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The research on the volatility of VLCC market

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WORLD MARITIME UNIVERSITY

Shanghai, China

THE RESEARCH ON THE VOLATILITY OF VLCC MARKET

By

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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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DRECLARATION

I certify that all the material in this research paper 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.

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WANG YANWEI

………………………..

Supervised by

Professor ___Yin Ming____

Shanghai Maritime University

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Content

Abstract

Title of Integrative paper: **The Research on the Volatility of VLCC Market**

Degree: **MSc in International Transport and Logistics**

Oil is known as “the blood of industry”, which is the guarantee of global economic development and political stability and an important strategic resource. Besides, due to the imbalanced distribution of the oil resources, the oil trade is critical to every country. As the derivative of the oil trade, tanker transportation is an important part of the shipping industry, and the freight is easily influenced by many factors such as economy, politics and oil price, which causes the strong volatility of the freight. As the main type to transport the crude oil, VLCC tankers are becoming more and more important for shipping companies. More and more companies pay attention to the VLCC market. It is necessary to research on the volatility of the market.

Firstly, the research paper introduces the basic characteristics of tanker market and analyzes the VLCC market from the aspects of demand and supply and finds some factors which may cause the market volatility, which lay foundation for later analysis. Then, the paper introduces the models to investigate the volatility. In this thesis, I apply the GARCH model to analyze the VLCC freight index of the four routes (TD1, TD2, TD3 and TD15) and compare the different characteristics among different VLCC routes. In the end, I put forward several suggestions for VLCC shipping companies as a reference for their further development.

Key words: VLCC market, Demand and Supply Analysis, Volatility, GARCH model

1. Introduction

1.1. Backgrounds and purpose of the dissertation

Crude oil has always been one of the world's most important strategic resources and has a crucial position in the economic development of various countries. Its supply and demand directly affects the global economy. International crude oil transport market is an important part of international shipping market, as well as other shipping markets. The tanker transportation is a derived demand from international crude oil trade, which makes it strongly influenced by the global economy. In addition, the change of political factors, natural conditions, trade patterns can impact the crude oil transportation market. Since the global economic crisis in 2008, the crude oil transportation market fell to the bottom, and super tanker rates dropped sharply. During the six years from 2008 to 2014, large crude oil carrier had experienced the most difficult time. Nevertheless, the tanker market takes a turn to the better due to the low oil price recently, from which we can find the huge volatility of the market. The VLCC rate has always been a barometer of international tanker transportation market, and its freight movements can reflect the overall status of international tanker transportation market which also determines the intensive fluctuations of VLCC market. The volatile change of VLCC freight rate has brought great difficulties to the large crude oil transportation enterprises to operate and manage the fleet. This leads them to concern more about the research of the tanker rate and its fluctuation. If an oil tanker company can master the regulation and characteristics of VLCC freight rate and learn more about its fluctuation, they can make an accurate forecast about the change of crude oil transportation market for a period of time in future. And they can develop a timely plan to evade the risks in the market operating according to it. Besides, the research can also provide theoretical basis for the enterprise to make the management decision. At present, there is not enough theoretical researches on volatility of VLCC freight rate among Chinese academia, which is far behind the development of the Chinese crude oil transportation enterprise. It has led to the situation that many large domestic oil transportation enterprises has no principle to rest on in the process of market development, and makes them at a competitive disadvantage in the global market.

1.2 Literature review

1.2.1 Research on crude oil transportation

Fulkerson and Dantzing (1954) introduced and analyzed the main circuits of global crude oil transportation. Then they set the minimized number of oil tankers as the goal, and constructed the tanker fleet planning model for the first time. This paper uses both qualitative and quantitative analysis to research the problems of crude oil transportation. Glenn w. Graves and Gerald g. Brown (1987) put forward the point of view that oil companies should own their own crude oil tanker fleet and make a reasonable maritime transport planning, which can reduce the risks, save a lot of operational costs, and lead to higher economic efficiency for oil companies. Then the paper discussed the existing problems of the crude oil transportation route and schedule, and gave suggestions and solutions in the end. A.N. Peraki Sandw and M.B Remer (1992) analyzed the potential external and internal risks during crude oil transportation and gave a comprehensive introduction about safe tanker operation during voyage, and under the premise of considering the safety cost the paper built up an optimized model of crude oil transportation network. E.Iakovou and C.Douligeris (1997) analyzed the patterns of American crude oil transportation from the angle of preventing oil spill and ocean pollution, and found the tanker companies have the problems that lack of risk assessment before transportation and the imperfect responses after emergencies. Based on the summary of a large number of data, the author put forward some pertinent suggestions for tanker operating companies to improve their safety management.

Liu Xiaotong and Luo Hongbo (2010) compared the development conditions and modes between Chinese and foreign tanker companies, and found that Chinese companies were far behind the foreign companies on various aspects such as fleet scale and management and couldn't satisfy crude oil transportation demand in China. They suggested that Chinese tanker companies should accelerate the tanker fleet construction and attach importance on the development of larger oil tankers like VLCC and ULCC.Gao Jie (2013) mainly researched the crude oil from Middle East and its strategic meaning for Chinese energy safety. The paper expounded the potential risks during the crude oil shipping routes from Middle East to China and pointed out that China should strengthen the control over resources and transport routes of imported crude oil from the lesson of the serious accident of French "Limbaugh" super tanker in the gulf. Peng Chuta (2014) forecasted the future demand of imported crude oil in China and analyzed the shipping capacity of Chinese tanker companies. And he found local shipping supply can't meet the demand of crude oil transportation. Then the author established a tanker fleet planning model with the target of minimizing the annual operating costs and researched how to optimize Chinese tanker fleet scale. In the end, he gave the advice about the tanker capacity scale which China should add and the best strategy of purchasing new tankers and second hand tankers and also pointed out that Chinese tanker companies should improve the share of VLCC and SUEZMAX type in their fleet.

1.2.2 Research on the influence factor of tanker freight

Kavussanos (1996) built up the theory framework about the problem of freight and the TC (Time Charter) rent. He pointed out that if the oil shortage occurred, oil rate fluctuation was relatively severe, as the oil crisis 1973 and 1980. At the same time, he proposed the correlation between tanker ship size and freight rate fluctuation. It is that large ships' volatility is more serious than small vessels. Mayr and Tamvakis (1999) studied the relationship between U.S. crude oil price and the freight rate. The results show that they are closely linked. The increase demand for exporting oil will lead to the growing demand for the shipping, so as to make the same effect to the freight rate. Alizadeh and Nomikos found that there was a long-term equilibrium relationship between the tanker freight rate and the oil price. Poten (2005) pointed out that one of the main factors influencing the VLCC freight rate is the developing countries, especially China and India's rising demand for crude oil. Besides, he researched the relationship between oil inventories and the volatility of tanker freight rate, and found that Aframax tanker freight had the same fluctuations with exported oil price of the Arabian Gulf. Specifically, if the Arabian Gulf exports ten thousand barrels of crude oil, it will push the VLCC freight rate to increase 25 points.

Han Peiting (2008) researched the investment risks of tankers and introduced the certain equivalent coefficient method, Fuzzy Analytic Hierarchy Process (F-AHP) and risk evaluation method to evaluate the investment profits and risks. She also put forward practical and effective methods for risk assessment for oil tankers transport enterprises. Qian Yuan and Xie Xinlian (2008) analyzed the risk factors for tanker transport enterprises such as the operational risk, economic risk, environmental risk and safety risk, and used the fuzzy comprehensive evaluation method to evaluate the risk. In the end, they constructed the risk evaluation model of tanker transport enterprises by using the combination of entropy weight evaluation method and the fuzzy comprehensive evaluation method. Teng Yahui (2000) built up an econometric model depicting the tanker freight rate under different market conditions after analyzing the influencing factors of the tanker transportation market. Pan Xiaodan (2002) applied the method of time series analysis, clustering analysis and factor analysis on the research of influencing factors of tanker freight, and found the main factors were the price and the sea born trade of crude oil. Fan Yonghui and Yang Hualong (2009) constructed the grey association model to analyze linking mechanism between freight index and its influencing factors, and got the conclusion that the tanker fleet size, shipping volume of crude oil and oil production are the main factors influencing the tanker freight fluctuation.

1.2.3 Research on tanker freight

Kavussanos (1996) introduced the econometric model, Auto-Regressive Conditional Heteroskedasticity Model (ARCH Model), into the study of tanker shipping market, and compared the fluctuation characteristics among the three types of tanker freights: VLCC, Suezmax and Aframax. The research showed that the price of crude oil had greater influences on VLCC and Suezmax than other tankers. Parsons (1997) used the Neural Network prediction to forecast the tanker freight index, and analyzed its developing tendency. Lyridis (2005) put forward a new kind of tanker freight index, and through the analysis and comparison, the author thought that the new index can better reflect the features and fluctuations of the tanker transportation market than the Baltic tanker freight index. Meng Nan(2005) used the BP neural network model to forecast and analyze the tanker freight rate index on the basis of the demand and supply in tanker market. The result showed that BP neural network model is better than ARMA model to predict the tanker index

Kavussanos (2002) used co-integration and error correction model to contrast the different types of ships in the spot and the time charter market. The study found that the time charter market had smaller risk compared to the spot market, and small vessels' operational is less risky than large ships. Kavussanos and Alizadeh (2006) adopted random markov switching model to research the freight volatility of the four tanker types, VLCC, Suezmax, Aframax and Handysize , under different market conditions, and found that the fluctuation characteristics were closely related to the ship types and market conditions. Adiand and Culinane (2005) firstly applied the nonparametric model on freight market study, using generalized non parameter markov diffusion model to analyze the characteristics of the tanker freight market volatility. They found that there was a positive correlation between tanker freight rate and its fluctuation in the short term, and that the freight presented the feature of non-stationary.Jiang Liping (2008) used the GARCH model to research the continuity and sensitivity of the international tanker transportation market on the basis of the analysis of international tanker transportation market volatility. Wan Jiuwen (2010) applied the fractal model, generalized autoregressive conditional heteroscedastic model and vector autoregressive model on the study of four ship types. He analyzed the sustainability, sensitivity, the correlation, fractal characteristics of the freight rate volatility, which provided theoretical support and management guidance for the development of international tanker transportation enterprise.

1.3 Outline of the paper

On the basis of VLCC transportation market, this thesis will use the econometric model to analyze the crude oil tanker freight index released by the Baltic exchange. According to the analysis of characteristics and fluctuation of the international dirty tanker freight index, the influence factors and the market supply and demand, I will make a summary about the regulation of the VLCC freight. In the end, I will provide some valuable suggestions to oil transportation companies about how to make proper business strategies. I hope that the research can help our VLCC shipping companies accurately grasp the fluctuation characteristics of the tanker transportation market, and can be a useful reference for their management.

