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Research Article

Risk Assessment of Urban Rail Transit Project Using Interpretative Structural Modelling: Evidence from China

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Public-private partnership (PPP) projects require comprehensive risk assessment and management, including Urban Rail Transit (URT). A more effective risk management can benefit from an accurate understanding of the two-way influence of PPP project risk factors. This paper uses the content analysis method to filter out, compare, and analyze PPP-related literature; 12 categories of 22 PPP risk factors are extracted and identified, and the possible correlations between these risk factors are judged preliminarily. With the knowledge and advice provided by PPP experts, the initial risk relationships are adjusted and supplemented, which then help to determine a reasonable logical relationship among risk factors. The logical relationship helps analyze the risk factors based on the ISM model analysis method and builds a hierarchical structure relationship of risk factors including 6 levels. Finally, the direct, intermediate, and autonomous factors that lead to problems or failures in PPP projects are analyzed which explains in detail the paths of risk transmission and risk prevention measures of PPP companies operating URT. It lays a foundation for PPP project companies operating URT to recognize, manage, and control risks in a targeted and systematic manner.

1. Introduction

Public-private partnership (PPP) mechanism is a long-term arrangement where a number of risks are transferred to the private sector, for which they are financially compensated [1]. According to Ahadzi and Bowles [2], the data indicate that 98% of government projects have had overruns in their precontract time estimates ranging from 11 to 166% and there were equally substantial overruns on the advisory and bidding costs, ranging from 25 to 200%. In contrast, PPP model enables a win-win situation for all stakeholders as work is conducted under government guidance, while operations are market driven, and cooperation is voluntary. Owing to government agencies' lack of resources and expertise to undertake infrastructure development projects requiring significant capital outlay, private involvement in public projects not only helps the government reduce its financial pressure, but also improve the efficiency of public service delivery. Therefore, the PPP model is widely used in public service construction fields such as transportation, education, health, garbage disposal, etc.

With continuous economic vitality and upgrading of life quality, the number of URT projects has tremendously grown in China's first-tier cities since the 2000 s. As private capital for developing URT enterprises, they have obtained unprecedented opportunities for participating in PPP projects. However, these projects require large amounts of money, including the initial construction cost and the operation and maintenance cost. Compared with traditional projects that need to focus only on the construction process, URT enterprises encounter more challenges and risks.

There have been several studies on risks involved in PPP projects, including URT projects. To identify and classify the risks, several scholars [3–7] have summarized the risk elements of PPP projects by studying cases of problems or failures in PPP projects. Some scholars [8–10] studied the risk factors of PPP projects through brainstorming, literature review, or Delphi technique. However, these methods

cannot generate an organized, inductive, and deductive list of risks and fail to make risk decisions possible on the basis of efficient and effective management of the risks involved.

With mass of participation and the long concession period commonly associated with PPP arrangement, analysis of the inherited complex and varied risks is indispensable. Ren [11] classified the basic patterns of relationship as independence, dependence, parallel, and series by using physics view; Valipour et al. [12] prioritize significant risks in PPP projects applying a fuzzy analytic network process (FANP) method for overcoming the problems of interdependencies and feedback among different risk-ranking alternatives. Wang and Zhang [13] and Xie and Thomas Ng [14] use the Bayesian network techniques to explore the risk relationship of PPP projects by forecasting risk occurrence probability. However, the shortcoming of these studies is that they did not probe into research on the hierarchical relationship and the transmission path between different risks, and, therefore, lack the overall understanding of the risk network.

Interpretive Structural Model (ISM) is a commonly used method in system engineering research for identifying relationships among specific items. Because of the increasing complexities, there always are different factors responsible for failure of a project. However, compared to considering an individual factor in isolation, it is more accurate to interpret an issue by considering the direct and indirect relationships between different factors. The ISM model decomposes the complex system and transforms the disordered one-to-one structure into an intuitive relational structure model by using the incidence matrix principle, so as to better analyze the interactions of the overall system [15]. There are many risk factors responsible for failure of PPP projects, and their interactions and common influence exist throughout the stages of financing, construction, and operation. Consequently, the objective of this study is to provide an ordered, directional framework for the various aspects of risks of URT projects and give decision makers a realistic picture of the situation and the risks involved.

