Risk analysis and evaluation of highway public-private Partnership (PPP) project

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Abstract. Since the introduction of the PPP model in China, the highway PPP project has been the focus of many people's attention. If the project with large investment scale, long construction cycle and long operation time wants to obtain win-win results, it must control and manage the risk in an all-round way. In this paper, the literature method and Delphi method are used to analyze and sort out the life cycle risks of highway PPP projects, and the risk matrix is used to evaluate and grade them, which provides technical support for transportation construction enterprises in risk management of such projects to a certain extent.

Keywords: Highway PPP; Risk Matrix; Identification and Evaluation.

1 Introduction

PPP model means public-private partnership system, private development of public services, etc., that is, government departments and social capital signed an agreement, authorized social organizations on behalf of the government to carry out infrastructure construction and operation management, and provide services to the public. Since the model was introduced in the 1980s and 1990s, with the reform and opening up brought about by the city to modernize development and the government to undertake urban infrastructure projects under increasing pressure two important factors, PPP cooperation model has attracted more and more attention from all walks of life. At the Third Plenary Session of the 18th CPC Central Committee held in 2013, it was formally proposed to "allow social capital to participate in urban infrastructure investment and operation through franchising and other means", in order to broaden financing channels for urbanization construction. The "Measures for the Management of Infrastructure and Public Utilities Franchise" issued in 2015 also indicates that "encourage and guide social capital to participate in the construction and operation of infrastructure and public utilities". As of February 2023, 10,347 PPP projects have been registered nationwide, involving 1693.36 billion yuan[1-3].

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Among many PPP projects, highway PPP projects are typical types of projects with long construction period, large investment scale and low return on capital. Moreover, they are limited by the Highway Law, the Regulations on the Administration of Toll Roads and other laws and local regulations, and the operational highways should be recovered by the state free of charge after the expiry of the agreed operating period[4,5]. Especially since the development of PPP model to today, China has experienced a "boom" period in which a large number of projects are launched with the help of PPP model, making it a financing tool for local governments to realize large-scale infrastructure project investment. The operation form of the project is also a variant of bond investment, which brings huge financial risks to local governments[6]. It has also experienced the trough period caused by the "strict control of low-margin trade, financial derivatives, PPP and other high-risk businesses" and "requiring central enterprises to improve the PPP business control system and properly carry out PPP business" proposed by the state when it comes to control and control[7,8]. This model has always lacked real support at the legislative level, and the rules and regulations issued by local governments vary from time to time. In order to ensure profitability, social capital must prevent the source of risk, monitor the process and reasonably avoid it.

In recent years, risk identification, assessment and sharing are also popular directions for risk research on PPP projects[9]. Based on previous studies and previous achievements, this paper adopts the method of literature research, Delphi method and risk matrix method to conduct qualitative and quantitative analysis on the risks encountered in the construction, operation and handover period of highway projects and their sources, and forms a risk list and evaluates them. It provides some technical support for the risk management theory of highway PPP projects and expands the risk management framework of PPP projects.

2 Risk identification of highway PPP projects

2.1 Risk identification method

Risk identification is a prerequisite for risk management, and accurate and comprehensive identification of all factors and sources of risk is the basis for subsequent risk avoidance, transfer, sharing and digestion. In particular, PPP projects will have more diversified and far-reaching risks than traditional public procurement, privatization and outsourcing projects[10]. In terms of risk identification methods, Jiang Ying et al. took the PPP project of the Undersea tunnel as an example and preliminarily concluded 32 PPP project risk factors that fit the project through literature analysis and field research. Hu Yinan et al. proposed that "Risk identification can be judged by perceptual understanding and historical experience. It can also be obtained by recording, analyzing, summarizing and sorting out various objective data and risk cases, and experts can be organized to discuss if necessary "[11,12]. In addition, the commonly used methods for risk identification include SWOT analysis, event tree analysis, multi-criteria decision analysis, etc., but these methods may be subjective in risk identification and analysis. It may also require large amounts of input data and expertise, resulting in high costs, making the identification process at risk of ignoring certain factors.

