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Empirical research of the Chinese coastal coal freight index derivatives hedging effectiveness

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DRECLARATION

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

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

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ABSTRACT

Affected by the financial crisis, the world economy is the sharp decline in the Baltic Dry Freight Index (BDI) weak in recent years, serious surplus bulk vessel capacity in the international market, the international market, domestic ship reflux, severe crush domestic capacity, to carriers coastal bulk shipping companies caused by the heavy pressure. In complex coastal bulk shipping market situation, the fluctuations in freight rates is even more dramatic, especially coal freight. So the market is in urgent need of a new risk management tools to control the losses caused by fluctuations in freight rates to the enterprise.

As the major project of Promoting Shanghai international shipping and financial center, Shanghai Shipping Freight Exchange Co. (SSEFC) is the forefront of the company in China shipping freight market, which successfully launched Shanghai Containerized Freight Index Forward Contract with routes of Shanghai to Europe and Shanghai to U.S. West Coast in 2011 Jun 28th. The shipping freight exchange product is a product that provides service for line companies, shippers, forwarders, NVOCCs, manufacturers and investors who participate in shipping freight trading activities. It is an effective tool which can be used for hedging the risks from the spot shipping freight market, targeting operating cost.

However, how to correctly realize and effectively use the shipping freight exchange product for avoiding risks will be an important meaning to the participants in container transport market. In addition, it has a great significance on success or failure of business operation. Consequently, rightly analyzing the relationship between spot freight and forward freight will be an important subject in shipping management.

Based on one representative voyage in i coastal bulk shipping, Qinhuangdao to shanghai/guangzhou, his paper use minimum variance Hedging model，bring in Kendall’S rank correlation model，Copula model and GED—GARCH mode to estimate the ratio of forward freight and spot price after hedging in use of Qinhuangdao to shanghai/ guangzhou two routes，and moreover, the results of

estimating hedging are satisfactory. Finally, by comparing the time series between beforeand after hedging the price，through analyzing the hedging effectiveness，it call be concluded that using the Tail Dependence to calculate the rate sequence of return after hedging as a smaller mean and variance， and its fluctuations are much more moderate than before hedging， SO it prove hedging function is very effective.

KEYWORDS: Coastal coal transportation, freight derivatives, hedging effectiveness, GED-GARCH model

Catalogue

Chapter 1 Introduction

1.1 Research background and significance

International dry bulk shipping market is stagnant in recent years. In 2015, the Baltic dry freight index (BDI) fell to an all-time low of 594 points. The depression of international dry bulk shipping market leads to excess transport capacity in market, and ships running international dry bulk transportation begin to dabble in domestic markets, which brought great pressure to domestic coastal coal transportation market and caused frequent fluctuations of China's coastal coal freight. All shipping companies and owners have to face huge risk.

There are two freight trading products: Qinhuangdao-Shanghai route and Qinhuangdao-Guangzhou, which are the first domestic dry bulk freight derivatives [35]. China coastal coal freight derivatives adopted electronic trading that is first used in area of international dry bulk freight index derivatives

More and more people deal in shipping derivatives business, so trading volume increases gradually. Market liquidity gradually improves, with the holdings also increasing. Since China coastal coal freight derivatives launched its trading products, by participating in trading, some owners and freight enterprise have achieved hedging and risk aversion and also got certain security in terms of stable profits. However, coastal coal transportation market participants can’t neglect how to correctly recognize and effectively operate shipping derivatives in order to avoid freight fluctuation risk, which is also significant for success of enterprise management. Therefore, correct analysis of the relation between spot freight and forward price, analysis of hedging effectiveness of shipping freight derivatives, will become a major topic in the study of shipping management.

1.2 Literature Review

At present, there is still little research on SSEFC shipping derivatives, although they have been on market for over a year. As part of derivatives with the related properties, SSEFC shipping derivatives can have their hedging effectiveness judged

by reference from the research methods of derivatives and Forward Freight Agreement (FFA).

1.2.1 Review on foreign research status

By concluding the previous research, we have discovered that hedging theory is mostly used in stock index futures, crude oil futures, metals, the grain futures and other related industries, but seldom in shipping derivatives market. The definition of hedging is proposed first by Working (1953), Johnson (1960) and Stein (1961). Later Ederington (1979) raised the minimum variance hedging ratio on the basis of their theory. Cecchetti later discovered by means of ARCH model that the optimal hedging ratio was never all the same but kept changing with time. After the research on CC-GARCH, Tse and Tsui came up with GARCH (TVC. GARCH) model with better hedging effects than the previous models. Baillie and Mayers made an analysis on the optimal dynamic hedging ratio of various commodity futures with the help of GARCH model, and by the analysis on FYSE100, Sim&Zurbruegg (2001) announced that time-varying hedging ratio produces better effects than simple constant hedging ratio.

Currently, the academic paper on FFA are mainly from abroad. Manolis, Ilias and Roy (2004) studied the changes of spot price fluctuation rate after panamax carrier introduced FFA to two cross-Atlantic and two cross-Pacific sea routes. The study result suggested the fall of the spot price fluctuation rates for all the sea routes and the increase in price information transmission speed and quality of the three sea routes. Manolis and Ilias (2004) also tested the relation between freight forward market and spot market in rate of return and fluctuation, and discovered that forward market price discovery speed is higher than spot market, due to the higher transaction cost at spot market. That explains why the price of FFA has a price discovery function for spot price on panamax carrier sea route. Steen, Roar and Sigbjern (2007) built freight derivative Asian option pricing model and proved that when spot price followed lognormal distribution, FFA price also followed the distribution before account settlement.

Julius Bell and Orin Sexon made a detailed explanation on the insurance

function of hedging business and thought “hedging aims to transfer credit and price risk, lock profit and limit loss, instead of commercial speculation and gaining profits”. Kavussanos and Visvikis (2005) conducted a research on the minimum variance hedge ratio targeted on four sea routes. The mathematical models he used included VECM,SURE-VECM,VECM-GARCH and VECM-GARCH-X, and in the research he concluded that FFA had a big difference in hedging efficiency on each of the sea route, and by comparison, the hedging efficiency on the cross-Atlantic sea routes are more ideal that the sea routes cross Pacific.

1.2.2 Review on domestic research status

Over these recent years, our domestic derivatives market are advancing at a fast pace, and with such trend, the research on derivatives hedge is also springing up.

Zhangjian and Yang Zhiyong (2006) analyzed the risk of dry bulk shipping market, explored the application of FFA in the market fluctuation risk management and thus suggested that Chinese ship-owners and charters should make positive use of this risk management tool. Yang Fan (2007) made a qualitative analysis on the relation between dry bulk FFA market and spot market, pointed out that most of the charters were judging the trend of spot market chartered freight on the basis of the trend of FFA market price. On top of this, he proceeded to analyze the dangers of excessive speculation on forward freight market, and suggested domestic shipping market participants to take advantages of the market for hedging and risk prevention, with the caution for over speculation. Duan Guodong (2009) made an analysis on the development and the current status of FFA and illustrated the hedging function of FFA with examples. Wang Jun (2010) made an empirical analysis on the hedging ratio and performance on hard wheat and soy derivatives market, with the help of the four models-OLS, BVAR, ECM and ECGARCH, and hedging performance index. According to the analysis results, the optimal hedging ratios of the four-week data of hard wheat and soy derivatives were respectively 0.28 and 0.48, and the hedging performances respectively 10.27 and 18.65, both the hedging ratios and performances higher than the first two weeks. And by comparison, it also found that the hedging ratio and performance of soy derivatives market were better than hard

wheat derivatives.

Lv Jianglin and Hu Zhishan (2011) tested and compared the hedging performance of the optimal hedging ratio models with and without the consideration for basic convergence. In his efforts, such conclusions had been drawn: under the high spot price water market structure, the optimal hedging ratio model with the consideration for basic convergence is superior to that without considering basic convergence; spot goods holders, either those who comprehensively weighing the revenues and risks or the extreme risk averters, would have their ratio performance well improved, in case of considering basic convergence in their hedging decisions and making the optimal hedging ratio properly less than 1. Hou Shufeng (2012) held that the basic convergence was mainly attributed to the theoretical price of stick index features and the difference from object stock index, and in stock futures hedging tractions, basic convergence was one of the major elements affecting hedging efficiency. However, basic convergence also varies with stock futures hedging strategies. Lu Guoli and Zheng Xiangqing (2011) discussed the connotation of financial futures, hedging theory in financial futures market, basic operation method and the basic convergence risk in futures business, as well as the effects of the varying basic convergence on the hedging. Ding Yan and Huang Jian (2013) made a research on basic convergence risk measurement of Nikkei 225 index futures, which mainly reflected that stock futures, as a risk prevention tool in futures contract, could use the related models to calculate the change direction of the basic convergence and thus make predictions of the stock market change. Li Bojie and Zhou Yan (2009) studied the basic convergence risk and introduced the management methods adopted by the enterprises for the risk.

1.3 Research contents and method

The thesis aims to explore the hedging effectiveness of SSEFC costal coal shipping freight derivatives with Qinhuangdao-Guangzhou and Qinhuangdao-Shanghai sea routes as the research examples. The thesis first respectively selected the spot and forward freight rates of the two sea routes as the

data samples, and estimated the optimal spot and forward hedging ratios of the two sea routes based on the minimum variance model under non-linear combination. The next the thesis made a comparative analysis on the change in the fluctuation of time series before and after hedging, and in the end the analysis also extended to the application of the derivatives of the Chinese coastal coal freight in coastal coal transport market.

The research above is to realize the following purpose:

(1) Allow the coastal coal shipping market participants to correctly understand the fluctuation rule of the spot and forward freight rates in coastal coal shipping market.

(2) Allow the coastal coal shipping market participants to effectively use Chinese coastal coal freight derivatives to avoid the freight risk.

(3) Provide reference for the developers and researchers of the Chinese coastal coal freight derivatives to formulate related transaction rule and strategies. Based on the specific contents of the thesis, the thesis is arranged in the structure as below:

Chapter 1: The introduction of the background, significance and contents of the research topic, and the research methods and conclusions in related research at home and abroad.

Chapter 2: Characteristics analysis on spot and forward costal shipping markets of coal, the overview of the influence factors for coastal coal freight index and its fluctuation, the introduction of the characteristics of the spot and forward freight rates of the costal coal, and the comparison between the spot and forward freight rates.

Chapter 3: The theories and model analysis on the hedging.

Chapter 4: The core part of the thesis-empirical analysis and research on the hedging effectiveness of Chinese coastal coal freight derivatives.

Chapter 5: Conclusion and prospect.

Chapter 2 Overview of spot and derivatives markets for costal coal

Chinese coastal coal shipping spot market and Chinese coastal coal freight index derivatives market are two different types of markets, but they are in close relation. Spot shipping market of coal is the basis on which Chinese coastal coal freight derivatives market exists and develops, and meanwhile, coastal coal freight index derivatives market is also the fruit of the development of coastal coal shipping market, and the vicissitude of coastal coal shipping market will directly affect the development of costal coal freight index derivatives market.

2.1 Overview of Chinese coastal coal shipping spot market

Over all the time, Chinese coastal coal shipping has been playing an essential role in our economic development, especially over the recent years, with the rapid growth of domestic economy, the increasing demands for coal has driven the rocketing rise of costal coal freight revenue and demonstrated the huge market potential[22]. In the following the thesis will make an analysis on Chinese costal coal shipping market from the terms of the costal coal shipping pattern and supply-demand factor.

