Research Article

Nonlinear Forecasting Model regarding Evolutional Risk of the PPP Project

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The special topic of this paper is to build a nonlinear measuring model between PPP project risk and multiple variables and test it through case analysis. Nonlinear regression method was used in this research to study the risk mutation of public-private partnership (PPP) projects without any significant events. Risk evolution is influenced by three factors which include (1) macroscopic environment, (2) micro environment, and (3) subject's capacity and their cooperative relationship. First, it reveals three main drive variables of project risk evolution through case analysis. Second, it builds a nonlinear time-varying measurement model which is then transformed to a classical regression model. Lastly, it estimates and tests the model parameter by an example. The study shows that there is an integral negative correlation among the three independent variables within a certain threshold range, revealing macro environment as the most significant factor of project risk. Analyzing the complex relationship between multiple impact variables and risk evolution of PPP projects can provide a basic tool for forecasting and control of risk.

1. Introduction

Under the current macroeconomic downturn pressure, infrastructure investment is still the main power promoting the growth of economy. The PPP model can effectively merge the resources and abilities of the public sector (government) and the private sector (enterprise), lower the unilateral risks of government and enterprise, and at the same time generate enthusiasm [1, 2]. Thus, nonprofit quasi-operational infrastructure projects with certain cash inflows are ideal. With the complex resonance of both internal and external environment changes and subject behavior evolution [3], the risk formation and evolution process of PPP projects is extremely complex for big investment scale, long construction, operation cycle, and multiple interest subjects. According to input variable changes, project risk evolution has two basic conditions. One is stability evolution owing to the inertia or continuity of PPP project risk evolution; the current project risk is highly correlated not only with the current environment and the height of subject variable, to a certain extent, but also with the risk in past periods [4–7]. When PPP project risk forms, an intrinsic motivation drives

its evolution until input variable changes within a certain gradual range, resulting in the characteristics of smooth and gradual evolution. The other basic condition is mutability evolution, wherein shock waves reach a certain point and the nature and structure of the project risk mutates, rapidly changing among different conditions so that the risk of volatility is relatively violent [8]; this type of situation usually occurs after a major sudden event.

C. Zhang et al. (2012) analyzed the dynamic evolution of PPP project risk from two aspects of endogenous and exogenous dynamics. F. Zo and Y. Zhang (2014) analyzed interactive evolution about risk elements of PPP project. L. Li (2014) analyzed the behavioral game between multiple subjects of PPP project and its impact on evolution of risk [9]. The evolution of PPP project risk is highly complex and nonlinear and this, therefore, poses a challenge to the prediction of PPP project risk. Many scholars have studied the nonlinear evolution of financial risk and have introduced this method into the field of engineering with a nonlinear time-varying measurement model for PPP project risk so as to help project owners better predict and manage risks [10–13]. The use of nonlinear science tools for analysis based

FIGURE 1: The main driving variables of PPP project risk evolution.

on the complicated nonlinear evolution of PPP project is suitable. We looked at existing research results of examples of the method of nonlinear regression model including the variable regression model [14], time-varying parameter model [15], and stochastic volatility model [16] and built a nonlinear time-varying measurement model to measure the relationship between PPP project risk and variables such as macro environment, micro environment, and the capacity and cooperative relationship of the subjects, as well as to estimate and inspect the regression coefficient combined with cases [17, 18]. In the model transformation, the logarithm and finite difference method not only simplify the nonlinear regression model to the multivariate linear regression model, but also basically eliminate the lagged effects of the previous risk by the finite difference method [19]. In order to avoid the phenomenon of “false return” [20] and ensure the validity of parameter estimation, we conducted the stationarity test, cointegration test, and Granger test [21], respectively, before the regression analysis of time series data. To obtain accurate parameter estimation, the least squares regression is used after ensuring the stable cause-and-effect relationship between effect variables. In previous studies, the nonlinear time-varying measurement model is mainly used to study the macroeconomic variables and the risk evolution of the financial market, whereas with this paper we introduce it to provide concise, practical analysis tools for project measurement and risk management.

