Research and Prevention of Local Government Debt Risk Based on the Improved KMV Model

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Abstract: Today, changing international relations and increased uncertainty about external pressures have put downward pressure on China's economic growth. To comply with development, some local governments have appropriately increased the taxes, raising the risk of debt default. This paper applies the improved KMV model to analyze and measure the relevant data of the Guangxi Zhuang Autonomous Region government from 2015 to 2023. The results show that the probability of government default is negligible if the debt scale of the Guangxi Zhuang Autonomous Region government is controlled below 29.217 billion yuan, 26.215 billion yuan, 24.733 billion yuan, and 27.433 billion yuan during the period of 2024 - 2027, respectively. The article concludes with a series of policy recommendations in the hope of effectively preventing and resolving local debt risks and safeguarding the healthy development of the local government economy.

Keywords: Local Government Debt, Debt Risk, Default Risk, KMV Model, GM(1,1) Model

1. Introduction

The 19th Party Congress, in determining the "three major battles" for China's economic development, made the prevention, control, and resolution of major risks a top priority, and pointed out the need to prevent and resolve financial systemic risks in close connection with the new development concept. For the Chinese government, preventing and resolving local debt systemic risk is undoubtedly an issue it will focus on and address in the future. In terms of the total amount, on December 31, 2024, according to the website of the National Bureau of Statistics (NBS), as of the end of 2024, the balance of local government debt nationwide was 475371 billion yuan. Although the total amount is still within the controllable range, it shows a trend of expanding local government debt growth. As an important medium for balancing government revenues and expenditures, local debt can to a certain extent, promote local government economic development. However, if local governments raise too much debt and use the debt funds inefficiently, it is very easy to threaten the regional economic security.Since the international financial crisis in 2008, to alleviate the problem of economic recession in China. China has adopted a combination of proactive fiscal policies to regulate. In this process, local governments at all levels have actively invested in various infrastructure construction projects of the debt financing model, and the manifestation of the systemic risk of local governments in China is thus opened. According to relevant statistics, by 2017, China's local government debt balances grew exponentially, and systemic risk gradually transformed into explicit risk. Under the deployment of the work of preventing and resolving major financial risks, it is especially necessary to deal with the risk management of local debt. For this reason, it is necessary to build a long-term mechanism to prevent local debt risk in the long term. [1] According to Deng Wenyong et al. (2007), at the end of May 2004, local government debt was as high as RMB 45.5 billion at all levels in Guangxi. However, as far as Guangxi's finances are concerned, according to the financial department statistics, the total debt of Guangxi will reach 1.23 trillion RMB by June 2024, nearly 27 times more than that of 2004. Considering the impact of real estate on the economy this year, Guangxi's economic growth will be further downward, and the economic growth rate is expected to be 4.1% in 2023. Driven by the rigid task of stabilizing growth, the balance of governmental debt will continue to rise, and the regional exposure to fiscal risk will gradually climb. In the face of the risk situation, the government of Guangxi Zhuang Autonomous Region promulgated the Implementation Opinions on Strengthening the Construction of Government Debt Risk Prevention and Control System (Gui Zhengfa [2018] No. 6) on February 2, 2018, to build a debt management mechanism that supports "borrowing, using, managing and repaying" as a means to deploy key links such as the supervision of the whole process of debt financing, the classification and disposal of existing debts, and the emergency disposal of risks.The implementation of the 23 supporting sub-policy documents issued by the opinion constitutes a "trinity" system that includes limits, budgets, and risk early warning, which opens up a

change in the governance mode from passive prevention to active containment of government debt risk management in border and ethnic areas in China. While there have been many academic discussions on local government debt risk early warning, the early stage of the study is to use indicators to assess the debt riskto assess the debt risk quantitatively, such as borrowing dependence, debt service ratio and so on, as proposed by [2]Wang Xiaoguang (2005), but scholars later realized that there are limitations in the measurement with a single indicator, so a comprehensive indicator system was proposed. [3] For example, Xie Zheng and Chen Guangyan (2012) develop an urban local government debt risk early warning model adapted to China based on gray correlation and BP neural network.[4] Xu Qiang and Qi Xin (2013) study on the three northeastern provinces based on the fuzzy comprehensive evaluation method and the hierarchical analysis method.[5] Liu Hua and Lu Ya juan (2014) based on the factor analysis and the K-mean cluster method will be platforms assets, liabilities, earnings, etc. into groups with a view to early warning of financial platform operation risk.[6] Liao Jiaqin and Wu Hong Fang (2015) Early warning of some local government debt scale, solvency, and level of financial expenditure in China based on the method of risk factor analysis.[7] Jin Wei feng, Zhang Hai Xing, and Sun Yi (2020) Constructing the core concept of entropy power based on local government debt risk indicators for different aspects of borrowing, utilization and repayment. In addition, regression models are widely used in local government debt risk early warning research.[8] For example, Gu Qiao Ming and Qiu Yi (2014) analyze the relationship between local debt issuance and default rate based on the KMV model.[9] Jia Zhi Lian and Wang Zuo Xiang (2015) evaluate the debt risk status of Inner Mongolia based on the improved KMV model.[10]Wang Jun (2015) evaluate the debt risk status of Inner Mongolia based on the data of four provinces and regions in China. Data of four provinces and regions in central and western China on regression based on improved KMV and vector autoregression.[11] Li Shu ting and Niu Yu (2022) Measurement of local government debt risk in Shanxi Province based on improved KMV model and related feasibility suggestions.

