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ARTICLE

Research on the Effectiveness of KMV Model in China's Bond Credit Rating Market

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ABSTRACT

In recent years, China's bond market has experienced rapid development, but the pace of credit risk supervision has not kept up. Since 2014, the number of domestic credit bond defaults has increased. In 2016, there were 79 domestic default bonds, with a default amount of up to 40.3 billion Yuan. From the perspective of domestic bond market credit risk supervision and early warning mechanism, rating is not objective, and tracking is not timely also rating methods are backward. Therefore, with the development of big data and other technologies, it is urgent to study credit risk supervision methods suitable for the domestic bond market. On the basis of combing the development of domestic bond market and analyzing the current situation of domestic credit rating, this paper combines the results of theoretical research at home and abroad, the information available in the domestic market, big data mining and automation technology, based on the financial and stock exchange information of listed companies, combined with BS option pricing theory, constructs KMV model.

1. Introduction

The U.S. sub-prime debt crisis in 2008 quickly spread to the world. In 2009, the sovereign debt crisis in Greece had a dramatic impact on the economic development and social stability of Greece and the EU. After 2010, a series of debt crises occurred in Europe. From the perspective of foreign bond market, a wide range of credit crisis is likely to continue to occur. Although a series of credit crises in Europe and the United States have had a certain impact on China, they have not directly impacted the domestic financial system. Relying on the power of scientific and technological information, China's financial market has made rapid development in recent years. Under the guidance of the government, the domestic bond market plays an important role in helping the development of the real economy, increasing social jobs, solving the financing problems of enterprises, and providing investors with diversified investment products. However, the domestic financial market is still facing several major problems. For example, the financing problems of small and medium-sized enterprises need to be solved urgently, also the credit risk of real estate credit in the banking system is increasingly serious, then the credit situation of local government debt is further deteriorated, and China's economy faces increasing uncertainties in the external environment. In this case, the healthy and stable development of bond market is of great significance to the reform of domestic financial market and the development

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of national economy. However, risk monitoring and the management system of the domestic bond market have not kept pace with the development of the domestic bond market. In November 2013, the "11 Zhangjiang smecn1" issued by Shanghai Zhangjiang science and technology defaulted, which attracted the attention of the regulators of the domestic bond market. In 2014, five bonds defaulted in the domestic bond market; by 2015, the number of domestic bond defaults increased to 19, involving 11.7 billion Yuan; in 2016, the number of domestic bond defaults reached 79, with the default scale exceeding 40.3 billion Yuan. With the advent of many bond maturities, domestic bond default events are likely to enter the high-risk period. A series of default events show that there are serious problems in China's bond market, such as incomplete information disclosure, not objective rating, not timely tracking, and relatively backward rating methods. Therefore, with the development of big data and other technologies, it is urgent to study credit risk supervision and early warning methods suitable for domestic bond market.

2. Merton Model

Merton's model first assumes that the value VT of a company's assets follows the LTO stochastic process.

$$\frac{dV_t}{V_t} = \mu d_t + \sigma dG_t \tag{1}$$

Where σ represents the volatility of the change of the return on assets of the company, while μ stands for the instantaneous return on assets of the expected company, and GT reflects a standard Wiener process. Then Vt gives expression to the value of the company's total assets at time t, while DT means the value of the non-redeemable zero-coupon bond with a residual maturity of T and a face value of m at time point t, and Et represents the option value. The three relationships can be expressed as follows.

$$V_t = D_t + E_t \tag{2}$$

Suppose that there are only two kinds of securities in a company, what are, one is a zero-coupon bond with a face value of F and a remaining maturity of T, and the other is a stock held by the owner. The debt treaty stipulates that if the company fails to pay its debts in accordance with the agreement on time, the creditors will be entitled to all the assets of the company according to law, and the shareholders of the company will have nothing. In addition, before the company has paid off its debts, it is prohibited for the company to issue any new shares or new debts with priority, and it is not allowed for the company to repurchase shares or distribute dividends in any form before paying off its debts. The value of the bond at maturity of the debt treaty is

$$D_T\ (V,T) = \min(V_T, F) \tag{3}$$

Assuming that the only channel of financing of the company other than the bonds is equity, the value of risk compensation obtained by the bondholders is the value of European options sold based on the value of the company. The face value f of the bond is the price when the option is executed, and the remaining term t of the bond is equal to the term of the option. When the owner of the company exercises the right when the bond matures, the bondholder obtains

$$D_T = F - \max(F - V_T, 0) \tag{4}$$

The value of options held by the owners of the company is

$$E_T(V) = \max(0, V_T - F) \tag{5}$$

Using Black Scholes model option pricing method and Merton theory to price credit risk bonds, we get the following expression.

$$E_t(V,T,\sigma,r,F) = V_t\,\mathrm{N}(d_1) - Fe^{-r(T-t)}\,\mathrm{N}(d_2) \tag{6}$$

$$d_1 = \frac{\ln(\frac{V_t}{F}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$$

And $$d_2 = d_1 - \sigma\sqrt{T-t}$$

$$\mathrm{N}(y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{y} e^{\frac{-u^2}{2}}\,du$$

