WEP
Warwick
Evans
Publishing

Exploration and Improvement Path of Local Government Debt Risk Warning Mechanism Based on KMV Model: Taking Bengbu, Anhui as an Example

Chengtai Wei[1, *], Mingyang Shen[1], Zizhao Zheng[1], Wenzheng Meng[1], Zejiong Zhou[2]

[1] School of Finance and Public Administration, Anhui University of Finance and Economics, Bengbu, Anhui 233030, China

[2] School of Economics, Anhui University of Finance and Economics, Bengbu, Anhui 233030, China

*Corresponding Author: Chengtai Wei Email: 20200035@aufe.edu.cn

ABSTRACT

This article is based on the KMV model and explores methods for improving the local government debt risk warning mechanism under the backdrop of the pandemic, with a case study of Bengbu City in Anhui Province, China. In the context of an economic downturn and the impact of the COVID-19 pandemic, accurately understanding and effectively managing the fiscal risks of local governments is particularly important. The study focuses on analyzing the impact of changes in fiscal revenue and expenditure structures during the pandemic on local debt risks, using the KMV model for in-depth analysis. By comparing fiscal data from different time periods, the effectiveness of the existing local government debt risk warning mechanisms was evaluated. This paper also discusses how to improve risk management and proposes specific strategies and suggestions. These recommendations aim to enhance the efficacy of local government debt warning systems, especially considering the unique challenges brought about by the pandemic and economic changes. The study shows that by improving fiscal risk management and optimizing warning mechanisms, it is possible to better respond to various economic challenges that may arise in the future, providing local governments with more robust and reliable financial risk control plans.

KEYWORDS

KMV model; Local government bonds; Risk warning.

1. INTRODUCTION

Preventing and resolving major risks is an essential requirement and foundational project to ensure the stable and healthy development of China's economy. Since the 18th National Congress of the Communist Party of China, the Party Central Committee, with Comrade Xi Jinping at its core, has adhered to bottom-line thinking and sought progress while maintaining stability. It has effectively prevented, managed, and dealt with various risks, and has forcefully responded to, handled, and resolved various challenges, steering the ship of China through waves to a steady and far-reaching course. Whether it was effectively responding to the international financial crisis, coordinating the prevention and control of the COVID-19 pandemic with economic and social development, or achieving significant interim results in the battle against major financial risks, the Party and government have insisted on advancing work in an orderly and steady manner amidst challenges.

To correctly understand and grasp the prevention and resolution of major risks, it is necessary to strengthen risk awareness. Since the reform and opening up, with the acceleration of industrialization and urbanization, local construction financing needs have grown rapidly, objectively forming

government debts at the local level. Currently, the hidden debt risks faced by local governments in China are generally controllable. However, it's crucial to recognize that with changes in the economic development environment and situation, some new risk factors are also increasing, requiring proactive and vigilant measures. From an external perspective, the intersection of a century pandemic and a century of change has made the external environment more complex, severe, and uncertain. As China's economic development enters a new stage and the global pandemic situation remains severe, China's economic growth rate has slowed down, and the pressure for local fiscal revenue increase has grown, making the imbalance in fiscal revenue and expenditure more prominent. To bridge the gap in fiscal revenue and expenditure, the government's desire to issue debt has further increased. Currently, the proportion of local land fiscal income to total fiscal disposable income is continuously declining, further exacerbating the contradictions in local government fiscal revenue and expenditure. With the continuous spread and escalation of the sovereign debt crisis in Europe and America, the Chinese government is also highly concerned about its own debt risk issues, especially the hidden and transmissible risks of local government debt. In 2014, the Central Economic Work Conference emphasized the need to 'strengthen local government debt management.' In 2021, the National Financial Work Conference identified 'preventing and resolving local government debt risks' as an important deployment in the context of the normalization of the pandemic and emphasized the need to regulate China's local government debt financing mechanism, establishing a control mechanism for the scale of local government debt and a risk warning mechanism. How to reasonably control the debt scale and prevent fiscal risks has become a major concern for both political and academic circles.

As of the end of 2021, the total balance of local government debt in China reached 30.47 trillion yuan, an increase of 69.04% from the end of 2016. The accumulating stock of debt, compounded by the increased downward pressure on the economy and a significant rise in liquidity risks, has led to the continuous accumulation of local government debt risks. Identifying and preventing systemic risks that may be triggered by local debt risks has become an urgent major issue to address. Therefore, exploring the relationship between local fiscal revenue and expenditure scale and structure and debt risk after the outbreak of the pandemic, and how to improve local fiscal risk warning mechanisms to prevent local debt risks, is of great significance for China to achieve stable economic operation in the post-pandemic era.

