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Study on factors influencing coal freight rate based on VAR Model

Junyi LIU

SHANGHAI MARITIME UNIVERSITY

WORLD MARITIME UNIVERSITY

Shanghai, China

STUDY ON FACTORS INFLUENCING COAL FREIGHT RATE BASED ON VAR MODEL

By

LIU JUNYI

China

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DECLARATION

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.

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

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Supervised by

Associate Professor Gu Weihong

Shanghai Maritime University

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List of Abbreviations

BDI: Baltic Dry Index

EUFR: Panamax Coal Voyage Rates USGulf/ARA 70,000t

JPFR: Panamax Coal Voyage Rates Newcastle/Japan 70,000t

EUINDP: Industrial Production Europe

JPSTLP： Japan Steel Production

DDEUSTLP: EU-27 Steel Production

NBPRICE: Average Bulkcarrier New Building Price

BSHPI: Bulk Carrier Secondhand Prices Index

PANAMAXFL: Panamax Bulkcarrier Fleet Development

BRENT: Brent Crude Oil Price

BUNKER: 380cst bunker prices, Rotterdam

ABSTRACT

Title of research paper: **Study on Factors Influencing Coal Freight Rate Based on VAR Model**

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

It is widely known that coal is main material for steel, cement and electricity production. Therefore, coal is important material for industrial production. There is an imbalance between the distribution of coal resource and the location of coal demanding countries. Therefore, international coal shipping is an important method to realize international coal trade and to fulfill the demand for coal consuming countries. Moreover, international coal shipping market plays an important role in international bulk shipping market. The volatility of the international coal freight leads to huge risk to participators in the market. Hence, analyzing the factors influencing the fluctuation of coal freight rate and estimating future trend based on the conclusion is very important and useful for relative companies.

As coal shipping market is derived from international coal trade, at the first part of this thesis, we analyze trading coal, the most important coal importing and exporting countries, important coal shipping routes, coal shipping demand and coal shipping supply to support the analysis of factors influencing coal freight rate. At the second part, we analyze the factors influencing coal freight rate qualitatively. According to microeconomics, coal shipping freight rate is determined by coal shipping supply and coal shipping demand. Therefore, we analyze the factors influencing coal freight rate by analyze those factors which has an effect on coal shipping demand and supply. The third part is empirical study based on previous analysis. We introduced Granger Test, VAR model and Impulse Response Analysis to do empirical study. And we analyze the effect of four groups of factors to European route coal shipping freight rate and

Japanese coal shipping freight rate.

There are conclusions from this thesis. Firstly, regional economy, commodity price, fleet, ship price and bunker price, having a significant effect on coal shipping freight rate. Secondly, there is a common point for the responses of freight rate to the innovation of above indicators. The response grows up during the first 3 or 4 months and then starts to decline. Thirdly, concentrated on the responses in the first 3 to 4 months, we can find that crude oil price and second-hand ship price has the biggest influence to these two coal freight rate.

KEYWORDS: International Coal Freight Rate, VAR; Granger Causality Test

CONTENTS

1. Introduction

1.1 Research Background and Purpose

World economy grows very fast before the crisis in 2008 and it starts to recover from 2010. To some degree, the growth of world economy depends on coal which is very important raw material for steel production and electricity production. As the imbalance of recourse distribution, the majority of coal is transported by ships with the advantages of big volume and low freight rate. And the volume of international trading coal is the second largest among international trading bulk cargoes which includes grain, iron ore, coal and minor bulks. Table1.1 showed the total tonnage of seaborne trade bulk cargoes and seaborne trade coal from2006 to 2013. It can be seen that the percentage of tonnage of coal transported by sea is more than 10% in recent years. And the percentage has a stable growing trend. Hence, the sea transportation of coal plays a very important role in international shipping.

Table 1.1 2006-2013 World Seaborne Dry Bulk Trade and World Seaborne Coal Trade

	2006	2007	2008	2009	2010	2011	2012	2013
World Seaborne Dry Bulk Trade （Million Tons）	7794	8127	8338	8003	8775	9170	9322	9641
World Seaborne Coal Trade （Million Tons）	704	753	777	777	900	946	1062	1111
Percentage of Coal （%）	9.0%	9.3%	9.3%	9.7%	10.3%	10.3%	11.4%	11.5%

However, the fluctuation of coal shipping freight rate is very high which brings a huge risk to market participators. Figure 1.1 shows Panamax coal voyage rates from

Richard Bay to Rotterdam. It shows that the average rate is 19.7 dollars/ton in 2005 and it soars to 35.9 dollars/ton in 2007. Then the average rate drops to 14.4 dollars/ton in 2009. Besides, the value of coal is so low that shipping cost takes big part of imported price of coal. Therefore, the fluctuation in freight rate leads to huge risks to trading companies, final coal demanders and shipping companies. Hence, analyzing the factors influencing the fluctuation of coal freight rate and estimating future trend based on the conclusion is very important and useful for relative companies.

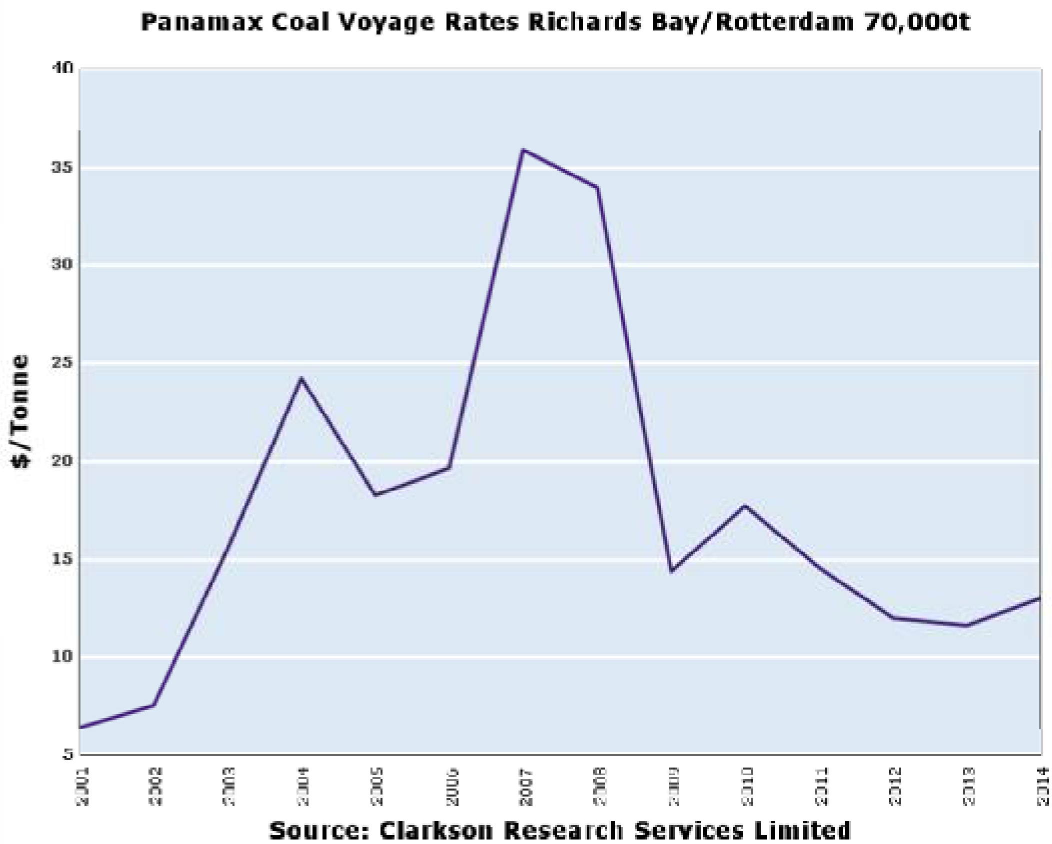


Figure 1.1 2001-2014 Panamax Coal Voyage Rates Richards Bay/Rotterdam 70,000t

1.2 Literature Review

However, in recent years, there are a lot of studies about factors influencing dry bulk market. Studies are focused on two aspects. One aspect is that which factors are influencing the fluctuation of dry bulk freight rate. The other aspect is the effect of these factors.

The majority of previous studies use qualitative methods, especially microeconomic theories, to find the factors influencing dry bulk freight market. And the previous studies analyze the effect of factors by building VEC or VAR model. Yuan Qun (2013) summarizes factors qualitatively. She considered world fleet supply, shipping demand, bunker price, environment factors, shipping financial market, world politics, competition and cooperation of companies as factors influencing dry bulk shipping market. Among those factors, world fleet supply is determined by second hand transaction, the tonnage of new building vessels, the tonnage of removals, and the tonnage of laid-up vessels [1]. And there are many studies analyzing the effect of these factors quantitatively. Zou Zongyu (2007) use VAR model to analyze the relationship between iron ore freight of different routes, the relationship between iron ore freight and laid-up fleet, iron ore import volume and bunker price [2]. Li Kun (2009) use ARIMA model to forecast dry bulk index and select fleet, bunker, cargo volume and commodity price as variables to build VAR model. Then compare forecast accuracy by compare relative statistics and add dummy variable presenting crisis to adjust the model [3]. Wang Yang (2009) studied the influence of iron ore negotiation, which is presented by iron ore import price, to freight. The author use VAR or VECM to analyze the influence of iron ore import price to freight by routes (Brazil- China, India- China and Australia- China) [4]. Zhang Haoran (2012) select the iron ore shipping freight rate, the volume of export iron ore from Brazil to China, IFO380cst price in Singapore, the capacity of Capesize fleet and LIBOR as the variables to build VECM model and analyze the influence of these factors. Jin Ming (2013) takes daily freight rate, the hire of half-year, 1-year, 3 year and 5-year as variables to build VAR model, analyzing the relationship between spot market and time charter market.

Through the review of previous literatures, there are two aspects to improve the study on factors influencing coal freight rate. Firstly, although there are many thesis analyzing factors influencing dry bulk shipping market or iron ore freight rate, there is little studies combined with the features in coal shipping markets. Secondly, as there are many kinds of data can present one factor, however, in existing study, there are little quantitative methods to select better data to present factors. Therefore, this dissertation would use quantitative method to select better time series to present factors and use these factors to improve the accuracy of model.

1.3 The content of this dissertation

This dissertation includes six chapters. The first chapter describes research background and purpose and literature reviews about the factors influencing freight rate.

Chapter two analyzes the coal shipping market. It includes the analysis of coal trade mode, main coal importing countries, main coal exporting countries, main coal shipping routes based on coal information published by OECD. And it analyzes coal shipping demand from the aspect of main importing countries. After that, it analyzes of coal shipping supply from two aspects. One aspect is vessel type, and the other one is vessel age.

Chapter three firstly analyzes the pricing mechanism in coal shipping market based on microeconomics theories and how deal price generated in business practice. Secondly, it qualitatively analyzes the factors influencing coal shipping demand and coal shipping supply for short run and for long run. [5]

Chapter four introduces the model and related analysis method which is used in this dissertation. In chapter five, we analyze factors influencing coal shipping freight rate by empirical study. Firstly, we decide to use coal voyage freight rate of 70,000 DWT vessels for USgulf-ARA route and Newcastle-Japan Route from 2003 to 2013 to be study samples for freight rate. And then based on the analysis in chapter three, we select four aspects of factors to study. And we select several indicators for each factor and choose the proper one through Granger causality test. After that, we build VAR model and impulse responses analysis to analyze how these factors influence coal shipping freight rate in European and Japanese route. Chapter six summaries the result of model and analysis and get several conclusions about the nature of the effect of these factors.

2 The analysis on international coal freight market

2.1 Trading coal

According to the statistics from BP, there are 860.9 trillion tons of coals which can be exploited in the world. Coals are spread in Asian-Pacific Region, Europe and North America, and reserves accounts for 30.9%, 35.4% and 28.5% respectively. [6]

There are two categories of coal trading around the world. One kind is stemming coal, and the other one is cooking coal. To be exact, stemming coal is the major raw material for electricity production. Meanwhile, cooking coal, which is similar with iron ore, is an important material for steel production. Therefore, coals play an important role in world economy development.

The major compositions of coal are fixed carbon, volatile matter and ash content. It can be self-ignited and can produce flammable gas. Therefore, this kind of cargo is fit for whole ship transportation. And the value of coal is relatively low compared to the freight cost, so the trading of coal is sensitive to the fluctuation of coal freight rate.

In 2013, the world seaborne export coal is 1114 million tons. To be exact, there is 849 million tons of stemming coal, raised by 12%, while 264.6 million tons of cooking coal, raised by 12.4%. Figure 2.1 shows the world seaborne coal export growth from 2000 to 2013. We can see that the growth for cooking coal is stable and the average annual growth for cooking coal is 3.4%. However, the growth for stemming coal increase dramatically and its average annual growth accounts for 7,5%.

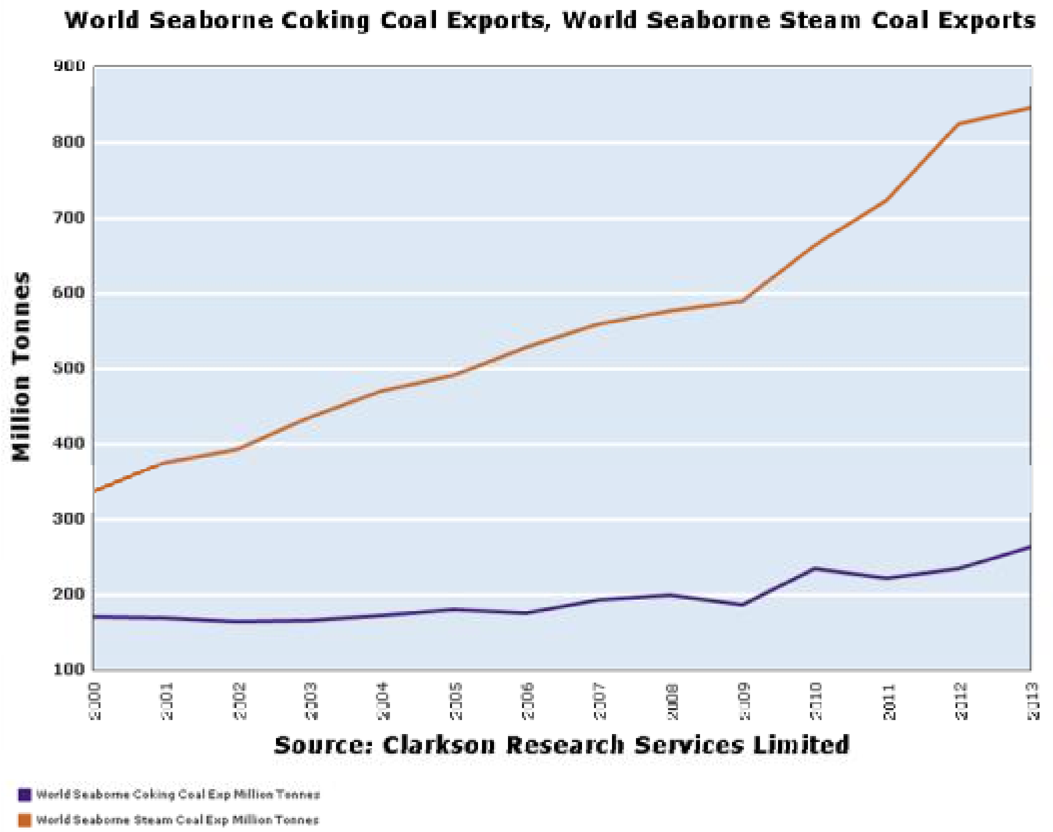


Figure 2.1 World Seaborne Cooking Coal Exports and World Seaborne Steam Coal Exports

There are two coal trading zones in the world. One is Pacific coal trading zone and the other one is Atlantic zone trading area. As for stemming coal, in pacific coal trading zone, main demanders are China, Japan, Korea, Chinese Taiwan and India and main suppliers are Indonesia and Australia. Meanwhile, in Atlantic coal trading zone, main demanders are UK, German and Spain, and main suppliers are South Africa, Russia and Columbia. The supply of cooking coal is relatively concentrated. Main suppliers of cooking coal are Australia, Canada, America and Russia. And South Africa can be a supplier for both coal trading zones when the freight rate accounts for little percentage of CIF price.