However, the existing research on local government debt in Guangxi is still insufficient, mainly focusing on the status of local government liabilities and formation factors in Guangxi. Deng Wenyong et al. based on the definition and subtypes of local government liabilities in Guangxi, empirically analyzed the scale of local government liabilities and the factors of liabilities formation at the end of 2005 and before, and[12] Yuan Jie,[13] Duan Yanping et al, deeply analyzed this issue from different perspectives. Second, the governance of local government debt in Guangxi. Scholars have studied the management of local government debt and the risk of government debt default in Guangxi ([14] Liu Jiakai,[15] Hu Shaoyu,[16] Lin Quan), but seldom analyze it specifically, and the data used have become old. Hit by the real estate market, society became less stable. The debt risk of local governments is increasing. This requires an accurate measurement and scientific determination of local government debt risk, which is also a prerequisite to ensure the health and sustainability of local governments and the entire economic system.

Synthesizing the literature above, it can be found that the development of local government debt risk research has been able to use regression models to predict local government debt risk. For the research on local government debt risk, although many scholars have combined with the KMV model to carry out research, there is still a significant shortage of specialized research on local government debt risk in Guangxi, and most of the research data also has the problem of timeliness. At present, Guangxi's economic development is also facing many new challenges and changes, such as changes in economic growth rate, changes in industrial structure, changes in the degree of dependence on land finance, tightening of financial regulation and other factors are superimposed on each other, which makes the formation mechanism and manifestation of Guangxi's local government debt risk further complex, which also determines that the local government debt risk of Guangxi is showing a continuous upward trend. For the local government debt risk in Guangxi to make scientific and reasonable judgment, and objectively and accurately the local government debt scale to determine at a certain level, for the stabilization of economic and social development in Guangxi, to promote the high quality of sustainable development of Guangxi's economy, and to maintain the financial security and stability of the Guangxi region is of great significance.

2. Theoretical Analysis of the Causes of Local Government Debt Formation

2.1 Fiscal institutional factors

Mismatch of financial power and authority: According to Wang Qiao and Wang Zhuwang's "Study on the Causes of Local Government Debt Risks and Ways to Resolve Them", since the reform of the tax

system, there is a mismatch between the allocation of financial power and authority between the central and local governments, and local governments have assumed a large number of relatively fixed authority such as infrastructure construction, education, medical care and other areas, but lack of relatively large tax revenue sources with relatively weak financial resources, and in the central and western parts of the country, for example, there is a large amount of capital investment required from local governments in areas such as compulsory education, transportation infrastructure construction and the other regions. Compulsory education, transportation infrastructure construction and other areas require local governments to make a large amount of capital investment, its tax revenues can not meet the demand for expenditure, revenue and expenditure gap is large, relying on debt financing to make up for the main institutional factors that cause local government debt in China and the expansion of the system. Transfer payments system is not sound: transfer payments are used to regulate the imbalance of financial resources between the regions, prompting the local government to basic public services to be According to Ma Haitao and Bai Yanfeng in "The Current Situation, Causes and Preventive Countermeasures of Local Government Debt Risks in China", the imperfections of transfer payment in China at this stage mainly include the unsound structure and irrational distribution of funds. The amount of general transfer payment is small, and the conditions of special transfer payment are many, so it is difficult for some regions to obtain sufficient guaranteed transfer payment funds to meet the needs of local financial expenditures, which leads to the phenomenon of borrowing instead of receiving.

2.2 Economic development and land finance factors

Economic Development Demand and Investment Impulse: To stimulate local economic development, local governments encourage increased investment in infrastructure and industry. They promote infrastructure projects, such as highways and urban rail transit, with significant investment amounts that local governments find difficult to bear alone. As they strive to seize development opportunities for rapid growth, there is a strong investment impulse. Funding is gathered through issuing local government bonds and establishing financing platforms, resulting in a continuous expansion trend of debt levels. land financial dependence: most studies believe that at this stage, some of China's local governments are overly dependent on land finances, and the continuous development of the real estate market results in China's local government fund income being the most important source of land grants. Liu Shouying and Xiong Xuefeng proposed in "Land System and Local Government Debt" that if the real estate market fluctuates, the land transfer fee will be reduced, and the local government's fiscal revenue will plummet. To protect the stability of financial expenditure, infrastructure construction, livelihood projects, and other continuous investments, local governments continue to increase the scale of debt financing, thus expanding local government debt.

