

Credit Risk Measurement of Listed Manufacturing Companies in China

Based on modified KMV Model for Empirical Analysis

Xuechan Lu

School of Economics and Management
Jiangsu University of Science and Technology
Zhenjiang, China 212003

Wei Di

School of Economics and Management
Jiangsu University of Science and Technology
Zhenjiang, China 212003

Abstract—The whole manufacturing industry is in overcapacity across China, which is a key field for the supply-side reform. In recent years, the industrial credit risks are increasing continuously, and it is becoming more and more important on how to reasonably measure and identify the credit risks of manufacturing companies. This article chooses the financial data of 2015 from 60 listed companies as samples for analysis, setting ten different default points, with the SPSS, Matla and other tools used so as to get, compare, analyze and verify the results under different default points, it is found that under the default points, the revised KMV model has a common difference to identify the credit risks of listed manufacturing companies. Finally, the article draws a conclusion and gives relevant analysis.

Keywords—credit risk; KMV model; default point; manufacturing industry

I. INTRODUCTION

It is predicted by the *Non-Performing Financial Assets Market Survey Report* that the non-performing loans rate of banks will come to 2%-3% in 2016, most of which take place in the manufacturing industry. The statistics data released by China Banking Regulatory Committee show, by the end of the first half of 2015, the balance of non-performing loans of commercial banks had reached 1,091.9 billion yuan, and the non-performing loan rate was 1.5%, 0.25 up over the end of 2014, who mainly took place in the manufacturing industry. Refer to "Table I" Details of non-performing loans in 2013 and 2015.

The credit risk of whole manufacturing industry increasing, and the industry is in an overcapacity, lacking of innovation, it becomes the key field for the current supply-side reform. As a capital-intensive industry, the manufacturing industry in a great need of capital, and the loans from banks are an important source of financing for manufacturing companies, which means that during the financing, it is becoming more and more important to weigh the credit risks of the companies concerned. Under the background, this article selects the 2015 financial data of 60 ST and * ST companies at random to verify and modify the model, and the modified KMV model is used to determine the credit risks of the listed companies selected at random out of the manufacturing industry, the

results are analyzed and compared so as to select the credit weighing model more suitable for the manufacturing companies listed in China, which has a significant role in the practice. Based on the theoretical and empirical analysis, this article is expected to more scientifically weigh the credit risk of manufacturing companies and present references for the healthy development of the field and the form of the whole manufacturing industrial structure.

TABLE I. NON-PERFORMING LOAN RATE OF BANKS

	2013		2015	
	Non-performing loan rate of banks	Non-performing loan rate taking place in the manufacturing industry	Non-performing loan rate of banks	Non-performing loan rate taking place in the manufacturing industry
Industrial and Commercial Bank of China	1.04%	1.82%	1.44%	3.04%
Agricultural Bank of China	1.22%	2.86%	2.02%	4.37%
China Construction Bank	1.42%	2.88%	1.45%	4.67%
SPD Bank	0.14%	1.6%	1.36%	4.28%
Ping'an Bank	0.89%	2.08%	1.45%	3.96%
Huaxia Bank	0.9%	1.64%	1.52%	2.77%

II. KMV MODEL

Experience type risk control method is mainly adopted in China for the credit risk control on the basis of static financial data, yet modern credit risk measurement methods that are commonly used around the world are little used in the country, which has seriously blocked the development of quantitative research on the credit risk in the country, doing bad to the improvement of credit system and the healthy development of economy. However, the KMV model, derived from the research of Black-Scholes-Merton (BSM) options pricing model [2], is a practical and efficient analytical method

developed by Merton who applied the options pricing theory on the risk loan and securities investment so as to measure the risk of the company's defaults. It takes into account both the company's liabilities, stock prices and fluctuation, so it is more accurate than analyzing the company's financial data only.

