



Debt Risk Research on PPP Model Based on VAR (Value at Risk) Model

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Abstract. The report of the 19th national congress points out that from now on to 2020 is the decisive period for building a moderately prosperous society in an all-round way, while PPP project investment involves 19 industries, such as transportation, comprehensive development of cities and towns, education, health care, pension, etc., providing more convenience and services for people's life. At present, the amount of investment in PPP projects in China is relatively large, and the cumulative investment is more than 13 trillion yuan. China's PPP projects have formed the largest PPP market in the world. The promotion of PPP model is conducive to solving the problem of funds shortage of local governments, but the poor application of PPP model will lead to debt risk, even financial risk. This paper first analyzes the current situation of PPP model in China, then uses VAR model to quantify the debt risk loss caused by PPP projects, and local governments should prepare corresponding reserve funds to prevent the loss. Finally, in view of the debt risk, it puts forward some policy suggestions, such as the establishment of PPP project feasibility analysis, implementation process supervision, performance evaluation, and risk prevention mechanism.

Keywords: PPP model · Value at risk · VAR model · Risk prevention

1 Introduction

PPP (public-private partnership) mode refers to the government's cooperation with social capital, which is mainly used in municipal engineering, transportation and other public infrastructure construction projects. It is also an important financing mode. In this mode, the government can not only solve the problem of finance shortage in infrastructure construction, but also reduce the cost and improve the efficiency of the project through private capital financing [1]. In recent years, with the increase of PPP project investment and the amount of investment, in order to standardize PPP projects, the government set up a PPP project management library in 2018. At the same time, PPP projects need the government and enterprises to sign project contracts or agreements, respectively regulating the rights and obligations of both parties [2].

Local government debt can be divided into explicit debt and implicit debt, direct debt and contingent debt, while under PPP mode, the government mainly faces implicit debt. According to the investment reporting mechanism, PPP projects can be divided into user paid projects, feasibility gap subsidy projects and government paid projects. User - paid items do not constitute government debt. Feasibility gap subsidy projects and government paid projects can adopt government budget expenditure according to PPP contract to form government direct debt, explicit debt and contingent debt. From the perspective of PPP project financing, it can be roughly divided into self-financing by enterprises through banks, bonds, funds, etc. and guaranteed financing by the government. The latter is the contingent liability that the government needs to bear when the enterprise cannot repay normally. The government does not reflect the debt in the budget. Once it occurs, it will form the government's implicit debt. In addition, many enterprises will turn projects that do not conform to the PPP model into PPP projects through packaging. If such PPP projects cannot be implemented normally or problems arise in the implementation process are eliminated, the government will bear corresponding debts, which also form the implicit debts of the government. Therefore, under the PPP model, the government mainly faces implicit debt risk.

Chinese experts and scholars have a lot of research on the debt risk of local governments under the PPP model: Ou Chunzhi and Jia Kang pointed out that PPP should fully consider its adaptability, value for money and financial tolerance in the process of promotion, so as to prevent inducing new financial risks [3]. Zhang Ping pointed out that the promotion of PPP model is indeed conducive to alleviating the finance shortage of local governments and controlling the debt increase of local governments, but at the same time, attention should be paid to the prevention and control of project risks [4]. Han Jun and others clearly pointed out that not all projects are suitable for PPP mode, and blindly use PPP may damage public interests and increase government debt burden [5]. Darrin and Mervyn also believe that although PPP mode financing has many advantages, it involves a series of complex implementation and supervision processes. Therefore, due to different national conditions, its implementation in different countries may lead to different consequences [6]. Bai Dequan pointed out that PPP has a double impact on local government debt risk. PPP is likely to induce local government financial risk in the short term, chain hidden debt risk in the medium term, and systemic financial risk in the long term [7]. Zhang Tong pointed out that in the PPP mode, the financing mode guaranteed by the government is the contingent responsibility that the government only assumes when the enterprises cannot repay the financing funds to the financial institutions in the PPP project, which will not be reflected in the financial budget and the balance sheet of the government, and will constitute the implicit debt of the government [8]. From the above expert's point of view, it can be concluded that the promotion of PPP model is conducive to solving the problem of funds shortage of local governments, but the poor application of PPP model will generate debt risk, even financial risk.

The government debt of PPP model in China has four important characteristics: universality, complexity, concealment and separation of rights and responsibilities [9]. At present, the amount of investment in PPP projects in China is relatively large, with a total investment of more than 13 trillion yuan, has formed the largest PPP market in the world. However, there are still many problems in the operation of PPP projects.