The rest of this paper is organized as follows. The next section identifies risk elements of the URT projects, based on literature analysis and expert interviews. Section 3 establishes a contextual relationship between risk elements. Section 4 introduces the method of ISM model to analyze the hierarchical relationship and transmission path between risk factors. Section 5 analyzes the direct, intermediate factors and autonomous factors that lead to problems or failures in PPP projects. Section 6 explains the transmission path of risks and comes up with the risk prevention measures for PPP companies in URT. Conclusions end the paper.

2. Identification of Risks in China's URT Projects through PPP Approach

This article first carries out a literature review to compare and analyze the relevant documents [7, 8, 10, 11, 16–19]. The literature theory is relatively mature, and the conclusions explained in published literature have many common points, which provides a good foundation for the research of this article.

Subsequently, according to the probability of occurrence and the magnitude of the loss, 7 experts with experience in implementing PPP projects of URT, selected from government, social organizations, and enterprises, ranked the results of the abovementioned literature risk identification. Finally, 4 categories and 20 key risk factors that lead to PPP project failure or problems are selected and extracted, forming a risk factor system (Table 1).

3. Materials and Methods

3.1. Establishment and Realization of ISM

3.1.1. Step 1: Relationship Confirmation. The ISM system analysis method requires a direct influence relationship between any two risk factors which constitutes the input for the analysis. Determining whether there is an impact relationship between the two risk factors of URT project with PPP arrangement can be divided into two steps. First, the relationship can be identified by common sense. Afterwards, in order to obtain a more reasonable and accurate risk relationship, experts with professional knowledge and practical experience are required to determine whether there is an influencing relationship. It can also be judged by referring to related research results and related theories in the existing literature.

3.1.2. Step 2: Building of Adjacency Matrix. The second step is to establish an adjacency matrix, which is essentially a Boolean matrix, in which the value of a_{ij} or a_{ji} is 0 or 1; that is,

If the risk factor in row i has a direct effect on the risk factor in column j, the value of a_{ij} is 1; if the factor in column j has a direct effect on the factor in row i, the value of a_{ji} is 1.

If the factor in row i has no direct effect on the factor in column j, the value of a_{ij} is 0; if the factor in column j has no direct effect on the factor in row i, the value of a_{ji} is 0.

The diagonal factors are all 0, indicating that the variable has no direct influence on the variable itself.

3.1.3. Step 3: Building of Reachability Matrix. The reachable matrix indicates whether there is at least one chain between any two variables. The specific mathematical algorithm is as follows:

Let A = adjacency matrix (we obtained in Step 2).

Let I = identity matrix (as the same matrix order as A).

The final reachability matrix (M) needs to satisfy $M = (A + I)^{n-1} = (A + I)^n$ ($n > 1$ and is an integer; use Boolean calculation).

In this paper, we use software MATLAB 8 to calculate the reachability matrix M, which is given in Figure 1.

Table 1: Risk factors interpretation.