2.2 Important coal importing countries

Japan

Japan is an important coal importing country in the world. According to Clarkson, in 2013, Japan imported 186 million tons of coal, which accounted for 16.7 percent of total world seaborne coal trade. Among those, there are 129.5 million tons of stemming coal and 56.6 tons of cooking coal. As Figure 2.1 shows, according to 2012 coal information from OECD, that stemming coal imported by Japan is mainly from Australia, Indonesia and Russia, and the proportion is 66%,18%, and 8% respectively. While, cooking coal imported by Japan is mainly from Australia, Indonesia, Canada and America, and the proportion is 55%, 21%, 10% and 9%, respectively (showed in Figure 2.3)

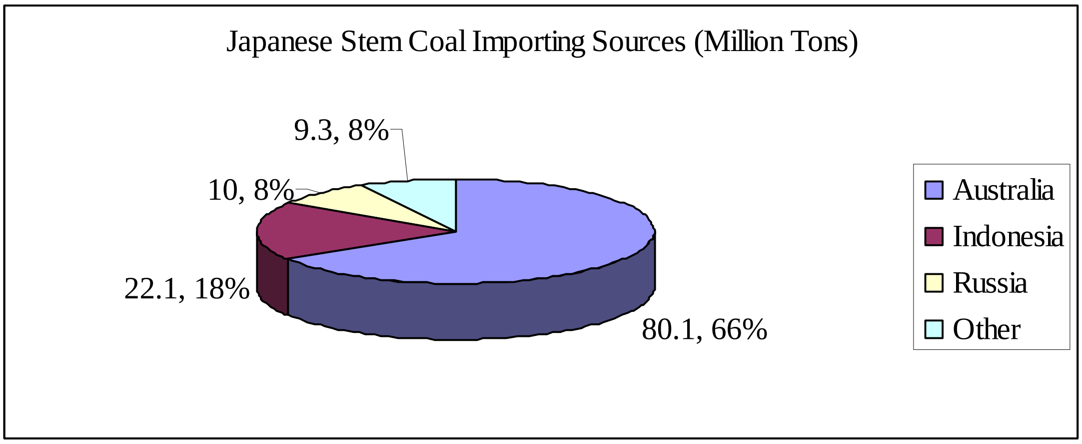


Figure 2.2 Japanese Stem Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

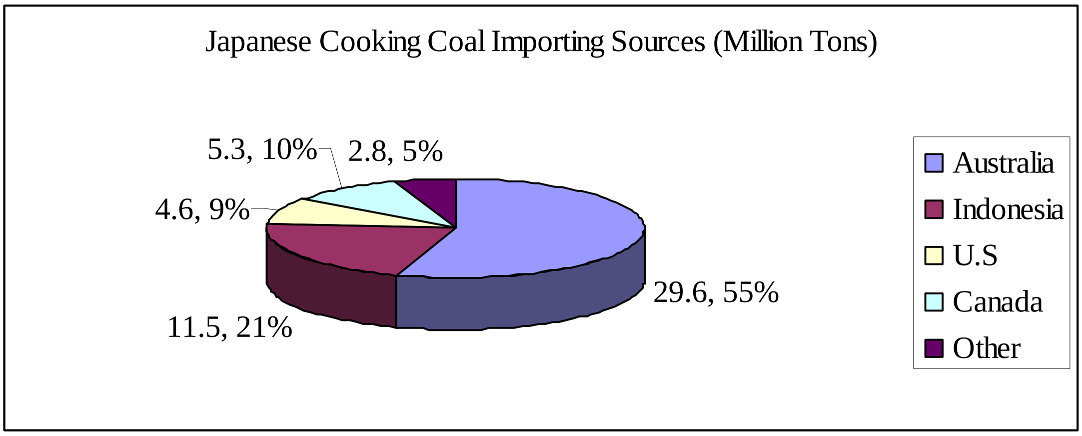


Figure 2.3 Japanese Cooking Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

Europe

Europe is an important coal importing area in the world. The most important coal importing countries in Europe are UK, German, Italy, Spain and Netherlands. According to Clarkson, in 2013, Europe imported 205.4 million tons of coal, which accounted for 18.4 percent of total world seaborne coal trade. Among those, there are 129.5 million tons of stemming coal and 56.6 tons of cooking coal. And the total seaborne import stemming coal and cooking coal volume of above 6 countries is 153 million tons and 52.5 million tons, which account for 18% and 19.8% of world imported stemming and cooking coal respectively. Figure 2.4 and figure 2.5 show the composition of coal imported by Europe.

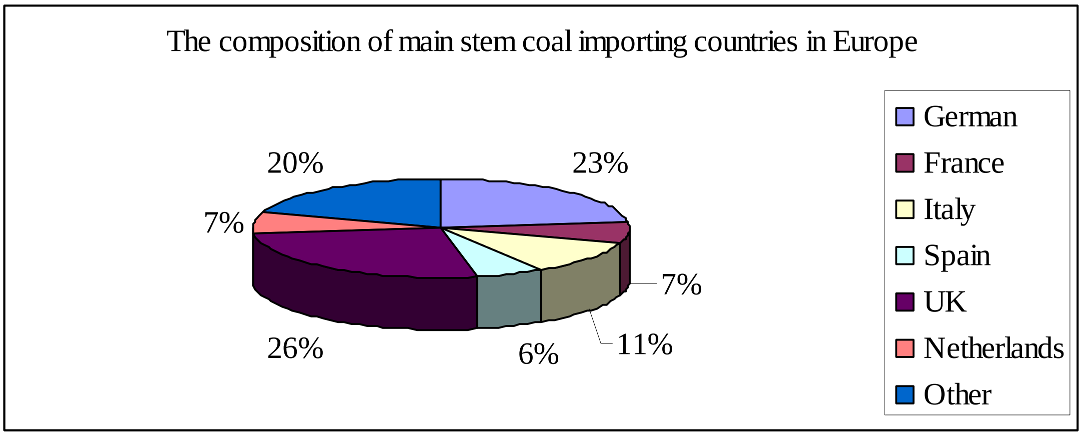


Figure 2.4 Composition of main stem coal importing countries in Europe

Source：OECD-2012 Coal Information

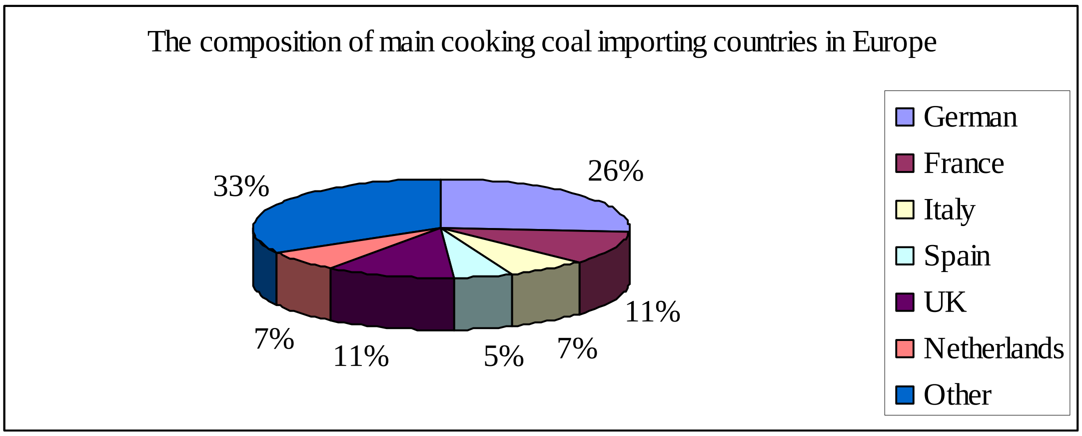


Figure 2.5 Composition of main cooking coal importing countries in Europe

Source：OECD-2012 Coal Information

As Figure 2.6 shows, according to 2012 coal information from OECD, that stemming coal imported by OECD Europe is mainly from South Africa, Indonesia, Russia, America and Columbia, and the proportion is 10%, 6%, 31%, 18.9% and 28% respectively. While, cooking coal imported by OECD Europe is mainly from Australia, Canada and America, and the proportion is 31%, 21%, 40%

respectively(showed in figure 2.7).

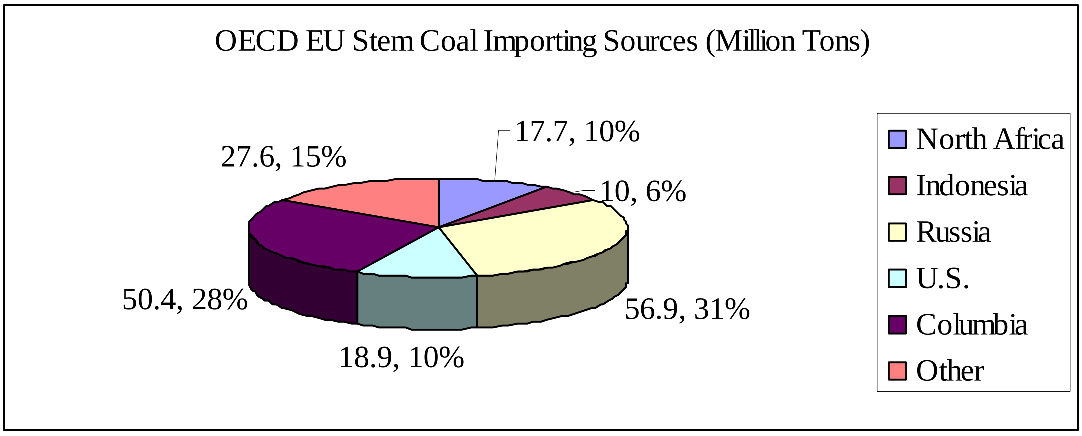


Figure 2.6 OECD EU Stem Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

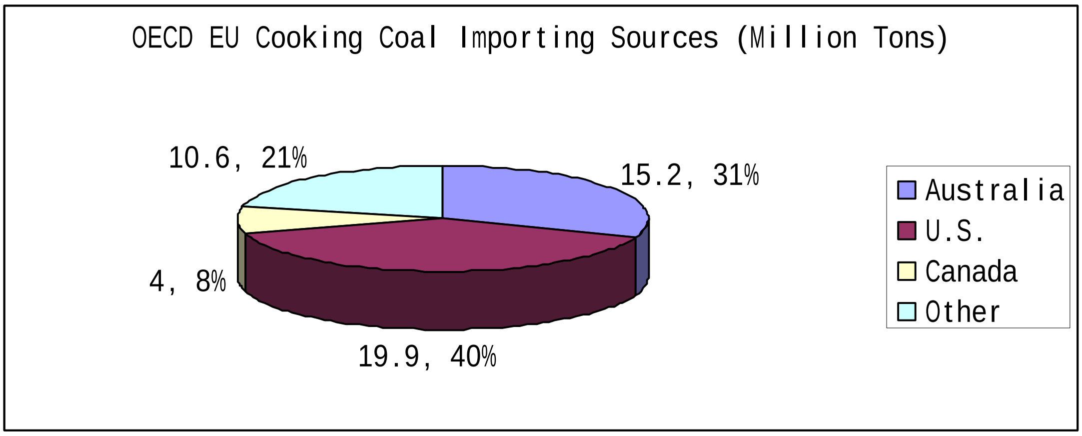


Figure 2.7 OECD EU Cooking Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

Other Asian area

Also, other Asian is another important coal importing area in the world. According to Clarkson, in 2013, other Asian countries imported 50.2 percent of world imported coals and the main importing countries in this area are China, Korea, Chinese Taiwan and India. As Figure 2.8 shows, according to 2012 coal information from OECD, that stemming coal imported by this area is mainly from Australia, Indonesia, Russia and South Africa, and the proportion is 16%,54%, 5% and 8% respectively. While, showed in figure 2.9, cooking coal imported by this area is mainly from Australia, Canada and America and Russia, and the proportion is 71%, 11%, 12% and 4%, respectively.

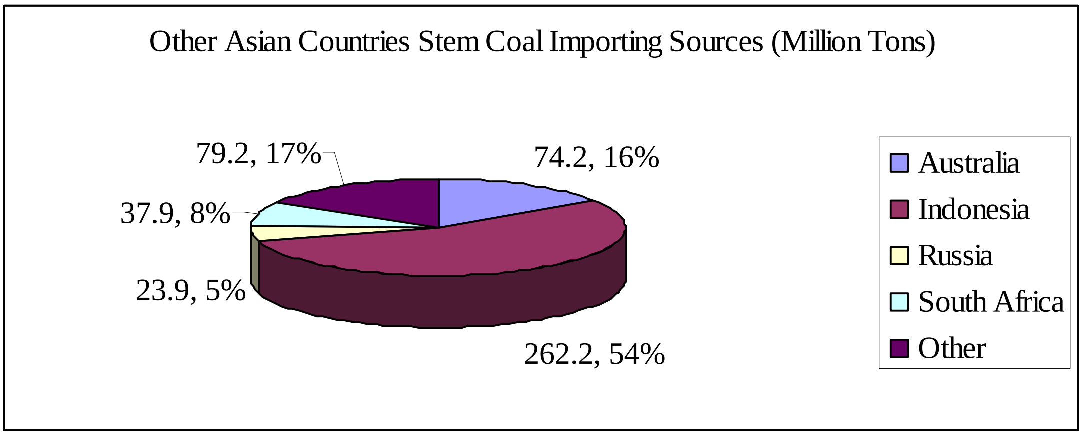


Figure 2.8 Other Asian Countries Stem Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

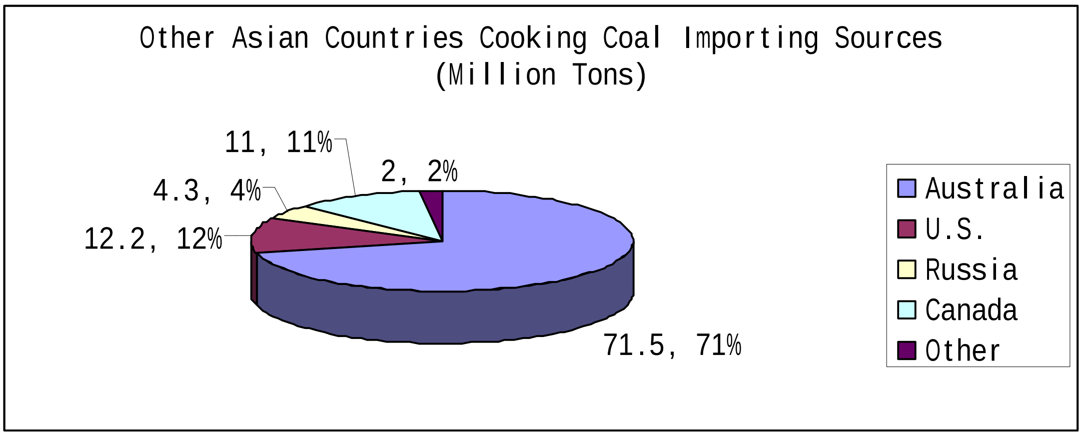


Figure 2.9 Other Asian Countries Cooking Coal Importing Sources (Million Tons)

Source：OECD-2012 Coal Information

Besides, during recent years, China has transferred to a coal importing country instead of a coal exporting country. China has a rich coal resource. However, the main demander for coal spreads in costal area in Southeastern China. Therefore, the price of domestic coal in demander location includes the cost of coal and the cost of road or trail transportation. As a consequence of globalization and low freight rate these years, imported coal becomes more and more competitive. The volume of imported coal firstly overcame exported coal in 2009. According to Clarkson, the volume of Chinese imported stemming coal is 50.4 million tons which is 17.7 percent of world seaborne import coal, while the volume of Chinese imported cooking coal is 264.4 million tons which accounts for 22.6%.

2.3 Important coal exporting countries

The most important coal exporting countries are Indonesia, Australia, Russia, America, South Africa and Columbia. The seaborne exporting coal volume for these 6 countries accounts for over 80 percent of total world seaborne trade.

Australia

Australia is the biggest coal exporting country in the world and over 70 percent of its coal production is to be exported. To be exact, Australia is the biggest cooking coal exporting country and the second biggest stemming coal exporting country following Indonesia [7]. According to Clarkson, Australia exported 187.6 million tons of stemming coal and 167.4 million tons of cooking coal accounting for 22% and 63.3% of total world exporting coal volume respectively. The main exporting market of Australia is Asia because of geographic location. For example, China, Japan, Korea, Chinese Taiwan and India are main demanders for coal exported from Australia. Besides, Australia coal has a market in Europe, too. As Figure 2.10 and Figure 2.11

show, according to 2012 coal information from OECD, cooking coal exported from Australia is mainly traded to Japan, other Asian countries and Europe, and stem coal is mainly traded to Japan and other Asian countries. Important coal terminals are located in Queensland and Newcastle and important coal producing and trading companies are BHP Billiton, AngloCoal, Xstrata and Rio Tinton.

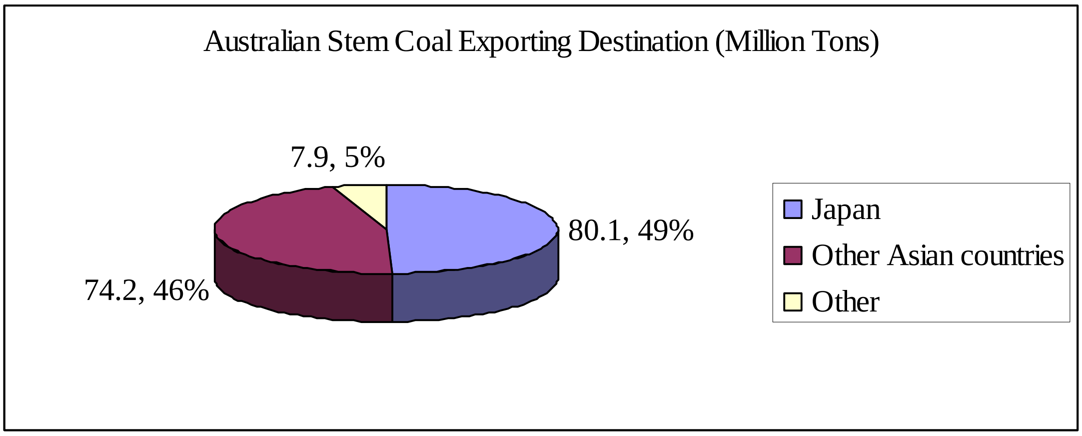


Figure 2.10 Australian Stem Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

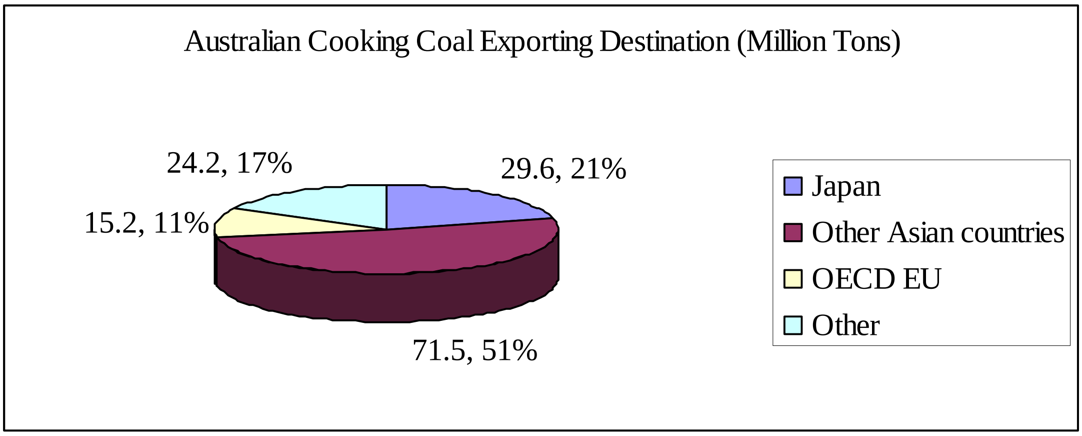


Figure 2.11 Australian Cooking Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

Indonesia

Indonesia is the biggest exporting country for stemming coal and it exports more than 75 percent of its production. In 2013, Indonesia exported 380.2 million tons of stemming coal which accounts for 44.8% of total world seaborne stemming coal trade volume. Indonesia supplies the demand of Europe, Japan, Korea, China and Chinese Taiwan. As Figure 2.12 shows, according to 2012 coal information from OECD, stemming coal exported from Indonesia is mainly traded to Japan and other Asian countries. The biggest market for Indonesia cooking coal is Japan which imports 85 percent of stemming coal from Indonesia. There is a great growth in the electricity industry in Indonesia in recent years. Consequently, the volume of exporting stemming coal decreases.