2.3 Appraisal and management factors

Distortion of performance appraisal mechanism: The traditional performance appraisal mechanism favors economic growth indicators, such as GDP growth rate, fixed asset investment scale, etc., but ignores debt risk prevention measures. Zhou Li'an mentioned in his research "China's local officials' promotion tournament mode research", based on the influence of such an assessment mechanism, local officials to seek promotion, easy to borrow heavily to develop infrastructure and economic construction, and in the short term to stimulate the development of regional economy, but often ignored the ability to repay the debt as well as the efficiency of the project, so that the scale of the debt is not to meet the local financial revenue, the scale of debt is expanding. The scale of debt has been growing. Regarding budget management, local government debt preparation is not fine enough, not scientific enough, and lacks budget constraints. Lou Jiwei has pointed out in his study "Deepening the Reform of the Fiscal System" that some local governments are not scientific and flexible enough in the management of debt revenue and expenditure, and arbitrarily change the direction of debt funds, resulting in the inefficient use of debt funds and raising the problem of debt risk. The local government debt supervision mechanism is not very good; there is a lack of external supervision, and an internal checks and balances mechanism has not been established. There are local government borrowing irregularities, a lack of adequate supervision, and a lack of control, resulting in the scale of local government debt being out of control to a certain extent.

2.4 Institutional factors for investment and financing

Due to the shortcomings of limited financing channels and regulatory problems, local governments have to resort to hidden financing channels such as urban investment platforms on the one hand, and the

other hand, the lack of regulation of these financing platforms has led to irregular debt financing behaviors and disorderly expansion of debt scale. In "The Influencing Factors of Local Government Debt Expansion and Its Economic Consequences", Fan Jianyong and Mo Jiawei found that urban investment platforms have the problems of insufficient information disclosure and high information disclosure cost as well as low investment efficiency in fund raising, which will lead to the expansion of local government debt as well as the increase of default risk. Financial market environment factors and financial policy factors also affect the scale of local government debt. In the case of loose financial policy, the financing interest rate in the financial market is low, and there are more funds, which leads to low financing costs, plus the difficulty of financing with the loose financial policy. Zheng Liansheng proposed in "Local Government Debt Risk: Formation Mechanism, Risk Assessment and Resolution Strategies" that, with the gradual tightening of regulatory policies, the requirements for government financing are getting higher and higher, and the difficulty of financing is increasing, while the difficulty of financing to stabilize the capital chain leads to the government's tendency to prefer some risky and costly financing methods, which is prone to increase the risk of debtto further increase the risk of debt; the loose financial regulatory policies have prompted the Loose financial regulatory policies, prompting local governments to over-indebtedness, resulting in a surge in the scale of debt.

3. Empirical Analysis of Local Government Debt--Taking Guangxi Zhuang Autonomous Region as an Example

3.1 Modeling

3.1.1 KMV model

The credit risk quantification model (KMV) is a measure of the likelihood of corporate default based on the debt default probability model introduced by the Merton model and the Black-Scholes option pricing model, using financial engineering methods, combined with the enterprise's asset-liability structure and the market value of equity as a dynamic variable. The core idea of the KMV model is to use the analysis model of European-style options to treat the loan pledged by the company's stock as a European-style call option. After the debtor obtains a loan by pledging the equity of the enterprise, its repayment behavior is a strategy to compare the future operating conditions of the enterprise according to the current value of the enterprise and the debt. After the debtor gets a loan by pledging the enterprise's equity, its repayment behavior is a strategy for comparing the enterprise's future operation status based on its present value and liabilities. In the case where the present value of the enterprise's equity is higher than the value of the liabilities, the debtor is more willing to exercise the option to obtain the residual value of the enterprise; on the contrary, when the enterprise's valuation is lower than that of the liabilities, the debtor will default on the debt toto minimize the losses incurred by the debt, in which case the actual value of the creditor's encashment will be lower than that of the claim.

$$DD = \frac{ln\frac{V}{L} + (\mu - \sigma_V)^2 \Delta t}{\sigma_V \sqrt{T}} \qquad (1)$$

$$P_t = N\left[\frac{ln\frac{V}{L} + (\mu - \frac{\sigma_V^2}{2})\Delta t}{\sigma_v \sqrt{T}}\right] \qquad (2)$$

3.1.2 Improved KMV model

In terms of the revision of the KMV model. The modified KMV credit risk model was first used to study the default probability of commercial credit institutions. In response to the current local emergence of regional debt problems in China, the domestic literature from about 2000 began to study the use of the KMV model to analyze the issues related to China's public finance, Han Liyan, Luo Wen and other scholars, who by the uniqueness of China's foreign debt of the local government to amend the original enterprise credit evaluation model and analyze the debt risk measurement model specifically for the government.