Thus, in the case of risk neutral, the value of the bond at the beginning is obtained.

$$\begin{aligned} D_0(V,T) &= Fe^{-rt} - [-\mathrm{N}(-d_1)V_0 + Fe^{-rt}\mathrm{N}(-d_2)] \\ &= \mathrm{N}(-d_1)V_0 + Fe^{-rt}\mathrm{N}(d_2) \end{aligned} \tag{7}$$

According to the above expression, the default probability of credit risk is

$$\mathrm{P}(V_T < F) = \mathrm{N}\left(\frac{\ln(\frac{F}{V_0}) - (\mu - \frac{1}{2\sigma^2})T}{\sigma\sqrt{T}}\right) \tag{8}$$

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Default margin CST (T) is

$$CS_t(TV_T<F)=\frac{1}{T}\ln[\mathrm{N}(d_2)+\frac{V_t}{Fe^{-rt}\mathrm{N}(-d_1)}] \quad (9)$$

Merton model is based on the option pricing method to approximate the risk spread of credit bonds. The interest rate risk structure in the model is an important supplement to the traditional interest rate term structure. The shortcomings of Merton model are as follows.

(1) First of all, there are too many assumptions in the model, which is quite different from the real market situation.

(2) The model regards the total assets of a company as a kind of assets that can be traded continuously. However, in the real market, the total assets of a company cannot be traded as frequently and quickly as stocks.

(3) The model assumes that the risk-free interest rate has a level and fixed structure, which is inconsistent with the reality. This will result in a huge difference between the credit spread calculated later and its theoretical value.

3. Background and Principle of KMV Model

KMV model is a credit risk measurement and early warning model developed by KMV company in 1993 based on MM theory and B-S Option pricing model. It can predict and update the probability of the occurrence of credit risk events according to the change of market value of Listed Companies in the stock market.

KMV model belongs to the modern credit risk measurement model, which has the following advantages compared with the technology of statistical measurement of tradition, neural network and other quantitative analysis methods.

(1) KMV model is based on Merton model, which is more theoretical. For it first combines the theory of modern corporate finance and theory of options. Based on the theory of modern corporate finance, the model makes full use of the relatively reliable and objective financial information of the company. Using option pricing theory for reference, the default is regarded as a call option for the value of the company's assets. using B-S Option Model for quantitative analysis, the company's financial information and the stock price in the capital market to calculate the default distance and probability, so as to measure the company's credit risk, which is prompter and more objective.

(2) KMV model uses the stock market information to update, and the financial information is objective. Because the stock of listed company has new trading information every day, the stock market value of listed company will adjust dynamically according to the expectation of investors every day. KMV model uses the market value of assets to calculate the equity value, which is more realistic. Therefore, KMV model is a dynamic model, which can capture the expected credit risk information in time. In the calculation of debt, the latest financial data is used, which is more objective, but also the attribute characteristics of debt.

(3) KMV model does not require high market efficiency. This model has been applied in many markets of emerging stock, such as Europe and the United States. When the interested parties of enterprises trade through insider information and institutional investors' information and R & D advantages, the stock price of related companies will change greatly. The fluctuation of the company's stock price contains a lot of information that investors analyze and judge the company's prospects.

KMV model is based on MM theory and B-S Option pricing model. There are many hypotheses in these two theories. In fact, these hypotheses may not be fully satisfied, so the results of the model may be distorted, which makes KMV model have the following shortcomings in practical application.

(1) KMV model is based on the theory of B-S model, which is constrained by the basic assumptions of B-S model. The model assumes that the stock price of the target company satisfies the stochastic process, investors are allowed to sell short in the market transaction. And there is no tax in the transaction process, also the risk-free interest rate remains unchanged for a long time, and there is no arbitrage opportunity in the market.

(2) KMV model assumes that the borrower's default is inconsistent with the reality. KMV model assumes that when the asset value is less than the debt value, the borrower will default. However, in reality, in many cases, the lack of liquidity will also cause the borrower to default; even if the value of the company is less than the value of the liabilities, because of the inconsistency of the maturity of the debts, the owners of the company may not choose to default in the face of the debts due first.

(3) KMV model assumes that the borrower's return on assets is normally distributed, and the change of the company's market value is the Brownian motion. However, these assumptions are not satisfied in many capital markets. The KMV model's assumption of the company's capital structure is inconsistent with the reality of the domestic market. The model does not consider the existence of China's non tradable shares. Although this paper has made some development in this area, it still cannot guarantee its perfection.

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4. Conclusion

This paper draws the following conclusions:

(1) The rating results of credit risk rating agencies in the domestic bond market have a guiding role for investors in identifying credit risk. And market investors have made a response to the measures taken by credit rating agencies to reduce the credit rating of bonds or issuers. Some investors perceive credit risk earlier than credit rating agencies.

(2) According to the KMV model, the default distance of a domestic listed company's bond issuer cannot be directly converted into a default probability if it does not obey the normal rules. When the model parameters change, the default distance will change greatly with the distribution of the credit status of the debtor. As the credit status of the changes of issuing entity, the expected value of the default distance has a certain regularity.

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