Risk groups	Types of risks	Factor interpretation	Literature source
Political	R_1: nonreliability and creditworthiness of public agencies	Government deprivation of the rights of the URT project implementer, including unilateral termination of the existing agreement, expropriation or nationalization of the project assets.	[2, 3, 8, 10]
	R_2: mistaken or long-winded public decision-making process	A URT project cannot be implemented as planned due to the government's inefficient willingness, policy violations, and excessive guarantees.	[2–4, 6, 9]
Private	R_3: opportunism risk of private agencies	A URT project company does not perform the contractually agreed or nonagreed responsibilities and obligations because of its own economic interests and brings risks to the project.	[10]
Legal and contractual	R_4: immaturity in government policies, laws, and regulations	The implementation of URT project encounters institutional obstacles due to immature government policies, laws, or regulations.	[1–5, 7–10]
Financial and economical	R_5: inflation	Inflation may greatly increase wages and prices, which will cause an unpredictable increase in costs of the URT project.	[1, 2, 4–10]
	R_6: interest rate fluctuation	Unpredictable fluctuations in interest rates of the central bank affect the income of all parties involved in URT projects, which affects the financing costs.	[1, 2, 4, 5, 9, 10]
	R_7: irrational financing structure risk	Different financing structures have different project debt levels. If the financing plan is improper, it will cause capital to cut off, which will seriously lead to overall failure of the project.	[9]
	R_8: unavailability of funds	The ability of a company to finance URT projects depends on availability of funds, and this too is a function of time, interest rate, and risk factors, among others. Factors such as these can lead to limited fund availability, necessitating capital rationing.	[2, 3, 5–7, 10]
	R_9: high-cost financing risk	An ill-managed URT company cannot maintain normal operations due to capital shortage. When a vicious circle takes shape, banks and shareholders gradually lose confidence in the company, and it becomes difficult for the company to obtain financial support, which further intensifies the degree of capital tension.	[2, 3, 5–10]
	R_{10}: shortage of market returns	Operating income of a URT is often not enough to make up for the cost, resulting in losses for the project company.	[2, 3, 5, 7]
Social	R_{11}: public opposition	A URT project is a complex municipal infrastructural venture with many stops and long lines. The construction and operation process inevitably has an impact on urban residents, competitors, and environment.	[2, 3, 8, 10]
	R_{12}: land acquisition and compensation problem	Before construction of the URT project, government departments lead the process of land acquisition in accordance with the planning scheme. In this process, government departments often have disputes over various interests of the related parties.	[1, 2, 7, 10]
Design	R_{13}: design deficiency	Some potential defects may occur due to the lack of comprehensive consideration in the initial design. Such defects can lead to inconvenience and even unreasonable accidents.	[1, 2, 4, 6, 9, 10]
Construction	R_{14}: construction cost overrun	Actual construction cost of the URT project is often higher than the budgeted price due to construction delays, design changes, rising labor or material prices, etc.	[1, 2, 4, 7–10]
	R_{15}: completion risk	Risk of failing to complete the URT project schedule as planned.	[1, 2, 6, 8–10]
	R_{16}: insolvency/default of subcontractor or suppliers	The subcontractor selected by the project company is unable or unwilling to perform the contractual duties.	[2, 4–6],
	R_{17}: labor risk/industrial relation risk	Disputes arising from enforcement of the laws, regulations or contract of the labor.	[2, 4–6, 10]

Table 1: Continued.

Risk groups	Types of risks	Factor interpretation	Literature source
Operation	R_{18}: demand/usage risk	Whether the output of the URT project can be successfully transformed into cash inflow through market consumption is fundamentally determined by market demand. The project decision-making needs to be based on scientific market forecasts and a cautious attitude; otherwise, the PPP project of URT operation may fall into difficulties.	[2, 4, 5, 7–10]
Relationship	R_{19}: lack of coordination between stakeholders	There may be a rift between stakeholders, resulting in them not performing or refusing to perform their responsibilities.	[3, 5, 7, 9]
Force majeure	R_{20}: force majeure	Such as war, terrorism, lightning, earthquake, hurricane, flood, typhoon, geological changes, etc.	[1, 2, 4–10]
Uniqueness	R_{21}: uniqueness risk	Only when the URT project can obtain stable income can it attract social investors to actively participate in construction of the project. If there is a competitive project, the actual demand for the URT project will inevitably decrease, thus threatening the life of the project.	[2, 8]
Environmental	R_{22}: environmental risk	Project construction brings environmental pollution risks, such as noise pollution, air pollution, water pollution, or solid waste pollution. These pollutions directly affect the normal life of surrounding residents and endanger people's health.	[1–5]

Note. [1] Phang, 2007; [2] Li and Zou, 2008; [3] Song et al., 2013; [4] Wang et al., 2004; [5] Li and Tiong, 1999; [6] Ghosh and Jintanapakanont, 2004; [7] Valipour et al., 2005; [8] Lina, 2016; [9] Carbonara et al., 2015; and [10] Shrestha et al., 2017.

