting the value of the project. It can be determined by the common comprehensive evaluation method. Its value range is generally $\epsilon(0,1)$, and the value of this project case can be assumed to be 0.8.

The calculation of fuzzy real options after $\alpha$-level set processing is mainly performed in the excel table. The data is shown in Table 1:

| B-S model parameters       | Value (interval) | Fuzzy parameters | Value (interval) |
|----------------------------|------------------|------------------|------------------|
| Asset value (present value) | (4.98, 5.41, 6.22) | Asset value (present value) | (5.324, 5.572) |
| Option execution price K   | (4.92, 5.18, 6.44) | Option execution price K | (5.128, 5.232) |
| Value volatility $\sigma$  | (0.20, 0.25, 0.30) | Value volatility $\sigma$ | (0.24, 0.26) |
| Risk free rate r           | 4.27%            | Risk free rate r | 4.27%            |
| Expire date T              | 18               | d1               | (1.304, 1.46)   |
|                            |                  | d2               | (0.201, 0.442)  |
|                            |                  | V                | (2.562, 3.792)  |

According to the previous calculations, the calculation results obtained by using the traditional PSC public sector reference comparison method show that the PPP model of this tourism creative park project is worth the money. When calculating the option value of a project using the Black-Scholes option pricing method, a triangular fuzzy number is introduced to adjust the model. From the calculation results of the parameters in the table above, it can be seen that the option value contained in this project is $[2.562, 3.792]$ (100 million yuan) When the PPP model is adopted, the government investment is 530.5 million yuan. Combined with the adjusted value, the total value of ppp is $5.305+[2.562, 3.792] = [7.867, 9.097]$ (100 million yuan), indicating that after considering the value brought by uncertainty, Compared with the traditional model, the PPP model is not more economically feasible. This paper introduces the fuzzy real option method on the basis of the original model. It is not a negation of the traditional evaluation method. From the perspective of public service efficiency and quality, due to the fact that some projects will have social benefits greater than the increased costs, although the evaluation results To the negative, the use of the PPP model is still open to question and feasible. Therefore, decision makers are reminded to consider the possibility and uncertainty of the project as much as possible in order to make the evaluation more consistent with the actual situation.

7. Conclusion

PPP projects have a large amount of funds, long duration, and complex influencing factors. The investment opportunities and flexibility that exist in the entire process will bring hidden value to the project and should be taken seriously. At present, the quantitative evaluation of value for money for PPP projects is still in the encouraging research stage. Most of the traditional evaluation method parameters are singular. In this process, due to the neglect of the value of uncertainty, it is easy to cause erroneous decisions, so it is necessary to introduce the real option method and make fuzzy
adjustments. The quantitative value for money analysis based on the triangular fuzzy real option method in this paper is mainly in the early project identification stage, and the real option value of this kind of uncertainty exists throughout the life cycle of the project. Comprehensive and in-depth study of factors, strengthening the application of ideological and method of fuzzy real options in PPP projects, and providing a more scientific basis for the decision-making process of ppp projects.

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