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Research on the Credit Risk of Listed Companies Based on KMV Model—Taking Gree Electric Appliances as an Example

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Abstract: *In the analysis of Gree s credit risk, this paper selects Gree s quarterly data from 2017 to 2021 and uses the KMV model to measure Gree s credit risk. At the same time, two Gree competitors, Midea and Haier, were selected for risk comparison. The results show that Gree's credit risk is significantly smaller than the other two companies. After that, the credit fluctuations in 2017 and 2018 are explained.*

Keywords: *Credit risk, KMV model*

1. Literature Review

Generally speaking, credit risk refers to the possibility that bank lenders cannot repay bank principal and interest due to various uncertainties. However, with the continuous innovation and emergence of financial products, the meaning of credit risk has also changed. Strictly speaking, credit risk has a narrow and broad sense. In the narrow sense, credit risk refers to the possibility that lenders cannot repay principal and interest and cause losses to banks. Credit risk in a broad sense refers to the possibility of default caused by the non-performance of any party after one party has reached a contract with the other party in economic activities.

For the measurement of credit risk, the method of expert scoring was first adopted. The famous classical analysis methods are 5W, 5C, 5P, etc., but they are subjective and easy to control[1].With the development of financial products, the management of credit risk is also facing great challenges. Classical risk analysis methods have been unable to meet the needs of measuring modern risks. Therefore, a large number of scholars have developed a series of advanced models for more accurate assessment of credit risk measurement from a quantitative perspective. These models mainly include KMV model, CredictMetrics model, CridictRisk + model and so on. These models have a certain theoretical basis, so that the model has a clear economic significance in the interpretation[2].Compared with other models, the KMV model has the following advantages. Firstly, China basically has the practical application conditions of the KMV model. Secondly, the data required by the KMV model is easy to obtain. Finally, the evaluation results of the modified KMV model are in line with the national conditions and are more objective, fair and accurate[3]. Altman et al. (1997) compared the KMV model with the traditional Probit multivariate discriminant model. The results show that the KMV model has a better recognition effect on credit risk than other models[4].Li Tao (2019) selected listed companies with negative total profits in Shanghai and Shenzhen stock markets as default groups, and selected 10 matched profit groups as non-default groups according to the size of the company for comparative analysis. The conclusion shows that the two groups of data have significant differences. Taking the real estate industry as an example, it shows that the KMV model has certain applicability in China's market[5].Zhang Ling et al. (2004) compared the theory of KMV model with other credit risk evaluation models, and concluded that KMV model is more suitable for evaluating the credit risk of listed companies[6].Therefore, this paper will use the KMV model to select Gree's quarterly data from 2017 to 2021 to study Gree's credit risk.

2. KMV Model

2.1 Basic assumptions of KMV model

(1) Assume that an enterprise only finances through equity value St and a zero-coupon bond, where the current market present value Bt of the bond expires at time T, and the total principal and interest at

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maturity is D. Corporate asset value:

$$V_t = S_t + B_t \tag{1}$$

(2) The company's asset value obeys the geometric Brownian motion.

(3) There is no transaction costs and short-selling restrictions, there are risk-free assets, transactions can continue.

(4) Assume that the company will not default when the value of assets is greater than the book value of liabilities. On the contrary, if insolvent, the company will choose to default.

2.2 The Basic Idea of KMV Model

The basic idea of KMV is that the change of asset value is the most important factor affecting the occurrence of credit default. When the market value of corporate assets is greater than the market value of corporate liabilities, the equity value is the difference between corporate assets and liabilities. When the value of corporate assets is less than the market value of the company's liabilities, the company is insolvent and the equity value is 0. Therefore, the actual income of shareholders can be expressed as:

$$V_E = \max\{V_A - V_B, 0\} \tag{2}$$

Among them, it is the asset value of the enterprise, the debt value of the enterprise, and the equity value. At this time, the above equation is a European call option whose option price is the equity value of the enterprise, the underlying asset is the asset value of the enterprise, and the execution price is the market value of the enterprise's liabilities. According to the pricing law of the option pricing model, the model satisfied by the enterprise can be constructed and calculated.