3.1.4. Step 4: Level Partitions. Level partitions are to divide the relationships between all factors into reachable and unreachable matrices and then divide the system into several parts. Reachability sets and antecedent sets can be derived from the reachability matrix we got above. The reachability set, denoted as $R(R_i)$, contains the factor itself and other factors that it may impact, whereas the antecedent set, denoted as $A(R_i)$, contains the factor itself and the other factors that may impact it. Afterwards, the common set (intersection of these sets), denoted as $R(R_i) \cap A(R_i)$, is derived for levels of different factors.

For a system with a multilevel system structure, factors at the highest level cannot reach a higher level, which means they will not lead the other factors. In this way, for the highest-level elements, the intersection set should be exactly the same as the reachable set. Once the highest factors are identified, they should no longer be considered. By repeating the same process, each element can be divided level by level until the level of each factor is found. These levels help build the diagraph and the ISM model. If $L_1, L_2, ..., L_k$ are used to represent the level from top to bottom in the ISM hierarchy, then the iterative algorithm for calculating $L_1, L_2, ..., L_k$ can be calculated as follows:

Let $L_0 = \Phi$ (the highest level is L_1; there is no zero level)

$L_1 = \{R_i \in P\text{-}L_0,\ R_0(R_i) = R_0(R_i) \cap A_0(R_i),\ i = 1, 2, \ldots, n\}$

$L_2 = \{R_i \in P\text{-}L_0\text{-}L_1,\ R_1(R_i) = R_1(R_i) \cap A_1(R_i),\ i \leq n\}$

$L_k = \{R_i \in P\text{-}L_0\text{-}L_1\text{-}\ldots\text{-}L_{k-1},\quad R_{(k-1)}\quad (R_i) = R_{k-1}(R_i) \cap A_{k-1}(R_i),\ i \leq n\}$.

Note. $R_{(k-1)}$ (R_i) and $R_{k-1}(R_i) \cap A_{k-1}(R_i)$ are the reachable set and common set obtained by the submatrix formed by the factors in the set $P\text{-}L_0\text{-}L_1\text{-}...\text{-}L_{k-1}$.

Therefore, an example of the division of the first-level factors is shown in Table 2, and the hierarchical factor division results are shown in Table 3.

3.1.5. Step 5: Conical Matrix. The conical matrix M* (Figure 2) can be converted from reachability matrix by clustering factors of the same level in rows and columns. Among them, the solid line area reflects the influence relationships of factors at the same level, and the dotted line area reflects the influencing relationships of adjacent level factors.

3.1.6. Step 6: Diagraph. Starting from the conic matrix listed above, a directed graph containing the transitive links can be obtained. By determining the corresponding pair of nodes in the conical matrix and connecting them with arrows from bottom to top, a final comprehensive diagraph is developed (Graph 1). The diagraph is a visual representation of risk factors and their interrelationships for URT project by PPP arrangements.

The materials and methods section should contain sufficient details so that all procedures can be repeated. It may be divided into headed sections if several methods are described.

4. Results, Model Analysis, and Discussion

The ISM model allows the risk factors of the URT project implemented under a PPP arrangement to be displayed hierarchically and systematically. The following analyze and explain the model based on the actual problems or failures of the URT project.

$$M = \begin{array}{c|cccccccccccccccccccccc}
 & R_1 & R_2 & R_3 & R_4 & R_5 & R_6 & R_7 & R_8 & R_9 & R_{10} & R_{11} & R_{12} & R_{13} & R_{14} & R_{15} & R_{16} & R_{17} & R_{18} & R_{19} & R_{20} & R_{21} & R_{22} \\
\hline
R_1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
R_2 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 \\
R_3 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_4 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
R_5 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_6 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_7 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_8 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_9 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{10} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{11} & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 \\
R_{12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{13} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
R_{14} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{15} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{16} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{17} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
R_{18} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
R_{19} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
R_{20} & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 \\
R_{21} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
R_{22} & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1
\end{array}$$

Figure 1: Reachability matrix.