2.1.1 Chinese costal coal shipping market pattern

In our water transport market, the traffic volume of the costal line and the main line of Yangtze River account for 70% of the total, and among the total traffic volumes of the two channels, coal takes up about 40%[37]. Therefore, costal line and the main line of Yangtze River are two major channels of our costal coal transport.

The water transport pattern for coal along our costal line is to first transport the coal from Shanxi (west of Yellow River), Shanxi (east of Yellow River), the west of Inner Monglia and Shandong areas to the large ports in North China by railway and highway, and then ship the resource to the needy areas of the country by water

transport along the costal line (such as Bohai Gulf, East and Mid-South of China, and Fujian). While the function of Yangtze River waterway is mainly to ship the coal to East China and the areas along the river with vessels starting from the ports along the river where the coal transported by railway from north are piled.

The coal shipping system along our costal line mainly start from such 7 loading ports in North China as Qinhuangdao, Tangshan, Tianjin, Huanghua, Qingdao, Rizhao and Lianyungang, with extra discharging wharfs in East and South China[22]. During January to November of 2014, coal shipment volume from the national major costal ports for domestic trade accumulated to 557mn tons, among, the seven ports in North China shipped 502mn tons. Furthermore, the major discharging ports for coal in South China are mainly Shanghai and Ningbo ports in East China and Guangzhou port in South, the three ports discharging almost 60~70% of the total volume of all the ports in South China.

2.1.2 Chinese coastal coal shipping market demand analysis

Over the recent years, despite the dramatic shrinkage of domestic coastal coal shipping volume, coal has never changed its role as the leading energy form in our country, and at the same time domestic capital coal shipping volume has been in steady growth. The thesis will make an analysis on our coastal coal shipping market demand situations from the following aspects.

(1) Sluggish demands for downstream products and the declines of coal discharging volume at various degrees

In 2012, under the influence of multiple factors, there appeared an overall sluggish demands for electricity in our country, and the six costal power plant saw a steady increasing trend in storage since the 10mn tons in that February[40]. High storage while low consumption brought a continuous dropping demand for coal, and the discharging volume of the coal for domestic trade also declined at different degrees at the six leading coal discharging ports. Among, coal discharging volume for domestic trade at Shanghai, Ningbo and Guangzhou Ports were respectively 65.686mn, 49.354mn and 32.756mn tons from January to November, respectively falling by 9.2%, 9.7% and 9.4% from the same period of last year, sharper declines

than the 7 ports in north. The cases was also the same in the market along Yangtze River, for example, during the first 11 months, Nanjing Port received only 8.203mn tons, 6.6% lower than the same period last year.

(2) The rapid increase in coal export contracting domestic coal shipping market demands.

In 2012, the sharp increase in coal export mainly results from the price advantages of the international market, especially the competitive prices of the steam coal from Australia and Indonesia pushing the export momentum higher than the last year. From January to October of 2012, we exported 225mn tons of coal at year-on-year growth rate of 33.5%, compared with 222mn tons through the whole 2011.during the third quarter, due to the dramatic fall in the price of domestic coal and the narrowing gap from the export coal, the export was once curbed; in the July of 2012, there first appeared the fall in link relative ratio, and when it came to the August, there could be seen a decline in both year-on-year ratio and link relative ratio, but still lingering around 200mn tons of export volume.

The export throughout that year had continuously impacted the domestic coal market and brought a serious challenge to coal shipping demands for domestic trade. The growth in expert volume was particularly remarkable in the major consumption area of East China. According to statistics, during the first 11 months, Shanghai and Ningbo ports respectively discharged 10.468mn and 5.654mn tons of export coal, with respectively year-on-year growth rates of 105.3% and 183.3%.The shrinkage of discharge volume of domestic coal was almost rightly filled by the export volume. Guangzhou Port, the major coal export area, also received a high volume of export coal at 16.781mn tons from January to November.

(3) Never a peak coal shipping demand during the peak season and lower in slack season.

We saw an embarrassing situation of coal shipping demand in 2012 that there was never a peak demand during peak season but a lower demand during slack season. During the peak period of high summer and the period of storage in winter, coal shipping demands remains suffering from the restrictions of high storage of the

power plant and the slow growth in domestic downstream demands. According to the statistics, during the June, July, August and November of 2012, coal shipment volume of the major domestic ports respectively dropped by 20.7%, 15.8%, 9.9% and 0.9% on year-on year basis, leading to a slow growth of domestic shipment volume and readjustment of the freight rates during the peak season. After the overhaul of Datong-Qin huangdao Rail Line in April, the coal storage at north ports reached to their capacity and broke the high record of 9.465mn tons, and what followed in September and October was the rapid decrease of the number of anchored ships at those ports suffered from the sluggish demands. That was also the true reflection of the slack season of 2012, during which coal freight rate was basically in the trend of unilateral decline.

2.1.3 Analysis of Coastal coal transportation market shipping supply

In coastal coal transportation market, ship supply capacity is influenced by many factors, such as transportation costs, new ship completion, ship trading market, and labor market and so on. When these factors change, ship capacity will change in the same direction or opposite direction. During a period of time, these factors determine the total tonnage of ship supply under a certain level of freight

In recent years, China's coastal market shows rapid growth in transportation capacity. According to Shanghai international shipping center, the total of coastal transportation vessels, in 2011, was 11923, which grew 13.8% than last year and also much higher than growth rate of 4.5% in 2010. At present , there are many domestic companies engaged in coastal coal transportation. On balance, ship blocks are generally small in china’s coastal coal transportation market and the ship's aging problem is more serious. In view of ship transportation capacity and operation of ship enterprises, it can be seen that domestic coastal coal transport capacity supply has the following characteristics:

(1) The number of domestic coastal coal transportation fleet is big, and the size of ship is small and ship aging problem is serious.

Domestic coastal transportation fleet have an obvious characteristic that fleet size is small and there are mainly small vessels in fleet. According to statistics, in

2012, there are only 1618 ships (49.4 million ton) engaged in coastal coal transportation. From point of ship age, eighty percent of operation ships' age is over 20 years. The average using age of main bulk ship and large tonnage cargo ship are over 25 years [33].

(2) Domestic shipping enterprises engaged in coastal coal transportation give priority to small and medium enterprises.

Domestic shipping enterprises engaged in coastal coal transportation give priority to small and medium enterprises, which amounted to over 5000(including shipping enterprises engaged in inland waterway transportation). The number of operation ships and their tonnage respectively occupies 64％ and 27％ of total ships of domestic coastal coal transportation enterprises and total tonnage. According to size, economic benefit and management norms of operation enterprise fleet, coastal transportation enterprises can be divided into the following levels:

First level: China shipping. As the largest coastal dry bulk transportation company, China shipping developed domestic coal trade ,of which the market share is far more ahead of the other companies. According to statistics, in the first half of 2011, China shipping owned 111 dry bulk ships, a total 5.555 million deadweight tons, and the fleet size has been listed as the world's top 10 for global independence ship owner[37].

Second level: local shipping companies, larger companies included: Xiamen ship, Zhejiang fu xing shipping, Fujian ships,, etc. Total transportation capacity of Ningbo shipping fleet is about 280000 ton, Ningbo shipping fleet including 4 ships with one thousand to five thousand dead weight tonnage , 2 ships with twenty thousand to thirty thousand deadweight tonnage, 4 ships with fifty thousand to sixty thousand deadweight tonnage[37].

Third level: free traders' shipping company. In recent years, many domestic companies especially with larger demand for coal formed their own fleet to reduce the transportation costs, strengthen enterprise competitiveness [37].

Level 4: the local small transport fleet. Because of high flexibility and small fleet size, there exist many single-ship companies occupying large proportion in coal

transportation market.

(3) Fleet operation placing emphasis on different routes. For now, China's coastal transportation market can be divided into east and south market. First level-China shipping occupies half of market share. In the two regional markets, there exists a huge difference in share occupied by the other ship companies.

2.2 Spot freight overview about Chinese coastal coal shipping market

In recent years, competition for domestic coastal bulk transportation market has got into incandescence stage. The degree of mercerization is more and more high. As an important type of dry bulk-coal occupies important position in coastal dry bulk shipping market.

2.2.1 Introduction of Chinese coastal coal freight index

Currently, coastal coal transportation market faces fierce competition--freight cost with frequent fluctuation and larger fluctuation range. In order to timely reflect frequent and severe freight cost fluctuation, Shanghai shipping exchange developed China's coastal coal freight index (CBCFI) system based on China's coastal (bulk) freight index（CBFI）[34]. CBCFI publishes daily coastal coal cargo routes/ship type spot market freight and comprehensive index. CBCFI makes September 1, 2011 as the base period and the starting index is 1000 points [35]. Freight information provided by China's coastal freight index (bulk) committee member units. Shanghai shipping exchange issues index at 3 o 'clock in index-day.

Index issued by CBCFI provides better base for the development of coastal coal freight index derivatives. Shanghai shipping exchange hope that China's coastal coal freight index becomes settlement basis for coastal coal transportation derivatives market trading, helps enterprises determine forward price, adjust transportation capacity, and avoid risks. Table 2-1 shows specific ship type routes of China's coastal coal freight index.

Table 2-1 Rutes and ship types of China coastal coal freight index（CBCFI）

China coastal coal freight index（CBCFI）	
Qinhuangdao-Guangzhou	5－6万 DWT
Qinhuangdao-Fuzhou	3－4万 DWT
Qinhuangdao-Ningbo	1.5－2万 DWT
Qinhuangdao-Shanghai	4－5万 DWT
Qinhuangdao-Zhang jiagang	2－3万 DWT
Tianjin-Shanghai	2－3万 DWT
Tianjin-Zheng jiang	1－1.5万 DWT
Huang hua-Shanghai	3－4万 DWT
Jingtan/Cao feidian-Ningbo	4－5万 DWT

In addition, there exists a difference between CBCFI and BDI. BDI index reflects changing in international dry bulk shipping market, while CBCFI reflects China's coastal coal transportation market alone. It professionally reflects nine coal transport routes with small range.

2.2.2 Chinese coastal coal freight index fluctuation characteristics

As we all known that China's coastal coal transportation market has obvious periodical characteristics, and freight level periodically fluctuated with changing supply-demand side. China's coastal coal freight has periodical characteristic: higher in summer and autumn, lower in winter and spring. China's coastal coal freight index is a "barometer" to reflect Chinese coastal coal transportation market. It provides scientific and authoritative basis for shipping ＆ trading enterprises to make daily operation-- decision. CBCFI fluctuations intuitively manifest market freight fluctuation. Figure 2-1 is CBCFI graph. According to freight index fluctuation, coastal coal freight has following features:

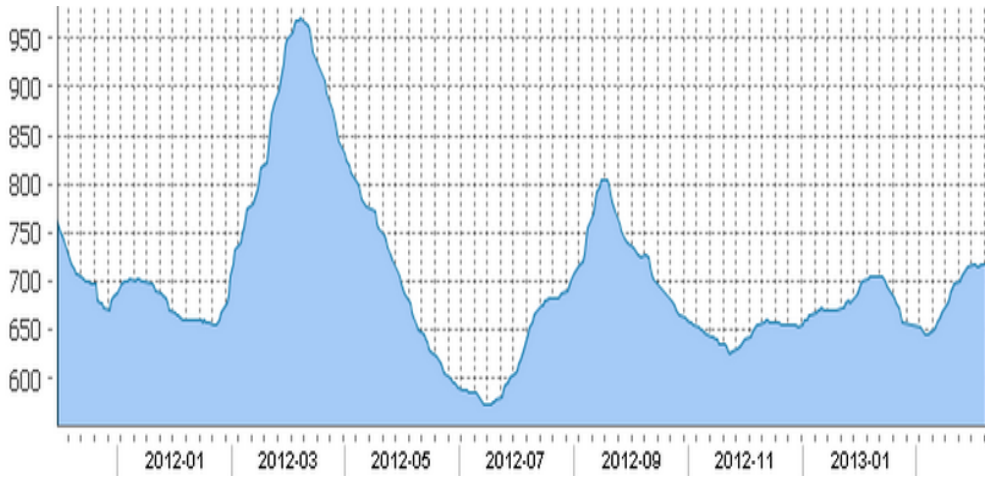

Figure 2-1 History curve of China coastal coal freight index（CBCFI)

Data sources: according to the Shanghai shipping exchange website www.sse.net.cn related data sorting.