2. Analysis of the VLCC market

2.1 Basic characteristics of tanker transportation market

After hundreds of years of development and changes, the tanker transportation market has become a vital role in the international shipping system. This is not only because of its high percentage in the total shipping capacity, large scale of tanker fleet and high cost, but also because oil has occupied an important position of strategic materials in every country, and can influences the whole international economy and politics environment. Besides, the geographical differences between international oil production and consumption make the oil transportation an economic tie to connect various countries and areas all over the world. To some extent, all these factors are conducive to international tanker transportation market to achieve a sustained and rapid development in the future. Since 1990s, global economy grows rapidly which leads to the increase of demands for energies, especially for petroleum. The trend of sustainable growth of oil production and exportation from crude oil exporters continues. As a result, the oil transportation volume and turnover both continue to increase. From the development of tanker transportation, we can conclude several basic characteristics of this market:

(1) High volatility

Crude oil is the major goods for tanker transportation, and more than 90% of crude oil transportation relies on tankers worldwide. International oil trade is an important factor for tanker transport. In addition, if there is a worldwide economic crisis, the political crisis or events such as a war, the international oil trade would be greatly affected. For example, since March 2015, as U.S. crude oil inventories continued to break the highest record, the international oil price on November began to fell gradually. At the same time, due to the sectarian conflicts between Saudi Arabia and Iran became more serious, the two countries gradually became the forefront of wars. What’s worse, after Saudi Arabia booming to the Yemeni rebels, the number of gulf countries involved in fighting gradually increased, which led to the international oil price undulating. The volatility of oil price influences the demands and volumes directly, which also causes the volatility of tanker freight. Due to the abundant resources of oil, the gulf region is always in trouble both internally and externally.

(2) Oligopoly market

According to different ship owners, the tanker fleet can be divided into two types: affiliated fleet belonging to oil companies and independent fleet belonging to professional tanker transportation companies. During recent years, independent tanker fleets have taken the dominant place in the oil transportation market. Besides, the frequency of merge and cooperation among these independent ship owners becomes higher and higher. Thus, many professional tanker fleets of large scale have taken shape.

(3) Long term contract

Tanker transportation as a service business is deeply influenced by the world economy. The development of tanker fleets rely on the increase of demand. According the observation on the tanker transportation market during the past several decades, we can find that the regularity and periodicity of tanker transportation market is quite obvious. And the freight rates also meet these features. On the one hand, in order to guarantee the stability of supply and reduce the market influence, international tanker operators usually choose to sign a long term contract of affreightment. On the other hand, long term COA can also guarantee the stable income for a certain period which helps them to get more loans from banks to support them to do other businesses. On the whole, tanker transportation companies can benefit from the long-term and stable relations of cooperation.

(4) Professional techniques

Tanker transportation is an industry of high risk which requires high professional techniques. During the voyage, tanker transportation companies need more attention to observe the safety technical specifications and handle the possible accidents in time such as leakage and pollution to avoid more losses. Tanker transportation gradually separates from container and bulk cargo transport industry during its development.

Every tanker transportation company in this industry has its own characteristics and professional techniques on its fleet management, operation specification, customer service and voyage plan.

(5) Single ship operation company mode

As we all know, the risk and cost of operating a tanker is quite high. Once some accidents occur, the ship owner will bear a lot of economic responsibilities. In order to avoid these potential risks and operate the fleet stably, ship owners usually choose to divide a whole fleet into different single ship. They register a single ship company on the base of one tanker to achieve the aim of resource integration and divestitures. Considering the high shipbuilding cost of a tanker, ship owners can use this strategy to financing and managing capital more flexibly. It is more convenient for them to manage the tankers, and rent or sell the asset. Besides, professional ship owners usually choose to register in the area where provides lower taxes and convenient policies for them.

2.2 Overview of VLCC market

VLCC (VERY LARGE CRUDE CARRIER) refers to supertankers whose deadweight tonnage is over 200000 tons, which is mainly used for crude oil transportation for a long shipping distance. VLCC can load 2 million to 3 million barrels of oil at one time, which make it one of the biggest ship types on the shipping market at present. In general, the distance of transporting crude oil by sea is quite long. It sets higher requirements for the performance of operating the vessel. The good performance of VLCC gives it the advantage to become the main ship type transporting the crude oil. The shipping routes of VLCC mainly include the Middle East to the United States Gulf, the Middle East to the Mediterranean/North-western Europe and the Middle East to the Far East, and West Africa to the Far East and West Africa to the United States Gulf. Larger scale ships have the economies of scale, so the unit transportation cost of VLCC is relatively lower than other tankers.

In recent years, larger ships have been the trend for the whole shipping market including the tankers, which pushes the development of VLCC. The freight rate of VLCC has always been a barometer of international tanker transportation market, and its freight movements can reflect the overall status of international tanker transportation market. From a historical point of view, the biggest characteristic of the super tanker market is large volatility of freight rate levels. The movement of VLCC freight fully proves the feature since the outbreak of the financial crisis in 2008. In the second half of 2008, the global financial crisis, which in turn triggered a global recession, caused a devastating blow to international tanker market, and the rents of 300,000 DWT VLCC fell brutally. In July 2008 the daily rent was $90,000 while the price dropped to $18000 in the middle of 2009. Affected by the low oil price recently, the rent increases rapidly.

The unbalanced distribution of global oil reserves triggered the transnational transfer of crude oil trade. The shipping routes connect the major crude oil importers with the exporters and form a huge oil transportation network. Oil demand mainly comes from the western developed countries and the Far East (mainly from China, Japan and Singapore), where are shortage of crude oil resources. While the crude oil production areas are mainly concentrated in the Persian gulf, the Caribbean, in the Middle East, and west Africa where are less developed. The three major oil-producing areas account for three-quarters of the world's oil exports. Among them, the Persian Gulf accounts for almost half of global exports.

From the point of view of cargo flow, the crude oil shipping concentrates on several main routes due to the concentration of the demand and supply of crude oil resources. Besides, for the reason of the limitation of loading and unloading facilities in different ports, berth depth (the full draft of VLCC tanker is between 18 to 21 meters), and the global problems such as narrow sea channel, the VLCC shipping routes are more concentrated. At present, there the following four typical routes for VLCC tankers:

Route 1: the Persian Gulf - Far East

This route refers that VLCC tankers leave from the Persian Gulf, and get through

Hormuz, after passing through the Gulf of Oman, Arabian Sea, across the Indian Ocean, the Lombok Strait and then sail north through Makassar Strait into the South China Sea. The ships may choose to enter Chinese waters or Japanese waters. The route can pass the VLCC of more than 250,000 tons. The total mileage of this route is 7000 nautical miles.

Route 2: the Persian Gulf - the US Gulf / North-West Europe

This route refers that VLCC tankers leave from the Persian Gulf, and get through the Hormuz, the Oman Gulf and Arabian Sea, over the Indian Ocean, and navigate through the Mozambique Channel. Then the ships bypass the Good Hope Cape and choose to keep sailing to the west, across the Atlantic, and finally come into the US Gulf/the East coast of the United States. Or, the tankers can choose to navigate to the north along the west coast of Africa, and cross the English Channel, and finally arrive at the north-west European ports. This route can pass the VLCC of more than 250,000 tons.

Route 3: West coast of Africa - Far East

The main oil producers are Angola, Congo and Nigeria in West Africa. Tankers sail to the south after leaving the loading ports in that area, and bypass the Good Hope Cape and navigate to the east, across the Indian Ocean, and then through the Lombok Strait in Indonesia. After getting through the Makassar Strait, the ships come into the South China Sea, and can choose to either enter China Select waters or Japanese waters. This route can pass the VLCC of more than 500,000 dwt. Its total mileage is up to 10,000 nautical miles.

Route 4: West Coast of Africa - US Gulf / North-West Europe route

The route means that after leaving the crude oil origin, the tankers stretch over the Atlantic, and directly get into the US Gulf / East Coast of the United States. Besides, the ships can choose to sail along the west coast of Africa and go north, through the English Channel, and finally into the north-west European ports. This route can pass

VLCC of more than 250,000 DWT.

2.3 Demand analysis

2.3.1 World oil resources distribution

The distribution of global oil resources is very uneven. At present, the world's major oil producing areas include the Persian Gulf in the Middle East, the Caribbean, and former Soviet Union and its western region. These areas output the crude oil accounting for three quarters of the world's oil exports. Especially, the Persian Gulf in Middle East produces about 60% of the global crude oil. From the angle of the reserves of crude oil resources, the Persian Gulf in the Middle East is the most oil-concentrated area, accounting for 61.7% of the world's oil reserves. In this region, Saudi Arabia's oil is the most abundant, accounting for 16.1% of the world, followed by Oman (9.65%), Iraq (9.27%), Iran (8.91%), and the United Arab Emirates (3.78%). In the Caribbean region, Venezuela accounts for 4.47% of the world's oil reserves ranking 1st in this area. In the former Soviet Union region, Russian resources account for 10.74% of global oil reserves, and Kazakhstan accounts for 3.3%. In West Africa, Angola's oil reserves reached 13.18%, followed by Nigeria (3.0%) and Sudanese (0.5%). In North America, America owns the largest crude oil reserves, followed by Canada and Mexico, and their crude oil reserves, in turn, are 2.5%, 1.4% and 1.2%. In Asia, China takes the first place, taking up 1.4% of the global oil reserves

Table 2.1 the top 10 countries of petrol

Rank	Country	Reserves（million tons）	proportion（%）
1	Saudi Arabia	4966.5	16.11
2	Angola	4064.9	13.18
3	Russia	3310.6	10.74
4	Oman	2974.3	9.65
5	Iraq	2746.2	9.27
6	Iran	2857.8	8.91
7	Venezuela	1378.6	4.47
8	United Arab Emirates	1165.2	3.78
9	Kuwait	1061.8	3.44
10	Colombia	1009.1	3.27

Source: BP Energy

2.3.2 The world's leading oil exporters

Currently, the world's main areas exporting crude oil are the Middle East in the Persian Gulf, West Africa, Brazil, and the Caribbean region such as Venezuela and Mexico Gulf. Among them, the Middle East gulf region is the world's largest oil exporter. Saudi Arabia and Iran are the most famous exporters, and the two countries' oil exports reaches around 50% of the world's crude oil output. Therefore the increase or decrease of the crude oil exports in this region will directly affect the market price of international crude oil. Western Africa takes the second place. The main oil producing countries there includes Angola, Nigeria and Congo, and their s oil exports account for 15%~17% of the world's oil consumption. West African produces the crude oil with low sulfur, which belongs to the high quality oil, so the demand for West African oil presents the trend of increasing year by year.

2.3.3 The world's major oil importers

At present, the global annual consumption of crude oil is about 3.3 billion tons, of which 80% are concentrated in North America, North-western Europe and the Far

East. These areas are the world's three largest industrial production bases, so they have huge demand for imported oil. Nevertheless, the three areas produce only 36% of global oil outputs. The imbalance between resource supply and consumption further stimulates the demand for crude oil in this area.