This paper introduces the improved KMV model, in the index design, its credit risk evaluation mechanism is designed in the following aspects: the government finance as an "institution", according to a certain amount of fiscal revenues to calculate the corresponding debt service funds available under the circumstances of the available financial resources, to build on this basis the corresponding credit risk mechanism That is to say, if in the face of the maturity of the debt repayment, the available financial

revenue can support the current maturity of the principal plus interest payments, then it can be recognized that this is a normal performance; otherwise, the actual situation of tax revenues is lower than the size of the debt repaid by the government in the same period, then, the actual debt default event has occurred.

Combined with the above thinking, the improved KMV credit risk measurement model replaces the credit risk evaluation parameters in evaluating government debt credit risk and utilizes evaluation indicators that are more compatible with government financial credit risk. Table 1 shows the replacement of specific key parameters in the KMV credit risk measurement model.

Table 1: Improved KMV model indicator replacement

pre-substitution	replacement
V: Market value of enterprise assets	R_t: Fiscal revenues at the disposal of local governments
μ: expected rate of return on business assets	g: Growth rate of local government revenue
L: Carrying value of enterprise liabilities	B_T:: Debt repayments required by local governments as they fall due
σ_v:: Volatility of the market value of an enterprise's assets	σ_m: Rate of change in local government revenues

The fiscal revenue that a local government uses to repay its debts is its disposable revenue, which is the remainder of the local government's total revenue after deducting its annual fixed expenditures. The reason for choosing the disposable financial income of local governments as a substitute for the market value of enterprise assets, rather than GDP, is that GDP only reflects the region's economic development, and does not reflect the ability to repay debt. Since local governments have different resources for debt repayment, there are significant differences in the proportion of fiscal revenues used. Still, one thing is sure: because of the impact of the scale of rigid expenditures to maintain the regular operation of governmental functions, the local government's income can not be fully used as the basis for debt repayment. Suppose the balance of local government revenues minus annual rigid expenditures can be fully utilized for debt servicing. In that case, there is no risk of debt default if it exceeds the maturity of the debt.

Thus, the improved KMV model is:

$$DD = \frac{ln\frac{R_t}{B_t} + (g - \frac{\sigma^2}{2})\Delta t}{\sqrt{\Delta t}} \tag{3}$$

$$P_t = N(-DD) = N\left[-\frac{ln\frac{R_t}{B_t} + (g - \frac{\sigma^2}{2})\Delta t}{\sigma\sqrt{\Delta t}}\right] \tag{4}$$

$$\sigma = \sqrt{\frac{1}{n-2}\sum_{t=1}^{n-1}(ln\frac{R_{t+1}}{R_t} - \frac{1}{n-1}\sum_{t=1}^{n-1}ln\frac{R_{t+1}}{R_t})^2} \tag{5}$$

$$g = \frac{1}{n-1}\sum_{t=1}^{n-1}ln\frac{R_{t+1}}{B_t} + \frac{1}{2}\sigma^2 \tag{6}$$

In the formula,R_t represents the government's disposable fiscal revenue in period t,B_T represents the total amount of debt the government needs to repay in period t, σ_m represents the rate of change of fiscal revenue, g represents the growth rate of fiscal revenue, DD represents the distance to default on the debt, andP_t represents the probability of default; andΔt represents the time of measurement, assuming that$\Delta t = 1$;

3.1.3 GM (1,1) model

In this paper, we will take the fiscal revenue data of Guangxi from 2015 to 2023 as a sample to forecast the general public budget revenue from 2024 to 2027, so we have to choose the most suitable forecasting model. Forecasting analysis is a heavy part of academic research, and various forecasting methods are widely used in practice, including the gray system analysis model, the time series analysis method, the deep learning method, and so on. China's local debt data was not published until the end of December 2015, but has two main characteristics: insufficient accumulation of historical data, and data gaps still exist in subsequent years; thus, the number of valid observations available is small and contains less valid information. Considering the dual reasons of small data sample size (n<10) and insignificant

time series variation, this paper chooses the first-order differential equation model GM(1, 1), which deals with a single system with insufficient information in the gray forecasting system. This model has theoretical feasibility in the small sample system forecasting problem with a small number of samples (n<10).

