Early Warning Research on Bond Default Risk Based on KMV Model

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Abstract: *Real estate is a pillar industry of the nation, but bond defaults are highly concentrated in real estate, and it is particularly important to discuss the early warning of bond default risk. On November 15, 2022, S&P downgraded Greenland Holdings' long-term issuer credit rating from "CC" to "SD", which aroused strong concern in the market. "SD", which triggered strong concern in the market. Based on the revised KMV model, this paper conducts quantitative early warning analysis on the bond default risk of Greenland Holdings, and horizontal comparison with real estate companies in the same industry, to explore the timeliness and accuracy of the KMV model for measuring bond defaults of Greenland Holdings and other real estate companies. Focusing on the bond default event of Greenland Holdings, it explores the problems behind it and analyze the reasons for the problems, which are mainly related to the following four aspects aspects: the endogenous funds are insufficient and pull up the financing cost; the structure of the liabilities is unbalanced; the Greenland holdings of the capital chain is tight; the macroeconomic situation of the real estate policy continues to tighten, and finally summarize the countermeasures to prevent the risk of corporate bond defaults proposed.*

Keywords: greenland holding; bond default; KMV model; risk early warning

1. Introduction

1.1. Introduction of Greenland Holding Company

Greenland Holdings Group Limited (stock code: 600606.SH), the company was founded on July 18, 1992, headquartered in Shanghai, at that time only a small enterprise mainly in property management, but is one of the representative enterprises born in the wave of China's market-oriented reform. Greenland Holdings is a state-owned mixed ownership listed company, and is also the first real estate-based company in China to enter the Fortune 500 group. After years of development, Greenland Holdings started from a registered capital of 20 million yuan, and after 29 years of sustained growth, it has formed a comprehensive business pattern of "real estate and infrastructure as the main business, and synergistic development of financial, consumer, health, science and innovation industries".

Greenland Holdings follows the economic development trend in its strategic development and vigorously develops overseas real estate projects. Since 2012, when it first explored overseas markets, Greenland Holdings has landed projects in Australia, the United States, the United Kingdom, Canada and other countries. The core business of Greenland Holdings is still the real estate business, and the quality of real estate-related business scale far exceeds the level of peers, and is one of the leading real estate enterprises in China. Greenland's real estate development strategy includes project diversification, with a particular focus on the residential and commercial sectors. Residential projects are mainly carried out to achieve objectives, followed by sales on the market. In addition, among other business objectives, the ongoing business operations mainly involve the sale of a small number of properties for hotel operations.

1.2. Analysis of bond default process

At the end of 2021, Greenland Holdings announced that its sector classification had been revised from an "estate trade" to a "civil engineering construction field". This alteration was predicated upon the fact that Greenland's infrastructure business accounted for more than half of its revenue, and that although it had been removed from the name of real estate enterprise, It had not been removed from the ranks of real estate enterprises that had been in the midst of thunderstorms. On November 15, 2022, a paper downgrade by S&P unveiled the fact that Greenland Holdings had defaulted. Because without a

rollover, Greenland Holdings Group did not repay the outstanding principal of the $362 million senior notes due on November 14, 2022, S&P downgraded Greenland Holdings to $4.5 billion. Therefore, S&P downgraded Greenland Holdings' long-term issuer credit rating from "CC" to "SD".

The reason behind this incident is that on May 27, 2022, Greenland Group announced that it intends to make certain amendments to "GRNLGR 6.75 06/25/22" and to waive the initiation of a consent solicitation to extend the maturity date of the company's U.S. dollar-denominated senior notes due June 2022, the outstanding principal amount of which is $488 million. This is a $500 million (approximately 3.6 billion yuan) offshore dollar bond maturing on June 25, 2022, with an interest rate of 6.75%, requiring a number of payment terms amendments and a waiver of the solicitation of initiation consent: extending the maturity date, joining the issuer's right to redeem all or part of the notes before maturity, etc. Greenland Group made an advance payment of 10% of the original maturity date outstanding as the principal amount, with the remainder being repaid on June 25, 2023. On October 31 of the same year, Greenland Holdings again announced that it intended to initiate a consent solicitation for its nine U.S. dollar-denominated bonds in connection with the rollover. These nine U.S. dollar bonds to the time of 2022-2025, with interest rates in the range of 5.6%-7.25%, total combined issue size of 3.72 billion U.S. dollars, the current outstanding total principal amount of about 3.182 billion U.S. dollars. On November 13, Greenland Holdings defaulted on a $370 million dollar bond with an outstanding balance of $362 million. S&P said the dollar debt is due and unpaid, and Greenland Holdings officially defaulted.

