A quantitative evaluation model and application of value for money for PPP projects on a toll expressway

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Abstract. Value for money (VFM) evaluation of projects is a policy requirement of the government for the management of Public Private Partnership (PPP) projects. The key is to construct comparable and measurable reference objects with the project and establish models for quantitative evaluation. This article focuses on the investment, financing, and construction management characteristics of PPP projects on a toll expressway. The government toll expressway project is used as a benchmark reference project to determine the public sector comparator (PSC) value, and the PPP value of the project is determined based on the present value of the government's net cost throughout the entire life cycle of a toll expressway PPP project. A quantitative evaluation model for the VFM of the toll expressway PPP project is developed. It considers factors such as different taxes and fees paid during the construction and operation period of government toll roads and toll expressway PPP projects, as well as different charging periods, to ensure the comparability, measurability, and applicability of the proposed model for the benchmark reference project. Finally, taking toll expressway Project A as an example, the proposed quantitative evaluation model of the VFM is applied to quantify VFM.

Keywords: expressway, public-private partnership, value for money, quantitative evaluation model, case study.

1 Introduction

Value for Money (VFM) evaluation is a method of evaluating whether a project adopts the PPP model to replace the traditional government investment and operating methods in providing public services. It is an important policy provision for the government to implement PPP project management. The "Guidelines for the Evaluation of Value for Money in PPP Projects (Trial)" (Cai Jin [2015] No. 167)[1] (hereinafter referred to as the "Guidelines") clearly stipulate the principles, procedures, qualitative evaluation, quantitative evaluation, evaluation reports, and information disclosure necessary for the implementation of value for money evaluation in PPP projects. Expressways are an important component of transportation infrastructure and a key area for the promotion and application of PPP modes of delivery. Currently, in foreign countries, the "VFM"[2],

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represented by the UK, was the first to construct a complete evaluation structure for PPP projects in 2004. This framework uses the basic calculation method of public sector comparator (PSC), and calculates the value of the expected cash flow discount under the same benchmark date and inflation rate conditions, thus giving an idea of the VFM. Zwalf[3]summarized the valuation methods and controversial points of discount rates in quantitative evaluation of the VFM around the world, pointing out the complexity of, and controversy associated with, the use of discount rates. In China, research into the VFM evaluation of PPP projects on toll expressways includes two categories: quantitative evaluation and qualitative evaluation. Among them, in terms of quantitative evaluation, Chi Lu[4] pointed out that only a small number of PPP projects have truly implemented the requirements of the "Guidelines" for VFM evaluation, and the evaluation quality of projects that have already conducted VFM evaluation work is poor. The main problem is that the quantitative evaluation is disconnected from reality, leading to inaccuracy; Liu Yang[5]believes that when calculating VFM, the discount rate should consider the influence of inflation. In terms of qualitative evaluation, the focus is on the construction of indicator systems such as indicator connotation and indicator weights. For example, Zhang Yingjie[6] *et al.* established a qualitative evaluation indicator system consisting of thirteen social benefit indicators and two economic benefit indicators. Overall, there is currently a lack of unified and standardized guidance paradigm for quantitative evaluation of the VFM in PPP projects on toll expressways. In practice, to promote the implementation of PPP models in projects, there are many practices that can determine VFM evaluation reference projects, construct relevant quantitative evaluation models, and select main parameters for quantitatively evaluating the VFM in expressway from the perspective of facilitating project VFM evaluation. This goes against the original intention of conducting VFM evaluations.

Therefore, the present research combines the expressway investment and financing model with the government's financial capacity to propose using the government toll road project as a reference project, and constructs a mathematical model for the PSC value of a toll expressway PPP project. Among them, the net cost of operation and maintenance should include the interest expenditure of government special bonds, in addition to including the additional income tax, value-added tax, and surcharges that need to be paid for PPP projects compared to the reference project, the adjusted value of the reference project's competitive neutrality also requires deduction of the water conservancy construction fund expenses that must be paid for the reference project. All risk costs should fully consider the risk of insufficient traffic volume. Then, a calculation model for the present value (PPP value) of the government's net cost throughout the entire lifecycle of expressway PPP projects is proposed, and a quantitative evaluation and calculation model for the VFM of expressway PPP projects is constructed. To enhance comparability, the charging periods of the reference project and PPP project are unified. Considering factors such as inflation and risk reward, a discount rate for the PSC value of the reference project and the PPP value of the PPP project is proposed based on LPR over a five-year period.