4.1. Autonomous Risk Factors. The risk factors located closer to the bottom indicate that there are fewer risk factors that can affect it without being affected by it; that is, they are not affected by the subjective efforts of the project participants. Once it happens, it will cause other risks through the transmission path, which will affect the success of the PPP project.

As can be seen from Graph 1, autonomous risk factors include immaturity in government policies, public opposition risk, force majeure, and environmental risk. By carefully analyzing the nature of these risk elements, it is not hard to find that they are related to legal environment, social climate, political conditions, and ecological environment. Therefore, steps need to be taken for management of these risk elements before the start of the project, especially in the feasibility study stage in which the status of these risk elements should be considered. Only by effectively assessing these risks can the future development of the project be under its own control. Otherwise, since these dominant variables are not easily controlled by the project participants, the project is likely to encounter various difficult situations. It is more difficult to recover the loss.

Table 2: Partition of first-level factors.

Risks (R_i)	Reachability set: $R(R_i)$	Antecedent set: $A(R_i)$	Common set: $R(R_i) \cap A(R_i)$
R_1	R_1, R_{10}, R_{12}, R_{14}, R_{15}, R_{18}, R_{21}	R_1, R_4, R_{11}, R_{20}, R_{22}	R_1
R_2	R_2, R_6, R_{10}, R_{12}, R_{14}, R_{15}, R_{17}, R_{18}, R_{21}	R_2, R_{11}, R_{20}, R_{22}	R_2
R_3	R_3, R_{10}, R_{14}	R_3	R_3
R_4	R_1, R_4, R_{10}, R_{12}, R_{14}, R_{15}, R_{18}, R_{21}	R_4	R_4
R_5	R_5, R_9, R_{10}	R_5	R_5
R_6	R_6, R_{10}, R_{14}	R_2, R_6, R_{11}, R_{20}, R_{22}	R_6
R_7	R_7, R_8, R_9, R_{10}	R_7	R_7
R_8	R_8, R_9, R_{10}	R_7, R_8	R_8
R_9	R_9	R_5, R_7, R_8, R_9	R_9
R_{10}	R_{10}	R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_{10}, R_{11}, R_{12}, R_{13}, R_{14}, R_{15}, R_{16}, R_{17}, R_{18}, R_{19}, R_{20}, R_{21}, R_{22}	R_{10}
R_{11}	R_1, R_2, R_6, R_{10}, R_{11}, R_{12}, R_{14}, R_{15}, R_{17}, R_{18}, R_{21}	R_{11}, R_{22}	R_{11}
R_{12}	R_{10}, R_{12}, R_{14}, R_{15}	R_1, R_2, R_4, R_{11}, R_{12}, R_{20}, R_{22}	R_{12}
R_{13}	R_{10}, R_{13}, R_{15}, R_{18}	R_{13}	R_{13}
R_{14}	R_{10}, R_{14}	R_1, R_2, R_3, R_4, R_6, R_{11}, R_{12}, R_{14}, R_{16}, R_{17}, R_{19}, R_{20}, R_{22}	R_{14}
R_{15}	R_{10}, R_{15}	R_1, R_2, R_4, R_6, R_{11}, R_{12}, R_{13}, R_{15}, R_{16}, R_{17}, R_{19}, R_{20}, R_{22}	R_{15}
R_{16}	R_{10}, R_{14}, R_{15}, R_{16}	R_{16}	R_{16}
R_{17}	R_{10}, R_{14}, R_{15}, R_{17}	R_2, R_{11}, R_{17}, R_{20}, R_{22}	R_{17}
R_{18}	R_{10}, R_{18}	R_1, R_2, R_4, R_{11}, R_{13}, R_{18}, R_{20}, R_{21}, R_{22}	R_{18}
R_{19}	R_{10}, R_{14}, R_{15}, R_{19}	R_{19}	R_{19}
R_{20}	R_1, R_2, R_6, R_{10}, R_{12}, R_{14}, R_{15}, R_{18}, R_{19}, R_{21},	R_{21}	R_{21}
R_{21}	R_{10}, R_{18}, R_{21}	R_1, R_2, R_4, R_{11}, R_{20}, R_{21}, R_{22}	R_{22}
R_{22}	R_1, R_2, R_6, R_{10}, R_{11}, R_{12}, R_{14}, R_{15}, R_{17}, R_{18}, R_{21}, R_{22}	R_{23}	R_{23}

