Research on Risk Assessment of Expressway Project under PPP Mode

Shengyue Jiang¹, Yanmei wang²

¹Transportation Engineering College, Anhui Sanlian college, Hefei, Anhui Province, 230601, China

²Transportation Engineering College, Anhui Sanlian college, Hefei, Anhui Province, 230601, China

Abstract: On the basis of literature survey, this paper combines qualitative research with quantitative research to evaluate the influencing factors of expressway project risk under PPP mode. This paper starts from three parts: Firstly, starting from the current situation of expressway construction projects at home and abroad through the analysis of the advantages and disadvantages of PPP mode and three characteristics, the necessity and importance of project risk management under PPP mode are obtained. Secondly, the paper elaborates the risk of PPP project of expressway identifies the corresponding risk, and initially determines the three major factors affecting the risk of expressway project under PPP mode. Finally, according to expert judgment, the most critical factor is determined and a scientific, reasonable and effective risk factor evaluation index system is established. The index system includes three first-level indicators and six second-level indicators. On this basis, the judgment matrix is constructed by using the analytic hierarchy process, so as to form the influencing factor model. Finally, taking Fuling-Fengdu Expressway in Chongqing as an example, this paper uses the analytic hierarchy process (AHP) to carry out an empirical study on the model, in order to determine the importance of different risk factors.

1 Highway Profile

Chongqing fuling-fengdu expressway is an important part of chongqing expressway network, it belongs to the "ten arrows" part of the "three rings ten radiations three lines" skeleton highway network in "chongqing expressway network planning. Along the route of this project, there are chongqing, fuling, qingxi, nantou, zhanpu, fengdu and shuanglu. According to the highway two-way four-lane standard to build, a total of 46.5 km, the total investment is 4.179 billion yuan [1]. Figure 1 is the highway route map from fuling to fengdu [2].¹

Figure 1. The highway route map from fuling to fengdu.

2 Mode of Operation

2.1 Adopt BOT+EPC Mode

The public sector issues special admissible management authority to the private sector, while the private sector controls and contracts the project by using the general contracting mode during the specified construction period

Corresponding author's e-mail: 465493242@qq.com

of the project. Once the admissible period of the government expires, the management authority of the facility is in the hands of the government.

2.2 Project Implementation Program

The management of the project is in the hands of private organizations, which are allowed to collect administrative fees for a period of 30 years. Project financiers have the right to collect vehicle tolls and to manage within the jurisdiction of the high speed.

The government said: "The public sector will severely rectify the emergence of other management methods caused by poor construction." The Chongqing Municipal People's Government has promised to introduce corresponding convenience measures and substantive priority to ensure a smooth return of the profits of the contractor. The Chongqing Municipal Government agreed to provide policy support to the contractor, provide reputation guarantee for its financing, and ensure a good social environment during the construction of the project.

3 Case Analysis

3.1 Build a Hierarchy

According to a large number of literature and expert evaluation, using the analytic hierarchy process (ahp) concluded that target layer is the PPP mode of project risk evaluation, criterion layer from the construction risk, cooperation risk, environment risk, nature, society, the design and construction are obtained, such as cost, negotiation and cooperation risk index layer, construct of the highway of chongqing fuling to video class hierarchy, as shown in table 1.

Table 1. Risk hierarchy table of PPP projects

The target layer	Rule layer	Index layer
Risk assessment of PPP projects	Environmental risk	Natural risk
		Social risk
	Construction risk	Design and construction risks
		cost risk
	Cooperation risk	Negotiation Risk
		Cooperation risk

Define the factor indicator as set X , $X = (X_1, X_2, \dots, X_n)$. Therefore, the influential factor sets are as follows:

$X = \{X_1, X_2, X_3\}$, $X_1 = \{X_{11}, X_{12}\}$,
 $X_2 = \{X_{21}, X_{22}\}$, $X_3 = \{X_{31}, X_{32}\}$.

3.2 Specific Calculation Process

According to expert rating and 1-9 scale method [3], the weights are determined from three aspects of environmental risk, construction risk and cooperation risk, as shown in table 2, table 3, table 4, table 5, table 6 and table 7.

Table 2. 1~9 scaling

scale	meaning
1	I is as important as j
3	I is slightly more important than j
5	I is more important than j
7	I is much more important than j
9	I is absolutely more important than j
2、4、6、8	It is between the two adjacent judgment scales mentioned above
The bottom	If the importance ratio of I to j is λ , then the importance ratio of j to I is $1/\lambda$

Table 3. Judgment matrix

X	X_1	X_2	X_3
X_1	1	2/6	2/6
X_2	2/6	1	1
X_3	6/2	1	1

Table 4. Weight table

Rule layer	Environmental risk	Construction risk	Cooperation risk	Weight	Rank
Environmental risk	1	2/6	2/6	0.184	3
Construction risk	2/6	1	1	0.265	2
Cooperation risk	6/2	1	1	0.551	1
$\lambda_{\max} = 2.757$		$CR = -0.235$			

Table 5. Weight table

Index layer	Natural risk	Social risk	Weight W_1	Rank
Natural risk	1	7/5	0.556	1
Social risk	5/7	1	0.444	2
$\lambda_{\max} = 2.013$		$CR = 0$		

