Credit risk evaluation of local government debt in Jiangsu Province

Dianhong ZHENG[1], Changsheng LI[1*]

[1]School of Humanities and Social Sciences, Harbin Institute of Technology, China
*Correspondence auther. E-mail: lichangsheng100@163.com

Abstract: In the process of economic development, local government's capital demand is expanding. With the acceleration of economic development and industrialization and urbanization process, local government needs more capital for local economic enhancement. Debt financing has become a major source of a local government method to capital. local government debt default situation is evaluated on the basis of recognition of Jiangsu province local government debt risk, structural risk, management risk and external risk, by comparing the four kinds of modern credit risk measurement model, selecting the appropriate KMV model, recognizing general budget revenue of Jiangsu province from 1994 to 2014 as a sample and constructing a quadratic curve which estimate annual revenue from 2015 to 2019.

[Dianhong ZHENG, Changsheng LI. **Credit risk evaluation of local government debt in Jiangsu Province.** *World Rural Observ* 2017;9(2):16-22]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 3. doi:10.7537/marswro090217.03.

Keywords: local government debt, credit risk, KMV model

Introduction

The credit risk is also called default risk, refers to the issuers who are not able to provide its contractual payment of principal and interest on time and in full amount. The risk comes from the instability of debt servicing. On the basis of credit risk identification, by comparing four types of credit risk measurement model which are commonly used, one was selected for the appropriate model to analysis local government debt credit risk in Jiangsu province, laying the foundation for credit risk management.

1. Model selection

Credit Metrics, McKinsey model, CSFP Credit Risk Plus Model and KMV model are important models of contemporary credit risk measurement.

The Credit Metrics model was a risk management product developed by J.P. Morgan in 1997 for quantitative analysis of credit risk. It evaluates credit risk from a portfolio of positions rather than a single asset. The Credit Metrics model's view is that the change in portfolio value was influenced by the borrower's default environment and the borrower's credit level transfer. Based on the credit rating of the known borrower, the credit rating transition matrices, the reclamation rates of overdue loan, and the credit risk spread on the bond market, the market value of the loan and its volatility, thereby the value of the personal loan and the combined loan are obtained.

The McKinsey model compensates for the shortcomings of Credit Metrics, deals with periodic components, and improves the immobilization of the rating transfer matrix at different periods. On the basis of Credit Metrics model, macroeconomic variables such as interest rate, unemployment rate, exchange rate, and economic growth rate and government expenditure are introduced. At the same time, the relationship between transfer matrix and macroeconomic variables is modeled and measure the "influence" of the periodic factor by Monte Carlo simulation model, thereby the change in probability of transfer is measured.

The CSFP model developed by Switzerland Credit Bank is a default model that differs from Credit Metrics by measuring the expected and unexpected losses in both cases of default and not the expected and unexpected value. The CSFP model's view is that changes in credit ratings and the corresponding changes in credit risk spreads are not part of credit risk but market risk. In this model, the probability of default is modeled as a continuous variable with a definite probability distribution, and each loan is treated as a small probability of a default event, and the probability of default for a single loan is independent of the rest of the loan, the loan portfolio has a default probability distribution similar to the Poisson distribution. CSFP takes into account the uncertainty of the amount of loss and the uncertainty of the probability of default, distinguishing the extent of the loss and the number of exposure risks, thereby increasing the accuracy of the risk measurement.

KMV model was a model which founded in the 1990s by United States KMV Company, with the idea of pricing ideas to assess the probability of borrowing business default probability. The KMV model holds that the market value of the borrower's wealth plays a decisive role in the credit risk of the borrower under the condition that the debt amount is determined. KMV model from the perspective of the loan business people think about the issue of loan settlement. If the

market value of the company's wealth is greater than the debt value of the company, the company's equity value is the difference between the market value of the company's asset wealth and the amount of the debt. The company will have the ability to repay the loan. When the company's market value of wealth is lower than the value of the debt, companies will choose to default, do not want to raise more funds to pay off debts.

