

# Research on Risk Allocation Model in PPP Projects Based on Stakeholder Network

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**Abstract.** The PPP project involves more stakeholders. Reasonable risk allocation in PPP projects is important for project performance management, which is a critical driving factor satisfying value for money. This paper aims first to identify involved stakeholders and multiple relationships and then to build a stakeholder network. Based on stakeholder network, this paper develops fuzzy analytical hierarchy process (FAHP) models for modelling risk allocation decision-making process in Public-Private Partnership projects.

## 1. Introduction

Infrastructure is one of the most active markets for PPP in China with higher capital consumption. Public-Private-Partnerships (PPP) model is a long-term cooperation relation established in infrastructure and public service sectors. Risk transfer is one of the biggest driving forces for VFM [1]. The main stakeholders involved in the PPP project is government, private capital, financing party, contractor, raw material supplier, professional operator, insurance company and professional organization. Market stakeholders are concerned that the optimal risk allocation should be assigned to the most appropriate party, not being followed [2]. The existing literature shows that the public sector and the private sector do not share a set of benefits, objectives and expectations [3]. Some empirical studies confirm that different partners' perceptions of risk, the motivations and behavior of rival partners in the risk allocation negotiations have produced significant complexity, which will undermine the success of the PPP project [4]. The uncertainty of the role of each potential risk source, in particular the private sector, how attractive risk factors affect the attractiveness of a particular project investment, and how public sector perceive risk [5].

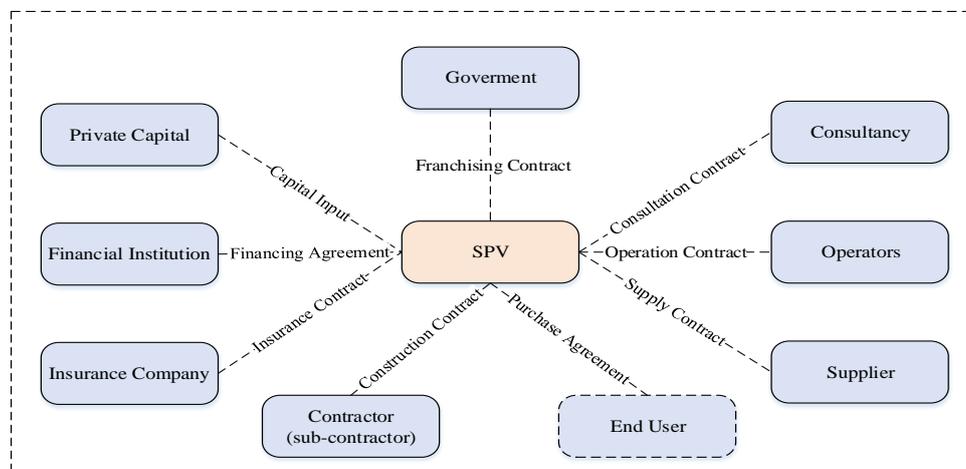
## 2. The Construction of Stakeholder Network

Based on the research on the project stakeholders' identification, this paper uses the statistical analysis of the literature to summarize the PPP project stakeholders in China [7]. Project is a work with phased features. At different stages of the project, not only the attributes and characteristics of the project will change, the subject of the project will also play a different role with different skills [8]. This paper divides the whole process of PPP project into three stages: project decision stage, construction stage and operation stage. This article eventually obtained 13 categories of PPP project key stakeholders shown in table1.

**Table 1. Identification of key stakeholders in PPP projects**

Number	Stakeholder	Relationship with PPP project	Participation stage
1	Local Government	Provide concessions for the project company, and ultimately may own a project	Full-life cycle
2	Private Investor	Major shareholders of the project company	Full-life cycle
3	Government Implementing Agency	Project planning, approval and full life cycle supervision	Full-life cycle
4	Project Company	Project construction and operation unit	Construction stage and Operation stage
5	Banking and Financial Institutions	Project creditor	Construction stage and Operation stage
6	Contractor	Direct construction implementer	Construction stage
7	Operator	Provide operational services	Operation stage
8	Supplier	Provide production factor	Construction stage and Operation stage
9	Prospecting and design unit	Project design and technology transformation	Decision stage and Construction stage
10	Consultancy	Give advice and guide project decision	Decision stage and Construction stage
11	End User	Project direct users	Operation stage
12	Public	The project may have an impact on the public's production and life	Full-life cycle
13	Insurance Company	Provide insurance for the project and project company	Construction stage and Operation stage

Project stakeholders act as a link to encourage and constrain behavior, and contractual relationship constitutes the institutional basis of project governance. Based on the identification in table 1, this paper constructs the key stakeholder network in PPP project management according to the contract relation, so as to analyze the structural characteristics of each stakeholder in the project process, as shown in Fig 1.



**Fig. 1 Key Stakeholder Network in PPP Project**

### 3. The Improved Method on Risk Allocation

#### 3.1 Index system construction

There are many factors and principles affecting the risk allocation based on the stakeholder network. Combined with the factors and principles affecting the risk allocation, this paper builds a two-level risk allocation evaluation index system in Fig 2.

