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Assessing the default risk of Chinese public companies in the energy industry with the KMV model

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Abstract

The structural approach to credit risk modeling has gained a growing attention in both the academics and in the industry. In this dissertation, we outline the basic ideas and structures of the KMV (Merton) model and also explain some related issues before implementing this model. Referring to the KMV model, we use the KMV model to identify the credit risk of listed companies in China. We use real data to examine the default probability of 30 companies (ST and non ST)[1] in the energy sector, and the time period is from 2001 to 2010. Our results indicate that the KMV model has the ability to early identify credit risk in the energy industry of China. Also, the recent share structure reform has affected the credit risk and equity volatility of the firms in the Chinese energy sector.

Keywords: listed company in China; credit risk; default risk; ST stock; share restructure reform; Merton; KMV model; distance-to-default

[1] ST and Non ST will be introduced in part 2.1

Contents

1. Introduction

Risk has been one of the hottest words over the past decade and risk management has been paid quite a lot attention as an indispensable function in many institutions. Modern risk management systems cut across any entire organizations, involving many aspects, such as credit risk, market risk, liquidity risk, operational risk, and so on. For different institutions, different risks have different importance. For example, credit risk usually is more important for the big commercial banks than market risk for them. However, credit risk always plays a key role in most institutions which can be certified by the dramatic development of credit derivatives in the past 20 years.

With the development of credit risk in theory circle, there are two main viewpoints, one of which is that credit risk is the risk of loss because the obligor doesn't meet its repayments on time. This repayment can be a loan or other line of credit, such as the principal or interest or both. In the case of default, the debtor does not fulfill legal obligations in accordance with the debt contract, or breach loan covenants of the debt contracts. The other one considers that credit risk is a probability of loss because of the market counterparty's default. In this thesis, we follow the first definition.

We mainly focus on credit risk of the firm, which is also called default risk of the firm. It is usually associated with bankruptcy, and is recognized as one of the masses of credit events. Once the default of the firm happens, significant losses should occur. Although this is a rare event, individuals and firms cannot discriminate between the firms that will default and the firms that will not. Therefore, modeling and forecasting default risk attract peoples' attention. As is known, many credit rating agencies, such as Standard and Poor, Fitch and Moody's, were born in such a case.

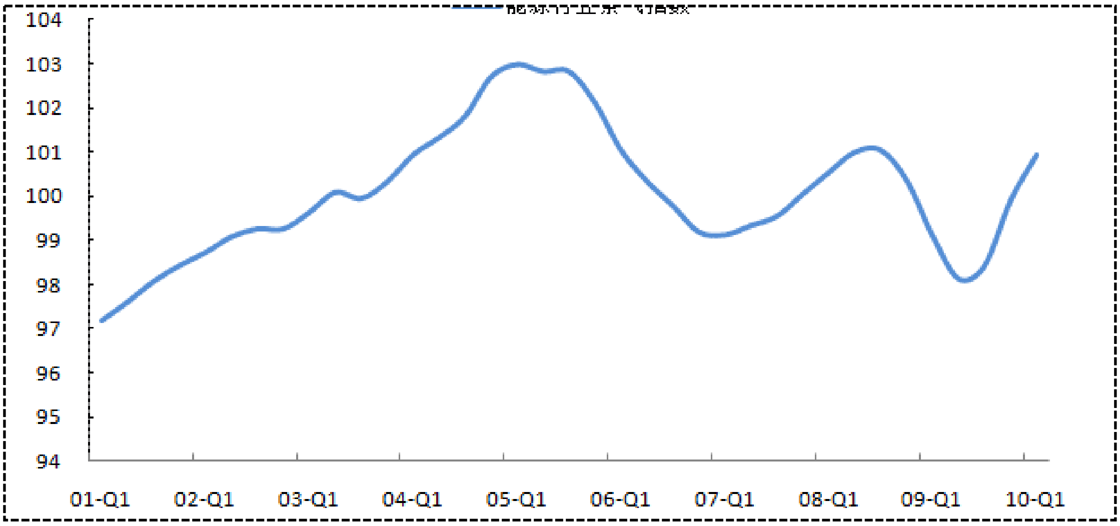
Since financial innovation and derivatives grow rapidly in the competitive financial industry, quantitative modeling of credit risk becomes a comprehensive topic. The structural approach of credit risk modeling has gained growing attention in both the academics and in the industry. Industry has long used the Moody's KMV models to predict defaults, and there are some other approaches used in academics, such as Flat Barrier, Black-Cox, Geske, Longstaff-Schwartz, Non parametric, and so on.

The four major categories of modern credit risk measurement models are J.P. Morgan's CreditMetrics, McKinsey's Credit Portfolio View, the CreditRisk+ model that developed by the Credit Suisse Financial Products, and the Moody's KMV. Since credit ratings lag on in China, the first two models that depend on the credit rating mechanism cannot be used. The CreditRisk+ model is also difficult to put into use in China, whose risk driven factors are debt default rate and the mutual debts are difficult to carry on. In this dissertation, the KMV model is applied to calculate the dynamics of credit risk for listed companies in China.

Energy sector plays a leading role for the increase of global economic growth in terms of designing new rules and making sure that they are obeyed. [2] Main components of this sector are the Oil Business, Power Production and Supply, and the Coal Mining industry. With the development of science and technology, different kinds of energy get involved in people's production and daily life. For example, Nuclear Energy, Renewable Energy Resources, Water Resources, Natural Gas, New Energy Resources, etc. The reasons for researching on energy sector in Chinese market are related to climate index, economy and national policy. According to energy sector climate index, the performance of energy sector is affected by macro-economy, climate and policy. In Figure 1, climate index in the first quarter of 2010 is 100.94, which is increased due to demand and price increase in the main sector. In the first place, the macro-economic recovery affects demand of Power Energy, and the increase of demand drives to increase the price of coal. In the second place, sustainable droughts over large tracts in the southwest of China cause lack of water and power. In the third place, pricing reversions on energy products and the implementation of Chinese fuel tax reform guarantee the increase trend of energy sector. Meanwhile, Chinese government put energy strategy adjustment in the Twelfth Five Year Plan as an important part at the beginning of 2011. The last but not the least, most of the companies in energy sector are full or part stated-owned, so

[2] Bommel P. (2011) wrote it in "Global Energy industry outlook - 2011". Designed and produced by: Deloitte Global Service Limited.

we can measure credit risk influence on the share structure reform according to these samples. Therefore, we focus on Chinese public companies in energy sector.



resources: ACMR

Figure1: Energy industry climate index

The thesis is organized as follows. Section one is introduction part. Section two, which contains problem discussion and purpose, is the research questions and the theoretical discussion. Credit risk model and analysis that contains theoretical framework of the Merton model and the KMV model is provided in section three, followed by description of methodology and analytical models in sample data. Then, the parameter estimation, research results and comparison are discussed in section five. Section six is conclusion.

2. Research question and theoretical discussion

2.1 Research question

This thesis explores default risk of Chinese listed companies in energy sector. It analyses 30 listed companies, which contain 15 normal companies and 15 special treatment (ST) companies. All of them are full or part of state-owned, and related to the Oil Business, Power Production, the Coal Mining industry, and New Energy industry.

Table 1: 15 normal stocks

Stock code	Company Name
600011	Huaneng Power International Inc.
600021	Shanghai Electric Power Co., Ltd.
600058	Minmetals Development Co., Ltd.
600121	Zhengzhou Coal Industry & Electric Power Co., Ltd.
600123	Shanxi Lanhua Sci-tech Venture Co., Ltd.
600256	Xinjiang Guanghui Industry Co., Ltd.
600348	Shanxi Guoyang New Energy Co., Ltd.
600395	Guizhou Panjiang Refined Coal Co., Ltd.
600397	Anyuan Industrial Co., Ltd.
600508	Shanghai Datun Energy Resourses Co., Ltd.
600714	Qinghai Jinrui Mineral Development Co., Ltd.
600744	Datang Huayin Electric Power Co., Ltd.
600971	Anhui Hengyuan Coal Industry And Electricity Power Co., Ltd.
600995	Yunnan Wenshan Electric Power Co., Ltd.
600997	Kailuan Clean Coal Co., Ltd.

Table 2: 15 ST stocks

Stock code	Company Name
600076	ST Weifang Beida Jadebird Huaguang Technology Co., Ltd.
600131	ST Sichuan Minjiang Hydropower Co., Ltd.
600155	ST Hebei Baoshuo Co., Ltd.
600179	ST Heilongjiang Heihua Co., Ltd.
600203	ST Fujian Furi Electronics Co., Ltd.
600299	ST Blue Star New Chemial Material Co., Ltd.
600301	ST Nanning Chemical Industry Co., Ltd.
600381	ST Qinghai Sunshiny Industry Co., Ltd.
600579	ST Qingdao Yellowsea Rubber Company Limited
600691	ST Dongxin Electrical Carbon Co., Ltd.
600722	ST Hebei Jinniu Chemical Industry Co.,ltd
600740	ST Shanxi Coking Co., Ltd.
600769	ST Wuhan Xianglong Power Industry Co., Ltd.
600792	ST Yunnan Malong Industry Group Co., Ltd.
600885	ST Wuhan Linuo Solar Energy Group Co., Ltd.