In recent years, the demand for crude oil resources, pushed by the economic prosperity and rapid industrial development, increases sharply in the Asia-pacific region. The Far East has become the area keeping the fastest growth rate of oil consumption. According to the statistics from international energy agency, by 2030, the crude oil demand in the Far East will soared to 28 million barrels a day from 12 million barrels a day at this moment. In the Far East, China and Japan are the largest consumers. According to the CLARKSONS statistics, by the end of 2016, China's oil demand is 5.65 million barrels a day. The United States used to be the world's largest importer of crude oil, importing about 25.9% of global imported crude oil. However, China has overtaken the United States as the largest country importing the most crude oil in 2015.

2.3.4 Crude oil trade and transportation

Due to the disproportion between the world's oil resources distribution and consumption, the leading producers of crude oil lie in the Persian gulf, west Africa, Brazil, Venezuela and the gulf of Mexico, etc. These areas have a common characteristic that the regional economic development is poor, and there is not much market for crude oil resources. On the contrary, the main crude importers, North-western Europe, North America and the Far East, are characterized by rapid economic development and high dependence on crude oil. The differences of economic and political development among these regions lead to the transport demand for crude oil resources today. This kind of situation will bring the crude oil trade and international transport, resulting in today's global oil trade patterns. Maritime transportation has the characteristics of low cost and high efficiency and flexibility. At present, there are more than 60% of crude oil is transported by sea.

As the following table shows, the total tonnage of the world seaborne crude oil trade is not constantly increasing during the past decade. In 2006, the total quantity of global crude oil trade by sea is 1891 million tons, and in the next two years, 2007 and 2008, world economy was at its most prosperous time, which boosted the global crude oil seaborne trade to exceed 1900 million tons. However, impacted by the economic crisis and global economy recession in the second half year of 2008, seaborne crude oil trade dropped sharply to almost 1800 million tons in 2009. Afterwards, the amount of seaborne trade keeps a stable trend with small concussion. In 2005, although the quantity rose slightly compared to the last year, it did not revert to its previous level in 2007. Besides, the tone-miles of world seaborne trade present a similar picture with its total tonnage. In 2009, 2013 and 2014, the international crude oil price was relatively at a high level, and put a lot of pressures on global economy. The total tone-mile of world seaborne crude oil trade suffered several times of recession under these conditions. However, last year, the international crude oil price dramatically dropped to its lowest time due to the excess production capacity of global oil. The total tonne-miles recovered to 9069 billion, which approached to its highest record in 2012. The world seaborne crude oil trade appears another characteristic that the growth rate of its total tonne-miles exceeds its total quantity's growth, which means that the crude oil is transported for a much longer distance than before. In reality, the oil producers like Venezuela in the US Gulf and Angola in Africa increases their oil exports to the Far East during the recent years and these routes are of the long distance and high capacity, which causes the difference between the seaborne tonnages and tone-miles.

Table 2.2 World seaborne crude oil trade from 2006 to 2015

Year	World Seaborne Crude Oil Trade	World Seaborne Crude Oil Trade	World Seaborne Crude Oil Trade
	Million Tonnes	billion tonne-miles	% Yr/Yr (tonnes)
2006	1891.79	8820.97	0.71
2007	1912.58	8726.69	1.10
2008	1903.49	8844.65	-0.48
2009	1819.75	8148.07	-4.40
2010	1871.87	8626.84	2.86
2011	1851.71	8714.25	-1.08
2012	1906.25	9136.96	2.95
2013	1836.57	8907.11	-3.66
2014	1805.75	8899.27	-1.68
2015	1864.58	9069.61	3.26

Source: Drewry shipping

2.4 Supply Analysis

2.4.1 VLCC fleet capacity

Imported crude oil usually travels over a long distance from the producers to the destination, which sets a quite high standard of technical requirements on tankers. In addition, considering the economics of scale, VLCC is the main type in the world's tanker fleet accounting for almost 40% of the total tanker fleet capacity. VLCC tankers generally are distributed to the routes of long distance such as the Middle East to the Far East, the Persian Gulf to the United States Gulf/ West Northern Europe, West Africa to the Far East and West Africa to the US Gulf / North West Europe. Since the global economic crisis in 2008, the total DWT and ship number continue to increase, but its growth rate has slowed down significantly.

As the chart shows below, in 2006, there were 421 VLCC tankers in the world's tanker fleet. Despite the shipping downturn and economy recession, the total number and deadweight tonnage of VLCC rises steadily. After the development for a decade, the world's VLCC fleet has increased to 1.5 times of the previous scale. In 2015, the total number of VLCC is 633 and its transport capacity is 200 million DWT.

VLCC fleet and total deadweight tonnage

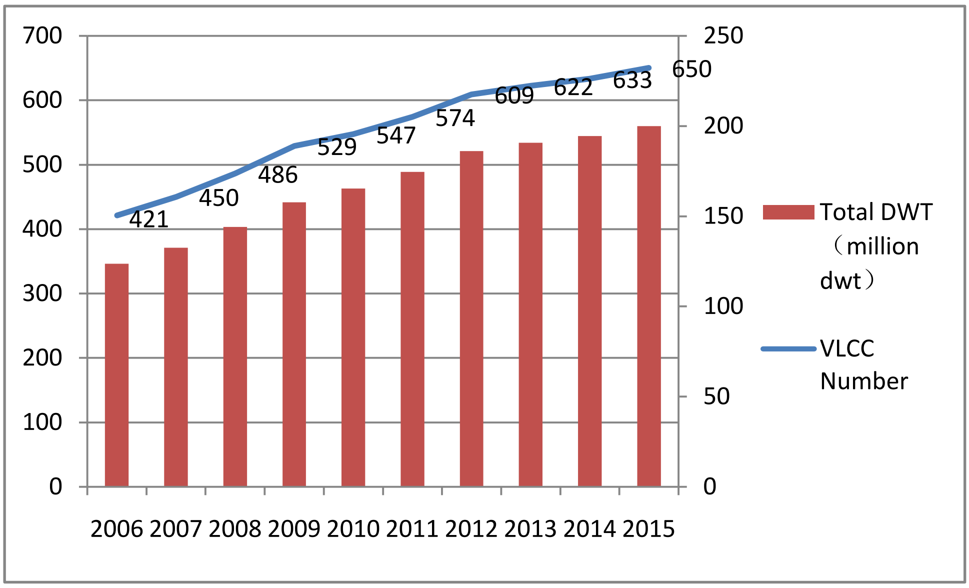

Figure 2.1 VLCC fleet and its capacity from 2006 to 2015

Source: Drewry shipping

From the Figure 3.3, we can find that the supply capacity of VLCC constantly exceeds the market demand since 2006. The gap between supply and demand enlarged in 2008 due to the economic recession. In 2008 and 2009, the global economy fell into the downturn and resulted in the decease of demand of crude oil, while the VLCC supply grows steadily during the past decade. The good news is that the low crude oil price pushed the demand for VLCC, and the tanker market shall experience a booming period since the downturn of the shipping market.

VLCC supply and demand

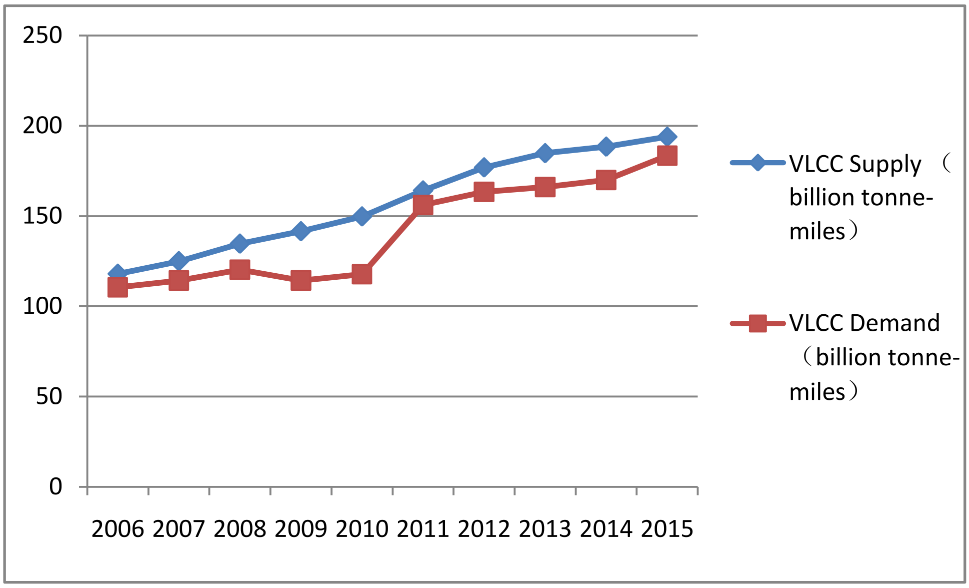

Figure 2.2 Supply and Demand of VLCC from 2006-2015

Source: Drewry shipping

2.4.2 Delivery and demolition

In 2006 and 2007, there were no demolitions in VLCC market. Since 2008, due to the recession and pessimistic expectations of the tanker market, some ship owners began to scrap their VLCC tankers. The decline in profitability of the tanker fleet put a lot of pressures on companies operating older tankers. Besides, the shipping market concerned more about the transport safety and environment pollution during recent years. IMO sets much stricter rules and standards for tankers such as eliminating single-hull tankers and setting ECA (Emission Control Area) at ports. Older VLCC tankers can't meet these requirements and lack of profitability, which forces its scrapping numbers to speed up in the next few years until 2014. By the end of 2012, there were more than 2.7 million dwt of VLCC capacity scrapped, and because of the market downturn was expected to last for a long period in the future, the average ages of scrapped tankers appeared to be much younger. The maximum demolition occurred in 2013, and there were 17 VLCC tankers scrapped that year. After several years of eliminating the older VLCC tankers, the demolition decreased since 2014. And the global VLCC fleets become much younger and more up-dated.

