

Research on China's Green Finance Credit Risk Measurement Based on Improved KMV Model — Credit risk assessment of new energy automobile industry

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Abstract. This paper focuses on the issue of green finance credit risk measurement, taking China's new energy vehicle listed companies as a sample, taking into account the actual situation of China's financial market, using a modified KMV model to estimate the default distance of selected companies, and comparing with the traditional industries in these three years. The results show that the average default distance of 30 new energy automobile companies is larger than that of 30 traditional automobile manufacturing companies, and the default probability is smaller. As the credit loan risk for the new-energy automobile industry is lower, commercial banks are encouraged to carry out green credit business, and policy and subsidy support related to the new-energy industry shall be given at the same time.

Keywords: green finance, credit risk, EGARCH-M model, KMV model

1. Introduction

China is the largest developing country in the world and the largest emitter of greenhouse gases. Ecological and environmental problems cannot be underestimated. At present, China has entered the stage of economic restructuring and transformation of development mode, and is adjusting to green development. Since the 19th National Congress of the CPC, ecological civilization has been explicitly included in the Constitution and the Constitution of the CPC; 2021 is known as the "first year of carbon neutralization," and General Secretary Xi Jinping promised at the 75th UN General Assembly that China will achieve the peak of carbon emissions by 2030 and the strategic goal of carbon neutralization by 2060; and the "double carbon" goal in March 2021 is included in the 14th Five-Year Plan and the long-term goal of 2035. It is necessary to integrate the green concept into the financial industry. The financial industry shall actively respond to the policies of the State on the development of green industries, carry out green finance business and assume social responsibilities.

Green finance was first established in the Federal Republic of Germany in 1974 as the world's first environmental protection bank to finance environmental protection and pollution control projects. Since then, governments and various international financial institutions have actively promoted the international development of green finance. In October 2002, the World Bank's International Finance Corporation and ABN Amro presented the "Equator Principles" at an international conference in London. The Equator Principles require financial institutions, when investing in a project, to make a comprehensive assessment of its potential environmental and social impact, and to use financial leverage to promote the project's positive role in environmental protection and the harmonious development of surrounding societies. In June 2003, 10 private banks, including Citigroup, Barclays Bank, ABN Amro and West Deutsche Bank, co-founded the Equator Principles. Since the Equator Principles were put forward, many countries have voluntarily joined the Equator Principles.

Green finance is booming in China. The Outline of the 13th Five-year Plan calls for "establishing a green financial system, developing green credit, green bonds and establishing a green development fund", and building a green financial system has become a national strategy. The State Council, the central government's cabinet, also specified in the 13th Five-year Comprehensive Work Plan for Energy Conservation and Emission Reduction that the "green financial system shall be improved" and the "top-level design of the green financial system shall be strengthened to promote the innovation of green financial business". The State Council also pointed out that the supporting policies for energy

conservation and emission reduction shall be improved, including the improvement of price and fee collection policies, fiscal and tax incentive policies and the improvement of the green financial system. In 2016, the People's Bank of China, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Environmental Protection, the China Banking Regulatory Commission, the China Securities Regulatory Commission and the China Insurance Regulatory Commission issued the Guiding Opinions on Building a Green Financial System. This is the first comprehensive policy framework of green finance dominated by the government in the world, and provides the top-level design for the development of green finance^[1]. Our country attaches great importance to the development of green finance, the follow-up issued a series of related policies, vigorously promote the development of green finance.

Green credit is derived from the traditional "credit". Commercial banks shall, by means of credit, strengthen the support for green development, further fulfill their social responsibilities, and enhance their participation in financial activities of environmental and social performance. They shall, by restricting the inflow of credit funds into the fields with high pollution and high energy consumption, guide the investment of credit funds in green industries, to bring the role of social capital allocation into play. Green credit plays an important role in China's green financial system and is an important source of green and low-carbon development funds for the real economy^[1]. From 2017 to 2021, China's green credit continued to develop. As a business of green finance, NEV loan has shown great potential in recent years under the promotion of related national policies. This paper focuses on the green credit problem in the NEV industry and compares the NEV industry with the traditional industry by using the KMV model based on China's national conditions.