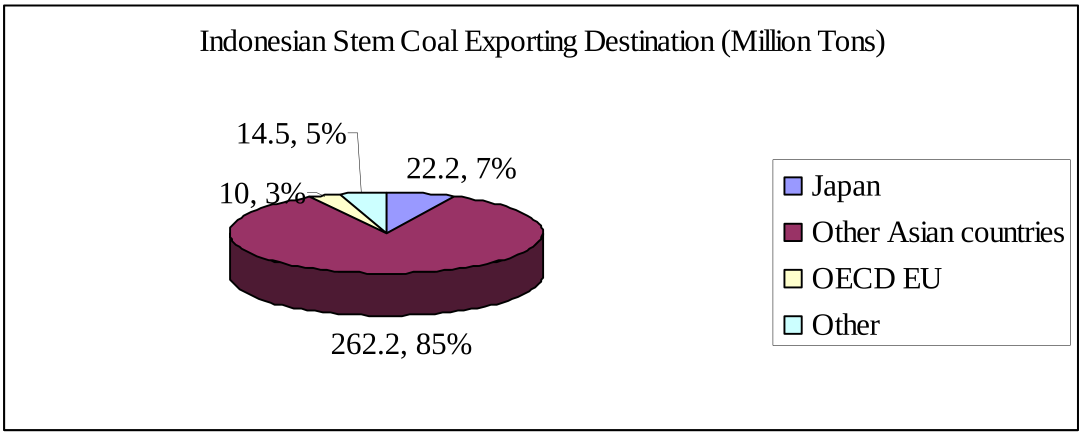


Figure 2.12 Indonesian Stem Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

South Africa

The majority of coal exported from South Africa is stemming coal. According to Clarkson, the volume of stemming coal exported from South Africa is 70.8 million tons which takes 8.3 percent of the total. The main market of South Africa is Europe as it is located in Atlantic coal trading zone. However, when the freight rate is low enough, its market can be expended to Asian. As Figure 2.13 shows, according to 2012 coal information from OECD, stemming coal exported from Indonesia is mainly traded to Europe and other Asian countries. The coal terminal capacity in South Africa is the main limit to its development of coal exporting.

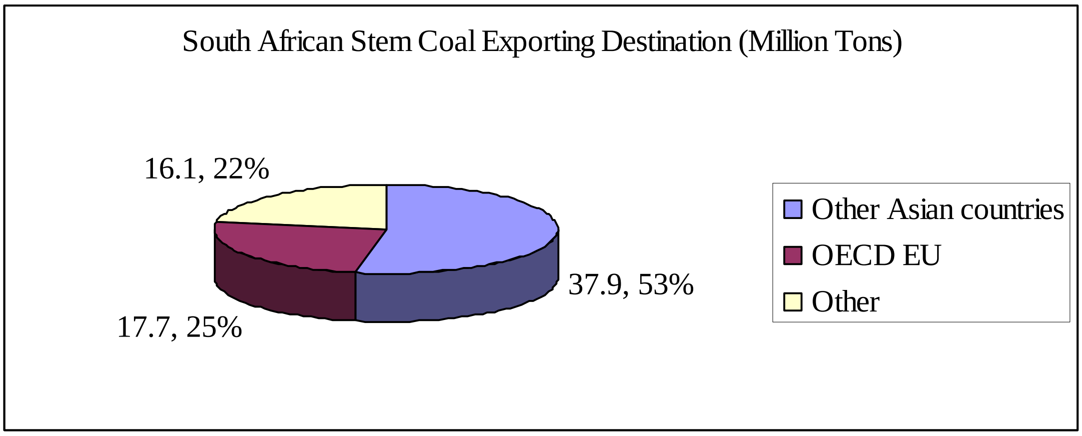


Figure 2.13 South African Stem Coal Exporting Destination (Million Tons)

Source： OECD-2012 Coal Information

America

Although America is not so important in coal exporting as it was, it still plays an important role. According to Clarkson, the volume of stemming coal exported from America is 43.6 million tons which takes 5 percent of the total. Meanwhile, the volume of cooking coal is 56.4 million tons which takes 21.3 percent of the total. As Figure 2.14 and figure 2.15 show, according to 2012 coal information from OECD, stemming coal exported from America is mainly traded to Europe and other Asian countries, while cooking coal is mainly traded to Japan and other Asian countries. And coal terminals in America are mainly located in north part of America.

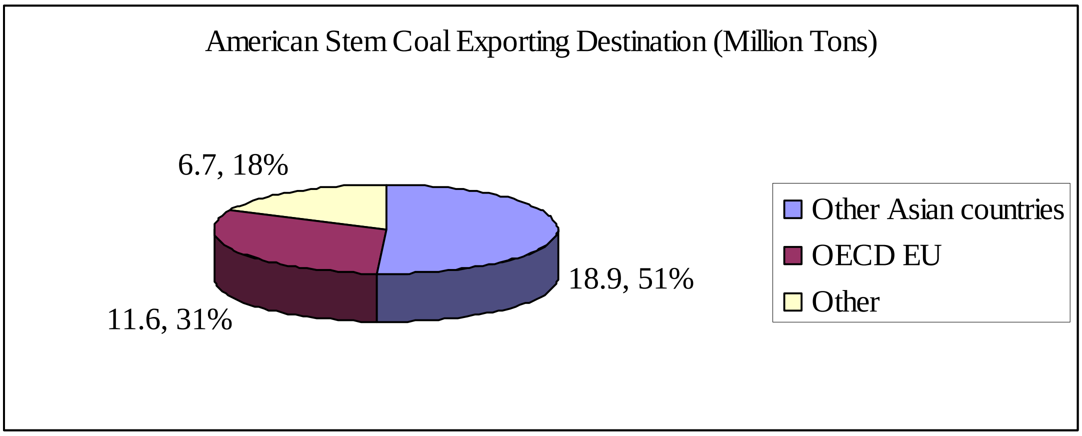


Figure 2.14 American Stem Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

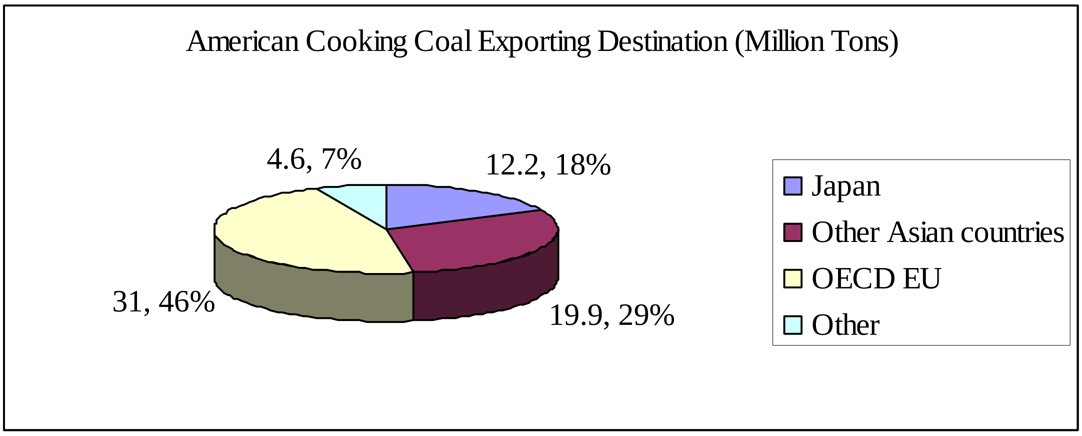


Figure 2.15 American Cooking Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

Russia

The main product of Russia is stemming coal. As Figure 2.16 shows, according to 2012 coal information from OECD, there is 109.4 million tons of stemming coal exported from Russia. And stemming coal is mainly traded to Europe and other Asian countries, while cooking coal is mainly traded to Japan, Europe and other Asian countries.

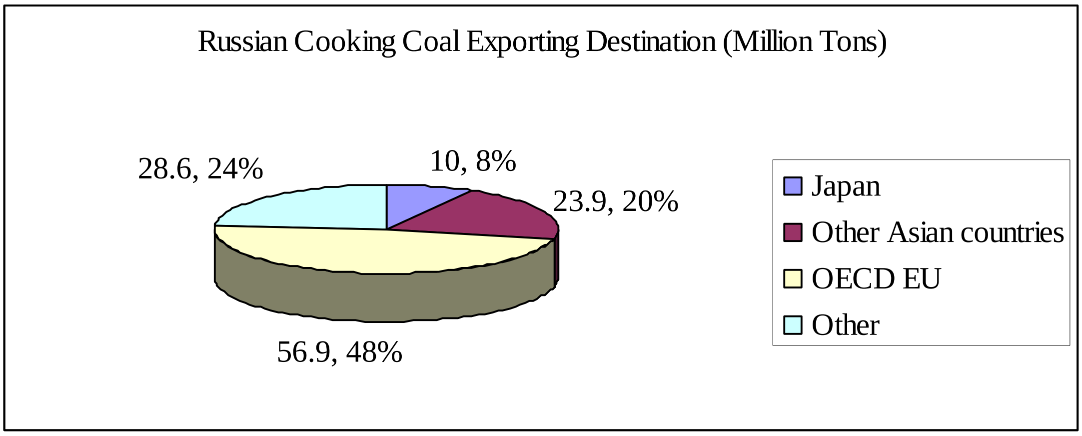


Figure 2.16 Russian Cooking Coal Exporting Destination (Million Tons)

Source：OECD-2012 Coal Information

2.4 International coal shipping supply

Bulk carrier fleet the supply for coal shipping as bulk carrier can load and transport several kinds of different dry bulk cargoes including coal, iron ore, wheat and sand. Generally, coal shipping supply can not be classified clearly as coal is not a special cargo for transportation. However, there are still some features in coal-transporting fleet. In this paper, we can analyze coal shipping supply from the aspect of vessel type and vessel age.

2.4.1 Vessel type

Bulk carrier can be classified into 5 kinds by its deadweight tonnage (DWT). The deadweight tonnage ranges for handysize, handymax, supramax, capesize are from 10,000 to 30,000DWT, from 30,000 to 50,000, from 70,000 to 100,000 and from 100,000 to 200,000. Specially, panamax bulk carrier can pass Panama Canal when it is fully loaded. The maximum LOA, BOD and depth of vessels which would pass Panama Canal is 427m, 55m and15m for the next generation Panama Canal. As capsize is too big to pass Panama Canal or Suez Canal, it can only voyage to Cape of Good Hope. Although the distance of route is long, it can load more cargoes to reduce the unit cost.

Panamax bulk carrier is the main type of vessel carrying coal.Over 40 percent of Panamax fleet is used for carrying coal. Small vessels, such as handysize and handymax, are more flexible for route, port and cargo. The majority of Capezise fleet is used for carrying iron ore, but there is still a considerable percentage of capesize fleet carrying coal. But capesize bulk carrier is always allocated to long-distance coal routes.

As Table 2.1, according to Clarkson dry bulk outlook, shows bulk fleet profile at the end 2013. For capesize fleet, there are 58 percent of vessels is younger than 5 years. The total deadweight tonnage of capesize takes 41 percent of total bulk carrier tonnage. And the deadweight tonnage of panamax takes 26% of total bulk carrier tonnage.

Table 2.1 Bulk Fleet Profile (Million DWT)

Bulk Fleet Profile (Million Dwt)			
	2011	2012	2013
Handysize	85.8	86.9	86.1
Handymax	130.7	146.3	157.0
Panamax	151.8	169.9	185.3
Capesize	249.5	279.3	292.9

2.4.2 Vessel age

In practice, there is a preference for ship owner or ship operator to choose the cargo to be carried. There are some bulk cargoes which may bring harm to the hall of the vessel or bring danger to the voyage. For example, iron ore or nickel minerals is an unpopular bulk cargo as its moisture content is relatively high. High moisture content may cause free surface which can reduce the vessel stability. It can lead to ship's sinking. Hence, ship owners are not likely to allow new ships to carry this kind of cargo. However, coal is a relatively popular cargo to carry. Hence, coal-carrying vessels are relatively new.

Table 2.2 Age Profile (% Fleet)

Age profile (% Fleet)					
	20+	15-19	10-14	5-9	0-4
Handysize	20%	11%	8%	13%	47%
Handymax	7%	11%	11%	18%	54%
Panamax	8%	12%	13%	18%	50%
Capesize	8%	10%	8%	16%	58%

As Table 2.2, according to Clarkson dry bulk outlook, shows age profile of bulk carrier fleet at the end of March, 2014. For capesize fleet, there are 58 percent of vessels is younger than 5 years. And the vessels which are between 5 and 9 years take 16 percent of the whole fleet. Similarly, the percentage of ships which is younger than 5 years is 50 percent in Panamax fleet. And a 18 percent of the whole Panamax fleet ages from 5 to 9. It shows that the age profile of whole bulker fleet is relatively young. And this part of new ships prefers safer cargoes like coal.

2.5 *International coal shipping demand*

Rapid development of industry booms the demand for coal is important raw material for steel production and electricity production. According to the report from international energy agency, 74 percent of coal is used for electricity production and 13 percent of coal is used for metallurgy, and the proportions used for cement production and others are 10% and 3%. [8]Athough there are other sources of power, there are 42% of power is generated from burning coal. Therefore, the demand for coal is very large in countries with rapid development of economy and industry. International coal trade can meet the gap between consumption and production in the region. As there is a location imbalance between the place of origin and the place of consumption, sea transportation is a necessary process. As the transportation parcel is very large and the value of coal is very low, sea transportation is the most popular way to convey coal. There are more than 90% of coal is transported by train. Therefore, international coal trading drives international coal shipping demand directly.

However, there are two factors in coal shipping demand. One factor is the volume of the cargo that should be transported and the other one is the distance that coal should be transported. And coal shipping demand is represented by the product of the number of these two factors. Therefore, the consumption and production in coal demanding countries and the distance important coal shipping routes are the subject that should be analyzed.

2.5.1 The coal demand from main importing courtiers

Table 2.3, according to 2012 OECD coal information, shows that the consumption of coal in Japan stays above 100,000 tons. There is an annual growth rate at about 1%

from 2000 to 2011. But the domestic coal production stopped from 2005. After that year, all consumption is supported by importing coal. And trend extrapolation is used in this paper to forecast the coal volume that should be imported and the estimated volume in 2014 is 1,676 million tons.

Table 2.3 Japanese Coal Production and Consumption (1,000 Tons)

	1985	1990	1995	2000	2005	2008	2009	2010	2011
Coal Consumption	107448	110805	125826	138503	156500	162575	144742	163739	154823
Coal Production	14144	6379	5050	2196	0	0	0	0	0
Gap	93304	104426	120776	136307	156500	162575	144742	163739	154823

Table 2.4 Chinese Coal Production and Consumption (1,000 Tons)

	1985	1990	1995	2000	2005	2008	2009	2010	2011
Coal Consumption	803907	1050745	1316108	1377767	2274375	2686468	2941280	3102909	3648126
Coal Production	584359	748354	964805	1050934	1717734	2042446	2162647	2345504	2593282
Gap	219548	302391	351303	326833	556641	644022	778633	757405	1054844

According to 2012 OECD coal information, table 2.4 shows that the coal consumption in China increases dramatically after reforming and opening up. The annual growth rate arrives at 13.6% from 1985 to 2011. And the growth rate of the domestic coal production is 13.2% from 1985 to 2011. However, the gap between domestic production and domestic consumption grows very fast. The annual growth rate is 14.6%.In this paper, trend extrapolation is used to forecast the coal volume that should be imported and the estimated volume in 2014 is 859 million tons.

According to 2012 OECD coal information, table 2.5 shows that the coal consumption, production and their gap in other Asian countries including India, Korea and Chinese Taiwan. India, recently as a fast-developing country, brings a large demand for coal.

Table 2.5 Three Asian Regions Coal Production and Consumption (1,000 Tons)

	1985	1990	1995	2000	2005	2008	2009	2010	2011
Coal Consumption	209819	282713	364740	475588	605498	739214	786585	826666	852008
Coal Production	121047	160800	190609	214178	270038	324582	351526	350693	363025
Gap	88772	121913	174131	261410	335460	414632	435059	475973	488983

The annual growth rate is 11.7% from 1985 to 2011. However, the growth rate of the domestic coal production is only 7.7% from 1985 to 2011. This gap gets bigger and bigger and brings a larger and larger volume of importing coal for every year. In this paper, trend extrapolation is used to forecast the coal volume that should be imported and the estimated volume in 2014 is 582 million tons.

Table 2.6 European Coal Production and Consumption (1,000 Tons)

	1985	1990	1995	2000	2005	2008	2009	2010	201
Coal Consumption	393142	364484	273646	247602	251338	236234	201411	209398	21192
Coal Production	319403	279379	181702	128156	107507	93298	85959	84881	8509
Gap	73739	85105	91944	119446	143831	142936	115452	124517	12682

Main countries importing coals in Europe are UK, German, France, Italy, Spain, and Netherlands. According to 2012 OECD coal information, table 2.6 shows that the coal consumption, production and their gap from above 6 countries. The location of economy development transferred with time. Moreover, as environment problem has attracted more and more attention in Europe in recent years, the development and application of clean energy technology declines the demand for coal. However, the coal consumption in this area still stays above 200 million tons and the gap volume is still above 120 million tons. In this paper, trend extrapolation is used to forecast the coal volume that should be imported and the estimated volume in 2014 is 128 million tons.

2.5.2 The distance of main coal shipping routes

The other factor of shipping demand is the distance of coal which should be transported. As the coal importing countries and coal exporting countries are fixed in some degree, the main coal terminals and coal shipping routes can be listed. We analyze the distance from the aspect of importing countries.

Japan imports coal mainly from Australia, Indonesia, Canada, Russia and China. Table 2.7 shows that the proportion of coal importing volume from each country, the distance of main coal shipping routes and each voyage time. The biggest exporting country for Japan is Australia and the distance of typical route, from Newcastle to Japan, is 4142 sea miles. And the voyage time will be 14.4 days if voyage speed remains at 12 knots all the time.