Considering that this paper is based on the perspective of transportation construction enterprises in highway PPP projects to observe the corresponding changes of risks in the project cycle, it is necessary to consider the actual characteristics of risks and the specific characteristics of long-term operation of the project, as well as the horizontal and vertical correlation between risks, reflecting the hierarchical thought of management by objectives theory. Therefore, the combination of literature research and Delphi method is adopted for risk identification. This gives consideration to the breadth of literature research on risk identification, and enables Delphi method to weaken its own research limitations from the perspective of experts. In addition, the primary conclusions contributed by literature investigation method can be directly discussed by the expert group, which can reduce the disadvantage of Delphi method that it needs to spend most of its time communicating with experts.

2.2 Risk factor screening

Compared with ordinary PPP projects, highway PPP projects not only occupy a leading position in the construction volume, but also their investment scale and construction period are larger and longer than ordinary projects, with more participants and more complicated legal relationships. Moreover, the risk structure and cycle of highway PPP projects are also different for different entities. Therefore, Table 1 below is from the perspective of social capital, taking G3018 Jinghe to Alashankou PPP project as the main object of investigation, and making statistics on relevant online literature and the contents of two evaluations and one case of other projects. The risk sources and specific meanings of construction period, operation period and transfer period are obtained. Moreover, an excellent and successful PPP project cannot be achieved without political support, organizational support, and legal supervision[13], which are also included in the risk list.

However, the data obtained by the literature survey method alone may have some hidden dangers of being subjective and purposeful. Therefore, a questionnaire was sent to transportation construction enterprises in Xinjiang based on the detailed data obtained earlier, and unreasonable risk classification or some time-effective risk factors were removed after two rounds of discussion and screening. A specific risk list (Table 1) was established, including the risks during the construction period, the operation period, the financial risks throughout the life cycle of the project, the legal and contractual risks, the government risks and the description of the risk factors. This list contains 26 items in 5 categories.

Table 1. List of risks.

Risk category	Risk factor	Risk description
Construction risk	Land acquisition risk	Risks arising from the uncertainty of land ownership and fluctuations in land acquisition costs
	Project management risk	The lack of organization and coordination ability of the project company leads to increased communication costs and conflicts among all parties involved
	Engineering design change risk	The risk that the project cannot be adjusted according to the original plan due to design, environmental and other factors
	Risk of adverse climatic and geological conditions	Risks such as increased costs caused by adverse natural conditions in the project location

	Supply risk	Loss caused by untimely supply of raw materials, equipment and energy
	Project company breach of contract	The risk that the project company fails to perform the relevant contract for various reasons
	Subcontractor default risk	The risk that the subcontractor fails to perform the relevant contract for various reasons
	Technical risk	The use of immature technology, difficult to meet the predetermined requirements, poor applicability, resulting in the need for technical transformation of the risk
	The charge rate is unreasonable risk	Fee rate argument is insufficient, affecting the risk of profit
	Risk of operating cost overruns	Government forced improvement of product and service standards, poor operation management, and other market environment factors lead to the risk of operating cost overruns
Operational risk	Traffic fluctuation risk	The risk of losing money if the traffic volume in the operating period falls short of the two evaluation criteria
	Project handover risk	Due to overload, overuse, poor maintenance and other situations during the operation period, the project status fails to meet the handover requirements when the cooperation term expires
	Project uniqueness risk	The project has the risk of competitive diversion
	Risk of changes in market demand	In addition to unique risks, changes in demand caused by economy, society, demographics, and regulations
	Capital placement risk	The risk that the funds required for the project will not be available on time, causing the project to be blocked or even stopped
Financial risk	Financing costs increase risk	The risk of cost increase due to unreasonable financing structure and difficulty in raising funds
	Inflation risk	The rising price level leads to an increase in project costs
	Insufficient risk of bidding competition	Including unfair, unfair, opaque bidding procedures, lack of competitors or malicious competition
Legal and contractual risks	Contract risk	Risks caused by imperfect contract design, unclear division of risk sharing and scope of rights, responsibilities and interests in contract documents, and inadequate storage of contracts
	Risk of inadequate legal and regulatory systems	The risk is caused by the low level, poor effectiveness, conflict and poor operability of the existing PPP legislation
	Risks of changes in laws and regulations	At present, there is a lack of clear legal support for PPP projects, and local requirements do not meet the risk of changes in laws and regulations
	Government regulators adjust risk	The risk of reporting and communication difficulties during the operation of the project after adjustment by the government management department
	There is the risk of homogeneous competition in project database review	The government or other investors to build or rebuild other projects, the project to form substantial commercial competition
Government risk	Approval delay risk	The project approval process is complicated, involves too many departments, and the efficiency of the staff is low
	The risk of expropriation and public ownership	When macro policies are adjusted, the project contract violates the policy direction, forcing private capital to withdraw, and the risk of government confiscation of the project
	Risk of excessive government intervention	Excessive intervention of government management departments in the independent decision-making rights of project builders and investors leads to the risk of project efficiency reduction or suspension and rework