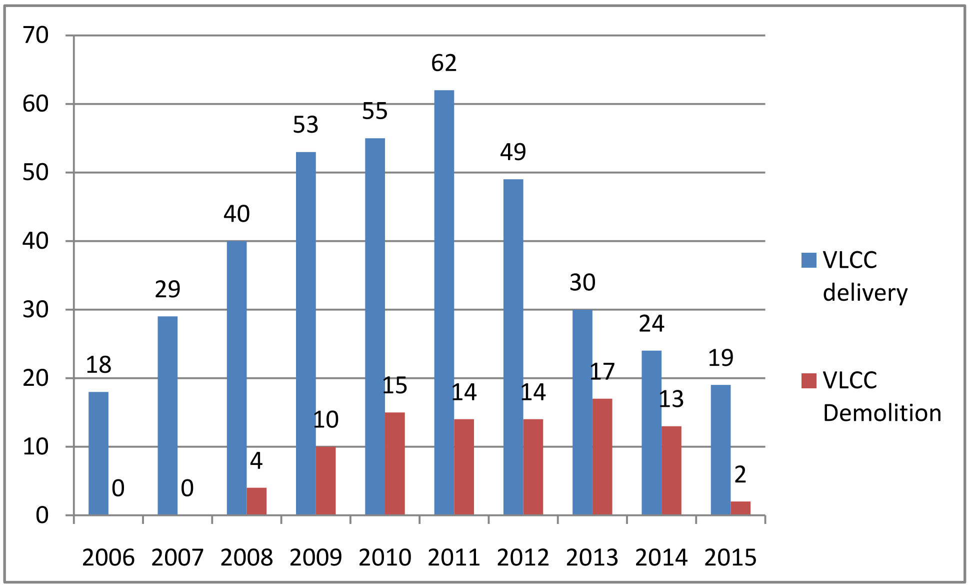

Figure 2.3 Delivery and Demolition of VLCC tankers from 2006-2015

Source: Drewry shipping

2.4.3 New Orders

As the following chart shows, during the period from 2006 to 2012, the new orders of VLCC tankers have an obvious characteristic that if there is large amounts of new orders in the previous year, the number of orders will decrease in this year. This phenomenon might explain the cause of market volatility. The ship owners might be affected by the total capacity of the last year and make a hysteretic reaction. The number of new orders continues to increase since 2012, which shows the positive expectations of the VLCC owners and the recovery of the tanker market.

According to DREWRY statistics, from 2006 to 2015, the global VLCC new building market can be divided into two stages

The first stage refers the period from 2006 to 2010. At this stage, the global tanker market experienced the situation of soaring freight and capacity shortage. The whole shipping market is in a period of prosperity, and many ship owners ordered new VLCC tankers blindly and with no limits. During this short period, VLCC capacity increased significantly. In 2008, the VLCC orders reached to its historical maximum, 36 million DWT, which causes the overcapacity of the tanker market for the next few years.

The second stage refers to the period from 2011 to 2015. On the contrast to the first stage, the shrinking market demand and excess capacity of tankers, VLCC owners experienced a very difficult time. Investors were reluctant to invest VLCC tanker market, resulting in the drastic decrease of VLCC orders. By the end of 2012, orders from the world's major shipyards were only 5 million DWT. The decrease of new orders reflects the negative prospects of the tanker market for the future, but it will help the market reach to a balance between supply and demand.

Recently, stipulated by the downturn of the crude oil price, the VLCC market began to recover since 2015. In 2015, the new orders increased to 19.3 million DWT, which is the largest orders since 2008.

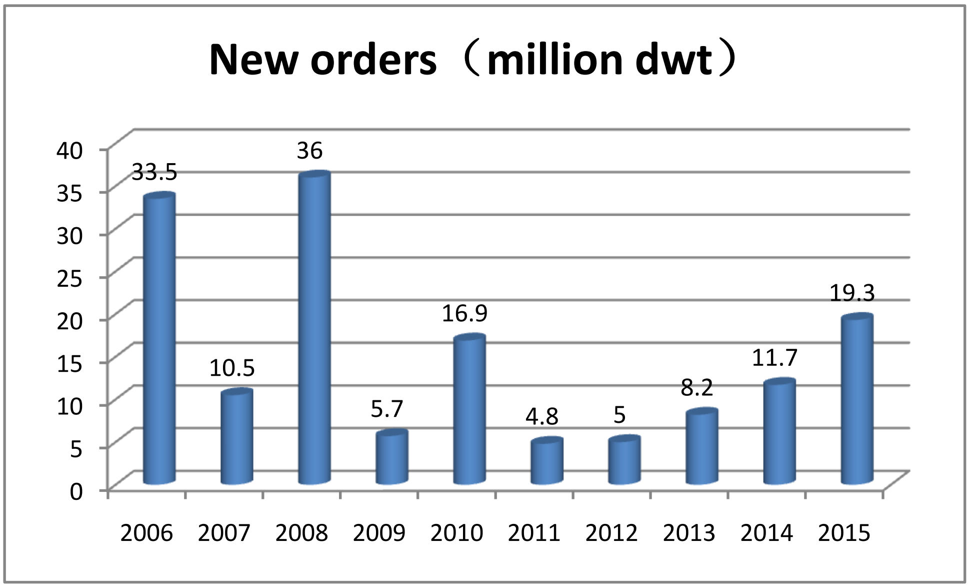

Figure 2.4 New orders of VLCC tankers from 2006-2015

Source: Drewry shipping

2.5 The emergence and development of BITR index

In the shipping market, the Baltic exchange must be the most authoritative one. Because of its long history, rich shipping information, authoritative evaluation institutions, BITR (The Baltic International Tanker Routes) which is released by the Baltic exchange enjoys a high reputation in the tanker transportation market. The index has a very good reference value for reflecting the variation trend and changes of the tanker freight rate, and it can be seen as the "barometer" for tanker transportation market. Therefore, this thesis uses the BITR index as the research object, and makes a brief introduction of the basic conditions, which will lay a foundation for later analysis.

The Baltic exchange was founded in 1744 based on a cafe for businessmen resting in Virginia, a state of the United States. Now it is headquartered in London and becomes the most famous exchange all over the world. There are 656 member companies joining in the organization, spread of 46 countries in the world. However, the Baltic exchange is a private enterprise and it requires member companies must have shares in the company. Staffs within the shipping exchange provide services to the shipper, owner and charterer, and committee to promoting the connection among the three parties, so as to promote the development of marine economic and trade.

In April 1998, The Baltic exchange issued the BITR (The Baltic International Tanker Routes) index reflecting the regulation of the Tanker day rate variation. BITR was originally made up of the freights from 7 tanker transport routes. After that, in order to adapt to the development of the international oil tanker transportation market, BITR gradually added other important oil tankers transport routes to ensure that the index can more accurately reflect the level of different ship forms in the spot market. In recent decades, with the rise of emerging countries such as China, India, Asia's demand for oil is increasing quickly, which drastically changed the pattern of consumption market of crude oil and refined products, and resulted in the constantly changing and the expansion of the tanker transportation market and transportation routes.

So far, the number of reference tanker transportation routes of BITR index is 26, including 9 product oil routes and 17 crude oil routes. These routes count for the same weight in the consisting structure of BITR index. For further optimization of the index, and reflecting the market environment, the Baltic exchange formally separate the

BITR index into BDTI (Baltic Dirty Tanker Index) and BCTI (Baltic Clean Tanker Index) in 2001. BDTI represents the Baltic crude oil tanker freight index, while BCTI represents the Baltic product oil tanker freight index. At this time, BITR index has already become an indicator of international tanker freight rate levels, and accurately reflects the fluctuations of rate level. It becomes one of the most important indexes in shipping market. There are 18 shipping routes chosen as the standard routes, and these routes connect the major oil importers and exporters and can reflect the condition of the tanker market. Among them, TD1 (the Persian Gulf to the US Gulf), TD2 (the Persian Gulf to Singapore), TD3 (the Persian Gulf to Japan), TD4 (West Africa to US Gulf) and TD15 (West Africa to China) are the routes reflecting the VLCC market.

Table 2.3 BDTI route specific composition

No.	Deadweight(MT)	Route	Route example	Maximum vessel age(year)
TD1	280000	the Persian Gulf to the US Gulf	Ras Tanura-Loop	20
TD2	260000	the Persian Gulf to Singapore	Ras Tanura-Singapore	20
TD3	260000	the Persian Gulf to Japan	Ras Tanura-China	15
TD4	260000	West Africa to US Gulf	Bonny-Loop	20
TD5	130000	West Africa to the Atlantic coast of the United States	Bonny-Philadephia	20
TD6	135000	Black Sea to the Mediterranean	Novorossiysk-Augusta	20
TD7	80000	The North Sea to	Sullom	20

		Europe	Voe-Wihelmshaven	
TD8	80000	Kuwait to Singapore	Mena al Ahmadl-Singapore	20
TD9	70000	The Caribbean to US Gulf	Puerto la Cruz-Corpus Christ	20
TD10	50000	The Caribbean to the Atlantic coast of the United States	Aruba-New York	20
TD11	80000	Trans-Mediterranean route	Banlas-Lavera	20
TD12	55000	Europe to the US Gulf	Antwerp-Houston	20
TD14	80000	Southeast Asia to the coast of Australia	Seria-Sydney	15
TD15	260000	West Africa to China	Bonny-Ningbo	20
TD16	30000	Black Sea to the Mediterranean	Odssa-Augusta	20
TD17	100000	Baltic Sea to Europe or the UK	Primorsk-Wihelmshaven	15
TD18	30000	Baltic Sea to Europe	Tallinn-Rotterdam	15

Source: Baltic Exchange

3. Research on the volatility of VLCC freight index

3.1 Introduction to the GARCH model

According to the traditional method of quantitative analysis, the scholars generally assume that sample variance remains unchanged, which means the study sample is a constant variance at different times. Nevertheless, that assumption is not right for sample data consisting of uncertainty and risk prediction for decision-making because ignoring the existence of heteroskedasticity will make the variance of the residual have larger errors, which makes the obtained sample parameters meaningless. Besides, the parameter cannot pass the significance test and will affect the fitting accuracy of the model. In order to make up for deficiencies in the conventional method, in 1982, Professor Engel, the author of "econometrics", first proposed the Autoregressive Conditional Heteroskedasticity model in his article. ARCH models can use the collected data and information data to characterize the changes of variance in the form of a self-regression. For a time series, the sample data are different from each other for the reason of collecting various information in different. So their heteroskedasticities are also different. It is through the ARCH model to characterize the different variances over time, and to study the sample data with heteroskedasticity. Then after continuous improvement and optimization of the ARCH model, it has formed a complete theory of autoregressive conditional heteroskedasticity. To study the changes in VLCC freight rates, I choose to use the GARCH model, which is one of the most widely used ARCH models.