The KMV model takes the company's equity as a European call option to buy, which is based on the market value of the company's assets with the company's debts as strike price. On the day when the company's debts are due, if the market value of the company's assets is lower than the face value of debts that the company has to repay, the company will default; if the market value of the company's assets is higher than the face value of debts that the company has to repay, the company will repay the debts. The model takes the default distance to represent the distance between the company's asset market value and the default point, the longer the distance is, the less the company will default, vice versa [3].

Basic assumptions for the model include: (1) The company's stock prices are at random, subject to a lognormal distribution; the stock trading is continuous, no friction and the stock price fluctuation is continuous; and the company's assets value is subject to the geometric Brownian motion. (2) When the company's debts are due, if the expected value of the asset market value is greater than the face value of debts, it means that the company is in a worse operation, possible of default. (3) There is a risk-free rate, which is constant. (4) The company's capital structure only rests in current liabilities, long-term liabilities and owner's equity [4].

According to the option pricing model, the formula between the company's assets value and equity value is given as follows:

$$E = V \cdot N(d_1) - D \cdot e^{-rT} \cdot N(d_2) \quad (1)$$

Where, E means market value of the company's equity; V: the company's assets value; D: the company's debts value; $N(d)$: standard cumulative normal distribution function; r: risk-free rate; T: period for debts repayment. Take the derivative of two sides of the equation, followed by the expectation to get the relations between the fluctuation of the company's stocks and the assets' fluctuation.

$$\sigma_E = \frac{V}{E} \sigma_V \cdot N(d_1) \quad (2)$$

Where, σ_V : fluctuation rate of the company's assets value; σ_E : fluctuation rate of the company's equity value; E and σ_E both can be got from the stock market, according to (1) and (2), get V and σ_V , then calculate the default distance, which is an integrated default risk measurement indicator raised in the KMV model, its formula is:

$$DD = \quad (3)$$

Where, E(V) is the expected value of the company's assets; DPT is the default point, that is, debts to be repaid after period T.

At last, the default distance is converted to the default probability EDF. The KMV company adopts the empirical

EDF method to get the EDF value. Namely supported by the large database of default data and non-default data, it gets the mapping relations between the default distance and the actual default probability, input the expected default distance to get the EDF value immediately. For the default database in China is not complete, and the experience EDF method is unsuitable for the country, so when credit risk forecast is conducted on the listed companies in the country, the default distance indicators are adopted mostly [5]. Therefore, this article adopts the default distance as a standard to measure the credit of listed companies.

III. OPERATION OF KMV MODEL

In this article, the * ST companies are taken as default companies, the non-ST companies as non-default companies, for the * ST companies can eliminate the * ST only through a large scale of re-organization, and solve the financial dilemma, so it is flexible to take the * ST company as samples of the default group. Take the KMV model to calculate the default distance of the two types of companies, verify that the *ST company's default distance is different obviously, verify the KMV model is valid to measure the credit risk of the industry. Set parameters at the default point to modify the KMV model, conduct statistic analysis on the results and prove that the modified KMV model has higher recognition over the credit risk.

A. Samples Selection

In order to ensure the accuracy of the equity market value, this article select the manufacturing companies listed in share A of Shanghai and Shenzhen, excluding those listed at shares A, B or A, H or A, B, H.

1) *Selection of Default Group*: This article selects the * ST Companies as default group, which are released with "Warning for delisting risk" due to two-year loss from Jan 1 to Dec 31, 2015, but excluding the sample data of negative net asset value in the analysis period, for if the net value of the company is negative, the value of its assets is less than the value of liabilities, then it has a higher possibility of financial crisis and the default, at that time the measurement of credit risk is lacking in value.

2) *Selection of Non-default Group*: In order to make the samples comparable and reduce the impact of the differences between industries divided in the manufacturing, the samples of non-default group adopts non-ST companies which are listed in the same exchange with the ST and * ST companies.

Based on the above analysis, this article adopts 30 *ST companies and 30 companies under normal operation in the manufacturing industry in 2015 Shanghai and Shenzhen.