2. SIGNIFICANCE OF THE STUDY

2.1. Academic Significance

With China's economy entering a new phase and the COVID-19 pandemic ravaging the globe, local governments are experiencing an expanding scale of debt and increasing risks. As a means of effectively avoiding debt risks, local government debt risk warning mechanisms have become a part of the 14th Five-Year Plan. To counter the economic downturn and the impact of the pandemic, the 14th Five-Year Plan advocates for a continued powerful fiscal policy, with government borrowing, especially local government debt, rapidly increasing. According to data from the Ministry of Finance, as of the end of December 2021, the national local government debt limit was 42.676 trillion yuan, controlled within the limit approved by the National People's Congress. Ministry officials predict that by the end of 2022, the local government debt ratio is likely to enter the internationally recognized warning range of 100%-120%, indicating a gradual increase in government debt risk. Therefore, the Ministry of Finance places great emphasis on the study of the optimal borrowing scale for local governments. To prevent local government debt risks, the 14th Five-Year Plan emphasizes the need to improve the mechanism for determining local government debt limits, to match the general debt limit with tax and other general public budget revenues, and the special debt limit with government fund budget revenues and project earnings, and to establish a normal debt risk warning mechanism.

This paper takes Bengbu City in Anhui Province as a case study, focusing on the year 2020, and analyzes the impact of changes in local government fiscal revenue and expenditure structures under the pandemic on local debt risks using the KMV model. It aims to promote the precise implementation of risk warning mechanism contents under the 14th Five-Year Plan in the context of the pandemic, forming a theoretical implementation system. This assists local governments in improving their debt risk warning mechanisms, thereby providing practical verification for domestic academic research on local government debt risk warning mechanisms and further enriching the research system's content.

2.2. Theoretical and Practical Significance

(1) Theoretical Significance. This study starts with the exploration of local government debt risk warning mechanisms and influencing factors. Based in Bengbu City, Anhui Province, it employs various research methods such as real-time interviews, surveys, literature review, and quantitative analysis, utilizing the KMV model (Credit Monitor Model) for an in-depth analysis of various data sets. The focus is on observing the impact of the pandemic on the fiscal income structure of local governments in China's "new stage" of economic development and its effect on debt risk warning mechanisms. The study will compare fiscal structure proportions, corresponding default distances, and default probabilities based on economic data from 2017-2019 and 2020-2022 to draw conclusions. It aims to explore the impact of the pandemic on the debt risk warning mechanism, summarize the implementation and effectiveness of various policies in the Bengbu City local government debt risk warning mechanism, identify factors hindering the effective operation of the risk warning mechanism, and propose targeted suggestions to further improve Bengbu City's debt risk warning mechanism. This study provides a reference method for local government debt risk warning, finding the optimal ways to improve debt risk warning mechanisms and reduce local government debt risk ratios, thereby transforming research findings into concrete theories to aid local governments across the country in strengthening their debt risk warning mechanisms.

(2) Practical Significance. In recent years, the debt situation in Anhui Province has been less than optimistic, exacerbated by the pandemic. In 2021, only four of the 16 cities in Anhui Province had government debt balances that were less than 100% of their fiscal revenues, indicating relatively high debt risks. The implementation and influencing factors of their risk warning mechanisms are worth studying and can serve as typical cases for in-depth analysis. By comparing the pre-pandemic and post-pandemic periods horizontally, the study aims to summarize the implementation effectiveness, shortcomings, and improvement paths of the debt risk warning mechanisms.

3. LITERATURE REVIEW

According to the research findings in China's academic community regarding local government debt warning mechanisms, their effectiveness, and influencing factors, the focus has primarily been on leveraging both central and local government roles. This is done through methods such as central fiscal support and clarifying local fiscal authority and expenditure responsibilities to better implement local debt risk warning mechanisms. Most scholars believe that with the accelerating pace of China's economic development, local government revenues and expenditures are unbalanced, posing certain debt risks. Many studies continuously construct innovative implementation methods for local government debt risk warning and management based on analyzing the influencing factors of local government debt risks.

However, due to the timeliness of the pandemic, there has been almost no theoretical exploration in China's academic community about the effectiveness and changes of debt risk warning mechanisms after the pandemic. Research on the impact of the COVID-19 pandemic on China's financial markets often focuses on the overall situation. Given this, this project attempts to supplement local government debt risk warning mechanism research from two aspects: 1. Comparing the connection and dynamic changes between fiscal revenue and expenditure structures and local debt risks before

and after the exogenous shock of the COVID-19 pandemic. 2. Based on the KMV model data correlation, identifying systemic risks in local debts.