According to the latest data released by the Ministry of finance, as to April 23, 2018, there are 1695 projects that have been cleaned up and returned to the treasury, involving an investment of 1.8 trillion yuan; there are 2005 projects that need to be rectified, involving an investment of 3.1 trillion yuan [10].

Table 1. Statistics of items returned from management warehouse, rectification and withdrawal of reserve list

Items to be withdrawn from the management warehouse, rectification and reserve list	Numbers
PPP mode is not suitable	397
Early preparation not in place	506
Failure to carry out “two arguments” as required	217
No more PPP implementation	1120
No compliance with standard operation requirements	277
Suspected illegal debt guarantee	14
Failure to disclose information as required	488
Removed or rectified for other reasons	1354
Total	4373

From the above statistical table, it can be seen that the number of PPP projects which will no longer continue to adopt PPP mode and other reasons is as high as 56%, and the number of projects which are not in place in the early stage and have not made information disclosure as required is 22%. From the above Table 1, it can be seen that PPP project operation is not standardized, and there is no effective supervision in the operation process. At present, there are still some problems in PPP projects in China, such as the local government’s illegal borrowing, the irregular financing mode which has large scale, the disguised borrowing through the financing platform, the inadequate competition, the inadequate supervision, the lack of legal constraints on PPP projects and so on. If the PPP project is not well operated, it will bring debt risk to the government. The following content of this paper uses VAR (value-at-risk) model to quantify the investment risk of PPP project in China, and provides suggestions for preventing the debt risk of PPP.

2 Empirical Study on VAR Model

Value at risk refers to the maximum possible loss of a certain investment portfolio in a given confidence level in a certain period in the future under normal fluctuation. Value at risk is the amount of a loss. VaR is a tool for measuring risk, which applies statistics and technology to risk management and quantify risk. In this paper, VAR model is used to analyse the amount of investment and the quantity of investment under PPP mode in China, and quantify the debt risk generated by PPP project through VAR model, and then propose the debt risk response measures.

2.1 Data and Analysis

As of the end of the first quarter of 2019, the investment of PPP management base projects in China is shown in Table 2, mainly involving 19 industries such as transportation, municipal engineering and tourism, with a total cumulative investment of 13421.1 billion yuan and 8843 investment projects. The top three cumulative investment are transportation, municipal engineering and urban comprehensive development, accounting for 29.9%, 29.8% and 13.8% of the amount of total investment respectively, and the project investment accounts for 14.4%, 39.3% and 9.6% of the quantity of total investment respectively. Therefore, municipal engineering accounts for a large proportion in the amount of investment and the quantity of total investment of the project, which is an important management project in PPP project management.

Table 2. Investment of PPP management base project at the end of the first quarter of 2019

Project	Cumulative investment (100 million yuan)	Cumulative number of investment projects
Transportation	40122	1269
Municipal engineering	40034	3474
Urban comprehensive development	18584	561
Ecological construction and environmental protection	9395	849
Tourism	4763	334
Water conservancy construction	3053	374
Affordable housing project	2822	158
Education	2471	425
Others	2103	140
Government infrastructure	2101	205
Health care	1957	256
Culture	1788	193
Forestry	978	41
Sports	956	113
Technology	908	132
Agriculture	769	72
Pension	724	107
Energy	562	107
Social secure	121	33
Total	134211	8843

Correlation Analysis. According to the data in Table 2, the correlation analysis is carried out on the accumulated investment amount and the accumulated investment quantity of PPP projects at the end of the first quarter of 2019. The analysis results are shown in Table 3.

It can be seen from Table 3 that there is a large correlation between the accumulated investment quantity of PPP projects and accumulated investment amount of PPP projects.

Table 3. Correlation Analysis of investment amount and investment quantity of PPP project at the end of the first quarter of 2019

	Cumulative investment (100 million yuan)	Number of projects
Cumulative investment (100 million yuan)	1	
Number of projects	0.861862522	1

Sample t-test. The results of t-test on the selected samples are shown in Table 4. Through this table, it is known that the p value is less than 0.05, and the average value of the two groups of data is statistically different, that is, there is a significant difference between the quantity of cumulative investment and the number of cumulative investment projects of the selected sample PPP project, and the data is valid.

Table 4. t-test: two sample equal variance hypothesis.