In order to characterize the variance in different periods, the GARCH model uses the historical variance and its mathematical expectations to predict its future variance. It suggests that the variance of the sample data changes over time, and the change of present situation depends on the degree of its past variance‘s behavior. The GARCH (q, p) model is structured as follows

Variance equation

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \quad (3\text{-}1)$$

Mean equation

$$y_t = x_t \times \gamma + \varepsilon_t \quad (3\text{-}2)$$

These parameters should meet the following requirement:

$$\omega > 0, \beta_1 \geq 0, \alpha_1 \geq 0 \quad (3\text{-}3)$$

$$\sum_{j=1}^{q} \beta_j + \sum_{i=1}^{p} \alpha_i < 1 \quad (3\text{-}4)$$

The sum of $\sum_{j=1}^{q} \beta_j$ and $\sum_{i=1}^{p} \alpha_i$ can characterize whether the volatility is continuous and if the value is closer to 1, it indicates the continuity of the volatility is stronger. P and q separately represent the order of the GARCH and ARCH model. If both of them are greater than 1, it represents that the GARCH model is a high order model. Under normal circumstances, the condition of p = 1 and q = 1 has been able to describe mostly common time series. GARCH model's variance equation is as follows:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (3\text{-}5)$$

In this case, the conditional variance equation is consisted by the following three components:

Constant term ω refers to long-term average of the fluctuation;

ARCH term: When the latter data inherited the volatility information of preliminary data, the hysteresis of its random disturbance term square can measure the extent. The larger value indicates that the volatility is more sensitive to changes in the market;

GARCH term: refers to the prediction of the variance based on the previous data. The higher the value is, the longer the fluctuation duration lasts.

3.2 Research on the volatility of VLCC freight index

3.2.1 Data selection and analysis of its basic statistical characteristics

In fact, there are five VLCC shipping routes (TD1, TD2, TD3, TD4, TD15) calculated in the BDTI before 2015. However, the Baltic Exchange stopped releasing the index of TD4 (West Africa to US Gulf) since November 2015, so in this thesis, I select TD1 TD2 TD3 and TD15 to study the volatility of VLCC freight rate. When selecting the sample data, we need to care about the frequency of the data, because the low frequency data will affect the robustness and convergence of the parameter during the estimation process and make them fail to pass these tests. In this condition, most researched will choose to use the daily index data. What’s more, we need to eliminate the extreme cases in the sample data, such as the impact of the 2008 financial crisis, because these are not normal circumstances and may affect the extreme fitting effect. In this study, I select the data from January 3, 2011 to June 30, 2016. There are a total of 1330 trading days excluding non-trading dates. The following figures are the changing curves

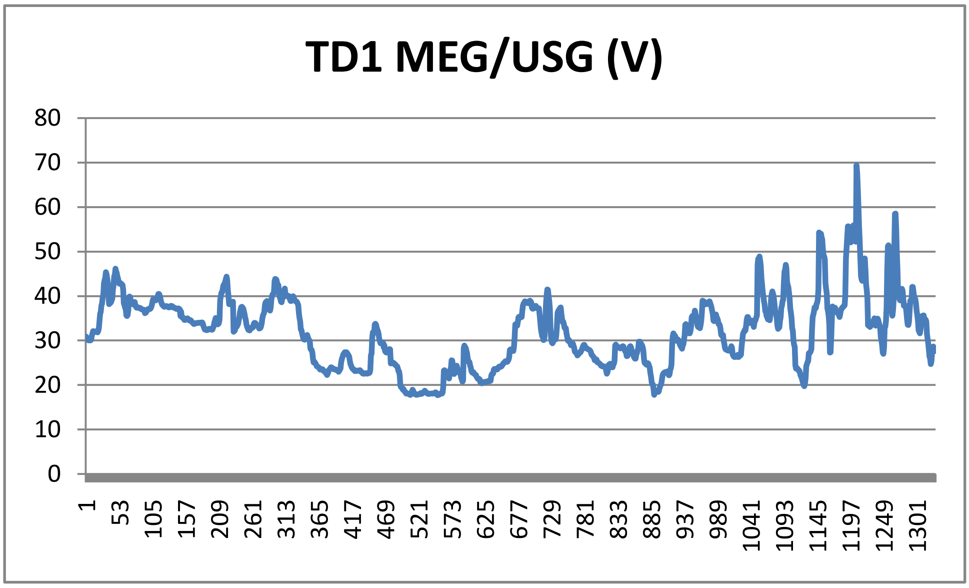

Figure 3.1 BDTI of TD1

Source: SSY TANKER

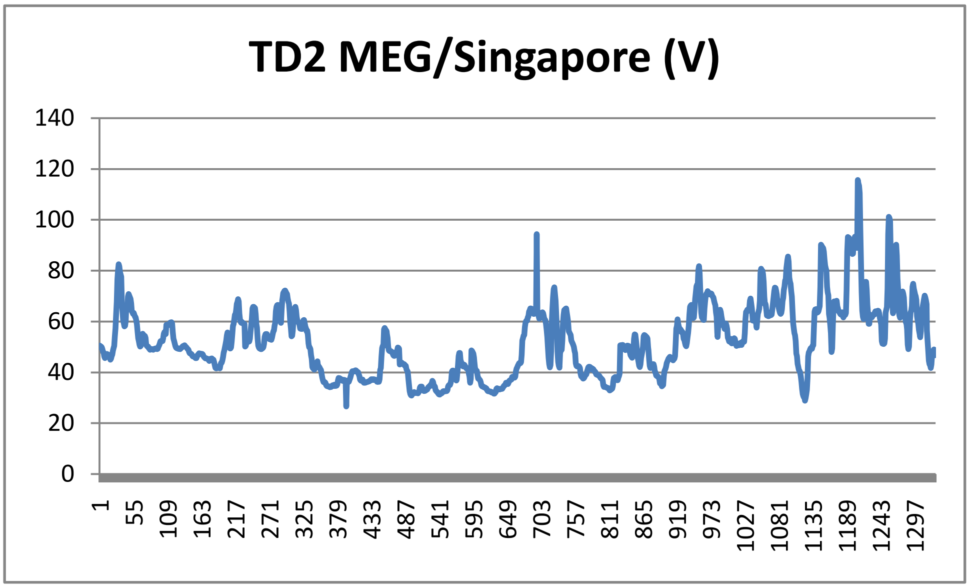

Figure 3.2 BDTI of TD2

Source: SSY TANKER

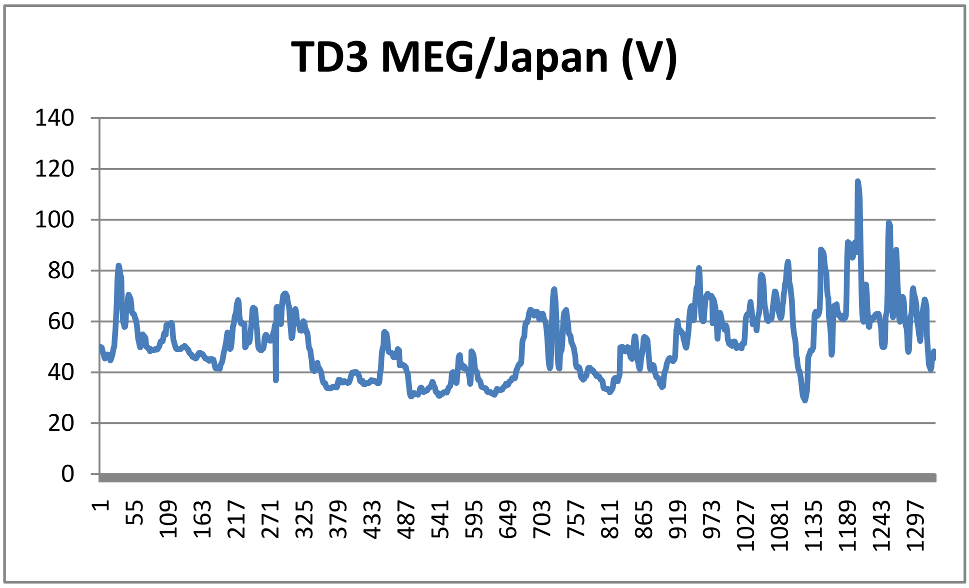

Figure 3.3 BDTI of TD3

Source: SSY TANKER

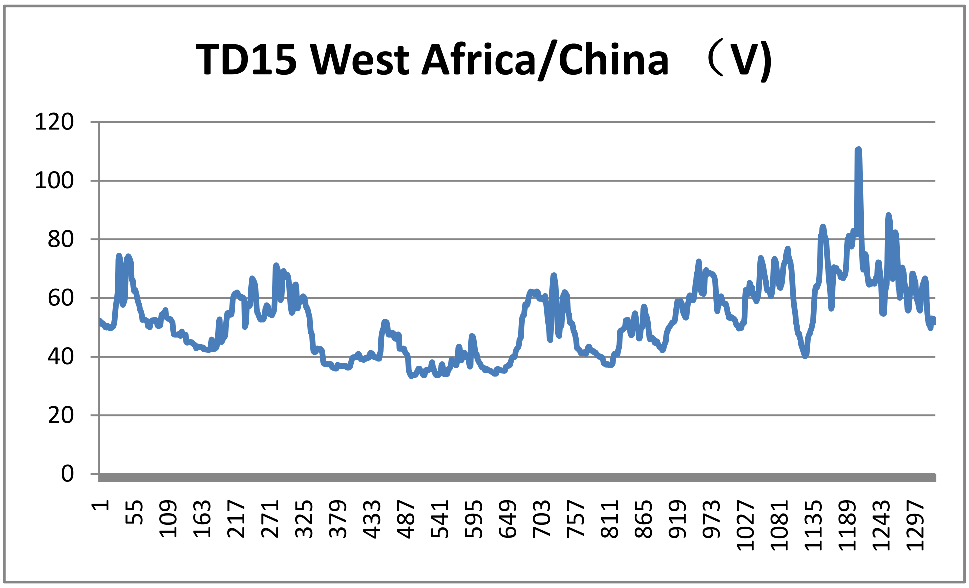

Figure 3.4 BDTI of TD4

Source: SSY TANKER

It should be noted that the price index cannot accurately predict the risk of decision-making. With respect to the price, the academia commonly uses the rate of return to measure whether investment opportunity is appropriate. So, it is necessary to process the raw data in before doing further researches. Currently, the common way to process the index data is the logarithmic difference method (index returns, R_t). The results are as follows:

$$R_t = \ln P_t - \ln P_{t-1} \quad (3\text{-}6)$$

After the processing the price index, the series lost its curve trend and present linear trend, which lead the series to obtain the stationarity. To facilitate the presentation, we make the following definitions:

RTD1 represents the returns of TD1 freight index;

RTD2 represents the returns of TD2 freight index;

RTD3 represents the returns of TD3 freight index;

RTD15 represents the returns of TD15 freight index.

After the logarithmic difference processing to the original data, I draw the trend sequence (see Appendix A). From the pictures we can see the four return series fluctuate around 0, which means there is a tendency to return to the average level.

Besides, the large fluctuations are generally followed by another large fluctuation, and small fluctuations followed by another small fluctuation. It proves that the series have significant fluctuations aggregation. In addition, the volatility has not decreased over time. We can initially identify that the sequences have the characteristics of persistence and aggregation.

Before building up the regression model, we need to analyze the statistical features of the four time series. Firstly, we calculate that the mean, median, standard deviation, skewness, and then do the JB test.