Table 6. Weight table

Index layer	Design and construction risks	Cost risk	Weight W_2	Rank
Design and construction risks	1	7/6	0.526	1
Cost risk	6/7	1	0.474	2
$\lambda_{\max} = 2.002$		$CR = 0$		

Table 7. Weight table

Index layer	Negotiation Risk	Cooperation risk	Weight W_3	Rank
Negotiation Risk	1	1/5	0.255	2
Cooperation risk	5	1	0.745	1
$\lambda_{\max} = 2.148$		$CR = 0$		

3.3 Total Hierarchical Ordering

For the target layer, the index $C_j[4]$ contained in the criterion layer B_i is calculated as follows:

$$W = W_{B_i} \times W_{C_j} \quad (1)$$

According to the weights W_1 , W_2 and W_3 , the following weight table is obtained, as shown in table 8.

Table 8. Weight table

$B_i \backslash C_j$	B_1	B_2	B_3
	0.184	0.265	0.551
C_1	0.556	0.526	0.255
C_2	0.444	0.474	0.745

The specific calculation process for table 1-8 is as follows:

Eigenvector:

$$W = W_{B_1} \times W_{C_1} = 0.184 \times 0.556 + 0.265 \times 0.526 + 0.551 \times 0.255 = 0.382$$

$$W = W_{B_2} \times W_{C_2} = 0.184 \times 0.444 + 0.265 \times 0.474 + 0.551 \times 0.745 = 0.618$$

Therefore, $W = (0.382, 0.618)^T$
(2)

Consistency check: Suppose that the consistency index of some factors in layer N to the J elements in layer $N-1$ is $CI_j^{(k)}$, and the average random consistency index is $RI_j^{(k)}$.

$$CR^{(k)} = \frac{\sum_{j=1}^{Nk} w_j^{(k-1)} CI_j^{(k)}}{\sum_{j=1}^{Nk} w_j^{(k-1)} RI_j^{(k)}} \quad (3)$$

When $CR^{(k)} \leq 0.10$, it shows that the results of the total ranking are consistent[5]. From the above weight table, we can see that $CI_1 = 0.013$, $CI_2 = 0.018$, $RI_1 = 0$, $RI_2 = 0$, because the judgment matrix with the order less than or equal to 2 has complete consistency, so there is no need for consistency test[6], therefore,

$$CR = \frac{0.382 \times 0.013 + 0.618 \times 0.002}{0.382 \times 0 + 0.618 \times 0} = 0 \leq 0.10 \quad (4)$$

So, the judgment matrix has the whole consistency.

3.4 Evaluation Results

Therefore, it can be known from the above calculation that the consistency of all judgment matrices has passed the test, and the single-level ranking result is the overall ranking result. The specific analysis results are as follows:

Among the influencing factors of expressway risk projects under PPP mode, the proportion of cooperation risk is the highest, followed by construction risk, and the proportion of environmental risk is the lowest.

Among environmental risk factors, the proportion of natural environment and social environment is equal, so it is the main influencing factor for chongqing fuling-

fengdu expressway project. During the construction of the project, it is necessary to make early preparation, take preventive and remediation measures against uncontrollable factors such as topography, geology and weather, timely communicate with the government, and implement land expropriation and demolition and related policies.

In the construction risk, the weight of design is equal to that of construction risk and cost risk, so it is also an important influencing factor. In the whole process of project construction, design, construction and other processes should be strictly controlled to prevent or prevent the occurrence of risk factors as early as possible, so as not to cause unnecessary losses.

The proportion of credit risk is relatively large and the negotiation risk is relatively low, which indicates that during the cooperation period of this project, the government should prevent the contractor from exaggerating its own strength in order to obtain the right of management. At the same time, the chongqing government also needs to keep its promise to avoid losing credibility with the public, so the policies should be timely made public and reviewed by the public.

4 Epilogue

On the basis of consulting a large number of documents and case studies, this article starts with the relevant theory of PPP model, expounds the basic steps of project risk management, and makes a preliminary identification of the risks of expressway projects under PPP model, using Chongqing Fuling to Fengdu Expressway As an example, the main risk factors of the project were obtained through the establishment of a model and analysis, and the study of risk management analysis was conducted, and the following conclusions were obtained:

Based on the principle of holism and omnibearing, based on the basic theory of the PPP model, the analysis of the highway project under this model shows that the hidden risk factors in the project are very complicated. According to the different degrees of project risk sources, project risks are classified into systematic risks and non-systematic risks. Systemic risks include political risks, financing risks and force majeure risks; non-systemic risks include construction risks and cooperation risks.

Taking Fuling Fengdu Expressway in Chongqing as an example, it can be seen that cooperation risk is the main risk of the project, followed by construction risk, and the weight value of environmental risk is the least. According to the inspection, the direction that the project should be strictly controlled in the construction process is defined, that is, the government and all parties involved should abide by their commitments and jointly undertake the possible problems during the construction of the project.

This study not only verifies the practicability and scientificity of AHP, but also judges the risk factors that may exist in the process of expressway construction, providing scientific guidance for the construction of Expressway under PPP project in China, and provides a new idea and optimal design for scientific risk sharing.

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