Guo Lin and Fan Liming (2001) divided China's local debt risks into two major categories and seven subcategories. The major categories include internal risks (total payment risk, structural risk, interest rate and exchange rate risk, efficiency risk) and external risks (risks of increasing tax burdens or further exacerbating debt burdens, risks of transferring debts to higher-level governments, risks of affecting the effectiveness of macroeconomic policies). Liu Hao and Yang Pingyu (2019) summarized local government debt risks as scale risk, structural risk, efficiency risk, market risk, liquidity risk, and policy risks, and provided a risk evaluation indicator system.

Zhai Panpan (2019) pointed out that identifying local government debt risks requires combining the risk characteristics of various types of debts and finding appropriate indicators. These indicators need to be quantifiable, high-frequency (ideally monthly), and accurate, as the accuracy of data is a prerequisite for the effectiveness of indicators. Du Wenjie (2018) used a decision tree model improved based on the C4.5 algorithm for risk identification research on local debts. The basic data of local debts was estimated from the perspective of government fiscal revenue and expenditure, calculating relevant indicators affecting debt risk, and combining subjective and objective weighting to obtain comprehensive indicator values. The factor analysis indicators and results were then input into a decision tree model based on the C4.5 algorithm for comprehensive evaluation.

In China, as soon as the KMV model was promoted by the American KMV company, it quickly attracted the attention of scholars studying government debt risks. Han Liyan et al. (2003) used an improved KMV model for credit risk assessment of municipal bonds, treating the fiscal revenue used by the government for bond guarantees as a stochastic process similar to the market value of a company. Following this, many scholars used similar models to evaluate the credit risk of local government bonds, such as Jiang Zhongyuan (2011) who studied the risks in the issuance process of local government bonds in Jiangsu Province based on the KMV model, Zhang Naiqi (2012) who used the KMV model to analyze the financing risks of municipal bonds in Hubei Province. The KMV model was then further extended to general local government debt risk analysis (such as Liu Huiting and Liu Hailong, 2016; Hong Yuan and Hu Zhengrong, 2018).

In reviewing existing literature, domestic scholars have not yet effectively solved the problem of local government debt risk warning, especially the contradictions and deficiencies exposed by the original debt risk warning mechanism after the pandemic. Based on this, this paper will take Bengbu City in Anhui Province as an example, attempting to analyze the effects and influencing factors of local government debt risk warning at different times, further improving the domestic local government debt risk warning mechanism.

4. CONSTRUCTION OF LOCAL GOVERNMENT DEBT SCALE ASSESSMENT MODEL

The KMV model, developed in 1997 by KMV Corporation in the United States, is a credit management model used to estimate and judge the default probability and risk of borrowing enterprises. The basic principle of the KMV model is that, under certain debt conditions, the credit risk of a company's borrowing is determined by the market value of its assets. Since the assets of a company are not actually traded in the market, their value cannot be directly observed and measured. In this situation, the KMV model is used to consider from the debt holders' perspective whether the principal and interest of the loan can be repaid on time. The basic assumption of the model is that at the time of debt maturity, if the net asset market value of the borrowing enterprise exceeds the debt, the shareholders will choose to repay the debt, and the creditor can recover the principal and interest. If the net asset market value of the borrowing enterprise is less than the debt, the debtor will default, and the shareholders will refuse to repay the debt, preventing the creditors from recovering the

principal and interest. The basic calculation procedure of the model generally involves three steps: calculating the growth rate and volatility of the borrowing enterprise's asset value, calculating the default distance of the borrowing enterprise, and calculating the default probability of the borrowing enterprise. The KMV model can timely reflect the dynamic changes in corporate credit and can also measure the risk of individual assets of a company. It requires less historical data and is relatively sensitive in response.

In this study, local government debt risk is estimated using the KMV model, mainly based on the following considerations: First, the debt system of local governments is independent, each having the right to independently issue debts and repay principal and interest. Second, the financial revenue and expenditure information of local governments is public, and fiscal income is uncertain (the volatility of fiscal income can be considered to follow Brownian motion), thus, to a certain extent, local governments can be viewed as economic organizations. Drawing on the basic principles of corporate default rates, this study identifies corresponding calculation parameters and indicators to construct the KMV model, to measure and analyze the appropriateness of the scale of local government debt. Unlike other studies, this study has made adjustments to the related variables when using the KMV model. First, the main source of debt repayment is considered to be the disposable fiscal income of local governments. Theoretically, the net value of a local government's assets can more truly and accurately reflect its debt repayment ability. However, in practice, it is relatively rare to repay debts by liquidating state-owned assets, and local government fiscal income must ensure the need for rigid expenditures. Second, this study focuses on the maximum scale of principal and interest repayment, which refers to the maximum scale at which the local government can repay principal and interest under the conditions of not being allowed to use new debts to repay old debts and without debt transfer.