Not all the shares in a company incorporated in China that listed on a stock exchange are freely tradable. The shares in Chinese stock market can be divided into two parts: tradable shares and non-tradable shares. Only about one-third of the shares in a listed Chinese company are freely tradable before the share structure reform. This is the so called China's split-share structure. Because of the existence of a large amount of non-tradable shares, the market value of equity cannot be measured only by stock price. For example, the non-tradable shares create an "overhang" on the prices of A- shares. Moreover, the split-share structure makes a conflict of interest between tradable shareholders and non-tradable shareholders.

Since the unique split-share structure is problematic, the China Securities Regulatory Commission

(CSRC), led by the State Council, issued the Guidance Notes on the Split-share Structure Reform of listed companies on June 2005.The share structure reform, which shall be dealt with in a dynamic and prudent manner[3], is to float the non-tradable shares through the open market. Such legal person shares could, under the reform program, be converted to tradable A-shares. The converted A-shares are subject to a lockup period. Compensation programs are also being introduced by offering tradable shareholders bonus shares or cash. The illustration of structure reform can be found in the Figure 2.

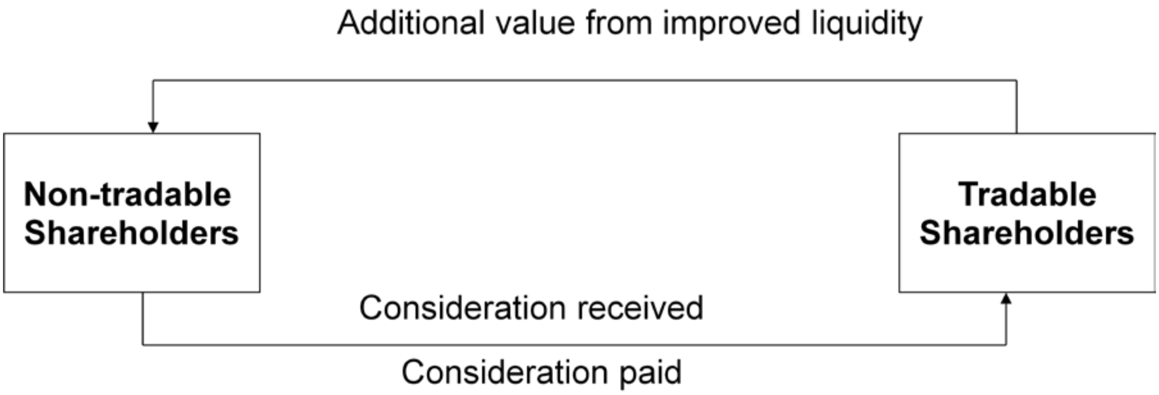


Figure 2: Illustration of structure reform

Considering the unneglected non-tradable portion before the reform, a special method would be used to value the non-tradable stocks; after which, the KMV model was used to test whether the reform of share structure can affect credit risk, which is the first question that would be solved in this paper.

The second question solved in this paper is about "ST", which stands for "special treatment". On April 22, 1998, Shanghai and Shenzhen Stock Exchange announced that they planned to make special treatment for the stock exchanged listed companies whose financial conditions and other financial situations are unusual.

The exception refers primarily to two situations:

[3] It is approved by State Council.

1) The continuous two years' audited financial reports show that the net profits are negative;

2) A listed company's recently audited financial report shows that the net asset value per share is lower than the face value of the stock price.

When the shares of listed companies are traded in the special treatment period, the stock exchange should follow three rules. Firstly, the daily price limits should not be more than 5% in every trading day[4]. Secondly, the name of the original stock should be changed with the "ST" in its front, for example, "ST steel". Thirdly, a listed company's interim report must be audited.

Since the ST companies have a worse finance situation, they are usually considered had a larger credit risk. Through comparing the distance-to-default in years before they recognized as ST companies, the early identification capacity of the KMV model in Chinese energy sector is tested. This is the other task in this paper.

Meanwhile, we also measure how different parameters affect distance-to-default. By introducing different default points, asset volatility, and asset value, we check the correlation between distance-to-default and each of them.

In short, the purposes of this paper are to test the influence of credit risk because of the share structure reform and testify the credit risk early identification of the KMV model in energy sector of China stock market.

2.2 Theoretical discussion:

2.2.1 Theoretical discussion worldwide

Many scholars and practitioners did a lot of work to examine the contribution and accuracy of the

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[4] The stock exchange imposes a 10% price limit on non-ST stocks. Price limits were introduced in July, 1990 with the birth of the Chinese stock market. Initially, trading on the stock market was very thin. In order to stimulate trading, the price limit was abandoned on May 12, 1992. From 1992 to 1995, the market gradually became heated. To maintain the stability of China's stock market, the price limit was restored on December 16, 1996 to prevent excessive speculation. The policy remains effective to date.

KMV Model by empirical analysis.

McQuown (1993) pointed out that credit risk measurement approach can be accurate when the financial report and the market price are used at the same time.

Kealhofer and Kurbat (2001) used Merton’s approach to examine the default forecasting by capturing all the information about debt rating and accounting variables. The test result showed that the agency credit ratings had no cumulative value for default prediction.

Kurbat and Korablev (2002) compared the levels of the expected default frequency (EDF) with realized default rates from 1991 to 2001 for US large companies. They found that there were a limits of sampling error between predicted and realized levels. The replication of Moody’s research results in their paper showed that the Moody’s KMV captured more information and performed better than other models of traditional rating agencies. They also proved that the KMV model was very effective.

Crodbie and Bohn (2003) modified some assumptions on KMV model to calculate the market value and the volatility of the asset based on the equity value and volatility. They used financial firms as example and obtained the distance-to-default. After calculating EDF value, they found that the changes of credit quality in pre-insolvency or when a credit event happened could be monitored accurately and sensitively.

Hillegeist, Keating, Cram and Lundstedt (2004) suggested that Black and Scholes (1973) and Merton (1974) model should be widely used in research compared with Altman's Z-score and Ohlson's O-Score model. Since their result showed that the Black and Scholes (1973) and Merton (1974) model provided significantly more information than the two accounting based models.

In 2004, the “New Basel Capital Accord” promoted to use Internal Rating Based Approach (IRB) to manage credit risk. At that time, the KMV model was introduced to be used to conduct Internal

Rating by banks, and then it was widely used and recognized in international community.

Korablew and Dwyer (2007) compared the performance among the rating agencies, EDF model, the reduced structure model and the Altman's Z-Score model based on historical data from 1996 to 2006. Their results showed that the EDF model could effectively measure consistently in different periods, for different companies in size, and in different credit quality conditions for the second category. At the same time, by researching in North America, Europe and Asia, the data represented that EDF credit risk model was an effective measure tool that could be used all around the world.

2.2.2 Theoretical discussion in China

Chinese scholars have focused on the KMV model since 1998, but lots of empirical researches and related papers were published after 2002. Early research mainly concentrates on analysis of theory and structure of the KMV model. The ideas of the KMV model and relevant area are put into two categories. One is traditional KMV model, which can be tested by using sample data directly. The other is based on the modified KMV model, in which the modifications are made according to the complex capital structure in Chinese firms, for example, the non-tradable shares in most state owned enterprise.

Armed with the traditional KMV model, scholars used Chinese listed companies as the sample. They found that the KMV model in credit risk forecasting could make up the shortage of the traditional methods, and the prospect of this model is certainly alluring. Zheng (2005) introduced this model by using blue chip stock, special treatment stock and delisting shares as the sample data. The test result of the listed companies with good performance is correct, but the test EDF value is undervalued. The model outputted an opposite test results for both special treatment stock companies and delisting companies. For example, most of the high risk companies had low EDF value. According to reverse speculation, he realized that both the market value of equity and the market value of asset were overestimated. One reason for this is the imperfect mechanism of

Chinese stock market, and the other is normal distribution assumption is not that suitable.[5] Meanwhile, some scholars applied KMV model to one or several industries. Xie (2008) chose the Power, Steam and Hot Water industry and Real Estate industry as representatives. He used the KMV model to test ten companies of each industry respectively. His result showed that the KMV model could diversify credit risk for different industries and it was an appropriate measurement for Chinese listed companies. Zhou (2009) introduced the KMV model to test credit risk for insurance industry in China.

Considering the different macroeconomic background between the creation of the KMV model and recent economic environment of China, modifying and correcting this model in order to suit to Chinese market is meaningful. Most of researches considered the real conditions of Chinese capital market, and adjusted the value of non-tradable shares. This kind of adjustment is related to three parameters, they are expected value of firm's asset, the set of default point, and volatility of equity.

With respect to the setting of expected value of asset, the main solution is to introduce the growth rate of asset value. Li and Zhang (2007a) took arithmetic average value of the net profit growth rate in the recent three years as the annual asset value growth rate. Zhou and Yang (2007) compared static distance-to-default and distance-to-default under fixed growth rate assumption. They said that the latter had better distinctive ability than the former.