Affected by the industry winter, greenland holding's performance continues to be under pressure. In the first three quarters of this year, Greenland Holdings realized operating income of 305.777 billion yuan, a year-on-year decrease of 28.35%; realized net profit of 6.948 billion yuan, a year-on-year decline of 37.77%. But Greenland's biggest hidden danger is not performance, but debt. As of the third quarter of 2022, Greenland Holdings had total assets of 1.35 trillion yuan and total liabilities of 1.18 trillion yuan, with a gearing ratio of 87%. And Greenland Holdings' money funds were 61.362 billion yuan, of which unrestricted cash and cash equivalents were only 44.868 billion yuan, and the size of short-term liabilities was 139.152 billion yuan. Cash on its books, and its short-term liabilities from the funding gap, close to 100 billion seriously exceeded the central bank's "three red lines". As of the end of September 2022, Greenland Holdings internal meeting mentioned: the company's interest-bearing liabilities, 75% for bank loans, 15% for bonds, 3% for non-standard financing, 7% for other interest-bearing liabilities. The current debt pressure is extremely high, and if the rollover fails to pass, the company will carry out debt restructuring.

2. KMV model parameter setting and its correction

2.1. Principle of KMV model application

KMV model is a model established by the American KMV company in 1997 to study the probability of default of the borrowing company, KMV model believes that the value of the company's assets determines the size of the company's credit risk, and on the day of bond repayment, if the value of the company's assets is lower than its liabilities, then the company has a high likelihood of default on the bond risk [1].

However, there is no value of the company's asset value that can be directly observed, while the market value of equity is easy to obtain in the open market and has a strong timeliness, and the timeliness of the data is also required in analyzing the risk of bond default [2]. Therefore, the market value of the asset and its volatility are estimated through the equity market value and its volatility, and then the default distance of the bond is calculated through modeling, and finally the default probability of the bond is obtained.

The KMV model in this paper is based on the option pricing theory of Black and Scholes as a basis, and the equity value is used to derive the asset value formula as follows:

$$V_E = V_A \cdot N(\mathrm{d}_1) - DPT\mathrm{e}^{-\mathrm{rt}} \cdot N（\mathrm{d}_2）$$

(1)

V_E represents the value of equity, V_A represents the value of assets, DPT represents the value of debt, $N（\mathrm{d}）$ represents the standard cumulative normal distribution function, r is the risk-free interest rate, and t represents the debt repayment period.

$$d_1 = \frac{\ln \dfrac{V_A}{DPT} + (r + 0.7127\sigma^2{}_A)T}{\sigma_A \sqrt{T}}$$

(2)

$$d_2 = d_1 - \sigma_A \sqrt{T}$$

(3)

σ_A Represents asset value volatility, which needs to be calculated by the following formula using equity value volatility as the base data:

$$\sigma_E = \frac{N(d_1)V_A \sigma_A}{V_E}$$

(4)

The above formula can be used to calculate the asset value and asset value volatility using the equity value and its volatility, and finally the default distance and default probability can be calculated based on the asset value and asset value volatility, which is the distance between the company's asset value and the point of default, and the formula is as follows:

$$DD = \frac{E(V_1) - DPT}{\sigma_A E(V_1)}$$

(5)

$$E(V_1) = V_A \cdot (1 + \mu)$$

(6)

Which $E(V_1)$ represents the expected value of the company's asset value after one year, μ represents the growth rate of asset value, usually using historical data.

The above is the principle of KMV model application, this paper measures Greenland Holdings' bond default risk according to the above formula, and judges Greenland Development's bond default risk according to the final result, and finally achieves the purpose of early warning of the company's bond default risk.

2.2. KMV model modification

2.2.1. Market risk-free rate

China's bond market started late, and domestic scholars will combine the actual situation of China's bond market with the KMV model when using the KMV model for research, so that the application of the KMV model is more in line with the actual situation of China's bond market. This paper draws on the practices of Wang Ning (2019)[3] and Xie Yuantao et al. (2018)[4] to correct the market risk-free rate.