3 Risk assessment

The above Delphi method and literature survey method were used to screen and make statistics on the risk factors of highway PPP projects, obtain a risk list, and explain the risk formation factors. However, the lack of hierarchical evaluation as a guide would make the analysis and comparison vague, and relevant evaluation methods should be further used to grade the risk list. Considering that the influence of risk factors includes occurrence probability and impact severity, this paper adopts risk matrix method for index evaluation.

3.1 Design of risk assessment system

The risk assessment questionnaire must repeat the Delphi method and be sent to the expert group for assessment. Therefore, a five-level classification system is adopted for the occurrence probability and influence of risks, which is convenient for the expert group to evaluate.

In terms of risk occurrence probability, the probability is divided into five parts from 0% to 100%, and assigned according to the score value of 1 to 5. Specifically, the occurrence probability between 0 and 20% (including 20%) is minimal, and the score is 1 point; The probability of occurrence between 20% and 40% (including 40%) is small, and the score is 2 points; The probability of occurrence between 40% and 60% (including 60%) is moderate, and the score is 3 points; The probability of occurrence is between 60% and 80% (including 80%), and the score is 4 points; The probability of occurrence between 80% and 100% (including 100%) is maximum, and the score is 5 points.

The severity of risk consequences is also divided into five levels according to the impact of small, small, moderate, large, and very large, and is assigned 1 to 5 points from small to large, where small means that the consequences are negligible. However, records should be kept, small indicates that the goal can be achieved by using small control measures, moderate indicates that the goal can be achieved by using large-scale control measures, large indicates that the goal can be partially completed by using large-scale control measures, and large indicates that the project fails or is cancelled.

3.2 Statistics of expert survey results

The questionnaire will be designed based on the final risk list above and evaluated with the expert group. 30 copies will be sent out and 30 copies will be received. Through the summary of the questionnaire, we can obtain the summary table of the expert score of the risk occurrence probability (Table 2) and the expert score table of the severity of the risk occurrence consequence (Table 3).

Table 2. Summary of expert scores on risk occurrence probability.