With respect to the setting of default point (DP), Zhang and Yang (2004) calculated distance-to-default based on three different default points, and used t-test and Wilcoxon-test on the matching sample's distance-to-default. They drew a conclusion that the KMV model performed well when the default point value was equal to the value of current liability. Li and Zhang (2007b) compared distance-to-default between normal companies and default companies by using different default points. They realized that the strongest forecast ability could be gained when the value of default point was equal to the value of current liability plus a 10% long-term liability. Ma (2008) compared sample companies' distance-to-default value at four different default point levels, and

[5] Firm's asset value is under normal distribution around the expected asset value.

then he showed that the model performed better when default point value was equal to the value of current asset plus a 25% long-term liability.

With respect to the setting of equity volatility, Shi and Ren (2005) pointed that GARCH model might underestimate the volatility of China stock market systematically. Chen (2007), Xiong (2007), and Zhou (2009) used GARCH model to calculate the volatility of stocks in Chinese market. Jiang and Zhang (2008) proved that GARCH model was more suitable than the method of historical volatility. Zhang and Liu (2009) introduced Tompkins method instead of traditional method of historical volatility. Yan and Hua (2009) estimated equity volatility by using GARCH model. Since they should solve a simultaneous equation, they proposed an iterative process to estimate asset volatility and asset value.

Generally speaking, there are three main characteristics of empirical test after reading Chinese literatures. First of all, in respect of effectiveness test method, it is universal practice to calculate distance-to-default through the KMV model to separate special treatment and non-special treatment companies statistically. Second, in respect of equity value, most scholars use net asset value per share to valuate non-tradable shares. Some scholars apply regression analysis between net asset per share and the price on equity transfer agreement, they can obtain correcting price of non-tradable shares. Third, most scholars use one-year bank deposit interest rates at the same period as risk free interest rate.

3. Theoretical framework of the Merton model and the KMV model.

3.1 The Merton Model (1974)

In 1974, Merton proposed a model based on the option pricing techniques of Black-Scholes (1973) which is used to assess the credit risk of a firm.[6] The model links the credit risk to capital structure of the company. The fundamental idea of the Merton model is that the pay-offs to the shareholders of a firm are very similar to a call option they have purchased on the value of the firm with a strike price given by the amount of debt.

There are three particularly significant assumptions in the Merton model.

·The total value of a firm is assumed to follow geometric Brownian motion, and the firm's assets are tradable.

$$dV = \mu V dt + \sigma_v V dW$$

where V is the value of the firm, μ is the expected continuously compounded return on V, σ_v is the volatility of the firm value V, and dW is a standard Weiner process. Wt ~ N (0,t). V(t) follows log-normal distribution with expected value at time t.

$$V(t) = V(0)\exp\{\left(r - \frac{1}{2\sigma_v^2}\right)t + \sigma_v\sqrt{t}W_t\}$$

·The firms are funded by using debt and equity.

The balance sheet looks like:

	Asset	Liability
	Firm Value: V(t)	Debt: D(V,t)
		Equity: E(V,t)
Total	V(t)	V(t)

Figure 3: Balance sheet based on Merton's model

To follow the accounting identity, we have:

$$V(t) = D(V,t) + E(V,t)$$

6 Black,F. and Scholes, The Pricing of Options and Corporate Liabilities, Journal of Political Economy, Vol. 81, pp. 637-659, 1973.

·The firm has issued just a single and homogeneous discount bond maturing in T periods.

Under the three assumptions, the market value of equity is a call option on the underlying asset value of the firm with a strike price equal to the face value of the firm's debt and at maturity time T. Moreover, Black-Scholes-Merton Formula can describe the market value of equity as a function of the asset value of the firm. By put-call parity, the value of the firm's debt is equal to the value of a risk-free discount bond minus the value of a put option written on the firm, again with a strike price equal to the face value of debt and a time-to-maturity of T.[7]

Using symbols, the Merton model stipulates that the equity value of a firm satisfies

$$E = VN(d_1) - De^{-rT}N(d_2) = f(V, \sigma_V, r, D, T) \qquad (1)$$

where E is the equity value, V is the asset value, D is the default point, σ_V is the asset volatility, r is the risk-free interest rate, T is the debt maturity, N(*) is normal cumulative probability function.

$$d_1 = (\ln V/D + \left(r + \frac{\sigma_v^2}{2}\right)T)/\sigma_v\sqrt{T} \qquad (2)$$

$$d_2 = d_1 - \sigma_v\sqrt{T} \qquad (3)$$

3.2 The KMV Model

The KMV model is developed by the KMV Company; a firm specialized in credit risk analysis, and applies the framework of Black and Scholes (1973) and Merton (1974) model. In 2002, the Moody's corporation acquired KMV, and then we call it "Moody's KMV".

KMV model assumes that a company will default when the company's asset value is less than the book value of liabilities. Figure 4 shows the relationship between equity value and asset value. Based on the basic idea of the Merton model, the KMV model considers the value of equity as a call

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[7] Sreedhar T Bharath and Tyler Shumway described Merton model on 2004 in their paper "Forecasting Default with the KMV-Merton Model"

option, which regards asset value as the underlying asset and the debt value as the strike price. In Figure 4, L denotes shareholders' initial investment in the company; D denotes debt value at default point. When the asset value (V) is less than the value of debts (D), shareholders will transfer the total assets to creditors, which is consistent with a constant equity value. At this moment, shareholders choose default, and the call option is not executed. Meanwhile, when the asset value (V) is more than the value of debts (D), shareholders will gain remaining profits after paying debts, which is consistent with an increasing equity value. At this moment, shareholders don't choose default, and the call option is executed.

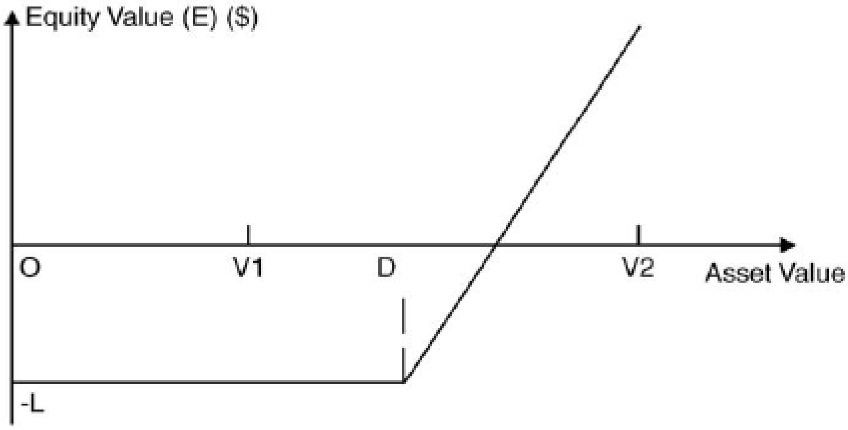

Figure 4: The relationship between equity value and asset value

Based on the Merton model, the KMV model is makes of two equations. The first one is the Black-Scholes-Merton equation, and it is equation (1) in our thesis. This equation indicates the firm's equity value as a function of the firm's asset value. Since there are two unknown parameters in equation (1), we introduce the relationship between the equity value volatility (σ_E) and the asset value volatility (σ_v).

$$\sigma_E = \frac{VN(d_1)}{E}\sigma_V = g(V, \sigma_v, r, D, T) \qquad (4)$$

This is the second equation which relates asset volatility to equity volatility.

The KMV model uses equation (1) and equation (4) to translate equity value and equity volatility into an implied default probability. Thereby, we can set a system of equations, where V and σ_v are unknown.

$$\begin{cases} f(V, \sigma_V) - E = 0 \\ g(V, \sigma_V) - \sigma_E = 0 \end{cases} \quad (5)$$

In order to solve the nonlinear simultaneous equations, we introduce Newton-iterative method, which builds iterative through Taylor expansion, to solve the asset value and asset volatility.

$$\begin{pmatrix} V^{(k+1)} \\ \sigma_V^{(k+1)} \end{pmatrix} = \begin{pmatrix} V^{(k)} \\ \sigma_v^{(k)} \end{pmatrix} - \begin{pmatrix} \frac{\partial f}{\partial V} & \frac{\partial f}{\partial \sigma_V} \\ \frac{\partial g}{\partial V} & \frac{\partial g}{\partial \sigma_V} \end{pmatrix}^{-1} \begin{pmatrix} f(V^{(k)}, \sigma_V^k) - E \\ g(V^{(k)}, \sigma_V^k) - \sigma_E \end{pmatrix} \quad (6)$$

Once this numerical solution is obtained, the distance-to-default (DD) can be calculated as

$$DD = \frac{V - DP}{V * \sigma_V} = \frac{\ln\left(\frac{V_0}{DP_T}\right) + \left(\mu - \frac{1}{2} * \sigma_V^2\right)T}{\sigma\sqrt{T}} \quad (7)$$

where DP is short for default point, DP_T is the default point at maturity time T.

In Figure 5, we can see that the six variables that determine the default probability of a firm over time horizon H. Vo is the current asset value (area 1); distribution of asset value at horizon H is indicated by 2; 3 stands for the volatility of the future assets value at time H; 4 shows the default point that is the book value of liabilities; 5 measures the expected growth rate in the asset value over the time horizon; 6 is the time horizon H.