2 Construction and Operation Characteristics of PPP Projects on A Toll expressway

2.1 Large initial investment, long construction cycle, and long investment payback period

Building and operating an expressway is a capital-intensive industry, requiring a large initial investment. Expressway project investment often amounts to several, even tens, of billions; the construction period is long, with a general construction period of 3-5 years, and some projects with large scale and high technical difficulty have a construction period of 5-8 years. Compared with ordinary highways, expressways have the benefits of reducing transportation costs, saving operation time, and reducing traffic accident grade differences. They also have the dual characteristics of public welfare and commodity, and are quasi-public goods. Therefore, according to relevant national policies, expressway operators can collect tolls from users to recover investment and obtain reasonable returns. However, due to the large initial investment and long construction cycle of expressway, the investment recovery period is often long.

2.2 Investment, construction and operation mode

With the continuous deepening of the national financial and tax system reform, the investment and financing models of expressways have also undergone significant changes. There are three types of investment and financing models that can be applied in the expressway industry: The first is the non-toll model, which means that the government fully invests in the construction of expressways through financial funds. Under this model, projects are not charged, and the public can use expressways without paying tolls. The second is the government toll road model, which means that the government only invests a portion of the road construction capital, and issues local government special bonds to raise the remaining funds to invest in the construction of the road. After the road is completed, toll fees are collected from the public to repay the principal and interest of the special bonds. According to the Regulations on the Management of Toll Roads, the maximum toll period for government toll roads shall not exceed 15 years (the longest in central and western regions shall not exceed 20 years); During the charging period, the water conservancy construction fund needs to be paid at 3% of the toll income, and no other taxes warrant to be paid. The third is the operational expressway model, which is invested and constructed by domestic and foreign economic organizations in accordance with the law or through cooperation between government and social capital. By collecting tolls, advertising, and service-area operating income, the investment is recovered and reasonable returns are obtained. According to the Regulations on the Management of Toll Roads, the maximum toll period for commercial expressways shall not exceed 25 years (the longest in the central and western regions shall not exceed 30 years); during the toll period of operating expressways, enterprise income tax, value-added tax, and surcharges need to be paid in accordance with relevant national laws and regulations. Due to the large scale of investment in expressways, limited government financial resources, and the fact that expressways are quasi-public goods with chargeable nature, the government toll road model and operational road model are commonly used in practice.

2.3 PPP payment mechanism

According to the relevant provisions of PPP policies, there are three main payment mechanisms for current PPP projects: firstly, the government pays the project company based on the availability of project facilities, the use of products or services, and the quality. The second is user payment, which means that the end consumer directly pays to purchase public goods and services, and the project company directly collects fees from the end user to recover the construction and operation costs of the project and gain reasonable profits. The third is feasibility gap subsidy, which refers to when the user's payment is insufficient to cover social capital or the project company's cost recovery and reasonable return, the government provides social capital or project company with economic subsidies in the form of financial subsidies (construction period investment subsidies, operation subsidies), equity investment, preferential loans, and other preferential policies to compensate for the gap beyond the user's payment. Due to high investment, expressway projects often require government financial subsidies (such as investment subsidies during the construction period, operation subsidies, *etc.*) when it is difficult to attract social capital solely by relying on user fees in practice, that is, implementing the feasibility gap subsidy model.

3 Calculation model based on project PSC value

The government toll road model is the most feasible and effective traditional government investment model in reality. Therefore, in the present research, the government toll road model is taken as the benchmark reference project, comprehensively considering the differences in tax collection, toll period, and risk cost, and makes corrections to construct a calculation model for the PSC value of the reference project.

3.1 Calculated based on the net cost of project construction and operation and maintenance

The net cost of expressway PPP reference project construction includes the total static investment of the project (construction and installation engineering fees, land use and demolition compensation fees, other engineering construction costs, reserve funds, *etc.*) and interest during the construction period (special bond interest). Operation and maintenance costs encompass maintenance fees, management fees, tunnel operation and maintenance fees, overhaul fees, and financial expenses (mainly special bond interest). Revenue during the operation period includes toll revenue, advertising and service area operating revenue, *etc.*

The construction, operation and maintenance net cost (PSC_O) of the reference expressway project is calculated as follows:

$$PSC_o = \sum_{i=0}^{a} \frac{C_{ci}}{(1+r)^i} + \sum_{i=a+1}^{n} \frac{C_{mi} + C_{ei} + C_{ti} + C_{oi} - T_i}{(1+r)^i} \tag{1}$$

where: C_{ci} is the construction investment in the i^{th} year (including interest during the current year of the construction period;

C_{mi} is the maintenance cost for the i^{th} year;

C_{ei} is the overhaul cost for the i^{th} year;

C_{ti} is the tunnel operation and maintenance fee for the i^{th} year;

C_{oi} is the financial expense for the i^{th} year (mainly the interest on special government bonds);

T_i is the operating income for the i^{th} year, including toll fees, advertising, and service area operating income;

a is the construction period;

n is the construction and charging period;

r is the discount rate.

