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WORLD MARITIME UNITERSITY

Shanghai, China

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Research on Value-at-Risk in International Crude Oil Shipping Market

By

Cui Xiaoyin

China

A research paper submitted to the World Maritime University in partial

Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):________

(Date):_____________

Supervised by

Professor Wang Xuefeng

Shanghai Maritime University

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ABSTRACT

Title of Dissertation: **Research on Value-at-Risk in International Crude Oil Shipping Market**

Degree: **Master of Science in International Transport and Logistics**

Abstract: The method of Value-at-Risk is an important risk management tool that was developing from 90's, which is currently widely used in the market risk management. VaR method can give the maximum potential loss of a certain financial asset or a portfolio within a given level of confidence. By calculating the VaR of Baltic Freight Index, this thesis try to evaluate the risks existing in the international crude oil transport market, and the Baltic Dirty Tanker Index of the used samples, and apply the logarithm (daily return rate) of this index into the study, rate of return applied to the study, so as to calculate the VaR value.

Because of the peak fat-tail Phenomenon and the cluster fluctuations, as well as the strong autoregressive conditional heteroscedasticity in the distribution of the daily return rate sequence, this thesis, based on the generalized error distribution (GED: General Error Distribution), makes use of the exponential autoregressive conditional heteroskedasticity model to fit the variance, and uses this variance to calculate the VaR value.

Since 2002, the shipping market is very prosperous, with the freight index reaching new highs for many times, while at the same time, the fluctuation of freight index experienced ups and downs. This thesis selected the price index from 2002 to 2008 as samples, and analyzed and calculated the freight risks in the shipping market. The calculation of VaR provides a quantitative risk, based on which, the international crude oil shipping operators and investors can make their own business strategies and investment strategies, which can better avoid risks and improve profits.

KEYWORDS: Risk value, Baltic Dirty Tanker Index, Transportation of crude oil, Conditional Heteroscedasticity

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LIST OF ABBREVIATIONS

VAR	Value at Risk
BFI	Baltic Freight Index
BDTI	Baltic Dirty Tanker Index
VLCC	Very large crude oil carrier
ULCC	Ultra large crude oil carrier
DWT	Deadweight ton
OECD	Organization for Economic Cooperation and Development
USD	United States Dollar
GBM	Geometric Brownian motion
ARCH	Autoregressive conditional heteroskedasticity
GARCH	Generalized autoregressive conditional heteroskedasticity
EGARCH	Exponential autoregressive conditional heteroskedasticity
GED	Generalized error distribution
ADF	Augmented Dickey-Fuller test
PAC	Partial autocorrelation coefficient
COA	Contact of Affreightment
FFA	Forward Freight Agreements

Chapter1 Introduction

1.1 Background of this dissertation

With the development of the world economy and international trade, the volume of world transportation has been growing continuously, which promotes the continuous growth and improvement of the international shipping market. In the systems of world trade and transportation, the shipping transportation accounts for a share of 90% of the total market which plays a significant role for the global economy. The transportation market of international crude oil is a market full of risk, at the same time; it is also an important component in the international shipping market. The factors influencing the transportation market of international crude oil not only include the situation of world trade , the shipbuilding market situation and the dismantling market as well as the ship repairing market conditions, but also include political and legal environment, science and the natural environment. The comprehensive effect of these factors is demonstrated by the price fluctuations of the shipping market, and the freight fluctuations will result in uncertainties for the business of the owner or charterer, which is probably to dispose the owner or charterer at a disadvantage status, even brought about great risk to them.

Since the year 2000, great changes have happened in the transportation market of international crude oil environment. The oil-related products which are carried in the crude oil transportation market provide an energy guarantee for economic development, whose importance is evident. With the rapid development of the global economy in recent years, the countries around the world, especially the developing countries, have been fiercely escalating the competition for oil resources, which give rise to the prosperity of the crude oil transport market. After the experience of the downturn trend of the late 20th century, the oil transport market started to get recovered compared with the year 2003, but is still turbulent tremendously. In addition, due to the sensitivity of the issue of oil, trend of freight is hard to find its law, so as to bring huge risk and opportunities to the market operators and investors. How to measure risk as well as the use of risk are the key factors for the charterers, owners and the investors to avoid risks and earn market benefits. This thesis will apply the method of Value-at-Risk to the measurement of risks arising from the fluctuations of the Baltic International Crude oil Freight Index in order to measure the risks in the international crude oil transportation market.

Baltic Crude oil Freight Index, as a comparison between a Standard value and the freight numerical value in a period of time, is the "barometer" of the crude oil transportation market, reflecting the trend of fluctuations of the crude oil transportation prices, which further reveals the supply and demand status in its market and related markets. This thesis will, by analyzing the characteristics of freight index fluctuations and based on the fluctuations characteristics of the samples, make a modeling and calculate the value at risk of the daily benefit for freight index within the samples.

1.2 Literature review

The concept of value at risk (VaR) was first proposed by the Group of 30 countries (group of 30) in July 1993 in its study "practices and principles of the derivatives ", in December 1994, JP • Morgan published its developed measurement models on risks - risk metric, in April 1995, The Basel Committee on Banking Supervision agreed with the request that the banks with conditions are allowed to measure market risks on the capital based on the internal VaR model. Hereafter, the VaR method is widely used in financial risk management, thus, the study on the calculation method and application with regard to VaR has flourished by leaps and bounds.

At present, the application of VaR is not merely limited to the initial measurement of financial market risks, but also being gradually applied in credit risks, liquidity risks, cash flow risks and operation risks. The VaR management models and its scientific, practical, accurate and comprehensive features to measure property portfolio risks are not only generally welcomed by the international finance industry, but also attract the a variety of scholars from the disciplines and areas of finance, measurement economy, mathematical statistics. Especially since the year 1999, on the bases of basic VaR management models such as the traditional historical simulation model and the variance- covariance model, the Monte Carlo simulation models, a variety of new risks management models are emerging in endlessly, and its applications keeps expanding, which promotes the development and innovation of the theory regarding VaR management.

Hendrics (1996) conducted a comparative empirical study on the parameter method, historical simulation method, as well as the Monte Carlo simulation method. Jorion. P (1997) described VaR as a measurement on the normal market fluctuations, and chances of loss for the value bigger than VaR are slim. KevinDowd (1998) pointed out that the VaR is the largest expected losses of property portfolio within a given period.

No matter the JP. Morgan model or the Kevin Dowd model occupies a unique position in the overall framework of risks measurement, and they respectively portray different characteristics of risks. Jean-Philippe Bouchaud and MarcPotters (1999) proposed how to use non-normal characteristics of fluctuations in the financial assets to simply calculate the complicated non-linear portfolio VaR.

Rachel Campbell, Ronald Huisman, Kees Koedijk (2001) applied the VaR risk management model into the portfolio selection and capital asset pricing, through theoretical inference, they came out the conclusion that risk management model of portfolio based on VaR came to the exactly same result with mean-variance model on the assumptions that the portfolio is in a normal distribution and there is no risk with zero interest rate, and pointed out the defects which were caused by excessive investment in risky assets due to the reason that the peak field and fat-tail distribution of benefits from portfolio will underestimate the risks by traditional mean- variance model.

Yiu, KFC (2004) discussed the issue of optimised portfolio subject to VaR. The Professor Philippe Jorion (1997) in Owen branch of California University, in his book “Value-at-Risk - new standards for Financial risk management”, laid emphasis on the following aspects such as the methods of risk measurement, VaR supervision, and the risks in the development and application of VaR system to measure the transactions and investment, as well as the procedures to perform safe risk management system.

The study conducted by Chinese scholars on the VaR Method originated from "financial risk management methods of VaR and its application" written by Zheng wentong in 1997, his book completely introduced the emergence background of VaR methods, calculation methods, VaR methods of use and the the necessity of its introduction to China.

Liu Yufei from Peking University (1999), in his article "VaR model and its applications in financial supervision," introduced its basic content, based on which, he paid much attention to the discussion on its application in financial supervision.

Fan Ying (2000) systematically discussed the method to calculate the index VaR method of weighted moving average (EWMA method), and respectively calculated the optimal attenuation factors of the two cities of Shenzhen and Shanghai combined with two cities' actual Composite Index data, what's more, based on which, he estimated the risk value of the market, and came to conclusion that the fluctuation of our stock market is relatively large. Peng Shoukang (2003), in his article, " VaR study on China's stock market index ", through the comparison between the historical simulation method, the general normal distribution model, the weighted model and Logistic normal distribution model, came to the conclusion that the predictive power of the historical simulation method and the Logistic Distribution Model is superior to that of the normal distribution model the general normal model and the weighted

Normal model. Yao Jing, Li Zhongfei (2004), according to the mean - variance the framework of model, established the average VaR model in the time when the VaR is used to substitute the variance or standard deviation to measure the index, and they also analyzed the internal relations of the two models.

From the development of VaR method, currently, this method is mainly applied to risk measurement and management of the stocks and securities market. Wang Hui from Dalian Maritime University, in his article "On the VaR methodology application in the risk measurement of international dry bulk shipping market", proposed to apply this method to the risk measurement of Baltic VaR international dry bulk freight index, order to measure the risks in the international dry bulk cargo transportation market. He conducted a empirical study on the its application to the international dry bulk shipping market, and studied daily benefit of three Baltic Dry Freight Index , and he also discussed its practical application.

1.3 The content and research method of this dissertation

This thesis introduces the international popular risk management method --- VaR, and systematically analysis the concept of VaR, and summarizes various calculation methods, as well as analysis the application in the measurement and control over the international crude oil transport market. The chapter 2 of this thesis introduces the overview of crude oil transportation market, including supply and demand of crude oil, carrying capacity in this market as well as the market current status and development. Chapter III discusses factors influencing the fluctuations of crude oil price, and introduces the Baltic Crude Oil Freight Index and analyzes the trend over the past few years. Chapter IV systematically describes the definition, application of VaR and the main methods to calculate VaR, meanwhile, including the conditional heteroscedasticity model. Chapter V is the use of VaR method to measure the freight risks arising from the transportation of crude oil. Finally, I come to the conclusions.

Chapter 2 Introduction of the Crude Oil Transport Market

2.1 The Supply and Demand of Crude Oil

Major petroleum export countries:

(1) Crude oil production of major producing countries in the former Soviet Union and African areas has significantly increased

Since the disintegration of the Soviet Union in 1991, Russia had been plunged into economic crisis, along with the serious imbalance in national economic development and the obvious shortage of investment in the exploration of energy as well as the continuously decline of crude oil production. After the year 2000, Russian crude oil production began to steadily rebound. From 2000 to 2008, its average annual growth rate of crude oil production had reached 7.8% and since 2002 Russia has been in the status of the world's second oil-producing country, while in 2008, the crude oil production is 488 million tons, 0.7 % decrease compared with that in 2007. Oil resources of Africa are mainly distributed in the North and West. In recent years, major oil companies stepped up investment in the oil industry in the region. Since 2000, the crude oil output in this region has achieved a 4.6% average annual growth rate, and the crude oil production in 2008 rises to 492 million tons.

(2) Crude oil production of major producing countries in the Middle East has steadily increased

The Middle East as the largest oil exporting region, of which the annual crude oil output accounts for almost a half of the world's total export volume and 75% of the crude oil produced is for export. However, the volatile situation in the Middle East has always been the impact on the increase production plans of the oil-producing countries in that area.

Since 2000, average annual growth rate of the Middle East oil production has been 1.2%, less than the average annual growth rate of 2.9% 10 years before. Although the oil production and exports of countries in the Middle East fluctuates hugely due to a variety of reasons, because of the steady growth of oil reserves in this region, the crude oil production has been still in the overall trend of growth. The crude oil production is 11.55 in the Middle East area, a significant increase of 5.4%, of which the production of Iraq, Saudi Arabia and Kuwait increased rapidly, reaching 13.2%, 8.5% and 7.4% respectively.