Risk factor \ Chance	[0,20]	(20,40]	(40,60]	(60,80]	(80,100]
Land acquisition risk	14	3	2	8	3
Project management risk	16	4	6	2	2
Engineering design change risk	0	3	4	8	15
Risk of adverse climatic and geological conditions	12	10	8	0	0
Supply risk	3	8	6	7	6
Project company breach of contract	5	16	8	1	0
Subcontractor default risk	2	10	12	6	0
Technical risk	11	8	5	3	3
The charge rate is unreasonable risk	3	10	11	6	0
Risk of operating cost overruns	2	6	4	15	3
Traffic fluctuation risk	0	0	2	10	18

Project handover risk	14	3	10	3	0
Project uniqueness risk	3	3	6	16	2
Risk of changes in market demand	1	5	10	8	6
Capital placement risk	0	3	6	14	7
Financing costs increase risk	6	15	4	4	1
Inflation risk	0	0	2	7	21
Insufficient risk of bidding competition	17	5	5	3	0
Contract risk	6	12	8	3	1
Risk of inadequate legal and regulatory systems	0	0	2	18	10
Risks of changes in laws and regulations	2	6	12	8	2
Government regulators adjust risk	6	8	13	3	0
There is the risk of homogeneous competition in project database review	21	4	3	2	0
Approval delay risk	2	3	8	15	2
The risk of expropriation and public ownership	23	7	0	0	0
Risk of excessive government intervention	6	3	12	5	4

Table 3. Summary of expert scores on the degree of impact of risk consequences.

Influence degree / Risk factor	minimum	small	moderation	large	Very large
Land acquisition risk	0	4	8	16	2
Project management risk	2	7	12	8	1
Engineering design change risk	0	2	11	15	2
Risk of adverse climatic and geological conditions	1	6	7	11	5
Supply risk	6	18	3	3	0
Project company breach of contract	0	4	8	12	6
Subcontractor default risk	1	12	10	6	1
Technical risk	3	8	12	7	0
The charge rate is unreasonable risk	0	3	6	18	3
Risk of operating cost overruns	1	5	11	13	0
Traffic fluctuation risk	0	0	3	6	21
Project handover risk	0	6	6	14	4
Project uniqueness risk	0	0	3	11	16
Risk of changes in market demand	4	4	12	6	4
Capital placement risk	0	0	5	13	12
Financing costs increase risk	1	2	12	11	3
Inflation risk	4	15	6	4	1
Insufficient risk of bidding competition	1	4	5	7	13
Contract risk	2	3	16	6	3
Risk of inadequate legal and regulatory systems	3	7	12	7	1
Risks of changes in laws and regulations	0	5	5	14	6
Government regulators adjust risk	4	13	4	9	0
There is the risk of homogeneous competition in project database review	1	3	4	7	15
Approval delay risk	5	4	13	5	3
The risk of expropriation and public ownership	0	0	2	5	23
Risk of excessive government intervention	0	4	12	7	7

3.3 Data processing

The above expert survey results may differ due to the different work experience and personal position of the expert group members, resulting in inconsistent score results. Such inconsistency of personal opinions makes it impossible to use risk matrix method to evaluate risk factors. Therefore, the fuzzy theory is used to classify the expert scores, and the risk probability and risk consequence severity survey table are processed. The specific method is as follows: r =z/Z, where r represents the evaluation index of degree, z represents the number of experts who identified the corresponding risk factor as the risk level, Z represents the total number of experts participating in the questionnaire survey (Z=30). The risk factors are represented by R, the occurrence probability of investment risk factors is represented by R_C, and the impact severity of investment risk factors is represented by R_S.

According to the expert evaluation and scoring results of the occurrence probability of risk factors in the above survey table, the membership matrix of the occurrence probability of 26 investment risk factors is obtained according to the fuzzy theory processing principle as follows:

$$R_C=\begin{pmatrix} R_C1 \\ R_C2 \\ R_C3 \\ R_C4 \\ R_C5 \\ R_C6 \\ R_C7 \\ R_C8 \\ R_C9 \\ R_C10 \\ R_C11 \\ R_C12 \\ R_C13 \\ R_C14 \\ R_C15 \\ R_C16 \\ R_C17 \\ R_C18 \\ R_C19 \\ R_C20 \\ R_C21 \\ R_C22 \\ R_C23 \\ R_C24 \\ R_C25 \\ R_C26 \end{pmatrix}=\begin{pmatrix} 0.467 & 0.1 & 0.067 & 0.267 & 0.1 \\ 0.533 & 0.133 & 0.2 & 0.067 & 0.067 \\ 0 & 0.1 & 0.133 & 0.267 & 0.5 \\ 0.4 & 0.333 & 0.267 & 0 & 0 \\ 0.1 & 0.267 & 0.2 & 0.233 & 0.2 \\ 0.167 & 0.533 & 0.267 & 0.033 & 0 \\ 0.067 & 0.333 & 0.4 & 0.2 & 0 \\ 0.367 & 0.267 & 0.167 & 0.1 & 0.1 \\ 0.1 & 0.333 & 0.367 & 0.2 & 0 \\ 0.067 & 0.2 & 0.133 & 0.5 & 0.1 \\ 0 & 0 & 0.067 & 0.333 & 0.6 \\ 0.467 & 0.1 & 0.333 & 0.1 & 0 \\ 0.1 & 0.1 & 0.2 & 0.533 & 0.067 \\ 0.033 & 0.167 & 0.333 & 0.267 & 0.2 \\ 0 & 0.1 & 0.2 & 0.467 & 0.233 \\ 0.2 & 0.5 & 0.133 & 0.133 & 0.033 \\ 0 & 0 & 0.067 & 0.233 & 0.7 \\ 0.567 & 0.167 & 0.167 & 0.1 & 0 \\ 0.2 & 0.4 & 0.267 & 0.1 & 0.033 \\ 0 & 0 & 0.067 & 0.6 & 0.333 \\ 0.067 & 0.2 & 0.4 & 0.267 & 0.067 \\ 0.2 & 0.267 & 0.433 & 0.1 & 0 \\ 0.7 & .133 & 0.1 & 0.067 & 0 \\ 0.067 & 0.1 & 0.267 & 0.5 & 0.067 \\ 0.767 & 0.233 & 0 & 0 & 0 \\ 0.2 & 0.1 & 0.4 & 0.167 & 0.133 \end{pmatrix}$$

According to the expert evaluation and scoring results of risk consequence severity in the above survey table, the membership matrix of 26 risk consequence severity degrees is obtained according to the fuzzy theory processing principle as follows:

$$R_S=\begin{pmatrix} R_S1 \\ R_S2 \\ R_S3 \\ R_S4 \\ R_S5 \\ R_S6 \\ R_S7 \\ R_S8 \\ R_S9 \\ R_S10 \\ R_S11 \\ R_S12 \\ R_S13 \\ R_S14 \\ R_S15 \\ R_S16 \\ R_S17 \\ R_S18 \\ R_S19 \\ R_S20 \\ R_S21 \\ R_S22 \\ R_S23 \\ R_S24 \\ R_S25 \\ R_S26 \end{pmatrix}=\begin{pmatrix} 0 & 0.133 & 0.267 & 0.533 & 0.067 \\ 0.067 & 0.233 & 0.4 & 0.267 & 0.033 \\ 0 & 0.067 & 0.367 & 0.5 & 0.067 \\ 0.033 & 0.2 & 0.233 & 0.367 & 0.167 \\ 0.2 & 0.6 & 0.1 & 0.1 & 0 \\ 0 & 0133 & 0.267 & 0.4 & 0.2 \\ 0.033 & 0.4 & 0.333 & 0.2 & 0.033 \\ 0.1 & 0.267 & 0.4 & 0.233 & 0 \\ 0 & 0.1 & 0.2 & 0.6 & 0.1 \\ 0.033 & 0.167 & 0.367 & 0.433 & 0 \\ 0 & 0 & 0.1 & 0.2 & 0.7 \\ 0 & 0.2 & 0.2 & 0.467 & 0.133 \\ 0 & 0 & 0.1 & 0.367 & 0.533 \\ 0.133 & 0.133 & 0.4 & 0.2 & 0.133 \\ 0 & 0 & 0.167 & 0.433 & 0.4 \\ 0.033 & 0.067 & 0.4 & 0.367 & 0.1 \\ 0.133 & 0.5 & 0.2 & 0.133 & 0.033 \\ 0.033 & 0.133 & 0.167 & 0.233 & 0.433 \\ 0.067 & 0.1 & 0.533 & 0.2 & 0.1 \\ 0.1 & 0.233 & 0.4 & 0.233 & 0.033 \\ 0 & 0.167 & 0.167 & 0.467 & 0.2 \\ 0.133 & 0.433 & 0.133 & 0.3 & 0 \\ 0.033 & 0.1 & 0.133 & 0.233 & 0.5 \\ 0.167 & 0.133 & 0.433 & 0.167 & 0.1 \\ 0 & 0 & 0.06 & 0.167 & 0.767 \\ 0 & 0.133 & 0.4 & 0.233 & 0.233 \end{pmatrix}$$