The GM(1,1) model starts by assuming that the original sequence is:

$$X^{(0)}(t) = \left\{ X^{(0)}(1), X^{(0)}\left(2, \dots X^{(0)}(n) \right) \right\} \tag{7}$$

By accumulating the initial sequence, we obtain a new sequence, and based on this sequence, we establish the GM(1,1) model, resulting in the form of the differential equation:

$$\frac{dx^{(1)}(t)}{dt} + ax^{(1)}(t) = u \tag{8}$$

In the equation, a is the gray number of development, and u is the gray number of endogenous control. From the least squares method, the vector of parameters to be estimated can be calculated:

$$\hat{a} = \begin{pmatrix} \alpha \\ u \end{pmatrix} = (B^T B)^{-1}) B^T Y_n \tag{9}$$

Among them:

$$B = \begin{pmatrix} -\frac{1}{2}\left(X^{(1)}(1) + X^{(1)}(2) \right) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}\left(X^{(1)}(n-1) + X^{(1)}(n) \right) & 1 \end{pmatrix} \tag{10}$$

$$Y_n = \left[X^{(0)}(2), X^{(0)}(3), \dots X^{(0)}(n) \right] \tag{11}$$

Further, the prediction model of the original sequence is obtained:

$$\hat{X}^{(1)}(K+1) = \left(X^{(0)}(1) - \frac{u}{\alpha} \right) - e^{\alpha k} + \frac{u}{\alpha} \tag{12}$$

Derivation of (3-12) gives:

$$\hat{X}^{(0)}(K+1) = \hat{X}^{(1)}(K+1) - \hat{X}^{(1)}(K) \tag{13}$$

By comparing the actual data and predicted data for error analysis, if the relative error is small, it indicates that the validity of the data is relatively high and the expected effect of the data will be more in line with the expectations, if the relative error is relatively large, the data can be preprocessed and then averaged to weaken the buffer arithmetic.

3.2 Empirical Analysis of Local Government Debt Risk

3.2.1 Guangxi Zhuang Autonomous Region

According to the improved KMV model to the empirical risk of local government debt risk, firstly, the probability of default of Guangxi government departments in different situations from 2024 to 2027 is measured. Then the upper limit of the debt scale of Guangxi government from 2024 to 2027 can be calculated, that is, the probability of default is almost equal to zero when the size of the government debt is lower than this upper limit.

The first step is to calculate the four parameters of the KMV model:

R_t: Represents the fiscal revenue that local governments can use to pay off local debts in period t, i.e., disposable fiscal revenue. Disposable fiscal revenue is obtained by first calculating the fiscal revenue and then subtracting the proportion of rigid expenditures.

B_T: It represents the scale of debt repayment to be paid by the local government in period t. This data is unavailable, so this paper adopts the ratio of debt repayment scale to disposable fiscal revenue, and sets the estimation range of 20%-90%.

σ_m: Represents the rate of change of local government revenue, which can be calculated from R_t according to equation (3-5).

g: Represents the growth rate of local government revenue, which can be calculated from R_t and σ_m

according to Equation (3-6).

3.2.2 Selection of financial indicators

Within the system of indicators for assessing fiscal payable financial capacity, it is necessary to calculate the indicators of fiscal payable financial capacity by the concept of a complete full-caliber budget. This needs to be done within the comprehensive budgetary revenue and expenditure, including three budget indicators: (1) Revenue indicators, i.e., general public budget revenue, including tax revenue and non-tax revenue. (2) Governmental fund budget revenue, including land grant and special revenue. (3) Transfer revenue, which refers to central transfer payments, special transfer payments, etc. Due to the strong inter-period and data availability limitations of governmental fund budget revenue and expenditure as well as transfer payment items, this paper adopts the principle of robustness, and replaces the transfer payment items and governmental fund budget items with general public budget revenue for alternative calculation under the general public budget revenue indicator, and the reasonableness of this treatment is also discussed by the Ministry of Finance's "Guidelines for the Preparation of the Comprehensive Financial Report of the Government" on the revenue recognition principle of prudence. The reasonableness of this treatment is also justified by the prudence principle of revenue recognition in the Guidelines for the Preparation of the Comprehensive Financial Report of the Government of the Ministry of Finance, which, to a certain extent, reduces the systematic bias caused by missing data.