The main goal of this study is to predict risk change by building a nonlinear model between PPP project risk and multiple variables. The main research methods are model building, questionnaire survey, statistical data analysis, and example analysis. The theoretical assumptions are as follows.

Hypothesis 1. The main influence variables of PPP project risk evolution include macro environment, micro environment, and subjects of PPP project.

Hypothesis 2. There is a complex nonlinear relationship between PPP project risk and multiple impact variables.

Hypothesis 3. The better the environment and the more the cooperation between the subjects, the lower the risk for PPP project.

2. Main Driving Variables and Mechanism of PPP Project Risk Evolution

The size of the PPP project risk is mainly codetermined by three variables including (1) the macro environment, (2) micro environment, and (3) the subject's capacity and game situation [22]. The interaction between internal elements, as shown in Figure 1 [23], reveals that the macro environment variables are basically independent and not affected by other variables, while the micro environment and the subject variables are interactive.

2.1. Main Driving Variables of PPP Project Risk Evolution.

Referring to the research results of B. Mohammad (2010) and others, this paper divides the main sources of PPP project risk into three aspects, (1) macro environment, (2) micro environment, and (3) the subject's capacity and cooperation relationship. Macro environment and micro environment are objective factors whereas the subject's capacity and cooperation relationship is the subjective factor. There are certain interactions between the two variables of micro environment

FIGURE 2: The mechanism of three risk variables of the PPP project.

and project subjects. Through case analysis [24], the main driving variables of the risk evolution are as follows:

(1) Macro environment variables (X): including political, economic, social, legal, and natural variables: ① political environment variables include government industrial policy adjustment, project examination and approval procedures changes, etc.; ② economic environment variables include fiscal policy and monetary policy changes, financial market volatility, macroeconomic slowdown, inflation, etc.; ③ social environment variables include public's opposition to the project construction, major public security issues or an incident of violence at the location of the project, etc.; ④ legal environment variables mainly refer to the legitimacy of the PPP projects, market demand, product/service charge, and the validity of the contract changes due to the change of laws and regulations, thus leading to normal damage, failure, or even the suspension of the project; and ⑤ natural environment variables include major natural disasters, deterioration of geological and hydrological conditions, continuous bad weather, etc.

(2) Micro environment variables (Y): including competition, market, operation, finance, management, technology, and other variables: ① competition environment variables are similar projects built by government investors forming substantial business competition to this project; ② market environment variables are when the market demand change leads to differences between actual demand and market forecasts; ③ operating environment variables include the actual price of PPP products or services being lower than expected and possible emergencies in operations; ④ financial environment variables can include investors unable to allocate funds in a timely manner, cash flow not being able to meet the target, difficulty financing, rising financial costs, etc.; ⑤ management environment variables include decision-making errors caused by substandard project management system, bureaucracy and lack of operating experience and ability, etc.; and ⑥ technical environment variables may include the inappropriate use of technology and outdated technology led by fast technology update

(3) Project subject variables (Z): including the cognitive level, behavior ability, and cooperation variables of the main associated subjects: ① investment subject variables include the inability to pay or fulfill the contract responsibility caused by main operation deterioration or bankruptcy, temporary withdrawal of funds or change of investment direction,

etc.; ② the contractor, subcontractor subject variables may be insufficient technology and management ability, lack of proper technical experts and managers, interruption or hidden quality control issues caused by technology and managerial errors in the construction, misunderstanding of owner's intentions and the bidding documents, improper pricing, etc.; ③ supplier subject variables would include the inability to supply the quality or quantity of materials on time; ④ design subject variables include errors in design, incomplete design documents, untimely delivery of drawings or inability to complete the design work, etc.; ⑤ supervision subject variables may be poor management and organizational skills, lack of work enthusiasm, professional ethics, and integrity, incorrect execution of contracts and instructions, etc.; ⑥ government subject variables include staff corruption, untimely payment of project funds, improper intervention, etc.; and ⑦ public subject variables may be a lack of public support for the project construction, the lodging of a protest or the imposing of strict requirements, etc.