(1) The coastal coal transportation season obvious cyclical changes

The mainly reasons for domestic coastal coal transportation changing with season are listed as follows. First, with climate changing, river channel will change under peer situation. Freight under poor navigation and blocked channel conditions is different from that under better navigation and smooth channel.

Second, changing season also affects demand of enterprises for coal, especially for electric power enterprise. The demand for electricity is more in Winter and summer ,so demand for coal is more in the two seasons. Figure 2-1 shows that obvious seasonal fluctuation characteristics exists in coastal coal freight, and the peak period for enterprises using electricity is different from freight peak period, because before using electricity peak period coming, 2 to 3 months , coal enterprises begin to purchase for a sufficient reserve, which is congruous with seasonal fluctuation period in graph.

(2) Frequent fluctuations of CBCFI, turning to fuzzy

In recent years, under domestic increasing demand for coal and price inversion at home and abroad, coal imports rise sharply in our country. Under the setting of increasing demand for coal and domestic constraining coal production, coal import is

increasing, which has certain restrictions to domestic coastal coal transportation.

At the same time, dry bulk shipping market is stagnant in recent years, there exist many restrictions to ship in market, and many ships dabbling in international dry bulk turn to domestic market, which put much more pressures to domestic coastal coal transportation market with surplus transportation capacity. In addition, in recent years, many domestic companies, especially companies demanding for lots of coal, have formed their own fleet in order to reduce transportation costs, strengthen the itself competitive power, and strengthen enterprise diversification strategies. For example, in order to ensure enough coal reserve, get rid of restrictions on transportation by others, Datang power group, in 2007, set up its own shipping company (Jiangsu Datang shipping co., LTD.). By now, the company's current total deadweight tonnage has reached to more than 300000 tons, the company's total capacity will increase to 500000 tons in 2015, and the annual volume of traffic will reach 8 million tons. Domestic coastal coal transportation capacity becomes more and more complex, so shipping companies will form fierce competition, eventually reflect in price, plus influencing by some sudden factors and policy, coastal coal freight index turn to fuzzy.

2.2.3 Influence of main factors on coastal coal freight fluctuation

(A) Impact of coal transportation demand

(1) Economic development

Economy is the leader of trade and continuous economy development uninterrupted expands new areas for commodity trade. When economy emerges high-speed growth, so does trade, strong demand for goods appears with continuous development and prosperity in the shipping market; conversely, with economic recession, trade shrinks. Insufficient goods make sea freight drop, at this time, the shipping market shows depression and recession accordingly.

Due to continuous economy development, there appear increasing national investment in fixed assets, rising urbanization and regional economic development. Increasing investment in infrastructure makes the required bulk commodity demand in construction continue to maintain a higher level.

As the necessity for each industry developing, coal has been affected by the economic development. With infrastructure continuously constructed and perfected, highly energy-consuming industries invested and livelihood service industries developed, demand for coal is increasing. Uninterrupted economic development makes each industry continuous demand for coal, therefore, it is concluded that economic development will have a great impact on demand for coal.

(2) Changeable season

Coal is different from the other commodity with special purpose, so the demand for it is changing with season. Previous study tells that in our country, the main coal consuming industries are water and electricity coal supply industry, product manufacturing and mining industry, of which electricity industry consumes lots of coal. In general, peak for electricity consumption emerges in summer and winter. Demands for electricity as well as coal are increasing with climate changing, so there appears relatively prosperous transportation market. Conversely, demand for coalrelatively reduces in spring and autumn. So, this analysis shows that as economic development factors, seasonal change also has an influence on coastal coal demand.

(B) Influence of coal supply capacity

(1) Transportation cost

In shipping market, changing transportation costs affect actual operation income of Ship Company, with transportation costs rising, operation income declining; On the contrary, when transportation costs reduce, operation income increases. Taking fuel prices, main ingredient of transportation costs, for an example. Due to scarcity and non-reproduction of fuel, its price shows continuously upward growth trend in recent years. Under this situation, transportation costs are also rising slowly. There are also other factors affecting transportation costs. Increasing demand for high quality crew, make crew training costs rise. With rising transportation costs, company actual income is decreasing, and its willingness entering market is also decreasing, which have an great impact on market transportation capacity.

(2) Existing shipping capacity situation of market

In general, transportation market demand and supply are maintaining balance in

corresponding level, transportation demand producing shipping supply. When market transportation capacity being in relative saturation state, shipping company is reluctant to put it into market operation. In transport market, when supply exceeds demand, market will reduce transportation price; conversely, when the demand is less than the supply, freight will rise. Ship Company wants to enter market under condition of relative insufficient market transportation capacity. When market transportation capacity is less than transportation demand, Transportation Company can take much action to raise freight and obtain operation income. While excess market transportation capacity make it hard for ship company to obtain benefit from market transportation, so Ship Company is reluctant to put ships into market operation. So, it can be concluded that current market transportation capacity is an important factor to affect transportation market.

2.3 Summary of Chinese coastal coal freight index derivatives

2.3.1 Chinese coastal coal freight index derivatives

Shipping freight index derivatives is risk management tools for related shipping enterprises to effectively avoid freight fluctuation in shipping market and ensure smooth running of enterprises. By means of buying coastal coal freight derivatives in derivatives market with same quantity and opposite direction, spot market participants evade risks due to spot market freight floating. If ship-owners and traders use certain technical means to forecast future price in certain time and lock the price, then by participating in shipping freight index derivatives trading, ship-owners or traders can lock enterprises profits at a time and evade market risk.

China's coastal coal freight index derivatives issues listed transaction on December 7, 2011. At present, Shanghai shipping freight trading co., LTD. (SSEFC) develops product on China's coastal coal freight index derivatives, including two routes: Qinhuangdao-Shanghai (hereinafter referred as the Qinhu, trading code QH), Qinhuangdao-Guangzhou QG (referred as "Qin Guang, transaction code QG) .

Shipping freight index derivatives contract is a standardized protocol and also is the object of shipping freight index derivatives trading. In general, the shipping

freight index derivatives trading contract mainly includes following elements:

(1) Subject of contract: China coastal coal freight index routes freight

(2) Quoting unit and minimal price change: China's coastal coal freight derivatives trading contract offers quoting unit of 100 tons, minimal price change is 2 yuan/hundred t.

(3) Contract months: shipping freight derivatives trading contract delivery month.

(4) Trading time: refers to the trading time of shipping freight derivatives contracts in SSEFC. Traders should pay attention that the last trading time in trading day may have special provisions.

(5) Price limits: trading price fluctuation of derivatives contracts in a trading day or certain period can't be higher or lower than 5% of rising range.

(6) Contract trading margin: contract trading margin accounts for 20% of total contract value.

(7) Delivery form: in the form of cash

(8) The last trading day and delivery day: shipping freight derivatives contracts in delivery day use cash to settle, the specific arrangement of the last trading day and delivery day executed by public announcement in trading contract.

Table 2-2 shows China's coastal coal freight derivatives contract.

Trading code	QH	QG
Contract object	China coastal coal freight Qinhuangdao-Shanghai route (4-5Wan DWT)	China coastal coal freight Qinhuangdao-Guangzhou route (5-6 Wan DWT)
Quoting currency	RMB	
Quoting unit	100t	

Contract value	100-100,000t
Minimal price change	2 yuan/hundred t
Contract months	Continuous three months and the following three months
Trading time	Am:9:00-11:30,Pm:13:30-15:00
Settlement price	Deal price made on contract-day, that is also weighted average price calculated on Volume
delivery price	From Contract months to delivery date, Shanghai shipping exchange published "China's coastal coal freight index (CBCFI)" , and last five index points of routes are chosen to calculate per one hundred ton of freight arithmetic mean (settlement price accurate to integer)
biggest limit on daily price fluctuations	Settlement price ±5% of last trading time
Trading margin ratio	20% of contract value
The single biggest order quantity	100,000t
Single dealer maximum order quantity	1,000,000 t
The last contract trading day	The penultimate Friday of expired contract month(announcement of listed contract will control)
Delivery day	The last trading day
Delivery form	Cash
Transaction fees	2yuan/hundred t(single aspect)
Average fees	For free

Delivery fees	5 Yuan/hundred t(single aspect)
Transfer or not	Transfer between traders

2.3.2 Introduction of China coastal coal freight index derivatives of the function

China's coastal coal freight index derivatives is essentially a kind of financial derivatives, related shipping companies can take advantage of coastal coal freight index derivatives for risk control and enterprise management. Its specific functions show as follows:

First, price discovery function. In shipping market freight system, Price discovery refers to the process of shipping market balancing price after dynamic adjustment of information, which put emphasis on excavation process of equilibrium price and guiding role for actual freight to stabilize shipping market freight and promote healthy and orderly development of shipping market. In public and efficient shipping freight forward trading market, many traders' bidding really reflect the value of freight price, also more truly reflect trend of transportation price change in the future. Index spot market price can only reflect current situation of demanders and suppliers rather than their changing trend in the future.

Secondly, risk aversion function. This function is achieved by hedging, which make for shipping company evading freight risk. Hedging is one kind of market behavior combining shipping freight forward transaction with shipping spot market to transfer spot market transaction freight risk. Generally speaking, index transaction is consistent with spot market in direction and amplitude. Shipping company or the owners face freight fluctuation in shipping transportation. No matter how freight change, some traders will loss. Traders can lock costs and profits through reverse operation in spot market and forward transaction market of shipping freight to avoid risk. On the other hand, to some extent shipping freight index transaction can reduce shipping freight fluctuation. For ship owners, hedging can not only lock freight income but increase advance sale time, guide transportation capacity allocation, and promote supply and demand balance in shipping market; for cargo owners, hedging can lock freight costs, improve trade capacity and guide production rhythm.

2.3.3 Basic characteristics of forward shipping freight

Shipping freight forward exchange market through its special way of buying and selling and standard organization system attract lots of traders involving in transaction, collect mass information, guarantee fair, open, and just market competition to the largest extent . Shipping forward price formation depends on multiple factors, such as social and political factors and future weather conditions, traditional transportation trade fade season and so on. Because of these factors affecting future price, traders involving in market respectively predict shipping forward freight. Because of knowledge gap, individual may have certain deviation in estimating price, as a whole, it is possible to make reasonable forecast and estimate in shipping forward price. Then information value will quickly be embodied in shipping forward price. The main features have the following aspects:

(1) Shipping forward price can reflect the relation between supply and demand in market and also reflect market price trend [27].

Participants of shipping freight forward exchange market are from all over the world with different trading purposes. All kinds of information form and disseminate within market. According to these obtained information, market participants make reasonable prediction and estimation to futures hipping market dynamic situation. So, shipping freight derivatives price formed on mass information dissemination can objectively and fully embody changing situation between demand and supply in shipping market and make judgment for buyer and the seller's prediction, therefore, it can reflect future shipping market price trend.