Firstly, the GM(1, 1) model is used to predict the fiscal revenue data of Guangxi Zhuang Autonomous Region from 2024 to 2027, so the fiscal revenue data of Guangxi Zhuang Autonomous Region from 2015 to 2023 are needed, and the data are from the Wind database. Table 2 shows the fiscal revenue data of Guangxi Zhuang Autonomous Region from 2015 to 2023

Table 2 Fiscal Revenue of Guangxi Zhuang Autonomous Region, 2015-2023 Unit: billion yuan

particular year	General public budget revenue
2015	1515.16
2016	1556.27
2017	1615.13
2018	1681.45
2019	1811.89
2020	1716.94
2021	1800.15
2022	1687.72
2023	1783.80

According to the fiscal revenue data of Guangxi Zhuang Autonomous Region from 2015 to 2023, the general public budget revenue of Guangxi Zhuang Autonomous Region from 2024 to 2027 is measured using the GM(1, 1) model. According to Matlab, the data are predicted. The reduced value and relative error of the data are obtained as follows, the average relative error between the reduced value and the original value in 2015-2023 is 2.45%, which is a relatively small error, so there is no need to process the data.

Table 3 GM (1, 1) model fitting effect of the general public budget of Guangxi Zhuang Autonomous Region

vintages	Original value (hundred million yuan)	Reduced value (hundred million yuan)	Relative error (%)
2015	1515.16	1515.16	0
2016	1556.27	1617.503	3.79
2017	1615.13	1642.2121	1.65
2018	1681.45	1667.2987	0.85
2019	1811.89	1692.7685	7.04
2020	1716.94	1718.6274	0.01
2021	1800.15	1744.8814	3.17
2022	1687.72	1771.5363	4.73
2023	1783.8	1798.5985	0.82

The GM(1, 1) model calculates the general public budget revenue of the Guangxi Zhuang Autonomous Region from 2024 to 2027, which is shown in the second row of Table 4. From the data provided by the Guangxi Bureau of Statistics, it can be concluded that during the period from 2015 to 2023, the proportion of rigid expenditures to fiscal revenues in the Guangxi Zhuang Autonomous Region is basically more than 90%, which

indicates that the proportion of budgetary revenues available for debt service by the local government in the region accounts for roughly 10%, but in reality, fiscal revenues used by the local government to service its debts are far more than the single source of general public budget revenues, and the sources also include governmental fund Revenues and subsidies from higher levels, governmental fund revenues and subsidies from higher levels and other data are more challenging to collect, so this section analyzes the general public budget revenues on behalf of the fiscal revenues, the proportion of debt service upward. Considering these factors, this section determines that the proportion of local government revenues of the Guangxi Zhuang Autonomous Region to be used for debt servicing is about 20%, and accordingly calculates the fiscal revenues available for debt servicing, i.e., disposable fiscal revenues that can be used for debt servicing, as shown in the third row of Table 3.

Table 4 Projected value of fiscal revenues and fiscal revenues available for debt servicing in the Guangxi Zhuang Autonomous Region

particular year	2024	2025	2026	2027
revenue	1826.0741	1853.9694	1882.2908	1911.0448
Financial income available for debt service	365.2148	370.7939	376.4581	382.2090

3.2.3 Measurement of growth and volatility

According to Table 4, the disposable fiscal revenues of R_t from 2024 to 2027 of Guangxi Zhuang Autonomous Region, the volatility of σ and the growth rate g of the fiscal revenues of Guangxi Zhuang Autonomous Region from 2024 to 2027 are calculated by Matlab according to the formulas of (3-5) and (3-6).

Table 5 Guangxi Zhuang Autonomous Region 2024 to 2027 volatility σ and growth rate g

	2024	2025	2026	2027
σ	0.1185	0.1894	0.1587	0.1797
g	0.0152	0.0152	0.0152	0.0152

3.2.4 Measurement of default distance DD and default probability p

Distance to default DD and probability of default p are measured. The credit risk measurement model is set up with the accurate measurement of future debt repayment cash flow as the basic parameter. However, in China's bond market, which has a significantly low degree of full public disclosure of information, the timeliness basis for parameter estimation is weak due to (1) the phenomenon of time lag in updating historical data (the latest testable transaction data is only available up to fiscal year 2013); and (2) the probability of a credit event is a forward-looking forecasting problem, due to the fact that in the context of a disclosure system that is not perfect, the formation of the future observed values of the key variables of the "data gap period", this double constraint leads to debt cash flow forecasts that are neither historically comparable nor future verifiable, and therefore present an endogenous bias problem in an econometric sense. Therefore, an estimation interval of 20%~ 90% was developed using only the ratio of maturing debt to debt serviceable debt as a proxy. Run with Matlab to measure the debt default distance and default probability of Guangxi in 2024-2027

Table 6 Distance to default DD and probability of default P for local governments in Guangxi Zhuang Autonomous Region from 2024 to 2027