In the KMV model, the risk-free rate is an important parameter, according to foreign literature can be seen that foreign countries generally choose libor as the market risk-free rate. But the development of China's capital market is still immature, so domestic scholars usually choose the central bank to publish the one-year savings deposit rate or treasury bond interest rate instead of the study, this paper adopts XieYuanTao et al. (2018)[4] practice, using the benchmark interest rate for one-year deposits of financial institutions published by the People's Bank of China, interest rate for one-year deposits at financial institutions in 2018-2022 is 1.5%.

2.2.2. Credit Risk Measurement Results

The KMV is used to calculate the default probability of a bond, and the default risk is measured by the value of the default probability. However, due to the short history of bond default in China, the database is not yet completely sound, and it is more difficult to obtain the mapping relationship of bond default probability. Then this paper draws on the practice of Wang Ning (2019) [3], and selects the default distance as a measure of bond default risk metrics, and the larger the default distance is, the smaller the bond default risk is represented.

2.2.3. Default point DPT

The default point in the KMV model is used as a horizontal line to measure bond default. When the bond expires, the company's asset value is higher than the default point. It means that the company has

the strength to repay the debt; when the value of the company's assets is lower than the default point, it represents that at this time, the company's bonds will be defaulted. k value is set to 0.5 after KMV analyzed a large number of default data for U.S. corporate bonds, but domestic scholars found k to be 0.5 when measuring the default point, but domestic scholars found k to be 0.5 when measuring the default point. Point measurement research found that k takes 0.5 and can not be a good response to the situation of China's capital market, this paper adopts Yu Miaozhi (2020) [5] based on genetic algorithm on the k value re-measurement, get in line with China's real estate industry k value of 0.7127, the default point calculation of the formula for: current liabilities + 0.7127 * non-current liabilities.

The specific data and its calculation results are shown in the table 1 below:

Table 1: Changes in equity value and equity volatility of Greenland Holdings from 2018 to 2022.

(unit: 100 million yuan)

Date	Current liabilities	non-current liabilities	DPT
2018Q1	5894.1844	1807.7844	7182.592342
2018Q2	6287.1057	1754.9077	7537.828418
2018Q3	6652.7087	1844.6468	7967.388474
2018Q4	7472.1603	1804.0358	8757.896615
2019Q1	7594.5659	2071.909	9071.215444
2019Q2	6750.635	2095.0012	8243.742355
2019Q3	7079.0009	2102.0018	8577.097583
2019Q4	8297.7582	1845.3841	9612.963448
2020Q1	7962.0026	2023.6183	9404.235362
2020Q2	8205.2869	2161.1924	9745.568723
2020Q3	8022.7125	2300.1333	9662.017503
2020Q4	10230.5035	2190.1206	11791.40245
2021Q1	10113.2547	2429.556	11844.79926
2021Q2	10048.1638	2290.4738	11680.58448
2021Q3	10065.1398	2163.0806	11606.76734
2021Q4	11548.3313	1503.8188	12620.10296
2022Q1	10912.3073	1457.7931	11951.27644
2022Q2	10576.1662	1327.9027	11522.56245
2022Q3	10591.6942	1204.1067	11449.86105
2022Q4	10769.1509	1241.3609	11653.86881

Data source: Wind Database

3. Greenland Holding bond default warning and result analysis

Based on the data of Greenland Holdings as the research object, this paper uses the KMV model to measure its default risk, and the original data comes from the Wind database and the company's official website. First of all, the original data was processed and processed through Excel tables, after the relevant parameters in the KMV model were calculated, the final result was calculated using Matlab software, and then the default distance of Greenland Holding was obtained. The following is the default distance and default probability of Greenland Holding from 2018 to 2022.

3.1. Default distance and default probability of Greenland Holding bonds

Corporate asset volatility and insolvency have a great impact on the default distance of corporate bonds. As far as China's current real estate enterprises are concerned, the problems of bond default mainly focus on the large short-term fund raising gap and insufficient liquidity within the company . From 2018 to 2022, Greenland Holding Company's default distance DD and default probability EDF shown in Table 2,the default distance of Greenland Holding Company shows an overall increase from 1.1787 at the beginning but a downward trend in the later period. The overall increase performance can also be seen through the linear trend line. This indicates that the company's bond default risk has decreased and then increased. Combined with the analysis of Greenland Holdings' internal and external operations, China's real estate enterprises have implemented tightening policies since 2016, and they have been strengthened in 2017. In 2020, the Ministry of Housing and Urban-Rural Development issued strict "three red lines", showing a tightening trend. At the same time, Greenland Holdings is in

the strategic period of rapid expansion. Due to the tightening of macro policies and the company's outward expansion strategy, the company's debt default risk is further deepened.