Table 2.7 Japanese Coal Importing Routes Information

	Australia Newcastle	Indonesia Kote Balikpapan	Canada Prince Rupert	Russia Vostochny	China Qingdao
Proportion	62.50%	20.10%	4.50%	6.80%	2.50%
Distance （N Miles）	4142	2777	3825	427	1354
Voyage Time (Day)	14.4	9.6	13.3	1.5	4.7

Other Asian countries import coal mainly from Australia, Indonesia, Canada, Russia, China, America, Columbia and South Africa. Table 2.8 shows that the proportion of coal importing volume from each country, the distance of main coal shipping routes and each voyage time. The biggest exporting country for Asian other countries is Indonesia and the distance of typical route, from Indonesia to Japan, is 2286 sea miles. And the voyage time will be 7.9 days if voyage speed remains at 12 knots all the time. And the second biggest exporting country is Australia and the distance of shipping route is 5012 sea mails.

Table 2.8 Other Asian Region Coal Importing Routes Information

	Australia Newcastle	Indonesia Kote Balik papan	Canada Prince Rupert	Russia Vostochny	China Qing dao	U.S. Long Beach	Columbia Bolivar	South Africa R.Bay
Proportion	25.4%	45.8%	2.5%	4.9%	1.4%	3.3%	1.4%	6.6%
Distance （N Miles）	5012	2286	4699	905	686	5629	8959	7725
Voyage Time (Day)	17.4	7.9	16.3	3.1	2.4	19.5	31.1	26.8

Coal imported to OECD Europe comes mainly from Australia, Indonesia, Canada, Russia, America, Columbia and South Africa. Table 2.9 shows that the proportion of coal importing volume from each country, the distance of main coal shipping routes and each voyage time. The biggest exporting country for OECD Europe is Russia, but a big percentage of coal transported from Russia is transported by road or rail transportation. And the second biggest exporting country is America and the distance of typical route, from Baltimore to ARA is 3497 sea mails. And the voyage time will be 12.1 days if voyage speed remains at 12 knots all the time.

Table 2.9 OECD EU Coal Importing Routes Information

	Australia Newcastle	Indonesia Kote Balikpapan	Canada Prince Rupert	Russia Vostochny	U.S. Baltimore	Columbia Bolivar	South Africa R.Bay
Proportion	8.0%	4.4%	2.3%	25.5%	16.8%	22.2%	7.9%
Distance （N Miles）	12432	13718	2606	0	3497	4352	7968
Voyage Time (Day)	43.2	47.6	9.0	0.0	12.1	15.1	27.7

2.6 International coal shipping routes

Because of economy of scale in shipping, big vessel is always assigned to long distance route. Therefore, the routes for different size of vessels are different.

For capsize vessels, in general, there are 6 routes. The loading ports are in South Africa, America and Australia and the discharging ports are in Japan and Europe. Table 2.10 shows main coal shipping routes for capsize bulk carriers.

Table 2.10 Main Coal Shipping Routes of Capesize Bulk Carrier

	1	2	3	4	5	6
Loading Port/Region	R. Bay	H. Rds	Q'land	Q'land	R. Bay	Baltimore
Discharging Port/Region	Japan	Rotterdam	Rotterdam	Japan	Rotterdam	Rotterdam

As for panamax vessels, there are typical 13 routes. The loading ports are concentrated in Canada, South Africa, America, Indonesia, Venezuela, Columbia and Australia, and the discharging ports are in Japan, Europe and India. Table 2.11 shows main coal shipping routes for Panamax bulk carriers.

Table 2.11 Main Coal Shipping Routes of Capesize Bulk Carrier

	1	2	3	4	5	6
Loading Port/Region	Roberts Bank	USGulf	Richards Bay	Newcastle	Roberts Bank	Indo
Discharging Port/Region	Japan	ARA	Rotterdam	Japan	Rotterdam	Rotterdam

	7	8	9	10	11	12	13
Loading Port/Region	Maracaibo	Bolivar	Ventspils	US Gulf	Samarinda	R. Bay	H. Rds
Discharging Port/Region	Rotterdam	ARA	Rotterdam	Jorf Lasfar	Vizag	Sp. Med.	ARA

3 The analysis on factors influencing coal freight rate

3.1 Coal freight and index

In microeconomics theory, price is determined by the supply and demand in the market. When other conditions are fixed, price would increase with the decrease of supply or the increase of demand. The quantity of supply and demand will be equal at a balance price.

There is a negotiation process to determine a price for a single route in practice. The negotiators are marker participators like coal traders, shipping companies or electricity-producing companies. And the negotiation is always through one or several chartering brokers. The negotiation power is determined by the volume recent open cargoes and vessels in a single market and how much of these information can be acquired by each part of negotiator. There are two questions that shipowner should take into consideration. One is to evaluate the cost, for example, the voyage cost for voyage chartering. The factors which affect cost would affect the offers from ship owner, such as bunker price or seasonality. And the other question is to forecast the trend of freight rate. If ship owner estimated the freight would go down, then shipowner should make a relatively long-run charter party to manage the risk. However, from the aspect of charters, the price trend and the time limit for cargo trade party is the fact which should be considered seriously. Therefore, the price for a single deal is determined by market situation and the information each party has.

Therefore, there are different indices aimed to provide an indicator of the trend of freight rate, published by different institutions in the world, such as JEHSI, LSE Index, SSY Index, LSM Index and Maritime Research freight rate index. Among those indices, BDI which is short for Baltic Dry Index and is published by Baltic Exchange is the most important one indicating the trend of bulk shipping market. BDI includes four shipping markets classified by ship size, namely capsize, panamax, supramax and handysize. There are four independent indices, namely BCI, BPI, BSI and BHSI, indicating the fluctuations of these four markets. And each one takes one quarter of BDI.

There are several strict principles for the calculation of BDI to make sure its seasonality. Firstly, shipping routes which has been added in BDI should be balanced. Routes should include both the trade in Atlantic area and Pacific area, and the weight for each route is not over 20 percent. Secondly, there should be some transactions everyday in these routes. Thirdly, some routes controlled by few charters should not be taken into consideration. And BDI is calculated based on the estimations from 20 famous broker houses with good reputations. And the estimations are based on the transaction condition in that day. And the whole process is strictly confidential.

3.2 The factors influencing coal shipping demand

Shipping demand is derivative demand as shipping is the most important process to realize international trade. Coal plays a very important role in industrial development as cooking coal is major raw material for steel production and stemming coal is important raw material for electricity production. Therefore, the development of regional economy brings demand of coal. However, the imbalance of natural recourse distribution and the location of coal-demanding countries derives the demand of coal shipping.

Therefore, coal shipping demand depends on the production and consumption from main coal exporting and importing countries. Among those, the coal consumption of main coal importing countries and the coal production of main coal exporting countries has a great influence on the coal shipping demand. Therefore, there are four factors influencing coal shipping demand, namely, regional economy, the price of energy commodity, seasonality and policy.

3.2.1 Regional economy

The growth of regional economy has a positive impact on the development of industry which brings a huge consumption of electricity and steel production. The major coal importing countries are concentrated in Europe and Asian. There are two reasons for that phenomenon. One is that there are few coal recourses in those places and the economy development in those areas is very fast. The growth of industrial production brings the demand for coal as raw material of steel production and electricity production. Therefore, regional economy is an important factor which can influence the shipping demand. Besides, as the world economy is globalized, world economy situation has a great impact on regional economy. It can be seen from the economy crisis in 2008 when the global economy has been hit.

3.2.2 The price of energy commodity

The demand for international coal shipping is derived by international coal trade. Therefore, the factors influencing international coal trade also have an impact on coal shipping demand. In short term, if the price of coal increases, coal trader would stop import coal and wait for the drop of coal price. Otherwise, if the coal price stayed at a low place, coal trader would take this chance to replenish their stock. Therefore, the price of coal has a negative impact on coal trade volume, and also has a negative impact on coal shipping demand.

Besides, as one kind of energy commodity, in terms of function, coal and crude oil are alternative in some degree. For example, there is an advance technology which can liquefy low-quality coal. This kind of liquefied coal can be used similarly with gasoline which is produced from crude oil. According to microeconomics, the price of alternative product can influence the price of the subject product. Therefore, when the price of crude oil increases the demand of coal as the alternative product would increase. Consequently, the coal shipping demand would increase.

3.2.3 Seasonality

The coal shipping demand has an obvious seasonality, especially the shipping demand for stemming coal. Before the summer and winter of North-hemisphere, electric power companies would purchase coal to replenish inventory. The international coal shipping demand would increase dramatically during his period of time. As Australia is an important coal importing country and China is an important coal importing country, we can study the seasonality of international coal trade from the trade volumes of these two countries. Figure 3.1 shows the Australia exporting coal volume and the Chinese importing coal volume. It can be seen from the Figure that, previous to the winter in north-hemisphere, from November to December, the coal shipping demand increases dramatically. But that demand decreases to a low level after those months for replenish inventory. Similarly, the coal shipping demand increases in May and June when it is before the peak season for electricity. Therefore, seasonality is an important factor which can determine the fluctuation of coal shipping demand for short term.

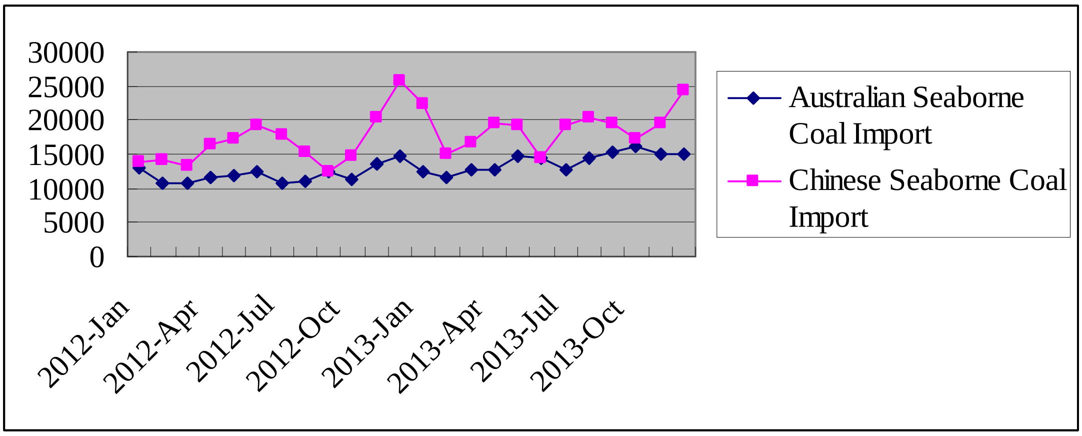


Figure 3.1 Australian Seaborne Coal Import and Chinese Seaborne Coal Import

Source: Clarkson Research Service Limited

3.2.4 Policy

Policy is a random factor infecting the fluctuation of coal shipping demand, and at the same time it is a factor has a long-term and great impact on shipping demand. Coal is an important energy recourse which is non-renewable. Therefore, coal exporting countries always issue some policies to protect its recourses. For instance, the policy of closing or reopening of some high-productivity coal mines, or the polity to limit the coal exporting can infect coal shipping demand.

3.3 The factors influencing coal shipping supply

The factors which can influence the coal shipping supply can be divided into two categories, namely short-run factors and long-run factors. Long-run factors influence the size of dry bulk fleet to affect the coal shipping supply. For example, policies related to vessel and ship price are long-run factors. On the other hand, short-run factors affect coal shipping supply through the adjustment of shipping speed and laid-off tonnage. There are factors are bunker price and seasonality.

3.3.1 Ship price

Ship price is a long-run factor which affects shipping supply through affecting the fleet size directly. And ship price factors include new building price, second-hand ship price and scrapping price. But, among those prices, new building price and scrapping price have the biggest impact on shipping supply. Unlike other kind of asset, the value of vessel fluctuated wildly. For instance, both new building price and second hand price stayed at a very high level in 2007 and the first half year of 2008. But, those prices dropped dramatically after the global economy crisis in 2008. And there is a close relationship between new build market and freight market. Ship-owner would try every effort to increase the shipping supply when freight rate staying at a high level. And the way that can really add the supply for the market is to build new vessels. Therefore, there is an imbalance for the high ship building demand and low ship building supply. Consequently, the new building price would increase with freight rate. Meanwhile, new building price will be low when the freight rate stayed at the bottom. That is because there is more shipping supply than shipping demand in the market. No more vessels are needed in this situation. However, some rich ship owner may choose this opportunity to build new vessels to update their fleet in order to reducing the high voyage cost of over-age fleet. In fact, tonnage supplied in the market will increase in 3 to y years. However, in low freight market, scrapping price would influence shipping supply. Generally, older ship means more fuel consumption. Some old ship would need to be overhauled in the near future which costs a considerable amount of money. In this situation, some ship owner may scrap the vessel at the condition that scrapping can make more money than selling it. Therefore, scrapping price can influence shipping supply.

3.3.2 Policy

Policy is another long-run factor which can influence shipping supply directly through leading to new building vessels or scrapping vessels. Although policy is random and unforeseeable, there would always be a period of time between the issue and performance of the policy. Therefore, participators would analyze the newest policy and take advantage of it to make more earnings and reduce risks. There are two kinds of policies that can affect shipping supply. One is the policy which regulate the vessel. For example, a lot of single-hull tanker was scrapped after a restrict zone for single-hull had been published. The other kind is the subsidy from government to support ship building or shipping industry. For instance, Chinese government allocated funds for scrapping old vessels and building new vessels in late 2013, but only for state-owned companies. In this situation, state-owned companies scrap some old ships and build some new vessels which can change the shipping supply.

3.3.3 Bunker price

Bunker price is a short-run factor which affects shipping supply through affecting the shipping speed. Bunker cost takes a large percentage of voyage cost. Fuel consumption is directly proportional with the cube of voyage speed. Therefore, slow stemming is a popular way to reduce cost and shipping supply in low market. For example, ship owner make full use of shipping speed to make more money when the freight rate is high. But after the crisis in 2008, ship companies try to survive in the condition that they can earn little hire but always with high cost attached to vessels. In that situation, slow stemming is the most effective way to reduce cost and increase competitiveness. Therefore, bunker price have an influence on shipping supply in short term.

3.3.4 Seasonality

Seasonality is another short-run factor which affects shipping supply through affecting the voyage speed. As the seaworthiness in different season is different, the capable speed is different in different seasons. Voyage time would be affected in winter when it is windy and cold. Therefore, seasonality is a short-run factor influencing shipping supply.

4 Methodology

4.1 Vector Auto-regression Model

Vector Auto-regression Model is a dynamic simultaneous equation model. It is widely used in the dynamic analysis of economical system.

The definition of Vector Auto-regression Model is as follow.

$$Y_t = \sum_{i=1}^{p} \pi_i Y_{t-1} + U_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \dots + \pi_p Y_{t-p} + U_t$$

In that formula, $Y_t = (y_{1t}, y_{2t} \dots y_{Nt})^T$ stands for a time series of one variable. p stands for the lag intervals and U_t stands for residuals.

The process of building a vector auto-regression model is as follow. The first step is to test if variables in the model have causality and which variable should be exogenous variable. The second step is to evaluate the lag intervals of the model. Large lag can describe the dynamicity of the model. However, there will be a lot of parameters to be estimated if lag is large. Therefore, multiple criteria evaluation is always used to evaluate lag intervals. The third step is to build the model and to test the stability of the model. If the model is proper then it can be used for impulse response analysis.

There are two uses for vector auto-regression model. One use is to forecast, especially fitting for long-run forecast. The other one is to do the impulse response analysis and variance analysis which can analyze the impact of innovations from different variables. This paper will use impulse response analysis to analyze the influence from different factors.

4.2 Model Test

As VAR model is a liner model, at first, we need to test whether there is a real interaction between variables and also need to figure out the lag interval for the model. Spurious correlation can always happen in the model which is built by economical time series. Spurious correlation means that although there is a high correlation coefficient between variables, there is no real relationship between these variables. Therefore, we need to test the causality between variables by Granger causality test.

Granger causality test is used to test that if X series is the cause of Y series. This means that adding X series to the model can make the forecast of Y series more accurate. If there are two variables in the model, X series and Y series, the formulas of the test is showed as below. In the formula, k is the lag.

$$y_t = a_0 + a_1 y_{t-1} + \cdots a_k y_{t-k} + \beta_1 y_{t-1} + \cdots + \beta_k y_{t-k}$$

$$x_t = a_0 + a_1 x_{t-1} + \cdots a_k x_{t-k} + \beta_1 y_{t-1} + \cdots + \beta_k y_{t-k}$$

And the null hypothesis is that X series is not the cause of Y series, namely, $\beta_1 = \beta_2 = \cdots = \beta_k = 0$ .And, in this dissertation, we use multi-criteria method which includes AIC, SC, HQ and so on to figure out the lag intervals for model.

Also, we need to test the stability of the model. However, if the variables which are used to build the model are stable, then the model is stable. In this dissertation, we use Augmented Dickey-Fuller test to test the stability of variables.

4.3 Impulse Response Analysis

Impulse response analysis can show the response of a variable and the change of the responses during a period of time when a S.D. innovation happens on another variable. In VAR model, a change on one variable can be delivered to another. Therefore, an innovation on one variable drives responses for a period of time. In this dissertation, we use the impulse response analysis based on VAR model to analyze the effect of different factors. There is a function in EVIEWS which can do impulse response analysis.

5 *Empirical Study*

In this chapter, we do an empirical study on factors influencing coal freight rate in European route and Japanese route respectively. To be exact, we analyze the effect of four aspects of factors, namely, regional economy, fleet, commodity price, ship price and bunker price. We also select several time series to be indicators for each factor. We can make sure if these factors are proper for the specific factor through Granger causality test. And remove unreasonable ones based on test result. After that, we build VAR models using two variables, namely, freight rate and one indicator for each route. After passing the stability of the model, we can do impulse response analysis to study the response of freight rate to each indicator.

5.1 Data and Sample

Firstly, we should describe the sample of freight rate. According to the analysis above, the major international coal shipping routes can be classified into two categories based on trading area, namely, Pacific shipping routes and Atlantic shipping routes. Therefore, the coal voyage freight rates for two routes, from US gulf to ARA and from Newcastle to Japan, for 70,000DWT dry bulk vessels, are the subject of this study. The data is monthly data and the sample range is from the January-2003 to December-2013. And all statistics is from Clarkson Research.

As VAR model is used to analyze the effect of factors, the subject time series should be stable. In this dissertation, we use ADF test to test the stability for two series of freight rate. The result is that both these freight rates are stable and can be used in VAR model to analyze the effect of factors influencing freight rate.