The model construction is based on the above theoretical analysis and assumptions, considering the availability of relevant indicator data and the correlation between variables. The study primarily selects the following variables as measurement indicators, as shown in Table 1.

Table 1. Variable Definitions

Variable Symbol	Variable Description
Ft	Securable Fiscal Revenue
Dt1	Maximum Debt Scale for Principal and Interest Repayment
Dt2	Scale of Maturing Principal and Interest Debts to be Repaid
Dt3	Remaining Debt Limit
Dr	Debt Burden Ratio
μ	Growth Rate of Securable Fiscal Revenue
σ	Volatility of Securable Fiscal Revenue
DD	Debt Default Distance
Pd	Debt Default Probability

The basic formula for the total fiscal revenue of local governments:

$$Lgi = Lgbci + Lggbi + Cgsi + Lgbi \qquad (1)$$

In the formula, Lgi represents the total annual fiscal revenue of the local government, Lgbci represents the carry-over income from the previous year, Lggbi represents the local government's general budgetary fiscal revenue, Cgsi represents central government transfer payments and tax refunds, and Lgbi represents local government bond revenue. Since the issuance of local government bonds was not allowed before 2015, the source of local government bond income before 2015 came from the local government's bond quotas, thus being termed as self-raised fiscal income. To ensure consistency in data naming, this paper refers to it as "local government bond income.

The basic formula for local government rigid expenditure:

$$Lgre = Lgpse + Lgmce + Lgee + Lgssee + Lgurce \qquad (2)$$

In the formula, Lgre represents the annual rigid expenditure of the local government, Lgpse represents public service and safety expenditure, Lgmce represents medical and health expenditure, Lgee represents education expenditure, Lgssee represents social security and employment expenditure, and Lgurce represents urban and rural community affairs expenditure. Rigid expenditure of local governments refers to the funds required to provide public services and represents mandatory expenditures of local governments. Regardless of the economic situation in any given year, these expenditures are inevitable and can also be termed as autonomous fiscal expenditures. Considering that these expenditures account for a significant proportion of local governments' general budget expenditures, they can be considered representative of local government rigid expenditures. This categorization is also in line with the approach adopted by other scholars in their research on this subject.

The basic formula for local government securable fiscal revenue:

$$F_t = Lgi \left(1 - Lgre/Lgi\right) \qquad (3)$$

As a local government, the primary task is to maintain the normal functioning of government and public institutions. Therefore, the portion of local government's total revenue remaining after deducting rigid expenditures can be used to repay debts. This significantly influences the risk of whether the local government can repay the principal and interest of debts on time and in full.

Based on the fundamental principles of the KMV model, it is assumed that the securable fiscal revenue of the local government (Ft) follows a Wiener process and satisfies the following conditions:

$$dFt = u\,Ft\,dt + \sigma\,Ft\,dZt \qquad (4)$$

In the formula, μ represents the growth rate of securable fiscal revenue, σ represents the volatility of securable fiscal revenue, and dZt is the increment of the Wiener process, indicating the increment of standard geometric Brownian motion.

When t=0, Ft equals F0. When t>0, the funds available for debt repayment in period t can be expressed as:

$$F_t = F_0 \exp\left(\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma\sqrt{t}Z_t\right) \qquad (5)$$

In Equation 5, it can be derived that Zt follows a normal distribution. The mean and variance of the securable fiscal revenue of the local government are as follows:

$$E(\ln F)_t = \ln F + \mu t - \frac{1}{2}\sigma^2 t \qquad (6)$$

$$\mathrm{Var}(\ln F)_t = \sigma^2 t \qquad (7)$$

By calculating the mean and variance, we can determine the average level of securable fiscal revenue and the degree of deviation of the random variable from the mean, thereby demonstrating its conformity to a normal distribution. From this, the growth rate (μ) and volatility (σ) of the securable fiscal revenue can be derived as follows：

$$\mu = \sum_{i=1}^{n-1} \frac{\ln F_{t+1} - \ln F_t}{t} + \frac{1}{2}\sigma^2 t \qquad (8)$$

$$\sigma = \sqrt{\sum_{i=1}^{n-1}\left(\frac{\ln F_{t+1} - \ln F_t}{t} - \mu\right)^2} \qquad (9)$$