2.2. The Mechanism of Three Risk Variables of the PPP Project.

The public-private partnership (PPP) project risk variables mentioned above will continue to change the level of project risk so as to change the combinational losses of the whole project value. The value losses brought by project risk are multidimensional, mainly shown as ① project delays, prolonged local (engineering activities, subdivisional work) or the construction and use time of the whole project; ② higher costs, including additional cost overruns and investment; ③ quality reduction of materials, technology, or engineering that does not pass approval levels; unqualified trial production and evaluation engineering quality; or the complete project not being able to meet the design production capacity; and ④ low revenue: less income and return on investment (ROI). The mechanism of three risk variables of the PPP project is shown in Figure 2, where the changes of the input and output variables are evident whereas the middle process is a "black box."

3. Nonlinear Time-Varying Measurement Model Construction about Smooth Evolution Risk of the PPP Project

The time series data of PPP project risk is nonlinear and irregular due to many factors; therefore, it is difficult for the

traditional linear model to accurately measure and describe the complex relation between multiple variables. Hence, we need to build a nonlinear time-varying measurement model which contains random fluctuations and will be relatively stable within certain threshold parameters.

3.1. The Construction of a Basic Model. Combined with the construction idea and method of stochastic volatility model and production function nonlinear time-varying model, the stochastic evolution model (formula (1)) of PPP project risk is built, which is used to describe the evolution rule and the sensitivity of PPP project risk under the action of environment evolution and subject's capacity and cooperative relationship changes.

$$R_t = X_t^\alpha \cdot Y_t^\beta \cdot Z_t^\gamma \cdot e^{\xi_t}, \quad t = 1, 2, 3, \dots, n. \quad (1)$$

In formula (1), R_t represents the size of the project risk in phase t ; X_t means the quality and stability of macro environment, Y_t is the quality and stability of micro environment, and Z_t is the cognitive level, behavior ability, and cooperation of associated subjects, assuming that macro environment (X), micro environment (Y), and the cognitive level, behavior ability, and game relation (Z) are basically independent and additive and multicollinearity does not exist; α, β , and γ are elasticity coefficients, which reflect the relative changes of explained variables to variables being explained; ξ_t is an unobservable random disturbance.

3.2. The Transformation of the Model. Formula (1) belongs to a linearized nonlinear time-varying model, replacing variables into multiple linear time-varying models and by taking the logarithm from formula (1) on both sides it can be transformed into

$$\ln R_t = \alpha \ln X_t + \beta \ln Y_t + \gamma \ln Z_t + \xi_t. \quad (2)$$

In order to eliminate the heteroscedasticity and multicollinearity caused by lagged variables, the following (formula (3)) is formed by further differential treatment.

$$\begin{aligned} \ln R_t - \ln R_{t-1} &= \alpha (\ln X_t - \ln X_{t-1}) \\ &+ \beta (\ln Y_t - \ln Y_{t-1}) \\ &+ \gamma (\ln Z_t - \ln Z_{t-1}) + \xi_t - \xi_{t-1} \end{aligned} \quad (3)$$

which can be expanded further:

$$\Delta \ln R_t = \alpha \Delta \ln X_t + \beta \Delta \ln Y_t + \gamma \Delta \ln Z_t + \Delta \xi_t \quad (4)$$

$$\begin{aligned} d(1) \ln R_t &= \alpha d(1) \ln X_t + \beta d(1) \ln Y_t + \gamma d(1) \ln Z_t \\ &+ \delta_t. \end{aligned} \quad (5)$$

The above variables in differential correction models appear in the form of difference; due to the low autocorrelation degree, there will be less multicollinearity to capture the long-term equilibrium relationship between variables. The variable substitution does not involve the use of regression coefficients, so the regression coefficients remain unchanged and can be calculated by the least square method.