Compared to the four commonly used models, KMV is more suitable for quantifying the default risk of local debt. On the one hand, in the above four kinds of credit risk measurement models, KMV model can carry out a single asset credit risk measurement, and other models are basically used for combination of risk management. On the other hand, due to the lack of statistics on the local debt data in China, it cannot meet the measurement method of predicting the default probability by using a large number of statistical samples. The risk measurement can be avoided by using the KMV model to avoid the requirement of default data, and the probability of default is calculated by the normal or logarithmic assumption of government revenue.

2. Model application

2.1 KMV model analysis

There are three steps to calculate the default rate by using KMV model: Firstly, estimating the local government revenue R which can be used to guarantee debt repayment, volatility σ and growth rate g. Secondly, calculating default distance DD with the help of statistical software. Thirdly, getting expected default frequency EDF.

Assuming local government revenue can be regarded as a statistical process obeying random process.

$$R_T = f(Z_T) \tag{1}$$

Where: R_T is the difference between fiscal revenue and and basic expenditure, refers to local financial revenue at time T which can be used to guarantee debt repayment on schedule, Z is random variable, $f(Z_T)$ is the specific function.

When the maturity date of the bond is T, the local government will default if the financial income of the local government used to secure for debt is lower than the repayment of the principal and interest. P is the probability of default, then the local government's expected default probability EDF can be expressed as following:

$$P = P[R_T < D_T] = P[f(Z_T) < D_T] = P[Z_T < f^{-1}(D_T)] \tag{2}$$

When a random variable follows a standard normal distribution, the formula can be changed to:

$$P = N[f^{-1}(D_T)] \tag{3}$$

Define the default distance, so the expected default rate EDF is:

$$P = N(-DD) \tag{4}$$

It is further assumed that the financial revenue that can be used to guarantee local government debt is subject to the following specific stochastic processes:

$$dR_t = gR_t dt + \sigma R_t dz_t \tag{5}$$

Where: g is the growth rate of local government revenue, and σ is the fluctuation rate of local government revenue, dZ_T is the increment of Wiener process (standard geometric Brownian movement). Defining t = 0, $R_0 = R$, when t>0, local government revenue available for debt guarantees can be calculated

$$R_t = R_0 \exp\left\{(g - \frac{1}{2}\sigma^2)t + \sigma\sqrt{t}Z_t\right\} \tag{6}$$

Now, define the above formula $Z_T \sim N(0,1)$, local government revenue follows log-normal distribution at this time, the mean and variance can be obtained:

$$E[InR_t] = InR + gt - \frac{1}{2}\sigma^2 t \tag{7}$$

$$Var[InR_t] = \sigma^2 t \tag{8}$$

In the detailed calculation process, you can take the time interval t = 1, that is expected default probability after a year of local government debt, so

$$g = \frac{1}{n-1}\sum_{t=1}^{n-1} In\frac{R_{t+1}}{R_t} + \frac{1}{2}\sigma^2 \tag{9}$$

$$\sigma = \sqrt{\frac{1}{n-2}\sum_{t=1}^{n-1}(In\frac{R_{t+1}}{R_t} - \frac{1}{n-1}\sum_{t=1}^{n-1} In\frac{R_{t+1}}{R_t})^2} \tag{10}$$

Expected Default Rate and Default Distance of Local Government Debt:

$$DD = \frac{In(\frac{R}{D_T}) + gT - \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}} \tag{11}$$

$$p = N\left[\frac{InD_T - InR - gT + \frac{1}{2}\sigma^2}{\sigma\sqrt{T}}\right] \tag{12}$$

In the empirical process, the model is usually used to estimate the default rate after a year, that is, take t = 1.