(3) Crude oil production in North America and Central and South America is basically stable.

Since 1990, North America's crude oil production has been basically in the maintenance of 650 million tons more or less, in which the production of Mexico and Canada has a slight increase overall, while that of the U.S. is gradually declining as a result of inadequate reserves of oil, from 353 million tons in the year 2000 dropping to 3.35 tons in 2008.

(4) The inadequate reserves in Asia-Pacific and Europe areas increased the difficulty in the output of crude oil.

Due to lack of proven reserves of oil, since 2000, crude oil production of Asia-Pacific region has basically maintained at about 380 million tons. Indonesia—the only OPEC member in Asia-Pacific region, whose crude oil production is in a clear downward trend in recent years, has 0.3% more in production in 2008 than that of last year.

Major petroleum import countries:

Asia-Pacific, Europe and North America regions, due to the inadequacy of oil, are the main oil-importing regions. The United States, Western Europe and Japan, the world's three major oil-importing countries (regions), whose imports in 2005 accounted for 64% of the world's total oil imports. The United States is the largest oil-importing countries, of which the oil imports accounting for the world’s oil trade from 20.2% in the year 1980 rose to 29.2% in 2008. The oil imports of the United States in 2008 are 641 million tons. Over the same period, the proportion of Europe and Japan dropped to 26.6%, 10.5% from36.7%, 15% separately. Crude oil imports of China reached 201 million tons in 2008, with an increase of 9.5%. At present, the countries (regions) whose crude oil imports international more than 100 million tons are the United States, Western Europe, China, Japan.

2.2 The world's major oil shipping route

The situation of producing and consuming crude oil area, decides the distribution of crude oil shipping route at sea. The main crude oil shipping routes at sea includes that from the Middle East to the north-west European, Mediterranean, North America, Japan and elsewhere in Asia, that from North Africa to the Mediterranean, and that from West Africa to North America, as well as that the Caribbean and North America.

(1) The Persian Gulf of the Middle East to South-East Asia and Japan routes--Starting from the Persian Gulf, by the Strait of Hormuz, through Colombo and the Straits of Malacca or Lombok Straits to the port of discharging in Japan, South Korea and other countries. The route mainly runs the ULCC and VLCC, 80% of Japan's crude oil imports through this route. The draft limitation of the Malacca Strait is 21m, so generally the oil tankers less than 300,000-ton may take this route. If deviating through the Indonesia Lombok Strait, of which the draft limitation up to 30.5m, it does not constitute a constraint for the ULCC.

(2) The North Africa to the north-west European routes—Transport volume in the route beyond 9000 million tons, starting from the Mediterranean Sea of North Africa, by the Strait of Gibraltar, to the end of north-west European. The draft limitation of the Strait of Gibraltar is 21.3m and thus in general, the oil tankers running the route is not excessive of 200 thousand tons.

(3) The Persian Gulf of the Middle East by the Cape of Good Hope to Western Europe or the America route—starting from the Persian Gulf, by the Strait of Hormuz into the Arabian Sea, then to the Indian Ocean, southward along the east coast of Africa, through the Mozambique Channel, around the Cape of Good Hope into the Atlantic, and then northward along the West Coast of Africa until the coastal countries of Western Europe. If sailing across the Atlantic, then the vessel may reach the east coast ports in North America. Draft limitation along the route basically does not constitute a restriction for the vessel, mainly running VLCC and ULCC.

(4) The Persian Gulf of the Middle East by the Suez Canal to Western Europe or the America route—starting from the Persian Gulf, by the Strait of Hormuz to the Arabian Sea, then westward through the Straits Mandela, the Red Sea, Suez Canal, the Mediterranean, the Strait of Gibraltar into the Atlantic, if sailing north along the east coast of the Atlantic, it may arrive at the oil ports of the Western Europe. If sailing across the Atlantic, it may be up to the ports along the east coast of North America. The type of vessel for the route is restricted by the Suez Canal within the fully loaded draft of 17.68m, largest width 49.91m and the largest deadweight for fully loaded is 150,000 tons.

(5) North-west Africa to North America route—along which the type of vessel is restricted by objective factors at the port of loading, the annual capacity is over 90 million tons.

(6) West Africa to Western Europe route—along which the type of vessel is constrained by the objective factors at the port of loading, the annual capacity beyond 40 million tons.

(7) Latin America to North America and the Caribbean route—generally runs the AFRAMAX and Panamax tankers, the annual capacity about 180 million tons.

The shipping capacity of the above seven routes at sea accounts for more than 72% of that of the world. What's more, there still routes, for example, the Black Sea - Mediterranean route, the Middle East – Australia/ New Zealand route, the Gulf of Mexico - Caribbean route, Mexico - Japan route, Southeast Asia - Japan route, China - Japan route, etc. Such routes are comparatively short, and the capacity is also comparatively small, generally applicable to small and medium-sized tankers.

2.3 Analysis on the international crude oil shipping market capacity

In the international oil tanker market, there are two main modes in the establishment and operation of tanker fleet: the affiliated tanker fleet of the oil companies and independent tanker fleet. The mode of the affiliated tanker fleet of oil companies had been the mainstream operating mode, mainly because the transportation costs of crude oil accounted for a greater proportion of CIF price, large oil companies led and controlled the development of the tanker transport industry.

After the70s, along with the emergence of supertanker, the scale of tanker transport was gradually reflected. The shipping speed has been accelerating as well as the shipping capacity of single vessel has expanded, thus under the circumstances of scale economies, the transportation cost (freight) gradually accounted for less and less proportion of CIF oil price. With the enhancement of the scale development of oil shipping by tanker, the cost of self-built fleet has also been getting heightened. Tanker transport gradually developed into the phase of specialization of operation by independent ship owners.

According to statistics of CLARKSONS, up to the end of 2008 there had been a total of 5372 vessels of various types, about 368.3 million dwt. While the tanker fleet is the world's largest kind of merchant shipping fleets, representing a proportion of 38.5% of the total tonnage of the world's merchant fleets. Distribution of the overall amount of oil tanker fleet is as follows:

Calculated by single-vessel deadweight, there are 505 VLCC of more than 200,000 tons, 149.1 million dwt, accounting for 40% of the total fleet capacity; 362 Suezmax oil tankers of 120,000 - 20,000 tons,54.9 million dwt, accounting for 15% of the total fleet capacity; 749 Aframax tankers of 80,000 -20 10,000 tons, 77.2 million dwt, accounting for 21% of the total fleet capacity; 343 Panamax tankers of 60,000 -8 10,000 tons, 24.1 million dwt, accounting for 6.5% of the total fleet capacity.

Table 2.1 World’s Number Distribution of Oil Tankers

Tanker Type	DWT（ton）	Tanker Number	Proportion（%）

VLCC（more than 200,000tons）	149,100,000	505	40
Suezmax Tanker （120,000-200,000tons）	54,900,000	362	15
Aframax Tanker （80,000-120,000tons）	77,200,000	749	21
Panamax Tanker （50,000-70,000 tons）	24,100,000	343	6.5
Handymax Tanker （30,000-40,000tons）	73,400,000	2,352	14.5
Small-size Tanker（less than 10,000tons）	10,200,000	2,038	3
Total	389,000,000	6,349	100

Source: British Clarksons (2008)

Calculated according to the national flag of vessel, the three largest oil tanker's flag state in the world are Panama with 822 tankers totally 51.48 million tons, Liberia with 512 tankers totally 41.55 million tons and Greece with 235 tankers totally 25.38 million tons. China is placed at the 17th of the world, with 165 tankers totally 3.39 million tons, accounting for about 1.1% of the world's total oil shipping capacity.

Calculated by DWT, three of the world's largest oil tanker owners are Fredriksen Group of Bermuda, 17 million tons total, owning 70 tankers, 240,000 dwt single; Mitisui O.S.K. Lines of Japan, 13.84 million tons total, owning 121 tankers, 120,000 dwt single; Nippon Yusen Kaisha of Japan, 10.01 million tons, owning 51 tankers, average 200,000 dwt single.

Table 2.2 World Oil Tanker Owner's DWT Rankings

Rankings	Tanker Owner	Country	Total DWT(tons)	Tanker Number	Average DWT(tons)
1	Fredriksen Group	Bermuda	17,004,396	70	242,920
2	Mitsui O.S.K. Lines	Japan	13,840,054	121	114,381
3	Nippon Yusen Kaisha	Japan	10,019,142	51	196,454
4	Teekay Shpg. Canada	Canada	9,076,610	83	109,357
5	Overseas Shipholding	United States	8,217,533	74	111,048
6	Zodiac Maritime Agy.	United States	8,089,551	72	112,355
7	Angelicoussis Group	Bermuda	7,508,916	30	250,297
8	Malaysia International Shipping Corporation	Malaysia	7,292,203	66	110,488

9	Euronav (UK) Agen.	United Kingdom	6,976,293	29	240,562
10	BW Ltd.	Hong Kong (China)	6,359,179	29	219,282

Source: British Clarksons (2008)

2.4 Crude oil shipping market status and trends

2.4.1 Current situation of the Market

International crude oil price in 2008 dropped gradually after reaching the peak dramatically. . Baltic Crude oil Freight Index was 1,914 at the beginning of 2008, then sharply dropped to 1,053 in February then rapidly rose to the peak of 2,347 in July. In the August, Baltic Crude oil Freight Index dived straightly and unable to go up again in the forth quarter along with the gradual appearance of the recession of global economy. It was reported 1,142 on 7th November. However, the average B of the abovementioned 10 months of last year is still 1,571, increasing 48% same period compared. The growth rate of freight on Persian Gulf to Japan route for VLCC is the biggest, average WS144, increasing 122% same period compared, with average earnings per day of 11.2 million. International crude oil price in 2008 arose, especially the anti-seasonally going up in the second quarter, for which the main reason is the getting slower growth in capacity, particularly the short-term shortage of capacity of VLCC. Except for the slowing down of the delivery of new vessel, other factors leading to the tight supply of capacity as following: skyrocketing of oil prices in the first half year, the slowing down of sailing speed and circling speed; abandoning the use of single-hull vessels; delays at port. In order to avoid the risks associated with intense oscillation of the current market, the number of Forward Freight Agreement (FFA) in 2009 increases accordingly. In accordance with the report of CLARKSONS the global oil tanker fleet kept an increase rate of 6% in 2008. Specific to the large-size tankers, VLCC fleet remained stable this year, mainly due to the hedge between the new capacity and the dismantling and refitting capacity. However, this situation no longer exists in 2009, a large number of tankers to deliver making growth rate to 10%. The situation of Suezmax tanker is similar to that of VLCC, after a slight increase in 2008 an increase rate of 14.2% of the tanker fleet has to be faced up with in 2009. The Aframax tankers increase 7% in 2008, but 12.2% increased in 2009. The growth rate of Panamax in2008 and 2009 is expected to stabilize at 9% level.

2.4.2 Transportation demand trend

Oil demand: since the past two years, the impact imposed by high oil prices on the growth of oil demand has gradually emerged in developed countries. International Energy Agency report in October estimated that global oil demand in 2008 was 86.5 million barrels per day, an increase of only 0.5%, which is far below the level of two years before. Among them, the daily oil demand of OECD countries was 48.1 million barrels, 2.2% decline same period compared, while that of non-OECD countries was expected to be 38.4 million barrels per day, an increase of 4.1%.

Oil supply: the growth of oil production of OPEC countries is still a source of global oil production increase. According to the International Energy Agency statistics, in the first three quarters, the world daily oil production reached 86.87 million barrels, an increase of 1.5%. The daily crude oil output of 13 country members is 32.28 million barrels, an increase of 6.6%. Among them, the daily output of Persian Gulf 6 countries is 21.7 million barrels, an increase of 7.0%. At present, the production per day of Saudi Arabia has been grown to 9.45 million barrels from 8.6 million barrels one year ago. The growth rate of oil output of non-OPEC countries is lower than what was expected before, the daily production in the first three quarters is 49.5 million barrels, 0.1% decreased, and the daily production in the whole year is expected to be 49.8 million barrels, growing 0.4%. Among them, the production of Russia in the first three quarters remains flat, expected a stoppage of growth. The production of Latin American countries decreased.