4. The Empirical Analysis

The PPP project of xx highway stretches about 63 km with 4 years of construction, a 30-year operation period, and a total investment of 10.5 billion RMB. During the construction, the local government became a shareholder by land demolition and invested 5 million RMB. Social investors are responsible for the remaining capital and financing. During the operation, the local government provides guaranteed subsidies for the project, which means when annual operation income does not reach a certain proportion of the total investment, the government will supplement the insufficient share. Now we will analyze the relationship between risks in the construction period and the main variables by the nonlinear time-varying econometric model.

4.1. The Source and Processing of Original Data. Lacking direct data of project environment and subject, we used the questionnaire method [25] to obtain the original data of the four main variables. The evaluation criterion of variables is that if the evaluation body thinks an index is better, it should give it the higher score. Project risk value is equal to the weighted average of the actual values of four indexes, that is, (1) construction time, (2) cost, (3) quality, and (4) revenue:

ΔT = extension of construction time/original completion time

ΔC = cost overruns and additional investment amount/original cost or amount

ΔQ = engineering quantity which is unqualified or failed to meet the design production capacity after the completion/total

ΔM = the reduced amount of cash flow to expected earnings/original expected earnings

$$R' = (\Delta T + \Delta C + \Delta Q)/3$$

$$R = |R' \times 100|$$

The data of the macro environment (X), micro environment (Y), and behavior ability and game relation (Z) comes from the average value of 120 staffs of *The Yiyang-Loudi High Speed PPP Project* according to the 100-grade point which includes government, investors, and contractors. 120 questionnaires were distributed through the mobile network platform and 112 valid questionnaires were recovered. Time series data of each quarter from 2014 to 2017 is obtained by calculation regarding the overall risk, macro environment, micro environment, and the subject ability and relation and is shown in Table 1.

Using SPSS software calculation, the variation coefficients of four groups of data shown in Table 1 are $R_t = X_t^{-6.146} \cdot Y_t^{-2.559} \cdot Z_t^{-0.658} \cdot e^{44.293}$, $V_X = 0.034$, $V_Y = 0.086$, and $V_Z = 0.069$, among which V_R is between 0.1 and 1.0 and belongs to medium variation, and the other three variation coefficients are less than 0.1 belonging to weak variation, while the data range differences of the four groups are small. To eliminate possible heteroscedasticity of original time series data and obtain the classical regression model variables, we took, respectively, the logarithm and first-order difference

TABLE 1: The original risk data of The Yiyang-Loudi High Speed PPP Project.

Year/ Quarter	The observed value of overall risk (R)	The superiority and stability evaluation value of macro environment (X)	The superiority and stability evaluation value of micro environment (Y)	The evaluation value of subject ability and cooperation level (Z)
2014/1	$ -4.2\% \times 100 = 4.2$	98.1	91.9	93.8
2014/2	$ -5.5\% \times 100 = 5.5$	99.3	92.2	86.6
2014/3	$ -3.3\% \times 100 = 3.3$	99.6	91.5	94.3
2014/4	$ -9.4\% \times 100 = 9.4$	95.4	83.5	86.9
2015/1	$ -12.7\% \times 100 = 12.7$	91.4	79.3	81.8
2015/2	$ -13.3\% \times 100 = 13.3$	90.9	76.6	76.5
2015/3	$ -14.1\% \times 100 = 14.1\%$	91.2	71.9	78.4
2015/4	$ -6.8\% \times 100 = 6.8\%$	94.5	86.9	87.1
2016/1	$ -5.7\% \times 100 = 5.7\%$	96.2	89.1	85.5
2016/2	$ -6.2\% \times 100 = 6.2\%$	94.6	88.5	86.2
2016/3	$ -10.9\% \times 100 = 10.9\%$	93.3	80.7	83.7
2016/4	$ -12.2\% \times 100 = 12.2\%$	92.4	81.2	81.5
2017/1	$ -12.8\% \times 100 = 12.8\%$	91.1	78.9	83.9
2017/2	$ -15.3\% \times 100 = 15.3\%$	89.2	72.2	73.1
2017/3	$ -13.1\% \times 100 = 13.1$	90.8	77.3	79.6
2017/4	$ -14.3\% \times 100 = 14.3$	91.9	73.4	78.9

TABLE 2: The original logarithm data of The Yiyang-Loudi High Speed PPP Project.