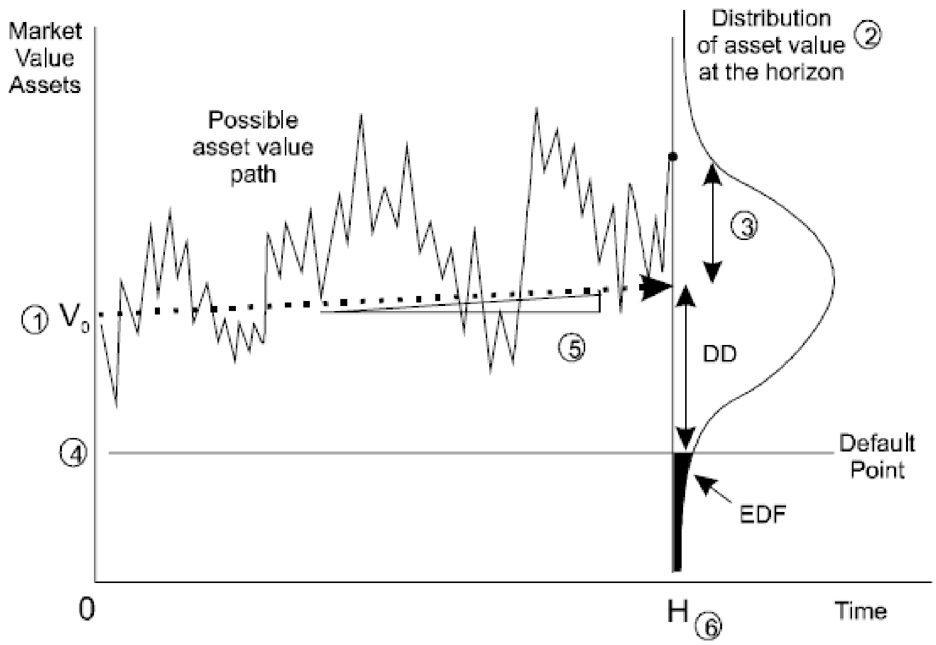

Figure 5: distance-to-default[8]

The KMV model assumes that the asset value follows normal distribution, the company's expected default frequency (EDF) can be calculated as:

$$EDF = N(-DD) \qquad (8)$$

Whether the asset value of the firm follows normal distribution or not is a question. The KMV Company uses the empirical value of EDF instead of the theoretical value, since it has a huge database of default companies to compare with.

The KMV model is much smarter than Merton's model which is a foundation on modeling credit risk, due to the usage of application in forecasting credit risk of the firm. The forecast performance relies on how realistic the assumptions are. Therefore, the thesis prefers the KMV model for the following analysis.

[8] The figure is downloaded from Moody's KMV handbook, Modeling default risk.

4. Methodology

4.1 Data Selection

To use the Moody's KMV equations, we choose thirty firms in total to observe their monthly distance-to-default from year 2001 to year 2010, which are all in energy sector. The sample includes 15 special treatment companies, and 15 normal companies. Another characteristic is that there are some non-tradable shares in each company before the share restructure reform.

4.2 Parameter's Estimation

·The volatility of equity

The volatility of equity is calculated by historical equity return data. Log return is introduced to solve this problem, under the assumption that the stock price follows the geometric Brownian motion. Since real stock closing price is ex-right price, which is affected by share dividend. The lower ex-right price after allotment of shares creates a false impression that the stock plunges. However, total equity value is not changed. Therefore, equity volatility may be overestimated by using ex-right price. In order to solve this problem, the price after the restoration of rights is introduced in our test. We assume that u_i is the log return at the ith day, S_i is the restoration of rights price at the ith day, and S_{i-1} is the restoration of rights price of the stock at (i-1)th day.

$$u_i = \ln \frac{S_i}{S_{i-1}} \qquad (9)$$

We can work out the volatility of equity based on this equation as below.

$$\sigma_E = \frac{\sqrt{\frac{1}{t-1}\sum(u_i-\bar{u})^2}}{\sqrt{\frac{1}{n}}} \qquad (10)$$

where n is the trading day, which is approximately equal to 250 per year.

When the stock was suspended for a long period of time, the stock price in that period is constant. We use average equity volatility in the previous period instead.

·The market value of equity

It is calculated by multiplying the number of stocks by the stock price. Since there is a special case in China that not all the shares are tradable in exchange, especially the shares of the stated-owned companies. The non-tradable shares' value is lower than the tradable shares'. So simply multiply the value of stock price and the number of the stocks will overestimate equity value. Here, we use net asset per share to estimate the non-tradable shares' value. Therefore, the total equity value should be:

Equity Value = the closing price of tradable shares * the number of tradable shares

+ Net assets per share * the number of non-tradable shares

We write VBA code to calculate monthly average closing price and equity volatility through excel, and the code can be found in appendix.

·Risk-free interest rate

We use one-year bank deposit interest rates at the same period as the risk-free interest rate. The data are from Bank of China's website[9].

·Maturity time

Since the liability structure is complex, we cannot gain the detail of the maturity time. In this case, we assume that the maturity time is **one year**.

·The value of the firm liability

Based on Moody's research, the value of the firm's liability is calculated by the short-term value plus half of the long-term value. We collected this data from the balance sheet (Y2001-Y2010) that can be downloaded from Sina Finance[10].

·The value and volatility of firm asset

The value and volatility of the firm's asset can be solved from the nonlinear simultaneous equations (2), (3) and (4). We use Newton iterative method (see Figure 6) to calculate asset volatility first, and then substitute it into equation (1) to obtain asset value. Matlab is used to realize this process, and

[9] http://www.boc.cn/

[10] http://finance.sina.com.cn/

the code is illustrated in appendix.

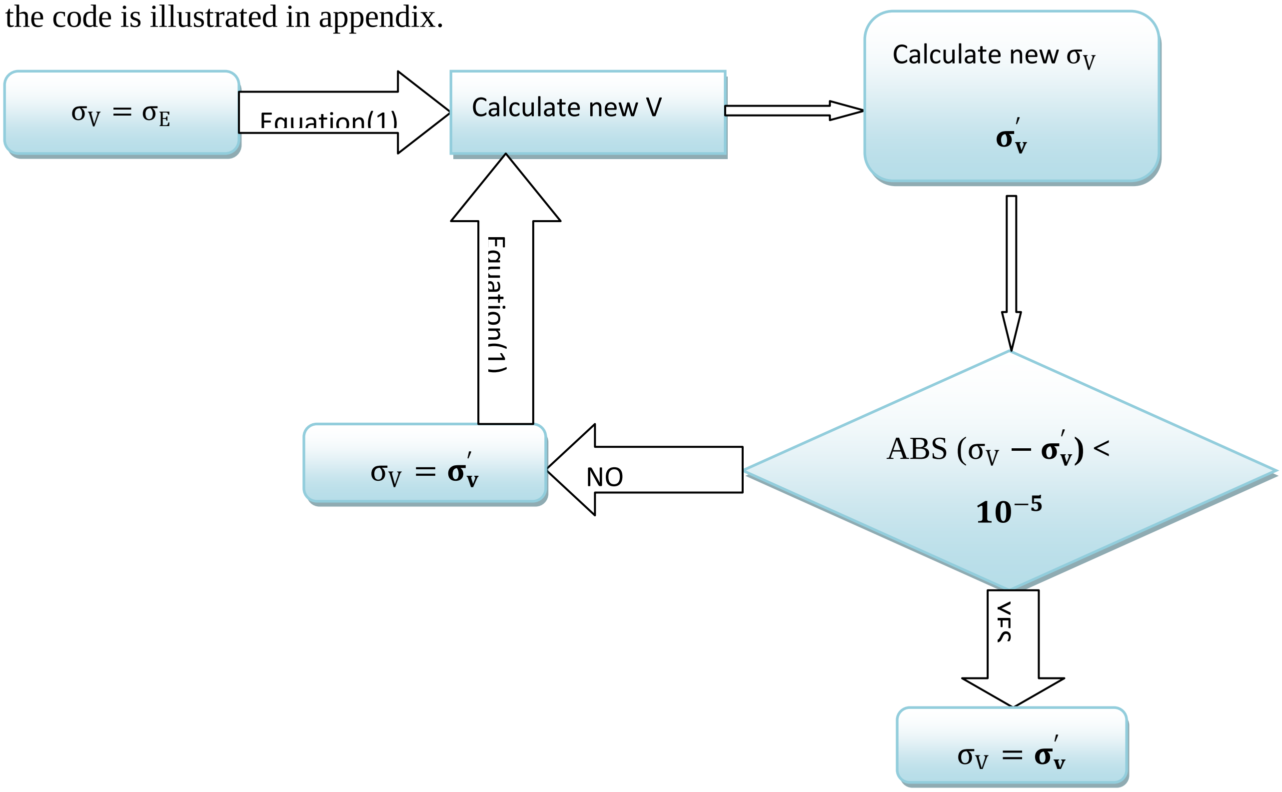

Figure 6: Newton iterative method

·Distance-to-default (DD)

After getting all the parameters, the distance-to-default can be calculated based on equation (7).