Table 2: Asset value, default distance and default probability of Greenland Holdings.

Date	Asset Value (billion yuan)	Asset value Volatility	Default distance	Default probability
2018Q1	901.6602	0.675271	1.1787	11.93%
2018Q2	795.7973	0.669327	1.1565	12.37%
2018Q3	795.7973	0.669348	1.1383	12.75%
2018Q4	743.4742	0.669819	1.1010	13.54%
2019Q1	917.4788	0.595687	1.3473	8.89%
2019Q2	831.0849	0.594028	1.3513	8.83%
2019Q3	859.0717	0.590505	1.3601	8.69%
2019Q4	845.6867	0.570385	1.3842	8.31%
2020Q1	658.2972	0.554239	1.3556	8.76%
2020Q2	751.9919	0.333524	2.4173	0.78%
2020Q3	775.1114	0.351856	2.3106	1.04%
2020Q4	709.4034	0.338453	2.2205	1.32%
2021Q1	680.1998	0.310377	2.3854	0.85%
2021Q2	663.1644	0.308679	2.3889	0.84%
2021Q3	600.4984	0.304747	2.3361	0.97%
2021Q4	554.5028	0.306175	2.1584	1.54%
2022Q1	688.6567	0.324029	2.2868	1.11%
2022Q2	505.9519	0.337656	1.9546	2.53%
2022Q3	392.1127	0.343161	1.6442	5.01%
2022Q4	418.8157	0.376901	1.5475	6.09%

Data source: Wind Database

It can be seen that after the Ministry of Housing and Construction and other ministries jointly issued the "three red lines" on the capital management of real estate enterprises in 2020, Greenland Holding's default distance is increasing, which means that the company's operating liquidity has improved. However, in 2022, a new reversal occurred, and the default distance has been declining, which, to some extent, reflects the company's default risk rising. Based on the KMV model results, Greenland Holdings is highly likely to default in 2022, and the fact is that bond default did occur in the fourth quarter of 2022. Therefore, combined with Greenland Holding's actual default situation, the KMV model can accurately judge Greenland Holding's level of debt risk.

3.2. Comparison of default distance in the same industry

In this paper, Vanke and Poly Development in the real estate industry are selected as comparison enterprises. The KMV model is used to measure the default risk of the three companies from 2018 to 2022, and the default distance of the three companies is calculated as shown in Table 3. The situation of Greenland Holding is placed in the same industry, and the accuracy judgment of Greenland Holding default risk is improved.

According to the KMV model theory, the larger the default distance, the smaller the default risk, and the smaller the default distance, the greater the default risk. As can be seen from Table 3, the default distance of Greenland Holding is smaller than that of Vanke and Poly Development, indicating that Greenland Holding has the greatest default risk from 2018 to 2022, followed by Vanke. By the first quarter of 2020, the default distance of Greenland Holdings has increased significantly and surpassed Vanke for the first time, indicating that the default risk of Greenland Holdings and Vanke is comparable, while the default distance of Poly Development is basically higher than that of Greenland Holdings and Vanke, and the default risk of Poly Development is relatively small. However, after entering 2022, the default distance of Greenland Holdings has further decreased, and even the default distance of Vanke and Poly Development has increased, and the default risk has increased. Just in the fourth quarter of 2022, Greenland Holdings defaulted on its bonds, and the default risk corresponding to the default distance can lead to substantial bond default.

Table 3: Comparison of industry default distance of Greenland Holdings from 2018 to 2022.