Table 3: Risk factor hierarchy.

Level	Risks
L_1	R_9 R_{10}
L_2	R_5 R_8 R_{14} R_{15} R_{18}
L_3	R_3
L_3	R_6 R_7 R_{12} R_{13} R_{16} R_{17} R_{19} R_{21}
L_4	R_1 R_2
L_5	R_4 R_{11} R_{20}
L_6	R_{22}

In China, legal provisions on PPP projects of URT have continuously improved, but the government's contract awareness and performance capabilities are not enough. In such circumstances, only PPP project companies continuously optimize the risk sharing mechanism and renegotiation mechanism through stringent implementations of the concession agreement which can help the government improve its ability. At the same time, PPP project companies also need to adopt a much more proactive approach to review changes in laws, policies, and regulations and take precautions against risks. In addition, most of the PPP projects are related to public interests and ecological environment. PPP projects of URT companies must not only consider their own reasonable return on investment, but also conduct reasonable assessments of social benefits, improve URT service quality, and thereby increase public satisfaction.

4.2. Intermediate Risk Factors. Intermediate risk factors in the middle of the structure diagram have a certain degree of influence and dependence. Therefore, they can be considered as intermediate risk factors in the system where the risk elements affect each other and can play a role in connecting the one before and the one following.

Intermediate risks include the second-level inflation risk, funding availability risk, completion risk, construction cost-overrun risk, and market demand/usage risk, the third-level irrational financing structure risk, land acquisition and compensation problem, lack of coordination between stakeholders, etc., and fourth-level nonreliability and creditworthiness of public agencies and mistaken or long-winded public decision-making process. Intermediate risk factors are in the middle part of their respective risk transmission paths. They are not only greatly affected by lower-level risks, but also affect higher-level risks

$$M^* = \begin{array}{c|cccccccccccccccccccccc}
 & R_9 & R_{10} & R_5 & R_8 & R_{14} & R_{15} & R_{18} & R_3 & R_6 & R_7 & R_{12} & R_{13} & R_{16} & R_{17} & R_{19} & R_{21} & R_1 & R_2 & R_4 & R_{11} & R_{20} & R_{22} \\
\hline
R_9 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{10} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_5 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_8 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{14} & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{15} & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{18} & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_3 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_6 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_7 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{12} & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{13} & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{16} & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{17} & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{19} & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_{21} & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
R_1 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\
R_2 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\
R_4 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 \\
R_{11} & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 \\
R_{20} & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\
R_{22} & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1
\end{array}$$

Figure 2: Conic matrix.

themselves, thereby increasing the uncertainty and the possibility of failure of PPP project of URT.

Compared with autonomous risk factors, intermediate variables have less influence and are easily affected by the autonomous risk factors. They are the most direct elements affecting the success or failure of a project and play a role as a link in the risk system. More importantly, intermediate variables are actually closely related to project participants and can be controlled through their own efforts. In other words, compared to the autonomous variables, for the URT project participants, intermediate risk factors have more practical significance for management when implementing the project. Hence, although the influence of the intermediate variables is not the strongest and the degree of

