

Risk Identification and Response of Social Capital in PPP Project of Rail Transit

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Abstract: The full name of PPP mode is “Public Private Partnerships”. PPP mode includes BOT (build-operate-transfer) mode, TOT (hand-over-operation-transfer) mode, ROT (rebuild-operation-transfer) and other operation modes. Based on the perspective of social capital, this paper firstly summarizes the theories related to the PPP project and risk management of rail transit. Then combined with the method of literature review and work breakdown structure, the risk factors of social capital in the PPP project of rail transit are preliminarily identified. For the identified risk factors, the improved grey relational degree method is adopted to carry out risk assessment and find out the key risk factors. Finally, some targeted countermeasures are proposed for the key risk factors. It has certain reference value for guiding social capital to carry out risk control, reducing the loss of social capital as much as possible, and effectively promoting the sustainable and healthy development of the PPP projects of rail transit.

1. Introduction

In today's society, people's demand for public infrastructure is also increasing, especially for public transportation. In order to relieve traffic pressure and reduce environmental pollution, the use of rail transit projects has significant advantages. And according to the national bureau of statistics, the whole society fixed asset investment from 64.12384 trillion yuan in 2017 rose to 64.5675 trillion yuan in 2018, but in 2017 the state budget is only 3.87417 trillion yuan of funds, visible state budgetary funds far cannot satisfy the investment in fixed assets.

Since 2014, China has issued relevant documents such as “opinions of the State Council on strengthening the management of local government debt” and “notice on issues related to the promotion and application of the cooperation model between the government and private capital”, giving great policy support to the PPP model. With the gradual obvious advantages of PPP model and strong support from the government, PPP model has been incorporated into the use of rail transit projects, pushing the PPP model into a highly developed stage. However, according to the annual statistics and analysis report on urban rail transit 2018 released by the China urban rail transit association in March 2019, 35 cities on the Chinese mainland have opened 185 rail transit lines up to the beginning of 2019, with a total length of 5,761.4 kilometers. In 2018, the average operating income ratio of urban rail transit in China is 78%. Only four cities with a national operating income ratio over 100% are Hangzhou, Qingdao, Shenzhen and Beijing, while the other 24 cities are all below 100%. Most of them are still living beyond their income. It can be seen that there are many risk factors facing social capital and the risk affects the result seriously. Social capital is in a wait-and-see state, which is not conducive to attracting private capital investment.

The risk management of social capital is the key to the success of rail transit PPP projects. In order to mobilize the subjective enthusiasm of social capital to participate in rail transit PPP projects, it is necessary to ensure that the risks of social capital are within the tolerable range and that they have certain benefits. Therefore, from the standpoint of social capital, risk management of rail transit PPP projects is of great significance to attract social capital to actively participate in the construction and operation of rail transit PPP projects.

2. An overview of PPP project risk management theory in rail transit

2.1 Theory related to rail transit PPP project

2.1.1 Characteristics of rail transit PPP projects

As a quasi-public product, rail transit project is competitive and exclusive [1]. The PPP model can not only make full use of the government's policy support, introduce a large number of funds from social capital, but also give full play to the advanced management experience and technical support of the enterprise, while saving the total cost of rail transit projects and improving the service quality of quasi-public products. By summarizing literatures and combining with cases of rail transit PPP projects, this paper concludes that rail transit PPP projects generally have the following characteristics:

- (1) Public welfare, ticket prices are subject to government control.
- (2) High degree of public participation.
- (3) Large construction scale, large investment and long payback period.
- (4) High investment threshold [2].
- (5) The construction environment is complex.

2.1.2 Stage division of PPP project of rail transit

Each project has its specific development stage, and the specific definition and division of each stage change with different projects. These stages constitute the whole life cycle of the project [3]. In order to make the rail transit PPP project meet the requirements in terms of cost, quality and schedule, it is necessary to plan, organize, coordinate and control the whole life cycle of the project. By reviewing relevant literatures and domestic and foreign cases, this paper divides the whole life cycle of the rail transit PPP project into five stages for research.

- (1) Project preparation.
- (2) Project bidding stage.
- (3) Project financing stage.
- (4) Project construction phase.
- (5) Project operation, maintenance and handover.