In order to reflect the average amplitude of fluctuation in the sample period, it is necessary to calculate the mean value. We can learn about the dispersion degree of the returns from the standard deviation of the sequence. The standard deviation value has a positive correlation relationship with the return's volatility. Skewness can reflect the symmetry of the sample distribution, and the skewness of normal distribution is 0. So the absolute value of the skewness can indicate the degree of deflection. When the skewness is greater than 0, the sample distribution is positively skewed (right side), and vice versa the negative bias (left side). To characterize the extent of steep curve, kurtosis is introduced here. Kurtosis of the normal distribution is 3, as a standard. When the Kurtosis of the studied curve is more than 3, it indicates that the studied curve is thinner than the reference curve, but the tail of studied curve is thicker than the reference curve. On the contrary, when the Kurtosis is less than 3, the studied curve is wider and fatter than the normal distribution curve, and has thinner tail than a normal distribution. JB test is designed to test whether the studied curve is normal distribution curve.

Using Eviews software, we can get all the statistical values of the four return series as follows:

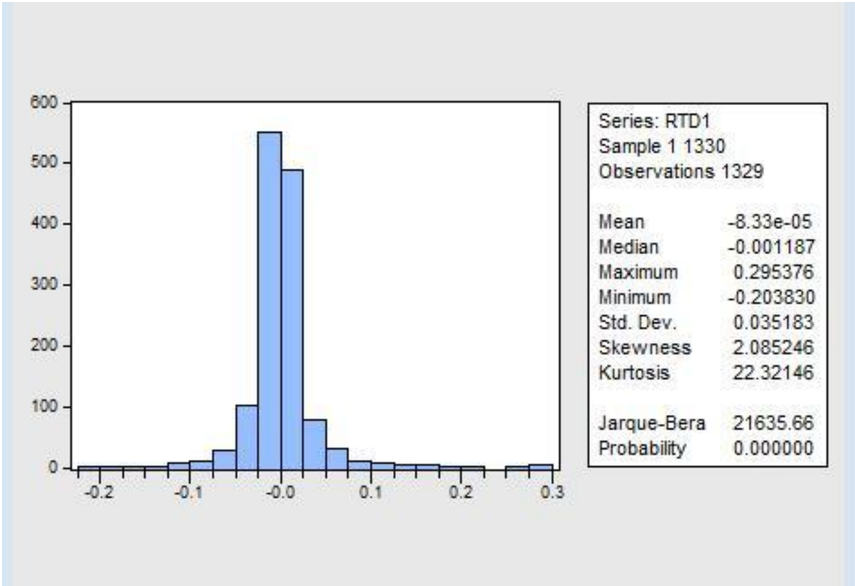

Figure 3.5 Statistical Characteristics of TD1

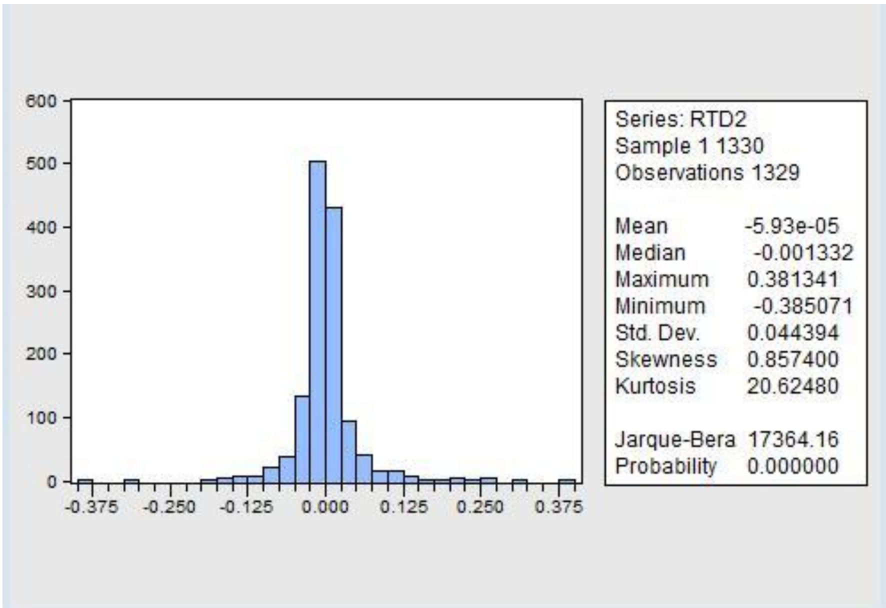

Figure 3.6 Statistical Characteristics of TD2

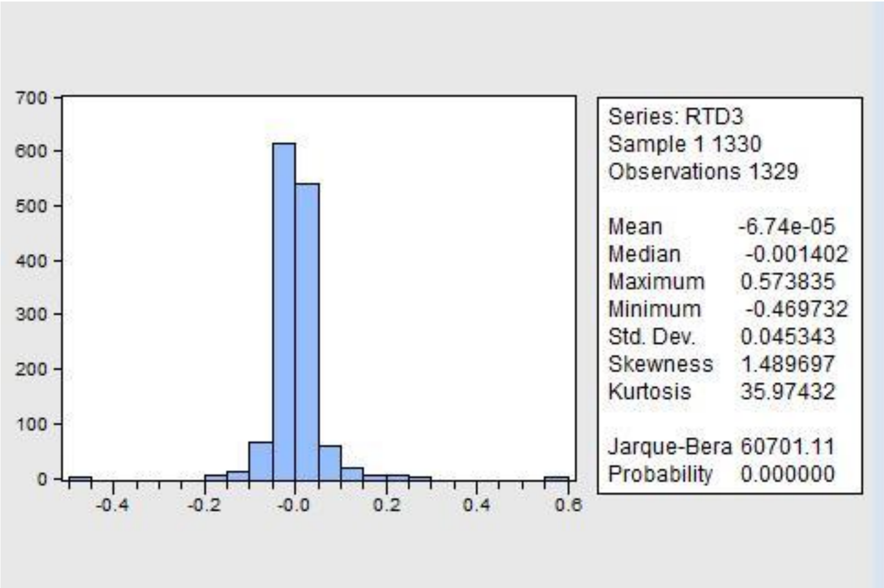

Figure 3.7 Statistical Characteristics of TD3

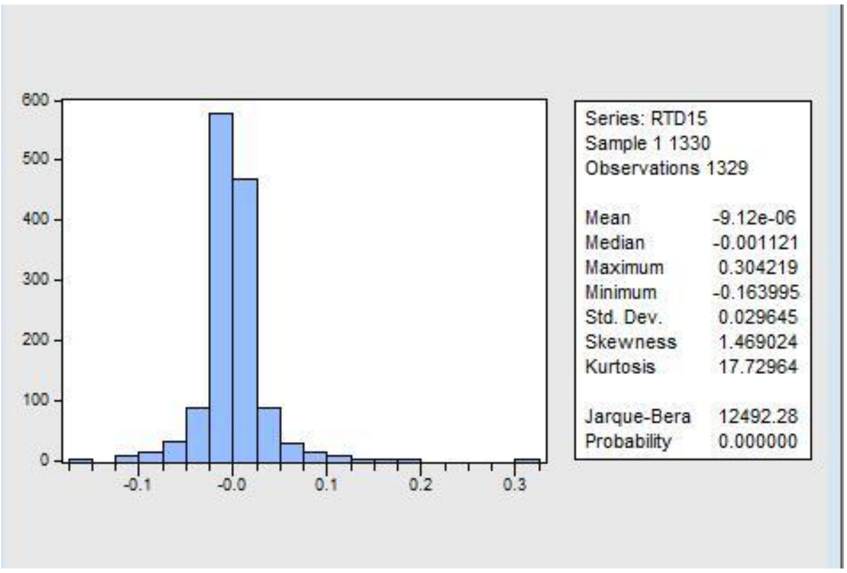

Figure 3.8 Statistical Characteristics of TD15

From statistical characteristics figures, we can find that the average yields of all sequences are negatives, indicating the number of declining days is larger than the rising days for VLCC market. The standard deviation of TD2 and TD3 are larger than the other two routes, indicating that operating VLCC tankers on the routes of MEG-SIG and MEG-JAP has more risks. By calculating the results of skewness we can find all skewness is greater than zero, indicating they are positively skewed.

Meanwhile, the kurtosis of all the returns is significantly higher than 3, which represents that they are not normal distribution and belong to the Kurtosis Distribution. As can be seen from the statistics, all concomitant probabilities are zero, which means the JB value is significant. In summary, it can be seen that these four returns series have a characteristic of fluctuation clustering, do not comply with the normal distribution and have an obvious peak and fat tails.

Table 3.1 Summary of Statistical characteristic

	TD1	TD2	TD3	TD15
Mean	-0.000083	-0.0000593	-0.0000674	-0.00001
Median	-0.001187	-0.001332	-0.001402	-0.00112
Std.Dev.	0.035183	0.044394	0.045343	0.029645
Skewness	2.085246	0.8574	1.489697	1.469024
Kurtosis	22.32146	20.6248	35.97432	17.72964
Jarque-bera	21635.66	17364.16	60701.11	12492.28

3.2.2 Unit root test on the return series

To test the series whether to be able to meet the requirements of GARCH model, we must firstly apply the stationary test on the sequences. The so-called stability test is used to test whether the regression equation contains a unit root. If the series cannot pass the stationary test, which means it is unstable, the model cannot be used to indicate the series. In practice, the ADF test (Augmented Dickey-Fuller test) is the most commonly used for the stationary test. When the ADF value in the results is less than the tolerance value under the 1%, 5%, 10% confidence interval, the series is stationary. The ADF test results are as follows:

Table 3.2 ADF test result of TD1

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-23.27156	0.0000
Test critical values:	1% level	-3.435063	
	5% level	-2.863509	
	10% level	-2.567868	

Table 3.3 ADF test result of TD2

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.61294	0.0000
Test critical values:	1% level	-3.435082	
	5% level	-2.863517	
	10% level	-2.567872	

Table 3.4 ADF test result of TD3

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.73305	0.0000
Test critical values:	1% level	-3.435082	
	5% level	-2.863517	
	10% level	-2.567872	

Table 3.5 ADF test result of TD15

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.19059	0.0000
Test critical values:	1% level	-3.435063	
	5% level	-2.863509	
	10% level	-2.567868	

According to the results in the table it can be seen that all of the test statistic are significantly smaller than its corresponding critical value. Therefore, the four return series are stable at significant level, and reject the original hypothesis that the return series have a unit root.

3.2.3 ARCH effects test

Before creating a GARCH model, we must first make sure that the sample data have ARCH effects. ARCH test means to test whether the residual of a regression model has the time-varying variance. When the model's random disturbance $\varepsilon_t \sim \mathrm{ARCH}(q)$, the variance of the ε_t meet:

$$h_t = \omega + \alpha_1 {\varepsilon_{t-1}}^2 + \alpha_2 {\varepsilon_{t-2}}^2 + \cdots + \alpha_q {\varepsilon_{t-q}}^2 \quad (3\text{-}7)$$

When all regression coefficients are zero, it implies that the sequence has no ARCH effect. If the probability of all parameters being zero at the same time is almost zero or one of parameters is not equal to zero, it indicates that the sequence has ARCH effects.