2. Literature Review

KMV model originated in foreign countries, and its technology applied in risk measurement is relatively mature in foreign countries. Matthew Kurbat and Irina Korablev (2002) combined financial data from thousands of U.S. companies to validate the KMV model^[iii]. Kezawa (2003) applies the KMV model to measure the credit risk of Japanese automobile companies, reflecting the forward-looking nature of the KMV model^[iiii]. Crosbie and Bohn (2003) studied the content of the KMV model in the measurement of default of financial companies and proved that the default distance can better predict the change of credit status of such companies^[iv]. Duffie (2003) studies the validity of the KMV model in forecasting default probability and constructs the term structure model of default probability^[v]. Patel and Vlamis (2006) empirically studied the application of the KMV model in early warning of financial crisis^[vi]. Dionysiou et al. (2008) deal with nonlinear solutions based on the modified KMV model^[vii]. W. Lee (2011) calculates the optimal default point in the KMV model.^[viii]

In recent years, KMV model has also been studied. Wang Qiong and Chen Jinxian (2002) empirically studied the validity of the coefficient 0.5 in the KMV model^[ix]. Ma Ruowei (2006) empirically studies that KMV model is superior to Logistic and Fisher models in predicting financial distress of listed companies^[x]. Jiang Jie and Gao Yu (2015) combined with China's actual situation, use the revised KMV model based on China's actual situation to evaluate the credit of listed companies in China^[xi]. Jiang Shubin (2016) calculates the dynamic default distance by using the KMV model according to the data of listed companies, and finally obtains the optimal default distance^[xii]. Yu Jia (2017) and others combined the time series analysis method with the KMV model to apply to the credit risk measurement of enterprises in the industrial chain^[xiii]. Zhang Jiantong et al. (2018) From the perspective of automobile supply chain finance, the effectiveness of the application of the modified KMV model to listed companies in China is verified^[xiv]. Zhang Binbin and He Dexu use KMV model and spatial panel Dubin model to analyze regional financial risk^[xv]. The above domestic research on KMV model shows its effectiveness in credit risk measurement in China.

3. KMV Model Construction

3.1 KMV model basic structure

The disadvantage of using the historical data of credit rating to estimate the PD is that the update of credit rating is slow, and the historical data cannot accurately reflect the PD of the corresponding company; the disadvantage of using the historical data to estimate the PD of bonds is that the liquidity of bonds is poor; therefore, we try to use the stock price to estimate the PD and use the Merton model. According to the definition of corporate default in Merton's model, the company defaults when the value of its assets is less than the value of its liabilities. The equity value of a company is a European call option which takes the assets of the company as the subject matter and takes the debt as the exercise price. When applying the model, the current value of the company's assets and the volatility of the company's assets cannot be observed in the market, and the calculation is needed. The asset value obeys the geometric Brownian motion, and is calculated according to the formula of Ito, we can get V_0, σ_V ; V_0, σ_V are substituted into the formula to get the default distance and the default probability.

KMV is generally applied through the following steps: first estimating the company's equity value E_0 and stock volatility σ_E ; determining the debt maturity T , par value D and risk-free interest rate r ; calculating the company's value V and volatility σ_V ; calculating the default point DPT ; calculating the default distance DD ; and calculating the default probability PD . KMV model is forward-looking, and the default distance can be used to rank the default possibility (credit status) of enterprises. Due to the late evaluation of credit status in our country, the historical default data of our country is not perfect, and the research on establishing the relationship between default distance and default probability by using historical default data is not mature enough. The beauty of KMV is that it is not based DD on the location of the distribution function to get PD , but on the default database, where the expected default rate can be mapped from the default distance.

Marks:

V_0, V_T : representing the current value of the company's assets and the value of the bonds at maturity;

E_0, E_T : which indicates the current and temporal value of the company's stock

D : Principal of corporate bonds at the moment

σ_V, σ_E : Volatility of assets and stocks of the company

r : Risk-free interest rate

T : Term of Debt

At the moment the value of the company's stock is:

$$E_T = \max(V_T - D, 0) \quad (1)$$

Derived from the BSM formula:

$$E_0 = V_0 N(d_1) - D e^{-rT} N(d_2) \quad (2)$$

Among them,

$$d_1 = \frac{\ln(V_0 / D) + (r + \sigma_V^2 / 2)T}{\sigma_V \sqrt{T}}, d_2 = d_1 - \sigma_V \sqrt{T} \quad (3)$$

The probability of default:

$$P\{V_T < D\} = N(-d_2) \quad (4)$$

The asset value obeys the geometric Brownian motion.