B. Parameters Setting

1) *Equity Value E*: Most of the listed companies in China have problems of equity division, tradable shares and non-tradable shares, for the non-tradable shares do not change with the market value, so the formula of equity value E is given as follows [6]:

$$E = \sum_{i=1}^n (P_i \cdot M + X_i \cdot N)$$

Where, M: number of tradable shares; P_i : closing price per day; N: number of non-tradable share; X_i : net assets of per share.

2) *Equity Value Fluctuation σE* : This article uses the historical fluctuation to estimate the coming one-year fluctuation of the equity time value of listed companies. According to the daily closing price of the stock, calculate the daily stock price logarithmic return R_i via the formula:

$$R_i = \ln \left(\frac{P_{i+1}}{P_i} \right)$$

Where, P_{i+1} and P_i mean closing prices on the $i+1$ day and the i day.

Suppose there are 250 trading days one year, according to the relations between the annual standard deviation and daily return rate of the stock, get the annual fluctuation rate of it via the formula:

$$\sigma E = \sqrt{\frac{250}{-1} \sum_{i=1}^n Y R_i - R_Y^2}$$

3) *Risk-free Rate r* : Generally the risk-free rate should adopt the yield rate of 90 days of national debts. However, current national debt market is undeveloped in China, so this article adopts a one-year deposit interest rate as a risk-free rate [1]. Select the year-end year rate of 2015, $r = 0.015$.

4) *Time period T* : $T = 1$.

5) *The Company's Expected Value of Assets $E(V)$* : According to hypothesis given in the Merton model, when a company has determined its debt structure, it will keep unchanged. Yet the company's expected value is dynamic and changing so as to more accurately calculate the company's credit risk. In this article, the growth rate (g) of the company's asset value is introduced to the KMV model [8]. This article adopts the arithmetic average of the growth rate of 3-year assets value from 2012 to 2015, which is calculated via the formula:

$$E(V) = V \cdot (1 + g)$$

6) *Default point DPT*: Basic assumptions for the KMV model include, the default point is at between the total face value of debts and the current liabilities, and the method of selecting the default point is $DPT = STD + 0.5 \cdot LTD$. However, the model itself ignores the industrial differences when setting parameters. Besides, the industries vary with development due different characteristics of the industries, it also includes the differences in the capital structure, business model and the cash inflows and outflows. Whether the default

points set for the KMV model are applicable for the companies in China and how it does still need to further study [9]. This article sets ten different default points, expecting to get the default points applicable for the credit risk measurement of the manufacturing companies in China via statistical analysis. Set the $DPT = STD + m \cdot LTD$, where STD: current liability; LTD: long term debt; $0 < m < 1$, here, set $m = 0.1, 0.2, 0.3, \dots, 0.9, 1.0$.

7) *The Company's Debt Value D* : Calculated with the formula: $D = STD + LTD$ [10]

IV. ANALYSIS OF CALCULATION RESULTS GOT BY MODULES

According to the model parameters set above, as for the transaction information and financial data of the two groups of listed companies, according to the statistical analysis method, calculate the equity value E , the equity value fluctuation rate σE , the company's liability value D , the assets growth rate g , put the parameter values got above to (1), (2), then take MATLAB software programming to get the assets market value V and the asset fluctuation rate σV .

According to the definitions on the default point DPT therein, according to the 2015 financial statements which show current liabilities and long-term liabilities of the sampled company, calculate the default distance DD of the company with different DPT values, then compare and analyze the results so as to get a better KMV model.

A. ROC Curve Verification

The Receiver Operating Characteristic (ROC) curve is used to measure and determine the model's accuracy and predictability. The area under the curve (AUC) is an effective indicator to measure the model's accuracy. If the AUC is kept between 1.0 and 0.5, the closer to 1 the AUC is, the better the predictability is, if the AUC is kept between 0.5 and 0.7, it will be in a less accuracy; if the AUC is kept between 0.7 and 0.9, it will be accurate to some degree; when the AUC is more than 0.9, it will be in a high accuracy. In this article, the ROC curve is got through SPSS, a statistical software, the vertical axis is a correct prediction of the proportion of ST company in all ST companies, the horizontal axis is a wrong prediction of the proportion of normal ST companies in all normal companies. The higher the AUC is, the lower the wrong predication of normal ST companies in all normal companies is, compared to the correct prediction of the proportion of ST companies in total ST companies, the higher the model's prediction effect is. Refer to "Fig. 1" for detail.