Secondly, we should describe the samples in the aspect of regional economy. According to the conclusion from the above, regional economy has influence on coal freight rate as coal is main material for power, cement and steel production. Therefore, we choose industrial growth, steel production and stock index for Europe and Japan to be the indicators standing for regional economy factor. And the stock index for Japan is NIKKEN255 index and for Europe is FTSE100 index. Granger causality test shows that stock indexes are not significant factors. Therefore, we can remove this indicator.

Thirdly, we should describe the samples in the aspect of fleet. The development of Panamax fleet have an influence on coal shipping supply as more than 40 percent of total Panamax tonnages are used for carrying coal. In this dissertation, to evaluate the effect of this factor, we choose two indicators, Panamax Bulk carrier Fleet Development and Panamax Bulker Orderbook, to represent the development of Panamax fleet. Based on the result of Granger causality test, there is no Granger causality between Panamax Bulker Orderbook and freight rate. Therefore, we remove this indicator.

After that, we should describe the samples in the aspect of commodity price. The price of energy commodity can influence the demand for coal. Therefore, this is an important factor influencing coal shipping demand and coal shipping price. Coal price and crude oil price is the main indicators in this factor. But international coal price data is not available. Hence, in this dissertation, we test the effect of Brent crude oil price. As there are several kinds of cargoes can be carried by dry bulk vessels, we also test the influencing effect of US wheat price and US corn price. Through granger causality test, we can remove the price of corn and wheat as these factors do not have a significant effect on coal freight rate.

Finally, we should describe the samples in the aspect of ship price and bunker price.

Ship price factor includes secondhand ship price, scrape value and new building price. This factor can influence the coal shipping price by influencing the expectation of shipping cost. In this dissertation, we test and study the effect of three indicators to evaluate this factor, namely, Bulk Carrier Second Hand Price index, Bulk Carrier New Building Price Index, Panamax Bulker Scrape Value.

According to the conclusion from the above, bunker price takes an important role in affecting coal freight rate as bunker cost takes more than 60 percent of voyage cost so that it is main factor to be considered when ship owner quote in the chartering process. And there are two kinds of bunker which are used in the voyage, namely, marine residual fuels and marine distillate fuels. Marine residual fuel is used by main engine and distillate fuel is used for auxiliary engine. And some new type vessels can use residual fuels for auxiliary engine. Therefore, we choose the price of 380CST in Rotterdam to stand by this factor.

5.2 Model and Test

5.2.1 Regional Economy

(1) Industrial Production

The first step is to test the stability of the time series of European industrial production growth and Japanese industrial production growth by ADF test. And the test result is that both of these series are stable series. After that, the step is to build a VAR model with the time series of industrial production growth and freight rate. Based on multiple criteria, the lagged intervals for European and Japanese model are 4. It can be seen from the result of Granger causality test that there is no granger relationship with Japanese industrial production and Newcastle-Japan route coal freight rate. However, USgulf-ARA route coal freight rate is the granger causality of

European industrial production.

In this group, we use USgulf-ARA route coal freight rate and European Industrial production to build a VAR model. The formula of the model is showed as follow.

Based on the VAR model, we can analyze the responses of coal freight rate to industrial production with one S.D. innovation through impulse response analysis (showed in Figure 5.1). It can be seen from the Figure that the response of coal freight rate to industrial production is positive. The response of the first month is 3% and it declines slowly with time. However, there is still 2% response after 10 months. It means that there is a constant positive response of coal freight rate to industrial production in this route. The economic explanation is that the growth of industrial production brings growing electricity demand and basic material demand. Consequently, the growing demand for coal shipping service drives up freight rate. The response stays at a relatively low level. However, it should be noticed by market participators as the response is constantly positive.

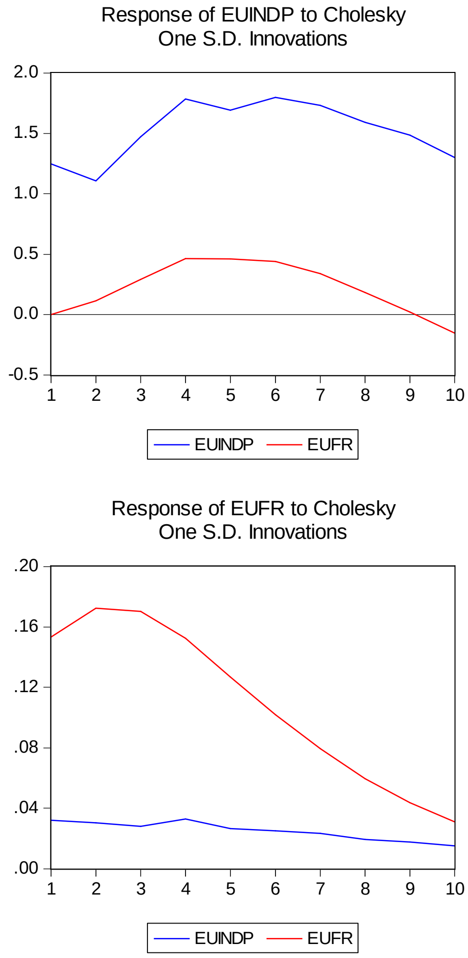


Figure 5.1 Response of EUFR to EUINDP with one S.D. innovation

(2) Steel Production

The first step is to test the stability of the time series of European steel production and Japanese steel production growth by ADF test. The result shows that the variable JPSTLP which represents Japanese steel production is stable. As there are two unit roots for the variance EUSTLP which represents European steel production, we calculate second difference of it. After that, the step is to build a VAR model with these two groups of variables. Based on multiple criteria, the lagged intervals for European and Japanese model are 7 and 6 respectively. It can be seen from the result of Granger causality test that EUFR, short for the coal freight rate from USgulf to ARA, is the granger causality of DDEUSTLP and JPFR is the granger causality of JPSTLP.

Based on the VAR model, we can analyze the responses of EUFR to DDEUSTLP with one S.D. innovation and the responses of JPFR to JPSTLP with one S.D. innovation through impulse response analysis (showed in Figure 5.2). As for European group, we can see the responses in first three months are close to zero and there is a negative response at about 2% in the fourth month. After that, the positive and negative response happens in turn. However, the responses stay at a low level which is about 2%. As steel production is just a part of industrial production, the response level of steel production should be lower than that of industrial production.

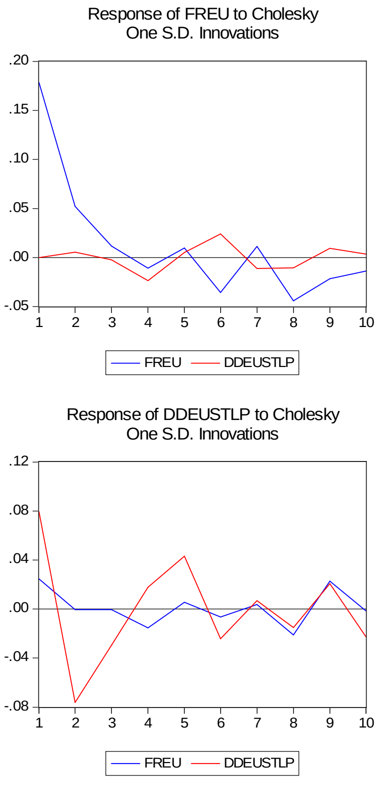


Figure 5.2 Response of EUFR to DDEUSTLP with one S.D. innovation

It can be seen from the Figure 5.3 that the response of JPFR to JPSTLP is constantly positive. The response of the first month is 3% and it declines to about zero at the third month. After that, the response level goes up slightly and stays at about 1%.The economic explanation is that the growth of steel production drives up the demand for cooking coal. However, compared to the response to industrial production, the response to steel industrial is not significant.

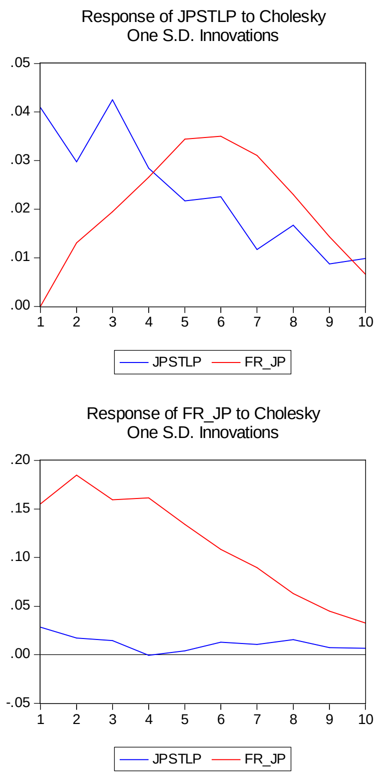


Figure 5.3 Response of JPFR to JPSTLP with one S.D. innovation

5.2.2 Crude Oil Price

Similarly, the first step is testing the stability of the time series of Brent crude oil price by ADF test. The result shows there are one unit root in the said time series. Therefore, we calculate the first difference of the said time series and recorded the first difference series as BRENT. After that, the step is to build a VAR model with two groups of time series, namely BRENT and EUFR, and BRENT and JPFR. Based on multiple criteria, the lagged intervals for European and Japanese model are 2. It is showed from the result of Granger causality test that there is Granger causing relationships within two groups of variables. Hence, VAR models can be built with these two groups of variables.

With the basis of VAR model, we can analyze the responses of EUFR to BRENT with one S.D. innovation and the responses of JPFR to BRENT with one S.D. innovation through impulse response analysis (showed in Figure 5.4). Generally, we describe the impulse response result for European group. The responses of EUFR to BRENT are positive all the time in the first 10 months. The response increases from about 4% to 10% and decrease from the fourth month. It declines to about 3% at the 10th month. The economic explanation is that crude oil consumers start to find alternative energy product, such as coal, to remit the pressure of rising crude oil price. And at the same time, the price of bunker which is one kind of product of crude oil increases. This increase could dive voyage cost up. Therefore, the influence of crude oil is significantly and constantly positive. And the peak of its influence is at the 3rd and 4th month.

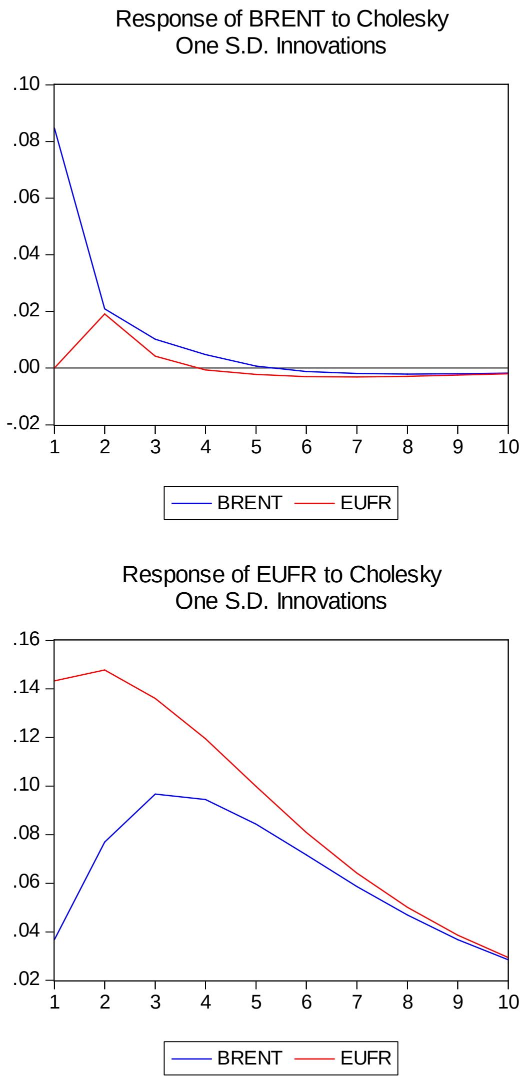


Figure 5.4 Response of EUFR to BRENT with one S.D. innovation

As we can see from the Figure 5.5 the response of JPFR to BRENT is also constantly positive. But the response in the first month is 0. The trend of responses in this group is similar with that of European group. The response soars significantly from 0 to about 7% in first 4 months. After that, it declines slowly and gets about 3% at the 10th month. The peak of response is at the 4th month, accounting at about 7%.

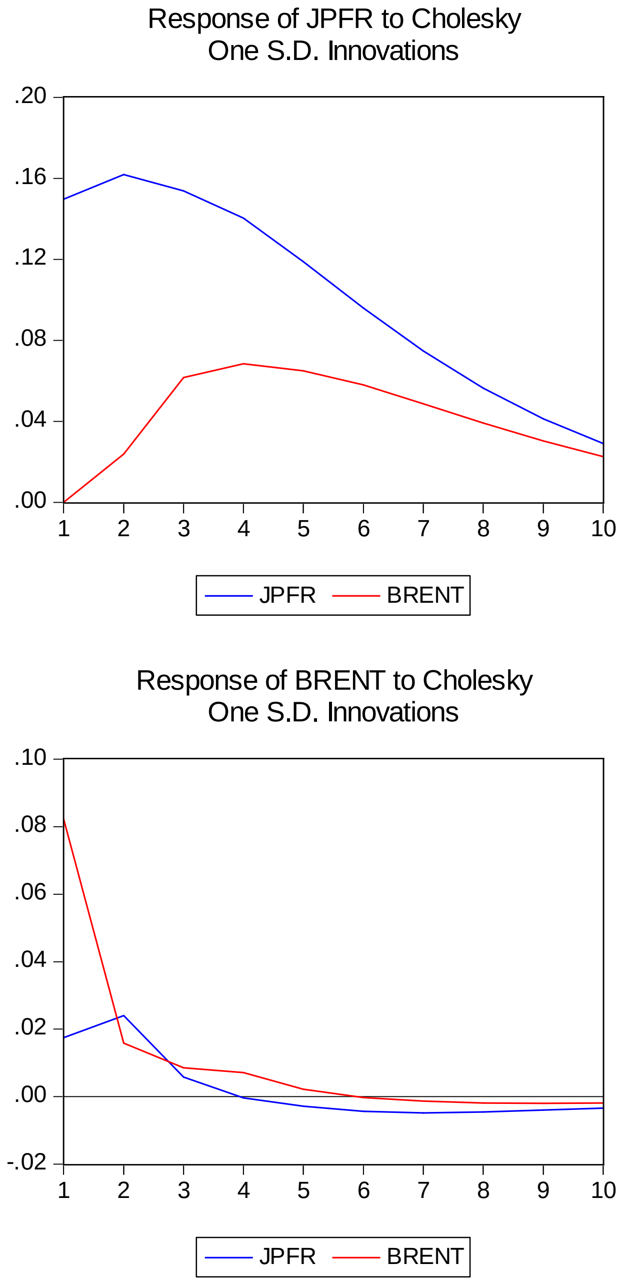
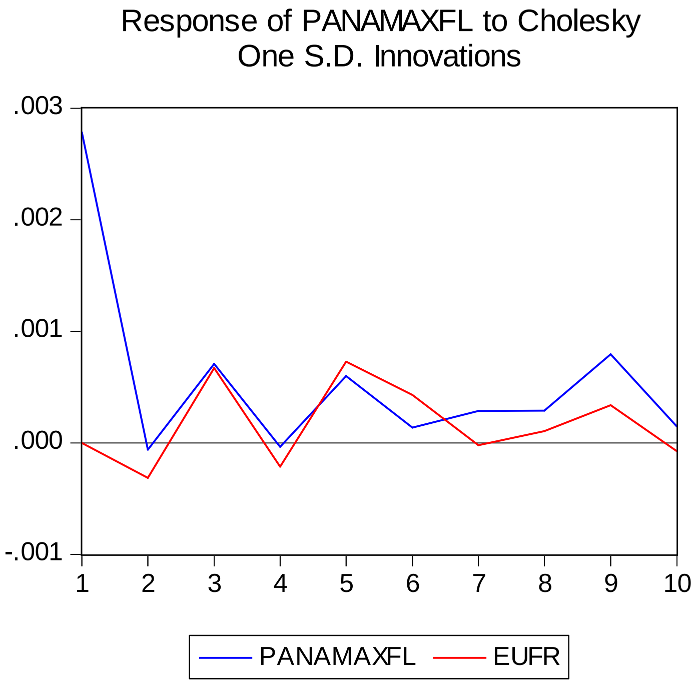


Figure 5.5 Response of JPFR to BRENT with one S.D. innovation

5.2.3 Fleet Development

After testing the stability of the time series of Panamax Bulk carrier Fleet Development by ADF test, we can see that this series of data is stable. Therefore, we record this time series as variable PANAMAXFL for convenience. The second step is to build a VAR model with two groups of time series, namely PANAMAXFL and EUFR, and PANAMAXFL and JPFR. Based on multiple criteria, the lagged intervals for European and Japanese model are 8 and 2 respectively. We got an conclusion from the Granger causality test that there is no granger relationship between PANAMAXFL and JPFR and EUFR is the granger cause of PANAMAXFL. Therefore, we can only build a VAR model with PANAMAXFL and EUFR.

Figure 5.6 illustrates the response of EUFR to PANAMAXFL with one S.D. innovation. It can be seen that the response in the 1st month is about minus 2% and it rises to about minus 6% in the third month. And the response declines with the time and be stable at minus 3% after the 6th month. The economic explanation is the increase in supply drive the coal shipping freight rate down based on the classic microeconomic theory. And the response to PANAMAXFL rises to the peak at the 3rd month, accounting to minus 6%.