	Variable 1	Variable 2
Average	7063.736842	465.4211
Variance	153565386	626739.8
Observed value	19	19
Combined variance	77096062.9	
Hypothetical mean deviation	0	
df	36	
t Stat	2.316214623	
P(T ≤ t) single tail	0.013176648	
t single tail criticality	1.688297714	
P(T ≤ t) double tails	0.026353295	
t double tails criticality	2.028094001	

Regression Analysis. On the basis of correlation analysis and sample t test, it is, there is a large correlation between the cumulative investment quantity and cumulative investment amount of PPP project and the selected data is valid. Then, regression analysis is

conducted on the cumulative investment quantity and the cumulative investment amount of PPP projects. The analysis results are shown in Table 5.

Table 5. Regression Analysis of accumulated investment quantity and accumulated investment amount of PPP project at the end of the first quarter of 2019

	Intercept	Project amount
Coefficients	784.7865	13.4909
Standard error	1733.205	1.925343
t Stat	0.452795	7.007012
P-value	0.656422	2.11E-06
Lower 95%	-2871.96	9.428784
Upper 95%	4441.529	17.55302
Lower limit 95.0%	-2871.96	9.428784
Upper limit 95.0%	4441.529	17.55302

From Table 5, it can be concluded that there is a linear relationship between the quantity of cumulative investment and the amount of investment of PPP projects. Assuming y is the quantity of cumulative investment of PPP projects and X is the amount of investment projects, it can be concluded that the relationship between the quantity of cumulative investment and the amount of investment projects is as follows:

$$Y = 784.79 + 13.49X \quad (1)$$

At the same time, according to the regression analysis of the data in Table 2, Fig. 1 is obtained. It can be seen from the analysis that there is a linear relationship between the quantity of cumulative investment of PPP projects and the amount of cumulative investment, with a slope of 784.79. The quantity of accumulated investment of PPP project can be predicted through Fig. 1. By the end of the first quarter of 2019, the total amount of PPP projects is 8843. When the total amount of PPP projects is predicted to reach 10000 in the future, the total quantity of investment will reach 13568.479 billion yuan. At the same time, through the linear regression analysis of the quantity of cumulative investment and the amount of investment in PPP projects, it is found that the quantity of cumulative investment of PPP projects is distributed in discrete form. When the VAR model is used to analyze the debt risk of PPP, the calculation formula of discrete distribution should be used.

2.2 VAR Model Analysis

VAR refers to the value at risk, that is, the maximum possible loss faced by a portfolio under a given confidence level in a certain probability level and a certain period in the

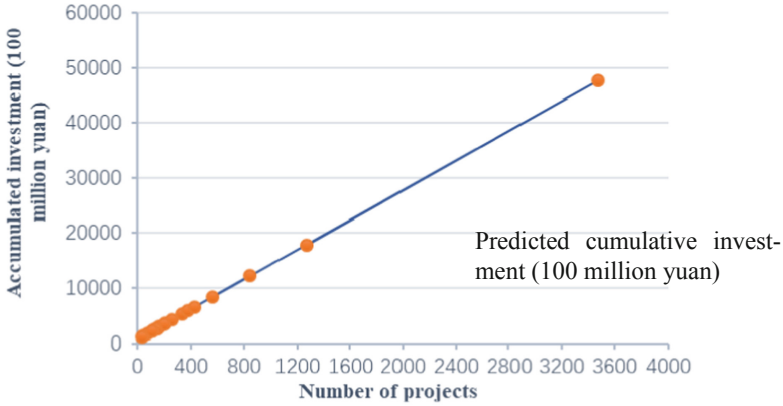


Fig. 1. The relationship diagram between the accumulative invest amount and the accumulative investment amount of PPP projects.

future under normal fluctuation. In this paper, the VAR model is used to quantify the debt risk of PPP project, and then we can know the maximum possible debt loss of PPP project.

According to the investment reporting mechanism, PPP projects can be divided into user paid projects, feasibility gap subsidy projects and government paid projects. Among them, feasibility gap subsidy projects and government paid projects need government subsidies or payments, which may form government debts in the future. By the end of the first quarter of 2019, there were 4892 feasibility gap subsidy projects and 324 government paid projects respectively, with an investment quantity of 8.7 trillion and 3.5 trillion respectively, accounting for 64.9% and 25.7% of the total quantity of investment of PPP projects. It can be seen that the feasibility gap subsidy projects and government paid projects account for a large proportion of the quantity of investment in PPP projects. Because the government bears the expenses of this part, if the PPP projects in this part are not well operated, or they cannot generate the expected income, or the expected income is greatly reduced, it will bring serious losses to the government. In this paper, VAR model is used to quantify the loss, so as to prevent the loss caused by local debt risk in advance.