(2) Financial characteristics of forward shipping freight

In shipping freight index derivatives trading market, China's coastal coal freight index derivatives not only have price property like spot market , but embody financial and game characteristics because of complex price forecasting process and unique way of transactions. So, price of China's coastal coal freight index derivatives trading is not only simply determined by supply and demand of market, but speculative factors.

2.3.4 Differences between forwards and spot shipping freight

Shipping forward market and spot market is shipping market important indispensable constituent elements, but the spot price and the shipping is shipping forward price is concerned, there are essential differences between them, it is mainly manifested in the following aspects:

(1) Market adjustment

There exist differences in the process of forming shipping forward price and spot price. Spot price formation is through negotiation between owners and traders, which is fragmented and individual process. While, by means of depending on current market supply and demand and using transparent and public bidding mode, forward price is formed through many sellers and the buyers' personal judgment of present market. At the same time, shipping forward price is not invariable ,affected by fluctuations of potential amount of supply and demand, and modified jointly and continuously by buyers and the sellers. Shipping freight index derivatives contracts whose price can reflect current as well as future relation between supply and demand have different delivery month . They have strong continuity in terms of forming price and also have certain advanced instructions in forecasting and adjusting market.

(2) Long-term prediction

Spot price is formed by spot market. Because shipping spot market embodies relation between demand and supply in short period of time, the price has a certain degree of volatility and blindness. According to this price, shipping company owners make operation strategies which will lead to larger price cyclical changes. On the contrary, the formation of shipping forward prices is as follows: derivatives market participants through various information make reasonable analysis and forecast to market, give personally reasonable price and then experience public bidding. Shipping forward price produced by estimating widely disseminated information can objectively reflect forward relation between demand and supply in shipping market, provide theoretical supports for operators and decision- makers of related shipping enterprises.

(3) Extensive publicity

Due to universality and openness of buyers and sellers participating in freight index derivatives market, mass information can efficiently reflect economic value in shipping forward price, which owns quick transmission speed and to some extent speed up market information dissemination. Buyers and sellers in shipping market can not only quickly know influence of each kind of information on shipping forward price, but its influence degree on market, through these information changing relation between supply and demand in shipping spot market can be got.

(4) Competitive price

By means of public bidding derivatives market participants form shipping forward price. Market participants hope to deal with favorable price and take actions in accordance with the price movements, because market participants have no ideas with the other transaction opponents and they won't sell or purchase to some participant to ensure trade with competition.

Chapter 3. Introduction of hedging theories and models

Water transport is the derivative demand of the trade, stemming from the water transport demand in domestic and international trade. That undoubtedly leaves water transport production under a kind of dependence and passivity with the factors that may worsen transport risks like economic fluctuation, change of international trade situation and even political and natural factors. Therefore, it has become the biggest concern for the shipping company and traders to take risk assessment and seek measures to avoid and reduce the risks.

One of the roles of freight index derivatives transaction market is to provide a hedging service for the market participants who wish to avoid and prevent the risks, and offset the risks from spot market price change in the approach of freight index derivatives contract. The sharply fluctuated shipping freight may bring the shipping company and the traders two risks: regular risk, which means the freight of each sea route is closely related to world economic situation and changes with its fluctuation, and the trend of the freight and the change of economic level are in a uniform rule; and irregular risk, which means the freight of certain sea route may plummet and change in an irregular pattern for some emergencies, while it can be reduced and separated by the reasonable risk management instrument and technology. The former is mainly brought by the change of the macro-environment, such as exchange rate, economic cycle, financial storm and political policy. Although it is impossible to transfer by taking measures at management and technology levels, it can be well prevented with the hedging function of the freight derivatives.

3.1 Related hedging theories

3.1.1 Basic definition of hedging

Hedging is an important economic function in futures market. Chinese futures association website[38] has made such a definition for hedging “hedging is a futures transaction behavior aiming to prevent spot price risk, in the process of transactions, while the production operators buy or sell certain amount of spot goods from spot

market, they also buy or sell the same amount of products from futures market, the products in the same variety but different directions (futures contract), in order to fill the possible loss in a market with the profits in the other and reduce transaction risk". We can see from the above definition that hedging is just a futures transaction behavior for the purpose of risk prevention by establishing a profit-loss offset mechanism between futures market and spot market. According to the above definition, the thesis has defined freight index derivatives hedging in this way "the hedging for freight index derivatives is a kind of freight index derivatives transaction behavior aiming to prevent the risk of the fluctuated freight in shipping market". In freight index derivatives transaction, shipping company or traders buy or sell certain amount shipping contractual commodities in spot shipping market, and at the same time buy or sell the same amount of freight index derivatives in the same variety but different direction from freight index derivatives market by contract, in an attempt to prevent the risk of shipping market freight fluctuation.

3.1.2 Type and case of shipping freight index derivatives hedging

Derivatives market has different views about price. Some market participants think price will fall and they buy derivatives contracts, whereas the others think the price will rise and they sell derivatives contracts. According to roles that participants play in the derivatives market, we divide hedging into long hedging with short hedging. Long hedging also is called buy hedging. In shipping freight index derivatives markets, buying hedging is hedging behavior that traders buy derivatives contracts because of worrying about rising spot freight transportation market, whose purpose is to lock buying price and avoid risk of rising freight. Short hedging also is called selling hedging. In shipping freight index derivatives markets, selling hedging is hedging behavior that shipping company sells derivatives contracts for fear of falling price in spot freight transportation market to avoid enterprise experiencing risk of lower freight price.

Through hedging, freight volatility risk can be transformed to be basis volatility risk (difference between forward price and spot price), to avoid risk of freight change. Take SSEFC China coastal coal freight index derivatives hedging as an example to

introduce two types of specific operation methods. Buying hedge: in April 2012, coastal coal spot market freight from Qin huangdao to Guangzhou is 4000 (Yuan/hundred tons), in the derivatives market, selling price of contract QG1106(Qinhuangdao to Guangzhou route) in June is 4000 (Yuan/hundred tons).

In June, a trader plans to transport 20000 tons of cargo from Qinhuangdao to Guangzhou. In order to alleviate effects caused by rising freight prices, in shipping freight forward trading system, the traders buy 200 open hand QG1106 contract with 4000 (yuan/hundred tons) and all of them are make a deal.

Two months later, Qin Guang route shipping freight in spot market rose to 4200 (yuan/hundred tons). At the same time, in shipping freight medium-forward trading system, QG1106contract shipping freight is 4200 (yuan/hundred tons). Traders sold for 4200 (yuan/hundred tons) all previously held positions.

Sell hedging: April 2012, spot price of coastal coal freight from Qinhuangdao to Shanghai is 3000(yuan/hundred tons). At this point, in shipping freight medium-forward trading system, latest purchase price for Qinhuangdao to Shanghai route contract in June is 3000 (yuan/hundred tons). In shipping freight medium-forward trading system, Shipping company sell 1000 open handQH1106 contract for 3000 (yuan/hundred tons) to lock profits , and all of them make a deal.

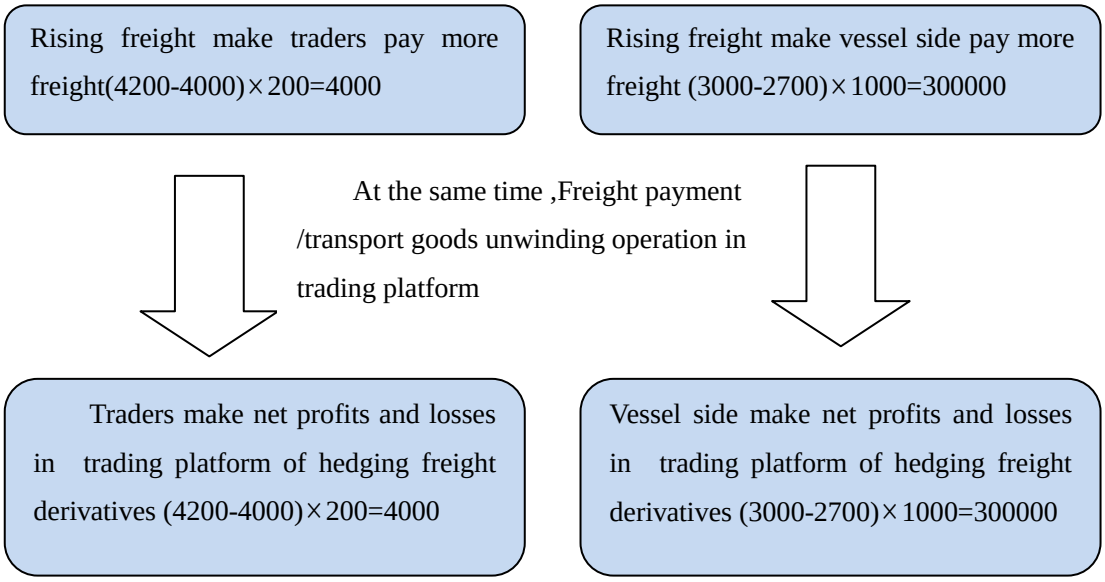

Figure 3-1 Hedging case diagram

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To June, with influenced by multiple factors, freight on the spot market dropped to 2700 (yuan/hundred tons).At the same time, in shipping freight medium-forward trading system, the shipping freight and long-term trading system, QH1106 contract shipping freight is for 2700 (yuan/hundred tons).

It is worth noting that the above hedging is only used to show the principle of hedging, but in reality, to some extent, there exists deviation in practice because factors affecting the price are more complex. Above cases show that hedging takes forward market as place to hedge risk, and sells (buy) contract with same quantity of spot market and opposite transaction direction, and make reverse operation in the future to hedge loss caused by freight fluctuation. Because forward market and spot market are highly correlated, making opposite operation in this two kinds of markets produces hedging effects. Shipping freight derivatives trading has shorting mechanism, the introduction of which provides ways to hedge risk. Traders who worry about falling market freight, can sell shipping freight derivatives contracts to hedge overall systemic risk caused by falling shipping market freight, which is conducive to alleviate influence of collective selling on the spot market.

3.1.3 Characteristics and functions of freight index derivatives hedging

Hedging function as a basic function of the freight index derivatives, it has the characteristics of several aspects as follows:

(1) The purpose of shipping freight index derivatives hedging is to avoid operation risk caused by fluctuating shipping freight in spot market. Hedgers in freight derivatives hedging transactions may give up profit opportunities in the derivatives market to lock the expected price profits, which does not mean hedgers can’t make profits in the derivatives market, but mean that profits in derivatives market offset losses of spot market and derivatives trading services pot market trading.

(2) Ships are hedgers in shipping market. Company, shipping company representatives, traders and traders representatives are investors that engaged in shipping or shipping demand in shipping spot market. Derivatives market participants are likely to use shipping freight index derivatives contracts for hedging,

when they are engaged in related shipping production and operation activities or have shipping requirements in spot market.

(3) Hedging for shipping freight index is to avoid freight fluctuation risk in shipping spot market. So hedging participant must participate in spot market and derivatives market at the same time, then operate in the two markets with same quantity and opposite price. Spot market trading is the basis of hedging [10].

For investors, the purpose of freight index derivatives hedging function is to evade price fluctuations in shipping spot market. Through freight derivatives hedging transactions, participants can deliver risks to derivatives market speculators to lock spot market profits; the purpose of hedgers participating in derivatives market is not to make profits in derivatives market but to lock spot market price. Though transaction condition is more complex in reality, hedging in the derivatives market can't completely offset risks of price fluctuation in shipping spot market, as long as there are no big mistakes in the direction and quantity, hedging in freight derivatives market is still able to offset most of risks of price fluctuation in shipping spot market. From micro and macro aspects, hedging has the following roles:

In terms of micro aspect, hedging roles are embodied in:

First, make related shipping enterprise gain greater autonomy, and are conductive to make strategic decision for enterprises, get price advantage in market competition.