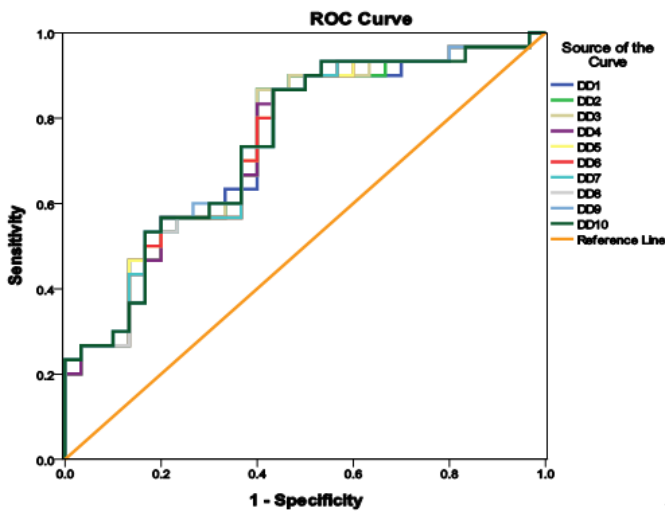


Fig. 1. ROC curve at different default points

Due to the limited number of samples selected, the ROC curve is not smooth. Seen from the figure, there are many overlapped lines in the curve, for the differences of the default distance of the companies at different default points are smaller, which are related to the wide existence of high current liabilities, low long term liabilities and zero long term liabilities in the debt structure of listed companies in the country.

Seen from the AUC values, the accuracy of KMV model is not seriously different at different default points. However, spoken as a whole, the selection of different default points still

has influences on the accuracy of KMV model recognition. When the default point is within those recommended by the KMV model ($STD + 0.5LTD$), the model recognition accuracy is only higher than $DPT = STD + 0.4LTD$, showing that the KMV model parameters set for the default points are not the best selection to identify the credit risks of companies at home. When setting $DPT = STD + LTD$, that is, when the default point is at the total liability, the model will have the highest accuracy to identify the risks "Table II".

TABLE II. AUC VALUES AT DIFFERENT DEFAULT POINTS

	m=0.1	m=0.2	m=0.3	m=0.4	m=0.5	m=0.6	m=0.7	m=0.8	m=0.9	m=1
A	0.7	0.7	0.7	0.72	0.7	0.7	0.7	0.7	0.7	0.7
U	16	21	16	0	26	28	30	36	41	98
C										

B. Average Value T Test and Wilcoxon Test of Two Independent Samples

In order to compare the significance of the difference in the average value of default distance between default groups and non-default groups at different default points, we will conduct T test on the default distance of two independent samples. Take Wilcoxon signed rank test of two paired samples to compare the significance of the difference in the default distance between the default groups and the non-default groups at different default points. Value P in T test and Wilcoxon signed rank test both are negatively correlated with the significance level of the difference in the sample groups, that is, with the decrease of P value, the degree of significant difference gradually increases. Refer to "Table III" for details.

TABLE III. T TEST AND WILCOXON SIGNED RANK TEST OF TWO PAIRED SAMPLES

	Average Value			T Test of two Paired Samples		Wilcoxon Signed Rank Test	
	Default Group	Non-Default Group	Average Value Difference	Value T	Value P	Value Z	Value P
m=0.1	2.34337	3.23271	0.88934	-2.734	0.031	-2.993	0.009
m=0.2	2.33134	3.22412	0.89278	-2.745	0.029	-2.972	0.006
m=0.3	2.31931	3.21553	0.89622	-2.755	0.026	-2.993	0.006
m=0.4	2.30728	3.20694	0.89966	-2.764	0.024	-3.034	0.005
m=0.5	2.295252	3.19835	0.90310	-2.773	0.021	-3.054	0.004
m=0.6	2.283222	3.18976	0.90654	-2.781	0.017	-3.034	0.004
m=0.7	2.271192	3.18117	0.90998	-2.789	0.014	-3.034	0.003
m=0.8	2.259162	3.17258	0.91342	-2.796	0.012	-3.013	0.003
m=0.9	2.247132	3.16399	0.91686	-2.803	0.011	-3.013	0.004
m=0.10	2.235102	3.15540	0.92030	-2.809	0.009	-3.034	0.002