2.3 KMV Model Calculation Steps

(1) Calculate the equity value and its volatility.

Since the equity value of the enterprise satisfies the pricing formula of the European call option, the following equations can be constructed.

$$V_E = V_A N(d_1) - V_B e^{-rt} N(d_2) \tag{3}$$

$$d_1 = \frac{\ln(V_A/V_B) + [(r+\sigma_A{}^2)/2]T}{\sigma_A\sqrt{T}} \tag{4}$$

$$d_2 = d_1 - \sigma_A\sqrt{T} \tag{5}$$

$$\sigma_E = \frac{V_A}{V_B} N(d_1) \tag{6}$$

Where σ_A is the value volatility of assets, T is the maturity date of debt, generally take 1, r is the risk-free interest rate, N is the cumulative distribution function of normal distribution variables. In the above four equations, except forV_A, σ_A, d_1, d_2, the values of other variables can be obtained. Therefore, the above equations can be solved.

(2) Calculate the default distance

Assuming that the asset value of the enterprise obeys the normal distribution, the default distance of the enterprise can be expressed as:

$$DD = \frac{V_A - DP}{V_A \sigma_A} \tag{7}$$

DP is the implementation point, which consists of short-term liabilities and long-term liabilities, but it is not a simple sum. Its calculation formula is as follows:

$$DP = B_S + kB_L \tag{8}$$

Among them, $B_S$is the short-term debt of the enterprise (the value of short-term bonds under 1 year), B_L is the long-term debt of the enterprise, k is the long-term and short-term debt coefficient ratio, generally 0.5.

(3) Estimate the probability of default

Since the KMV model assumes that the asset value of the enterprise obeys the normal distribution,

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the expected default probability of the enterprise can be expressed as:

$$EDF = 1 - N(DD) \quad (9)$$

The KMV model has a large number of corporate default data, and the expected default probability of the research enterprise can be obtained by using the default distance and the bankruptcy frequency of the enterprise.

3. Calculation Process

(1) According to the financial statement information disclosed by Gree, its equity value V_E and volatility σ_E can be obtained.

The market value of shareholders ' equity can be calculated according to the price of the stock. The volatility of the equity value can be calculated according to the stock price daily yield $u_i = \ln\frac{P_i}{P_{i-1}}$, and then calculate the sample standard deviation $S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(u_{i-} - \bar{u})^2}$ of the daily yield, to represent the stock daily volatility yield, where $\bar{u}$ is the mean value of u_i, n is the number of daily yield of all trading days in the stock every quarter. The stock price volatility is $\sigma_E = S\sqrt{N}$, N is the trading days of the company 's stock every half year.

(2) Risk-free interest rate

Risk-free interest rate refers to the interest rate that can be obtained by investing funds to an investment object with no risk or little risk, which is actually a compensation for the opportunity cost. Generally, SHIBOR, treasury bond interest rate and 1-year deposit interest rate are selected as risk-free interest rates. This paper chooses the national debt interest rate as the risk-free interest rate.

(3) Debt maturity

Since the repayment pressure of corporate liabilities mainly comes from short-term liabilities, the debt maturity in the model is set to 1 year.

(4) Default point and default risk

Taking the book value of debt in the balance sheet of the enterprise as the default point, the default distance DD is calculated, and then the default risk is calculated according to DD.

4. Results Analysis:

This paper selects Gree Electric Appliance Company and its two competitors from 2017 to 2021 as research samples, and selects various indicators such as daily closing price of stocks, long-term and short-term liabilities, risk-free rate of return and equity value. The value of assets, volatility of return on assets, distance of default and probability of default are calculated by Matlab software. The results are shown in Table 1, Table 2 and Table 3.