Chapter 3 Analysis of freight in crude oil shipping market

3.1 Influencing factors of freight

3.1.1 The influence of cost over crude oil price

Due to the scarcity and the characteristics of non-renewable of resources, the price of all kinds of resources has been in a growing trend, for example, there has been a continuous growing tendency for marine fuel price. Meanwhile, there are several other factors influencing the transport cost, such as tanker price, crew cost and port charges, etc. Growth in demand for high-quality crew members making the crew cultivation cost rising, the increase of ship-building price and port dues results to all the fees constituting the transport cost in a rising trend. Under the effect of the growing tendency of transportation costs, the crude oil price also presents a rising trend.

3.1.2 The influence of supply and demand on the freight of crude oil

Shipping demand includes shipping volume, type and structure of cargo, transport distance and time requirements, etc. The sum of material objects of the service in shipping market is used to show the vessel's capacity. The main indicators of capacity supply are the tonnage of vessel, that is, the tonnage supplied by the owners. The crude oil price is a balanced market price achieved by the supplier and the demander of the international crude oil transport through freely price competition in the completely competitive market. The balanced market price is the price achieved through a variety of opposed and changed powers during the process of conflicting with each other, adjusting and moving reached a temporary balance status of powers as well as supply and demand. When the opposed balanced powers of the crude oil transport market changed, under the role of the market mechanism, the original equilibrium price will be broken, reaching new market equilibrium and a new equilibrium price. The relation between supply and demand becomes another important factor influencing the freight of crude oil except for the cost.

3.1.3 The influence of international trade over the freight of crude oil

Transportation production is a continuity of the course of products production in the area of circulation, which is closely linked with the trade and business activities, more prominent in the performance in the international shipping industry. Maritime transportation is a main means to realize the communication of economy and international uniform within the scope of the whole world. Therefore, the shipping demand is derived from the international trade, that is, derivation demand. This feature show that change and development of the international shipping market is directly influenced by the international trade, therefore, the environment factors which influence the international trade also influence the change of the shipping demand. However, the development of international trade is completely decided by the development of the world economy. The paramount economic factor influencing the fluctuation of international shipping market freight is the change or development of the world economy.

3.1.4 The influence of seasonality and random factors on the freight of crude oil

Other non-economic factors with respect to the international shipping industry are also important factors resulting to the fluctuation of the freight. The reflection of the influence of the natural seasonal climate over the surface environment is fiercer at sea than any other area. In different season, the difference of the natural conditions faced by the vessel sailing at sea leads to difference of shipping cost and that of the seaworthy of the vessel in different season, therefore, the seasonality of the shipping cost as well as the supply of capacity arises therefrom. In general, the cold and windy season renders the freight arising, the summer is just the opposite. The activities of the consuming party of the transportation labor merchant also have the feature of seasonality. The production, storage and consumption of all kinds of material merchandise have obvious seasonality, making the demand for the shipping goods inevitably have the feature of seasonality. The seasonality of the activities of both parties in shipping market unavoidably leads to the seasonality of the freight fluctuation.

The random factors bringing the freight fluctuation are mainly the international political and military affairs, etc, which primarily includes the conflict of international relations, wars among countries, coup of a country and civil war, etc. These affairs would influence the increase of world economy, or change the trade relations as well as the flow of goods, or alter the average transport distance, etc, then influence the shipping demand. Their influence on the shipping demand posses the feature of paroxysm then brings about the random fluctuation of freight.

3.2 Baltic Dirty Tanker Index

3.2.1 The emergence and development of the Baltic Freight Index

The Baltic Freight Index is released by the Baltic Shipping Exchange. Baltic Shipping Exchange is the shipping market with the longest history in the world. The cafe bar which was born in 1744 in the United States Baltic of Virginia is the currently world's leading Shipping Exchange located in London, 656 companies of the world's 46 countries are Baltic Shipping Exchange members. Baltic Freight Index (BFI for short) is realized to the whole world everyday by the London shipping market. It is a comprehensive index, consisting of the freight of the world's 12 principal traditional dry bulk carrier routes according to their respective importance degree and proportion in the shipping market. It was arisen along with the foundation of the Baltic International Freight Futures Exchange. Baltic Freight Index takes January 4, 1985 as 1000. It was initially consisted of the freight of voyage charter on 13 shipping routes, afterward adjusted to 12 shipping routes. There have been changes in the importance degree of some shipping routes due to the recent development of international political and economic situation. Therefore, on August 6, 1990 and February 5, 1991 Baltic Shipping Exchange respectively adjusted the routes constituting the Baltic Freight Index. In the Baltic Shipping Exchange, there is a team of 8 member companies responsible for the intraday Baltic Freight Index. Every morning, the 8 companies separately submit to the member team their freight level or daily hire level of each route thought to be intraday feasible by them, and they would keep it strictly confidential to ensure fairness and accuracy. When calculating, the team would deduct the Maximum number and minimum number and separately calculate the average freight and hire level of each route, then separately multiplied by conversion constant, thus achieve the conversion index of each route;

after that, adding together the conversion index of each route, the result of which is the intraday Baltic Freight Index.

Baltic Dirty Tanker Index，BDTI for short，is the embranchment specifically referring to oil tanker freight in the Baltic Shipping Index. BDTI was firstly emerged in 1998. Because of the singleness of the crude oil trade route at that time, there were only two routes of the Persian Gulf - Japan and West Africa - U.S. Gulf at the beginning of foundation. Afterward, along with the increase of oil production places and growth of the number of import countries, BDTI routes gradually increase every year. Until the end of 2008, BDTI had owned 18 routes of kinds from 30,000 to 300,000 tons, basically covering all the main crude oil import and export countries of the world.

3.2.2 Constitution of BDTI route

See details of the BDTI 18 routes in the table below:

Table 3.1 Constitution of BDTI routes

Route: TD1
280,000mt, Middle East Gulf to US Gulf. Ras Tanura to LOOP with laydays canceling 20/30 in advance. Maximum age 20 years.
Route: TD2

260,000mt, Middle East Gulf to Singapore. Ras Tanura to Singapore with laydays/cancelling 20/30 days in advance. Maximum age 20 years.
Route: TD3
260,000mt, Middle East Gulf to Japan. Ras Tanura to Chiba with laydays/cancelling 30/40 days in advance. Maximum age 15 years.
Route: TD4
260,000mt, West Africa to US Gulf. Off Shore Bonny to LOOP with laydays/cancelling 15/25 days in advance. Maximum age 20 years.
Route: TD5
130,000mt, West Africa to USAC. Off Shore Bonny to Philadelphia with laydays/cancelling 15/25 days in advance. Maximum age 20 years.
Route: TD6
135,000mt, Black Sea/Mediterranean. Novorossiyk to Augusta with laydays/cancelling 10/15 days in advance. Maximum age 20 years.
Route: TD7
80,000mt, North Sea to Continent. Sullom Voe to Wilhelmshaven, with laydays/cancelling 7/14 days in advance. Maximum age 20 years.
Route: TD8
80,000mt, Crude and/or DPP Heat 135F, Kuwait to Singapore. Mena al Ahmadi/Singapore with laydays/cancelling 20/25 days in advance. Maximum age

20 years.
Route: TD9
70,000mt, Caribbean to US Gulf. Puerto La Cruz to Corpus Christi with laydays/cancelling 7/14 days in advance. Maximum age 20 years. Assessment basis – Oil Pollution Act premium paid.
Route: TD10D
50,000mt, fuel oil, Caribbean to USAC. Aruba to New York with laydays/cancelling 7/14 days in advance. Double hull vessel, Maximum age 20 years.
Route: TD11
80,000mt, cross Mediterranean/Banias to Lavera with laydays/cancelling 10/15 days in advance. Maximum age 20 years.
Route: TD12
55000mt, fuel oil, Amsterdam-Rotterdam-Antwerp range to US Gulf. Antwerp to Houston with laydays cancelling 15/20 days in advance. Double hulled vessels
Route: TD14
80000 mt, no heat crude, SE Asia to EC Australia, Seria to Sydney with laydays/cancelling 21/25 days in advance. Double hull and max 15 years old.
Route: TD15
260000 mt, no heat crude, West Africa to China. Serpentina FPSO and off shore

Bonny to Ningpo with laydays cancelling 20/30 days in advance. Double hull and max age 20 years.
Route: TD16
30000 mt fuel oil heat 135 F, Black Sea to Mediterranean. Odessa to Augusta with laydays/cancelling 8/14 days in advance. Double hull and max 20 years.
Route: TD18
Trial – 30,000 mt fuel oil Baltic to UK-Cont. Tallinn to Rotterdam with laydays/cancelling 10/15 days in advance. Double hull. Max 15 years.

3.2.3 The recent years' trend of Baltic Dirty Tanker Index

Crude oil products are strategic sources of the development of national economy. Demand for crude oil of all countries in the world is comparatively stable due to its importance to national economy. Unlike the demand for dry bulk which is mainly from the Eastern developing countries like China and India, demand for oil is a global competition. However, the oil supply is not satisfying and has a lot of uncertainties because the Middle East and the Caribbean as the largest export regions are often troubled by the political and military problems. While the international oil market relying on the international oil trade is inevitable fluctuation with a higher degree. The chart below is of the going trend of the freight of oil market after 2002. After the recession at the end of the 20th century, the oil shipping market started to recover in 2003 and is still fiercely turbulent. Due to the sensitivity of the oil issue, it is hard to find the rule of price movements affected by many factors. Nevertheless, we can see the market peaked in 2004, but then fall back to the level of 2003.

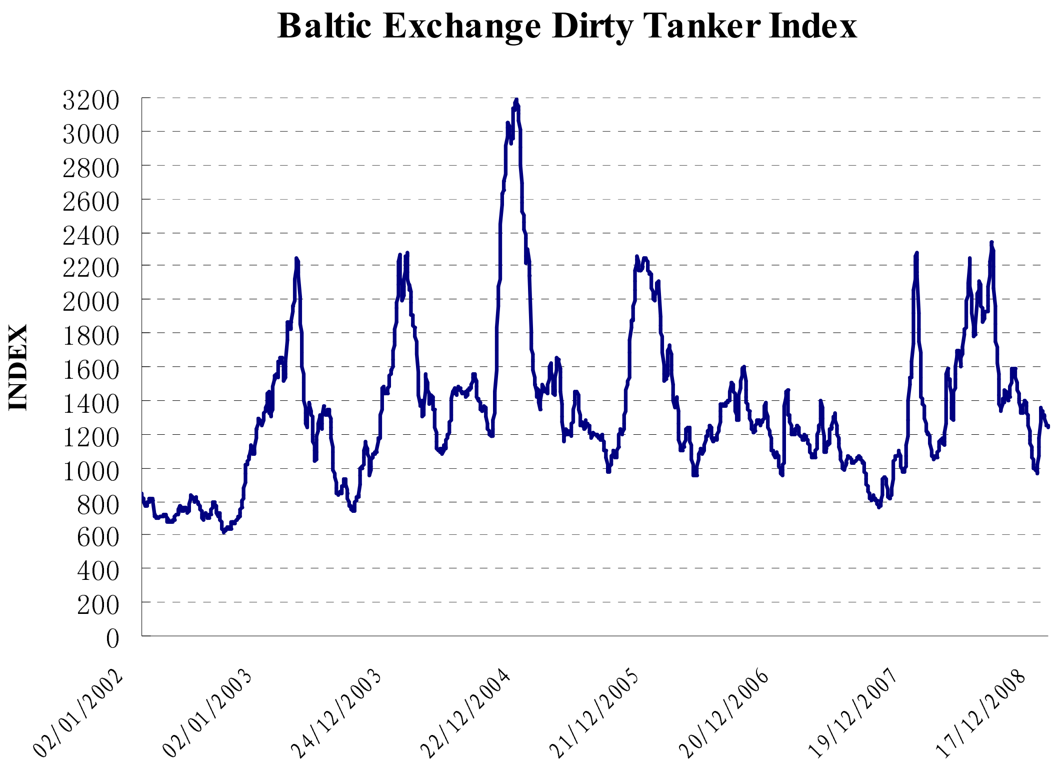

Figure 3.1 Line graph of Baltic Dirty Tanker Index

Chapter 4 The method of VaR

4.1 The definition of VaR Method

Under normal market conditions and within the given confidence degree, VaR is used to assess and measure the market risks and the potential maximum losses that may incur with regard to any financial assets and securities portfolio within the a stipulated period . For example, if we say that value at risk (VaR) of a certain exposure with 99% confidence level is \$ 10 million, which means that on average, the day in which the exposure will suffer actual loss more than \$ 10 million among the 100 trading days is only one day, (i.e., 2 to 3 days each year). Mathematically, VaR can be expressed as an investment tool or a quantile (α—quantile) in the combination of the distribution of the profit and loss (P & L Distribution), the Formula is as follows:

$$\Pr ob(\Delta P_{\Delta t} \leq -VaR) = \alpha$$

$\Delta P_{\Delta t}$ represents the changes of market value for the combination of "P" in the holding period. The above Formula demonstrates that the probability of the loss value equal to or bigger than VaR is α. Or, under the rate of α, the loss value is bigger than VaR. Or it also can be said, the specific definition of VaR is: the biggest loss that may incur resulting from Portfolio "P" within a certain holding period△t, in a certain confidence 1-α.That is:

$$\text{Prob}(\Delta P_{\Delta t} \geq \text{-VaR}) = 1-\alpha$$

4.2 The calculation of VaR

The so-called VaR, from its literal interpretation, is “value at risk”. The method of VaR is the potential biggest loss faced by financial investment tools and portfolio within a certain holding period and in a certain degree of confidence. For example, Bankers Trust Company (BankersTrust) in its annual report in 1994 disclosed that average value of 99% VaR every day in 1994 is USD35 million, which shows that the bank can guarantee, with the possibility of 99%, that each portfolio, the average loss resulting from fluctuations of prices in market will not exceed USD35 million in the next 24 hours within a specific time in1994. Through the comparison between VaR Value and the annual profit from USD615 million and USD4.7 capital of this bank in 1994, the bank's risk situation can be at a glance. We can see the bank's ability to shoulder risks is still very strong, whose adequacy in capital is enough handle to possible maximum loss resulting therefrom.

For the purpose of calculating VaR, we first define ω_0 as initial investment and R as the return rate within a certain holding period of time. The portfolio value at end is $\omega = \omega_0 (1 + R)$.

Due to the existence of a variety of random factors, the return rate of “R” can be regarded as a random variable, whose average annual value and variance are respectively set as μ and δ, and set $\triangle t$ as holding period. Assuming that the annual income of the portfolio is not relevant, thus the average value and variance of the return rate on the investment portfolio during $\triangle t$ years are $\mu \triangle t$ and $\delta^2 \triangle t$ respectively. If we assume the markets are efficient, daily income Rt from the assets within 10 days is in same distribution and independent from each other, the income of 10 days R(10) = $\sum_{t=1}^{10} R_t$ is subject to normal distribution, the average value $\mu_{10} = 10\mu$, and the variance $\sigma_{10}^2 = 10\sigma^2$ (equal to the total of variance of10 same but is independent normal distribution).

Assuming the minimum return rate of ω_0 As R^* in the setting confidence level C, then the minimum value at end under the confidence level C is $\omega^* = \omega_0 (1 + R^*)$. (I.e. the probability of ω less than ω^* is 1 - C). The end of the value of ω_0 at the end of the period minus the minimum value of the investment portfolio is the maximum loss potential, that is, VaR. Therefore, the general sense,

$$VaR = E(\omega) - \omega^* \quad (1)$$

Because $E(\omega) = E[\omega_0 (1 + R)] = E\omega_0 + E\omega_0 R = \omega_0 + \omega_0 \mu$

$$\omega^* = \omega_0 (1 + R^*)$$

So, the Formula (1) can be converted to:

$$aR = \omega_0 + \omega_0 \mu - \omega_0 (1 + R^*) = \omega_0 (\mu - R^*) \quad (2)$$

If we introduce △t, the average value within △t time is μ△t, and as this time:

$$VaR = \omega_0 (\mu \triangle t - R^*) \quad (3)$$

It can be seen that, if we can work out the ω^* or R^* in C confidence level, we can work out the value of VaR of a portfolio in this confidence level. Hereunder, let's analyze the methods to work out ω^* or R^* under different probability for ω^* and R^*.

(1) The probability distribution function of ω and R is unknown

Under such circumstances, there is no way to know the exact form of the probability density function f (ω) about the future value of a certain investment portfolio. However, according to the definition of VaR, we can use the following Formula to fix ω^*:

$$C = \int_{\omega^*}^{+\infty} f(\omega)d\omega \qquad (4)$$

or

$$1 - C = \int_{-\infty}^{\omega^*} f(\omega)d\omega \qquad (5)$$

The formulas of (4), (5) show that, under a given level of confidence C, we can find ω^*, making probability (C) higher than that of ω^* or lower than that of ω^*, refers as 1 - C. rather than to calculate the specific f (ω). This method applies to all circumstances under which the random variable ω is in any types of distribution.

(2) ω and R is subject to the rule of the normal distribution

If the future return rate and value of the portfolio can be assumed to follow the normal distribution, then the VaR calculation process can be greatly simplified to the calculation of the standard deviation of the portfolio, the process is as follows:

Assuming the R is subject to the normal distribution of average value and variance, $\mu\triangle t$ and δ $\triangle t$ respectively, that is:

R～N ($\mu\triangle t$,δ^2 $\triangle t$).so $\frac{R-\mu\Delta t}{\delta\sqrt{\Delta t}}$,then $\frac{R-\mu\Delta t}{\delta\sqrt{\Delta t}}$ is Subject to the normal standard distribution with average value 0 and variance 1.That is $\frac{R-\mu\Delta t}{\delta\sqrt{\Delta t}}$ ～N (0,1), whose probability density function is $\phi(X)=\frac{1}{\sqrt{2\pi}}e^{-\frac{x^2}{2}}$.

Assuming R is subject to normal distribution, if we want to obtain R^* under the given confidence level C , we only need to make use of the standard normal distribution to find a site point α in the standard normal distribution Figure, which makes:

$$1 - C = \int_{-\infty}^{-\alpha}\phi(x)d\omega \qquad (6)$$

Then, in accordance with $-\alpha = \frac{R^*-\mu\Delta t}{\delta\sqrt{\Delta t}}$

We can calculate the R^* under the confidence level C.

$$R^* = -\alpha\delta\sqrt{\Delta t} + \mu\triangle t \qquad (7)$$

Then, according to the formula (3), we get:

$$VaR = \omega_0 (\mu\triangle t - R^*) = \omega_0 (\mu\triangle t + \alpha\,\delta\sqrt{\Delta t} - \mu\triangle t)$$

$$= \omega_0\,\alpha\,\delta\sqrt{\Delta t} \qquad (8)$$

(3) ω and R is subject to the non-normal distribution of probability

In some cases, although the assumption that ω and R is subject to the normal distribution can be used to approximately calculate the VaR, we find, based on the analysis of the actual data, that a large number of the tails of the probability density function regarding financial variables are thicker than the tails of the normal distribution. In other words, in reality, the more extreme cases (such as the huge profits or huge losses) the probability of occurrence is higher than that indicated by the standard normal distribution probability.

Under such circumstances, we can assume that the random variables are subject to the t distribution with freedom degrees n. When n is relatively small, the t's tail of distribution is bigger than that of standard normal distribution, whose tail size is decided by the degree of freedom n, when $n \to \infty$,the probability density function of t distribution is equivalent to that in the standard normal distribution, the tails of the two are just overlapping.

Regardless of the assumption that ω and R are subject to normal distribution or t distribution, whose distributions are symmetrical. This assumption of symmetrical distribution applies to the majority of financial products such as stocks, bonds, exchange rates, but it does not apply to Options as this income is a financial product in a non-symmetric distribution. However, for many types of day-to-day financial assets portfolio contained in banks and the companies, their proceeds are basically in a symmetrical distribution, therefore, the above method is still a simple and effective way to calculate VAR.

It must be stressed that, VaR indicates the financial risks of the portfolio in the future holding period, so probability distribution data of ω and R by the above described method of VaR should be the data in the future holding period, however, these data in advance is not available. Therefore, to calculate VaR, we must first use the historical data of the investment portfolio to establish a model on the future data. Currently, there are two methods to calculate VaR: the Historical Simulation Method (Historical Simulation) and Monte Carlo Simulation method (Monte Carlo Simulation).

In addition, VaR can not only calculate the risk of an individual financial instrument, but also can calculate the portfolio risk of a number of financial instruments. It this time, the income and return rate of portfolio is a multi-random variable. To get the probability density function of multiple random variables, we must, first of all, calculate the covariance matrix of the multiple random variables, so this shall involve a problem that how to determine the correlation coefficient of the multi-random variables. In practical application, it is to determine whether the earnings of different financial instruments are related and to which extent they are related. The different standards to determine the correlation coefficient would lead to different values of the VaR. Under normal circumstances, the more the amount of assets, the smaller the correlation coefficient is, and smaller the VaR is, and lower the risk is, which can be confirmed by empirical analysis the following context.

4.3 The major calculation methods of risk value

Basically, the measurement methods of VaR can be divided into two categories: The first is partial evaluation, including the Delta - normal evaluation; the second type is entire evaluation, including the historical simulation and Monte Carlo simulation method. These measurement methods have their own respective strengths and weaknesses, because, under different assumptions, the use different parameter settings and different measurement models will produce different results. Therefore, the method to measure VaR should not be confined to any one method, and we should select the appropriate parameters and model estimate the value at risk in accordance with their characteristics.

4.3.1 Delta - normal evaluation

The method is simple, but the distribution of return rate of many financial assets appear the Phenomenon of fat-tail, as VaR attempts to capture the earnings of investment portfolio in the left tail, so the fat tail is a big trouble, in which case, the model will underestimate the proportion of outliers based on the normal distribution model. In addition, based on change of time and weight distribution, there are sample variance method, the risk matrix method and the GARCH estimation method to estimate the delta values.

4.3.2 Historical simulation method

Historical simulation method assumes that the returns of portfolio present a independent and identical distribution, and the future fluctuation of market factors is exactly the same as that of historical fluctuation, whose core is to use return rate data on assets over the past period of time, to estimate the statistical distribution of return rate from assets, and then get VaR of the corresponding confidence level according to the Different quantiles. The steps of Historical simulation method are: (l) put in order of the return rate on stocks from smallest to biggest; (2) for the data window width (the length of the sample interval) T, the counterparts of 5^{th}-bit number and the 1^{st}–bit number of the stocks returns distribution after putting in order are 95% VaR and 99% VaR.

The advantages of historical simulation method are: simple, intuitive, easy to operate, no need to make assumption on the distribution of the return rate, and it can resolve the problems such as fat-tail distribution and asymmetric distribution of the return rate and so on, meanwhile, it avoids the discrepancy arising from parameter estimation and choice of model.

Historical simulation method also has many shortcomings. Details are as follows: Firstly, the return rate is fixed within the entire sample period, in the event of a reversal of historical trends, even the VaR of the original data will have bigger deviation from the expected largest loss; secondly, HS can not provide the expected loss worse than smallest return rate in the observed samples; Thirdly, the size of the samples will impose great impact on the VaR values, resulting in a larger variance; fourthly, HS can not be used as the sensitivity test under extreme scenarios.