Year/Quarter	$\ln R$	$\ln X$	$\ln Y$	$\ln Z$
2014/1	1.44	4.59	4.52	4.54
2014/2	1.70	4.60	4.52	4.46
2014/3	1.19	4.61	4.52	4.55
2014/4	2.24	4.56	4.42	4.46
2015/1	2.54	4.52	4.36	4.40
2015/2	2.59	4.51	4.33	4.34
2015/3	2.65	4.51	4.28	4.36
2015/4	1.92	4.55	4.46	4.47
2016/1	1.74	4.57	4.49	4.45
2016/2	1.82	4.55	4.48	4.46
2016/3	2.39	4.54	4.39	4.43
2016/4	2.50	4.53	4.37	4.40
2017/1	2.55	4.52	4.36	4.43
2017/2	2.73	4.50	4.27	4.29
2017/3	2.57	4.51	4.33	4.38
2017/4	2.66	4.52	4.29	4.37

of the project risk evaluation value (R), the superiority and stability evaluation value of macro environment (X), micro environment superiority and stability evaluation value (Y), and subject ability and cooperation level evaluation value (Z), with the results shown in Tables 2 and 3.

4.2. The Correlation Analysis of Variables. To analyze the correlation among variables from the intuitive perspective, Figure 3 is output through Eviews8.0, showing that the change trend correlation among $\ln R$ and $\ln X$, $\ln Y$, and $\ln Z$ is not obvious, whereas the negative correlation among $d(1) \ln R$

and $d(1) \ln X$, $d(1) \ln Y$, and $d(1) \ln Z$ is obvious through the first difference.

4.3. The Smoothness Test of Variables. To further quantitatively analyze the correlation among variables, regression analysis of the time series data is needed, before which variables data should pass the smoothness test so as to exclude “spurious regression” phenomenon and make sure of the validity of regression model parameters. Using ADF test methods [26], the results are shown in Table 4.

TABLE 3: The first-order difference of $\ln R$, $\ln X$, $\ln Y$, and $\ln Z$.

Year/Quarter	$d(1)\ln R$	$d(1)\ln X$	$d(1)\ln Y$	$d(1)\ln Z$
2014/2	0.26	0.01	0	-0.08
2014/3	-0.51	0.01	0	0.09
2014/4	1.05	-0.05	-0.1	-0.09
2015/1	0.3	-0.04	-0.06	-0.06
2015/2	0.05	-0.01	-0.03	-0.06
2015/3	0.06	0	-0.05	0.02
2015/4	-0.73	0.04	0.18	0.11
2016/1	-0.18	0.02	0.03	-0.02
2016/2	0.08	-0.02	-0.01	0.01
2016/3	0.57	-0.01	-0.09	-0.03
2016/4	0.11	-0.01	-0.02	-0.03
2017/1	0.05	-0.01	-0.01	0.03
2017/2	0.18	-0.02	-0.09	-0.14
2017/3	-0.16	0.01	0.06	0.09
2017/4	0.09	0.01	-0.04	-0.01

FIGURE 3: The change trend correlation analysis of risks and variables.

4.4. The Cointegration Test of the Variables. As seen in Table 4, the data is still unsmooth by logarithm, while the data by the first difference is smooth, which means that although the sequence data of a single variable is unstable, there may be a stable equilibrium relationship between independent variables and dependent variables. Therefore, the cointegration test of variables can be undertaken so as to conduct the Granger test. The results of analyzing data of four groups after taking the logarithm by Eviews8.0 are shown in Table 5.