Table 1: KMV results of Gree Electric Apparatus

TIME	V_A	σ_A	DD	Risk	Risk %
2017/03/31	2.99×10^{11}	0.08	6.29	1.53×10^{-10}	1.53×10^{-8}
2017/06/30	3.52×10^{11}	0.13	4.39	5.65×10^{-6}	5.65×10^{-4}
2017/09/30	3.89×10^{11}	0.10	6.11	4.91×10^{-10}	4.91×10^{-8}
2017/12/31	4.02×10^{11}	0.14	4.41	5.20×10^{-6}	5.20×10^{-4}
2018/03/31	4.54×10^{11}	0.11	6.38	8.91×10^{-11}	8.91×10^{-9}
2018/06/30	4.19×10^{11}	0.15	4.43	4.68×10^{-6}	4.68×10^{-4}
2018/09/30	4.01×10^{11}	0.10	6.09	5.67×10^{-10}	5.67×10^{-8}
2018/12/31	3.81×10^{11}	0.09	6.29	1.54×10^{-10}	1.54×10^{-8}
2019/03/31	4.19×10^{11}	0.09	6.45	5.44×10^{-11}	5.44×10^{-9}
2019/06/30	5.12×10^{11}	0.10	6.60	2.11×10^{-11}	2.11×10^{-9}
2019/09/30	5.18×10^{11}	0.10	6.07	6.56×10^{-10}	6.56×10^{-8}
2019/12/31	5.32×10^{11}	0.11	6.40	7.93×10^{-11}	7.93×10^{-9}
2020/03/31	5.25×10^{11}	0.11	6.47	4.85×10^{-11}	4.85×10^{-9}
2020/06/30	5.02×10^{11}	0.10	6.39	8.21×10^{-11}	8.21×10^{-9}
2020/09/30	4.91×10^{11}	0.11	6.04	7.72×10^{-10}	7.72×10^{-8}
2020/12/31	5.33×10^{11}	0.11	6.34	1.12×10^{-10}	1.12×10^{-8}

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2021/03/31	5.50×10^{11}	0.10	6.43	6.24×10^{-11}	6.24×10^{-9}
2021/06/30	5.51×10^{11}	0.10	6.32	1.28×10^{-10}	1.28×10^{-8}
2021/09/30	4.59×10^{11}	0.09	6.15	3.97×10^{-10}	3.97×10^{-8}
2021/12/31	4.25×10^{11}	0.08	6.16	3.54×10^{-10}	3.54×10^{-8}

Table 2: KMV results of Midea Group

TIME	V_A	σA	DD	Risk	Risk %
2017/03/31	3.47× 1011	0.09	5.97	1.18× 10-9	1.18× 10-7
2017/06/30	3.85× 1011	0.10	5.94	1.47× 10-9	1.47× 10-7
2017/09/30	4.21× 1011	0.11	5.70	5.87× 10-9	5.87×10-7
2017/12/31	4.94× 1011	0.11	5.96	1.23× 10-9	1.23× 10-7
2018/03/31	5.33× 1011	0.11	6.03	8.00× 10-10	8.00× 10-8
2018/06/30	5.01× 1011	0.11	6.08	1.12× 10-9	1.12× 10-7
2018/09/30	4.54× 1011	0.10	5.98	2.10×10-11	2.10× 10-9
2018/12/31	4.25× 1011	0.09	6.60	3.05× 10-12	3.05× 10-10
2019/03/31	4.65× 1011	0.10	6.88	3.59× 10-10	3.59× 10-8
2019/06/30	5.21× 1011	0.10	6.16	1.91× 10-11	1.91× 10-9
2019/09/30	5.39× 1011	0.12	6.61	5.92× 10-9	5.92× 107
2019/12/31	5.76× 1011	0.11	5.70	1.44× 10-9	1.44× 10-7
2020/03/31	5.61× 1011	0.11	5.94	5.15× 10-10	5.15× 10-8
2020/06/30	6.01× 1011	0.10	6.10	8.45× 10-10	8.45× 10-8
2020/09/30	6.98× 1011	0.12	6.03	5.85× 10-9	5.85× 10-7
2020/12/31	8.27× 1011	0.12	5.70	9.71× 10-10	9.71× 10-8
2021/03/31	8.86× 1011	0.12	6.00	5.02× 10-10	5.02× 10-8
2021/06/30	7.97× 1011	0.11	6.11	9.90× 10-10	9.90× 10-8
2021/09/30	7.24× 1011	0.11	5.80	3.40× 10-9	3.40× 10-7
2021/12/31	7.35× 1011	0.11	5.95	1.38× 10-9	1.38× 10-7