2.2 Overview of PPP project risk management in rail transit

2.2.1 Risk characteristics of PPP project of rail transit

The concept of risk first proposed by Haynes is the uncertainty of loss occurrence. After that, scholars conducted a large number of studies on risks, most of which could be attributed to the following two understandings: one is the uncertainty of the outcome of the event in the future, and the other is the deviation of the outcome from the expected goal in the future. From the perspective of this paper, the two viewpoints are actually identical. It is the uncertainty of the result that leads to the difference between the result and the target.

Risk generally has the characteristics of objectivity, universality, uncertainty and variability. Due to the large number of participants, large project volume and complex project, PPP project risks, in addition to the above characteristics, also have the characteristics of complexity and diversity, greater uncertainty and stage characteristics.

2.2.2 The process of PPP project risk management in rail transit

Risk management of rail transit PPP project means that in the whole life cycle of the project, the project participants reduce the impact of risk occurrence on the project through certain methods and measures. With the change of the project itself and the external environment, risks are constantly changing, so risk management is also a dynamic process. The risk management process of rail transit PPP project can be roughly divided into the following stages.

- (1) Risk identification.
- (2) Risk assessment.
- (3) Risk sharing.

(4) Risk management.

3. Risk identification of social capital parties in PPP projects of rail transit

3.1 Risk identification method of rail transit PPP project

Risk identification is the primary and fundamental stage of risk management. The main purpose of risk identification is to obtain an effective risk list with certain methods, so as to make subsequent risk management more effective. The commonly used risk identification methods mainly include literature research method, risk checklist method, Delphi method, case analysis method, questionnaire survey method, scenario analysis method, causal analysis diagram method, fault tree method, brainstorming method, interview survey method and work breakdown structure method.

Each risk identification method has its own merits and demerits. The selection of risk identification method is related to the characteristics of the project, the surrounding environment, technicians and other factors, and the appropriate risk identification method should be selected according to the specific project, so as to make the risk identification more comprehensive and accurate.

In this paper, firstly, based on the work decomposition structure method, the work of each stage of the rail transit PPP project is analyzed. As shown in Figure 1, the internal risks are divided into five parts. Then, the tasks in each stage of the PPP project of rail transit are decomposed. Meanwhile, some risks are caused by external factors, which can be classified as external risks.

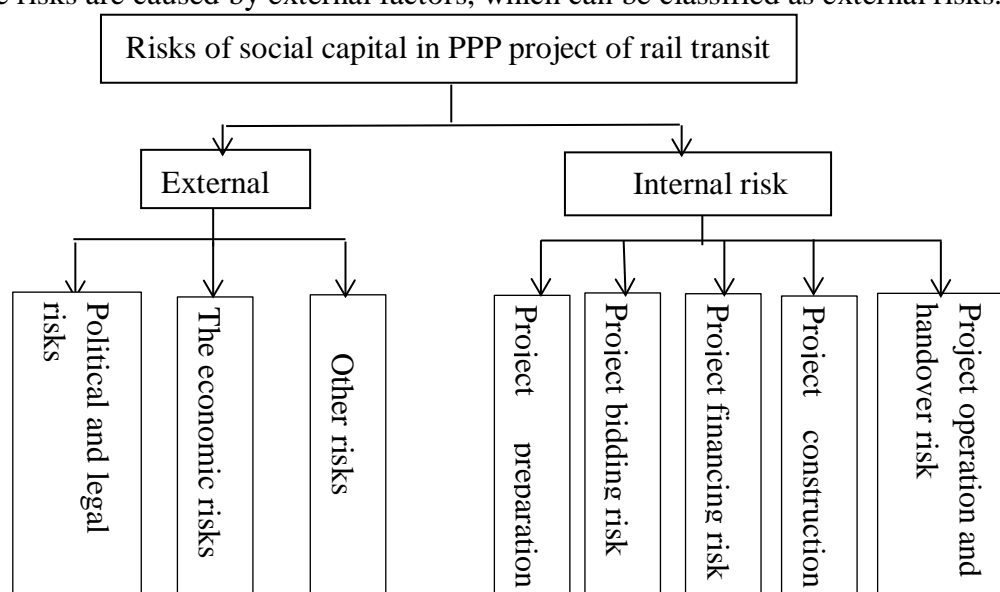


Figure 1 Risk classification of social capital in PPP projects of rail transit.

3.2 Risk identification results of rail transit PPP project

Based on the related literature as the basis, to sorting, summary of literature, in combination with the Beijing subway line 4, the Taiwan high speed rail BOT, according to the characteristics of rail transit PPP projects for the screening of the risk, and use the work breakdown structure method for the identification of risk, observes, identify 25 risk factors, as shown in Table 1.