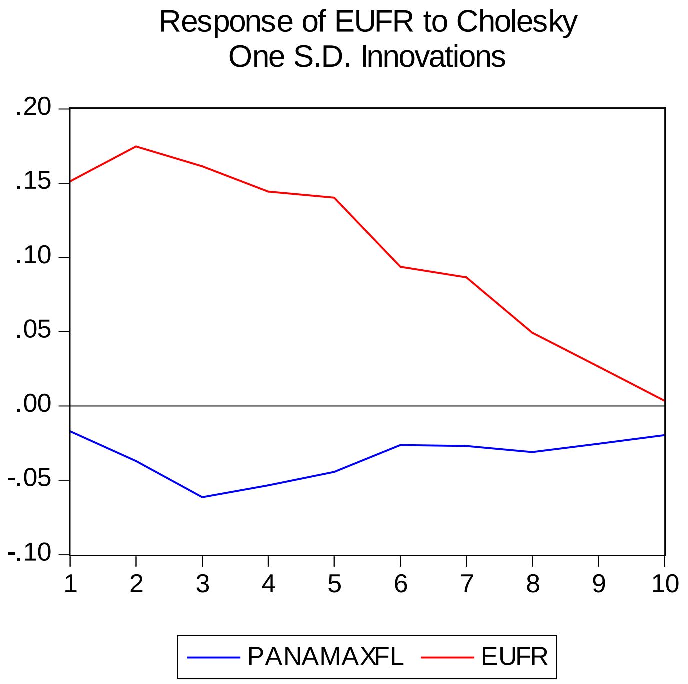


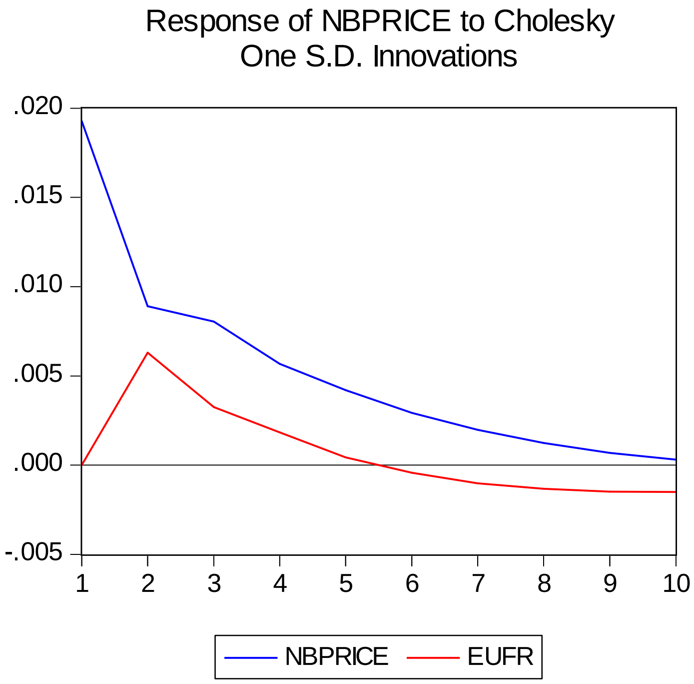
Figure 5.6 Response of EUFR to PANAMACFL with one S.D. innovation

5.2.4 Ship Price

(1) New building price

Similarly, the first step is to test the stability of the time series of Bulk Carrier New Building Price by ADF test, we can see that there is an unit root in this time series. Therefore, we calculate its first difference and record this new time series as variable NBPRICE for short. The second step is to build a VAR model with two groups of time series, namely NBPRICE and EUFR, and NBPRICE and JPFR. Based on multiple criteria, the lagged intervals for European and Japanese model are 2 and 4 respectively. After the Granger causality test, we can get the fact that EUPR is granger cause of NBPRICE and JPFR is granger cause of EUFR. Therefore, we can build a VAR model with two groups of variables.

Figure 5.7 shows the response of EUFR to NBPRICE with one S.D. innovation. We can be see that the response is constantly positive and stays at a relatively low level. The response is at about 2% in the 1st month and it rises to above 4% which is the peak in the third month. And the response stays stable at that level and drops slightly at the 10th month. The economic explanation for this trend is that shipping company would increase the quotation as higher capital cost in the future is taken into account.



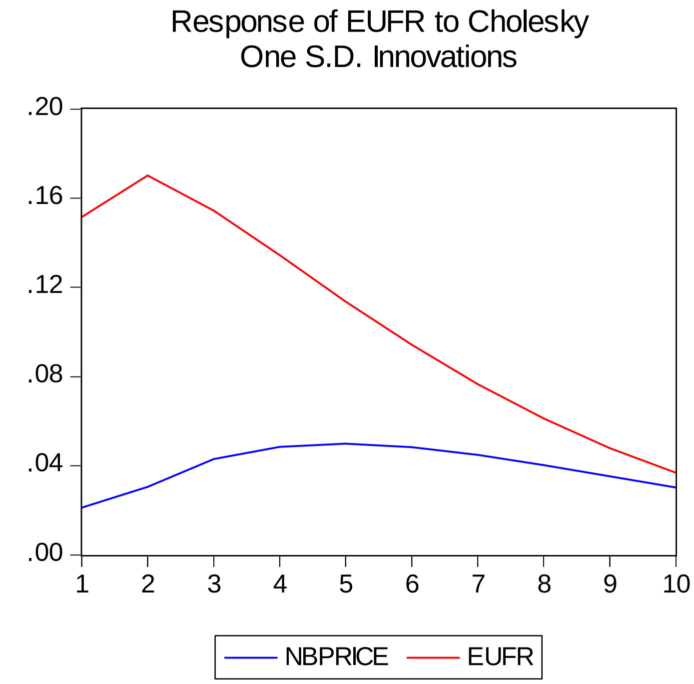


Figure 5.7 Response of EUFR to NBPRICE with one S.D. innovation

It is illustrated by Figure 5.8 that the response of JPFR to NBPRICE with one S.D. innovation is constantly positive. The trend of the response of JPFR is similar with that of EUFR but it is more significant than that of EUFR. The response is close to 4% in the 1st month and it climbs to about 6% which is the peak in the fourth month. After that, the response starts to decline at a stable rate and gets about 3% at the 10th month.

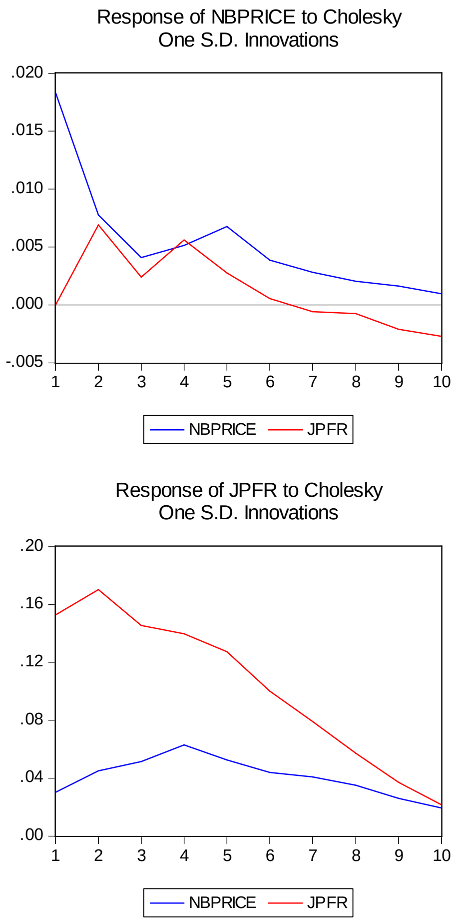


Figure 5.8 Response of JPFR to NBPRICE with one S.D. innovation

(2) Second-hand ship price

The first step is to test the stability of the time series of Bulk Carrier Second Hand Price index by ADF test. The result shows that the said series is stable and we can record the series as BSHPI for short. The second step is to build a VAR model with two groups of time series, namely BSHPI and EUFR, and BSHPI and JPFR. We can get the lagged intervals for European and Japanese model are 1 and 5 respectively based on multiple criteria. The result of the Granger causality test shows that EUFR and BSHPI is the granger cause for each other and BSHBI is the granger cause for JPFR. Therefore, we can build VAR models with two groups of variables.

Figure 5.9 illustrates the response of EUFR to BSHPI with one S.D. innovation. The response is constantly positive and significant at the first several months. The response gets above 8% in the 1st month and it goes up sharply to about 13% which is the peak in the third month. After that, it drops sharply with a stable rate. At the 10th month, it drops to close to 0.

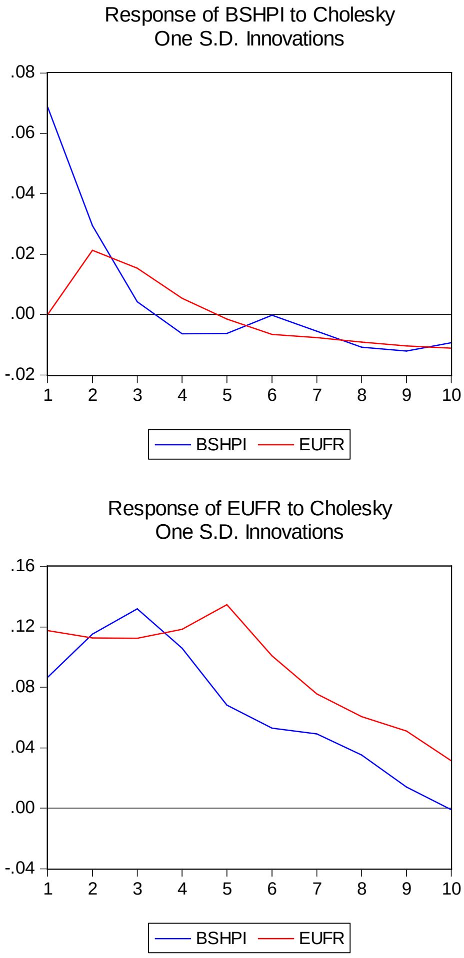


Figure 5.9 Response of EUFR to BSHPI with one S.D. innovation

Figure 5.10 shows the response of JPFR to BSHPI with one S.D. innovation. The response is constantly positive and significant at the first several months. At the first month, it is more than 8%. Then it rises significantly by about 4% at the second month. The response gets the peak at the 3rd month, which is about 13%. After that, it drops sharply with a stable rate. At the 10th month, it drops to close to 5%. The trends of these two series of response are similar. However, the fluctuation of responses of JPFR is more significant.

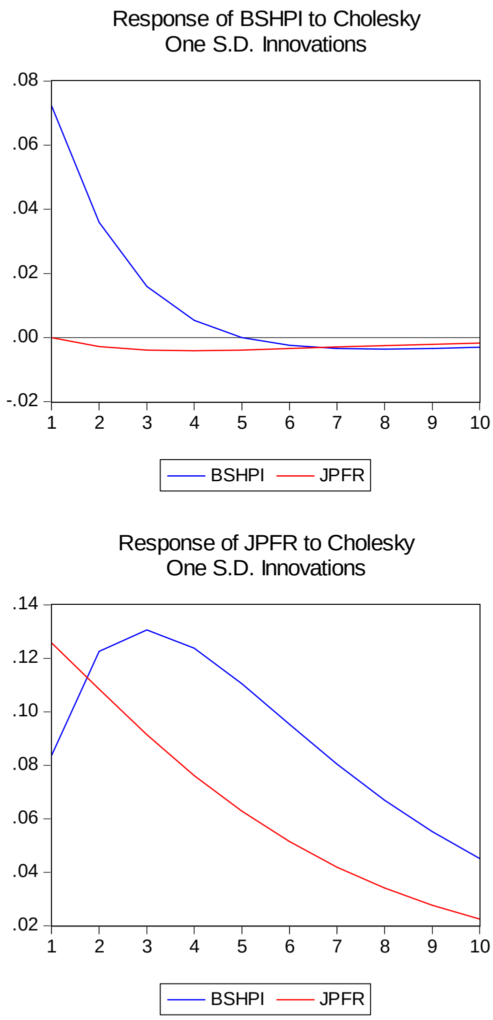


Figure 5.10 Response of JPFR to BSHPI with one S.D. innovation

5.2.5 Bunker Price

The first step is to test the stability of the time series of the price of 380CST in Rotterdam by ADF test. It can de seen from the result hat there is an unit root in this time series. Therefore, we calculate its first difference and record this new time series as variable BUNKER for short. The second step is to build a VAR model with two groups of time series, namely BUNKER and EUFR, and BUNKER and JPFR. Based on multiple criteria, the lagged intervals for European and Japanese model are both 2. We can get the fact that there is a both-way causing relationship between BUNKER and EUFR and BUNKER is the granger cause for JPFR. Therefore, we can build a VAR model with two groups of variables.

The next step is to do the impulse response analysis based on the above VAR model. Figure illustrates the response of EUFR to BUNKER with one S.D. innovation from the first month to the 10th month. Figure shows the response of JPFR to BSHPI with one S.D. innovation. The response is constantly positive and it is about 4% at the first month. Then it rises sharply during the following two months and gets about 9% at the 3rd month. After that, it drops with a stable rate. At the 10th month, it drops to close to 3%. This is because that bunker price takes a large percentage of voyage cost. And market participators who quote voyage freight regard bunker price fluctuation is an important factor in quotation.

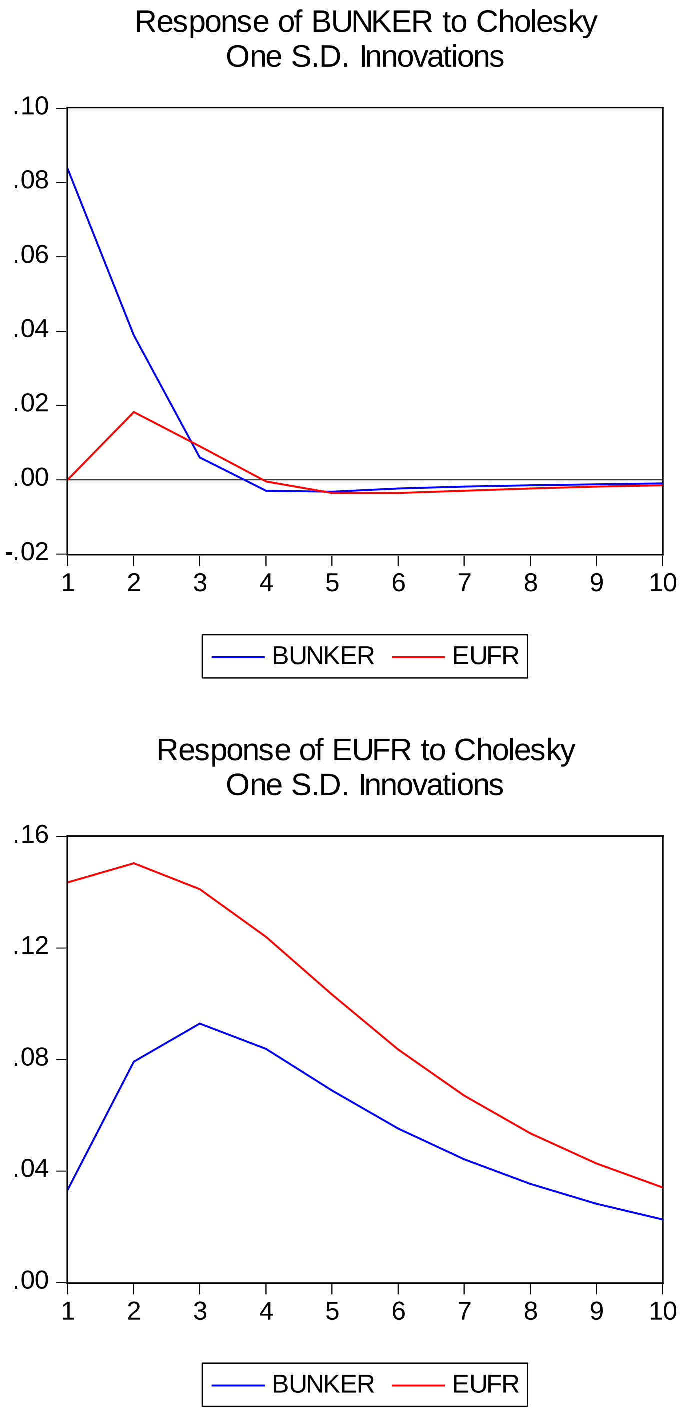


Figure 5.11 Response of EUFR to BUNKER with one S.D. innovation

Figure 5.11 shows the response of EUFR to BUNKER with one S.D. innovation from the first month to the 10th month. The trends of these two series of response are similar. However, the fluctuation of responses of JPFR is more significant which is showed in figure 5.12. The response in first month is about 4% and it grows to about 8% in the 3rd month. It drops slightly at the 4th month and then drops at a stable rate. At the 10th month, it arrives to about 3%.

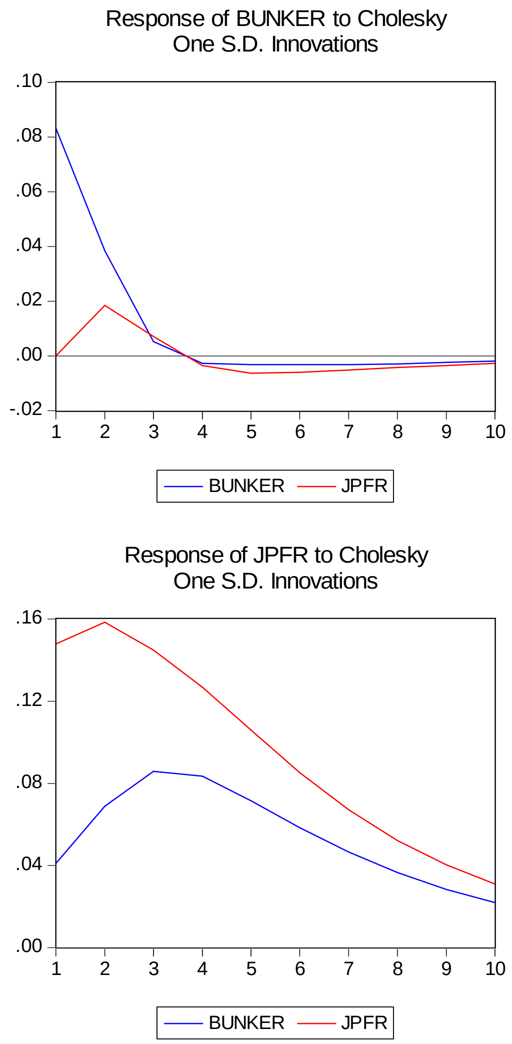


Figure 5.12 Response of JPFR to BUNKER with one S.D. innovation

6 *Conclusion*

Firstly, we get a conclusion that there are indicators in all these four factors, namely, regional economy, commodity price, fleet, ship price and bunker price, having a significant effect on coal shipping freight rate. To be exact, in the indicators of regional economy, industrial production growth and steel production has a positive effect on European coal shipping freight rate, while only steel production have a positive influence on Japanese coal shipping freight rate. In the group of commodity price, crude oil price has a positive effect on two coal shipping freight rate, while wheat price and corn price can not influence coal shipping price. As for the indicators related to fleet, only Panamax fleet development has a influence on two coal freight rate but the effect is negative. Both new building ship price and second-hand ship price have a positive effect on two coal shipping freight rates. Also, bunker price have an significant and positive effect on coal shipping freight rates.