There are two kinds of VAR calculation, one is based on continuous distribution and the other is based on discrete distribution. According to the regression analysis of the above data, it is found that the quantity of cumulative investment of PPP projects is distributed in a discrete form. Therefore, this paper calculates the possible losses of PPP projects through the discrete VAR model.

VAR calculation based on continuous distribution. Let V_0 represent the current market price of an investment exposure, whose return follows the normal distribution $R \sim n(\mu, \sigma^2)$ at any future point, and the market value of the exposure is:

$$VT = V_0 * (1 + RT) \quad (2)$$

$$\text{Expected value } E(V) = V_0 * (1 + \mu) \quad (3)$$

Let R^* denote 99% confidence, the worst return of the portfolio in the next trading day,

$$\text{Market value } V^* = V_0^* (1 + R^*) \tag{4}$$

$$\Delta V = E(V) - V^* = V_0 \alpha \sigma \tag{5}$$

That is, the absolute value

$$\text{Var} = V_0 \alpha \sigma \tag{6}$$

Relative value

$$\text{Var} = \alpha \sigma \tag{7}$$

In the above formula, V_0 represents the cumulative investment of PPP projects, V_t represents the market value of PPP projects at any point in the future, RT represents the return on investment, μ represents the mean value, σ^2 represents the variance of random variables, and V_0 represents the current market price of an investment exposure.

VAR Calculation Based on Discrete Distribution. For population X and given C ($0 < C < 1$), if x exists, the formula is:

$$F(x) = P(X \leq x) = \int f(u)du = C \tag{8}$$

Then x is called the C quantile of X (or the probability distribution of x). In the value at risk (VAR), we can use the cut-off point to explain the probability of occurrence, which will not be greater than the loss of a certain probability. Because in discrete distribution, C represents the probability of integration.

$$C = \int_{-\infty}^x \frac{1}{b-a} dx \tag{9}$$

Where C represents the probability of loss, X represents the maximum loss amount under the condition of probability C (that is, VAR of discrete distribution), b represents the maximum income of the investment project, and a represents the maximum loss amount of the investment project.

According to the regression analysis of the quantity of cumulative investment and the amount of investment projects, it is found that the investment amount of PPP projects is discrete distribution, and the discrete distribution method is used in the calculation of VAR. By the end of the first quarter of 2019, the total quantity of investment of PPP project is 13421.1 billion yuan, assuming a return on investment is 6.56%. According to the formula of one-year compound interest final value:

$$F = P \times (F/P, i, n) \tag{10}$$

It is calculated that when the total quantity of investment of PPP project is 13421.1 billion yuan and the return on investment is 6.56%, the return on investment in one year is 143015.5 billion yuan. VAR is calculated based on the amount of return on investment.

Among the assumptions: (1) the probability of cumulative investment loss of PPP project is 1%; (2) the outlook period is 1 year; (3) the confidence degree is 99%; then the VAR is calculated as follows:

$$1\% = \int_{-\infty}^x \frac{1}{b-a} dx = \int_{-143015}^x \frac{1}{b-a} dx \quad (11)$$

Among them, b is the maximum income of the PPP projects investment and a is the maximum loss of the PPP projects investment.

It is calculated that

$$x = 14015.5 \text{ billion yuan} \quad (12)$$

That is to say, the total quantity of investment of PPP project is 13421.1 billion yuan. In the case of one year's outlook and 99% confidence, there are 1% possible to generate 14015.5 billion yuan of investment loss. Therefore, local governments in China should do a good job in debt loss in order to prevent of PPP projects in advance, that is to say, 140.155 billion ($14015.5 \times 1\% = 140.155$ billion yuan) of reserve funds should be prepared to prevent the debt risk of PPP projects.

3 Conclusions and Suggestions

3.1 Conclusions

Based on the above analysis, it can be concluded that the project investment of PPP management base in China mainly involves 19 industries, such as transportation, municipal engineering, tourism, etc. There is a linear relationship between the quantity of accumulated project investment and the amount of accumulated project investment. The future investment can be predicted according to the linear regression line. As of the first quarter of 2019, the total investment of PPP project is 13421.1 billion yuan. In the prospect period of one year, under the condition of 99% confidence, when the return on investment is 6.56%, the maximum loss will be 14015.5 billion yuan, that is, there are 1% possible to generate 14015.5 billion yuan of investment loss. Local governments in China should do a good job in debt loss prevention of PPP projects in advance, that is to say, 140.155 billion yuan of reserve funds should be prepared to prevent the debt risk of PPP projects. At the same time, we found that the larger the investment quantity of PPP project, the greater the debt risk faced by the government, and the greater the possibility of investment loss. Therefore, the government should control the investment scale of PPP projects and carry out strict supervision.

