Research on "PPP+ABS" Management Model of Infrastructure Project Based on AHP and Entropy Method

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Abstract. Infrastructure construction projects as an important part of social development, have effectively ensured the healthy development of society and promoted the improvement of the national economic level. In the context of the continuous innovation of the government’s investment and financing system, in order to optimize the construction of infrastructure projects, this paper creates a risk management evaluation model for infrastructure construction projects based on the “PPP+ABS” model, which is of great significance for promoting our country's infrastructure construction projects to find financing methods that suit their own development.

1. Introduction

A series of operational difficulties have emerged in the practice of PPP engineering projects recently. The most prominent problem is the difficulty of financing. For example, the financing channels are not smooth and financing costs are high. Funds are an important foundation for the construction and operation of PPP projects. The most important thing is to broaden the financing channels and solve the financing problems of PPP projects.\(^{[1]}\) Asset securitization of PPP projects is essentially the use of the capital market to improve asset liquidity and solve the dilemma that PPP project participants “can come in but cannot exit”.\(^{[2]}\) This paper combines the characteristics of PPP projects and asset securitization, uses analytic hierarchy process and entropy method to comprehensively determine the weights, and builds a set of quantifiable asset securitization risk evaluation system specifically for PPP projects, which is useful for promoting asset securitization of PPP projects.

2. Literature Review

Some scholars have conducted research from the perspective of PPP project pricing. Xiaosu Ye used a multi-objective programming method to find the optimal solution for the price of PPP project products and services, and proposed that too high or too low pricing is not conducive to the development of the project.\(^{[3]}\) Daming You used cash flow model and capital asset pricing model as theoretical support, comprehensively considers many influencing factors such as project cost, investment income, risk sharing, consumer benefits and government subsidies, finally established the intercity rail transit PPP project pricing model.\(^{[4]}\) Some scholars analyzed from the perspective of government compensation for PPP projects. Shan Zhang proposed that the government payment mechanism should determine the market feasibility of facilities or services, set the maximum and minimum usage, set up objective performance evaluation standards and monitoring mechanisms, and establish a government-paid price adjustment mechanism based on relevant economic coefficients or data.\(^{[5]}\) In addition, some scholars are concerned about the risks of the PPP project itself. Lin Li...
established a bargaining game model for PPP project risk allocation under complete and incomplete information conditions from the perspective of the asymmetry of the status of project participants. He believes that under the condition of complete information, the share of risk transferred from the public sector to the private sector is greater.\cite{6}

Based on the above literature analysis, it can be known that the academic circles have paid attention to the risks of PPP projects, but the existing literature mostly focuses on the qualitative analysis of risks in the process of asset securitization of PPP projects, but few scholars have conducted quantitative analysis on the risks of asset securitization.

3. Construction of Risk Evaluation Index System in Asset Securitization of PPP Projects

3.1. Selection of Risk Evaluation Index

Based on the characteristics of PPP projects and asset securitization, this paper uses literature analysis to screen and identify various risk factors, and obtain the following five types of risks as shown in table 1.

| Serial number | First-level index       | Secondary index                                   |
|---------------|-------------------------|---------------------------------------------------|
| 1             | Environmental risk \cite{7} | Local GDP growth rate                             |
|               |                         | Proportion of the tertiary industry               |
| 2             | Completion risk \cite{8}   | Unfinished risk                                   |
|               |                         | Delayed completion                                |
|               |                         | Unqualified quality after completion              |
| 3             | Credit risk \cite{7}      | Promoter debt ratio                               |
|               |                         | General budget revenue of government              |
|               |                         | Local government deficit rate                     |
| 4             | Technology risk \cite{7}   | Credit enhancement                                |
|               |                         | Product pricing risk                              |
| 5             | Operational risk \cite{7}  | Project operating hours                           |
|               |                         | Bankruptcy isolation effect                       |

3.2. Data collection

This article uses a questionnaire survey method to collect research data. Use the Likert scale to score these 11 secondary indicators, and set the scoring range from 1 to 5. 1 indicates that this type of risk is low, and 5 indicates that this type of risk is high. A total of 201 questionnaires were issued in this survey, and 179 valid questionnaires were recovered. The valid questionnaire rate reached 89.05%, which met the needs of this research. By collecting the questionnaires and sorting out the data, the probability of occurrence of the above five risk indicators is evaluated.

4. Construction of Risk Evaluation Model for Asset Securitization of PPP Project

Based on the survey data, the AHP-entropy method is used to calculate the comprehensive weight of each risk factor. The comprehensive weight is based on the subjective weight calculated by the analytic hierarchy process, and then the objective weight is calculated by the difference coefficient of the entropy method, and the optimized weight combination is obtained.

4.1. Subjective weight calculation based on analytic hierarchy process

This study uses YAAHP software to build a PPP project asset securitization risk evaluation model, and conducts matrix consistency test and data analysis.

Taking credit risk as an example, relevant professionals score the importance of the indicator factor set to obtain the judgment matrix of all levels of indicators, calculate the eigenvalue and maximum value of the judgment matrix, and perform the consistency test of the single-level ranking. After calculation, the calculation results of the weight coefficients of each secondary risk factor are shown in the table 2.
Table 2. Calculation results of the weights of secondary index factors in credit risk.

| Credit risk | Promoter debt ratio | General budget revenue of government | Local government deficit rate | Wi  |
|-------------|----------------------|-------------------------------------|-----------------------------|-----|
| Promoter debt ratio | 1.0000 | 2.0000 | 0.5000 | 0.2970 |
| General budget revenue of government | 0.5000 | 1.0000 | 0.3333 | 0.1634 |
| Local government deficit rate | 2.0000 | 3.0000 | 1.0000 | 0.5396 |

According to the calculation result, λ_{max} (the maximum eigenvalue of the judgment matrix) is 3.0092, and the consistency ratio is 0.0088<0.1, which meets the consistency detection.