Secondly, there is a common point for the responses of freight rate to the innovation of above indicators. The response grows up during the first 3 or 4 months and then starts to decline. Responses decline sharply for some indicators, such as crude oil price. For some indicators, it drops slowly with a stable rate, such as new building price.

Thirdly, concentrated on the responses in the first 3 to 4 months, we can find that crude oil price and second-hand ship price has the biggest influence to these two coal freight rate. The responses to these two indicators can arrive to 7 to 8% at the first month. And responses would grow to 10 to 13% at the peak. And the bunker price has a medium level of effect to two coal shipping freight rates. The range of the responses is from 4 to 8%. While, indicators like industrial production growth, steel production, new building price and Panamax fleet development has a low effect on these two coal shipping freight rates. The responses for these factors are below 4%. Compared with bunker price, crude oil have a larger effect as it can also has a positive influence on coal demand in coal consuming countries. And compared to new building ship price, second-hand price has a more direct relationship to the coal shipping market. Hence, second-hand ship price and crude oil price are the indicators that market participators should notice.

Reference

[1]Yuan Qun.2013: The study on factors influencing dry bulk shipping market, 2013.3

[2]Zou Zongyu.2007: The analysis on the factors influencing iron ore freight rate, 2007.6

[3]Li Kun.2009: Modeling of the spot freight rate in dry bulk shipping, 2009.2

[4]Wang Yang.2009:Study on the influence of iron ore negotiation to freight, 2009

Stopford M.2009: Maritime Economics (3rd edition), Routledge published

[5]Zhang Haoran.2012: The research on iron ore freight rate based on VECM model, 2012.5

[6]Liu Jingqing, Li Hong.2013: The tendency of world coal trade, Comprehensive Transport

[7]Zhang Tonggong.2010: The study on the influence of international coal trade pattern change, China Energy

[8]Fang Lin.2005: The study on Chinese power demand

[9]Liang Xiaoming.2003: Western Economics, Peking University Press

[10]Dong Chengzhang.2011: Econometrics, China Machine Press

[11]Xu Bangzhen.2008: Carriage of Goods by Sea, China Communications Press

[12] Stopford Martin.1997: Maritime Economics, Psychology Press.

[13]Shuo Ma. 2013. Maritime Economics: Sea Trade Evolution & Maritime Geography

[14]Rong Zhaohe.2002: Western Transportation Economics, Economics Science Press

[15]Clarkson Research Services- Fleet forecast Jan-14

[16]Drewry Maritime Research-Dry Bulk Insight December 2013

[17]Clarkson Research Services- Ship type orderbook monitor forecast Jan-14

[18]Drewry Maritime Research-Dry Bulk Forecaster Quarter 3 2013

[19]Coal Information 2012. OECD, 2013

[20] Manolis G. Kawssanos and Amir H. Alizadeh-M, Seasonality patterns in dry bulk shipping spot and time charter freight rates, Transportation Research PartE37,2001,446~452

[21] Alizadeh, Amir H. Trading volume and volatility in the shipping forward freight market. Transportation Research Part E: Logistics and Transportation Review49.1 (2013): 250-265.

[22]Yang Bin.2012: The research on factors influencing dry bulk freight rate in Southeast Asia, China Ports

[23]Jin Ming.2013: A study on shippers' strategy of carriage of iron ore by sea based on GHM model, 2013.3

[24]Wu Liyi.2009: The influence to China from international coal trade pattern in 2009, China Coal

[25]Zhang Lanfang.2005: The study on the elements in international dry bulk shipping market

[26]Yin Xiangda.2008: The study on Chinese costal coal shipping market

[27]Li Xiang.2011: The analysis on China coal importing, Coal Economy Study

[28]Wang Jianhua.2009: The study on Panamax shipping market based on VAR model, Dalian Maritime University Journal

Appendices

Appendix A

Panamax Coal Voyage Rates USGulf/ARA 70,000t $/Tonne

Jan-02	5.96	Jul-04	18.77	Jan-07	19.56	Jul-09	24.58	Jan-12	17.00
Feb-02	5.98	Aug-04	20.50	Feb-07	19.94	Aug-09	18.32	Feb-12	16.12
Mar-02	6.62	Sep-04	20.62	Mar-07	21.60	Sep-09	19.92	Mar-12	17.60
Apr-02	6.48	Oct-04	22.50	Apr-07	23.25	Oct-09	20.83	Apr-12	20.19
May-02	6.73	Nov-04	26.59	May-07	27.50	Nov-09	27.60	May-12	20.38
Jun-02	6.19	Dec-04	26.15	Jun-07	29.10	Dec-09	25.49	Jun-12	16.95
Jul-02	6.25	Jan-05	24.00	Jul-07	38.75	Jan-10	26.23	Jul-12	16.92
Aug-02	6.74	Feb-05	23.81	Aug-07	33.92	Feb-10	22.98	Aug-12	15.58
Sep-02	7.61	Mar-05	26.38	Sep-07	33.94	Mar-10	28.05	Sep-12	13.65
Oct-02	8.08	Apr-05	25.02	Oct-07	39.87	Apr-10	25.54	Oct-12	15.62
Nov-02	8.12	May-05	20.54	Nov-07	43.92	May-10	29.48	Nov-12	15.40
Dec-02	8.75	Jun-05	19.20	Dec-07	42.36	Jun-10	23.62	Dec-12	15.66
Jan-03	8.95	Jul-05	14.47	Jan-08	42.00	Jul-10	17.79	Jan-13	14.90
Feb-03	9.21	Aug-05	11.51	Feb-08	41.10	Aug-10	21.39	Feb-13	14.75
Mar-03	9.99	Sep-05	13.40	Mar-08	45.60	Sep-10	22.24	Mar-13	16.15
Apr-03	10.84	Oct-05	15.06	Apr-08	48.25	Oct-10	18.61	Apr-13	16.36
May-03	11.73	Nov-05	13.50	May-08	60.45	Nov-10	18.34	May-13	15.20
Jun-03	11.24	Dec-05	12.95	Jun-08	51.38	Dec-10	21.06	Jun-13	15.94
Jul-03	12.20	Jan-06	11.71	Jul-08	52.94	Jan-11	18.90	Jul-13	16.44
Aug-03	12.51	Feb-06	11.62	Aug-08	42.99	Feb-11	19.00	Aug-13	15.24
Sep-03	12.32	Mar-06	12.20	Sep-08	29.66	Mar-11	21.69	Sep-13	15.50
Oct-03	17.10	Apr-06	12.41	Oct-08	13.06	Apr-11	20.31	Oct-13	19.62
Nov-03	17.81	May-06	13.06	Nov-08	9.82	May-11	20.76	Nov-13	19.09
Dec-03	22.38	Jun-06	15.04	Dec-08	7.10	Jun-11	22.19	Dec-13	22.12
Jan-04	25.30	Jul-06	16.12	Jan-09	8.24	Jul-11	21.72		
Feb-04	25.81	Aug-06	17.60	Feb-09	13.25	Aug-11	20.88		
Mar-04	24.75	Sep-06	19.30	Mar-09	15.21	Sep-11	20.81		
Apr-04	22.90	Oct-06	17.12	Apr-09	11.60	Oct-11	22.81		
May-04	18.69	Nov-06	17.50	May-09	18.52	Nov-11	21.69		
Jun-04	15.22	Dec-06	18.55	Jun-09	21.62	Dec-11	21.10		

Appendix B

Panamax Coal Voyage Rates Newcastle/Japan 70,000t $/Tonne

Jan-02	5.94	Jul-04	19.30	Jan-07	21.62	Jul-09	18.46	Jan-12	16.21
Feb-02	5.70	Aug-04	19.60	Feb-07	20.62	Aug-09	18.31	Feb-12	15.25
Mar-02	5.88	Sep-04	20.18	Mar-07	22.40	Sep-09	17.50	Mar-12	15.81
Apr-02	5.62	Oct-04	22.65	Apr-07	24.12	Oct-09	18.55	Apr-12	16.81
May-02	6.09	Nov-04	26.51	May-07	26.50	Nov-09	23.38	May-12	16.30
Jun-02	6.48	Dec-04	25.64	Jun-07	26.70	Dec-09	23.44	Jun-12	13.76
Jul-02	6.59	Jan-05	21.62	Jul-07	35.82	Jan-10	23.24	Jul-12	14.08
Aug-02	6.24	Feb-05	22.09	Aug-07	36.10	Feb-10	22.45	Aug-12	14.01
Sep-02	6.91	Mar-05	24.10	Sep-07	45.69	Mar-10	24.10	Sep-12	13.15
Oct-02	7.70	Apr-05	19.52	Oct-07	54.21	Apr-10	24.21	Oct-12	13.90
Nov-02	8.22	May-05	15.90	Nov-07	53.45	May-10	25.20	Nov-12	14.42
Dec-02	10.18	Jun-05	14.16	Dec-07	43.21	Jun-10	21.09	Dec-12	13.61
Jan-03	11.68	Jul-05	12.50	Jan-08	31.66	Jul-10	17.53	Jan-13	13.10
Feb-03	10.82	Aug-05	13.90	Feb-08	31.97	Aug-10	19.40	Feb-13	13.62
Mar-03	10.00	Sep-05	15.31	Mar-08	39.98	Sep-10	20.66	Mar-13	15.85
Apr-03	10.76	Oct-05	17.31	Apr-08	38.69	Oct-10	18.13	Apr-13	15.64
May-03	12.14	Nov-05	14.38	May-08	42.75	Nov-10	18.19	May-13	13.31
Jun-03	12.20	Dec-05	13.83	Jun-08	46.22	Dec-10	15.26	Jun-13	12.58
Jul-03	12.91	Jan-06	12.95	Jul-08	40.94	Jan-11	13.44	Jul-13	13.42
Aug-03	11.99	Feb-06	13.20	Aug-08	31.23	Feb-11	17.01	Aug-13	13.39
Sep-03	12.78	Mar-06	17.30	Sep-08	29.31	Mar-11	19.96	Sep-13	16.79
Oct-03	24.83	Apr-06	14.19	Oct-08	12.75	Apr-11	16.65	Oct-13	19.91
Nov-03	23.69	May-06	14.56	Nov-08	9.44	May-11	18.41	Nov-13	16.92
Dec-03	24.50	Jun-06	16.70	Dec-08	7.44	Jun-11	18.30	Dec-13	16.75
Jan-04	25.65	Jul-06	17.00	Jan-09	6.60	Jul-11	15.20		
Feb-04	25.00	Aug-06	18.62	Feb-09	9.32	Aug-11	15.58		
Mar-04	25.25	Sep-06	21.45	Mar-09	10.35	Sep-11	17.44		
Apr-04	21.45	Oct-06	22.85	Apr-09	9.60	Oct-11	18.36		
May-04	16.94	Nov-06	23.12	May-09	12.00	Nov-11	18.15		
Jun-04	13.64	Dec-06	22.25	Jun-09	18.19	Dec-11	17.34		

Appendix C

Industrial Production Europe % Yr/Yr

Feb-02	-2.65	Aug-04	2.84	Feb-07	5.27	Aug-09	-13.12	Feb-12	-2.88
Mar-02	-0.80	Sep-04	3.25	Mar-07	5.15	Sep-09	-11.63	Mar-12	-2.22
Apr-02	0.34	Oct-04	1.96	Apr-07	4.17	Oct-09	-8.58	Apr-12	-2.63
May-02	-0.08	Nov-04	1.76	May-07	3.91	Nov-09	-5.76	May-12	-2.80
Jun-02	0.02	Dec-04	0.61	Jun-07	3.44	Dec-09	-1.66	Jun-12	-3.18
Jul-02	1.19	Jan-05	0.92	Jul-07	4.20	Jan-10	2.89	Jul-12	-2.51
Aug-02	-0.68	Feb-05	0.92	Aug-07	4.18	Feb-10	4.57	Aug-12	-1.15
Sep-02	0.94	Mar-05	0.20	Sep-07	3.89	Mar-10	7.34	Sep-12	-3.15
Oct-02	1.73	Apr-05	1.11	Oct-07	4.56	Apr-10	8.39	Oct-12	-3.50
Nov-02	2.81	May-05	0.10	Nov-07	3.57	May-10	9.30	Nov-12	-3.94
Dec-02	1.49	Jun-05	1.01	Dec-07	1.95	Jun-10	8.01	Dec-12	-2.67
Jan-03	2.00	Jul-05	1.11	Jan-08	4.49	Jul-10	7.09	Jan-13	-2.94
Feb-03	1.52	Aug-05	1.63	Feb-08	3.43	Aug-10	7.82	Feb-13	-2.80
Mar-03	0.74	Sep-05	2.23	Mar-08	2.03	Sep-10	6.05	Mar-13	-3.20
Apr-03	0.69	Oct-05	2.53	Apr-08	4.19	Oct-10	7.07	Apr-13	-0.30
May-03	-0.59	Nov-05	3.56	May-08	0.00	Nov-10	7.17	May-13	-1.66
Jun-03	-0.25	Dec-05	3.87	Jun-08	0.65	Dec-10	8.24	Jun-13	-0.03
Jul-03	1.54	Jan-06	3.35	Jul-08	-0.73	Jan-11	6.98	Jul-13	-1.75
Aug-03	0.40	Feb-06	3.85	Aug-08	-2.01	Feb-11	7.55	Aug-13	-2.29
Sep-03	0.28	Mar-06	4.78	Sep-08	-2.56	Mar-11	5.25	Sep-13	0.25
Oct-03	2.24	Apr-06	3.20	Oct-08	-5.81	Apr-11	3.76	Oct-13	1.04
Nov-03	1.30	May-06	5.86	Nov-08	-8.62	May-11	3.80	Nov-13	2.28
Dec-03	3.11	Jun-06	4.90	Dec-08	-12.30	Jun-11	2.28	Dec-13	1.41
Jan-04	2.12	Jul-06	4.59	Jan-09	-16.46	Jul-11	3.33		
Feb-04	2.65	Aug-06	5.83	Feb-09	-17.58	Aug-11	4.17		
Mar-04	3.19	Sep-06	4.57	Mar-09	-17.38	Sep-11	1.22		
Apr-04	3.65	Oct-06	3.85	Apr-09	-19.11	Oct-11	-0.09		
May-04	5.10	Nov-06	4.42	May-09	-16.07	Nov-11	-0.47		
Jun-04	4.66	Dec-06	5.48	Jun-09	-15.31	Dec-11	-1.08		

Appendix D

Japan Steel Production 1,000 tonnes

Jan-02	8482	Jul-04	9551	Jan-07	10064	Jul-09	7660	Jan-12	8630
Feb-02	7867	Aug-04	9397	Feb-07	9206	Aug-09	8307	Feb-12	8612
Mar-02	8706	Sep-04	9209	Mar-07	10256	Sep-09	8269	Mar-12	9324
Apr-02	8757	Oct-04	9736	Apr-07	9740	Oct-09	8801	Apr-12	9077
May-02	9390	Nov-04	9451	May-07	10172	Nov-09	8858	May-12	9224
Jun-02	9141	Dec-04	9565	Jun-07	9980	Dec-09	8951	Jun-12	9198
Jul-02	8977	Jan-05	9519	Jul-07	10017	Jan-10	8724	Jul-12	9251
Aug-02	9241	Feb-05	8654	Aug-07	9962	Feb-10	8445	Aug-12	9207
Sep-02	9124	Mar-05	9590	Sep-07	9929	Mar-10	9341	Sep-12	8802
Oct-02	9457	Apr-05	9476	Oct-07	10371	Apr-10	8987	Oct-12	8836
Nov-02	9305	May-05	10034	Nov-07	10120	May-10	9727	Nov-12	8505
Dec-02	9299	Jun-05	9454	Dec-07	10382	Jun-10	9352	Dec-12	8569
Jan-03	9324	Jul-05	9430	Jan-08	10250	Jul-10	9222	Jan-13	8863
Feb-03	8386	Aug-05	9233	Feb-08	9811	Aug-10	8899	Feb-13	8321
Mar-03	9394	Sep-05	9171	Mar-08	10775	Sep-10	9233	Mar-13	9453
Apr-03	8957	Oct-05	9683	Apr-08	10143	Oct-10	9508	Apr-13	9169
May-03	9651	Nov-05	9143	May-08	10547	Nov-10	8987	May-13	9625
Jun-03	9320	Dec-05	9087	Jun-08	10370	Dec-10	9173	Jun-13	9280
Jul-03	9258	Jan-06	9453	Jul-08	10193	Jan-11	9655	Jul-13	9291
Aug-03	9249	Feb-06	8878	Aug-08	10168	Feb-11	8936	Aug-13	9144
Sep-03	8994	Mar-06	9665	Sep-08	10086	Mar-11	9113	Sep-13	9289
Oct-03	9427	Apr-06	9356	Oct-08	10097	Apr-11	8433	Oct-13	9527
Nov-03	9277	May-06	9928	Nov-08	8815	May-11	9049	Nov-13	9273
Dec-03	9284	Jun-06	9690	Dec-08	7488	Jun-11	8886	Dec-13	9336
Jan-04	9338	Jul-06	9859	Jan-09	6378	Jul-11	9152		
Feb-04	8945	Aug-06	9613	Feb-09	5479	Aug-11	8909		
Mar-04	9285	Sep-06	9612	Mar-09	5739	Sep-11	8889		
Apr-04	9180	Oct-06	10115	Apr-09	5734	Oct-11	9478		
May-04	9625	Nov-06	10008	May-09	6476	Nov-11	8697		
Jun-04	9420	Dec-06	10057	Jun-09	6883	Dec-11	8397		