It can be seen from Table 1 that although Gree's default distance and default probability fluctuated greatly during 2017-2018, the values were small and the default probability was generally smaller than the other two competitors, indicating that there was no credit risk problem.

(1) Longitudinal comparison

According to the results obtained (Table 1), we can see that in the past 5 years, Gree's default probability has fluctuated greatly in the early 2017 and 2018, but the overall default risk is still in the order of 10-4, the default risk is small, and the default probability in the remaining period is generally in the order of 10-8, and the credit is excellent. Generally speaking, Gree Electric has no credit risk problem.

Table 3: KMV results of Haier Group

TIME	V_A	σA	DD	Risk	Risk %
2017/03/31	1.49× 1011	0.07	5.43	2.81× 10-8	2.81× 10-6
2017/06/30	1.68× 1011	0.08	5.44	2.74× 10-8	2.74× 10-6
2017/09/30	1.81× 1011	0.08	5.23	8.63× 10-8	8.63× 10-6
2017/12/31	2.09× 1011	0.09	5.49	2.00× 10-8	2.00× 10-6
2018/03/31	2.25× 1011	0.10	5.57	1.24× 10-8	1.24× 10-6
2018/06/30	2.18× 1011	0.09	5.52	1.71× 10-8	1.71× 10-6
2018/09/30	2.13× 1011	0.09	5.30	5.77× 10-8	5.77× 10-6
2018/12/31	1.92× 1011	0.08	5.47	2.24× 10-8	2.24× 10-6
2019/03/31	2.12× 1011	0.08	5.56	1.38× 10-8	1.38× 10-6
2019/06/30	2.22× 1011	0.08	5.49	2.07× 10-8	2.07× 10-6
2019/09/30	2.18× 1011	0.08	5.25	7.42× 10-8	7.42× 10-6
2019/12/31	2.25× 1011	0.08	5.46	2.36× 10-8	2.36× 10-6
2020/03/31	2.30× 1011	0.08	5.64	8.44× 10-9	8.44× 10-7
2020/06/30	2.30× 1011	0.08	5.53	1.59× 10-8	1.59× 10-6
2020/09/30	2.58× 1011	0.09	5.38	3.69× 10-8	3.69× 10-6
2020/12/31	2.99× 1011	0.10	5.56	1.38× 10-8	1.38× 10-6
2021/03/31	3.24× 1011	0.11	5.68	6.75× 10-9	6.75× 10-7
2021/06/30	3.17× 1011	0.10	5.59	1.12× 10-8	1.12× 10-6
2021/09/30	2.98× 1011	0.10	5.39	3.53× 10-8	3.53× 10-6
2021/12/31	3.08× 1011	0.10	5.54	1.54× 10-8	1.54× 10-6

(2) Horizontal comparison

This paper compares Gree Electric Appliances with Midea Group and Haier Group. It can be seen from the results of the model (as shown in Table 1, Table 2 and Table 3) that the overall default probability of Gree Electric Appliances is less than that of the two competitors, and the credit risk is the lowest. The

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cost of Gree Electric Appliances is higher than that of the two competitors, which means higher quality. However, except for the cost, the cost is lower than that of Midea and Haier. Most channels are self-built, the maintenance cost is much lower than the agency cost, and the net profit is more considerable. So in the short term, credit risk is low. Although the default probability of Gree Electric is less than that of Midea and Haier, from the results of the model, the credit risk of the three enterprises is very small, and they all have their own development advantages.

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