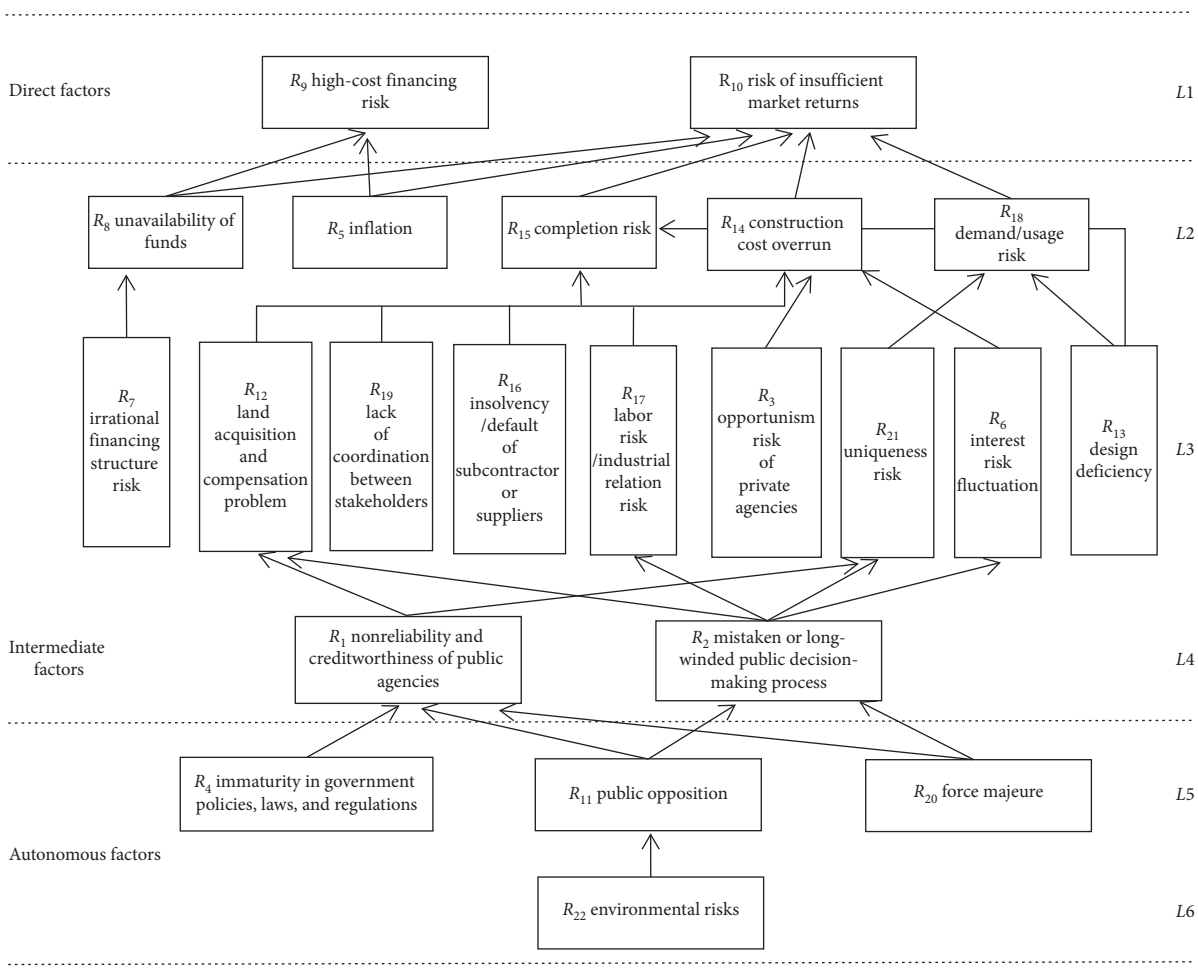

Figure 3: Structure diagraph.

importance is not the highest, once the project enters the implementation stage, monitoring and management of these risk elements becomes the most important.