In this thesis, I choose to use the Lagrange multiplier test proposed by the Engel in 1982 to test whether the ARCH effects exist.

The test statistic: $LM = TR^2 \sim {X_\alpha}^2(p)$ (3-8)

Where

T : the number of sample data,

R^2 : the secondary return the coefficient of determination (least squares estimation),

Significance level : $\alpha = 5\%$

The degree of freedom: p

According to the return series, we can preliminarily determine that the four sequences have the characteristic of volatility clustering, which means they have autocorrelation. And we use the Correlogram in the EVIEWS to do the autocorrelation test. The results are as follows:

Table 3.6 Results of ARCH Effect

	TD1	TD2	TD3	TD15
F-statistic	37.6016	95.09315	120.1928	64.4828
Prob. F	0.0000	0.0000	0.0000	0.0000
Obs*R-squared	37.2657	94.82135	113.7155	63.5916
Prob. Chi-Square	0.0000	0.0000	0.0000	0.0000

From the table above, we can find that the probabilities of F-statistic and Obs*R-squared of the four routes are zero, which indicates that these four series have significant ARCH effect.

3.2.4 Parameter Estimation and ARCH effects test

Compared to ARCH model, the GARCH model has the advantage of avoiding excessive parameters in the model. As mentioned earlier, GARCH (1,1) is the most widely used model in the financial analysis and is able to describe a lot of the time series. Therefore, this thesis intends to establish a normal distribution, t-distribution and generalized error distribution (GED) under GARCH (1,1) model to find the model which describes the characteristics of leptokurtosis and fat-tail. Using Eviews software, after repeated checking and adjusting, I ultimately establish the models as follows:

Results of GARCH model

RTD1

GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1) (3-9)

Table 3.7 GARCH model results of TD1

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.659797	0.039576	16.67171	0.0000

		Variance Equation		
C	1.42E-05	1.27E-06	11.24793	0.0000
RESID(-1)^2	0.436417	0.022210	19.64929	0.0000
GARCH(-1)	0.770631	0.005186	148.5886	0.0000

RTD2

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) (3-10)

Table 3.8 GARCH model results of TD2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.703312	0.028861	24.36851	0.0000
AR(2)	-0.074328	0.027774	-2.676162	0.0074
		Variance Equation		
C	0.001085	1.98E-05	54.71892	0.0000
RESID(-1)^2	0.371722	0.040051	9.281281	0.0000
GARCH(-1)	-0.082772	0.013636	-6.070122	0.0000

RTD3

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) (3-11)

Table 3.9 GARCH model results of TD3

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.590084	0.037277	15.82960	0.0000
AR(4)	-0.102922	0.027220	-3.781182	0.0002
		Variance Equation		
C	0.002369	5.04E-05	47.04077	0.0000
RESID(-1)^2	0.222550	0.026850	8.288565	0.0000
GARCH(-1)	-0.170420	0.014288	-11.92728	0.0000

RTD15

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) (3-12)

Table 3.10 GARCH model results of TD15

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.680611	0.035257	19.30441	0.0000
AR(3)	-0.101777	0.027904	-3.647441	0.0003
Variance Equation				
C	0.000371	2.01E-05	18.44971	0.0000
RESID(-1)^2	0.327663	0.036435	8.992982	0.0000
GARCH(-1)	0.156795	0.044592	3.516183	0.0004

According the results above, we can get the final GARCH models as follows:

TD1 GARCH model

$$\mathrm{RTD1}_t = 0.659797\mathrm{RTD1}_{t-1} \quad (3\text{-}13)$$

$$h_t = 1.42 \times 10^{-5} + 0.436417 \times \varepsilon_{t-1}{}^2 + 0.770631 \times h_{t-1} \quad (3\text{-}14)$$

TD2 GARCH model

$$\mathrm{RTD2}_t = 0.703312\mathrm{RTD2}_{t-1} - 0.074328\mathrm{RTD2}_{t-2} \quad (3\text{-}15)$$

$$h_t = 0.001085 + 0.371722 \times \varepsilon_{t-1}{}^2 - 0.082772 \times h_{t-1} \quad (3\text{-}16)$$

TD3 GARCH model

$$\mathrm{RTD3}_t = 0.590084\mathrm{RTD3}_{t-1} - 0.102922\mathrm{RTD3}_{t-4} \quad (3\text{-}17)$$

$$h_t = 0.002369 + 0.222550 \times \varepsilon_{t-1}{}^2 - 0.170420 \times h_{t-1} \quad (3\text{-}18)$$

TD15 GARCH model

$$\mathrm{RTD15}_t = 0.680611\mathrm{RTD15}_{t-1} - 0.101777\mathrm{RTD15}_{t-3} \quad (3\text{-}19)$$

$$h_t = 0.000371 + 0.327663 \times \varepsilon_{t-1}{}^2 + 0.156795 \times h_{t-1} \quad (3\text{-}20)$$

The next step is to check whether the ARCH effects exist in the original residual series after establishing the GARCH models, in order to determine whether the model is applicable. In this paper I still use the Eviews software to do the ARCH LM test on the four models. The results are in the following table.

Table 3.11 Summary of ARCH tests

	TD1	TD2	TD3	TD15
F-statistic	0.105605	0.074679	0.001368	0.049820
Prob. F	0.7453	0.7847	0.9705	0.8234
Obs*R-squared	0.105756	0.074787	0.001370	0.049894
Prob. Chi-Square	0.7450	0.7845	0.9705	0.8232

We can find that all the probabilities of the F-statistic and Obs*R-squared of the four series are larger than 5%, which indicates that the GARCH models of TD1, TD2, TD3 and TD15 do not have the significant ARCH effects. In conclusion, the GARCH models can describe the trend of returns series of the four VLCC routes.

3.3 Result analysis

Firstly, the constant in the variance equation denotes the return coefficient. The greater its value is, the greater impacts the external shocks cause to the market, and it also indicates the market has faster reaction to the fluctuations. According to the results above, the return coefficients of TD1 and TD15 series are relatively small. While TD3 has the largest yield return coefficient, followed by TD2. On the one hand, TD2 and TD3 are the routes from the Middle East to Japan and Singapore. Japan is the third biggest oil importer, and Singapore is the main crude oil transshipment port for the Far East area. These two countries are more sensitive to external shocks. Besides, Japan mainly uses its own shipping companies to transport the crude oil, and more than 90% of imported oil is shipped by their own crude oil tankers, which is conductive for their quick reaction to the market volatility. On the other hand, the standard ship's age on TD3 is relatively younger to other routes. The maximum limit of the VLCC tanker’s age on TD3 is 15 years, while the limit of other routes is 20 years. New VLCC tankers in good condition are able make rapid response to the external impacts.

Secondly, the regression coefficient in the variance equation is also the hysteresis index. It can characterize the continuity of the market volatility. The greater is its value, the stronger memory of the fluctuations the market has. According to the model results, the TD3 return sequence has the worst volatility memory, and its value is -0.170420. TD1 has the strongest memory to the volatility, followed by TD15, and their values are separately 0.770631 and 0.156795. TD1 and TD15 separately represent the route from the Persian Gulf to the US Gulf and the route from West Africa. The two routes both are long distance routes and their shipping distance is more 10000 miles. VLCC tankers operating on the routes have stronger memory of the market volatility and react more slowly and less sensitive to the sudden impacts than TD3.

Thirdly, the sum of return coefficient and regression coefficient is the persistence indicators of the volatility. When the value of the sum is less than 1, it means the effect of fluctuations on the conditional variance of the return series is limited. In other words, the random impacts from the market have limited influences on the sustainability of the VLCC freight market's fluctuations. When the market was the impacted by some information, the conditional variance can gradually return to the mean over time, which means it has the stable characteristic. If the sum of the two coefficients is closer to 1, it means the impact on conditional variance has continuity. According to calculations, it can be seen that the sum of TD1 (the Persian Gulf to the US Gulf) is close to 1, which means its volatility can last for longer period than other routes, followed by TD15, TD2 and TD3.

4. Suggestions for VLCC shipping companies

The freight fluctuation of VLCC shipping market is very complex, but it also has certain regularity. Companies can effectively circumvent the risks from the market price fluctuations by grasping the market rule, and improve their working efficiency. Therefore, based on the research of VLCC freight rate fluctuations, I put forward the following suggestions for these crude oil transportation enterprises.

4.1 Using freight derivatives to dodge the risk of rate volatility

It is an important means for VLCC transport enterprises to use freight derivatives to avoid freight fluctuation risk. At present, there are two main types of freight derivatives in the oil tanker transportation market: Forward Freight Agreement (FFA) and Freight option. Forward freight agreement refers to a freight agreement between the seller and the buyer. The agreement stipulates specific routes, freight price, cargo quantity, etc. And the two parties agree to charge or pay the balance between the price on the basis of the Baltic exchange index and the contract price of the freight. VLCC transport enterprises can hedge against the risks with FFA on basis of the analysis and forecast of the shipping market in the future. To be specific, if the enterprises make the prediction that the freight market will fall in future, they can sell FFA at the present price, which can keep the freight value to ensure the enterprise's income in future. On the contrary, if the enterprises make the prediction that the freight market will rise in future, they can buy FFA at present price which can be lower than the price in future. In addition to FFA, freight option is another kind of freight derivative, and it is developed on the basis of option and FFA. Freight option refers to the buyers and sellers agree on the contract of selling the right for specific routes, freight price, cargo quantity and so on. The buyer has the right to determine whether to execute the contract while the seller can only do the business according to the request of the buyer. To be specific, if the VLCC transport enterprises predict that the shipping market will fall, they can buy a certain number of the freight options. Thus if the market actually fall as predicted, the companies can gain some profits in the options market.

4.2 Alliance to improve the competitiveness

Cooperation and alliance among enterprises are the important modes to realize win-win development. In tanker transportation market, the enterprises can improve its competitiveness by actively taking the alliance strategy. Therefore, I suggest VLCC transport companies should keep trying to cooperate with other members in the market to promote the competitiveness of the enterprise. On the one hand, VLCC transport enterprises can cooperate with other shipping companies to build the "capacity pool". This model can make the ship owners get benefits from the economics of scale, and realize the resource sharing of manpower, materials and information among ship owners which helps reduce the operating costs, and is advantageous to improve the management level and employees quality by communicating with each other. On the other hand, VLCC transport enterprises can build strategic alliance with the shippers and share resources with each other to ensure in order to ensure the stable freight revenue. For example, VLCC transport enterprises can sign a long-term contract (Contract of Affreightment, COA), which will ensure a long time and stable cooperation relationship with each other and guarantee a stable freight revenue for a long term.