4.3.3 Monte Carlo simulation method

The calculation of VaR based on Historical simulation method is the n kinds possible results of combination of profit and loss based on the change of historical actual price of the market factors, in order to calculate the VaR via quantile based on profit and loss of the observed distribution. The calculation of VaR based on Monte Carlo simulation is similar, and the only difference is that changes in market factors are not from historical observations, but by the random simulation. Whose basic concept is to repeat the simulation of the random process of financial variables, making it include most of the possible circumstances, and thus the overall portfolio value distribution can be obtained by simulation, based on which, the VaR can be calculated.

The calculation of VaR based on Monte Carlo simulation method can be carried out in three steps:

First, the Formation of scenarios. Choosing the random process and the distribution of the changing market factors of, and to estimate that the corresponding parameters: simulating the changing path of market factors, and establish f the future scenarios of the market factors.

Second, valuation of the portfolio. To calculate the value and changes of portfolio by the way of pricing formula or other methods on every scenario of the market factors.

Third, estimation of VaR. In accordance with simulation results of the distribution changes of the portfolio, we calculate the VaR under a specific confidence level.

The specific steps of the use of Monte Carlo simulation method to calculate VaR are as follows:

First, select a stochastic model:

In the Monte Carlo simulation, the first choose the stochastic model and distribution which reflects changes in the prices, and to estimate the relevant Parameters. Geometric Brownian motion (GBM) is one of the most commonly used models in the changes of stock price, which assumes that the change in the value of the assets is irrelevant in time, and its discrete form can be expressed as:

$$\Delta S_{t+1} = S_t(\mu\Delta t + \sigma\varepsilon\sqrt{\Delta t}$$

Among which： $\Delta S_{t+1} = S_{t+1} - S_t$

S_t refers to the asset prices at the time of t

S_{t+1} refers to the asset prices at the time of t+1

μ refers to the average value of the profit rate of assets

σ refers to the fluctuation rate of the assets

ε refers to the Random variables

As the general Monte Carlo simulation method is the fluctuation rate under the assumption that it is in the normal distribution, in this time, σ is the standard deviation of the return rate from the assets, and ε is subject to the random variables under standard normal distribution.

Second, the prices of stochastic simulation:

Under the random model, produce the corresponding random sequences ε_i (i=1, 2, … n), and based on which to calculate the simulation price S_{t+1}, S_{t+2},…, S_{t+n}.

Define t as current time, T is the target time, at the time t, we simulate the price for the time T, $\tau = T - t$ is the time interval of simulation, in order to generate a series of random variables S_{t+i} within the time of τ,

i=1,2,…n, $\Delta t = \tau / n$.

In order to simulate the price of the random variables S, starting from the current prices, according to the order i=1, 2, … n, and according to random number ε_i, we obtain:

$$S_{t+1} = S_t + S_t(\mu\Delta t + \sigma\varepsilon_1\sqrt{\Delta t})$$

$$S_{t+2} = S_{t+1} + S_{t+1}(\mu\Delta t + \sigma\varepsilon_2\sqrt{\Delta t})$$

$$S_{t+n} = S_{t+n-1} + S_{t+n-1}(\mu\Delta t + \sigma\varepsilon_n\sqrt{\Delta t}) = S_T$$

Which has simulated the future direction of a random variable S ($S_{t+1}, S_{t+2}, \dots, S_{t+n}$) and the price S_T at the time T.

Third, the estimation of VaR:

Repeat the second step, the more the times of repeating (use k) are, the closer the true distribution will be, which we can get a series of asset prices $S_T^1, S_T^2, \dots, S_T^k$, at the time of T, In a given confidence level, VaR is loss of the k(1－α) simulation price in ascending order in the K times of simulation results. For example, the simulation times are1000 (k = 1000), confidence level is 95% (α=95%),and find quantile $S_T^{\min 5\%}$ (Penultimate number 50 , 1O00*(l－95%)=50) with 5% after the sequence of asset prices, and then in accordance with $\omega_0 - \omega^* = -\omega_0 R^*$, the VaR under 95% confidence level can be defined as:

$$VaR = \omega_0 - \omega^* = S_t - S_T^{\min 5\%}$$

The function of Monte Carlo simulation technique is very powerful, and its applications are also very flexible, which can be used for different assumptions of return rate, as well as the simulation analysis in the event the return rate is subject to different distributions. Monte Carlo simulation technique using computer simulation to generate a large number of scenarios confers to the capacity to generate more reliable and comprehensive conclusions than the analysis methods at its calculation of risks. In addition, the Monte Carlo simulation method is a full-value estimation method, which reflects the convexity of the non-linear assets, effective solve the difficulties encountered in dealing with non-linear, non-normal problems.

However, this method also has many shortcomings: One is the large amount of calculation. In general, the complex portfolio often includes a variety of financial instruments with different currency bonds, stocks, and long-term options, and whose market factors include a variety of different currencies, different period of interest rates, exchange rates, stock indexes, which makes the market factors into a huge assembly, even if the number of market factors are relatively small, it is very difficult to simulate for thousands of or even millions of times on the multi-vector distribution of the market factors. Second is the model selecting discrepancy. Price fluctuation of financial products is a random process, and different products have different ways of price fluctuations, so it is difficult to use a particular model to describe, therefore, the selection of model will bring the choice of a certain discrepancy.

4.4 Conditional heteroskedasticity model

From the analysis of 4.1, the calculation of the variance of δ^2 is the key of VaR, which needs an accurate model to describe the variance of financial series.

Many scholars found that the fluctuations of financial time series will relatively concentrate in certain period, and the fluctuation with a relatively small degree will be concentrate in other periods, with features of cluster of the fluctuations. The phenomenon of cluster of the fluctuations is closely related to phenomenon of fat-tail, the phenomenon of cluster of the fluctuations is often manifested by characteristics of "fat-tail peak" and the discrepancy of the return rate has the problems such as correlation and conditional heteroskedasticity.

In order to characterize a certain relevance that may exist in the conditional variance, Engel (Engle) proposed the Autoregressive conditional heteroskedasticity (ARCH) model. Its mathematical description is as follows:

Set y_t as the dependent variable, and x_t as the Column vectors constituted by explanatory variables, and μ_t as the random interference, in general, the existence of auto-regressive model:

$$y_t = x_t \times b + \mu_t \qquad (4.1)$$

Among them, the pre-determined explanatory variables x_t may include the lagged value y, b is the parameters. A common form of formula (4.1) is:

$$y_t = b_0 + b_1 \times y_{t-1} + b_2 \times y_{t-2} + \cdots + b_m \times y_{t-m} + \mu_t \qquad (4.2)$$

If $\{\mu_t\}$ meets:

$$\mu_t = \sqrt{h_t} \times v_t \qquad (4.3)$$

$$h_t = \alpha_0 + \alpha_1 \times \mu_{t-1}^2 + \alpha_2 \times \mu_{t-2}^2 + \cdots + \alpha_p \times \mu_{t-p}^2 \qquad (4.4)$$

We call μ_t as Autoregressive Conditional Heteroscedasticity process at the stage of p, record as ARCH (p), whose process can also be written as follows:

$$\mathrm{var}(\mu_t) = \delta_t^{\ 2} = \alpha_0 + \alpha_1 \times \mu_{t-1}^2 + \alpha_2 \times \mu_{t-2}^2 + \cdots + \alpha_p \times \mu_{t-p}^2 \qquad (4.5)$$

In the process of ARCH (p), because μ_t is Random, μ_t^2 can not be negative, so for the all realized value of $\{\mu_t\}$,only when $\mathrm{var}(\mu_t) = \delta_t^{\ 2} = \alpha_0 + \alpha_1 \times \mu_{t-1}^2 + \alpha_2 \times \mu_{t-2}^2 + \cdots + \alpha_p \times \mu_{t-p}^2$ is positive, it is then reasonable. Therefore, only when $\alpha_i \geq 0$， $\alpha_1 + \alpha_2 + \cdots + \alpha_p < 1$,the process of ARCH (p) is a smooth covariance.

ARCH model can be better combined with practice, but there are also some shortcomings: to get a better fitting effect of ARCH models in practical applications often take a huge order p, which not only increases the computation, but also result in other issues such as explanatory variables and multi-line; In the ARCH model, μ_t

is set to follow the normal distribution, but a growing number of studies have shown that, in a few financial series, this normality assumption is not realistic.

In view of such situation, Bollerslev proposed generalized autoregressive conditional heteroskedasticity (GARCH) model. GARCH model is approach with the heteroscedastic time series modeling in the family of ARCH models. GARCH model is the expansion of ARCH models; the equation in second-order moments introduced their own Lagging items of the second-order moment, which better describes the conditional variance. The description of conditional variance in GARCH models:

$$\operatorname{var}(\mu_t / \varphi_{t-1}) = \delta_t^2 = \omega + \sum_{j=1}^{q} \beta_j \delta_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \mu_{t-i}^2 \qquad (4.6)$$

Among which, φ_{t-1} all information at the time of $t-1$ and before the time of $t-1$, $q \geq 0$, $p \geq 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$, $\omega \geq 0$ .If $\sum_{j=1}^{q} \beta_j + \sum_{i=1}^{p} \alpha_i < 1$,if $\sum_{j=1}^{q} \beta_j + \sum_{i=1}^{p} \alpha_i < 1$,which means the process of GARCH is Smooth covariance.

GARCH conditional variance model is not only lagging behind the linear function of squared residuals, but also and lagging behind the linear function of conditional variance, when the calculation is not big, GARCH process easily describes the process of high-level f ARCH, and thus more applicable. However in practice, GARCH still exist some inadequacies: First of all, GARCH model can not explain the phenomena of negative correlation between the fluctuations of return rates. GARCH models assume that conditional variance is a function of past squared residuals, so the symbol of residuals does not affect the fluctuations, that is, the reflection of conditional variance to positive and negative price fluctuations s is symmetric, however, in empirical studies, we found the fluctuations may not asymmetric. For example, when the bad news occurs, that is, the expected rate of return will decline, the fluctuations tend to increase, when the good news occurs, that is, the expected return is expected to rise, the fluctuations would tend to reduce, however, and GARCH model can not explain this non-symmetry. Secondly, in order to ensure the non-negative of conditional variance, all coefficients bound by GARCH model are bigger than zero, which not only rules out the random fluctuations behavior with regard to conditional variance, but also bring the difficulty to estimate the parameters of GARCH model.

In consideration of the inadequacies existing in GARCH model, there are many methods of improvement, EGARCH (exponential autoregressive conditional heteroskedasticity) model is one of them. EGARCH model better solves the above problem, and it can analyze the non-symmetrical effects arising from market information, what's more, the model parameters are not subject to restrictions of the non-negative. In the EGARCH model, the description on Variance is as follows:

$$\ln\left(\delta_t^2\right) = \omega + \sum_{j=1}^{q} \beta_j \ln\left(\delta_{t-j}^2\right) + \sum_{i=1}^{p} \alpha_i \left| \frac{\mu_{t-i}}{\delta_{t-i}} - E\left(\frac{\mu_{t-i}}{\delta_{t-i}}\right) \right| + \sum_{k=1}^{r} \gamma_k \frac{\mu_{t-k}}{\delta_{t-k}} \qquad (4.7)$$

In the formula (4.7), the left side of the equation is the logarithm of conditional variance, which means that the leverage will affect index, rather than secondary, so the predictive value of conditional variance is certain to be non-negative. the existence of Leverage effect can be tested by the assumption $\gamma < 0$, that is, γ is the non-symmetrical effect parameter of the market impact, when γ=0, the positive and negative impact is Symmetric, when γ<0, the impact on the fluctuations from the negative is bigger than the positive; when γ>0, the impact on the fluctuations from the negative is bigger than the positive, it is evident that the EGARCH model can describe the impact of asymmetric information.