Date	Vanke	Poly development	Greenland Holdings
2018Q1	1.980716945	2.272546901	1.178736188
2018Q2	1.930654174	2.30141399	1.156588461
2018Q3	1.919132447	2.298061339	1.138363177
2018Q4	1.914672288	2.303861957	1.101096107
2019Q1	1.982266265	2.373843421	1.347312388
2019Q2	1.966948493	2.32888559	1.351363748
2019Q3	1.980858524	2.383787824	1.360105587
2019Q4	2.068882846	3.011684852	1.384242955
2020Q1	2.004739951	2.998757316	1.355643927
2020Q2	2.003185898	3.437244911	2.417359642
2020Q3	2.023775012	3.735511017	2.310663944
2020Q4	2.533276837	3.700246477	2.220585235
2021Q1	2.45702365	3.63804689	2.385404914
2021Q2	2.366987479	3.478800163	2.388971305
2021Q3	2.905123172	3.045821936	2.336168593
2021Q4	3.015730027	3.010620071	2.158408543
2022Q1	2.989905505	3.004399481	2.286884252
2022Q2	3.067511547	2.896278389	1.954692392
2022Q3	2.995391702	2.902700353	1.644295
2022Q4	2.533821993	2.660821003	1.547555316

Data source: Wind Database

To sum up, the KMV model can show good accuracy in measuring the default risk of Greenland Holdings and other companies, and can play an early warning role in corporate bond default risk to a certain extent. On the one hand, Greenland Holdings can describe the changes in bond default risk from 2018 to 2022 through the results measured by the KMV model, and can specifically quantify the company's default risk to provide investors with a timely risk warning. On the other hand, by comparing the default distance of the three real estate companies from 2018 to 2022 with the KMV model, it is found that the default risk in 2021 and 2022 is larger than before, and the data measurement of the three real estate companies is exactly in line with the situation of corporate bond default, indicating that the KMV model is accurate in measuring the default risk. Therefore, in the early warning of corporate bond default risk, the KMV model can be used as a measurement tool to disclose default information to appropriately adjust the bond credit rating, so as to make the bond early warning more timely and accurate.

4. Greenland Holding bond default problem and reason analysis

As a real estate enterprise, Greenland Holdings has a high demand for funds. When its own funds fail to meet its future business activities and expansion and development, it will raise funds by bond financing and other means. This part will focus on the bond default event of Greenland Holdings, explore the problems behind it and analyze the causes of the problems, which mainly involve the following three aspects: insufficient endogenous funds increase financing costs; Structural imbalance of liabilities; Greenland Holding capital chain is tight, the real estate policy continues to tighten.

4.1. Greenland Holding lacks endogenous funds

With sufficient endogenous funds, real estate companies can reduce their financing costs. When endogenous funds are abundant, real estate companies can directly invest in real estate projects . Greenland Holding's endogenous funds are greatly affected by the operating situation, and are also constrained by macro policies. In the face of high capital demand, Greenland Holding's financing capacity is declining. Compared with the financing level of the same industry, Greenland's shareholding is much lower than that of other companies , and the high leverage risk will lead to a higher financial crisis for Greenland. Due to the suspension of industry caused by the outbreak of the new coronavirus epidemic in 2020 and the economic downturn under a high base, Greenland Holdings' endogenous funds are particularly scarce, and can only rely on high debt to raise financing, which will increase the risk of financial leverage.

From 2018 to 2022, Greenland Holdings' retained earnings continued to rise, but its proportion did not increase in the same proportion but showed a decreasing trend, indicating that while Greenland Holdings achieved scale expansion, its own endogenous funds did not improve. Therefore, It is an important part of the sustainable development of real estate enterprises for Greenland Holdings to enhance the endogenous capital ability of enterprises.

4.2. Greenland Holdings' debt structure is unbalanced

Greenland Holdings, as discussed above, cannot obtain sufficient endogenous funding. Based on the theoretical analysis of priority financing, Greenland Holdings gives priority to debt financing. From 2018 to 2022, Greenland Holdings' current liabilities to total liabilities ratio continued to increase, indicating that the company is increasingly relying on current liabilities to obtain funds, the debt structure is unreasonable, and the ratio of short-term debt to long-term debt is unbalanced, resulting in insufficient short-term debt repayment capacity.

By observing the ratio of current and non-current liabilities to total liabilities, it can be found that current liabilities account for more than 80%, which is much higher than the debt ratio of the same industry. The imbalance in debt structure leads to greater potential risks in Greenland Holding's financing, and the main component of current liabilities is accounts payable. It shows that Greenland's financing from 2018 to 2022 is more short-term financing. Although short-term financing can quickly reduce Greenland Holdings' capital demand and financing costs to a certain extent, large-scale short-term financing requires a large amount of cash flow as a collateral. Once Greenland Holdings breaks the capital flow, the debt repayment risk will become large, and even affect the daily business activities of the enterprise. As a result, the uncertainty of the company's subsequent bond maturity payment increases, aggravating the debt crisis.