Second, provide risk control tools for related shipping enterprises against freight fluctuations in shipping market, help enterprises lock expected profits in market with increasingly severe price fluctuation, and keep price.

In terms of macro-economy, hedging function embodied in:

Firstly, ensure stability of social production cost. Through derivatives hedging, enterprises can lock expected price and profit, more reasonably arrange production and business operation activities of enterprises, reduce social costs consumed by enterprise' excessive production.

Secondly, are conductive to form healthy price. Hedging transactions in the derivatives market can stabilize spot price. When price is lower, participants through

buying derivatives contracts in market to promote price rising; When price is at a higher level, participants' selling derivatives contracts in market are conducive to price dropping. The above process can effectively stabilize market price and produce reasonable and healthy price.

Thirdly, save social resources. Benefiting from derivatives market margin trading system, and hedging participants in derivatives market through leveraged deals use less money to realize spot transaction behavior. This approach to great extent improves economic capital liquidity and save social resources.

3.2 Introduction of correlated hedging model

3.2.1 Basic principle of Copula model

Copulas function theory is proposed by Sklar, in 1959, and Copula means "connect" in English. Sklar pointed that n-dimensional joint cumulative distribution function can be decomposed into n-marginal cumulative distribution and Copula function. Marginal distribution describes variable distribution and Copula describes correlation between variables. That is, actually Copula function is one kind of function that connect variable joint cumulative distribution function with marginal cumulative distribution function, so it was called "connection function"[12].

In real life, the relation between shipping freight index derivatives and shipping spot market is changing, especially when earnings reach to a extreme value, correlation between them is significant, even there appears asymmetric relation, that is to say, when there appear particularly positive earnings or negative returns, correlation degree between them is different. This phenomenon puts forward request to us ,that is correlation coefficient determination between shipping freight index derivatives change and shipping spot market price change can embody nonlinear and correlated tail movement between shipping freight index derivatives and spot market yields. As function connecting variable joint cumulative distribution function with marginal cumulative distribution function, Copulas function calculates correlation coefficient between shipping freight index derivatives yields and shipping spot market price yields [14].

We assume that U_1, U_2, uniform distribution between [0, 1], is marginal distribution of Copulas function, then multi-dimensional *Copula* function can be defined as:

$$C = C(u_1, u_2 ..... u_n) = P\{U_1 \le u_1, U_2 \le u_2 ..... U_n \le u_n\} \quad (3.1)$$

According to SKLAR theorem, in terms of multivariate distribution function F, assuming that $F(X_1), F(X_2), ..., F(X_n), ..., F(X_N)$ is one of its marginal distribution function and continuous, then Copulas function has one way to say:

$$F(X_1, X_2, ... X_n, ... X_N) = C(F_1(X_1), F_2(X_2), ... F_n(X_n), ... F_N(X_N)) \quad (3.2)$$

On the contrary, if $F(X_1), F(X_2), ..., F(X_n), ..., F(X_N)$ is one-dimensional distribution, we think joint distribution function of marginal distribution $F(X_1), F(X_2), ..., F(X_n), ..., F(X_N)$ is function *F*.

Above shows that on the one hand ,joint distribution function can be quickly got through Copula function, on the other hand correlation between variables can be accurately described.

Genast And Mackey explained Archimedes' *Copula* function[23]. Analysis shows that it is easy to describe upper tail dependence and calculate results by using Archimedes' Gumbel Copula function, so we choose Gumbel Copula function to analyze opposite number of the sample data. For more special *Copula* function, like Gumbel Copula function, we use following formula to show:

$$C(u_{1t}, u_{2t}, \theta) = \frac{\left\{-\left|\left|-\ln(u_{1t})\right|^{\theta} \pm \left|-\ln(u_{2t})\right|^{\theta}\right|^{\frac{1}{\theta}}\right\}[\ln(u_{1t})\ln(u_{2t})]^{\theta-1}\left\{-\left|\left|-\ln(u_{1t})\right|^{\theta} \pm \left|-\ln(u_{2t})\right|^{\theta}\right|^{\frac{1}{\theta}} + \theta - 1\right\}}{u_{1t}u_{1t}[\left|-\ln(u_{1t})\right|^{\theta} \pm \left|-\ln(u_{2t})\right|^{\theta}]^{2-\frac{1}{\theta}}}$$

(3.3)

In above formula, $\theta \in (0, \infty)$ is correlation coefficient, $\theta \to 0$. Through analysis of research, we can prove that Gumbel Copula can more reasonably depict tail

dependence that is unsymmetrical. Since *Copula* model applied to financial sector, risk analysis in the financial field has reached to a new step. It is well known that "peaks thin tail thick" is a distinct characteristic in financial time series. Studies show that in the process of risk management, tail correlation is generally paid more attention. Because falling yields in financial market will soon feedback to assets yields falling with decrease in financial market, we pay more attention to tail correlation in the study process [23]. Copula model is applied to the correlated study of shipping freight index derivatives and spot market yields for its advantages. Firstly, in terms of continuous multivariate distribution function, we can use Copula model to show related structure between variables in the model. Secondly, supposing that we make nonlinear monotone increasing transformation, then correlated measurement value obtained from Copula model did not change, which is helpful to obtain nonlinear relations between variables. Finally, using Copula model can quickly find out tail information with asymmetric distribution, which is beneficial for us to do correlation analysis.

In long time use process, *Copula* model is a good way to analyze tail correlation . Assuming that vector group is (X,Y), marginal distribution function is U_1,U_2, then:

$$\lambda(u)=P(U_2>u\,|\,U_1>u)=\frac{P(U_1>u,U_2>u)}{P(U_2>u)}=2-\frac{1-C(u,u)}{1-u} \tag{3.4}$$

Under $u\to\infty$, if $\lambda(u)$ has extreme value, then it can embody tail correlation size of two assets yields , so $\lambda_{up}=\lim_{u\to 1}\lambda(u)$ is not relevant. Tail correlation coefficient can be obtained by the *Copula* model. Archimedes model can be represented as:

$$\theta=2-\lim_{s\to 1}\frac{\partial C(s,s)}{\partial s} \tag{3.5}$$

$$\theta(1)=\lim_{s\to 1}\frac{\partial C(s,s)}{\partial s} \tag{3.6}$$

According to SKLAR theorem [16], when marginal distribution is continuous, the existence of *Copula* function is unique. In this paper, supposing that shipping

forward freight and spot freight are continuous distribution, bivariate *Copula* distribution caused by shipping forward freight and shipping spot freight yields is unique. Durrelman Pointed that the marginal distribution wrongly set can lead to biased estimation of *Copula* function. So we can use KedallS tau to determine the *Copula* function. Binary *Copula* function can be expressed in the following formula:

$$C(u_1,u_2,\theta)=\varphi^{-1}(\varphi(u_1)+\varphi(u_2))=\exp\left\{-[(-\ln u_1)^{\theta}+(-\ln u_2)^{\theta}]^{\frac{1}{\theta}}\right\} \quad (3.7)$$

In above formula, (u_1,u_2) is marginal distribution function of (X,Y), $\theta\in[1,\infty)$ is continuous function parameter. But if *Copula* function of random variables, X and Y, is Archimedes *Copula* composed of $Q(t)$, we can use more simple and quick methods to determine the function, then the consistency between X and Y- Kendall, its correlation coefficient τ can be shown as:

$$\tau=1+4\int_0^1\frac{\varphi(t)}{\varphi(t)}dt \quad (3.8)$$

By experience value τ, rank correlation coefficient of random variables, we can function parameter θ, specific formula of θ is as follows:

$$\theta=\frac{1}{1-\tau} \quad (3.9)$$

We can estimate shipping forward freight and spot freight yield sequence of rank correlation coefficient to get parameters θ in *Copula* function, and then respectively introduce θ,u_1,u_2 into formula (3.8) to get you can get *Copula* value of any derivatives and spot yield sequence under their respective quintile. Then *Copula* function calculates correlation of two groups of random variables containing related tail information, and correlation is treated as correlation coefficient of derivatives yields and spot yields [40].

An important step to calculate yield correlation of shipping forward freight and shipping spot freight is to match earning shipping forward price with loss of shipping spot price, that is, shipping forward price yield hedges shipping spot yield above median, at the same time shipping forward price yield hedges shipping spot yield

below median. So, it is an important question to determine *Copula* median. According to meaning of *Copula*, we assume $u_1 = u_2 = \alpha = 50\%$ then

$$\rho^* = 4C(50\%, 50\%) \tag{3.10}$$

In above formula, $\rho*$ is median correlation coefficient, $C(50\%, 50\%)$ is value of median *Copula*.

3.2.2 *Kendall* Rank correlation analysis model

The scope of *kendall* rank correlation coefficient value is in the interval [-1, 1], which is an index to reflect variable correlation. *kendall* rank correlation analysis which is nonparametric have no requirement weather variables is normality assumption or not. So, if variable is under non normality assumption, analyzing variable with *kendall* rank correlation coefficient is effective.

We make (x_1, y_1) and (x_2, y_2) independent and identically distributed random vector, then *Kendall* rank correlation coefficient can be showed as:

$$\tau(X,Y) = P[(x_1 - x_2)(y_1 - y_2) > 0] - P[(x_1 - x_2)(y_1 - y_2) < 0] \tag{3.11}$$

$\tau(X,Y)$ is index to measure the consistency of X and Y. When $\tau(X,Y) = 1$, we think changing between X and Y is consistent, so they are positive correlation; When $\tau(X,Y) = -1$, we think changing between X and Y is opposite, so they are negative correlation; when $\tau(X,Y) = 0$, half of changing between X and Y is oppositely consistent, while the other half is completely consistent, so it is not sure whether they are correlation; When $\tau(X,Y)$ is any value in addition to 0, 1, 1, we have to judge degree of correlation between X and Y according to particular situation.

3.2.3 GARCH model

GARCH model is used to deal with actual financial data. but there exist some disadvantages, such as, nonnegative constraints of model to coefficient parameters, and influence of external impact on conditional variance depending on the size of

absolute value of external shocks, having nothing to do with symbol impact. But the actual economic time series often exist leverage effect that is price fluctuation is more influenced by negative external shocks than positive external shocks with equal amplitude, and positive and negative impact is asymmetry. Formula of GARCH (p,q) model is as follows:

$$y_t = rx_i + u_i \quad (3.12)$$

$$u_t = \sigma_t v_t \quad (3.13)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{i=1}^{p} b_j \sigma_{t-j}^2 \quad (3.14)$$

In above formula, y_i is dependent variable of mean equation, x_i is independent variable of mean equation; r is independent variable coefficient of mean equation ; u_i is random error term; σ_{t-j}^2 is conditional heteroscedaticity.

When parameters meet following formula:

$$E(v_t) = 0\,, \quad D(v_t) = 1$$

$$E(v_t, v_s) = 0, (t \neq s);\ p \geq 0, q \geq 0, a_i \geq 0, \beta_i \geq 0, \omega \geq 0 \quad (3.15)$$

If $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_i < 1$,then CARCH processes is covariance stationary.

CARCH (1.1) is the most effective CARCH model, can accurately depict fat-tailed features of variable, available formula expressed as follows

$$\sigma_t^2 = \omega + \alpha \mu_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (3.16)$$

In above formula, $\omega \succ 0, a \geq 0 and \beta \geq 0$.