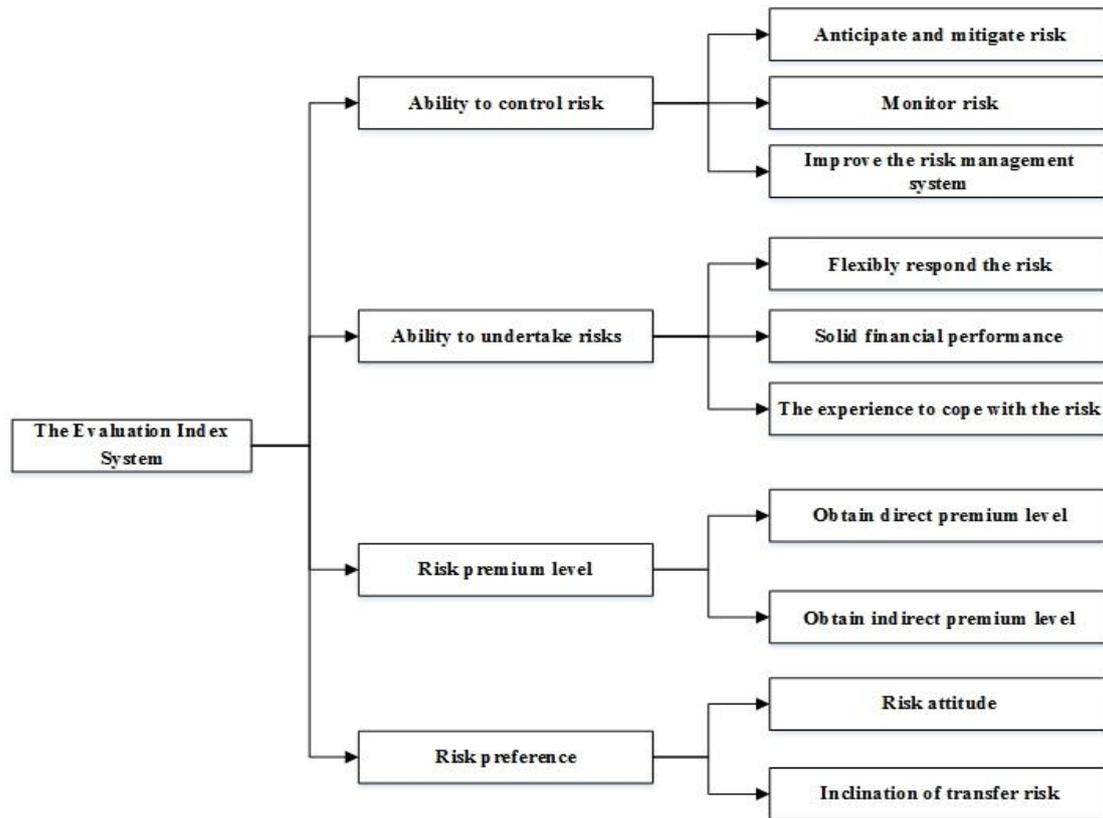


Fig. 2 The Evaluation Index System

### 3.2 The determination of risk allocation ratio under each indicator

In order to avoid the subjectivity of the results, this section introduces the method of calculating the weight of the analytic hierarchy process to determine the proportion of risk allocation under each index.

Construct a comparison matrix

Table 2 Comparison matrix under the second-level indexes

Second-level index $I_{ij}$	Stakeholder $S_1$	Stakeholder $S_2$	...	Stakeholder $S_n$
Stakeholder $S_1$	1	$a_{12}$	...	$a_{1n}$
Stakeholder $S_2$	$1 / a_{12}$	1	...	$a_{2n}$
...	...	...	1	...
Stakeholder $S_n$	$1 / a_{1n}$	$1 / a_{2n}$	...	1

Calculate the allocation ratio matrix of each stakeholder

$$p_i = \frac{\sum_{j=1}^n \frac{r_{ij}}{\sum_{i=1}^n r_{ij}}}{\sum_{i=1}^n \sum_{j=1}^n \frac{r_{ij}}{\sum_{i=1}^n r_{ij}}} \quad (i = 1, 2, 3, \dots, n, j = 1, 2, 3, \dots, n) \quad P_i = [p_1, p_2, p_3, \dots, p_n] \quad (i = 1, 2, 3, \dots, n)$$

Consistency check

Calculate the consistency index  $CI = (\lambda_{max} - n) / (n - 1)$ .  $\lambda_{max}$  is the maximum eigenvalue. Calculate the consistency ratio  $CR = CI / RI$ . If  $CR < 0.1$ , the calculated results will be valid. Otherwise, it need to be recalculated.

Calculate the comprehensive result

$$P = [P_1^T, P_2^T, \dots, P_m^T]_{n \times m}$$

### 3.3 Calculate the weight of the indicator

Considering the subjectivity of expert evaluation system, this paper adopts the analytic hierarchy process (AHP) to determine the subjective weight matrix  $W_1 = [W_{11}, W_{12} \dots W_{1m}]$ .

Table 3. The evaluation of index weight

	Index I <sub>1</sub>	Index I <sub>2</sub>	...	Index I <sub>m</sub>
Index I <sub>1</sub>	1	r <sub>12</sub>	...	r <sub>1m</sub>
Index I <sub>2</sub>	1 / r <sub>12</sub>	1	...	r <sub>2m</sub>
...	...	...	1	...
Index I <sub>m</sub>	1 / r <sub>1m</sub>	1 / r <sub>2m</sub>	...	1

### 3.4 Calculate the risk-allocation ratio of each stakeholder

Combine the above model steps, the risk-allocation ratio matrix of each stakeholder  $S = P \bullet W^T = [S_1, S_2, \dots, S_n]$

## 4. Conclusion

Risk allocation is the key factor to ensure the success of infrastructure PPP projects, this paper explores the complex stakeholder network to reveal the complex game relation between stakeholders and the relations mechanism. In addition, this paper builds the allocation model based on fuzzy comprehensive evaluation and analytic hierarchy process, which can lead to theoretical innovation about risk control technology and a better understanding of the dynamic risk management in PPP projects. It is also expected that the research can generate practical implications and a decision support tool to implement risk control analysis under the stakeholder network in PPP projects. Due to the lack of empirical data, this paper has not yet validated the applicability of the model, nor does it construct dynamic model combining the changes in the life cycle of the PPP project, which will be reflected in the further research.

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