4. Risk assessment of the social capital side of the PPP project of rail transit

4.1 Grey relational analysis

In the previous chapter, various risk factors of social capital in rail transit PPP projects have been identified. In order to better conduct risk management, it is necessary to evaluate the risk impact degree, and determine the weight of each risk factor through quantitative methods as far as possible, so as to obtain the evaluation results intuitively. Grey relational degree analysis method is a

method to analyze the degree of correlation between various factors in the system. The basic idea is to rank all factors by relativity according to the degree of correlation. The basic calculation process is as follows:

Table 1 Summary of literature on social capital risks in rail transit PPP projects.

Risk categories		The name of the risk
external risk	Political and legal risks	Political risk
		Risk of contract change
		Legal completeness and risk of change
	The economic risks	Interest rate risk
		Currency risk
		Inflation risk
		Tax adjustment risk
	Other risks	Irresistible risk
		Risk of poor geological conditions
Internal risk	Project preparation risk	Site acquisition risk
		Risk of delay in approval
	Project bidding risk	Insufficient risk of bidding competition
	Project financing risk	Financing completion risk
		Financing cost risk
	Project construction risk	Engineering quality risk
		Improper design scheme and risk of change
		Raw material supply risk
		Project completion risk
		Construction cost overrun risk
		Construction safety risk
	Project operation and handover risk	Operating income risk
		Operational service quality risk
		Operating cost risk
		Operational safety risk
		Operator credit risk

(1) First of all, m experts were invited to score the 25 risks that had been preliminarily identified, and score the influence degree of each risk factor to form a judgment matrix X :

$$X = \begin{pmatrix} x_1(1) & x_1(2) & \cdots & x_1(m) \\ x_2(1) & x_2(2) & \cdots & x_2(m) \\ \cdots & \cdots & \cdots & \cdots \\ x_{25}(1) & x_{25}(2) & \cdots & x_{25}(m) \end{pmatrix} \quad (1)$$

The maximum score was selected from the obtained influence degree as the reference value $x_0(k)$, and the correlation degree r_i was calculated from formula (2) and (3). The discrimination

coefficient $\rho \in [0,1]$, generally take $\rho=0.5$, then weight w_i is equal to r_i .

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|} \quad (2)$$

$$r_i = \frac{1}{n} \sum_{k=1}^n \xi_i(k) \quad (3)$$

However, in the application process, scholars Cui Jie, Dang Yaoguo and others found that the method had certain defects [4]. First of all, too many factors affect the weight result. For example, the selection of reference value $x_0(k)$ and the value of resolution coefficient ρ will all affect the calculation result of correlation coefficient $\xi_i(k)$, thus affecting the calculation result of weight.

Secondly, the weight is less differentiated. Because of the general take $\rho = 0.5, |x_0(k) - x_i(k)| = a$,

$\min_i \min_k |x_0(k) - x_i(k)| = b, \max_i \max_k |x_0(k) - x_i(k)| = c$, then $r_i = \frac{b+0.5c}{a+0.5c}$, $b \geq 0, c \geq 0$, So r_i is the

smallest when a is equal to c. $r_i = \frac{b+0.5c}{c+0.5c} > \frac{0.5c}{c+0.5c} > 0.333$. That is, the correlation degree r_i is always greater than 0.333, so the weight discrimination degree will be small.

Therefore, this paper adopts the improved method of grey relational degree proposed by Cui Jie, Dang Yaoguo and other scholars. Based on the expert experience scoring method, the evaluation index is obtained and the evaluation matrix X is formed. Select the maximum value from X as the public reference value to form a reference series. The distance between each index and the reference sequence is obtained. The weight can be further solved and normalized. This method does not involve the setting of the subjective value such as the resolution coefficient, which ensures the subjectivity of the expert score to some extent.

4.2 The expert grading method determines the judgment value

In this paper, in accordance with the definition of risk influence degree by L.Y. Shen in the calculation process, each risk factor is quantitatively evaluated, namely:

Risk influence degree = $\sqrt{\text{probability of occurrence of risk factors} \times \text{hazard degree of risk factors}}$ Six experts in this field were invited to

grade the probability of the occurrence of risk factors and the degree of harm of risk factors in the PPP project of rail transit. According to Likert five-point scale, the score was set, and the influence degree of each risk factor was calculated according to the expert score results, as shown in Table 3.