Many scholars found that financial time series often have a feature of high peak distribution, comparison between the unconditional distribution of the variables yield with the assumed normal distribution, it will show a larger kurtosis, and its tail is more thicker than that of normal distribution, which is the so-called peak fat-tail phenomenon. In accordance with this situation, this thesis introduces GED (generalized error distribution) to describe the characteristics of peak fat-tail in the sequence of the yield.

The most important feature of GED distribution is the distribution parameters v which is used to describe the tail, that is, the degrees of freedom of GED distribution. Through the adjustment of parameters v, it can fit the different changes in the graphics, and deal with different levels of "peak fat-tail" phenomenon. When v is 2, the generalized error distribution is standard normal distribution; when v <2, the probability density has a thicker tail and thinner peak than the normal thickness, and the smaller the value v is, more prominent the “peak fat-tail” phenomenon will be; when v> 2, the tail is thinner than normal distribution.

Therefore, the introduction of EGARCH fluctuation model based on the GED distribution can better grasp the properties of yield sequence of the financial data, such as the peak fat-tail, the cluster, the outbreak, persistent, the relevance, and the mean-reversion.

Chapter 5 Measurement of freight risk for international crude oil marine operators by VaR method

5.1 The selection and Processing of historical freight data

According to the model of VaR selected in this thesis, it should be based on a market factor that should be able to have a major impact and has a representative to measure the market freight risks. So this thesis selects the index of BDTI from July 2002 to December 2008 to model, a total of 1692 observational data, this thesis defines the price sequence as BDTI.

This thesis applies EGARCH model to fit the Autoregressive Conditional Heteroscedasticity of the freight yield fluctuations, therefore, first of all, we need to calculate the daily yield rate of the freight of crude oil. On the processing of the data of daily yield rate, in general, there are two ways: one is the simple rate of yield, that is, yield $= R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$, P_t means the freight at the time of t; the other is the logarithmic rate of yield, that is $R_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$. Simple rate of yield assumes that the time series is discrete, but logarithmic rate of yield assumes that the time series is continuous, at the premise of small fluctuations of the price, the results of the two is similar. However, the logarithmic changes transform the growth of these queues from a curve trend into a linear trend, while the differential further ruled out linear trend. Many articles in the financial time series used logarithmic yield rate, the thesis also used the method of logarithmic yield rate to calculate the daily yield rate of the above freight series.

We will take the freight data of July3, 2002 as the start data to calculate the logarithmic yield rate freight, and data sequence is recorded as: RBDTI.

5.2 The statistical characteristics of the sequence of the daily yield rate of Freight

5.2.1 Analysis of the descriptive statistics on Sequence

In VaR model, we usually assume that the sequence of yield rate obeys normal distribution, but the practice has proved a lot of the yield rate sequence is not consistent with the assumptions of normal distribution. So in order to select fluctuations model which can effectively describe the sequence of freight yield rate, we must make some tests of normality of the sequence of freight yield rate. There are many ways; the most simple test method is to test the skewness and kurtosis. Skewness is a statistic of non-symmetry around its mean value of the sequence data of yield rate, and it is to describe the degree of deviation of the distribution curve; while the kurtosis is a Statistical measures of the degree of a flat and peak of the sequence of yield rate, and it is used to describe the extent of steep of the distribution curves.

For any random variable r, if its mean is μ, variance is σ^2, and then its Skewness is defined as the standardized third-order central moment of this random variable:

$$S(r) = \mathrm{E}\left(\frac{(r-\mu)^3}{\sigma^3}\right) \qquad (5.1)$$

The kurtosis is defined as the standardized fourth-order central moment of the random variable

$$K(r) = \mathrm{E}\left(\frac{(r-\mu)^4}{\sigma^4}\right) \qquad (5.2)$$

Skewness of the normal distribution equals to 0, kurtosis equals to 3. All symmetrical distributed skewness is zero, the kurtosis of the distribution of peak and fat-tail is greater than 3, and some even have infinite kurtosis.

The statistic of Jarque-Bera is one of the indicators of normality for testing the data series, JB value determines the normality of the data series through checking the difference between the normal sequence and these kewness and kurtosis, and its calculation formula is:

$$JB = \frac{N-n}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right) \qquad (5.3)$$

Of which: N is the sample data capacity, n is the number of the estimated coefficient used for the production of samples sequence, S is skewness value, K is value for the kurtosis. In the original assumption of normal distribution, JB statistic obeys the chi-square distribution whose degrees of freedom are 2, the conspicuous level of testing is 1% in this article.

Skewness is greater than 0, which means the number of days of the rate of yield lower than the average are less than that of the rate of yield higher than the average; on the contrary it means that the number of days of the rate of yield lower than the average is more than that of the rate of yield higher than the average. When the kurtosis is greater than 3, and the JB value is greater than the critical value of chi-square distribution, which is statistically significant, it shows a Leptokurtic Distribution sequence and fat-tail distribution of the data. Figure 5.1 is about the descriptive statistical analysis of the sequence of RBDTI.

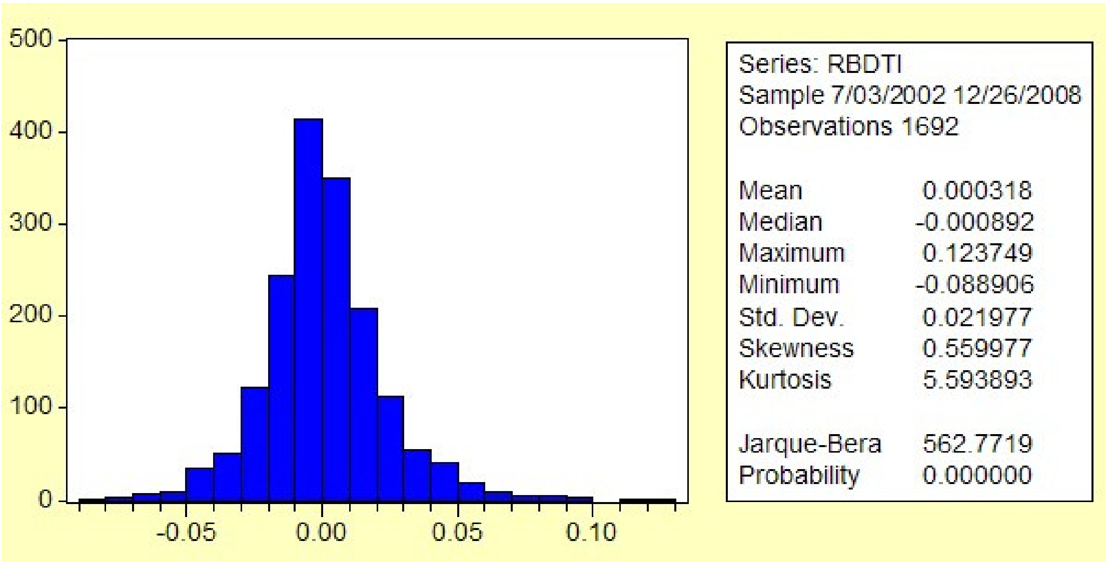

Figure 5.1 Descriptive statistics scattergram of RBDTI

We can see from Figure5.1, the skewness of RBDTI sequence is greater than 0, the left side, the right tail is longer; kurtosis is greater than 3, the degree of uplift is greater than normal distribution; the statistic of JB statistic is significant, and the associated probability, that is the probability which accepts the assumption of normal distribution is 0. Thus this article holds that the RF1 sequence does not obey normal distribution.

From the above analysis we can see that the distribution of sequence RBDTI compared with the normal distribution both has the feature of "fat-tail peak", which shows that the daily yield rate of the international oil freight is with similar characteristics of distribution on common financial time series, the use of GED distribution to describe the sequence of tariff yield rate is feasible.

5.2.2 The smooth test of sequence

P-order autoregressive-AR (p) applies only to the self-relevance which is used to describe the stationary time series, usually a stationary time series can be effectively described by using its mean, Variance, covariance and auto-correlation function, and the random in time-series at various time points obeys the distribution of probability to a certain degree. In other words, through the information of the past point in time in time series, we could establish model to simulate the past information, and then predict the future. But practice has proved a lot of financial and economic time data are mostly non-stationary time series, which illustrates that the dependent variables except those that can be explained by the independent variables, the rest changes irregularly. So it is difficult to grasp the random of the whole sequence through the known information. In order to test whether the sequence RBDTI can be described by autoregressive process so as to select the appropriate model, we need to test the smooth of the RBDTI sequences. This thesis tests the stability of freight yield sequences through the unit root, the method is ADF (Augmented Dickey-Fuller test).

For a simple first-order autoregressive equation:

$$y_t = \rho y_{t-1} + \mu_t \tag{5.4}$$

The item of disturbance μ_t meet the zero mean disturbance, constant variance and non-auto-correlation classical assumptions, if $\rho = 1$, some problems about unit root came out, showing that y_t is a non-stationary series.

ADF test controls the high-order sequence correlation by adding the differential lag of dependent variable at the right side of the regression equation, the following is the mathematical expression:

$$\Delta y_t = \gamma y_{t-1} + a + \delta t + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + u_t \qquad t = 1,2\cdots,T \tag{5.5}$$

In which a is a constant, δt is a linear trend function, $\sum_{i=1}^{p} \beta_i \Delta y_{t-1}$ is the differential lag of the dependent variable. If γ equals to 0, there exists a unit root in the sequence. ADF test is a t-test on γ, the original assumption is that there exists a unit root in the sequence.

Table 5.1 on the ADF test of RBDTI

Null Hypothesis: RBDTI has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic based on SIC, MAXLAG=24)				
			t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic			-16.94851	0.0000
Test critical values:	1% level		-3.434013	
	5% level		-2.863045	
	10% level		-2.567619	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(RBDTI)				
Method: Least Squares				
Date: 05/30/09 Time: 19:27				
Sample (adjusted): 7/05/2002 12/26/2008				
Included observations: 1691 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RBDTI(-1)	-0.290705	0.017152	-16.94851	0.0000
C	9.10E-05	0.000377	0.241365	0.8093
R-squared	0.145352	Mean dependent var		-1.79E-06

Adjusted R-squared	0.144846	S.D. dependent var	0.016763
S.E. of regression	0.015501	Akaike info criterion	-5.494626
Sum squared resid	0.405841	Schwarz criterion	-5.488200
Log likelihood	4647.706	F-statistic	287.2519
Durbin-Watson stat	2.003372	Prob(F-statistic)	0.000000

We can see from Table 5.1, under the three significant levels, ADF values (Augmented Dickey-Fuller test statistic) are all smaller than the critical value of t-Statistic, which illustrates that RBDTI sequence does not contain unit root. The original assumption is refused, and the RBDTI is stable.

5.2.3 The analysis of the autocorrelation of Sequence

The auto-correlation of time series means that the data before and after the time series affect each other, the increase or decrease of the current data has some impact on the latter change, then in the time series there will appear some autocorrelation.

In the classical linear regression model assumptions, the random disturbance items μ_t don't correlate with each other, namely:

Covariance $\operatorname{cov}(\mu_t, \mu_{t-s}) = 0 \qquad s \neq 0, t = 1,2 \cdots T$

Since the usual assumption is that the random disturbance obeys the mean value 0, as the normal distribution of variance, and then sequence correlation can be expressed as:

$$E(\mu_t, \mu_{t-s}) \neq 0, \qquad s \neq 0, t = 1,2 \cdots T$$

The existence of Disturbance sequence of the linear regression model will lead to the distortion of the estimated result of the model. We need to amend the linear regression model.