There are three hypotheses in GARCH model residual distribution, normal (Gaussian) distribution, student t distribution and generalized error distribution (GED). Given a distribution assumption, CARCH model often uses method of maximum likelihood to estimate[27]

(1) If disturbance subject is in accordance with GARCH $(1,1)$ model distributed by Normal$\left(\text{Gaussian}\right)$, the logarithmic likelihood function is:

$$\ln L(\theta) = -\frac{T}{2}\ln(2\pi) - \frac{1}{2}\sum_{1}^{T}\ln h_i^2 - \frac{1}{2h_i^2}\sum_{1}^{T}(y_t - x_t\gamma)^2 \quad (3.17)$$

Here, h_t^2 is Conditional variances of ε_t

(2) If disturbance subject is in accordance with GARCH (1,1) model distributed by student, the logarithmic likelihood function is:

$$\ln L(\theta) = -\frac{T}{2}\ln\left\{\frac{\pi(k-2)\Gamma(\frac{k}{2})^2}{\Gamma(\frac{k+1}{2})^2}\right\} - \frac{1}{2}\sum_{1}^{T}\ln h_t^2 - \frac{k+1}{2}\ln\left\{1+\frac{(y_t - x_{i\gamma})^2}{h_i^2(k-2)}\right\} \quad (3.18)$$

In the case of freedom degrees $k \succ 2$, estimated parameters can be understood t evaluate maximum value of logarithmic likelihood function. In the case of $k \to \infty$, the Student - t distribution is close to normal distribution.

(3) If disturbance subject is in accordance with GARCH (1,1) model distributed by GeneralizedErrorDistribution(GED), the logarithmic likelihood function is:

$$\ln L(\theta) = -\frac{T}{2}\ln\left\{\frac{\Gamma\left(\frac{1}{r}\right)^3}{\Gamma(\frac{r}{2})^2\left(\frac{3}{r}\right)}\right\} - \frac{1}{2}\sum_{1}^{T}\ln h_t^2 - \sum_{1}^{T}\ln\left\{\frac{\Gamma\left(\frac{3}{r}\right)(y_t - x_i\gamma)^2}{h_i^2\Gamma\left(\frac{3}{r}\right)}\right\}^{\frac{r}{2}} \quad (3.19)$$

$r > 0$ in above formula. As GED parameter, r determines degree of thick of distribution tail, when $r \prec 2$, tail is more thick than normal distribution, when $r = 2$, GED distribution degrades to standard normal distribution; when $r \succ 2$, tail is thinner than normal distribution.

3.3 Spot principle of minimum variance hedging model of shipping freight

3.3.1 Concept of hedging ratio

Hedging ratio is the ratio of possessing future positions and amounts of assets exposed to risk. For example, a simple hedging ratio 1 means that investors use1 unit futures position to hedge 1 unit spot. What deserves to be mentioned is the hedging is

based on same changing amplitude between forward price. When investors operate hedging, spot price and full hedging can be reached and risk can be avoided. Based on expectation theory, ederington (1979) deduced in general situation, changing of derivatives price is not synchronized with that of spot price that is basis risk is existing. So, simple hedging strategy can't minimize risk [18].

When investors use short position of derivatives to hedge, this paper assumes that the hedging period for investor is from $t-1$ to t .Given the definition of Baille & Myers(1991):in the end of hedging , hedging portfolio yields hold by investors is:

$$R_t = R_t^s - h_{t-1} R_t^f \tag{3.20}$$

R_t is asset portfolio yield from $t-1$ to t; R_t^s is spot yield from $t-1$ to t; R_t^f is derivatives yield from $t-1$ to t; h_{t-1} is hedging ratio.

3.3.2 Hedging model of minimum variance

According to hedging ratio formula in previous sections, we can write yield condition variance formula as following:

$$Var(R_t \left| \Omega_{t-1}) + h_{t-1}^2 Var(R_t^f \right| \Omega_{t-1}) - 2h_{t-1} Cov(R_t^s, R_t^f \left| \Omega_{t-1}) \right. \tag{3.21}$$

It is known that when yield condition variance in hedging portfolio reach to minimum, h_{t-1} is optimal hedging ratio. That is , this paper obtains h_{t-1} --order partial from $Var(R_t \left| \Omega_{t-1}) \right.$. So, the variance minimum hedging ratio is

$$h_{t-1} = Cov(R_t^s, R_t^f \left| \Omega_{t-1}) / Var(R_t^f \right| \Omega_{t-1}) \tag{3.22}$$

Can also be written as

$$h^* = \frac{C_f}{C_s} = \frac{Cov(R_s, R_f)}{Var(R_f)} = \rho \frac{\sigma_s}{\sigma_f} \tag{3.23}$$

In above formula, h^* is the minimum variance hedge ratio, R_f R_s is spot market freight fluctuation, R_f is the freight fluctuation in shipping freight

derivatives market, σ_s is to standard deviation in spot market freight yield, σ_f is standard deviation of freight yield in shipping freight derivatives market, ρ is correlation coefficient between shipping freight derivatives market yields and spot market freight yield[28].

Therefore, in order to minimum variance hedge ratio, firstly we need to estimate correlation coefficient ρ between shipping freight derivatives market yields and spot market freight yield, secondly estimate yield standard deviation σ_s in shipping freight derivatives market and yield standard deviation σ_f in spot market freight.

3.3.3 Matching and prediction principle of freight yield rate

It is known that this paper uses hedging to match changing of coastal coal transportation forward freight price with changing of spot freight price for minimizing yield fluctuation between them. Hedging mainly reflects in how to make sure the yield correlation between coastal coal freight forward market price and the spot market freight price, firstly, the nonlinear yield correlation between coastal coal forward market freight price and spot market freight price, secondly, tail correlation between coastal coal freight forward market price and spot market freight price under intense fluctuation in yield. Copula model is used to calculate correlation coefficient containing tail information, nonlinear yield correlation between coastal coal forward market freight price and spot market freight price can be solved to greatly improve hedging effect[30].

Because yield fluctuation existing in forward market freight price and spot market freight price is different, we estimate the minimum variance hedging ratio, at the same time, embody yield fluctuation in coastal coal forward market freight price and spot market freight price. This paper chooses GARCH models to calculate fluctuation value of coastal coal freight index derivatives, not only can this paper realize the dynamic forecast of hedging ratio, also can improve prediction accuracy. Detailed flow chart is shown below:

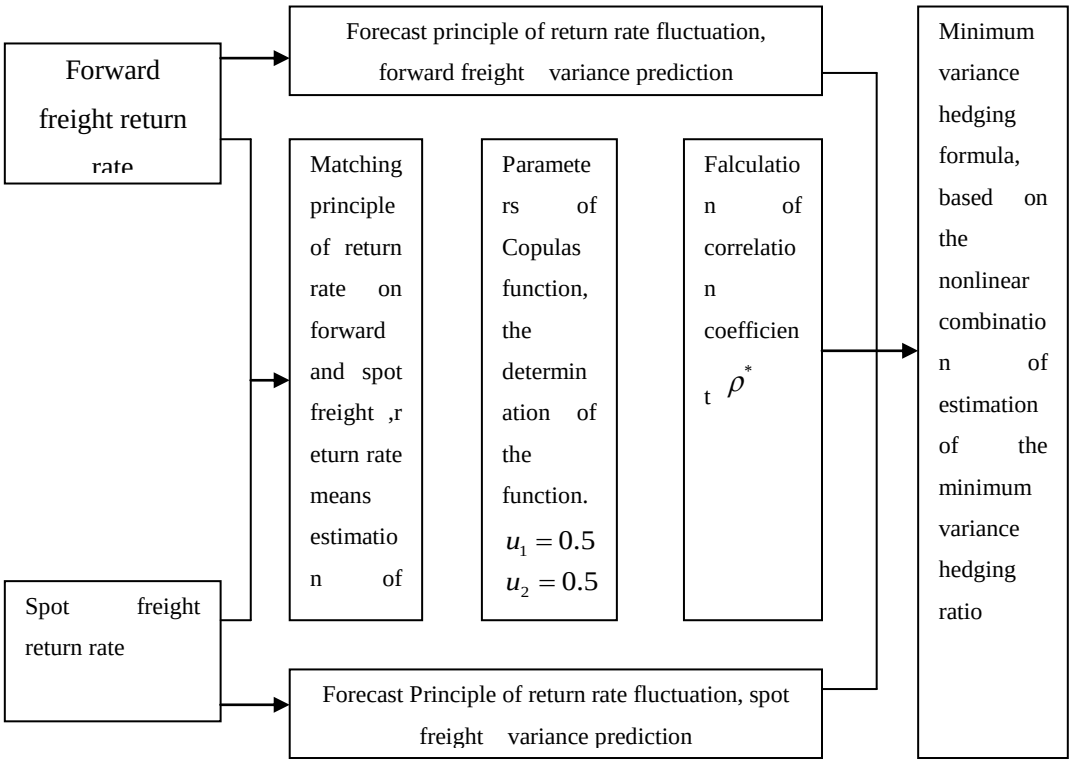

Figure 3-2 Research thought of hedging effectiveness

Chapter 4 Empirical research on Chinese coastal coal freight derivatives hedging effectiveness

This article selects Qinguang, Qinhu two routes of freight derivatives as samples, to explore the SSEFC China coastal coal freight derivatives hedging effectiveness. For the selection of sample data, we use the model of the minimum variance of Qin Guang, Qin Hu two routes of the forward and spot prices for the calculation of the optimal hedging ratio, and then we will not hedged and hedging after a comparative study on time series, the last of China's coastal coal freight derivatives application in coastal coal transportation market are analyzed.

4.1 Data selection and instruction of sample

Data of forward freight and spot freight is directly selected from web sites of Shanghai shipping exchange (http://www.sse.net.cn/) and Shanghai shipping freight trading co., LTD. (http://www.ssefc.com). With short transaction for listed shipping derivatives and limited data resource, this paper chooses forward and spot freight of Qinguang route and Qinghu route-China coastal coal freight derivatives, from December 7, 2013 to December 7, 2014 . In the whole sample interval, each route has 245 observations.

4.1.1 Selection of spot freight

Spot freight selects China’s coastal coal freight index (CBCFI) Qinguang and Qinhu route index. For timely reflecting coastal coal transportation market increasingly frequent and severe freight fluctuation and speeding development of shipping freight index, Shanghai shipping exchange issued China's coastal coal freight index (CBCFI) released at 15:00 Pm of each index issue day and adjusted on meeting statutory holidays. As derivatives offer unit for yuan/hundred ton, CBCFI index is yuan/ton, so the unit is identified, the selection of index data samples expanded 100 times over original index.

4.1.2 Selection of the forward rate

Forward freight is selected from settlement price of Qinguang route and Qinhu route-China coastal coal freight derivative, in every transaction day. Each derivative contract will expire in six months, so it is discontinuous. In terms of each derivative contract, its time span is not infinite. When derivative contract exceeds delivery month, the contract will stop trading. In each transaction day, several derivative contracts with different delivery month are trading at the same time, with the same derivative having different contact data in the same transaction day. overcoming discontinuous shortcomings of shipping freight index derivatives price needs to produce continuous derivatives price sequence. according to the following method this paper constructs continuous derivative contract.

This paper takes Qinguang route for an example to show special method: selecting each trading day's settlement price of main contract (i.e., daily largest volume contract). Because main contact holds large amounts of positions, it is the most active in market with large volume. In simple words, most of speculators take part in main contract-the easiest contract to deal in trading day of market.

Table 4-1 shows main contract in China's coastal coal freight derivatives trading market and main contract period from December 7, 2013 to December 7, 2014, according to derivatives trading data.