$$\begin{aligned} \text{so, } V_T &= V_0 e^{\left(r - \frac{1}{2}\sigma_v^2\right)T + \sigma_v \sqrt{T}\varepsilon}, W_T \sim (0, T), \varepsilon \sim N(0, 1) \\ P\{V_T < D\} &= P\left\{V_0 e^{\left(r - \frac{1}{2}\sigma_v^2\right)T + \sigma_v \sqrt{T}\varepsilon} < D\right\} = P\left\{\varepsilon < \frac{\ln \frac{D}{V_0} - \left(r - \frac{1}{2}\sigma_v^2\right)T}{\sigma_v \sqrt{T}}\right\} \\ &= P\{\varepsilon < -d_2\} = N(-d_2) \end{aligned} \quad (5)$$

According to Ito's formula:

$$\sigma_E E_0 = N(d_1) \sigma_v V_0 \quad (6)$$

$$\begin{aligned} dV_t &= rV_t dt + \sigma_v V_t dW_t \text{ (asset)} \\ dE_t &= rE_t dt + \sigma_E E_t dW_t \text{ (stock)} \\ E_t &= f(V_t) \\ dE_t &= \frac{\partial E}{\partial t} dt + \frac{\partial E}{\partial v} dv + \frac{1}{2} \frac{\partial^2 E}{\partial v^2} (dv)^2 = \left(\frac{\partial E}{\partial t} + rV_t \frac{\partial E}{\partial v} + \frac{1}{2} \sigma_v^2 V_t^2 \right) dt + \frac{\partial E}{\partial v} \sigma_v V_t dW_t \end{aligned} \quad (7)$$

From the BSM equation, we get $\Delta = \frac{\partial C}{\partial V} = N(d_1)$, then $\sigma_E E_0 = N(d_1) \sigma_v V_0$

The two nonlinear equations obtained above are calculated by numerical method, we get V_0 σ_v and then inverse inversion of the PD formula gives the PD.

The formula for breach distance:

$$d_2 = \frac{\ln(V_0 / D) + (r - \sigma_v^2 / 2)T}{\sigma_v \sqrt{T}} \quad (8)$$

The smaller the default distance d_2 is, the greater the default probability $N(-d_2)$ is, the greater the possibility of corporate default is;

The larger the default distance d_2 is, the smaller the default probability $N(-d_2)$ is, and the smaller the possibility of corporate default is.

Principle of KMV model: Default distance is:

$$DD = \frac{V - DPT}{V\sigma_v}, V \text{ is the value of enterprise assets, } \sigma_v \text{ is the volatility of the value of enterprise}$$

assets

$DPT = STD + 0.5LTD$, DPT is Default Point, STD is Short-term Liability, LTD is Long-term Liability

3.2 Model Modification in Line with China's Capital Market

Considering the development of credit risk in China, it is not effective to use classical KMV model to evaluate the default risk in China's financial market. First, the classic KMV model is based on a large number of empirical studies of the U. S. financial market, the U. S. financial market is very mature, although China's financial market development momentum is good, but there is still a considerable gap compared to the U. S. market; Second, there is a lack of statistical data on the time of default, and there is no perfect enterprise credit database, and there is a lack of necessary PD calculation information. Therefore, this paper revises the classical KMV model, and gets the conclusion that the model adapts to China's capital market, so as to better serve China's financial market.

3.2.1 Stock value of company E_0

Different from the hypothesis of company share capital in the traditional KMV model, the share capital of listed companies in China covers both tradable and non-tradable shares, and some net asset companies still have the problem of restricted shares in a locked state, which will lead to a higher result if only the calculation is based on tradable shares. This article uses the pricing method

$$E_0 = NF * PF + NN * PN \quad (9)$$

NF : Number of tradable shares

NN : Number of non- tradable shares

PF : Tradable share price

PN : net assets per share

Note: The share price of tradable shares is the closing price of tradable shares, net assets per share = shareholders' equity/total share capital.

3.2.2 Volatility of equity value σ_E

In the past studies, the historical volatility of equity value is calculated by historical sample estimation algorithm, which represents the future volatility of equity value in KMV model. In fact, the unconditional rate of equity value is calculated.

$$R_t = \ln \frac{P_{i+1}}{P_i}, \quad \bar{R} = \frac{1}{n} \sum_{i=1}^n R_i \quad (10)$$

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (R_i - \bar{R})^2}, \quad \sigma_E = \sigma * \sqrt{250} \quad (11)$$

R_t is the daily logarithmic return on the stock, $\bar{R}$ is the average daily return on the stock. P_i is the i day's closing price, P_{i+1} is the $i+1$ day's closing price,

σ is daily stock volatility of the company, σ_E is annual stock volatility of the company