Table 2 Likert five-point scale

score	Probability of occurrence of risk factors	Risk factor hazard degree
1	Very Low Frequency	Insignificant
2	Low Frequency	Minor
3	Moderate Frequency	Moderate
4	High Frequency	Major
5	Very High Frequency	Sever

Table 3 Calculation table of influence degree of social capital risk factors in PPP project of rail transit

The secondary indicators	The score of each expert					
Political risk	3.87	3.87	5	4.47	4.47	3.46
Risk of contract change	3	3.46	4	4	3	3
Legal completeness and risk of change	4.47	5	4.47	3	3.46	3.46
Interest rate risk	2	2.45	3	2	2	2.45
Currency risk	1.41	1.73	1.41	2	1.73	2
Inflation risk	1.73	1.73	1.41	1.41	2	1.41
Tax adjustment risk	1.41	1	1	1.41	1	1
Irresistible risk	2.24	2.24	2.45	3	3.16	1.73
Risk of poor geological conditions	2	2.45	1	2	1.73	1.41
Site acquisition risk	2.45	1.73	1.41	2	1	2.45
Risk of delay in approval	2.45	3	2.83	3	3.46	3.46
Insufficient risk of bidding competition	3.46	1.73	2	2.45	3	2
Financing completion risk	3.46	3.16	2.45	3	3.87	3
Financing cost risk	2.45	1.41	1.73	2.45	1.41	2.24
Engineering quality risk	2	2	1.73	1.73	3.16	2.83
Improper design scheme and risk of change	2.45	2	2	1.73	3.46	1.73
Raw material supply risk	2	1.73	2	3.46	2.45	3
Project completion risk	3	3.46	1.73	2.83	3	2.23
Construction cost overrun risk	1.41	1.73	2	2	1.41	2.45
Construction safety risk	3.46	2.83	4	3.16	2	2.24
Operating income risk	3	2.45	2	3.16	2.45	3.46
Operational service quality risk	2.83	2	3	2	2	1.41
Operating cost risk	3	2	1.41	2	2.45	2
Operational safety risk	2.83	2	3.16	2.83	1.73	3.87
Operator credit risk	2.45	1.41	2.45	2.45	2	4

4.3 Calculate risk factor weights

(1) According to the risk impact degree table, a judgment matrix is formed to form a judgment matrix X .

$$X = \begin{pmatrix} x_1(1) & x_1(2) & \cdots & x_1(6) \\ x_2(1) & x_2(2) & \cdots & x_2(6) \\ \cdots & \cdots & \cdots & \cdots \\ x_{25}(1) & x_{25}(2) & \cdots & x_{25}(6) \end{pmatrix}$$

Find out the maximum influence degree $x_0(k)$ from the judgment matrix, take it as a reference value and assign it to each influence degree, thus forming a new matrix X' .

$$X' = \begin{pmatrix} x_0(k) & x_0(k) & \cdots & x_0(k) \\ x_1(1) & x_1(2) & \cdots & x_1(6) \\ x_2(1) & x_2(2) & \cdots & x_2(6) \\ \cdots & \cdots & \cdots & \cdots \\ x_{25}(1) & x_{25}(2) & \cdots & x_{25}(6) \end{pmatrix}$$

And then, using formula $D_i = \sum_{k=1}^6 [x_0(k) - x_i(k)]^2$, we get the distance D_i .

$$D_i = (5.49, 16.37, 9.30, 44.00, 65.16, 69.05, 89.78, 39.82, 64.08, 61.59, 23.95, 41.57, 21.54, 57.09,$$

$$47.48, 48.26, 41.57, 33.45, 60.97, 28.08, 31.76, 48.60, 50.39, 33.77, 42.40)$$

(2) After obtaining the distance value D_i , the weight $W_i = \frac{1}{1 + D_i}$ of each risk factor was obtained from W_i .

$$W_i = (0.1542, 0.0576, 0.0970, 0.0222, 0.0151, 0.0143, 0.0110, 0.0245, 0.0154, 0.0160, 0.0401, 0.0235, 0.0444, 0.0172, 0.0206, 0.0203, 0.0235, 0.0290, 0.0161, 0.0344, 0.0305, 0.0201, 0.0195, 0.0288, 0.023)$$

(3) The obtained weight value can be normalized to obtain the final weight result W'_i .