Table 4-1 Main contract replacement of coastal coal freight derivatives

Trading contract of Chinene coastal coal freight derivatives	During main contracts
QG1203 QH1203	2013-12-07 to 201402-07
QG1206 QH1206	2014-02-08 to 2014-05-10
QG1209 QH1209	2014-05-11 to 2014-08-06
QG1212 QH1212	2014-08-07 to 2014-10-16

QG1303 QH1303	2014-10-17 to 2014-12-07

Therefore, this paper obtains a continuous contract sequence. The advantage of continuous derivatives contract is that derivatives trading is relatively active and forward price owns better representativeness.

4.2 Calculation and analysis of basic statistics

4.2.1 Analysis of price correlation

It is known that the price discovery function of shipping freight index derivatives is assurance of hedging function effectively implementing. So we firstly conduct empirical research to understand derivatives market price discovery function from the basic correlation coefficient test. We know that correlation coefficient can reflect closely degree of various variables. In order to reduce the rounding error, We write shipping market spot freight and shipping market forward freight as natural logarithm form when estimated, constituting daily yield sequence of the shipping spot freight and shipping forward freight. The formula is as follows:

$$\Delta S_t = R_t^s = \ln\left(\frac{P_t^s}{P_{t-1}^s}\right) \tag{4.1}$$

$$\Delta F_t = R_t^F = \ln\left(\frac{P_t^F}{P_{t-1}^F}\right) \tag{4.2}$$

P_t^s, P_t^F respectively represent shipping market spot freight and shipping market forward freight in t^{th} day.

Table 4-2 Correlation coefficient of Qin-Guang spot and forward price

	Spot price	Forward price
Spot price	1	0.946315
Forward price	0.946315	1

Table 4-3 correlation coefficient of Qin-Hu spot and forward price

	Spot price	Forward price
Spot price	1	0.965255

Forward price	0.965255	1

From above chart we can see that coastal coal transportation freight forward market price has close relation with spot freight price. Through Eviews calculating the correlation coefficient, their results are respectively 0.946315 and 0.965255.So, We conclude that coastal coal transportation freight forward market price is highly correlated with spot freight price, which prove Coastal coal freight index derivatives has good price discovery function.

4.2.2 Analysis of sample data time series

In our common theoretical research and analysis, we often use such set as yield abiding normal distribution, actually financial yields generally don't obey normal distribution, so we need to study time series before research to discuss statistical characteristics of Qinguang and Qinhu freight daily yield sequence.

Table 4-4 Statistics on daily rate characteristics of spot and forward freight

Statistical characteristics	spot price		forward price	
	Qin-Guang	Qin-Hu	Qin-Guang	Qin-Hu
Average	-0.000639	-0.000544	-0.000545	-0.000424
Median	0.000000	0.000000	-0.000507	-0.000608
The maximum value	0.031749	0.037622	0.118471	0.150761
The minimum value	-0.018692	-0.044233	-0.046726	-0.079939
Standard deviation	0.007244	0.010356	0.019326	0.022946
Partial degrees	0.513258	0.048962	1.765666	1.627815
kurtosis	4.272452	5.648805	13.49868	13.67437
JB test	27.06281	71.13578	1247.374	1266.170

Table 4-4 shows that normal distribution kurtosis should be greater than 3 and 4 sequence kurtosis is greater than 3, with significant JB statistics, variable value

distribution is higher than standard . As far as normal distribution, distribution of four freight yield owns Aiguille ands. Fat-tail characteristic shows that yield absolute value is bigger than expected value. It is concluded from above analysis that daily yield distribution of spot freight price and forward freight price in coastal coal Qin Guang route and Qinhu route owns Aiguille and Fat-tail characteristic and general daily yield characteristic of financial time series. So it is reasonable to use general financial time series method to study spot freight price and forward freight price of coastal coal Qin Guang route and Qinhu route.

4.2.3 Stationarity test

In order to ensure sample data can be analyzed by GARCH model, firstly, we need to guarantee time series stability. So we adopt augmented $\mathrm{Dick-Fuller(ADF)}$ inspection method for stationary test of coastal coal transportation spot market price and forward freight yield sequence. Using ADF test, yield sequence of coastal coal transportation spot market freight price and forward freight price can be dealt as following:

$$\Delta y_t = u + \lambda t + r y_{t-1} + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \varepsilon_t \quad (4.3)$$

On the above formula, $\alpha_i = -\sum_{k=i+1}^{p} r_k, r = \left(\sum_{i=1}^{p} r_i \right) - 1$, y_i is index of yield, t refers to the time sequence. To coastal coal transportation spot market price of freight and the sequence of yield of the forward freight prices to return, according to the results of analysis for unit root. The results are shown in table 4 to 5.

Table 4-5 Freight return rate unit root test

Unit root test	Spot price		Forward price	
	Qin-Guan	Qin-Hu	Qin-Guang	Qin-Hu
ADFtest value	-14.10866	-25.21573	-13.45529	-13.74888
Associated probability	0.0000	0.0000	0.0000	0.0000

Critical value	-3.457630	-3.457400	-3.457747	-3.457747
Critical value	-2.873440	-2.873339	-2.873492	-2.873492
Critical value	-2.573187	-2.573133	-2.573215	-2.573215

The above table shows that the absolute value of ADF statistics is less than critical value, regardless of significance level is 1%,5% or 10%, So the original hypothesis is rejected, that is yield sequence of coastal coal transportation spot market freight price and forward freight price is stable. GARCH model is used for regression for volatility sequence of coastal coal transportation spot market freight price and forward freight price.

4.2.4 ARCH effect inspection

In order to make sure auto-regressive conditional heteroscedasticity model species can be use, regression model residuals must have ARCH effect. This paper uses the Lagrange multiplier method, namely the LM test, to analyze weather yield sequence of coastal coal transportation spot market freight price and forward freight price have ARCH effect or not.

If random disturbance item is $\varepsilon_i \sim ARCH(q)$, then auxiliary equations can be shown by the following formula:

$$h_i = a_0 + a_1\varepsilon_{t-1}^2 + a_2\varepsilon_{t-2}^2 + \ldots\ldots + a_q\varepsilon_{t-q}^2 \tag{4.4}$$

If the probability of regression coefficient being zero is high in above formula, this sequence does not exist ARCH effect. On the contrary, If the probability of regression coefficient being zero is low in above formula, this sequence exists ARCH effect. $H_0 : a_1 = a_2 = \ldots\ldots = a_q = 0 \quad (1 \le i \le q)$ is tested for null hypothesis. $H_t : \exists a_i \neq 0 \ (1 \le i \le q)$ is alternative hypothesis for test.

Expression of testing statistics is as follows:

$$LM = nR^2 \sim \chi^2(q) \tag{4.5}$$

Giving significance level a and free degrees of q, If $LM > \chi^2(q)$, H_0 is

declined, sequence has ARCH effect. If $LM \le \chi^2(q)$, H_0 is not declined, sequence does not have ARCH effect. Results are shown in table 4-6, 4 to 7. q is lag order, $q = 1,3,5$.

Table 4-6 Return rate sequence test of Qin-Hu freight

q	Spot price		forward price	
	F	Prob	F	Prob
1	1.563289	0.000000	2.031476	0.000000
3	3.698741	0.000000	4.120369	0.000000
5	4.325149	0.000000	5.214896	0.000000

Table 4-7 Return rate sequence test of Qin-Guang freight

q	Spot price		Forward price	
	F	Prob	F	Prob
1	2.153687	0.000000	3.874412	0.000000
3	2.698415	0.000000	4.269854	0.000000
5	1.653215	0.000000	2.562147	0.000000

It can be seen from the above two tables that all F statistic has reached 1% significant level. At the same time, Prob value is equal to or approximately equal to zero. It can be concluded that rejecting the null hypothesis, namely, daily yield sequence of all freight price has ARCH effect, can use autoregressive conditional heteroscedasticity model to deal with coastal coal transportation spot market freight price and forward freight price.

4.3 Estimation of earnings standard deviation between spot and forward in coastal coal shipping market

Previous sections show that through analysis of basic statistic for coastal coal

transportation spot market freight price and forward freight price yield in Table 4-4, four daily yield sequence has Aiguille and Fat-tail feature. In order to better depict their Aiguille and Fat-tail feature, this paper uses generalized error distribution (GED) to depict. Combined with the advantages of the model listed in the previous sections, we uses *GED* GARCH model to deal with fitting processing of heteroscedasticity.

The specific expression is as follows:

$$y_t = rx_t + u_t \tag{4.6}$$

$$u_t = \sigma_t v_t \tag{4.7}$$

$$\sigma^2 = \omega + \sum_{i=1}^{q} a_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{4.8}$$

$$\ln L(\theta) = -\frac{T}{2}\ln\left\{\frac{\Gamma\left(\frac{1}{r}\right)^3}{\Gamma\left(\frac{3}{r}\right)\left(\frac{r}{2}\right)^2}\right\} - \frac{1}{2}\sum_{1}^{T}\ln h_t^2 - \sum_{1}^{T}\ln\left\{\frac{\Gamma\left(\frac{3}{r}\right)\left(y_t - x_t\gamma\right)^2}{h_t^2\Gamma\left(\frac{1}{r}\right)}\right\}^{\frac{r}{2}} \tag{4.9}$$

In formula (4.9), $r \succ 0$. r is the parameter of GED and decides thickness of tail. When $r \prec 2$, it shows tail is thicker than normal distribution. When $r = 2$, GED distribution turns into standard normal distribution. When $r \succ 2$, compared with normal distribution, tail is more thin. Estimation results of Variance are shown in the following table.

Table 4-8 Estimation of GARCH model conditions variance Parameter on GED

Parameter	Sport price		Forward price	
	Qin-Guang	Qin-Hu	Qin-Guang	Qin-Hu
ω	2.64E-05	6.59E-06	2.31E-05	3.62E-05
α	0.496587	0.241785	0.249635	0.115648
β	0.602315	0.714569	0.851269	0.874126
γ	1.235689	1.402785	1.215648	1.201862

Above table shows value of generalized error distribution r were significantly less than 2, which manifest selected sample, coastal coal transportation spot market freight price and forward freight price sequence, exist Aiguille and Fat-tail feature. φ in coastal coal transportation spot market freight price and freight forward price is significantly and statistically not equal to zero under 90% confidence level and all is greater than zero. Four φ sequence were not significant in statistics. Similarly, we also calculated results of z test significant level, which is shown in table 4-9 and 4-10.

Table 4-9 Qin-Guang Z test magnificent level

Parameter	Sport price		Forward price	
	z	Prob	z	Prob
ω	4.212651	0.0000	2.365874	0.0023
α	7.612589	0.0000	4.712564	0.0000
β	14.325415	0.0000	22.365487	0.0000
γ	18.012365	0.0000	20.365489	0.0000

Table 4-10 Qin-Hu Z test magnificent level

Parameter	Sport price		Forward price	
	z	Prob	z	Prob
ω	2.561236	0.0032	3.102569	0.0049
α	5.632149	0.0000	3.698745	0.0000
β	17.369851	0.0000	28.235415	0.0000
γ	14.236547	0.0000	22.369821	0.0000

We can see from above two tables that compared with standard normal

distribution P, p value, whether it is equal to or approximately equal to zero, is smaller. So we conducted the variance prediction is correct. At the same time, each sequence meets GARCH model stable condition and $\alpha+\beta<1$,so equation fitting is correct. From formula (4.6) to (4.8) , we can estimate the variance and standard deviation of the yield, as shown in tables 4 to 11.