Line 3 in Table 5 shows trace test value $P = 0.0001$ and the Max-Eigen test value $P = 0.0018$ are less than 0.05; these values deny the null hypothesis and show that there exists a cointegration relationship between variables. In Table 5, line 4, the trace test value $P = 0.0581$ and the Max-Eigen test value $P = 0.2831$ are greater than 0.05, which accepts the null hypothesis and indicates there exists one cointegration equation. The test values of P in line 5 and line 6 of Table 5 are less than 0.05 which denies the null hypothesis and shows that the number of cointegration equation is less than 2. To

sum up, there is only one long-term equilibrium relationship among the four variables.

4.5. The Granger Test of the Variables. The cointegration relationship among four variables indicates that there is at least one direction of Granger causality. As to what kind of Granger causality exists, multivariable Granger test is needed for further analysis [27, 28]. The results achieved by using Eviews8.0 software analysis are shown in Table 6.

The values of P in lines 1, 3, and 5 of Table 6 are less than 0.05, showing that the change of macro environment, micro environment, and subject capacity and cooperative relationship is the Granger cause of the project risk in the second lag period. But in return, the project risk is not the Granger cause of the change of macro environment, micro environment, and subject capacity and cooperative relationship.

4.6. The Parameter Estimation and Validity Test of the Model. After the above three tests, we used the linear least square

TABLE 4: The smoothness test of The Yiyang-Loudi High Speed PPP Project risks and variables.

Variables	t-Statistic	Prob.*	Results under Significance Level		
			1%	5%	10%
ln R	-1.834031	0.3504	-4.004425 Unsmooth	-3.098896 Unsmooth	-2.690439 Unsmooth
ln X	-3.079101	0.0517	-4.004425 Unsmooth	-3.098896 Unsmooth	-2.690439 Unsmooth
ln Y	-1.660200	0.4297	-3.959148 Unsmooth	-3.098896 Unsmooth	-2.681330 Unsmooth
ln Z	-2.647012	0.1059	-3.959148 Unsmooth	-3.081002 Unsmooth	-2.681330 Unsmooth
$d(1) \ln R$	-4.339817	0.0081	-4.200056 Smooth	-3.175352 Smooth	-2.728985 Smooth
$d(1) \ln X$	-3.735237	0.0207	-4.004425 Smooth	-3.175352 Smooth	-2.728985 Smooth
$d(1) \ln Y$	-3.542382	0.0229	-4.004425 Smooth	-3.098896 Smooth	-2.690439 Smooth
$d(1) \ln Z$	-5.360417	0.0009	-4.004425 Smooth	-3.098896 Smooth	-2.690439 Smooth

TABLE 5: The results of Johansen cointegration test on the variables.

Trace Test		Max-Eigen Test	
Null Hypothesis	Prob.**	Null Hypothesis	Prob.**
None *	0.0001	None *	0.0018
At most 1 *	0.0581	At most 1 *	0.2831
At most 2 *	0.0179	At most 2 *	0.0432
At most 3 *	0.0154	At most 3 *	0.0154

TABLE 6: The results of Granger test on the variables.

Null Hypothesis	Obs	Lags	Prob.
ln X is not the Granger cause of ln R	14	2	0.0480
ln R is not the Granger cause of ln X	14	2	0.4984
ln Y is not the Granger cause of ln R	14	2	0.0359
ln R is not the Granger cause of ln Y	14	2	0.5812
ln Z is not the Granger cause of ln R	14	2	0.0377
ln R is not the Granger cause of ln Z	14	2	0.0780

(LLS) method to estimate parameters and the results obtained by SPSS software calculation are shown in Table 7.

The VIF of three variables shown in Table 7 are less than 10, revealing that the three influencing variables of PPP project risk are independent and there is no approximate linear relationship among them; therefore, a multicollinearity problem does not exist in this model. In addition, the significant coefficient model calculated by SPSS software, $Sig = 0.000 < 0.005$, shows that the model is significant and credible; $2 < DW = 2.241 < 4 - d_u$ (when $n = 16$, $k = 4$, $d_u = 1.664$) shows that there is no first-order sequence autocorrelation; the fitting degree $R^2 = 0.930$ shows that 93.0% of the model can be predicted and the regression equation has a high fitting degree. Thus, in this case, the nonlinear time-varying measurement model of the