4.3 Credit risk before and after the share structure reform

Wang and Liang (2008) compared credit risk of Shanghai and Shenzhen listed companies before and after the share structure reform. They realized that credit risk increased obviously after the share structure reform. Through sensitivity analysis, they found that equity volatility is the most sensitive factor to distance-to-default. Chen et al; (2010) introduced Fisher test and Wilks' lambda to test whether share reform would affect credit risk of Chinese listed SMEs[11]. Zhang et al; (2008) use Paired-samples T Test to compare the means of distance-to-default before and after the share structure reform. The test works by testing the average difference between pairs of data points against a value of zero. Since Paired-samples T Test requires that the sample data should be in normal population, they use One-sample Kolmogorov-Smirnov Test on distance-to-default

[11] SME means small and medium enterprises

(pre-share structure reform and post-share structure reform) and equity volatility (pre-share structure reform and post-share structure reform) separately.

We use similar methods to test whether the share structure reform impacts on credit risk in energy sector. We divide the value of distance-to-default into two parts with the boundary of the share structure reform date: pre-shares reform refers to the period from the beginning of 2001 to the initial date of reform, and post-shares reform refers to the period from the initial date of reform to the end of 2010.

In the first step, we use data analysis tool called “F Test – Two samples” in excel to compare the two samples. The test was done twice. In the first test, the one null hypothesis is that the variance of distance-to-default (pre-share structure reform) is equal to the variance of distance-to-default (post-share structure reform) while the other null hypothesis is that the variance of equity volatility (pre-share structure reform) is equal to the variance of equity volatility (post-share structure reform).

After “F Test – Two samples” showed whether the two distance-to-default samples have the same variances, we choose “T Test – Two samples with the same variance” or “T Test – Two samples with different variance” to test the mean of distance-to-default (pre-share structure reform) is equal to the mean of distance-to-default (post-share structure reform). Similarly, the hypothesis that whether the mean of equity volatility (pre-share structure reform) is equal to the mean of equity volatility (post-share structure reform) is tested

4.4 Early identification of credit risk

Relying on the characteristics of ST companies, we know that they have continuous two year negative profit or one year net asset value per share that is less than the face value of stock price which may suggest that the value of distance-to-default around ST period should be smaller than usual. Therefore, we find the year when the stock becomes “ST”, and then compare the value of distance-to-default.

5. Results

We present a number of empirical results, including the share structure reform influence with two samples tests, time implied distance-to-default regressions and significant test, correlations of distance-to-default with default point, asset volatility and asset value. We discuss each type of the results in turn.

5.1 The share structure reform influence

In our sample data, all the companies' shareholder structures have been reformed. Table 3 shows the date of share structure reform for the 15 normal stocks, and Table 4 shows the date of share structure reform for the 15 ST stocks. We also split share structure reform schedule in Table 5 (see Table 3-5 in appendix).

After collecting two types of DD and equity volatility before and after the share structure reform, we use "F Test – Two samples" and "T Test – Two samples" to compare the variance and mean value.

- DD_1 denotes the value of distance-to-default before the share structure reform;
- DD_2 denotes the value of distance-to-default after the share structure reform;
- sigma e 1 denotes equity volatility before the share structure reform;
- sigma e 2 denotes equity volatility after the share structure reform.

The output of "F Test – Two samples" shows we should reject the null hypothesis that DD_1 and DD_2 have the same variance at 5% significant level (see Table 6). Relying on this result, we choose "T Test – Two samples under heteroscedasticity assumption" to test the difference between the mean of DD_1 and DD_2. The test result indicates that there is significant difference before and after the share structure reform on DD's mean in statistics at 5% significant level which implies the average DD value becomes smaller after the share structure reform (see Table 7).

Table 6: F Test-two samples for DD

	DD_1	DD_2
MEAN	3.047115	2.139713
VARIANCE	2.796148	33.28269
OBSERVE	1715	1624
Df	1714	1623
F	0.084012	
P(F<=f) ONE TAIL	0	
F ONE TAIL	0.922619	

Table 7: T Test-two sample for DD under heteroscedasticity assumption

	DD_1	DD_2
MEAN	3.047115	2.139713
VARIANCE	2.796148	33.28269
OBSERVE	1715	1624
ABS(MEAN1-MEAN2)	0	
Df	1880	
t Stat	6.100443	
P(T<=t) ONE TAIL	6.4E-10	
t ONE TAIL	1.645665	
P(T<=t) TWO TAILS	1.28E-09	
t TWO TAILS	1.961227	

Similar tests are also done as it be shown in (see Table 8 and Table 9) [12], which illustrate equity volatility before and after the share structure reform are not the same, and the average value of equity volatility after the share structure reform becomes bigger than before.

[12] Table 7: F Test – Two samples' result shows that variance (DD_1) is not the same as variance (DD_2). So T Test under heteroscedasticity assumption is chosen to test the mean of DD_1 andDD_2.

Table 9: F Test – Two samples' result shows that variance (sigma e 1) is equal to variance (sigma e 2), so T Test under homoscedasticity assumption is chosen.

Table 8: F Test-two samples for equity volatility

	sigma e 1	sigma e 2
MEAN	0.396920477	0.548051625
VARIANCE	0.034505154	0.034963237
OBSERVE	1715	1624
Df	1714	1623
F	0.986898151	
P(F<=f) ONE TAIL	0.393704831	
F ONE TAIL	0.922619494	

Table 9: T Test-two sample for equity volatility under homoscedasticity assumption

	sigma e 1	sigma e 2
MEAN	0.396920477	0.548051625
VARIANCE	0.034505154	0.034963237
OBSERVE	1715	1624
Polled variance	0.034727949	
ABS(MEAN1-MEAN2)	0	
Df	3337	
t Stat	-23.42239374	
P(T<=t) ONE TAIL	9.3525E-113	
t ONE TAIL	1.645310383	
P(T<=t) TWO TAILS	1.8705E-112	
t TWO TAILS	1.960675085	

"F Test – Two samples" and "T Test – Two samples" are also used to test all the companies separately. 22 companies out of 30 have the same result that the mean of DD value before and after the share structure reform is not the same. The test result can be found in appendix (Table 10). All test results show that credit risk before and after the reform can be discriminated effectively.

Combined with the previous results, we can draw a conclusion that there is an obvious difference in credit risk before and after the share structure reform, and the reform has impacts on credit risk. In general, default risk is increased in energy sector of China.

5.2 Warning capacity of KMV model in energy sector of China

After obtaining monthly DD value of all companies, we annualized them and split the yearly DD value for all the thirty companies in Table 11. The DD value at the year in which the company become "ST" company was highlighted in yellow. In Table 11, we can realize that the value of DD decreases obviously during the two years before the companies become to special treatment companies. We also draw the picture to show the trend of DD value over year 2001 to 2010 for each company (see Figure 7-9). Stock 600076 can be regarded as an example of this trend. It becomes a ST stock in 2006. The Figure 7 shows that both DD values in 2004 and 2005 were lower than usual, and the DD value declined between 2001 and 2005. A downward trend of DD, likewise, is seen as a means of warning the credit risk of companies. The lower the DD value is, the higher the credit risk is.

The above studies indicated that the KMV model can be used to warn credit risk of the firms in energy sector of China. Moreover, the modified KMV model fits the test requirements of Chinese market, and it can show us a meaningful result to measure credit risk of firms in energy sector. We can analyze the trend of DD values that is obtained from KMV model to improve risk warning capability.

Table 11: Annual DD value of ST stocks

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
600076	3.863508	2.965208	2.634383	1.9745	1.978617	2.289125	1.851067	1.859475	2.129608	2.744058
600131	3.187575	3.785558	3.47185	3.075	2.491225	2.476442	1.4365	1.255792	2.150925	2.890617
600155	3.5345	3.6545	4.236033	3.694408	2.930183	2.923067	1.928975	2.165583	2.100358	2.796867
600179	4.231617	3.526883	4.147983	2.619217	2.296658	2.648308	1.525525	1.22915	1.803542	2.325525
600203	3.285858	3.354725	3.437933	2.189725	2.692725	2.3455	1.992492	1.461283	1.916742	2.15725
600299	2.856242	3.374492	2.962233	2.625717	2.288742	2.064942	1.740775	1.335633	1.893583	2.428775
600301	3.137383	3.2318	2.931592	2.951142	2.360842	2.605108	1.496567	1.415658	1.9846	2.637617
600381	2.966514	4.260208	3.75075	2.595067	2.060483	2.321242	1.553742	1.88395	2.320908	2.775442
600579		3.848625	2.924392	2.640575	2.078092	1.872133	1.733533	1.713283	2.137108	2.710233
600691	2.87685	3.279842	3.417967	1.921767	1.995292	2.387775	2.096492	1.7708	2.029425	2.279875
600722	3.485575	3.510858	4.016075	2.890308	2.227883	2.309075	1.621217	1.699692	2.196892	2.602642
600740	2.91655	3.560592	3.689508	2.127708	2.341933	2.569092	1.719617	1.331133	1.687025	2.439717
600769	4.06755	3.671725	3.550225	2.490342	2.468983	2.453192	1.922508	1.637558	1.828742	2.3399
600792	4.52165	5.74265	11.15659	5.390967	2.535742	2.489433	1.2712	21.49856	2.197267	2.8872
600885	3.012442	3.180433	3.27075	2.604892	1.959517	1.832717	1.341825	1.448508	1.778283	2.272792