Current year debt service requirements/current year disposable financial income	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2024 Required to pay principal and interest on debt	73.042964	109.564446	146.085928	182.60741	219.128892	255.650374	292.171856	328.693338
Default distance	8.413358543	7.569476687	6.72559483	5.8817 12974	5.0378 31117	4.8022 26553	3.3500 67404	2.5061 85548
probability of default	1.99217E-17	1.87365E-14	8.74385E-12	2.0302 1E-09	2.3541 8E-07	7.8455 5E-07	0.0004 03959	0.0061 02078
In 2025, required to pay principal and interest on debt	74.158776	111.238164	148.317552	185.39694	222.476328	259.555716	296.635104	333.714492
Default distance	5.263901729	4.735918624	4.20793 5519	3.6799 52415	3.1519 6931	2.6795 95392	2.0960 03101	1.5680 19997
probability of default	7.05149E-08	1.09033E-06	1.28857E-05	0.0001 16639	0.0008 10867	0.0036 8556	0.0180 40958	0.0584 38233
2026 Required to repay principal and interest on the debt	75.291632	112.937448	150.583264	188.22908	225.874896	263.520712	301.166528	338.812344
Default distance	6.282186436	5.652066713	5.02194699	4.3918 27268	3.7617 07545	3.1979 54352	2.5014 68099	1.8713 48377
probability of default	1.66922E-10	7.9265E-09	2.55752E-07	5.6201 E-06	8.4378 7E-05	0.0006 92031	0.0061 83979	0.0306 48405
2027 Required to repay principal	76.441792	114.662688	152.883	191.10	229.32	267.54	305.76	343.98

and interest on the debt			584	448	5376	6272	7168	8064
Default distance	5.54804111	4.991558082	4.43507 5055	3.8785 92028	3.3221 09	2.8242 36735	2.2091 42946	1.6526 59919
Probability of default (%)	1.44444E-08	2.99471E-07	4.60201 E-06	5.2531 4E-05	0.0004 46699	0.0023 69668	0.0135 8235	0.0492 00048

As shown in Table 6, once the scale of local government liabilities in Guangxi Zhuang Autonomous Region exceeds a certain level, there is a risk of default. The empirical analysis of Han Liyan (2003) found that the default probability of local government bonds in China has the risk of default if it exceeds 0.4%, and 0.4% is the default warning value. Based on the results of 2024, if the local government's debt ratio does not exceed 0.7, i.e., the sum of the existing debt principal and interest does not exceed 25,565,037.4 million yuan. At this time, the overdue default rate of the debt will be close to 0, and theoretically, there is no default risk. When the Guangxi Zhuang Autonomous Region local government liabilities accounted for more than 0.9, the current debt should be returned to 32.869 billion yuan, the possibility of default is 0.61%, far more than its warning value.

3.2.5 Calculating the debt size ceiling

Using the interpolation method combined with the data in Table 5 can be calculated the ratio of local government debt to disposable fiscal revenue from 2025 to 2027ρ, if the probability of default is to converge to 0. Guangxi should controlρ less than the following values from 2024 to 2027, the results are as follows:

$$\rho_{2024} = 0.8$$

$$\rho_{2025} = \frac{(0.004 - 0.003) \times (0.8 - 0.7)}{0.018 - 0.003} + 0.7 = 0.707$$

$$\rho_{2026} = \frac{(0.004 - 0.00008) \times (0.7 - 0.6)}{0.00692 - 0.00008} + 0.6 = 0.657$$

$$\rho_{2027} = \frac{(0.004 - 0.002) \times (0.8 - 0.7)}{0.013 - 0.002} + 0.7 = 0.718$$

When 2024-2027 Guangxi government debt repayment/government disposable financial resources <0.800, 0.707, 0.657, 0.718, the possibility of default is zero, can be calculated as 2024-2027 Guangxi government government debt sustainability ceiling amount of 29.217 billion yuan, 26.215 billion yuan, 24.733 billion yuan, 27.443 billion yuan, respectively. billion yuan, 26.215 billion yuan, 24.733 billion yuan, 27.443 billion yuan.

4. Conclusions and Recommendations

In this paper, the risk of local government debt in Guangxi Zhuang Autonomous Region is initially identified. Based on the fiscal revenue data within the general public budget of Guangxi from 2015-2023, the GM (1,1) model is used to predict the economic indicators from 2024-2027, and the growth rate of the fiscal revenue, volatility, distance to default, and probability of default are used As a measurement parameter, this calculation gets the upper and lower limits of Guangxi government debt scale in 2024-2027 are 29.217 billion yuan, 26.215 billion yuan, 24.733 billion yuan and 27.443 billion yuan, that is, controlling the debt scale is within the upper and lower limits, and the risk of default of Guangxi government is extremely low. However, based on the complexity of the economic environment and the impact of inter-regional imbalance, it is still necessary to carry out strong risk prevention and control. Combined with the actual situation in Guangxi, this paper puts forward the following four suggestions.