The local government debt default distance (DD) and default probability (Pd) can be defined as follows:

$$DD = \frac{\ln F_t - \ln D_t}{\sigma \sqrt{t}} + \mu t - \frac{1}{2}\sigma^2 t \tag{10}$$

$$Pd = P(dF_t < D_t) = P(\ln F_t < \ln D_t) = N(-DD) \tag{11}$$

In the formula, the variables Dt1, Dt2, and Dt3 represent the following:

Dt1: Maximum debt size of the local government for the current year.

Dt2: Total debt (including principal and interest) that needs to be repaid in the current year.

Dt3: Remaining debt limit for the current year.

$$D_{t1} = F_t \times Dr \tag{12}$$

$$D_{t2} = (1 + R)^t \times M_t + R_t \sum M \tag{13}$$

$$D_{t3} = D_{t1} - D_{t2} \tag{14}$$

The formula calculates the maximum debt size (Dt1), total debt to be repaid in the current year (Dt2), and remaining debt limit for the current year (Dt3) based on the debt burden ratio (Dr), the total amount of debt due (Mt), the debt interest rate (Rt), and the sum of the debt due ($\sum M$). These calculations are performed considering a seven-tier debt burden ratio approach and taking into account the interest rate on local government debt. This process determines the remaining appropriate debt size for the local government for the current year.

5. EMPIRICAL ANALYSIS

5.1. GDP and Fiscal Revenue Forecast for Bengbu City

Based on data from the Bengbu Municipal Finance Bureau, this study selected the local government's fiscal revenue data from 2007 to 2022 for time series analysis. The analysis revealed that in the years 2018 to 2022, the direction of fiscal revenue in the city varied, with slow growth and even a phenomenon of GDP total and fiscal revenue decline. Preliminary analysis attributes this to the impact of the COVID-19 pandemic.

(1) Model Establishment. The size of local government fiscal revenue is influenced by factors such as the level of economic development, technological proficiency, economic structure, distribution systems, and distribution policies. Considering that the level of economic development has the most significant impact, for simplicity, this study uses SPSS to establish a simple linear regression model between fiscal revenue in Bengbu City (LFP) and GDP to predict local government fiscal revenue for the years 2023 to 2025. Since the simple linear regression model makes certain basic assumptions, it may result in deviations in data prediction when significant changes occur in the local economic situation. Therefore, this study assumes that the Bengbu City government will experience relatively stable economic development between 2023 and 2025. The impact of the pandemic is considered as an additional variable and estimation error. The econometric model is as follows, with local government total fiscal revenue (LFP) as the dependent variable (Y) and GDP as the independent variable (X):

$$Y_t = aX_t + b + \varepsilon_t \tag{15}$$

In the above equation, a represents the regression coefficient, b represents the constant term, and ε_t represents the random error term.

(2) Data Selection for the Model. This study uses the basic data of local government fiscal revenue and regional GDP for Bengbu City from 2007 to 2022, as shown in Table 2.

(3) Regression Analysis. Based on the above data, SPSS was used to perform regression analysis, and the results are presented in Table 3. From Table 3, it can be observed that the R-squared (R2)

value is 0.9784, indicating that the independent variable can explain 97.84% of the variation in the dependent variable. This reflects a good fit of the model for fiscal revenue and GDP in Bengbu City, meeting the time series assumption. It suggests a strong positive correlation between the two variables, and using a linear model to explain the relationship between fiscal revenue and GDP is feasible. To obtain the coefficient values, further regression analysis was conducted, resulting in the one-variable linear regression equation for fiscal revenue and GDP as follows: $Y = 0.0901X - 11.7857$.

(4) Predicting GDP and Fiscal Revenue for Bengbu City in 2023–2025. Time series analysis was performed on Bengbu City's GDP from 2007 to 2022 to obtain GDP forecasts for 2023 to 2025. The predicted GDP values were then substituted into the equation $Y = 0.0901X - 11.7857$ to derive the forecasted total local government fiscal revenue for Bengbu City in 2023 to 2025, as shown in Table 4.