Appendix E

EU-27 Steel Production 1,000 tonnes

Jan-07	17978	Jul-09	11215	Jan-12	14158
Feb-07	16903	Aug-09	10509	Feb-12	14173
Mar-07	19028	Sep-09	13307	Mar-12	15729
Apr-07	18119	Oct-09	14272	Apr-12	14951
May-07	18438	Nov-09	14012	May-12	15415
Jun-07	17827	Dec-09	12018	Jun-12	14716
Jul-07	17157	Jan-10	13700	Jul-12	14228
Aug-07	15448	Feb-10	13314	Aug-12	12028
Sep-07	17163	Mar-10	15548	Sep-12	14301
Oct-07	17793	Apr-10	15419	Oct-12	14161
Nov-07	17188	May-10	16509	Nov-12	13595
Dec-07	17051	Jun-10	15180	Dec-12	11975
Jan-08	17792	Jul-10	13790	Jan-13	13511
Feb-08	17063	Aug-10	12249	Feb-13	13280
Mar-08	18726	Sep-10	14338	Mar-13	14404
Apr-08	18093	Oct-10	15507	Apr-13	14116
May-08	18749	Nov-10	14653	May-13	14631
Jun-08	18163	Dec-10	12953	Jun-13	14068
Jul-08	17412	Jan-11	14699	Jul-13	13543
Aug-08	15855	Feb-11	14647	Aug-13	11997
Sep-08	17168	Mar-11	16312	Sep-13	14346
Oct-08	16112	Apr-11	15662	Oct-13	14652
Nov-08	12756	May-11	16335	Nov-13	14305
Dec-08	9069	Jun-11	15858	Dec-13	13124
Jan-09	9821	Jul-11	14951		
Feb-09	10071	Aug-11	12649		
Mar-09	10315	Sep-11	14674		
Apr-09	9483	Oct-11	15273		
May-09	10787	Nov-11	15274		
Jun-09	11225	Dec-11	15674		

Appendix F

Panamax Bulkcarrier Fleet Development Million DWT

Jan-02	76.17	Jul-04	82.98	Jan-07	101.51	Jul-09	117.19	Jan-12	151.79
Feb-02	77.24	Aug-04	83.67	Feb-07	102.13	Aug-09	117.38	Feb-12	154.03
Mar-02	77.39	Sep-04	84.06	Mar-07	102.74	Sep-09	117.92	Mar-12	155.58
Apr-02	77.88	Oct-04	84.83	Apr-07	103.38	Oct-09	118.60	Apr-12	157.20
May-02	78.06	Nov-04	85.29	May-07	104.02	Nov-09	119.35	May-12	158.10
Jun-02	78.59	Dec-04	85.82	Jun-07	104.35	Dec-09	120.01	Jun-12	160.56
Jul-02	78.68	Jan-05	86.21	Jul-07	105.00	Jan-10	120.28	Jul-12	162.97
Aug-02	78.74	Feb-05	86.67	Aug-07	105.50	Feb-10	121.71	Aug-12	164.45
Sep-02	78.79	Mar-05	87.13	Sep-07	106.07	Mar-10	122.50	Sep-12	166.03
Oct-02	78.66	Apr-05	87.98	Oct-07	106.47	Apr-10	123.28	Oct-12	167.04
Nov-02	78.65	May-05	88.76	Nov-07	106.72	May-10	124.91	Nov-12	167.61
Dec-02	78.80	Jun-05	89.45	Dec-07	107.44	Jun-10	125.72	Dec-12	169.21
Jan-03	78.89	Jul-05	89.92	Jan-08	107.93	Jul-10	126.93	Jan-13	169.90
Feb-03	79.10	Aug-05	90.85	Feb-08	108.41	Aug-10	127.93	Feb-13	173.03
Mar-03	79.25	Sep-05	91.16	Mar-08	108.89	Sep-10	128.86	Mar-13	173.15
Apr-03	79.33	Oct-05	91.94	Apr-08	109.67	Oct-10	130.50	Apr-13	174.77
May-03	79.42	Nov-05	92.57	May-08	110.06	Nov-10	131.65	May-13	175.92
Jun-03	79.57	Dec-05	93.23	Jun-08	110.76	Dec-10	133.39	Jun-13	177.47
Jul-03	79.69	Jan-06	93.53	Jul-08	111.09	Jan-11	134.71	Jul-13	177.92
Aug-03	79.69	Feb-06	94.80	Aug-08	111.50	Feb-11	135.86	Aug-13	179.28
Sep-03	79.78	Mar-06	95.03	Sep-08	112.35	Mar-11	136.94	Sep-13	180.19
Oct-03	79.89	Apr-06	96.02	Oct-08	113.13	Apr-11	138.28	Oct-13	181.30
Nov-03	80.05	May-06	96.52	Nov-08	113.89	May-11	139.31	Nov-13	183.05
Dec-03	80.12	Jun-06	97.14	Dec-08	114.13	Jun-11	141.06	Dec-13	184.89
Jan-04	80.05	Jul-06	97.79	Jan-09	114.16	Jul-11	142.54		
Feb-04	80.51	Aug-06	98.35	Feb-09	114.21	Aug-11	143.76		
Mar-04	80.96	Sep-06	99.08	Mar-09	114.58	Sep-11	144.83		
Apr-04	81.50	Oct-06	99.92	Apr-09	114.97	Oct-11	147.37		
May-04	82.04	Nov-06	100.31	May-09	115.45	Nov-11	149.11		
Jun-04	82.60	Dec-06	100.95	Jun-09	116.07	Dec-11	150.79		

Appendix G

Average Bulkcarrier $/cgt

Jan-02	1178.58	Jul-04	1756.71	Jan-07	2334.60	Jul-09	2028.11	Jan-12	1663.49
Feb-02	1156.73	Aug-04	1822.79	Feb-07	2447.33	Aug-09	1962.21	Feb-12	1633.85
Mar-02	1165.94	Sep-04	1873.22	Mar-07	2516.23	Sep-09	1914.80	Mar-12	1630.40
Apr-02	1163.86	Oct-04	1957.22	Apr-07	2539.36	Oct-09	1897.41	Apr-12	1624.61
May-02	1172.38	Nov-04	1999.32	May-07	2649.07	Nov-09	1909.81	May-12	1624.61
Jun-02	1190.80	Dec-04	2011.95	Jun-07	2711.38	Dec-09	1904.01	Jun-12	1616.64
Jul-02	1184.04	Jan-05	2103.63	Jul-07	2778.79	Jan-10	1898.22	Jul-12	1613.76
Aug-02	1184.04	Feb-05	2119.57	Aug-07	2868.03	Feb-10	1900.43	Aug-12	1585.83
Sep-02	1195.63	Mar-05	2208.85	Sep-07	2925.58	Mar-10	1906.20	Sep-12	1572.08
Oct-02	1201.43	Apr-05	2227.27	Oct-07	2999.49	Apr-10	1961.47	Oct-12	1561.34
Nov-02	1209.43	May-05	2231.68	Nov-07	3032.52	May-10	1981.76	Nov-12	1557.90
Dec-02	1214.53	Jun-05	2132.91	Dec-07	3077.10	Jun-10	2011.74	Dec-12	1557.90
Jan-03	1251.85	Jul-05	2132.91	Jan-08	3053.91	Jul-10	2008.20	Jan-13	1557.90
Feb-03	1259.85	Aug-05	2053.11	Feb-08	3060.80	Aug-10	1993.74	Feb-13	1557.90
Mar-03	1274.86	Sep-05	2034.24	Mar-08	3066.60	Sep-10	1970.61	Mar-13	1563.69
Apr-03	1274.86	Oct-05	2029.83	Apr-08	3066.60	Oct-10	1970.61	Apr-13	1572.38
May-03	1277.07	Nov-05	2010.31	May-08	3086.08	Nov-10	1961.92	May-13	1583.95
Jun-03	1277.07	Dec-05	2010.31	Jun-08	3091.87	Dec-10	1959.02	Jun-13	1583.95
Jul-03	1307.90	Jan-06	1977.28	Jul-08	3116.10	Jan-11	1941.63	Jul-13	1602.79
Aug-03	1346.90	Feb-06	1962.68	Aug-08	3156.61	Feb-11	1930.09	Aug-13	1624.44
Sep-03	1384.92	Mar-06	1969.86	Sep-08	3107.22	Mar-11	1906.80	Sep-13	1636.04
Oct-03	1422.93	Apr-06	1969.86	Oct-08	2963.52	Apr-11	1903.93	Oct-13	1682.91
Nov-03	1512.53	May-06	1998.49	Nov-08	2764.03	May-11	1903.93	Nov-13	1704.70
Dec-03	1532.93	Jun-06	2027.12	Dec-08	2723.82	Jun-11	1903.93	Dec-13	1709.78
Jan-04	1620.75	Jul-06	2109.17	Jan-09	2482.50	Jul-11	1828.50		
Feb-04	1648.95	Aug-06	2168.68	Feb-09	2284.94	Aug-11	1799.84		
Mar-04	1739.47	Sep-06	2232.07	Mar-09	2267.55	Sep-11	1768.55		
Apr-04	1847.14	Oct-06	2269.80	Apr-09	2248.53	Oct-11	1706.62		
May-04	1782.16	Nov-06	2281.40	May-09	2232.55	Nov-11	1685.27		
Jun-04	1713.14	Dec-06	2288.28	Jun-09	2125.93	Dec-11	1685.27		

Appendix H

Bulk Carrier Secondhand Prices Index

Jan-02	84	Jul-04	160	Jan-07	264	Jul-09	189	Jan-12	164
Feb-02	84	Aug-04	173	Feb-07	272	Aug-09	190	Feb-12	146
Mar-02	87	Sep-04	180	Mar-07	293	Sep-09	183	Mar-12	143
Apr-02	89	Oct-04	181	Apr-07	307	Oct-09	176	Apr-12	140
May-02	90	Nov-04	194	May-07	328	Nov-09	180	May-12	141
Jun-02	90	Dec-04	197	Jun-07	336	Dec-09	187	Jun-12	138
Jul-02	89	Jan-05	224	Jul-07	356	Jan-10	198	Jul-12	132
Aug-02	88	Feb-05	231	Aug-07	400	Feb-10	205	Aug-12	129
Sep-02	88	Mar-05	233	Sep-07	422	Mar-10	213	Sep-12	122
Oct-02	89	Apr-05	238	Oct-07	453	Apr-10	219	Oct-12	120
Nov-02	90	May-05	236	Nov-07	472	May-10	226	Nov-12	119
Dec-02	92	Jun-05	228	Dec-07	462	Jun-10	229	Dec-12	118
Jan-03	96	Jul-05	200	Jan-08	436	Jul-10	215	Jan-13	117
Feb-03	98	Aug-05	197	Feb-08	449	Aug-10	215	Feb-13	121
Mar-03	99	Sep-05	209	Mar-08	461	Sep-10	219	Mar-13	121
Apr-03	100	Oct-05	204	Apr-08	471	Oct-10	216	Apr-13	124
May-03	100	Nov-05	198	May-08	485	Nov-10	214	May-13	131
Jun-03	101	Dec-05	187	Jun-08	495	Dec-10	202	Jun-13	132
Jul-03	103	Jan-06	186	Jul-08	500	Jan-11	203	Jul-13	132
Aug-03	105	Feb-06	181	Aug-08	493	Feb-11	200	Aug-13	131
Sep-03	108	Mar-06	187	Sep-08	441	Mar-11	188	Sep-13	138
Oct-03	119	Apr-06	186	Oct-08	221	Apr-11	187	Oct-13	143
Nov-03	122	May-06	189	Nov-08	166	May-11	189	Nov-13	150
Dec-03	133	Jun-06	194	Dec-08	158	Jun-11	187	Dec-13	150
Jan-04	161	Jul-06	218	Jan-09	162	Jul-11	179		
Feb-04	178	Aug-06	233	Feb-09	165	Aug-11	168		
Mar-04	192	Sep-06	244	Mar-09	164	Sep-11	168		
Apr-04	191	Oct-06	248	Apr-09	162	Oct-11	171		
May-04	167	Nov-06	250	May-09	173	Nov-11	167		
Jun-04	148	Dec-06	258	Jun-09	182	Dec-11	155		

Appendix I

380cst bunker prices, Rotterdam $/Tonne

Jan-02	104.50	Jul-04	162.90	Jan-07	229.12	Jul-09	382.80	Jan-12	682.38
Feb-02	103.25	Aug-04	167.00	Feb-07	251.50	Aug-09	429.38	Feb-12	694.62
Mar-02	120.50	Sep-04	161.75	Mar-07	272.70	Sep-09	412.38	Mar-12	712.60
Apr-02	136.12	Oct-04	173.90	Apr-07	312.00	Oct-09	423.10	Apr-12	697.00
May-02	140.80	Nov-04	146.50	May-07	325.88	Nov-09	462.00	May-12	651.50
Jun-02	135.00	Dec-04	143.50	Jun-07	325.90	Dec-09	438.75	Jun-12	572.40
Jul-02	142.75	Jan-05	157.50	Jul-07	359.88	Jan-10	457.20	Jul-12	597.12
Aug-02	145.90	Feb-05	171.25	Aug-07	353.70	Feb-10	445.50	Aug-12	640.50
Sep-02	161.38	Mar-05	203.00	Sep-07	374.00	Mar-10	453.25	Sep-12	640.00
Oct-02	154.00	Apr-05	231.90	Oct-07	412.50	Apr-10	467.00	Oct-12	616.75
Nov-02	125.70	May-05	230.12	Nov-07	476.10	May-10	437.38	Nov-12	588.00
Dec-02	134.38	Jun-05	232.25	Dec-07	447.50	Jun-10	424.38	Dec-12	582.75
Jan-03	173.50	Jul-05	248.90	Jan-08	447.75	Jul-10	423.70	Jan-13	608.75
Feb-03	175.12	Aug-05	261.75	Feb-08	436.90	Aug-10	439.62	Feb-13	634.50
Mar-03	148.25	Sep-05	288.40	Mar-08	477.38	Sep-10	431.50	Mar-13	605.60
Apr-03	126.38	Oct-05	270.50	Apr-08	494.88	Oct-10	458.60	Apr-13	584.00
May-03	137.90	Nov-05	256.38	May-08	542.90	Nov-10	476.00	May-13	580.20
Jun-03	147.50	Dec-05	255.80	Jun-08	593.76	Dec-10	488.60	Jun-13	580.00
Jul-03	170.50	Jan-06	282.88	Jul-08	679.50	Jan-11	514.75	Jul-13	596.75
Aug-03	159.70	Feb-06	294.75	Aug-08	635.60	Feb-11	575.25	Aug-13	601.60
Sep-03	147.75	Mar-06	300.30	Sep-08	544.12	Mar-11	606.38	Sep-13	597.50
Oct-03	151.90	Apr-06	320.12	Oct-08	398.00	Apr-11	641.60	Oct-13	588.50
Nov-03	154.75	May-06	324.62	Nov-08	217.62	May-11	621.75	Nov-13	575.90
Dec-03	141.00	Jun-06	301.40	Dec-08	194.50	Jun-11	631.25	Dec-13	584.25
Jan-04	141.40	Jul-06	316.50	Jan-09	225.70	Jul-11	647.50		
Feb-04	139.00	Aug-06	311.00	Feb-09	239.12	Aug-11	634.38		
Mar-04	144.50	Sep-06	280.50	Mar-09	244.50	Sep-11	640.50		
Apr-04	152.60	Oct-06	266.12	Apr-09	276.25	Oct-11	633.00		
May-04	170.62	Nov-06	262.38	May-09	327.50	Nov-11	645.12		
Jun-04	159.50	Dec-06	255.90	Jun-09	384.25	Dec-11	623.80		

Appendix J

Brent Crude Oil Price $/bbl

Jan-02	19.48	Jul-04	37.24	Jan-07	53.32	Jul-09	64.81	Jan-12	111.80
Feb-02	20.37	Aug-04	43.38	Feb-07	56.55	Aug-09	72.42	Feb-12	119.79
Mar-02	23.68	Sep-04	42.01	Mar-07	61.82	Sep-09	68.22	Mar-12	124.11
Apr-02	25.52	Oct-04	49.27	Apr-07	67.58	Oct-09	71.55	Apr-12	117.18
May-02	24.17	Nov-04	43.20	May-07	67.77	Nov-09	76.65	May-12	107.98
Jun-02	25.58	Dec-04	40.11	Jun-07	70.58	Dec-09	74.08	Jun-12	91.23
Jul-02	25.33	Jan-05	44.06	Jul-07	76.30	Jan-10	72.32	Jul-12	104.18
Aug-02	27.33	Feb-05	44.97	Aug-07	71.39	Feb-10	73.43	Aug-12	113.02
Sep-02	28.33	Mar-05	53.10	Sep-07	76.45	Mar-10	78.69	Sep-12	110.35
Oct-02	27.08	Apr-05	52.26	Oct-07	81.12	Apr-10	83.76	Oct-12	108.11
Nov-02	24.67	May-05	48.54	Nov-07	92.64	May-10	76.27	Nov-12	110.26
Dec-02	30.19	Jun-05	53.69	Dec-07	91.95	Jun-10	74.60	Dec-12	108.83
Jan-03	31.50	Jul-05	57.22	Jan-08	94.47	Jul-10	75.75	Jan-13	111.35
Feb-03	33.16	Aug-05	63.20	Feb-08	95.72	Aug-10	73.78	Feb-13	115.30
Mar-03	28.63	Sep-05	63.83	Mar-08	105.11	Sep-10	78.85	Mar-13	107.43
Apr-03	25.32	Oct-05	58.88	Apr-08	108.61	Oct-10	84.49	Apr-13	100.61
May-03	26.25	Nov-05	56.01	May-08	122.44	Nov-10	85.10	May-13	101.47
Jun-03	27.65	Dec-05	56.35	Jun-08	132.54	Dec-10	94.28	Jun-13	103.39
Jul-03	30.27	Jan-06	62.61	Jul-08	137.19	Jan-11	96.86	Jul-13	108.40
Aug-03	29.89	Feb-06	60.87	Aug-08	116.93	Feb-11	104.60	Aug-13	111.12
Sep-03	29.33	Mar-06	57.30	Sep-08	101.10	Mar-11	114.59	Sep-13	109.98
Oct-03	26.45	Apr-06	70.07	Oct-08	75.64	Apr-11	123.91	Oct-13	110.11
Nov-03	28.72	May-06	70.06	Nov-08	52.97	May-11	114.90	Nov-13	109.32
Dec-03	30.02	Jun-06	68.53	Dec-08	41.33	Jun-11	115.85	Dec-13	110.34
Jan-04	33.03	Jul-06	73.67	Jan-09	41.81	Jul-11	117.95		
Feb-04	30.61	Aug-06	74.50	Feb-09	43.26	Aug-11	109.93		
Mar-04	33.93	Sep-06	63.18	Mar-09	46.30	Sep-11	113.79		
Apr-04	32.96	Oct-06	57.75	Apr-09	50.21	Oct-11	109.29		
May-04	37.69	Nov-06	59.16	May-09	55.68	Nov-11	106.82		
Jun-04	35.83	Dec-06	62.41	Jun-09	66.14	Dec-11	107.06		