PPP project risk passes the parameter test and the parameter estimation is valid. Therefore, the relationship between the project risk and macro environment, micro environment, and the subject ability and cooperation level can be quantitatively described as $R_t = X_t^{-6.146} \cdot Y_t^{-2.559} \cdot Z_t^{-0.658} \cdot e^{44.293}$, suggesting that when macro environment index changes a unit toward a positive direction, project risk changes 6.146 units toward the negative direction; when micro environment index changes a unit toward a positive direction, project risk changes 2.259 units toward the negative direction; and when the subject ability and cooperation level index changes a unit toward a positive direction, project risk changes 0.658 units toward the negative direction. It shows that project risk is negatively related to three influencing variables, being most sensitive to the macro environment and least sensitive to the subject body.

5. Conclusion and Prospect

With this research we introduce an econometrics model into project risk analysis and evaluation. We studied the dynamic evolution relationship between the overall risk of large PPP projects and three variables without any significant events through model building and empirical analysis. The main research conclusions are as follows:

(1) When the PPP project risk steadily evolves within a certain threshold (e.g., the impact of project risk on the

TABLE 7: The regression coefficient of the model.

Model	Unstandardized Coefficients		Standardized Coefficients		t	Sig.	Multicollinearity Statistics	
	B	Standard Error	Trial Version				Tolerance	VIF
1	(Constant)	44.293	9.102		4.866	.000		
	ln X	-6.146	3.151	-.432	-1.950	.075	.114	8.745
	ln Y	-2.559	1.308	-.463	-1.957	.074	.100	9.996
	ln Z	-.658	1.325	-.092	-.497	.628	.163	6.135

project value is within 20%, which belongs to the lower level, and the nature of the project risk is not radically changed), the complex relationship between PPP project risk and multiple variables can be measured by nonlinear multiple regression model. Although the linearized model parameters share a certain approximation, it can simulate the interactive relationship between project risk and variables under stable conditions

(2) There exists a nonlinear negative correlation relationship among the size of the PPP project risk and the quality and smoothness of macro environment, the quality and smoothness of micro environment, and the subject ability and cooperation level. Therefore, project risk can be controlled by input variables such as the internal and external environment and the subject ability and cooperation relation. Because the relationship among variables is a complex nonlinear combination, a single independent variable and a dependent variable are not necessarily negatively correlated at some period of time (e.g., when an influencing variable slightly weakens and the other two variables significantly strengthen, it can decrease the whole project risk)

(3) Among three variables, the coefficient absolute value of macro environment variable is maximum showing that project risk is most sensitive to macro environment changes; that being said, the macro environment is relatively stable with small fluctuation and out of control by the subject, so it is not the main object of project risk control. However, the coefficient absolute value of micro environment and the subject is small, while their volatility and controllability are strong. Therefore, focus should be put on improving the micro environment, enhancing cognition level and behavior ability, strengthening the subject cooperation and reducing the game conflict, etc. In addition, it would be useful to control the risk to clear the risk management responsibility of the main body in the PPP project contract and give full play to their respective advantages

(4) The PPP project risk data predicted by this model is the same as the risk value obtained from actual observation regarding *The Yiyang-Loudi High Speed PPP Project*. It shows that the model has good prediction function. It also shows that the complex nonlinear influence relationship among variables can be measured by a certain exponential model. Indeed, the research presented here is limited to the smooth trend of PPP project risk; thus, for complex situations such as smooth evolution mixed with risk mutation, nonlinear approaches such as time-varying parameter model, Markova probability matrix, and the BP neural network would be required to further expand the risk evolution measurement model so as to improve its scientific and applicable scope

This paper builds a risk evolution prediction model for PPP project. It provides a useful tool for risk forecasting and control. The research is limited to the risk of PPP projects with stable trends. In the case of mutations, the model needs to be modified.

Data Availability

The data used to support the findings of this study are included within the article. Raw data was obtained through questionnaires. Other data were calculated by SPSS.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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