Now we can make use of Ljung-Box Q statistic to test the autocorrelation of RBDTI sequences. The expression of Q statistic is:

$$Q_{lb} = T(T+2)\sum_{j=1}^{k}\frac{r_j^2}{T-j} \tag{5.6}$$

In which r_j is the j-order correlation coefficient of a residual sequence which is autoregressive process, T is the sample capacity, k is the lag order of settings. LB-Q test of the original assumption is that the k-order autocorrelation does not exist in the sequence, Q statistic obeys chi-square distribution at this time. Table 5.3 is the results of LB-Q.test on RBDIT sequence.

Table 5.2 Test of autocorrelation on RBDTI sequence

Date: 05/30/09 Time: 19:28						
Sample: 7/03/2002 12/26/2008						
Included observations: 1692						

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
|***** |	|***** |	1	0.709	0.709	852.72	0.000
|**** |	| |	2	0.504	0.002	1284.0	0.000
|*** |	| |	3	0.370	0.023	1516.2	0.000
|** |	| |	4	0.269	-0.004	1639.0	0.000
|* |	| |	5	0.183	-0.026	1695.7	0.000
|* |	| |	6	0.104	-0.039	1714.2	0.000
| |	| |	7	0.054	-0.005	1719.2	0.000
| |	| |	8	0.026	0.002	1720.4	0.000
| |	| |	9	0.015	0.013	1720.8	0.000
| |	| |	10	0.009	0.003	1720.9	0.000
| |	| |	11	-0.013	-0.035	1721.2	0.000
| |	| |	12	-0.010	0.024	1721.4	0.000
| |	| |	13	-0.002	0.009	1721.4	0.000
| |	| |	14	0.028	0.053	1722.7	0.000
| |	*| |	15	0.011	-0.059	1722.9	0.000
| |	| |	16	0.012	0.022	1723.2	0.000
| |	| |	17	0.023	0.018	1724.1	0.000
| |	| |	18	0.022	-0.010	1725.0	0.000
| |	| |	19	0.039	0.039	1727.6	0.000
| |	| |	20	0.031	-0.024	1729.2	0.000

Table 5.2 Autocorrelation means correlogram, Partial Correlation, means partial Correlogram, natural number sequence means the value of lag k. AC row is the estimated correlation coefficient, PAC is the estimated partial autocorrelation coefficient, and PAC can be used to determine the order of autoregressive models, the value of AC and PAC correspond with their gram. Q-Stat means the value of Q statistic, Prob means that the value of Q statistic is greater than the probability in which the sample calculate Q value, and also means the probability to accept the original assumption.

From Table 5.2, we can see that in the lag from the course 1-20, AC value are not 0. Still take a significant level as 1 percent, at this time the Q statistic value is significant, and the probability of acceptance of original assumption is 0, so we should therefore refuse the original assumption and assume the existence of autocorrelation of the RBDTI sequence. The picture of partial autocorrelation is First-order truncation, which shows the process of the autoregressive of basis can be set as the AR (1), but still needs the model amending.

5.2.4 The test of conditional heteroskedasticity on Sequence

As a result of this article adopting EGARCH model to simulate the residual sequence of disturbance item in autoregressive model, so first we need to test the ARCH of residual sequence. In this we use the ARCH LM test.

The statistic of ARCH LM test is calculated by an auxiliary test. In order to test the original hypothesis: ARCH effect does not exist until the P-order in all the residual sequence, which means that all lagged residual coefficient is 0, the need for return are as follows:

$$\hat{u}_t^{\ 2} = \beta_0 + \left(\sum_{s=1}^{p} \beta_s \hat{u}_{t-s}^2 \right) + \varepsilon_t \tag{5.7}$$

(5.7) $\hat{u}_t$ is the residual, which means the lag of the residual sum of squares on a constant and up to a p-order of the residual sum of squaresand, and also a return made by the random disturbance item. There are two statistics in the test return:

(1) F statistic is an omitted variables test on the joint significance of all the lagged residual squared.

(2) c statistic is Engle's LM test statistic, which is the result of number of observations multiplied by the regression test R^2.

We do not know the exact distribution of F statistics, while the LM test statistic usually progressively obeys the distribution of $\chi^2(p)$, given the significant level a and the freedom degree p, if $LM > \chi_a^2(p)$, then refuse the original assumptions that all of the lagged residuals coefficient are 0, but that the residual sequence has ARCH effect; on the contrary the residual sequence does not have ARCH effect.

According to the analysis of section 5.2.3, we could establish an AR (1) model on RBDTI, by calculating we could get:

Estimation Command:

=====================

LS RBDTI C RBDTI (-1)

Estimation Equation:

=====================

RBDTI = C (1) + C (2)*RBDTI (-1)

Substituted Coefficients:

=====================

RBDTI = 9.099393392e-005 + 0.7092946663*RBDTI (-1) (5.8)

We could make ARCH LM test on the equation (5.8) to get the follows:

Table 5.3 The results of the test on two RF sequence ARCH LM

ARCH Test:			
F-statistic	12.61906	Probability	0.000392
Obs*R-squared	12.54026	Probability	0.000398
Test Equation:			

Dependent Variable: RESID^2				
Method: Least Squares				
Date: 05/30/09 Time: 19:46				
Sample (adjusted): 7/08/2002 12/26/2008				
Included observations: 1690 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000219	1.44E-05	15.19503	0.0000
RESID^2(-1)	0.086142	0.024249	3.552331	0.0004
R-squared	0.007420	Mean dependent var		0.000240
Adjusted R-squared	0.006832	S.D. dependent var		0.000545
S.E. of regression	0.000543	Akaike info criterion		-12.19675
Sum squared resid	0.000498	Schwarz criterion		-12.19032
Log likelihood	10308.25	F-statistic		12.61906
Durbin-Watson stat	2.009696	Prob(F-statistic)		0.000392

Table 5.3 is the results of the test on two RF sequence ARCH LM, in which p means the lag order. Significant level is taken as 1 percent, by looking up the table We

could know that LM statistic are bigger than the critical value in different lag orders, at the same time the accompanied probability P is 0, So we refuse the original assumption that RBDTI has ARCH effects, and can describe it by the amended AR (1) process.

5.3 The estimation of parameter of EGARCH model based on the GED distribution

This thesis has analyzed in 4.2, that an important feature of GED (generalized error distribution) is the distribution parameters v which is used to describe the tail, that is, the degrees of freedom of GED distribution. We could simulate the different graphics and grasp the different levels of "peak fat-tail" phenomenon through the adjustment of parameters v. According to the analysis of 5.2, RBDTI sequences all have the characteristics of fat-tail, so this thesis adopts the GED distribution to describe the distribution of RBDTI. At the same time, the model of GARCH ethnic has a good characteristics of describing the of financial time series, that is the ability to describe the time-varying variance and the ability to deal with fat-tail, which can be used to describe the market factor. And compared with the GARCH model, EGARCH model can describe the emerging feedback and leverage effects in practice, reflecting the asymmetric impact of market information in more extensive and flexible form. Therefore, this article adopts the EGARCH models based on the distribution of GED to describe the daily yield rate sequence of maritime freight of the international crude oil.

Model of RBDTI is as follows:

$$
\begin{cases}
rf_t = rf_{t-1} \times b_1 + \mu_t \\
\mu_t = Z_t \times \delta_t \\
\mu_t \ / I_{t-1} \sim GED(0, \delta^2, v)
\end{cases}
\tag{5.9}
$$

$$\ln(\delta_t^{\ 2}) = \omega + \beta \ln(\delta_{t-1}^2) + \alpha \left| \frac{\mu_{t-1}}{\delta_{t-1}} \right| + \gamma \frac{\mu_{t-1}}{\delta_{t-1}}$$

(5.9) rf_t means the yield rate at time t; μ_t is regression error item, δ^2 is the obedience conditional variance, the freedom degree of the distribution of GED is v; I_{t-1} t-1 is the information set at time t-1; in the logarithmic description equations of conditional variance, γ of the is the non-symmetrical effect parameters under the market impact, when γ= 0, positive and negative impact is symmetric; When γ <0, the increase of the fluctuations of negative shocks is more than that of positive; When γ> 0, the increase of the fluctuations of negative shocks is less than that of positive.

Table 5.4 Estimate of RF1model parameters

Dependent Variable: RBDTI		
Method: ML - ARCH (Marquardt) - Generalized error distribution (GED)		
Date: 05/30/09 Time: 19:48		
Sample (adjusted): 7/05/2002 12/26/2008		

Included observations: 1691 after adjustments				
Convergence achieved after 25 iterations				
Variance backcast: ON				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000596	0.000264	-2.256714	0.0240
RBDTI(-1)	0.691115	0.015233	45.36982	0.0000
	Variance Equation			
C	2.39E-05	6.95E-06	3.445400	0.0006
RESID(-1)^2	0.147731	0.032352	4.566398	0.0000
GARCH(-1)	0.763640	0.046024	16.59222	0.0000
GED PARAMETER	1.054671	0.043771	24.09517	0.0000
R-squared	0.501772	Mean dependent var		0.000317
Adjusted R-squared	0.500293	S.D. dependent var		0.021984
S.E. of regression	0.015540	Akaike info criterion		-5.677778
Sum squared resid	0.406924	Schwarz criterion		-5.65850

			0
Log likelihood	4806.561	F-statistic	339.3968
Durbin-Watson stat	1.962078	Prob(F-statistic)	0.000000

Table 5.4 is the estimated value calculated from the model parameters, we can see value of v is 1.054671, less than 2, proving that the distribution of RF1 does have characteristics of peak fat-tail compared to normal distribution. The statistic of Log-likelihood is great, which illustrates that this model successfully describes the time correlation of the yield rate's fluctuations.

5.4 The calculation of VaR for one-day freight

Section 5.3 get the degrees of freedom v value of the GED distribution by calculation, the thesis calculated GED distribution quantiles whose confidence level is 99% and under 95%, the, the results are shown in Table 5.6.

Table 5.5 GED distributions corresponds to the sub-median whose confidence level is 99% and 95%

confidence level	RBDTI （v=1.054671）
99%	2.9382
95%	1.5710

Because this thesis adopts the GED-EGARCH model to describe the sequence fluctuations of daily yield rate so as to calculate the value of VaR, we can transform the general one-day VaR model into the form below:

$$VaR_t = P_t \times \varphi_\alpha(v) \times h_t \tag{5.10}$$

Among them, P_t is the maritime fright of international crude oil on day t, φ_α is the degree of freedom v, the sub-median of the GED distribution under the confidence level α, h_t is the estimated conditional standard deviation of RF sequence from the EGARCH model on the day. The Calculated VaR means the maximum of the possible down freight next day.

In order to ensure the accuracy of the calculation, the thesis calculates the freight VaR value for each day during samples period. For example, the October 24, 2005 VaR value of freight index when the confidence level under 95% is calculated as 0.0674, which means that probability that the yield rate of freight index on next day (25 days) is less than -0.0674 is 95% .

Figure 5.2 Compares the VaR value under confidence level 95% with the absolute value of daily yield rate.