The final calculation of the judgment matrix and weight of each first-level indicator is shown in the table 3. According to the calculation result, λ_{max} (the maximum eigenvalue of the judgment matrix) is 5.2813, and the consistency ratio is 0.0628<0.1, which meets the consistency detection.

Table 3. The calculation results of the weights of various first-level indicator factors.

| Risk assessment | Completion risk | Credit risk | Technology risk | Environmental risk | Operational risk | Wi  |
|-----------------|-----------------|-------------|-----------------|-------------------|------------------|-----|
| Completion risk | 1.0000          | 1.0000      | 3.0000          | 2.0000            | 3.0000           | 0.2826 |
| Credit risk     | 1.0000          | 1.0000      | 6.0000          | 4.0000            | 5.0000           | 0.4200 |
| Technology risk | 0.3333          | 0.1667      | 1.0000          | 2.0000            | 3.0000           | 0.1310 |
| Environmental risk | 0.5000 | 0.2500 | 0.5000 | 1.0000 | 2.0000 | 0.1026 |
| Operational risk | 0.3333          | 0.2000      | 0.3333          | 0.5000            | 1.0000           | 0.0638 |

4.2. Calculation of objective weight based on entropy method

The implementation steps are as follows:

1. Standardization of raw data

\[ \frac{X_{ij}'}{X_{ij}} = \frac{X_{ij} - \min_{j} \{X_{ij}\}}{\max_{j} \{X_{ij}\} - \min_{j} \{X_{ij}\}} \quad (1) \]

2. Normalization processing

\[ P_{ij} = \frac{Z_{ij}}{\sum_{j=1}^{m} Z_{ij}} \quad (2) \]

\( n \) is the number of first-level evaluation indexes, and \( m \) is the number of second-level evaluation indexes.

3. Calculate the entropy value \( e_{j} \) of the jth index under the secondary index

\[ e_{j} = -k \sum_{j=1}^{n} P_{ij} \ln(P_{ij}) \quad (3) \]

\( k = 1/\ln(n), e_{j} \geq 0 \)

4. Calculate the difference coefficient \( g_{j} \)

\[ g_{j} = 1 - e_{j} (j = 1, 2, 3, \cdots, m) \quad (4) \]

5. Obtain the difference coefficient set \( W_{j} \)

\[ W_{j} \]
W_j=(g_1, g_2, g_3, ..., g_j)=\{0.064, 0.072, 0.088, 0.102, 0.085, 0.073, 0.061, 0.132, 0.125, 0.068, 0.052, 0.078\}

4.3. Determination of comprehensive weight of risk indicators

In order to make up for the lack of subjectivity of the analytic hierarchy process, this paper calculates the objective weight based on the difference coefficient of the entropy method, and finally calculates the comprehensive weight.

(1) Adjust the weight
\[ W_p = W_p \times \omega_i = [\omega_{i1}, \omega_{i2}, \omega_{i3}, ..., \omega_{im}] \]  

(2) Normalization processing
\[ W_1 = \frac{W_p}{\sum_{p=1}^{m} W_p} = \{0.012, 0.024, 0.014, 0.104, 0.042, 0.134, 0.115, 0.106, 0.174, 0.068, 0.104, 0.103\} \]

(3) Calculate the comprehensive weight
\[ W = p_1 \omega_i + p_2 W_1 \]

\[ P_1 = \frac{\left( \sum_{j=1}^{m} \omega_j \right)^2}{\sqrt{\left( \sum_{j=1}^{m} \omega_j \right)^2 + \left( \sum_{j=1}^{m} W_j \right)^2}} \]

\[ P_2 = \frac{\left( \sum_{j=1}^{m} W_j \right)^2}{\sqrt{\left( \sum_{j=1}^{m} \omega_j \right)^2 + \left( \sum_{j=1}^{m} W_j \right)^2}} \]

Calculated that \( P_1 = 0.996, P_2 = 0.004 \)

According to the above calculation results, the comprehensive weight of each risk indicator in the process of PPP project asset securitization is obtained, as shown in the table 4.

| Serial number | First-level index       | Secondary indicators                                | Comprehensive weight |
|---------------|-------------------------|-----------------------------------------------------|---------------------|
| 1             | Environmental risk      | Local GDP growth rate                               | 0.682               |
|               |                         | Proportion of the tertiary industry                 | 0.318               |
| 2             | Completion risk         | Unfinished risk                                     | 0.423               |
|               |                         | Delayed completion                                  | 0.216               |
|               |                         | Unqualified quality after completion                | 0.361               |
| 3             | Credit risk             | Promoter debt ratio                                 | 0.268               |
|               |                         | General budget revenue of government                | 0.433               |
|               |                         | Local government deficit rate                       | 0.299               |
| 4             | Technology risk         | Credit enhancement                                  | 0.432               |
|               |                         | Product pricing risk                                | 0.568               |
| 5             | Operational risk        | Project operating hours                             | 0.322               |
|               |                         | Bankruptcy isolation effect                         | 0.678               |

5. Conclusion

This paper constructs a risk evaluation system with the characteristics of PPP project securitization through the application of analytic hierarchy process and entropy method. The PPP asset securitization
risk evaluation system constructed by this method is highly operable, and the selected indicators are also representative. Therefore, when evaluating and preventing PPP asset securitization risks, various indicators and weights of the PPP asset securitization risk evaluation system can be used as a reference, which is of great significance to the smooth implementation of PPP project asset securitization.

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