To avoid project failures, PPP project companies implementing URT projects should not only design a reasonable financing structure and improve their own funding capabilities, but also carefully analyze the risks of labor, design deficiencies, land acquisition and compensation, etc., that may arise in the entire process. At the same time, they must also pay attention to risks from the government. There are also reasons such as insufficient experience and ability of government personnel in operation of a PPP project of URT, overlapping management powers of multiple government departments, insufficient preparation, and information asymmetry. The decision-making time of the project is too long and even mistakes have occurred. Therefore, PPP project companies with URT projects should assess government credit in advance and take preventive measures to deal with government defaults.

4.3. Direct Risk Factors. It can be seen from Figure 3 that the high-cost financing risk and shortage of market return risk located at the top of the structure are more affected by other risks and are the results of accumulation of other risks. Thus, they are the direct risk factors that affect the success or failure of the whole project.

The direct risk factors are weak in influence and strong in dependence and have a certain effect of "indicating results." For example, the risk of short market return is a more specific and easy-to-measure risk, that is, whether the risk occurs and what is the consequence can be measured. Direct risk factors are not as abstract as intermediate variables such as nonreliability and creditworthiness of public agencies, nor are they relatively difficult to measure like autonomous risk factors such as public opposition or force majeure. The latter two types of variables cannot directly and clearly reflect the results of the project implementation.

Accordingly, direct risk factors can reflect the effect of the management of the intermediate and autonomous risk factors and can also be directly used to measure the quality of the project. In addition, by discovering the changes in direct risk factors, it becomes more important to summarize the gains and losses of management of the intermediate and autonomous risk factors. That is, once direct risk does occur, it means real loss. In the face of real loss, we should calmly summarize the lessons so that the next stage of work can proceed smoothly.

From the density of arrow pointing, we can easily find that the risk of insufficient market returns is the most prominent. Compared with the past, when URT contractors participated only in the construction process, they now participate in the whole life cycle process of financing (influenced by funding availability risk and inflation), construction (influenced by completion risk and cost-overrun risk), and operation (influenced by demand usage risk), which may lead to the problem of insufficient market return. For risk managers, except for summarizing the gains and losses we talked about above, URT project companies need to use quantitative risk analysis, risk-based Monte Carlo simulation, etc., to conduct demand forecasts and construction cost estimations [20]. Simultaneously, the government also needs to help the PPP companies to resolve or reduce certain market and income risks, such as tax support and financial subsidies.

The risk of high-cost financing is often caused by inflation, funding availability risks, and irrational financing structure risk. Therefore, it is very important for PPP companies in URT to choose reasonable financing channels. Yan [21] and Liu et al. [22] believed that asset securitization of PPP projects is an important financing channel to reduce financing costs and solve financing difficulties. It can provide a market-oriented and standardized capital withdrawal mechanism and protect the interests of PPP projects of URT companies.

5. Conclusions

Based on the ISM theory, this paper constructs a risk system structure model with a clear structure level for PPP projects for URT services. According to this model, we can clearly recognize the position of each risk factor in the entire risk system, that is, the image manifestation of these elements' influence and dependence. Besides, the most direct influence relationship between risk elements can also be reflected in this model. According to the nature of each level of these risk elements in this risk system structure model, this article divides all these risks into three major categories, namely, autonomous risk factors, intermediate risk factors, and direct risk factors, and proposes management of the risks in a targeted manner. However, the shortcoming of the interpretive structural model is that it can only qualitatively analyze the relationship between risks, and the conduction and influence between risks cannot be quantified. Therefore, subsequent research should also combine neural networks, complex networks, and other methods to establish quantitative models.

6. Further Research Discussion

As we mentioned in the conclusion, this ISM theory can only describe the relationship between risk factors qualitatively, quantitative methods should be combined with the interpretive structural model. Risk scoring methods can be used to determine the conduction and influence between risks. Furthermore, this ISM theory can be applied to different industries apart from the URT companies, even in PPP water project [23]. With some adjustments, the methods can be applied to shipping companies and other supply chain activities related companies. Big Data techniques can be also used for risk management in PPP projects as mentioned in Kuchta's paper [24].

Data Availability

The data used in the study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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