Figure 7: the trend of DD value over 10 year period for stock

600076/600131/600155/600179/600203

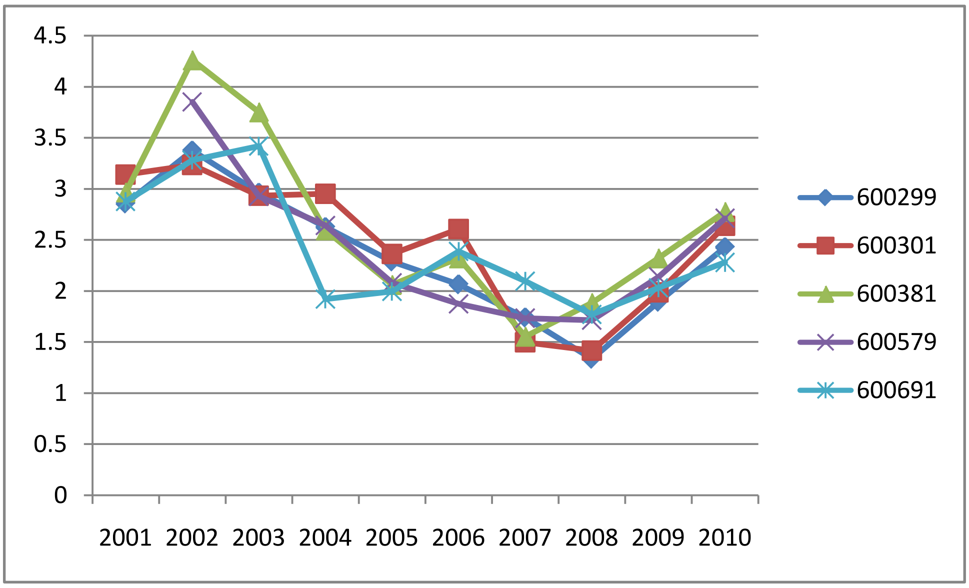

Figure 8: the trend of DD value over 10 year period for stock

600299/600301/600381/600579/600691

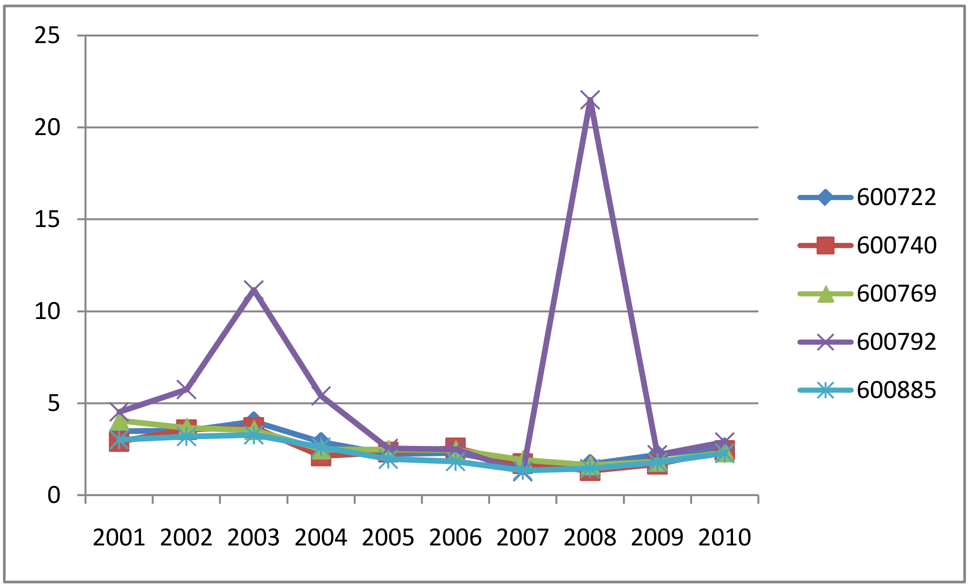

Figure 9: the trend of DD value over 10 year period for stock 600722/600740/600769/600792/600885

6. Conclusion

In this thesis, we describe the basic idea of the Merton model and the KMV model. After comparing with other modern structure models, we realized that the KMV model is the most appropriate one for the energy sector in Chinese market. We applied KMV model to 30 Chinese firms in energy sector over the period from 2001 to 2010.

By examining the real data, we propose a special attention to calculating equity volatility in KMV model. When we calculate the daily stock return we considered both capital gains and dividends gain, including cash dividends and stock dividends. For most stocks in our sample, there are some suspension time[13], during which period, the volatility calculation can be quite inaccuracy. Then the average equity volatility of previous period is used. Both these two methods can improve the accuracy of equity volatility.

In general, the KMV model performs well in measuring credit risk of energy sector in China. Through multiple tests, credit risk changes obviously before and after the share structure reform, which brings much more impacts on credit risk at test period. After calculating equity volatility in different year, we realized that equity volatility changed in counter trend comparing with the value of distance-to-default before and after the share structure reform. The value of distance-to-default becomes smaller, and the equity volatility becomes bigger.

The KMV model with tuned parameters is capable of identifying and warning the credit risk of Chinese published companies in energy sector. The measuring capability of the model is verified with the experimental results, which are very meaningful with reality. The test results show us that the value of distance-to-default is poorer in the first two years before the companies become ST companies. The closer to the date companies are identified as ST, the smaller the value of distance-to-default is. In other words, the closer to the date companies become ST companies, the

[13] Suspension time means there are no trading of the certain stock due to big event, such as potential M&A , is taking place. The stock will stop strading during that time, which can last from several days to more than 1 year.

higher the default risk is. Therefore, the KMV model has the warning capacity of credit risk in energy sector of China.

In summary, the KMV model is useful when applied to listed firms in Chinese energy sector; it can measure credit risk and identify firms with large or small credit risk. However, the variables of the KMV model are disputable and not defined for Chinese market, so the test results are not authoritative.

Firstly, because of the special capital structure of Chinese listed companies, the market value of equity is hard to determine. The total capital contains not only common shares, but also non-tradable shares. In our data analysis, we find that the non-tradable shares make up a significant proportion of the total equity. Since the real price for non-tradable shares is hard to measure, it is difficult to calculate the accurate market value of equity.

Secondly, we cannot easily find the default point for energy sector of China. KMV Company obtained the default point through huge historical database and lots of empirical tests. In allusion to Chinese credit market, we cannot get enough data to find an accurate default point. Moreover, whether the setting of default point in the KMV model suit to Chinese market or not is a question.

Thirdly, there is an important assumption that asset value follows normal distribution, so the default probability can be calculated through equation (8) as above. In Chinese energy sector, we are not sure whether asset value follows normal distribution strictly. Therefore, we stop our test on distance-to-default calculation.

Last but not the least; the equity volatility estimation may be biased because of the limitation of stock price moves. Based on the rules, the non-ST stock price are imposed a floor price and ceiling price. Every trading day, the price is limited to the interval between 10% higher than the previous day closing price and 10% lower than that. The ST stocks are at 5% limitation level. This kind of regulation limits the volatility of stock price, and then affects the calculation of equity volatility.

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References

Askventure. “What is split share structure and split share reform?”. http://www.askventure.com/what-is-split-share-structure-and-split-share-reform/

Bharath S.T. and Shumway T. (2004). “Forecasting Default with the KMV-Merton Model”. Paper presented at the American Finance Association 2006 Boston Meetings.

Black F. and Scholes M. (1973). “The Pricing of Options and Corporate Liabilities”, *Journal of Political Economy*, Vol. 81, pp. 637-659.

Bommel P. (2011). “Global Energy industry outlook - 2011”. Designed and produced by: Deloitte Global Service Limited.

Chen X.H., Wang X.D., and Wu D.S. (2010). “Credit risk measurement and early warning of SMEs: An empirical study of listed SMEs in China”, *Decision Support Systems*, Vol. 11, pp. 31-40.

Crosbie P.J. and Bohn J.R. (2003). “Modeling Default Risk - Modeling Methodology”. Published by: Moody’s KMV.

Hillegeist S.A., Keating E.K., Cram D.P., and Lundstedt K.G. (2004). “Assessing the Probability of Bankruptcy”, *Review of Accounting Studies*, Vol. 9, pp.5-34.

Hull J. (1997). “Options, Futures, and Other Derivative Securities, 3rd Edition”. Published by: Prentice Hall, New Jersey.

Jiang Z.Q. and Zhang N.F. (2008). “Modification and usage of KMV Model”, *Statistics and Decision*, Vol. 9, pp. 67-69.

Kealhofer S. and Kurbat M. (2001). “The Default Prediction Power of the Merton Approach, Relative to Debt Ratings and Accounting Variables”. Published by: KMV Corporation, LLC, San Francisco.

Korablev I. and Dwyer D. (2007). “Power and level validation of Moody’s KMV EDF™ credit measures in north America, Europe, and Asia”. Published by: Moody’s KMV Company.

Kurbat M. and Korablev I. (2002). "Methodology for Testing the Level of the EDF™ Credit Measure". Published by: Moody's KMV Company.

Li L.N. and Zhang K. (2007). "Modified KMV Model and the usage of measuring credit risk of Chinese listed companies", *Financial Perspectives Journal*, Vol. 13, pp. 48-50.