In fact, the return series in the stock market has the characteristic of thick tail and peak, and the conditional variance changes with time, there is cluster effect in the volatility of return, which cannot be described by normal distribution and t distribution. Therefore, some scholars combined conditional variance model with KMV model to modify the KMV model, and found that the modified KMV model is better than the classical KMV model in credit risk identification. However, the GARCH model has the same response to the positive and negative "perturbation", and the tail of GRACH model is thin, so it can not explain the fat-tail characteristics of the return series. Therefore, this paper uses EGARCH-M method to estimate the volatility of equity value. Firstly, EGARCH-M can describe the asymmetric effect of return better, and secondly, the conditional variance in this model can

describe the dynamic relationship of risk premium with time. In the established model, if $\gamma \neq 0$, the existence of leverage hypothesis is tenable.

$$y_t = xy + \rho\sigma^2 + \mu$$

$$\log(\sigma_t^2) = \omega + \beta \log(\sigma_{t-1}^2) + \alpha \left| \frac{\mu_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\mu_{t-1}}{\sigma_{t-1}} \quad (12)$$

3.2.3 Point of default DPT

The optimal default point in the classical KMV model is the sum of current liabilities and long-term liabilities. This paper does not focus on the optimal default point, so it is consistent with the classical KMV model $DPT = STD + 0.5LTD$.

3.2.4 Debt maturity T and risk-free interest rate r

Short-term liabilities refer to the debts to be repaid within an operating cycle of one year (including one year) or more than one year. Long-term liabilities refer to the debts with a term of more than one year. Short-term liabilities account for a higher proportion of the enterprises and have a greater impact on the capital chain of the enterprises. In this paper, the term of debts is set as one year, $T = 1$.

Most of the previous studies take the national debt or the inter-bank offered rate as the risk-free rate. In this paper, the weighted average of the overnight offered rate from 2018 to 2020 is chosen. First, in order to simplify the model; Second, in view of our country interest rate marketization unceasing thorough. $r = 2.08$

4. Empirical Research

In this paper, we use the modified KMV model. Previous studies show that improving the accuracy of stock value volatility can effectively improve the prediction accuracy of KMV model. Therefore, this paper focuses on improving the accuracy of volatility of equity value, introducing EGARCH-M model to model and estimate the volatility of 60 companies in the sample. Finally, the data are summarized, KMV model is established to calculate the default distance and measure the credit risk. From 2018 to 2020, 60 companies in Shanghai and Shenzhen Stock Exchanges, including 30 new energy automobile companies and 30 traditional automobile manufacturing companies, are selected for this study.

4.1 Empirical process analysis

First of all, it is necessary to determine whether the EGARCH - M model is suitable for the daily return of stock time series. The results show that the sample data series obey the stationary process and meet the application conditions of autoregressive heteroscedasticity model. Taking the volatility of the BYD (002594.SZ) log-day yield series in 2018 as an example, it can be seen from Table 1 that the series has obvious volatility and agglomeration: skewness = -0.106502 < 0, indicating that the yield series is left skewed, and the peak = 4.161074 > 3, indicating the spike of the yield series, so that the yield series does not follow the normal distribution, and has obvious peak-fat-tail characteristics; the J-B statistic is 14.05074, and the P value accompanying the statistic is 0.000889, indicating that the sample series does not follow the normal distribution. Table 1 shows that both AIC and SC indices of EGARCH-M (1, 1) are less than those of GARCH (1, 1), and their logarithmic likelihood values are greater than those of GARCH (1, 1). The above shows that EGARCH-M model can effectively measure the volatility of equity value of listed companies. Therefore, this study collects daily stock prices from wind, transforms them into logarithmic returns, establishes EGARCH (1,1) - M model, and obtains the volatility of equity value.

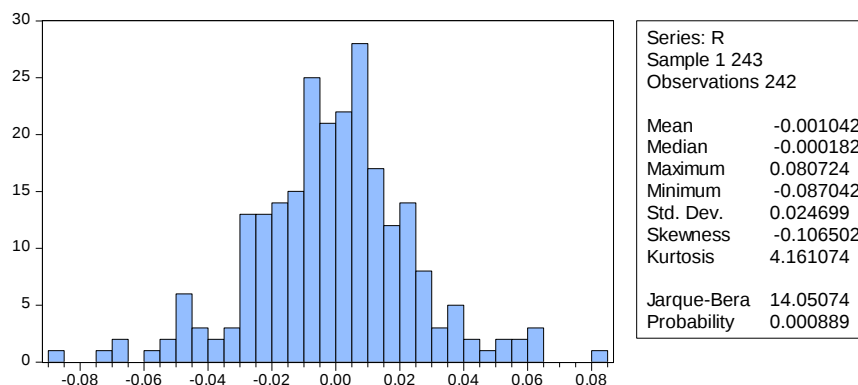


Figure 1. Analysis of Daily Return of BYD Company in 2018

Table 1. Comparison of Volatility Model Indicators

Statistical index	Model	
	GARCH(1,1)	EGARCH—M(1,1)
Akaike info criterion	-4.549036	-4.546409
Schwarz criterion	-4.47695	-4.459906
Log-likelihood	555.4333	556.1155