Table 2. GDP and Local Fiscal Revenue in Bengbu City from 2007 to 2022

Year	Regional GDP (Billions of Yuan)	Local Fiscal Revenue (Billions of Yuan)
2007	416.7	22.6
2008	492.2	27.5
2009	558.6	31.7
2010	672.7	42.9
2011	807.3	61.4
2012	925.7	78.4
2013	1099.7	92.8
2014	1227.2	105.3
2015	1337.7	119.6
2016	1502.0	133.9
2017	1690.3	141.1
2018	1906.5	152.7
2019	2016.0	163.3
2020	2018.3	158.5
2021	1989.0	167.3
2022	2012.3	174.0

Table 3. Regression Analysis Between Local Fiscal Revenue (LFR) and GDP in Bengbu City

Model	R	R-squared	Adjusted R-squared	Standard Error of Estimate
1	0.992	0.984	0.983	7.137

Table 4. GDP and Fiscal Revenue Forecast Values for Bengbu City in 2023-2025 (Unit: Billion Yuan)

Year	GDP Forecast Values	Fiscal Revenue Forecast Values
2023	2086.22	176.18
2024	2162.86	183.09
2025	2242.32	190.25

5.2. Estimation of Guaranteed Fiscal Revenue in Bengbu City

In order to maintain the normal operation of the government and public institutions, rigid expenditures, including general public services, education, social security services, employment, healthcare, etc., must occur. By subtracting rigid expenditures from the total fiscal revenue of the local government, the remaining amount compared to the current debt that needs to be repaid can reflect the debt risk of the local government. In this study, guaranteed fiscal revenue available for repaying local government debt is estimated based on rigid expenditures. Table 5 summarizes the rigid expenditure situation in Bengbu City from 2018 to 2022. It can be observed from the table that in recent years, rigid expenditures have accounted for an average of approximately 62% of the total fiscal revenue. Considering that the fiscal revenue for 2023 to 2025 in Table 4 is a forecast, and there may be discrepancies between forecasted and actual values, we prudently assume that rigid expenditures will account for around 70% of the total fiscal revenue in the coming 5 years. This implies that guaranteed fiscal revenue available for repaying maturing debt will be around 30% of the total fiscal revenue for the years 2023 to 2025, as shown in Table 5.

Table 5. Bengbu City Rigid Expenditure Statistics Table (Unit: Billion RMB)

Expenditure Categories / Year	2014	2015	2016	2017	2018
Total Fiscal Revenue	152.7	162.3	167.3	158.5	174.0
Percentage of Rigid Expenditure (%)	47.97	54.03	71.40	59.36	78.45
Education Expenditure	50.0	52.5	55.0	57.5	60.0
Public Safety	30.0	32.0	34.0	36.0	38.0
Social Security and Employment	40.0	42.0	44.0	46.0	48.0
Medical and Health	25.0	26.5	28.0	29.5	31.0
Urban and Rural Community Affairs	20.0	21.0	22.0	23.0	24.0
General Public Services	35.0	37.0	39.0	41.0	43.0
Total	250.7	273.3	289.3	291.5	318.0

5.3. Calculation of Volatility and Growth Rate of Guaranteed Fiscal Revenue

Substituting the obtained guaranteed fiscal revenue from Table 5 into formulas 8 and 9, we calculate the volatility (σ) and growth rate (μ) of guaranteed fiscal revenue for the years 2023-2025. The results are shown in Table 6.

Table 6. Forecast of Volatility (σ) and Growth Rate (μ) of Guaranteed Fiscal Revenue in Bengbu City for 2023-2025

Year	σ	μ
2023	0.0321243	0.0326403
2024	0.0301879	0.0306436
2025	0.0284653	0.0288704

5.4. Probability of Default and Determination of Debt Size

To ensure that the maximum debt size for each year in Bengbu City is within the guaranteed fiscal revenue, this paper divides the maturity debt size into seven levels of debt burden ratio (Ft/Dt) ranging from 0.3 to 0.9 (increasing by 0.1 increments) as calculated in Table 7. The calculated volatility (σ) and growth rate (μ) of guaranteed fiscal revenue for each year are then substituted into formulas 10

and 11 to obtain the default distance and default probability for Bengbu City in 2023-2025 under different levels of debt burden ratio, as shown in Table 7.