$$W'_i = (0.1884, 0.0703, 0.1186, 0.0272, 0.0185, 0.0174, 0.0135, 0.0299, 0.0187, 0.0195, 0.0490, 0.0287, 0.0542, 0.0210, 0.0252, 0.0248, 0.0287, 0.0355, 0.0197, 0.0420, 0.0373, 0.0246, 0.0238, 0.0351, 0.0282)$$

4.4 Results analysis

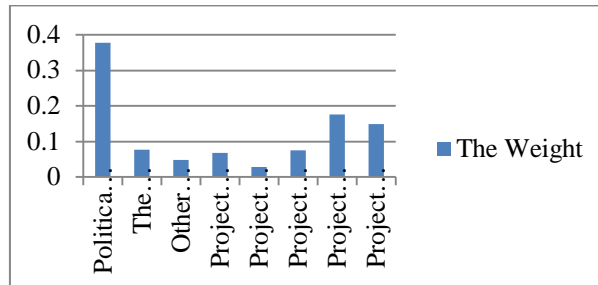


Fig.2 The weight of the influence degree of social capital risk factors in the rail transit PPP project

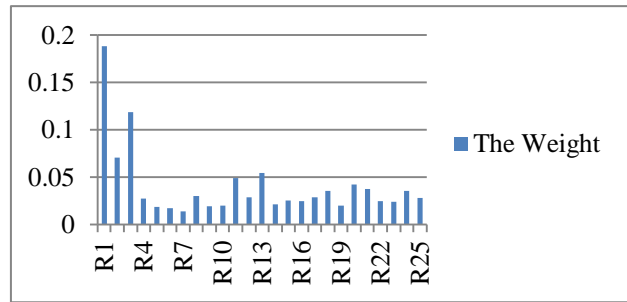


Fig.3 In rail transit PPP project, risk factors of social capital side influence degree weight

According to the final weight calculation result, as shown in Figure 2 and Figure 3. Among all the primary indicators, political and legal risks accounted for the largest weight, and three secondary indicators accounted for the top three. Due to the public welfare nature of the rail transit PPP project, the social capital side invests more capital, and the ticket price is subject to the government's control, and the social capital side needs the government's strong support in the process of participation, so the government's credit and intervention degree have a huge impact on the project. However, the PPP project has not been developed for a long time in China, and the law is still not perfect. In the following long-term operation of the project, it is easy to change the law, which will have a great impact on the project. Project construction risk ranked the second, project operation and transfer risk followed the third. Due to the large number of participants in rail transit PPP projects, long construction and operation cycle, and more uncertainties in relatively common construction projects, risks are more likely to occur during the construction and operation period. In terms of secondary indicators, financing completion risk and approval delay risk ranked fourth and fifth respectively. This is because the amount of design capital of rail transit PPP project is large and the construction period is long. Therefore, if the financing is not completed and the approval is delayed, the project will be unable to proceed, which will have a great impact on the project.

5. Risk response measures of social capital side in PPP project of rail transit

(1) Political and legal risk response measures

Political risks include government discredit, excessive government intervention and government corruption. Before participating in the project, the social capital side should organize professionals to evaluate the credit of the government side. When the credit assessment is completed and a contract or agreement is signed with the government, the functional responsibilities of both parties should be clearly defined and risk attribution should be done. During the whole process from the start of the project to the handover, the social capital side should maintain a vigilant attitude and ensure the management in strict accordance with policies, regulations and contracts. Meanwhile, the social capital side should supervise each other and timely communicate and give feedback to the government side. If the political risk has occurred, the government shall bear the risk and make up for it according to the contract.

Contract change risk: Because the contract signing of rail transit PPP project involves multiple participants, if the contract is changed, losses may be caused to each participant. When signing various contracts, professional contract management personnel should be introduced as far as possible to evaluate the items in the contracts and agreements, so as to minimize the appearance of imperfect clauses and fuzzy distribution of rights and responsibilities.

Incomplete laws and change risks: At present, the application of PPP model in China is still not mature enough, and various policies, laws and regulations are not perfect enough. With the promotion and application of PPP model, there is a great possibility for laws and regulations to be improved and changed. However, PPP projects of rail transit are more complex than ordinary PPP projects. Once such risks occur, it will have a great impact on social capital. The social capital side must have legal professionals, communicate reasonably with the government side, ensure compliance with the current legal policies, and make clear the responsibility distribution through contracts and agreements as far as possible for potential legal risks.