Li L.N. and Zhang K. (2007). "The choice of default point of China listed company - based on KMV Model", *Journal of Guangxi Financial Research*, Vol. 10, pp. 42-45.

Ma Y.S. (2008). "Empirical research on Chinese listed company's credit risk measurement", *Journal of East China Normal University*.

McQuown J.A. (1993). "A Comment on Market vs. Accounting - based Measures of Default Risk", Published by: KMV Corporation, LLC, San Francisco.

Shi X.J. and Ren R.E. (2005). "Learning the consistency of credit model based on both option and accounting information", *Systems Engineering - Theory and Practice*, Vol. 10, pp. 11-20.

WANG J.W.and LIANG Y.J. (2008). "An Empirical Study of the Credit Risk of Listed Corporation in China Based on the KMV Model", *Mathematics in Prictice and Theory,* Vol. 10, pp. 46-52.

Xie B.C. (2008). "The choice of credit risk measurement model of Chinese listed company", *Economic Perspectives*, Vol. 5, pp. 55-58.

Xu Y.P., Guo Y.F., and Jiang H. (2010). "The Effect of Price Limits on Price Discovery in China's Stock Market",http://home.cc.umanitoba.ca/~jiang2/price%20limit%20may%204%202010.pdf

Yan H.F. and Hua W.J. (2009). "Measuring credit risk of Chinese listed company based on KMV model", *Industrial Economic Research*, Vol. 3, pp. 14-22.

Yang H.C., Zhang S.J., and Zhu Y.J. (2006). "Float, Liquidity, Speculation, and Stock Prices: Evidence from the Share Structure Reform in China", Paper presented at the 2006 NTU International Conference on Finance, Singapore.

Zhang L. and Yang Z.S. (2004). "The usage of KMV Model for credit risk measurement of listed company", *Control System*, Vol. 11, pp. 84-89.

Zhang N.F. and Liu Q.Y. (2009). “The KMV Model research based on Tompkins method”, *Statistics and Decision*, Vol.14, pp. 40-42.

Zhang Z.J. etal (2008). “An empirical study of the credit risk of the listed SMEs in China based on the KMV model”, *Applications of statistics and management*, Vol. 1, pp. 164-175.

Zheng M. (2005). “Empirical Research of Credit Risk for the Public Company Using EDF Model”, *Journal of Industrial Engineering and Engineering Management*, Vol. 19, No. 3, pp 151-154.

Zheng Z.Y. (2009). “Quantitative Financial Analysis - Matlab”. Published by: Beijing University Press.

Zhou R.F. (2009). “The credit risk measurement of Chinese listed companies in Insurance industry based on KMV model”, *Insurance studies*, Vol.3, pp 77-81.

Zhou Z.Y. and Yang Y.S. (2007). “Use Distance-to-default to measure credit risk: an empirical analysis”, *Journal of Audit and Economics*, Vol. 2, pp. 81-85.

Appendix

VBA code – equity volatility & average stock price calculation

```
Sub variancecalculationforthewholebook()
Dim j As Integer
Dim FirstDate As Date
Dim IntervalType As String
Dim x, y, p As Integer
Dim r As Integer
Dim variance, annualvariance, av, total, totalvariance, totalprice As Double
For j = 1 To ActiveWorkbook.Sheets.Count
Worksheets(j).Activate
'tittle for each colomun
Range("c2") = "return"
Range("d2") = "time"
Range("e2") = "monthly variance of return(annualized)"
Range("f2") = "monthly average price"
Dim A, b, c, d As Date
Dim i, lastrow As Integer
lastrow = Cells.Find("*", _
    SearchOrder:=xlByRows, LookIn:=xlFormulas, _
    SearchDirection:=xlPrevious).EntireRow.Row
A = #1/1/2001#
b = #12/31/2010#
'sort data, delete the data outside the observation window, there is bug inside, can be just used for once, otherwise, one more line might be delete
For i = 3 To lastrow
c = Range("a" & i).Value
If b < c Then
ActiveSheet.Range("a" & i, "a" & lastrow).EntireRow.Delete
Exit For
Else
End If
Next i
lastrow = Cells.Find("*", _
    SearchOrder:=xlByRows, LookIn:=xlFormulas, _
    SearchDirection:=xlPrevious).EntireRow.Row
'calculate the return
For i = 4 To lastrow
Range("c" & i).Value = Log(Range("b" & i).Value / Range("b" & i - 1).Value)
Next i
'put the sheet into two parts, one which goes public earlies than 2001, one after 2001
```

```
If Range("a3") < A Then
For i = 3 To lastrow
c = Range("a" & i).Value
If A >= c Then
Else:
ActiveSheet.Range("a3", "a" & i - 1).EntireRow.Delete
Exit For
End If
Next i
'variance
'first thing we have to identify the monthly data
lastrow = Cells.Find("*", _
    SearchOrder:=xlByRows, LookIn:=xlFormulas, _
    SearchDirection:=xlPrevious).EntireRow.Row
IntervalType = "m"
FirstDate = "1 - 1 - 2001"
For i = 0 To 120
A = DateAdd(IntervalType, i, FirstDate)
b = DateAdd(IntervalType, i + 1, FirstDate)
'MsgBox a
     For x = 3 To lastrow
     c = Range("a" & x).Value
     If A > c Then
     Else
     Exit For
     End If
     Next x
          For y = x To lastrow
          c = Range("a" & y).Value
          If b > c Then
          Else
          Exit For
          End If
          Next y
d = "2 - 2 - 2011"
If y > d Then
Exit For
Else
'calculate variance
     Range("e" & i + 3).Value = "=sqrt(250)*stdev(c" & x & ":c" & y - 1 & ")"
     Range("d" & i + 3).Value = A
     Range("f" & i + 3).Value = "=average(b" & x & ":b" & y - 1 & ")"
If y - x < 10 Then
  Range("e" & i + 3).Value = "=average(e3 :e" & i + 2 & ")"
```

```
  Range("e" & i + 3).Select
    With Selection
        .Interior.Color = 65535
        Range("d" & i + 3).Value = A
        Range("f" & i + 3).Value = "=average(f3 :f" & i + 2 & ")"
        End With
Else
End If
End If
Next i
Else
'this is for the companies went public after 2001
'first thing we have to identify the monthly data
lastrow = Cells.Find("*", _
      SearchOrder:=xlByRows, LookIn:=xlFormulas, _
      SearchDirection:=xlPrevious).EntireRow.Row
IntervalType = "m"
Dim Message, Title, Default As String
Message = "enter the beginning month"
'this next sentence is used to input the date
'FirstDate = InputBox(Message, Title, Default)
' in this version, we will use the date of the first public date
p = Day(Range("a3").Value)
'MsgBox r
If p < 3 Then
FirstDate = Range("a3").Value
Else
FirstDate = Range("a3").Value - p + 1
FirstDate = DateAdd("m", 1, FirstDate)
End If
n = DateDiff("m", FirstDate, "2010 - 12 - 31")
For i = 0 To n
A = DateAdd(IntervalType, i, FirstDate)
b = DateAdd(IntervalType, i + 1, FirstDate)
'MsgBox a
        For x = 3 To lastrow
        c = Range("a" & x).Value
        If A > c Then
        Else
        Exit For
        End If
        Next x
                For y = x To lastrow
                c = Range("a" & y).Value
```

```
                If b > c Then
                Else
                Exit For
                End If
                Next y
    d = "2 - 2 - 2011"
    If y > d Then
    Exit For
    Else
    'calculate variance
        Range("e" & i + 3).Value = "=sqrt(250)*stdev(c" & x & ":c" & y - 1 & ")"
        Range("d" & i + 3).Value = A
        Range("f" & i + 3).Value = "=average(b" & x & ":b" & y - 1 & ")"
    If y - x < 10 Then
     Range("e" & i + 3).Value = "=average(e3 :e" & i + 2 & ")"
     Range("e" & i + 3).Select
      With Selection
        .Interior.Color = 65535
        Range("d" & i + 3).Value = A
        Range("f" & i + 3).Value = "=average(f3 :f" & i + 2 & ")"
        End With
    Else
    End If
    End If
    Next i
    End If
    Next j
End Sub
```

Matlab code – asset value, asset volatility, and DD calculation

KMV:

```
clc
clear all
dat=xlsread('F:\书及课件\dissertation\upload\ST 600155 Hebei Baoshuo Co., Ltd..xls');      % read
xls data
D1=dat(:,1);    %define column 1 as D
r1=dat(:,2);    %define column 2 as r
E1=dat(:,3);    %  ......        3  as  E
EquityVolatility1=dat(:,4); % ... 4 as sigma E
SD1=dat(:,5);              % ... 5 as SD
LD1=dat(:,6);              %  ...  6 as LD
T=1;
for i=1:120      % i: number of data in xls
        D=D1(i);
        r=r1(i);
        E=E1(i);
        EquityVolatility=EquityVolatility1(i);
        SD=SD1(i);    %SD: short debt
        LD=LD1(i);    %LD:  bng  debt
        DP(i)=SD1(i)+0.5*LD1(i);      %  DP=SD+0.5*LD    %DP:Defaut  point
        D=DP(i);    %D:Debt maket value
[Va(i),AssetVolatility(i)]=KMVIterative(E,D,r,T,EquityVolatility);
%compute Va and AssetVolatility
DD(i)=(Va(i)-DP(i))/(Va(i)*AssetVolatility(i));    %compute the distance
    end
% transpose of results
    (Va)'
    (AssetVolatility)'
(DD)'
```