It should be noted that, according to the current laws and regulations related to expressways, the longest charging period for government toll roads is 15 years (20 years in the central and western regions), while the longest charging period for PPP projects on a toll expressway is 25 years (30 years in the central and western regions). To ensure comparability between the PSC value of the reference project and the PPP value of the PPP project, unification of the charging period of the reference project and the PPP project according to a longer period is proposed; the reference project fee period is based on the PPP project fee period (25 years in the eastern region and 30 years in the central and western regions). According to the "Guidelines for the Evaluation of Value for Money in PPP (Trial) and the "Guidelines for the Demonstration of Financial Affordability of Government and Social Capital Cooperation Projects", the discount rate refers to the yield of local government bonds during the same period. Based on this, factors such as inflation and risk returns are considered, and use of a discount rate for quantitative evaluation of the VFM using the market quoted interest rate (LPR) for loans over five years is proposed.

3.2 Competitive neutrality adjustment

For the reference project, the government is required to withdraw the water conservancy construction fund based on 3% of the toll income, but there is no need to pay income tax, value-added tax, and surcharges (including urban maintenance and construction tax, education surcharges, and local education surcharges). The competitive neutrality adjustment value is given by:

$$CNA = \sum_{i=a+1}^{n} \frac{IT_i + VAT_i + UT_i + ES_i + LES_i}{(1+r)^i} \tag{2}$$

where: CNA is a competitive neutral adjustment value;

IT_i is the income tax paid for PPP projects in the i^{th} year;

VAT_i is the value-added tax paid for PPP projects in the i^{th} year;

UT_i is the urban construction and maintenance tax paid for PPP projects in the i^{th} year;

ES_i is the education surcharge paid for the PPP project in the i^{th} year;

LES_i is the local education surcharge paid for the PPP project in the i^{th} year;

CF_i is the water conservancy construction fund paid for the reference project in the i^{th} year, and the water conservancy construction fund is withdrawn at 3% of the toll income;

n is the construction and charging period;

r is the discount rate.

3.3 Total risk cost

Under the government toll road model, the government bears all risks such as project construction risk, operational risk, policy risk, legal risk, force majeure, *etc*. In addition, it is also necessary to fully consider the risk of insufficient traffic volume. Due to the lack of relevant statistical databases in the transportation industry and the difficulty in predicting the risk probability and risk consequence values of projects, this paper uses the proportional method to calculate the risk bearing cost, drawing on the practices of countries such as the UK and Australia. The total risk bearing cost is determined based on a certain proportion of project construction（including construction and installation engineering fees, land use and demolition compensation fees, other engineering construction costs, reserve funds, etc）, operating costs(including maintenance costs, major repair costs, tunnel operation and maintenance costs, etc), and vehicle toll income, with a general value of 5-20%. The total risk cost is calculated as follows:

$$RC = \beta(\sum_{i=0}^{a}\frac{C_{ci}}{(1+r)^i} + \sum_{i=a+1}^{n}\frac{C_{mi}+C_{ei}+C_{ti}+T_{ti}}{(1+r)^i}) \tag{3}$$

where: RC is the total risk cost;

β is the proportion of risk bearing costs;

C_{ci} is the construction investment in the i^{th} year (including interest during the construction period of the current year);

C_{mi} is the maintenance cost for the i^{th} year;

C_{ei} is the overhaul cost for the i^{th} year;

C_{ti} is the tunnel operation and maintenance fee for the i^{th} year;

T_{ti} is the toll income in the i^{th} year;

a is the construction period;

n is the construction and charging period;

r is the discount rate.

Based on the above analysis, the PSC value of the reference project is computed as follows:

$$PSC = PSC_o + CNA + RC \tag{4}$$

where: PSC is the PSC value of the reference project;

PSC_o is the net cost of construction, operation and maintenance of the reference project;

CNA is a competitive neutral adjustment value;

RC is the total risk cost.