2.2 KMV model empirical

2.2.1 Estimated financial income for secured debt

Table 1. Government public budget income and expenditure of Jiangsu Province over the years, Unit: 100 millions

Year	Public budget income	Public budget expenditure
1994	136.62	200.17
1995	172.64	253.49
1996	223.17	310.94
1997	255.59	364.36
1998	296.58	424.90
1999	343.36	484.65
2000	448.31	591.28
2001	572.15	729.64
2002	643.70	860.25
2003	798.11	1047.68
2004	980.43	1312.04
2005	1322.68	1673.40
2006	1656.68	2013.25
2007	2237.73	2553.72
2008	2731.41	3247.49
2009	3228.78	4017.36
2010	4079.86	4914.06
2011	5148.92	6221.72
2012	5860.69	7027.67
2013	6568.46	7798.47
2014	7233.14	8472.45

Source: "Jiangsu Statistical Yearbook 2015"

According to the KMV model analysis of the previous section, it is necessary to first calculate the financial income of Jiangsu Province which can be used to guarantee the debt. Generalized fiscal revenue includes budget general income, extra-budgetary income and so on. In different years, the general budget income fluctuation is small. It is the most important source of local government's disposable financial revenue, so selecting general budget revenue in Jiangsu Province as a measure of fiscal revenue indicators. In addition, taking into account tax reform in 1994 had significant effect on local fiscal revenue, so select data from 1994 to 2014 as samples to do prediction. The following data from the 2015 Statistical Yearbook of Jiangsu Province is showed in table 1.

Making scatter plot by using the data of general budget income in Jiangsu Province from 1994 to 2014 is showed in Fig. 1. The relation between Jiangsu Province's local fiscal revenue and the years comply with time series of parabolic trend can be found.

In view of this, it is possible to temporarily fit quadratic curve equation:

$$\hat{y}_t = c_1 t^2 + c_2 t + c_3 \quad (13)$$

Where: Y_t is the prediction value of time series, and c_1,c_2,c_3 is the parameter of the time series. Using Eviews to do regression analysis, the regression model is:

$$R = 27.806\,t^2 - 271.887\,t + 746.566 \quad (14)$$

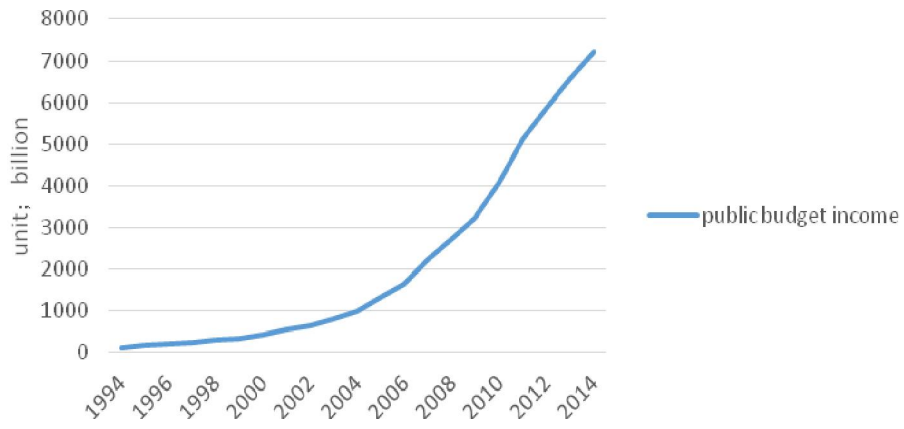

Fig. 1 Scatter plot of the general budget revenue in Jiangsu Province

The parameters of the regression model are shown in Table 2.

Table 2. Statistical Test of General Budget Revenue Return Model in Jiangsu Province

	Non - normalized coefficients	T value	P value	R^2	Adjusted- R^2	F
C_1	27.806	19.547	0	0.9924	0.9915	1170.657
C_2	-271.887	-8.438	0			
C_3	746.566	4.851	0.0001			

Table 3 Sample value and forecast value of general budget revenue of local government in Jiangsu Province unit: 100 millions

Year	Sample value	Forecast value
1994	136.62	502.485
1995	172.64	314.016
1996	223.17	181.159
1997	255.59	103.914
1998	296.58	82.281
1999	343.36	116.26
2000	448.31	205.851
2001	572.15	351.054
2002	643.7	551.869
2003	798.11	808.296
2004	980.43	1120.335
2005	1322.68	1487.986
2006	1656.68	1911.249
2007	2237.73	2390.124
2008	2731.41	2924.611
2009	3228.78	3514.71
2010	4079.86	4160.421
2011	5148.92	4861.744
2012	5860.69	5618.679
2013	6568.46	6431.226
2014	7233.14	7299.385
2015	—	8223.156
2016	—	9202.539
2017	—	10237.53
2018	—	11328.14
2019	—	12474.36