KMV Iterative:

```
function [Va,AssetVolatility]=KMVIterative(E,D,r,T,EquityVolatility)
%KMVIterative
%code by ariszheng@gmail.com
    EtoD=E/D;
    x0=[1,1]; % find the initial value
    VaVolatilityX=fsolve(@(x) KMVfun(EtoD,r,T,EquityVolatility,x), x0);
    Va=VaVolatilityX(1)*E;
    AssetVolatility=VaVolatilityX(2);
    % F=KMVmodel(EtoD,r,T,EquityVolatility,x)
```

KMV model:

```
function F=KMVmodel(EtoD,r,T,EquityVolatility,x)
   d1=( log(x(1)*EtoD)+(r+0.5*x(2)^2)*T ) / ( x(2)*sqrt(T));
   d2=d1-x(2)*sqrt(T);
   F=[ x(1)*normcdf(d1)-exp(-r*T)*normcdf(d2)/EtoD-1;
     normcdf(d1)*x(1)*x(2)-EquityVolatility];
```

Table 3: Split the date of share structure reform for normal stocks

Stock code	Company Name	the date of share structure reform
600011	Huaneng Power International Inc.	Apr-06
600021	Shanghai Electric Power Co., Ltd.	Nov-05
600058	Minmetals Development Co., Ltd.	Apr-06
600121	Zhengzhou Coal Industry & Electric Power Co., Ltd.	Aug-05
600123	Shanxi Lanhua Sci-tech Venture Co., Ltd.	Feb-06
600256	Xinjiang Guanghui Industry Co., Ltd.	Apr-06
600348	Shanxi Guoyang New Energy Co., Ltd.	Dec-05
600395	Guizhou Panjiang Refined Coal Co., Ltd.	Jul-06
600397	Anyuan Industrial Co., Ltd.	Aug-06
600508	Shanghai Datun Energy Resourses Co., Ltd.	Jan-06
600714	Qinghai Jinrui Mineral Development Co., Ltd.	Sep-06
600744	Datang Huayin Electric Power Co., Ltd.	Jul-06
600971	Anhui Hengyuan Coal Industry And Electricity Power Co., Ltd.	Feb-06
600995	Yunnan Wenshan Electric Power Co., Ltd.	Sep-06
600997	Kailuan Clean Coal Co., Ltd.	Jan-06

Table 4: Split the date of share structure reform for STstocks

Stock code	Company Name	the date of share structure reform
600076	ST Weifang Beida Jadebird Huaguang Technology Co., Ltd.	Aug-06
600131	ST Sichuan Minjiang Hydropower Co., Ltd.	Jan-07
600155	ST Hebei Baoshuo Co., Ltd.	Apr-06
600179	ST Heilongjiang Heihua Co., Ltd.	Jun-06
600203	ST Fujian Furi Electronics Co., Ltd.	Aug-06
600299	ST Blue Star New Chemial Material Co., Ltd.	Aug-06
600301	ST Nanning Chemical Industry Co., Ltd.	Oct-05
600381	ST Qinghai Sunshiny Industry Co., Ltd.	Nov-06
600579	ST Qingdao Yellowsea Rubber Company Limited	Nov-06
600691	ST Dongxin Electrical Carbon Co., Ltd.	Jul-05
600722	ST Hebei Jinniu Chemical Industry Co.,ltd	Nov-06
600740	ST Shanxi Coking Co., Ltd.	May-06
600769	ST Wuhan Xianglong Power Industry Co., Ltd.	Sep-06
600792	ST Yunnan Malong Industry Group Co., Ltd.	Jul-06
600885	ST Wuhan Linuo Solar Energy Group Co., Ltd.	Aug-06

Table 5: Split share structure reform schedule

Reform schedule	Jul-05	Aug-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Apr-06
Under the way or have finished	1	1	1	1	1	2	2	4
Reform schedule	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Nov-06	Jan-07	
Under the way or have finished	1	1	3	5	3	3	1	

Table 10 Two samples F Test &T Test for 30 companies

Stock code	mean (distance-to-default)		variance (distance-to-default)		F-value	P(F<=f) one tail	Significant level	T-value	Significant level	P(T<=t) two tails
	pre-shares reform	post-shares reform	pre-shares reform	post-shares reform						
600011	2.715661538	2.641508929	1.024985624	1.345704319	0.7616722	0.1638021	0.632191315	0.352762272	1.982597204	0.7249672
600021	2.8605	2.868170492	0.603311382	1.381525614	0.4366994	0.0137322	0.542781954	-0.035464282	1.996008331	0.971815
600058	4.775417188	1.854083929	4.020665685	0.737255466	5.4535583	8.026E-10	1.547208866	10.5976138	1.987289823	2.152E-17
600121	2.976489286	2.030929688	1.126247129	0.679372255	1.6577762	0.0264725	1.535883291	5.484772515	1.980272226	2.395E-07
600123	2.204546774	1.865831034	0.633345182	0.436640245	1.4504966	0.0790434	1.543172063	2.527153596	1.980272226	0.0128221
600256	3.462490625	1.863396429	2.928712923	0.431225209	6.7916088	9.148E-12	1.547208866	6.9159702	1.988959743	8.901E-10
600348	1.768371429	1.659446667	0.221061584	0.416593163	0.5306414	0.0365918	0.559618769	0.798546444	1.987934166	0.4267532
600395	1.941553226	1.627686792	1.330072545	0.309899203	4.2919521	1.492E-07	1.564126964	1.899608236	1.98637711	0.0606516
600397	3.339682	1.649832692	1.540253911	0.310860695	4.9548043	3.45E-08	1.597610259	8.810963654	1.996008331	8.349E-13
600508	2.921437736	1.93340339	1.097803132	0.473203211	2.3199402	0.0010159	1.560430092	5.828765283	1.987289823	9.03E-08
600714	2.945	2.030068627	2.175584825	0.316566965	6.8724316	3.006E-11	1.561183985	4.709800083	1.985801768	8.646E-06
600744	3.640329851	2.152098113	3.428347478	0.862929501	3.9729172	4.298E-07	1.554894034	5.730284593	1.983495205	1.022E-07
600971	1.442255556	1.686912069	0.204736272	0.334788654	0.6115389	0.1311171	0.484659135	-1.642151235	1.992543466	0.1048019
600995	2.354703704	2.217396078	0.446869495	0.790542528	0.5652694	0.0589438	0.548455691	0.70326081	1.991672579	0.4840421
600997	1.914665	1.853972881	0.191731357	0.554539931	0.3457485	0.0063556	0.504324631	0.440474437	2.002465444	0.6612595
600076	2.637363235	2.156421154	1.319329583	0.275190452	4.7942418	1.985E-08	1.557916955	3.060531089	1.9842169	0.0028438
600131	3.047763014	1.961087234	1.660686709	0.659861771	2.5167191	0.0005543	1.576900109	5.665555526	1.980272226	1.053E-07
600155	3.6497375	2.249830357	1.431055617	0.352172829	4.0635038	1.937E-07	1.547208866	8.270735995	1.985250956	8.068E-13
600179	3.32729697	1.789838889	2.154115585	0.312757841	6.8874871	1.182E-11	1.552106672	7.84275241	1.987608241	1.032E-11
600203	2.929563235	1.900009615	1.536788558	0.502226308	3.0599523	2.799E-05	1.557916955	5.732315024	1.981765221	8.787E-08
600299	2.730095588	1.869367308	1.155271892	0.352340744	3.2788484	1.017E-05	1.557916955	5.583370765	1.982173424	1.775E-07
600301	2.935422414	2.044729032	1.265214493	0.617623485	2.0485207	0.0032037	1.53753344	4.996668981	1.98373095	2.454E-06
600381	3.013830303	2.124781633	1.924245056	0.383251821	5.0208374	2.087E-08	1.576609473	4.623400312	1.985250956	1.189E-05
600579	2.54454	2.037594	0.642127727	0.346462342	1.8533839	0.0165052	1.607289464	3.605276529	1.986674497	0.0005112
600691	2.627619481	2.008053488	1.186898339	0.174028657	6.8201316	5.081E-10	1.597500717	4.441197236	1.982173424	2.17E-05
600722	3.09036338	2.026669388	1.839167331	0.390933449	4.7045535	5.038E-08	1.568489518	5.778727223	1.982815217	7.779E-08
600740	2.874252308	1.923056364	1.585097063	0.529789409	2.991938	2.991E-05	1.54954722	5.157170556	1.982815217	1.188E-06
600769	3.168214493	1.932586275	1.964876662	0.334078402	5.8814837	5.929E-10	1.561183985	6.602161732	1.984984263	2.235E-09
600792	5.521525373	6.534960377	18.13751787	1000.666341	0.0181254	0	0.651534504	-0.231578286	2.005745949	0.8177573
600885	2.683136765	1.730242308	1.353236675	0.279997761	4.8330268	1.719E-08	1.557916955	5.992559609	1.9842169	3.357E-08