With different M values, two groups of sample data both pass T test of two paired samples and Wilcoxon signed rank test of two paired samples, which prove that the two groups of samples have significant differences in the average value and mid-value of the default distance, showing that the default distance calculated via the KMV model can be used to identify and measure the credit risks of listed companies of manufacturing in China. From the average value results, the average value of ST company's default distance all is less than that of normal companies, that is, the credit risk of ST companies is relatively higher than that of normal ones. During the change of m from 0.1 to 1.0, the average value of the default distance between the two groups of samples are increasing gradually, up to the max value of 0.9203 at m = 1.0,

which is consistent with the best default point shown by the ROC curve. Meanwhile, during the changes of value m, the value P of T test is lowered gradually, besides, the decrease rate is smaller gradually, which proves that with the increase of value m, the significant difference in the average value of the two groups of default distances is becoming more and more significant. Moreover, the value P of the Wilcoxon signed rank test is in a trend of lowering, except for m = 0.9, though the lowering rate is not regular, yet with the increase of m, the significant difference in the mid value of the two groups of default distances is becoming more and more significant. When m= 1.0, the obvious significance of the two groups of default distance reaches the maximum, which is the same as the results shown by the ROC curve.

V. CONCLUSION

This article samples 30 groups of data of listed companies of manufacturing, and calculates the default distance and analyzes the sampled companies via the modified KMV models.

- The KMV model is suitable for the manufacturing industry to some degree in China. Through analyzing the influence of different parameters set in the same survey period on the model, set different default points, compare and analyze the accuracy of the risk evaluation via the model with different setting. The results show that when setting $DPT = STD + LTD$, the recognition degree of the model is the best.
- The results of ROC curve recognition, T test and Wilcoxon signed rank test show that the best default point of credit risk measurement is at the total liability of the listed manufacturing companies in the country, compared with the foreign $DPT = STD + 0.5LTD$, the choice is in much strict requirements, that is, compared to the listed companies in the US, the listed manufacturing companies in China have higher default risks, when the KMV model is used to measure the credit risks of manufacturing industry in the country, the setting of increased default points will make it better to identify the credit risks of the manufacturing industry in the country.
- Seen from the ROC curve values, with the parameters reset, compared to the original model, the credit risk recognition is not obviously improved. Main reasons include: I. this article is limited to sample, not all of the * ST companies with net assets being negative are sampled, and the income stocks are not selected for pairing; II. Even the ST or * ST companies are in dilemma, the eligibility or power as listed companies will bring a value growth in the future revenue opportunities, that is, the "shell" resources will bring them greater value increment. III. The capital market is undeveloped in the country, where the stock price is far to really reflect the operation of the listed companies, Chinese stock market had been through a period from bull to bear in 2015, in the bull market, the stock prices of * ST companies were speculated; in the bear market, the stock prices of companies with outstanding performances are over underestimated. In addition, some assumptions for the KMV model, for example the assumption that the asset value is subject to a lognormal distribution is not applicable in China, have resulted in certain limitation and influence on the application of the model.

In a word, the manufacturing industry is a base of the national economy, however, the excess capacity of industries has become a heavy burden to remove for the supply-side reform. According to actual situations of the listed manufacturing companies, it needs to further research and explore the KMV model so as to improve the recognition and prediction over the credit risks of manufacturing companies, which is good to the rational allocation of resources among companies, banks and the state and promote the structural

adjustment and optimization of the industries. Besides, to strengthen the applicability and practicability of the KMV model in all kinds of industries in China have great significance to improve the credit risk measurement system.

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