4.3. Greenland Holding capital chain is tight

Greenland Holdings' debt is relatively concentrated and mainly short-term debt, and repayment pressure is greater than that of the same industry. However, Greenland Holdings itself has the problem of limited funds available, so it is not possible to repay maturing debts through sales revenue and equity disposal. Although Greenland Group has completed a total sales of 63.3 billion yuan and a return of 57.1 billion yuan in the first half of 2023, Greenland Group has achieved a total sales of 63.3 billion yuan and a return of 57.1 billion yuan. However, due to the large amount of investment in the past few years, the problem of tight capital chains has not been effectively alleviated. However, the disposal of equity disposal requires slow approval at various levels, which also causes Greenland Holdings in a tight position in the capital chain. On the other hand, because the financing policy has been tightened, it is difficult for Greenland to obtain a large amount of financial support from the outside, and everything from bank loans to trusts, private placements, and overseas financing has been strictly supervised by regulators. According to an announcement released by Shanghai Changning District Tax Bureau, Greenland Holding Group Co., Ltd. added two new tax arrears, including a total value added tax of about 10.219,600 yuan and urban maintenance and construction tax of about 715,300 yuan. In addition to tax arrears, Greenland Group has a number of subsidiaries that have been included in the list of persons subject to enforcement for breach of trust, mainly because of a number of project companies in the real estate development sector due to disputes over project payments, default on project payments and other issues. Greenland Holding is facing a deteriorating financial environment and difficulties in recovering capital chain, which not only adversely affects its solvency, but also aggravates Greenland's debt dilemma.

5. Research conclusions

Since the collapse of the rigid credit bond market in China, a number of large housing enterprises have witnessed a series of storms. Based on the evaluation of Greenland Holding bond default risk measurement, this paper can draw the conclusion that under the measurement of KMV model, Greenland Holding default risk from 2018 to 2022 presents a trend of first decline and then rise, and the default distance from the first quarter of 2018 is 1.1787. The default risk remained below 1.5 until the first quarter of 2022, and then rebounded sharply to 2.4173 in the second quarter of 2020, indicating that the company's default risk declined significantly, and entered a new turning point in the first quarter of 2022, and continued to decline to about 1.5 in the fourth quarter of 2022. In contrast, there is a greater risk of bond default. Through the Greenland Holding bond default event study, the following

countermeasures can be obtained by focusing on early warning of default risk.

First, Greenland Holding's default was caused by a combination of many factors. The internal reasons were due to the shortage of endogenous funds, the liquidity crisis caused by radical strategic expansion, and the large-scale short-term debt overhang placed higher demands on the company's liquidity, while Greenland Holding's solvency was weak at this time. External factors are due to the depression of the general environment brought by the epidemic, the weakening of market expectations for real estate enterprises, and the tightening of macro policies on real estate, which lead to restrictions on the development of real estate enterprises.

Second, the real estate enterprises in our country have long had the characteristics of high leverage operation, once excessive borrowing is very easy to face the risk of bond default, so it is necessary to establish the consciousness of preventing bond default risk and perfect the early warning mechanism of the bond default risk. At present, the existing information disclosure and credit rating in China can reflect the enterprise's financial plight of enterprises to a certain extent and play an early warning role of default risk, but there are still many imperfections . Timely monitoring of the risk of high-grade bonds should be in place. Once default occurs, capital market sentiment will be greatly disturbed and the stability of the capital market will be affected. Such default characteristics of private corporate bonds are obvious, it is necessary to carry out early warning of bond default risks, and strengthen market protection for investors.

References

[1] Wang Ladi, Han Jiangxu. Financial risk evaluation of real estate listed companies [J]. Friends of Accounting, 2020(10):31-36.

[2] Shao Cuili. A credit risk assessment method based on KMV model and its application -- taking Vanke A as an example [J]. Friends of Accounting, 2018(19):34-39.

[3] Wang Ning. Research on resolving financial distress based on default distance [J]. Financial Issues Research, 2019(06):82-90.

[4] Xie Yuantao, Luo Runfang, Yang Juan. Credit risk measurement based on modified KMV model [J]. Statistics and Decision, 2018, 34(15):169-173.

[5] Yu Miaozhi, Hua Siyu. Research on corporate bond default risk measurement based on Genetic algorithm KMV model [J]. Science & Technology and Economy, 2019, 33(03):51-55.