As seen from the results of E views analysis, R^2 is equal to 0.9924, adjusted R^2 is 0.9915, the statistic F is 1170.657 and a corresponding P value is zero. In addition, the statistic of t^2, t and constant coefficient were 19.547, -8.438 and 4.851 respectively, the corresponding P value are 0,0 and 0.0001. It is obvious that the second trend curve of the corresponding fiscal revenue of Jiangsu Province is shown. According to the above regression equation, the general budget income of Jiangsu Province 2015-2019 can be predicted, which are 8223.156, 9202.539, 10237.534, 11328.141 and 12474.36.

Table 3 for the Jiangsu Province general budget revenue sample value and two times curve is calculated by fitting the predicted value. The trend of the sample value and forecasting value was shown in Fig. 2. From Fig. 2, we can see that long-term trend simulated by using a quadratic curve is reliable.

Assuming that each year the proportion of local fiscal revenue accounted for the necessary tax revenue a is a constant. Jiangsu is located in the coastal developed areas. The financial needs of economic construction, but most of the investment needs to be attached to the local government, so the higher the necessary expenses. Table 4 shows according to the general public services, public safety, education, social security and employment, health, urban and rural community affairs basic expenditure as the necessary expenditure of Jiangsu province in 2010 -2014. The budget can be used to protect the local debt to pay the local tax revenue. From table 5, during 2010 – 2014 years, the basic expenditure of the budget for the total budget revenue is nearly \$75%, so the proportion of local fiscal revenue can be used to guarantee the proportion of about six of the total revenue of about \$25%. Thus, in accordance with the proportion of 25% can be calculated in Jiangsu, during 2015-2019, the local government debt can be used to guarantee the fiscal revenue was 2055.789, respectively, 2300.635, 2559.38, 3118.59.

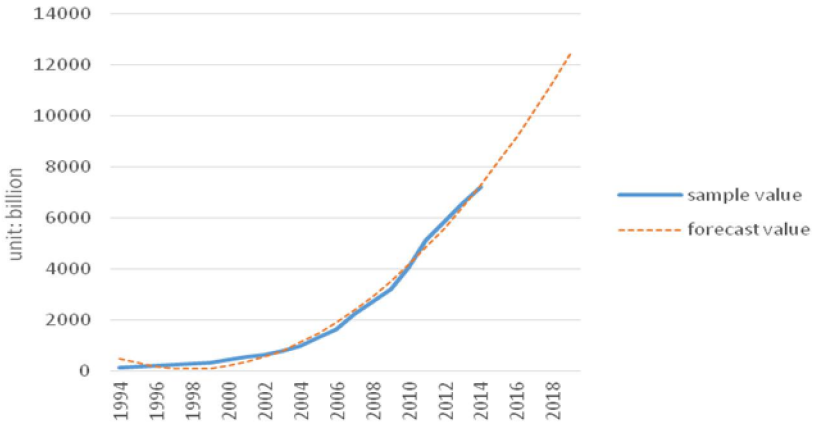

Fig. 2 Jiangsu local finance general budget revenue fitting trend

Table 4 Expenditure on public budgets in Jiangsu Province from 2010 to 2014 Unit: 100 millions

Indicators	2010	2011	2012	2013	2014
Public budget expenditure	4914.06	6221.72	7027.67	7798.47	8472.45
General public service	631.24	748.45	820.43	859.41	856.70
Public safety	326.80	371.40	407.78	452.99	473.83
Education	865.36	1093.22	1350.61	1434.99	1504.86
Science & Technology	150.35	213.40	257.24	302.59	327.10
Culture, sports and media	88.67	116.86	150.90	173.54	190.86
Social security and employment	364.48	481.65	557.77	631.15	709.59
Medical hygiene	249.69	349.86	418.14	475.86	560.93
Energy saving and environmental protection	139.89	170.37	193.83	229.18	237.78
Urban and rural community affairs	624.53	812.06	858.13	1006.80	1221.64
Agriculture, forestry and water affairs	489.16	618.13	754.09	868.34	899.31
Transportation	276.00	391.69	436.58	448.58	496.93
Resources exploration power information and other affairs	262.96	294.39	283.18	345.89	364.33
Other expenses	444.92	560.24	538.99	569.15	628.59