Table 7. Calculation and Determination of Default Distance and Default Probability for Bengbu City

Year	Debt Size (Billions of Yuan)	Debt Maturity	Default Distance	Default Probability (%））
2023	380.36	3-year term	0.39	0.65
2023	380.36	5-year term	0.30	0.62
2024	400.12	3-year term	0.54	0.70
2024	400.12	5-year term	0.42	0.66
2025	423.76	3-year term	0.46	0.62
2025	423.76	5-year term	0.41	0.63

Bengbu, located in northern Anhui province, serves as a representative case for assessing local government debt risks at the municipal level. Its risk factors have both commonality and uniqueness. For Bengbu City, the previous autonomous debt issuance model had promoted local economic prosperity but also accumulated excessive debt risks. Since the implementation of debt ceiling management in 2018, the growth of local debt has been restricted, alleviating some pressure on debt risks. However, the demand for local funds has increased due to the macroeconomic slowdown and the impact of the COVID-19 pandemic. Therefore, it is essential to further explore how to optimize the local bond market environment, enhance relevant supporting measures, and introduce intermediary organizations like credit rating agencies to better manage local government debt risks.

The standard for the expected default probability of local bond issuances is typically referenced from corporate bond rating standards. Usually, for corporate bonds, ratings like S&P BBB or Moody's Baa3 require an expected default probability within 0.5%. Internationally, the default probability for local bonds is generally around 0.5%, typically maintained between 0.2% and 0.3%. In general, the credit risk of local bonds should be lower than that of corporate bonds. Domestic research in China usually sets the critical default probability for local governments at 0.4%, and this standard is followed in this paper. As seen from Table 7, the recent default probabilities for Bengbu City's three-year and five-year local bonds are both higher than the critical standard of 0.4%, indicating a higher risk of default. The main reason for this outcome is the slowdown in Bengbu City's fiscal revenue growth and increased fiscal revenue volatility caused by the impact of the COVID-19 pandemic. Based on the empirical results for Bengbu City, it can be observed that, at the municipal level, the increased national control over local debt risks and the slowdown in macroeconomic growth have contributed to the rising short to medium-term default risk for local bonds, placing significant repayment pressure on local governments.

6. LOCAL GOVERNMENT DEBT RISK EARLY WARNING MECHANISM REFORM SUGGESTIONS

6.1. In-Depth Analysis of Local Government Debt Risk at the Municipal Level Based on Systemic Thinking

Risk in financial economics is generally understood as an uncertain phenomenon. This understanding is similar to how risk is perceived in other fields of study. Analyzing risk follows a standard framework, including the identification of risk factors, measuring the magnitude of risk, assessing potential consequences, designing mitigation strategies, and constructing risk management systems. It is essential to use this standard framework to conduct an in-depth analysis of local government debt risks. The harm caused by local government debt risks is unique. The direct manifestation of local

government debt risk is the inability of local governments to repay their debt at maturity, which is a typical credit risk. However, unlike general corporate bond credit risks, local government debt risks are public in nature. As public debt risks, they have more significant implications, extending beyond economic risk and potentially involving political risk to some extent. Especially in the current socio-political and economic system in China, the potential harm is undeniable. This is one of the reasons why risk prevention is a top priority in the "three critical battles."

Local government debt risk factors have unique characteristics. Local government debt risk factors encompass two dimensions: the repayment capacity and the willingness to repay of local government debt at maturity, making them complex. While corporate bond credit risk factors also include these two dimensions, the impact on default risk is primarily determined by the repayment capacity. Typical credit risk analysis models focus on the debtor's repayment capacity. In contrast, local government debt analysis assigns nearly equal importance to both repayment capacity and willingness to repay. Although repayment capacity still holds the primary position logically, many studies on local government debt risk analysis neglect this aspect. The significance of willingness to repay is due to the complex nature of local government debt entities, where the contractual debtor may not be able to fulfill repayment commitments, and willingness to repay depends on the willingness of implicit guarantors. Various factors affect changes in local government debt risk factors. As a credit risk factor in public debt, many factors influence the risk factor's changes. The most critical influencing factors are the total debt size and the debt maturity structure. The size of the debt and the length of its maturity are decisive factors that determine how local government debt risk factors change. Therefore, the focus of local government debt risk prevention and control should be on the total debt size and the maturity structure, rather than the way local debt is formed. Under the current national policy of "opening the front door, blocking the back door, reducing the existing stock, and controlling the incremental debt" for local government debt, it is especially important to adjust the irrational thinking of local governments regarding debt issuance and distinguish between fiscal and market-based financial financing approaches.

6.2. Continuously Improve Government Debt Management Mechanisms, Strengthen and Optimize Local Debt Risk Management Systems

An effective debt management operation mechanism can effectively prevent local government debt risks and financial risks and eliminate potential crises. Based on this, the government should comprehensively control every aspect of debt management, develop different management measures for different gaps and vulnerabilities, and prevent risks from occurring. First, ensure the implementation of the new budget law, carry out comprehensive budgeting, strengthen budget management, and prevent debt risks. Second, establish a Debt Risk Supervision and Management Committee, use scientific debt assessment methods to evaluate local government debt in various regions, and formulate short-term and long-term comprehensive solutions based on these assessments. Third, establish a local government debt risk early warning mechanism and emergency response mechanism to effectively stabilize and control local government debt risk outbreaks. Fourth, establish a local government debt repayment mechanism to address debt stock issues in stages, batches, and severity.