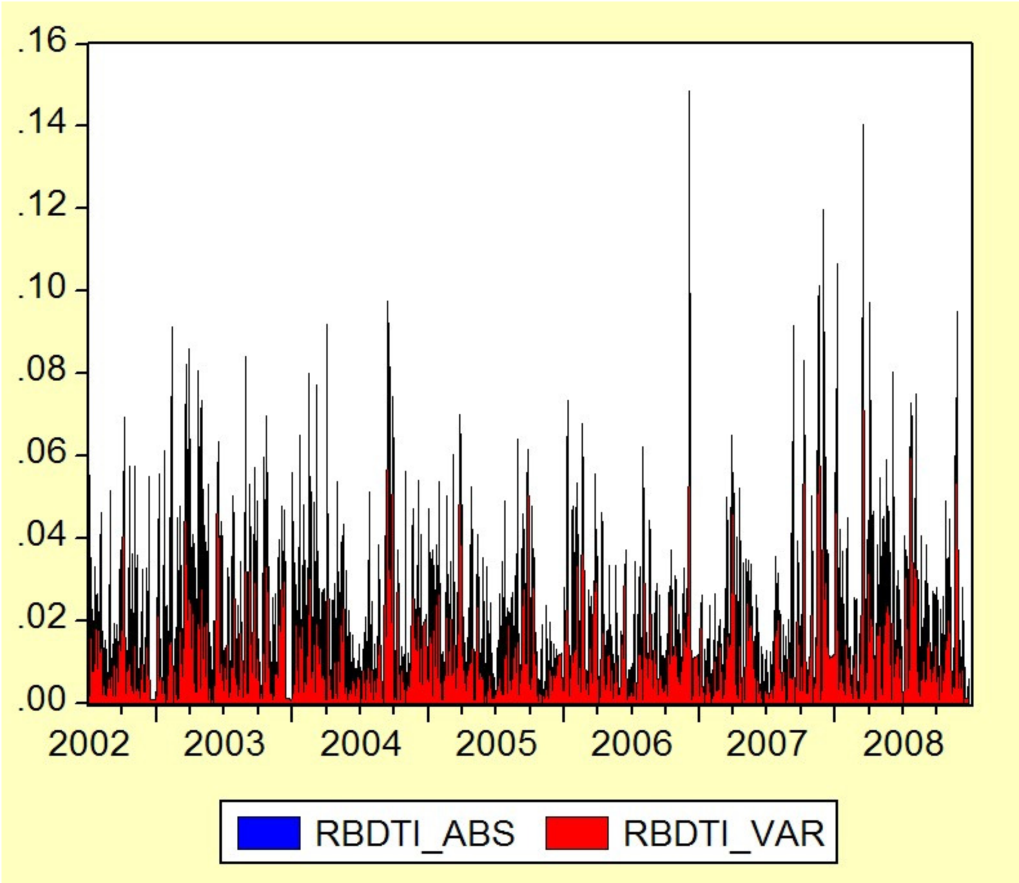

Figure 5.2 Absolute value of RBDTI compared with the 95%threshold value of VaR

5.5 With regard to posteriori tests on the results of VaR calculation

A posteriori test means the extent of coverage to which the results of the calculation on the VaR model covers the actual loss.

This thesis selects the absolute value of RBDTI and the 95% threshold VaR value in all trading days during sampling period to make comparisons, and calculate the number of overflow days E:

$$E = \sum_{t=1}^{n} E_t$$

$$E_t = \begin{cases} 0, & \text{if} VaR_t \geq P_t - P_{t+1} \\ 1, & \text{if} VaR_t < P_t - P_{t+1} \end{cases} \qquad (5.11)$$

$$e = E \div T$$

Among them, P_t means the freight of international crude oil at time t, E means number of overflow days when VaR value is less than the actual decline value, e is the overflow rate, T means the total number of days during the sample period. Compared to the significant level, if $e > 1 - \alpha$, it means that the model underestimated the risk; if $e < 1 - \alpha$, the prediction result of model covers the actual loss, but if e is too small it means the model is too conservative.

For sample 1, in accordance with the above method of calculating we may get:

When the confidence level is 99%, e = 33 ÷ 1692 = 0.0195, more than $1-99\%$, it means that the model underestimated the risk;

When the confidence level is 95%, e = 73 ÷ 1692 = 0.0431, less than $1-95\%$, it means that at this confidence level, the model better predicts the risk.

Through the above analysis we can see that the model in this thesis on the condition that confidence level is 95%, could better forecast the risks, and can be used to predict the long-term freight risk.

5.6 The analysis of VaR calculation results

Now this article makes a analysis about VaR value of the two-stage one-day freight under confidence level 95%.

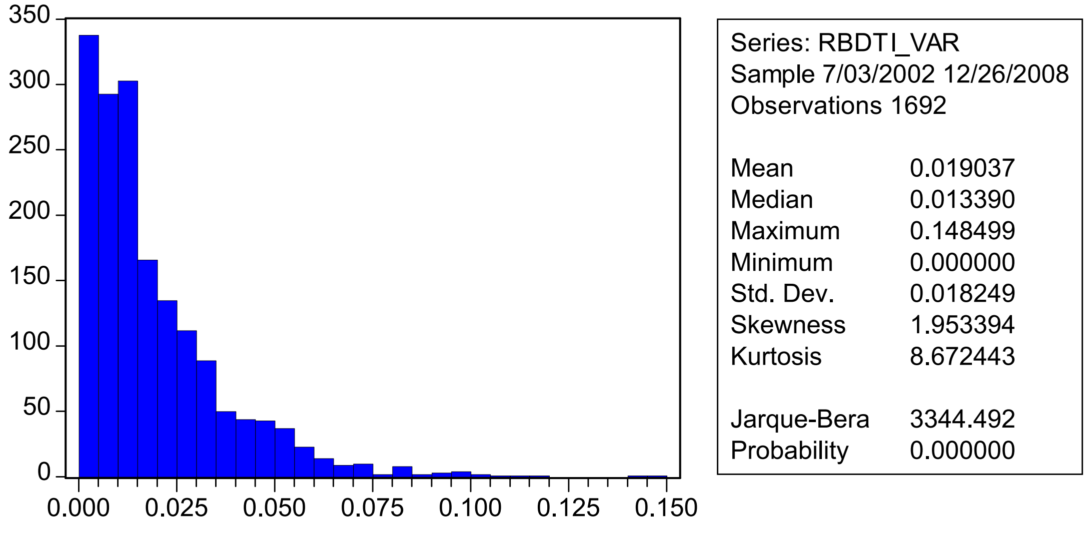

Figure 5.3 Statistics feature of one-day freight VaR value of the sample at first stage

From figure 5.3 we can see that, in the first stage, the average of one-day freight VaR is 0.019037, maximum 0.148499, minimum .000000. Combining the table 5.8 (GED-EGARCH estimates result of model parameter), the factor of the proceeds leverage γ is less than 0, indicating that at this stage the impact of good and bad news of the international crude oil transport market is asymmetry, and the impact on the freight of bad news is greater than the impact of good news, the leverage effect exists; if α is larger than 0, it means that the fluctuations of transport freight has a cluster phenomenon, there are even more substantial fluctuations after relatively large fluctuations; if $\alpha + \beta$ is larger than1,it shows that the fluctuation has a persistent feature, the past information is important to predict conditional variance of the future freight yield rate sequence; if ω is less than 0, it indicates that the level of freight revenue balance was negative, the market risk is relatively big.

5.7 The Application of VaR calculation results in the formulating business strategy

Because of the long transportation distance, high freight rates in the import and export of crude oil, these operators are in high-risk co-exist with the high-yield state. This thesis aims to quantify the freight risks faced by Maritime operators, through VaR calculation. We try to express the maximum possible down value in the form of easy-to-understand data in the future period of time, so that the shipping operators could clearly understand the freight risks they are facing with, thereby providing decision support. This article holds that the calculation results of VaR can be applied to the following aspects:

(1) To determine the Venture capital for the losses arising from the change of freight.

International crude oil transport operators can be used to estimate VaR value of the price movements of venture capital. This is not only for the market of crude oil transportation, but also the container transportation as well as the dry bulk cargo transportation, here we could take the example of Danzas the company in China to illustrate this, by the end of 2007 this company prepared to lease a 175,000 dwt Capesize ship for the transportation of China and Pakistan iron ore, the lease is one year, the average freight level of iron ore acquired by Danzas is 87.68 U.S. dollars / ton. This net dwt of this ship is estimated at 170,000 tons, a round-trip voyage from Brazil to China will take about 93 days, under normal circumstances there can be four return voyages in one year, where the freight income of iron ore in the return voyage is considered. According to the calculation results of 5.3, there is 95% certainty that in 2008 year the most possible down value of China-Pakistan's iron ore freight may be 34.74 U.S. dollars / ton, considering the extreme case the most possible down value of freight income is: $34.74 \times 17 \times 4 = 23.6232$ million U.S. dollars. Danzas takes into account three factors when chartering: income, cost and profit. Assume that its expected profit rate is 15%, then Danzas need to control the relative costs at: (87.68 17 4) / 1.15 = 51,845,600 U.S. dollars, and the expected profit is 7,776,800 U.S. dollars. If the freight revenue goes down 23,623,200 U.S. dollars, then Danzas shall bear the maximum possible loss of costs caused by changes in freight : 2362.32 - 777.68 = 15,846,400 U.S. dollars.

If Danzas see the China-Pakistan iron ore maritime market is very good, but the hire of Capesize vessels and the cost of oil make the current expected revenue equals to the cost if the Danzas charter the ship, that is to say, even if from the present situation it is in the state of the balance of payments, Danzas thinks that there are enormous space of profits to enter in this market, then the venture capital that Danzas need to prepare for the changes of freight is: 23,623,200 U.S. dollars, because he did not have expected profits to offset the loss of freight. But what must be noted is that the confidence level to determine the above-mentioned venture capital is 95%, that is to say, there is a 5% possibility of venture capital exceeding the value above. Maritime operators, therefore according to its own funds decide whether they are able to bear the venture capital prepared for the change in freight, and then determine the appropriate timing for the charter.

(2) Combine with the contract of COA to avoid the risks.

As I indicated earlier, although the overall trend of international crude oil price rose, but the fluctuations of freight in short-term is relatively larger, the Change in freight will cause a great deal of influence on shipping operators. Therefore, after ensuring the risk of freight, we should deal with risks. For the ship operators who have leased the capesize vessels for a long term, COA (Contract of Affreightment) could be used to lock the price, and to avoid risks.

In addition, the freight VaR values of the international crude oil can also support the operation of FFA. FFA (Forward Freight Agreements) is a long-term freight agreement, which deals with the freight in thesis. In FFA trading, buyers and sellers reach a long-term freight agreement, which provide for specific routes, freight, quantity, delivery date and so on. When entering the delivery date, the two sides charge or pay the price (based on the Baltic corresponding route Freight Index to calculate) and the difference of freight agreed in the contract. FFA has become an effective tool for speculation and hedging. There are strong correlation and convergence between FFA and spot market, so the calculation of future freight the VaR value has the guiding role for FFA trading. We could estimate the appropriate price for the sale of FFA and the duration of contract through VaR value, through the FFA to offset the profit and loss of the spot market, so as to achieve the hedge of freight. Of course, if the future crude oil freight VaR value calculated is too large and lack of confidence in the rising freight, shipping operators should not lease a ship or immediately sublet ships on hand so as to avoid or transfer risks.

Chapter 6 Conclusion

This thesis makes use of the EGARCH-VaR model based on the GED distribution to study the fluctuation risks of the Crude oil freight index issued by the Baltic Shipping Exchange. Data cited by this thesis comes from the Crude oil freight index issued by the Baltic Shipping Exchange, the period of samples is from July 2002 to December 2008. The daily return rate has a clear statistics characteristic of peak fat-tail, which exists a strong correlation, and the residuals sequence from the regression model has an ARCH effect. The use of EARCH based on GED model can be better fit the fluctuations characteristics of the sequences which are reflected, based on which model, VaR model could be built so as to calculate the daily risk value of the daily return rate sequence, whose result passed the VaR testing based on failure rate. The Daily return rate sequence of Baltic Freight Index exist a strong correlation, therefore, the dramatic increase and slump of prices over a period of time are happening from time to time. When calculating the VaR, the correlation coefficient must be taken into account, in order to avoid the bottom risks. Although the daily VaR mean of Samples period studied by in this thesis has a certain degree of representativeness, it can not be widely applied to every period of the samples, because the fluctuation characteristics of the freight index at some stage are different from the characteristics of overall fluctuations of its samples. Therefore, the in practical application, we should select the appropriate daily level of VaR by the way of choice of a sample period and characteristics at a specific study phase.

Limited by the time, length, and data sources, there is a lot of work in this thesis that is still not comprehensive, which needs learning, improving and perfecting in the future work and study.

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