Source: "Jiangsu Statistical Yearbook 2015"

Table 5. Proportion of necessary financial income from 2010 to 2014 in Jiangsu province unit: 100 millions

	2010	2011	2012	2013	2014
Total expenses of six financial projects	3062.1	3856.64	4412.86	4861.2	5327.55
General budget income	4079.86	5148.92	5860.69	6568.46	7233.14
proportion	75.05%	74.90%	75.30%	74.01%	73.65%

Source: "Jiangsu Statistical Yearbook 2015"

Table 6. Forecast value of Jiangsu province's general budget income used for guarantee debt from 2015 to 2019 unit: 100 millions

year	2015	2016	2017	2018	2019
revenue	2055.789	2300.635	2559.38	2832.04	3118.59

2.2.2 Local government revenue growth rate and volatility

According to the formula 9 and 10 and table 6 data, local government revenue growth rate g and volatility σ value of Jiangsu province from 2015 to 2019 can be estimated. The results are as follows:

Table 7 g and σ values for Jiangsu Province 2015-2019

	2015	2016	2017	2018	2019
g	0.1283	0.1125	0.1066	0.1012	0.0964
σ	0.0639	0.0643	0.0665	0.0689	0.0715

2.2.3 Calculating default distance and default rate

According to the formulas 11, 12 and table 7, the different period of Jiangsu provincial government bond issuance scale, default distance and default rate can be calculated. Due to the lack of government debt scale statistics, here assume that the scale of the bond is 0.9-0.1 times the financial income of the secured debt, thus measuring the default distance and default rate. Table 8 shows default distance and default rate according to different assumption of issuance scale.

From table 8, it can be found that the larger the size of the debt is, the greater the default rate is. Combined table 8 with relative statistic, we can find that Jiangsu Province has the responsibility to repay the debt of 150.458 billion Yuan in 2015, the amount of debt in 2015 is 0.7 times more than the local income that can guarantee the debt, in this year, the default rate is greater than 12%, and the default risk is bigger. In 2016, Jiangsu Province has the responsibility to repay the debt of 86.509 billion Yuan, the debt is 0.3-0.4 times than the local revenue that can guarantee the debt, the default rate is between 0.3% -1%, and the default risk is lower than 2015. Jiangsu Province has the responsibility to repay the debt of 48.49 billion Yuan in 2017, the default rate is less than 0.1%.

Due to the lack of a specific amount of debt repayment obligations after 2017, the specific rate of default can not be calculated. With the expected default rate of 0.4% as a measure, the amount of debt that should be paid by Jiangsu provincial government is reasonable and the default rate is small, when the debt scale is between 0.2-0.3 times than the local income that can guarantee the debt.

Table 8. Debt default distance and default rate of Jiangsu province from 2015 to 2019