(2) Project construction risk response measures

First, more experienced partners should be selected through bidding. Next, social capital square should want to cooperate each participator, do the investigation work of the project jointly, consult together design program. In the process of signing the contract, the contracting parties should clearly divide their responsibilities and specify the time, quality, capital and other constraints for the project. In the process of project construction, it is necessary to pay close attention to the procurement and construction links of the project at all times. In case of deviation from the plan, timely feedback, negotiation and corrective measures shall be taken.

(3) Project operation and handover risk response measures

The PPP project of rail transit has a long operation period and many participants, so various risks are easy to occur during the operation period. Moreover, due to its public welfare nature, the ticket price is controlled by the government, so the risk of operating income is greatly affected. First, before the project operation, the market of the project location should be investigated in depth. At the time of signing the contract with the government, negotiate the lowest fare, or may take the fare difference compensation to carry on the fare formulation. At the same time, we should choose to cooperate with experienced operators to negotiate all aspects of the operation process. In the process of project operation, always pay attention to supervision, if any deviation should be discussed in a timely manner, to find out the cause of timely correction. For the loss caused by risks, liability compensation shall be made according to the agreement of the project contract.

(4) Financing completed risk response measures

Due to the large amount of funds involved in rail transit PPP projects, the rationality of financing structure and timely availability of funds play a crucial role in the smooth operation of the project. We should consider not only the financing cost, but also the timely availability of funds, and choose a more appropriate financing scheme. If the way of bank loan is adopted, the guarantee bank can be considered to improve the feasibility of the loan. In addition to bank loans, trust financing, establishing project fund through negotiation with the government, and equity transfer in cooperation with state-owned enterprises with good credit can also be considered. Next still should want to make detailed plan, to the use direction of each fund does have in mind, assure the reasonable use of fund, still can reduce capital idle at the same time.

(5) Approve delayed risk response measures

Due to the large number of participants in the rail transit PPP project, there are many documents to be signed and approved. However, there is no consensus process for the approval of documents, and the government does not have relatively mature management experience, which easily leads to the complicated approval process of the project and causes economic and time losses to the social capital. First of all, both parties should have a good communication on the details of the project, such as time and process, and sign an agreement and contract after reaching consensus through negotiation. If the project is not consistent with the expected situation, it should be communicated in a timely manner so that all the participants can get ready in time. In the process of making major decisions, social capital can strive for auditing supervision. While ensuring timely feedback and adjustment, it can also reasonably safeguard its own rights and interests, so as to ensure the quality and quantity of the project on schedule. If the approval is too long and the approval time cannot be shortened, the next step can be discussed as appropriate, so as to ensure the time is not wasted, reduce the influence of risk factors and stop loss timely. It is also possible to discuss whether the participation of the agency can be accepted and the agency can take the place of the project approval. If there is any risk of delayed approval during the operation of the project, compensation shall be made according to the relevant provisions of the contract to reduce the loss caused by the risk as much as possible.

6. Conclusion

The construction of rail transit projects is in a stage of rapid development, and the application of PPP model can not only guarantee the control of the government, but also absorb a large amount of funds from the social capital side, and make better use of the management experience and technical

level advantages of the social capital side. Due to the inherent characteristics of rail transit PPP project, it has many risk factors and greater uncontrollability, which also makes social capital parties shy away from it. Therefore, risk identification and response of social capital parties are of great significance for the sound and sustainable development of PPP projects. Based on the perspective of social capital, this paper identifies and evaluates the risk factors in the PPP project of rail transit and puts forward some Suggestions on countermeasures.

References

- [1] Weibao You, Jianbo Wang, Diying Yang, Fangmeng Liu. Research on financing risk management of PPP project of urban rail transit. *Engineering economy*, 2018, 28(09), 77-80.
- [2] Lanping Zhou, Xiaoli Fan, Jiehui Jiang. The four problems and countermeasures of PPP in urban rail transit. *Building*, 2017, (14), 38-41.
- [3] Qiang Liu, Risk management based on the whole life cycle of international engineering projects. *Journal of civil engineering and management*, 2017, 34 (06), 1-9+16.
- [4] Jie Cui, Yaoguo Dang, Sifeng Liu. An improved method to calculate index weight based on grey relational degree. *Chinese management science*, 2008, (05), 141-145.