Table 4-11 estimation of Spot and forward price return rate variance and standard deviation

Parameter	Sport price		Forward price	
	Qin-Guang	Qin-Hu	Qin-Guang	Qin-Hu
Variance	0.00154963	0.00094528	0.00168217	0.00150876
Standard deviation	0.031599	0.036571	0.034719	0.039254

4.4 Estimation of hedging effectiveness index

4.4.1 Kendall rank correlation coefficient

Estimation of τ in Kendall rank correlation coefficient proves weather coastal coal transportation spot market price is positively correlated with forward freight price or not. We use SPSS software to estimate rank correlation coefficient τ of yield sequence existing in coastal coal transportation spot market freight priceand forward freight price . Table 4-12 shows the results.

Table 4-12 Correlation coefficient estimation of spot and contract freight

	Correlation coefficient τ
Qin-Guang route	0.756
Qin-Hu route	0.719

Estimation result in table 4-12 shows the correlation coefficient τ is close to $1, p<0.05$, which proves the coastal coal transportation between the spot market freight price is positively correlated with forward freight price. In above computing process, we also got Pearson correlation coefficient which can depict close

connection between fixed pitch. The specific expression is:

$$r_{xy}=\frac{n\sum XY-\sum X\sum Y}{\sqrt{N\sum X^2-\left(\sum X\right)^2}\sqrt{N\sum Y^2-\left(\sum Y\right)^2}} \quad (4.10)$$

X and Y are variables, n represents total samples, r depicts strength of the correlation degree between variables. In order to prove the correlation between two variables, we can use statistic t to testify null hypothesis with overall correlation coefficients is 0. If t test is significant, we reject the null hypothesis, that is there exists linear correlation between variables; If t test is not significant, we can't reject the null hypothesis is, that is there doesn't exist linear correlation between variables.

Table 4-13 Correlation coefficient estimation of spot and forward freight

	Pearson Pearson correlation coefficient
Qin-Guang route	0.987
Qin-Hu route	0.925

Table 4-13 shows that coastal coal transportation spot market freight price is highly correlated with forward freight price, that is there exists high similarity between them.

4.4.2 Estimation of median correlation coefficient

As mentioned above, we select Gumbel Copula function of CopuIa family, which is corresponding to Archimedes CopuIa function feature. So, Kendall rank correlation coefficient τ can obtain θ. In the case of $u_1=u_2=a=50\%$, correlation coefficient ρ^* between coastal coal transportation spot market freight yield and forward freight price yield can be estimated, specific result is shown in Table 4-14.

Table 4-14 Estimation of correlation coefficient ρ^*

Correlation coefficient value	Qin-Guang	Qin-Hu
τ	0.756	0.719

θ	3.915489	4.795691
ρ^*	0.815623	0.869475

4.4.3 Estimation of coastal coal freight index derivatives hedging ratio

Through results obtained in previous sections, the minimum variance hedging yield can be estimated. Median correlation coefficient ρ^*, coastal coal freight index derivatives yield standard deviation and coastal coal transportation spot market freight yield standard deviation are respectively introduced into formula (3.23), then optimal hedging yield is obtained.[35]

Table 4-15 Hedging rate estimation

	Hedging rate h^*
Qin-Guang route	0.7423
Qin-Hu route	0.8101

As shown in above table, hedging yield h^* of spot market freight price and forward freight price in both Qinguang and Qinhu routes is around 0.8, which shows better hedging effect. It is worth noting that due to different traffic volume and transportation capacity, different route has different hedging yield.

4.5 Analysis of coastal coal freight index derivatives hedging effectiveness

In this section, we use comparative study to analyze hedging effectiveness of coastal coal freight index derivatives. The concrete method is to compare the basic statistic which is calculated a hedging yield with non-hedging plans. Yields of non-hedging and hedging are expressed as follows, respectively.

$$R_u = S_t - S_{t-1} \tag{4.11}$$

$$R_H = S_t - S_{t-1} - h^*(F_t - F_{t-1}) \tag{4.12}$$

In above formula, h^* is the optimal hedging yield, RU and RH are non-hedging

yield and hedging; respectively, ST and FT represent the logarithm of coastal coal transportation spot market freight and forward market freight price at the moment t, respectively. Hedging sequence RH can be got through the formula (4.11). statistical characteristics of fore and post hedging yield are expressed as follows.

$$R_u = S_t - S_{t-1}$$

$$R_H = S_t - S_{t-1} - h^*(F_t - F_{t-1})$$

Table 4-16 Characteristics description of hedging return rate

Statistical characteristics	Non-Hedging portfolio		Hedging portfolio returns	
	Qin-Guang	Qin-Hu	Qin-Guang	Qin-Hu
Mean	–0.000639	–0.000544	–0.000256	–0.000128
median	0.000000	0.000000	0.000000	0.000000
Maximum	0.031749	0.037622	0.028563	0.036954
Minimum	–0.018692	–0.044233	–0.015633	–0.040217
Standard	0.007244	0.010356	0.005214	0.009521
Skewness	0.513258	0.048962	0.615894	0.085126
Kurtosis	4.272452	5.648805	3.695214	4.623351
JB test	27.06281	71.13578	21.23691	58.32145

Through unit root test (ADF test) and stationarity test of time series after hedging, the results are shown in following table.

Table 4-17 Stationery test of hedging time sequence

Unit root test	Non-hedging set		Hedging-set	
	Qin-Guang	Qin-Hu	Qin-Guang	Qin-Hu
ADFtest value	-14.10866	-25.21573	-16.56744	-27.11256
associated	0.0000	0.0000	0.0000	0.0000
Critical value	-3.457630	-3.457400	-3.457641	-3.457401
Critical value	-2.873440	-2.873339	-2.873456	-2.873336
Critical value	-2.573187	-2.573133	-2.573189	-2.573132

From the result of the above, we can draw the following conclusion: whether in 1%, 5% or 10% significance level, ADF are smaller than the critical value of the absolute value of statistics, so reject the null hypothesis, namely after the hedging rate return sequences are stable. At the same time, through Jarque-Bera statistic significance, we can see that the hedging ratio sequences do not obey the normal distribution.

From Table 4-16 calculation results, it can be seen that the hedging rate yield sequence of the mean and variance are relatively small, it has hedged floating degree before ease a lot. This shows that the coastal coal rate after hedging rate's ability to resist and control risk enhanced obviously, and degree of floating rate significantly reduce. Therefore, we may safely draw the conclusion: China's coastal coal freight index derivatives has a strong price hedging function. In the use of China's coastal coal freight index derivatives for hedging, participants can effectively control risk brought by the freight rate fluctuations. This demonstrates that the coastal coal freight index derivatives hedging effect is effective.

4.6 Application and suggestion of coastal coal freight derivatives

It can be seen from the previous empirical results that Chinese coastal coal freight index derivatives market has a strong hedging effectiveness, and the shipping companies shall make reasonable use of the derivatives. Currently, except the few large state-owned enterprises, domestic shipping enterprises have not begun a large-scale freight fluctuation risk management, and most of them still have to passively bear the cost burden caused by the unreasonable increase or decrease of freight, and shift the cost to downstream industries, bringing about an extremely unfavorable effect to the sustainable development t of the whole national economy. To prevent the risk from freight fluctuation, the related domestic enterprises shall develop a proficiency in the practical operation of shipping derivatives and learn how to use the hedging function of the shipping derivatives market to save their profit and prevent unnecessary loss.

While in current derivatives freight transaction market, there are only a quite small proportion of Chinese enterprises involved in derivatives transaction market, which has caused the passive acceptance of the most trade enterprises and manufacturers for the freight change. That is an obviously inconsistent with China's position in international dry bulk spot market.

It has been inferred that the phenomenon is mainly caused by the insufficient knowledge of Chinese shipping companies about the derivatives products, and the ignorance of the derivatives products forces many shipping companies to face the large market risk. It is undoubtedly a huge loss for the enterprises to suffer in succession when faced up to violent fluctuation in market freight, due to the lack of risk management consciousness.

Therefore, while development the mid and forward freight agreement of Chinese coastal coal shipping market; we can absorb the successful experience of other countries in developing dry bulk FFA transactions. First, we shall allow more enterprises in the market to understand the specific function and usage specification of the mid and forward freight agreement, and after developing a market recognition, we shall absorb more operation subjects to the transaction market and enhance market risk prevention capacity of the shipping companies in both micro and macro-levels, improve their risk management level and the ability to transfer the freight risk resulting from the violent market fluctuation. Then, considering the initial stage of the freight derivatives products in our country and the unsound political system and auxiliary facilities in this regard, we shall positively draw international successful experience and make further modification for our political system to provide a powerful follow-up guarantee for their involvement into the market

On such basis, we can propose the following suggestions while developing the mid and forward freight agreement of our coastal coal market:

(1) Regularly organize costal coal market mid and forward freight derivatives transaction forum, generalize the derivatives among the shipping companies, make them clear of the concrete usage specification and the possible effects to help them promptly involve into derivatives products transaction based on market change and

prevent the unnecessary loss due to the violent market fluctuation.

(2) Establish an effective risk prevention mechanism inside the enterprises and improve their risk prevention system by reference from the international successful experience.

(3) Continually improve our FFA management method, regulate the transactions by carrying out micro-control measures and formulating relation legislations, and increase the transparency of the transaction to make sure the operation feasibility of costal coal FFA.

(4) Take reference from the central transaction system of the new FFC researched by Baltic Exchange and develop the transaction system on exchange suitable to our freight market, to make an easier coastal coal forward freight derivatives transaction on exchange and improve their market usage rate.

Chapter 5. Conclusions and prospect

5.1 Conclusions

The thesis, with the freight derivatives of Qin huangdao-Guangzhou and Qin huangdao-Shanghai sea routes as the samples, aims to explore the hedging effectiveness of SSEFC Chinese coastal coal freight derivatives. It has used the minimum variance model to estimate the optimal hedging ratios of the two sea routes, and made a comparative and analytical research on the float change of the hedged and unhedged time series.

By empirical analysis, it has discovered that coastal coal freight will have a stronger risk resistance and apparently weaker fluctuation aided by the hedging function. Thus it is suggested that domestic dry bulk enterprises shall hold a familiarity with the practical operation of the freight derivatives to prevent the risks from dramatic rise and fall of the freight, and learn to use derivatives market hedging function and FFA to lock their profits and prevent the unnecessary loss.

5.2 Prospect

After all, as a new kind of product, Chinese coastal coal freight derivatives remain in a strong wait-and-see market atmosphere and face a relatively weak fluidity. However, with the development of the “double centers”, Chinese coastal coal freight derivatives will become more and more active in transaction and the days for realizing the hedging function can be expected. That can provide quantitative basis for the authority to analyze the supply-demand relation in shipping market and judge its future possible trend, help the related departments to better carry out macro-regulation and realize the reasonable allocation of national economic resources throughout the whole nation.

Freight derivatives transaction can help the enterprises related to shipping service make scientific and rational prediction about future shipping business, make reasonable arrangement in their activities investment, financing, leasing, transport, operation plan budget and business. It is helpful to realize the steady operation in

such related industries as shipbuilding, steel, port, electric power, shipping, logistics, banking and insurance, and avoid the radical changes of the shipping business and other related industries.

SSEFC is a key project located in Shanghai international shipping center. The project also shoulders the arduous historical mission of seeking speaking right and pricing power in international shipping business for our shipping companies, apart from supplying hedging service. When the freight derivatives transaction market of the company grows to a level, the pricing function of the market also take shape. Shanghai shipping freight will become one of the most important references for the whole world shipping business.

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