4 PPP Value Calculation Model for Expressway PPP Projects

The financial expenditure responsibility (PPP value) for the entire life cycle of an expressway PPP project mainly includes equity investment, operation subsidies, risk bearing, and supporting investment.

4.1 Equity investment

Equity investment expenditure responsibility refers to the equity investment expenditure responsibility borne by the government when the government and social capital jointly establish a project company. If social capital establishes a project company separately, the government will not bear responsibility for equity investment expenditure. The calculation formula for government equity investment expenditure is as follows:

$$SR = \sum_{i=0}^{a} \frac{CF_{ci}}{(1+r)^i} * ER \tag{5}$$

where: SR is government equity investment expenditure;

CF_{ci} is the capital contribution for the project in the i^{th} year;

ER is the equity ratio of the government;

a is the construction period;

r is the discount rate, the same as the PSC value discount rate, and the same hereafter.

4.2 Operating subsidies

To compensate for the insufficient income of social capital investment projects and make the projects have market value, the government often grants a certain amount of financial subsidies, namely, operating subsidies, to the projects year-on-year during the operating period, as given by:

$$OS = \sum_{i=a+1}^{n} \frac{OS_i}{(1+r)^i} \tag{6}$$

where: OS is the operating subsidy;

OS_i is the operating subsidy for the i^{th} year, and the operating subsidy is calculated using the project cash flow method. That is, under the proposed financing plan, based on the net cash flow of each year within the entire life cycle of the project. The capital cash flow statement is used for discount calculation to calculate the amount of operating subsidy under a certain internal rate of return (after tax) of project capital;

a is the construction period;

n is the construction and charging period;

r is the discount rate.

4.3 Risk taking

Total risk bearing cost=transferable risk bearing cost+retained risk bearing cost.

Government retained risk bearing expenditure responsibility refers to the financial contingent expenditure responsibility caused by the government's assumption of risks in expressway PPP projects, which usually comprises legal risks, policy risks, government credit risk, minimum demand risks, termination of project contracts due to government reasons, and other emergencies borne by the government, as well as force majeure risks that need to be shared by the government and social capital at the same level, leading to financial contingent expenditure responsibility, the government retained risk cost is a certain proportion of the total risk cost, as given by:

$$GRC = \alpha * RC \tag{7}$$

where: *GRC* is the cost of government retained risk;

α is the proportion of government retained risks;

RC is the total risk cost.

4.4 Supporting investment

The responsibility for supporting investment and expenditure denotes other investment responsibilities such as supporting projects provided by the government, usually including land acquisition and consolidation, construction of supporting measures for some projects, completion of the connection between the project and existing relevant infrastructure and public utilities, investment subsidies, loan discounts, *etc*. The responsibility for supporting investment is calculated as follows:

$$SI = \sum_{i=0}^{n} \frac{SI_i}{(1+r)^i} \tag{8}$$

where: *SI* is supporting investment;

SI_i is the supporting investment for the i^{th} year;

n is the construction and charging period;

r is the discount rate.

Based on the above analysis, the PPP value of expressway projects is determined as follows:

$$PPP = SR + OS + GRC + SI \tag{9}$$

where: *PPP* is the PPP value of the expressway project;
SR is government equity investment expenditure;
OS is operating subsidies;
GRC is the cost of government retained risk;
SI is supporting investment.

5 Quantitative Evaluation Model for VFM of PPP Projects on Toll expressways

VFM is calculated as follows:

$$VFM = PSC - PPP \tag{10}$$

When the PPP value is less than or equal to the PSC value, it means that the cost of government payment for adopting the PPP mode is lower. It is believed that, through quantitative evaluation of the VFM, it is appropriate to adopt the PPP mode for implementation, and the larger the difference, the more appropriate it is to adopt the PPP mode. When the PPP value is greater than the PSC value, it means that the cost of traditional government procurement mode is lower, and it is considered that the PPP mode is not suitable for implementation because it has not passed the test encompassed within the quantitative evaluation of the VFM.

6 A Case STUDY

6.1 Basic information of the project

Investment: The static total investment of Expressway Project A is 13.154 billion yuan(Including 10.121 billion yuan for construction and installation engineering, 1.503 billion yuan for land use and demolition compensation, 0.444 billion yuan for other engineering construction costs, and 1.086 billion yuan for reserve funds), construction period: 3 years, investment ratio of each year: 30%: 40%: 30%, interest during the construction period: 669 million yuan (calculated based on bank loan interest rate of 4.2%), and the total investment of the project is 13.824 billion yuan, with a capital ratio of 20%, all funded by social capital; The remaining funds are financed by the project company through bank loans. The project mileage is 80 km, and the tunnel mileage is 17 km.