4.2 Analysis of empirical results

Analyze the credit risk of new energy automobile industry. In view of the fact that some companies have not prepared their financial reports for 2021, we have selected the daily stock closing data for the three years from 2018 to 2020 for processing, and randomly selected 30 companies related to new energy vehicles and 30 traditional automobile manufacturing companies from the wind industry database for analysis, established a KMV model, and calculated the default distance of these 60 companies. Statistical analysis is made on the new energy automobile related companies and traditional automobile manufacturing companies, and the average default distance of 30 new energy automobile enterprises and 30 traditional automobile manufacturing companies each year is calculated, and the internal standard deviation of the two industries is analyzed and compared.

Table 2. Default Distance between New Energy Automobile Industry and Traditional Industry

	New energy automobile industry				Traditional automobile manufacturing industry			
Year	Average value	Standard deviation	Maximum value	Minimum value	Average value	Standard deviation	Maximum value	Minimum value
2018	0.866173	0.185745	2.440579	-2.14183	0.829165	0.441718	3.83563	-9.10563
2019	1.23579	0.210078	3.150022	-0.77114	0.900872	0.326668	4.676276	-2.52247
2020	1.002632	0.171854	2.317593	-2.76475	0.864754	0.235687	3.683643	-2.83243

According to the above table, firstly, the average default distance of the new-energy automobile industry in the three years from 2018 to 2020 is larger than that of the traditional automobile manufacturing industry, and the larger the default distance in the KMV model, the smaller the default probability of the enterprise; the smaller the default distance, the greater the default probability of the

enterprise; therefore, from the perspective of average value, the default probability of the new-energy automobile industry is lower and the credit risk is lower. Second, the average default distance of the above companies in the past three years is less than 3, and very stable, the whole automotive industry default probability is smaller. Thirdly, the standard deviation of the new-energy automobile industry within three years is slightly lower than that of the traditional automobile manufacturing industry in each year, which indicates that the comprehensive performance of the new-energy automobile in terms of the default distance is better than that of the traditional automobile manufacturing industry at some time. Because the number of samples selected does not cover all the automobile industries and is random, the maximum and minimum values are not reviewed here. The empirical results show that the difference of credit risk among the enterprises in NEV industry is smaller than that of the traditional automobile industry.

Using SPSS software to test independent samples of data from 2018 to 2020, in the variance equation Levene test, except 2019, P value is higher than 0.05 in the other two years; in the mean value equation t-test, P value is higher than 0.05 in the last three years, which shows that there is no significant difference in the default distance between the new energy automobile industry and the traditional industry.

Table 3. Levene test and T test

Year		2018	2019	2020
Levene test	F value	3.386	4.346	3.045
	P value	0.071	0.042	0.086
T test	T value	0.077	0.862	0.473
	P value	0.939	0.393	0.638

5. Conclusion

The country promotes the development of green credit, but there are many problems in the development of green credit^[xvi]. Risk prevention and control is a crucial step in the process of green credit. Based on the former research, this paper modifies the classical KMV model, introduces the EGARCH-M model to calculate the volatility of equity value, and obtains the KMV model. Using the modified KMV model, this paper analyzes the credit risk situation of new energy automobile industry and traditional automobile manufacturing industry. The conclusion of the empirical study is as follows: First, the overall difference of credit risk between the two types of credit business is little, and the credit risk performance of new energy automobile industry is slightly better than that of traditional automobile manufacturing industry. Second, the credit risk of the two auto industries is relatively stable, commercial banks to vigorously promote green credit business measures in the future period of time are feasible. Third, the modified KMV model can be better applied to green credit risk management.

According to the general rule of the past industry development, in the next few years, with the continuous maturity of the green industry, the government is bound to reduce support for green industry. In the market without government subsidies, the competitiveness and profitability of green industry will be greatly affected^[xvii]. Therefore, how to improve the KMV model according to the development of the industry in the future to better apply to green finance business is the follow-up need to solve the problem.

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