According to the membership matrix of the occurrence probability and severity of impact of 26 risk factors, the maximum membership principle is adopted to process the statistical results of fuzzy evaluation [14], and the rating table of the occurrence probability of risk factors and the severity of risk consequences of highway PPP projects can be obtained (Table 4).

Table 4. The result of fuzzy evaluation of probability of occurrence and severity of influence of risk factors.

Risk factor	Probability of occurrence	score	severity	score
Land acquisition risk	(20,40]	1	small	4
Project management risk	(40,60]	1	moderation	3
Engineering design change risk	(20,40]	5	small	4
Risk of adverse climatic and geological conditions	(60,80]	1	large	4

Supply risk	(20,40]	2	small	2
Project company breach of contract	(40,60]	2	moderation	4
Subcontractor default risk	(20,40]	3	small	2
Technical risk	(60,80]	1	large	3
The charge rate is unreasonable risk	(40,60]	3	moderation	4
Risk of operating cost overruns	(20,40]	4	small	4
Traffic fluctuation risk	(60,80]	5	Very large	5
Project handover risk	[0,20]	1	minimum	4
Project uniqueness risk	(20,40]	4	small	5
Risk of changes in market demand	(40,60]	3	moderation	3
Capital placement risk	(20,40]	4	small	4
Financing costs increase risk	(20,40]	2	small	3
Inflation risk	(40,60]	5	moderation	2
Insufficient risk of bidding competition	(20,40]	1	small	5
Contract risk	(20,40]	2	small	3
Risk of inadequate legal and regulatory systems	(40,60]	4	moderation	3
Risks of changes in laws and regulations	(40,60]	3	moderation	4
Government regulators adjust risk	[0,20]	3	minimum	2
There is the risk of homogeneous competition in project database review	(20,40]	1	small	5
Approval delay risk	(40,60]	4	moderation	3
The risk of expropriation and public ownership	(20,40]	1	small	5
Risk of excessive government intervention	(60,80]	3	large	3

Therefore, according to the risk matrix method, risk level is expressed as the product of the probability of occurrence of risk factors and the severity of impact. Because the risk level is represented by R, the occurrence probability of risk factors is represented by R_C, and the impact severity of risk factors is represented by R_S, the expression of risk level is as follows: $R=R_C \times R_S$[15]. The grade distribution table of risk factor matrix of highway PPP project can be obtained after calculation (Table 5).

Table 5. Grade distribution table of risk factor matrix of highway PPP project.

R_S \ R_C	[0,20]	(20,40]	(40,60]	(60,80]	(80,100]
minimum	1	2	3	4	5
small	2	4	6	8	10
moderation	3	6	9	12	15
large	4	8	12	16	20
Very large	5	10	15	20	25

25 is divided into 5 intervals and regarded as five risk levels, among which 1-5 is classified as first-level risk, 6-10 as second-level risk, 11-15 as third-level risk, 16-20 as fourth-level risk and 21-25 as fifth-level risk. The higher the risk level is, the more important it is. The evaluation results of the two dimensions of the above 26 risk factors are multiplied according to the evaluation method and corresponding according to the risk matrix evaluation table, and then the risk factor grade confirmation table of highway PPP project is obtained (Table 6).