Operating income: The project has a 30-year operation period, and the annual toll income, advertising, and service area operating income are shown in the table 1:

Table 1. operating income of the project in each year of operation (unit: 10,000 yuan)

Number of years of operation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Toll revenue	33,437	36,549	39,958	43,693	47,786	52,272	56,677	61,465	66,668	72,322
Revenue from service areas	334	365	400	437	478	523	567	615	667	723
Number of years of operation	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Toll revenue	84,906	89,539	94,439	99,623	105,106	110,907	114,971	119,200	123,603	128,186
Revenue from service areas	849	895	944	996	1051	1109	1150	1192	1236	1282
Number of years of operation	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Toll revenue	140,966	144,107	147,338	150,662	154,079	157,482	160,982	164,582	168,284	172,089
Revenue from service areas	1410	1441	1473	1507	1541	1575	1610	1646	1683	1721

Operating costs: The costs during the operation period of the project mainly include daily maintenance costs for the expressway, daily management costs, tunnel operation and maintenance costs, and expressway overhaul costs. The daily maintenance costs for the first year of the project are calculated at 140,000 yuan/km, daily management costs are calculated at 260,000 yuan/km, and tunnel operation and maintenance costs are calculated at 400,000 yuan/km, with an annual growth rate of 2% thereafter. The expressway overhaul is scheduled for the 10^{th}, 20^{th}, and 30^{th} years of the operating period. The overhaul fee for the 10^{th} year of the operation period is calculated at 2.6 million yuan/km, and thereafter will increase at 2% *per annum*.

Operation subsidy: To ensure the project has market value, based on the internal rate of return on project capital of 6%, the capital cash flow method is used, and the government needs to provide 184.75 million yuan of operating subsidies for the project in each year of the operation period.

6.2 Quantitative evaluation of project VFM

(1) Calculation of PSC value of Project A

The reference project for Project A is the government toll road, which refers to the interest rate of local government toll road special bonds, and takes into account factors such as inflation and risk return. The discount rate is set at 4.2% of the current five-year LPR value, and the proportion of risk bearing costs β is calculated based on a value of 10%. After calculation:

Refer to the project's net cost of construction, operation and maintenance (PSC_O) = 5169.92 million yuan;

Competitive Neutrality Adjustment Value (CNA) = 1355.77 million yuan;

Total risk cost (RC) = 3192.17 million yuan;

Reference project PSC value (PSC) = $PSC_O + CNA + RC$ = 9717.86 million yuan.

(2) Calculation of PPP value of Project A

Government equity investment expenditure (SR) = 0, and there is no equity investment during the government construction period;

Operation subsidy (OS) = 2756.43 million yuan (184.75 million yuan for each year during the operating period);

Government retained risk cost (GRC) = 638.43 million yuan (the government retained risk ratio α is 0.2);

Supporting investment (SI) = 0, there is no government supporting investment for Project A.

The PPP (*PPP*) value of an expressway project = *SR* + *OS* + *GRC* + *SI* = 3394.86 million yuan.

(3) Quantitative evaluation of the VFM in Project A

The PPP value of Project A (3394.86 million yuan) is less than the PSC value (9717.86 million yuan), indicating that Project A has passed the test of quantitative evaluation of the VFM and can be implemented using the PPP mode.

7 Conclusion

This paper is based on the policy requirements of quantitative evaluation of the VFM of PPP projects conducted by the government, combined with the investment and financing models and operational management characteristics of high-speed toll roads. After revising the government toll road projects in terms of tax collection, toll period, risk cost bearing, *etc*., it serves as a reference project for PPP projects on a toll expressway. Furthermore, a mathematical model for the PSC value and the present value (PPP value) of government net costs over the entire lifecycle of expressway PPP projects is constructed. A quantitative evaluation model for the VFM of road PPP projects on a toll expressway is proposed, and application of the evaluation model is analyzed based on a case study. The results indicate that, when constructing a reference project, the interest expenses of government special bonds are included in the assessment of net operating and maintenance costs, the income tax, value-added tax, surcharges, water conservancy construction funds, and other expenses that need to be paid are included in the assessment of the competitive neutrality adjustment value of the reference project. The risk of insufficient traffic is included in the assessment of risk costs, and measures such as unifying the charging terms of the reference and PPP projects are taken; this enhances the comparability of reference projects and improves the applicability and rationality of the proposed VFM model.

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