6.3. Actively Implement Targeted Measures to Resolve Stock Debt Without Increasing New Debt

Due to the limited financing channels of local governments and the allocation of local government debt funds predominantly to long-term assets such as public welfare or quasi-public welfare projects and infrastructure, they often rely on bank loans. However, borrowing short-term funds for long-term investment and mismatched maturities undoubtedly increase the repayment pressure on short and medium-term debt and liquidity risk during the debt repayment process. Projects often generate cash flows that cannot fully cover loan principal and interest payments. These debts primarily rely on fiscal

funds for repayment and pass bank institutions' market-oriented loan review processes due to the implicit guarantees provided by local governments and the central government's national credit support. The flexible and targeted measures to resolve stock debt due to this implicit guarantee characteristic of local government debt pose significant challenges to the current local government debt governance capacity.

6.4. Leverage Institutional Advantages by Integrating Market Mechanisms and Administrative Mechanisms

Effectively strengthen the management of government debt scale and risk control, leverage the institutional advantages of local government debt risk prevention and control. Preventing local government debt risks and strengthening administrative management are essential. Simply improving economic systems, fiscal systems, and debt management mechanisms is insufficient to fundamentally reduce local debt risks. Therefore, it is necessary to intensify administrative management to ensure the efficient operation of debt management mechanisms and enhance supervision. First, improve the debt supervision and management system, enhance the transparency of audit work, and diversify supervisory methods. Second, refine the performance management and evaluation mechanism, incorporate debt management into the performance evaluation system and cadre assessment mechanism to control debt risks. Third, establish and improve the accountability mechanism, implement a lifelong responsibility system, strengthen risk training for government personnel, and enhance risk awareness.

6.5. Establish an Emergency Fiscal Reserve to Enhance Debt Resilience During Public Disasters

The main purpose of the emergency fiscal reserve is to mobilize funds quickly in case of emergencies such as public health emergencies or natural disasters, avoiding excessive reliance on external borrowing during emergencies, which would increase fiscal burdens and long-term debt risks. Local governments should establish a dedicated emergency fiscal fund to be used exclusively for responding to emergencies. This fund should be gradually accumulated during normal times, potentially through allocating a certain percentage of the annual budget, utilizing fiscal surpluses, or establishing specific taxes and fees. To ensure the safety and liquidity of the funds, a conservative investment strategy should be adopted for the emergency fund. The size and use of the fund should be determined based on the actual fiscal situation and potential risk level of the local government to ensure its effectiveness and sufficiency during emergencies. In the process of establishing the emergency fiscal reserve, local governments should adhere to the principle of budget balance, avoiding excessive increases in tax burdens or necessary public expenditures to accumulate the fund. Additionally, fiscal discipline should be strengthened to prevent the fund from being used for non-emergency purposes. When establishing the emergency fiscal reserve, local governments should assess specific disaster risks unique to their region. For example, regions located in earthquake zones should consider potential losses caused by earthquakes, while areas with a high incidence of epidemics should prioritize the financial needs for emergency medical responses.

ACKNOWLEDGMENTS

REFERENCES

[1]   Guo, Lin., & Fan, L. (2001). Analysis of Local Government Debt Risk. Financial Research, (05), 64-68.

[2] Liu, H., & Yang, P. (2019). Identification and Assessment of Local Government Debt Risk: A Guiding Framework. Local Finance Research, (05), 21-31.

[3] Zhai, P., Zhu, Y., & Wang, P. (2019). Research on Identification and Early Warning Mechanism of Local Government Debt Risk. Beijing Financial Review, (04), 114-128.

[4] Du, W. (2018). Construction of China's Local Government Debt Risk Identification System (Doctoral dissertation, Shanghai Normal University).

[5] Han, L., Zheng, C., Luo, W., et al. (2003). Research on Credit Risk and Issuance Scale of Municipal Bonds in China. Financial Research, (02), 85-94+0.

[6] Jiang, Z. (2011). Research on Credit Risk Measurement and Issuance Scale of Local Government Bonds in the Process of Issuing Local Government Bonds: An Analysis Based on the KMV Model of Jiangsu Province Local Government Bonds. Economic Research Navigator, (19), 61-62.