3.2 Suggestions

Improve the Risk Prevention Mechanism of PPP Project. PPP project is an agreement or contract signed by the government and the enterprise department. Although PPP project is a debt risk shared by the government and the enterprise, when the enterprise is in crisis or bankruptcy, the government will bear all risks for the debt. Therefore, the

government should establish a risk prevention mechanism for PPP projects. The specific contents include the following aspects: firstly, the government should conduct a comprehensive investigation on the cooperative enterprises to ensure that the enterprises have certain economic strength and credit conditions; secondly, the government can stipulate in the agreement or contract that the cooperative enterprises should reserve certain working capital as the guarantee fund for the PPP projects when the PPP projects In case of problems, this part of funds can be used; secondly, it is clear that the government and the cooperative enterprises bear the responsibility in proportion, which can reduce the debt risk borne by the government when there is debt risk in the PPP project; finally, during the implementation of the PPP project, the government should assign special personnel to supervise and manage, to ensure the effective implementation of the PPP project, to avoid uncompleted projects, which will lead to the debt risk borne by the government.

Establish Double Warning Lines for Debt Risk Assessment Indicators of PPP Projects. In the process of PPP project operation in China, financing often plays an important role, because PPP project involves amount Large, most enterprises finance through banks, trusts, funds, etc. as an important participant in PPP projects, financial institutions often provide more than 70% of the total amount of projects [8]. Some PPP projects are government guaranteed financing, once there is a problem in PPP projects, it will bring serious losses to the government, which forms the government's implicit debt. At present, China's PPP project has set a financial capacity warning line of 10%, but has not yet established a PPP project financing warning line. Therefore, in order to prevent the debt risk of PPP project, we should establish a dual warning line of PPP project financing and financial capacity. The compliant PPP project should not only meet the financial capacity, but also the financing scale should not be too large, otherwise it will bring implicit debt to the PPP project and the government.

Establishment of PPP Project Life Cycle Supervision System. PPP project life cycle includes identification, preparation, procurement, implementation and handover. PPP projects should be strictly reviewed in the identification stage. For example, some projects that do not conform to the PPP model are transformed into PPP projects through packaging. Such PPP projects should be strictly reviewed. At the same time, government funded representatives should be prohibited from signing any supporting documents. If such PPP projects occur, they should be stopped immediately. In addition, in the process of PPP project implementation (i.e. preparation, procurement, implementation and other stages), real-time monitoring shall be carried out at each stage, mainly to comprehensively monitor whether the cost amount and cost of the project are reasonable, the implementation progress and the specific implementation process [11]. Problems in the implementation of PPP project shall be found and solved in time to avoid the interruption of PPP project and failure to continue the implementation, and the debts incurred by this part shall be borne by the government. At the same time, we should be careful to carry out government paid projects to prevent the rapid growth of the government's financial expenditure on the project, so as to exceed the financial tolerance.

Establish Performance Appraisal System of PPP Project. The performance appraisal system of PPP project is to carry out comprehensive evaluation in the whole PPP project, i.e. according to the PPP project. All stages of the life cycle. In the identification stage of PPP project, it is necessary to assess the debt risk of PPP project, whether it is within the financial tolerance range, i.e. no more than 10% of the warning line. PPP projects beyond the warning line will not be passed, and the financing scale will also be considered. In the implementation process of PPP projects, success factor analysis, data envelopment analysis and balanced scorecard can also be used to assess the performance of PPP projects [12]. After the PPP project is completed, it also needs to be assessed, that is, whether the completion of each indicator of the PPP project is consistent with the budget. For the inconsistent PPP projects, the reasons should be found and analyzed, so that the subsequent PPP project implementation can learn from the experience and lessons. In addition, for the PPP projects that are not completed as required, corresponding countermeasures shall be given to avoid the failure of the PPP project, and the government will incur large debts. Meanwhile, the Department and person in charge of the project shall bear corresponding responsibilities. As for the PPP project completed according to the regulations, and the completion effect is good, it can be vigorously publicized and promoted, so that other PPP projects can learn from the experience of the successful project.

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