Table 6. Identification table of risk factor levels for highway PPP projects.

Risk factor	R_C*R_S score	Risk level
Land acquisition risk	4	first-level risk
Project management risk	3	first-level risk
Engineering design change risk	20	fourth-level risk
Risk of adverse climatic and geological conditions	4	first-level risk
Supply risk	4	first-level risk
Project company breach of contract	8	second-level risk
Subcontractor default risk	6	second-level risk
Technical risk	3	first-level risk
The charge rate is unreasonable risk	12	third-level risk
Risk of operating cost overruns	16	fourth-level risk
Traffic fluctuation risk	25	fifth-level risk
Project handover risk	4	first-level risk
Project uniqueness risk	20	fourth-level risk
Risk of changes in market demand	9	second-level risk
Capital placement risk	16	fourth-level risk
Financing costs increase risk	6	second-level risk
Inflation risk	10	second-level risk
Insufficient risk of bidding competition	5	first-level risk
Contract risk	6	second-level risk
Risk of inadequate legal and regulatory systems	12	third-level risk
Risks of changes in laws and regulations	12	third-level risk
Government regulators adjust risk	6	second-level risk
There is the risk of homogeneous competition in project database review	5	first-level risk
Approval delay risk	12	third-level risk
The risk of expropriation and public ownership	5	first-level risk
Risk of excessive government intervention	9	second-level risk

According to the above risk assessment process, the 26 risk factors are sorted out into 5 risk levels (from low to high importance):

First-level risks: land acquisition risk, project management risk, adverse climate and geological conditions risk, supply risk, technical risk, project transfer risk, insufficient

bidding competition risk, homogeneous competition risk in project library review, expropriation, public ownership risk.

Secondary risks: project company default risk, subcontractor default risk, market demand change risk, financing cost increase risk, inflation risk, contract risk, government management department adjustment risk, government excessive intervention risk.

Three-level risks: unreasonable fee rate risk, imperfect legal and regulatory system risk, law and regulation change risk, slow approval risk.

Level 4 risks: engineering design change risk, operational cost overruns risk, project uniqueness risk, fund availability risk.

Level 5 risk: Traffic fluctuation risk.

4 Conclusion

The PPP model can effectively solve the problem of shortage of funds and accelerate the construction of "transportation power". However, compared with the traditional construction model, the PPP model faces many investment risk factors. Whether these risks can be effectively controlled is directly related to the success or failure of the project, and also directly affects the enthusiasm of social capital to participate in national infrastructure construction. After the above process of identifying and evaluating risk factors, relevant conclusions can be drawn:

First, for the 26 risk factors identified as land acquisition risk, project management risk and engineering design change risk in highway engineering PPP projects, we conducted comprehensive identification and analysis and found that the risk level of traffic volume fluctuation was the highest from the two dimensions of risk factor occurrence probability and impact degree. The risk of engineering design change, the risk of operating cost overruns, the risk of project uniqueness, and the risk of fund arrival are the second. The change of traffic volume is directly related to the profitability of the operation period, which has a great impact on social capital and is difficult to predict. Therefore, the accuracy of the feasibility study report, value for money evaluation report and financial affordability demonstration report in the early stage can determine the success or failure of the project in a certain sense. The other four level four risks show that the high-risk risks in the construction period of the project involve design changes and capital failure, and the risks in the operation period involve cost control failure and competition, which should be paid attention to in the process of the project.

Secondly, the income source of highway operation is relatively simple, but it belongs to infrastructure and has a certain nature of social services, so when determining the PPP model for a highway project, the project's traffic flow, charging standards and the balance between the two should be fully calculated. At the same time, in addition to tolls, the government can provide financial subsidies, interest and tax policies and other aspects of support should be fully considered.

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