Year	Issuance scale		Default distance	Default rate
	D_T/R_T	D_T	（DD）	（P）
2015	0.9	1850.2101	0.3912437	34.80%
	0.8	1644.6312	0.7824875	21.70%
	0.7	1439.0523	1.1737312	12%
	0.6	1233.4734	1.5649749	5.90%
	0.5	1027.8945	1.9562186	2.50%
	0.4	822.3156	2.3474624	0.90%
	0.3	616.7367	2.7387061	0.30%
	0.2	411.1578	3.1299498	0.10%
	0.1	205.5789	3.5211936	0
2016	0.9	2070.5715	0.3888253	34.90%
	0.8	1840.508	0.7776506	21.80%
	0.7	1610.4445	1.1664759	12.20%
	0.6	1380.381	1.5553012	6%
	0.5	1150.3175	1.944127	2.60%
	0.4	920.254	2.332952	1%
	0.3	690.1905	2.721777	0.30%
	0.2	460.127	3.110602	0.10%
	0.1	230.0635	3.499428	0.00%
2017	0.9	2303.442	0.375959	35.30%
	0.8	2047.504	0.751918	22.60%
	0.7	1791.566	1.127877	13%
	0.6	1535.628	1.503836	6.60%
	0.5	1279.69	1.879795	3%
	0.4	1023.752	2.255754	1.20%
	0.3	767.814	2.631713	0.40%
	0.2	511.876	3.007672	0.10%
	0.1	255.938	3.383631	0.00%
2018	0.9	2548.836	0.36285	35.80%
	0.8	2265.632	0.7257	23.40%
	0.7	1982.428	1.088549	13.80%
	0.6	1699.224	1.451399	7.30%
	0.5	1416.02	1.814249	3.50%
	0.4	1132.816	2.177099	1.50%
	0.3	849.612	2.539949	0.60%
	0.2	566.408	2.902799	0.20%
	0.1	283.204	3.265648	0.00%
2019	0.9	2806.731	0.34966	36.30%
	0.8	2494.872	0.699321	24.20%
	0.7	2183.013	1.048981	14.70%
	0.6	1871.154	1.398642	8.10%
	0.5	1559.295	1.748302	4%
	0.4	1247.436	2.097963	1.80%
	0.3	935.577	2.447623	0.70%
	0.2	623.718	2.797284	0.30%
	0.1	311.859	3.146944	0.00%

3. Conclusion and discussion

This study selects general budget revenue of Jiangsu province in 1994-2014 as sample, the fitting quadratic curve predicting in 2015-2019 financial general budget revenue, and selecting of 25% can be secured debt guaranteed revenue ratio to calculate the future can be secured debt finance income. By changing the KMV model, the default distance and default rate of local debt in Jiangsu province we can expect. The analysis shows that in order to reduce the risk of default, the local government debt in Jiangsu province should be between 0.2 and 0.3 times the

income of the local government.

However, this model also has some problems, mainly shown in two aspects, on the one hand, when predicting local fiscal revenue in 2015-2019, by 1994-2014 sample data fitting conic, despite the regression results show higher fitting degree, but expected revenue growth rate can't completely follow the regression equation. On the other hand, when selecting can guarantee the financial income of the debt ratio of alpha, it is estimated by the necessary expenses accounts for the general budget revenue ratio estimation in recent years, however, the fact is that alpha is only an ideal value, when the economy of Jiangsu province changes, fiscal spending will also be necessary, in this way, the predicted value which can guarantee is not precise enough.

In general, although the model is not perfect, but the model still has some practical significance, it is in recent years, Jiangsu Province, debt credit risk situation for reference, but also for the future scale of Jiangsu Province to provide theoretical sup.

References

1. Filipiak, Beata. Local Government Level of Public Debt in 2000-2009 on the example of units of west Pomerania voivodeship [J]. Research Papers of Wrocaw University of Economics, 2011(152):12.
2. Cheng Yanting, the construction of long-term mechanism of local government bond issuance in China [J]. Taxation and Economy, 2010 (01): 32-38.
3. Kunyu Tao. Assessing Local Government Debt Risks in China: A Case Study of Local Government Financial Vehicles [J]. China & World Economy, 2015(5): 1 –25.
4. Yang Daji, Wang Ruojun, Xia Youwei. Study on Local Government Debt Based on Competition [J]. Economics and Management Research, 2014 (01): 86-94.
5. Ma Tingyu, Liu Zelong. Study on the Measurement of Credit Risk of Local Government Bonds Based on Improved KMV Model [J]. China Foreign Investment, 2012 (20): 57-58.
6. Ma Degong, Ma Xinjie. Local government debt risk prevention and control mechanism empirical analysis - based on KMV model of Sichuan local debt risk assessment [N]. Southwest University for Nationalities, 2015-02-10 (05).
7. He Huiling, Zhang Daijun. Study on Credit Risk and Security Debt Scale of Local Government Debt - Empirical Analysis Based on KMV Model [C]. 21st Century Quantitative Economics. Beijing: Economic Management Press, 2015: 207-22.

5/28/2017