4.1 Optimizing central-local fiscal relations and local tax structure

Guangxi and other central and western provinces in the tax system after the reform of the general phenomenon of financial rights and responsibilities do not adapt, coupled with the "camp to increase" after the lack of local central tax, border trade instability and the impact of the epidemic under the decline in tourism revenue and other factors, Guangxi financial revenue and expenditure is under great pressure. The next step, first, the central and local government affairs, financial power adjustment, should further strengthen the consultation with the central government, strive for the introduction of the central government for the border ethnic areas transfer payment policy, in promoting the "one belt and one road" construction, the opening up of the border, etc., on the central and local government tax share of the

proportion of expenditure to be clarified; second is the characteristics of the cultivation of local tax sources, the development, production and sales, and other aspects of local tax sources. Secondly, the cultivation of local tax sources with special characteristics, strengthening the collection of value-added tax (VAT) for cross-border service industries and the retention of surtax on tourism consumption in the links of R&D, production and sales, continuing to grant tax exemptions to local governments in proportion to the consumption of specific products, and taking advantage of the opportunity brought about by the RCEP to expand the share of tax revenue from ASEAN for the collection of imported goods; thirdly, the reform of the tax burden on the layout of resources with special characteristics, and studying the tax burden of the characteristic and advantageous resources, such as bauxite and sugar, and arranging different tax brackets. Arrangement of different tax rate ladder, into the "use resources, resources," "compensation for ecological compensation" within the scope of the resource tax framework; third is the operation of financial expenditure, the "cultural tourism + infrastructure" of the special Third, the financial expenditure operation, the "culture and tourism + infrastructure" special budget allocation to form a closed loop, reduce the amount of inefficient and low-level subsidies to reduce expenditure, reduce the administrative examination and approval expenditure of the "hall of government", the "digital government" platform to realize the formation of the closed-loop transparent management of the government budget, and to further release the potential of financial funds that can be used to pay off the debt.

4.2 Building a multi-source debt service guarantee mechanism

Constructing a debt service fund under the perspective of "double-circle" to enhance the guarantee of debt repayment: Source of the fund: 3%-5% of the general budget revenue, 10% of the net proceeds from land premiums, and 1% of the amount of new debt will be extracted; and a certain proportion of the revenue from the increase in tax revenue generated by the cross-border financial cooperation zone will be allocated according to the ratio. Fund use: to be handed over to the China-ASEAN cross-border capital management platform for investment in low-risk products, and to realize value-added by focusing on low-risk assets such as REITs of western land and sea new corridor infrastructures, green bonds, etc., and to make preparations for early repayment. Fund Trigger: Setting up alert lines for debt ratio and interest provision ratio, once the debt ratio and interest payment rate touch the alert value, the fund repayment mechanism will be automatically activated.

4.3 Strengthening full-cycle performance management of special bonds

Given that Guangxi's annual demand for new special bonds is about 18% (mainly for the construction of new western land and sea corridors, the Pinglu Canal, and other projects), it is necessary to make good use of the funds. Optimize project selection: Form a "China-ASEAN project database", promote China-ASEAN cross-border industrial chain projects, smart ports, and other projects, and clarify the self-balancing period of the project within 8 years. Utilizing blockchain technology to build a "penetrating" supervision platform for infrastructure construction funds of the Beibu Gulf International Gateway Port and the Pilot Free Trade Zone. Explore financing: Innovate TOD (Transportation Oriented Distribution) mode in transportation and logistics, and the proceeds from the appreciation of the surrounding land created by the project can be used for debt repayment.

4.4 Improvement of the debt-through-budget management system

Combined with the actual situation of Guangxi's hidden debt body concentrated in urban investment companies, government budgeting and management: the preparation of a full-caliber debt budget, PPP projects, government purchased services into the government's general budget (schedule) compilation; 12 counties and municipalities along the border of the debt to implement the "debt limit + transfer payments" linkage mechanism. Using intelligent early warning system to predict the risk of financial financing; developing and applying China-ASEAN big data credit management and monitoring information service platform, "big data" technology to monitor enterprise finance, taxation and economic information, effectively identifying hidden debt risks, establishing intelligent early warning with big data technology; and the same caliber early warning mechanism with social public security, together forming a platform for mutual relief of risks. Forming a platform for mutual relief of risks. On the one hand, establish a joint prevention and control system for China-ASEAN cross-border debt risk disposal, and deepen the risk mitigation of domestic and foreign capital flows; on the other hand, study and design the establishment of a debt-service reserve fund in the common budget of China-ASEAN border provinces and regions, as well as a risk buffer account for cross-border trade settlements - China-ASEAN Border

Trade Settlement Fund Pool. The second is to study and design the establishment of a debt service reserve within the common financial budget of China-ASEAN border provinces and regions, and a cross-border trade settlement risk buffer account - the China-ASEAN border trade settlement pool - as a comprehensive management system.

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