4.3 Optimization of the fleet structure

The reasonable structure of a fleet is directly related to its overall business situation, which is also an important question which should be aware of during the development of VLCC transport enterprises. According to the analysis of ship ages of VLCC all over the world, it shows that 43% of the VLCC typed vessels are four years and below, 23% for 5 to 9 years, and 34% for 10 years and above. As for VLCC transport enterprises, they should optimize the structure of enterprise's fleet, according to the market situation. When the market is relatively high, they can lend the old ships in poor conditions and lack of competitiveness in the fleet for a long period. At the same time, in order to maintain the fleet size, they can build new ships or rent new ships in the better situation to supplement the shortage of the fleet capacity. This measure can not only ensure the stable rental income, but also guarantee a high competitiveness of the fleet.

4.4 Improving enterprise management level

The management level of a shipping company can be the determining factor to its survival, progress and development. For oil tankers transport enterprises, especially VLCC, safety management is the key of the enterprise management. Due to the nature of crude oil, tanker transport companies always face a greater risk of marine oil pollution. Once an accident happened during the voyage, the company will be trapped into huge accounts of oil pollution compensation, which can be devastating to any companies. Therefore, VLCC transport enterprises should strengthen the safety management by learning the developed experiences form the international oil tanker company, and establish and perfect the responsibility system for operation safety, and formulate the safety production rules and technical operation procedures, etc. All these methods can be helpful to improve the enterprise’s management level. What’s more, VLCC transport companies should keep improving the safety awareness of employees and staff quality by providing some training or courses for them, and constantly enhance the operation model of ship safety management, so as to improve enterprise's safety management level.

4.5 Strengthening the construction of enterprise information system

With the development of information technology, oil tankers enterprises should make full use of information technology to strengthen the enterprise information-based construction and improve their competitiveness. On the one hand, VLCC transport enterprises can make use of the ERP, MRP, RFID and other modern information management technology to provide decision-making reference for business by collecting, storing and analyzing both internal and external information of the market. On the other hand, the enterprises can build an information platform to realize resources sharing and associate with the units related to the development of the enterprise through network connection.

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Appendix A

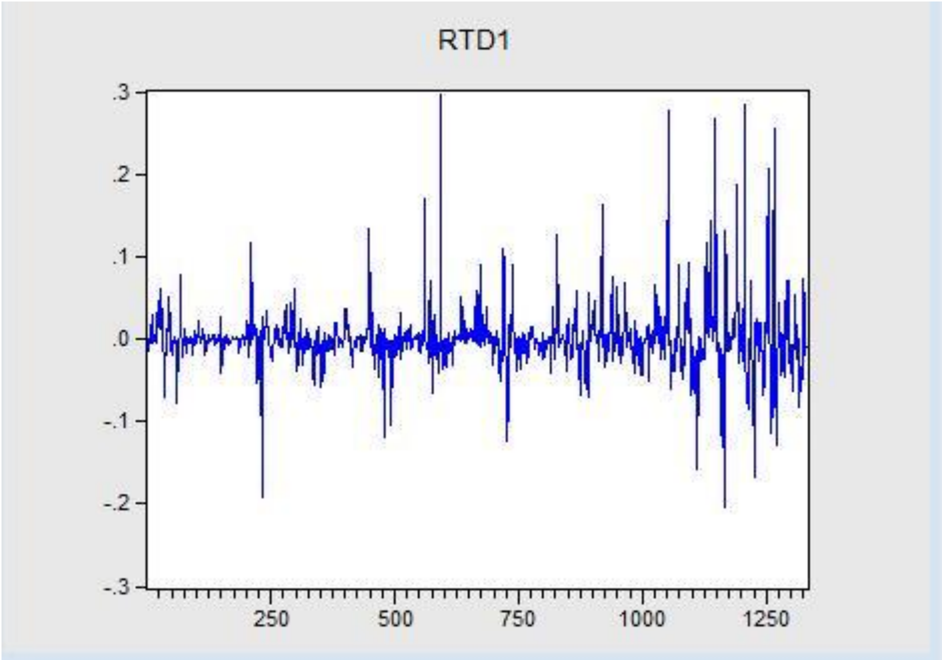

Figure.A1 Return series of TD1

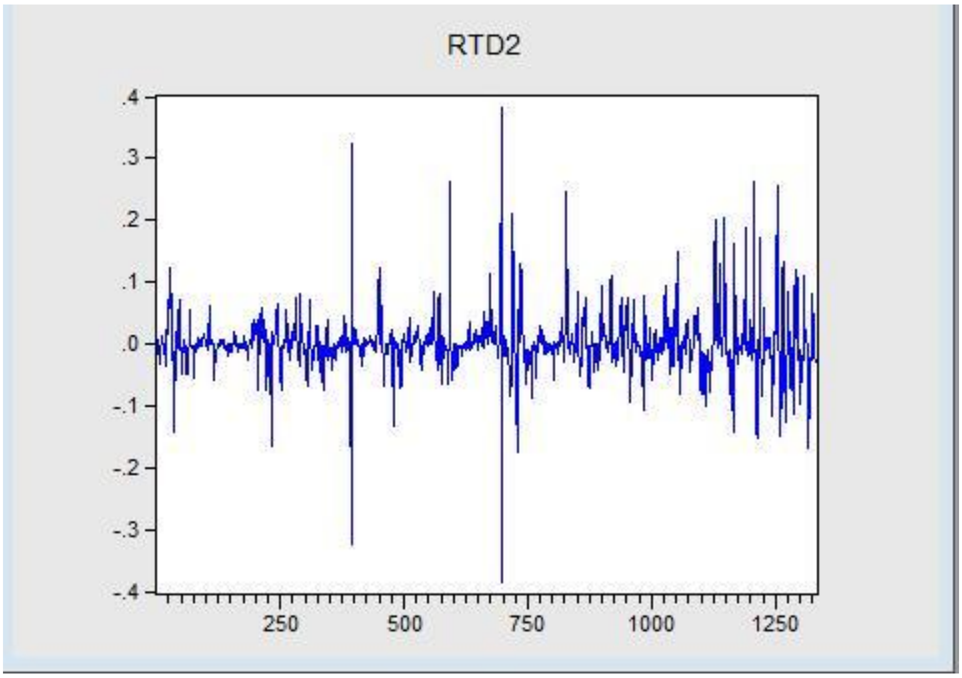

Figure.A2 Return series of TD2

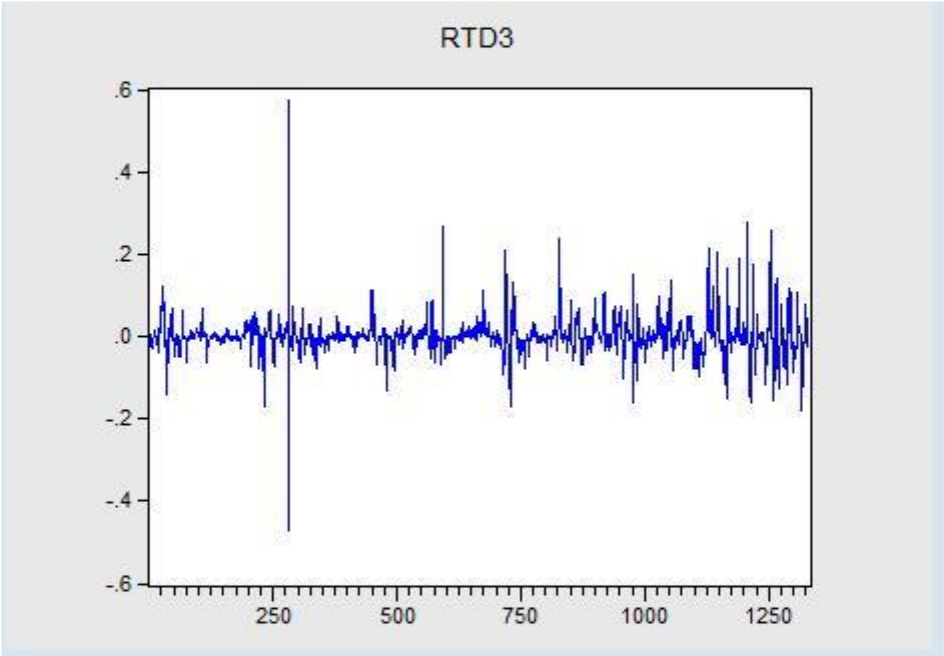

Figure.A3 Return series of TD3

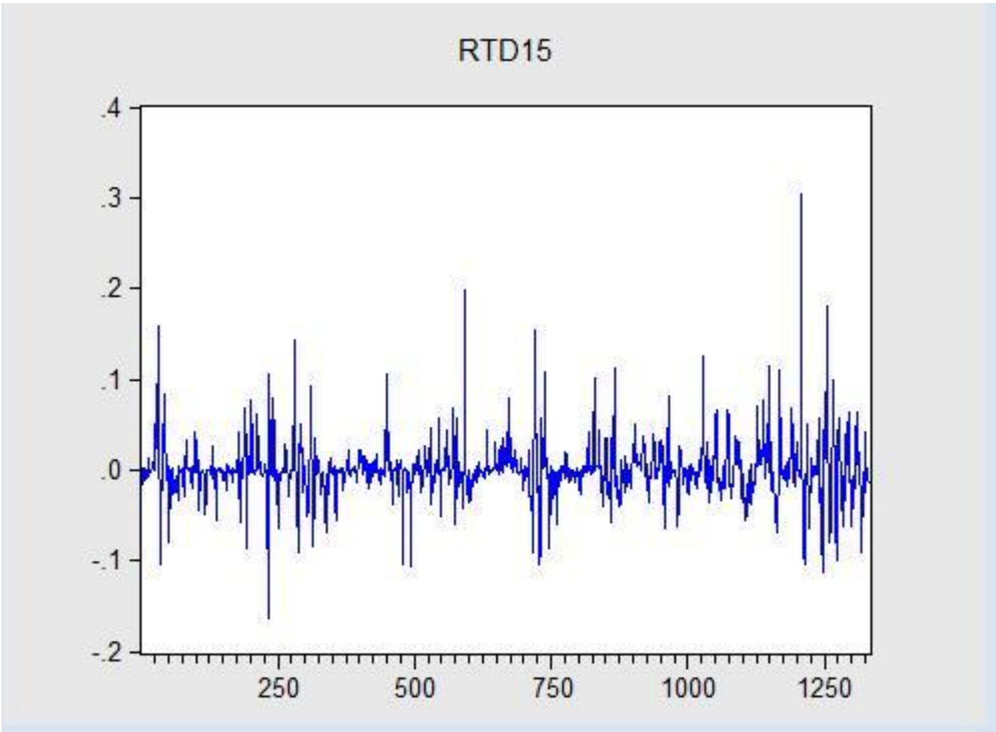

Figure.A4 Return series of TD15