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Study on volatility of China Containerized Freight Index based on GARCH family model

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Study on Volatility of China Containerized Freight Index Based on GARCH family Model

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DECLARATION

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

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

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ABSTRACT

Title of Dissertation: Study on Volatility of China Containerized Freight Index Based on GARCH family Model

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Abstract: With the gradually increasing container transport proportion in the international shipping, as well as container freight changes, research Containerized Freight Index volatility has become the consensus of people in the world shipping community. As we all know, since China accession to the WTO, China and the world's trading activities are growing, and the rapid increase in container liner shipping industry also will be correspondingly. The competition is so fierce in the container liner shipping market. In order to allow shipping companies to stand in an undefeated position, therefore, to study the variation characteristics and to grasp the market dynamics of China Containerized Freight Index (CCFI) plays a crucial role of investment decisions making to container transport operators and investors..The CCFI index fluctuating influences significantly on the entire export container transportation market. Under normal circumstances, the fluctuations in the transport market is reflected by the form of transport price and freight rate volatility is often used to reflect the size of the freight index. Hence, through China Containerized Freight Index to learn about the fluctuating trend of China's export container freight and a better grasp of the export container transportation market fluctuations in prices, we can provide effective suggestions for decision making to the related business operations and government. GARCH models, widely used in financial research, will be applied to China's export container transportation market, examining the law of fluctuations in freight index. For accomplishing these objectives, using a combination of qualitative and quantitative research methods, a combination of theoretical models and empirical analysis are carried out in the following analysis and research:

First, a brief study of Chinese export container shipping market as well as market supply and demand. Introducing of CCFI the origin and development, on the basis of

analysis of a large number of historical data, summarizing the characteristics of the volatility in China Containerized Freight Index: long-term decline trend, cyclical, seasonal operation and three-wave characteristics, followed by fluctuations reasons, focusing on analysis of the direct factors and indirect factors affect China's exports of container shipping freight, and in China Containerized Freight Index fluctuations movements to make predictions.

Then, the introduction of a theoretical model - the theory and development of the GARCH model, the model including symmetric and asymmetric GARCH model. Parts of China Containerized Freight Index as the research object, stationary test found that the freight index sequence is not stable, so processing the data to obtain the sequence of stable first-order differential freight index sequence, the freight index yields. Then establishing research models of China Containerized Freight Index Volatility, based on the EGARCH model to analyze the example, the freight index seasonal fluctuations and cyclical fluctuations, but also the seasonal fluctuations and irregular fluctuations of the sequence. And they have close links to the leverage effect of the freight index. Conclusion, China Containerized Freight Index is very sensitive to good news than the bad news.

Finally, by the mean equation, with the model based on the EGARCH (1,1) model derived from the sequence of the predicted value of the CCFI freight index returns, we indicate that the trend of China Containerized Freight Index fluctuations, and to put forward suggestions.

The end summarizes the main conclusions of this paper, and paper in-depth study of the prospect.

KEYWORDS: China Containerized Freight Index, the GARCH model, persistence and sensitivity, leverage

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LIST OF ABBREVIATIONS

CCFI	**China Containerized Freight Index**
BDI	**Baltic Dry Index**
UNCTAD	**United Nations Conference on Trade and Development**
ARCH	**Auto-Regressive Conditional Heteroskedasticity Model**
GARCH	**General Auto-Regressive Conditional Heteroskedasticity Model**
EGARCH	**Exponential General Auto-Regressive Conditional Heteroskedasticity Model**
TGARCH	**Threshold General Auto-Regressive Conditional Heteroskedasticity Model**
VAR	**Vector Auto-Regressive**

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Chapter 1 Introduction

1.1 Research background

To show the movement and the situation of the market, freight indexes are used wide range in the modern shipping market. For this sake, charged by Chinese Transportation Department, China Containerized Freight Index, short for CCFI, is declared by Shanghai Shipping Exchange beginning in 1998, which reflects the movement of freight rate and the relatively change of the rate. The aim of declaring CCFI is to reflect the movement of china export container market objectively and precisely, to be a reference for shipowners, agencies, brokers, cargo owners, etc. to realize the change of supply and demand and make the proper strategy. Same time, transportation departments can also know the volatility of the China export container transportation market and design the appropriate policy for the shipping market.

So far, CCFI has got strongly response from the international shipping market, triggering a huge benefit both society and economy. Then, because of the science and authority, it becomes the authoritative figures of UNCTAD after the Baltic Dry Index.

The beach mark of CCFI is 1000, based on the beach point 1st Jan 1998, which consist of 11 routes as the sample, including Hong Kong, Korea, Japan, Southeast Asia, Australia-New Zealand, Mediterranean, Europe, East-West Africa, West coast, East coast, South Africa. And Dalian, Tianjin, Qingdao, Shanghai, Nanjing, Ningbo, Xiamen, Fuzhou, Shenzhen, Guangzhou are base ports in domestic market.

The freight rates come from the 16 famous and dominant China and abroad container liner companies that submit the information about freight rate voluntarily. They are CMA-CGM， OOCL, Maersk, MOL, etc.

The study on the volatility of the CCFI, abstracting the characteristics of the container transportation market, can let the companies and government understand the market better, knowing how to prepare facing the market risk.

1.2 Literature review

Both scientists in China and abroad have done quite a lot of research on the volatility of different kinds freight index.

China Containerized Freight Index, CCFI, is the unique containerized freight index, which is the origin of Shanghai Containerized Freight Index, SCFI. Nowadays, it becomes the critical index to reflect the situation of Chinese container transportation market. According to the known volatility principles of CCFI, government or the enterprise can make better market strategies.

Currently, mostly scientists in China and abroad are focusing on the research of the volatility of Baltic Dry Index, BDI, but few to container freight index. In Veenstra's article (1997)1, we can see the Vector Auto-Regressive (VAR) model is applied to analyze dry bulk freight rate index. Gongjin (2001)2 did a research on the seasonality benefit return of Baltic Dry Index. As well as Wang Jun (2011)3 was talking about the volatility of world scale based on the Generalized Auto-Regressive Conditional Heteroskedasticity model. Similarly, Lu kecong 4 utilized Auto-Regressive Conditional Heteroskedasticity (ARCH) model to analyze the Baltic Capesize Index (BCI). Liu Cuilian5 used ARCH family models on the China Coastal Bulk Coal

[1] Veenstra A W, Franses P H. 1997: A Co-integration Approach to Forecasting Freight Rates in The Dry Bulk Shipping Sector, Transportation Res, No. 31(6), p 447-458.

[2] Gongjin. 2001: Practical Research on Risk of International Dry Bulk Freight Rate and Related Problems, Shanghai Maritime University Published, 2001.

[3] Wang Jun, Zhang Lina. 2011:The Risk of International Crude Oil Freight Rate Analysis by GARCH Model, Shanghai Maritime University published, 2011 No. 32(2), p 20-24.

[4] Lu Kecong. 2008: Analysis the Volatility of Baltic Capesize Index, Shanghai Maritime University published, 2008 No. 29(4), p 29-33.

[5] Liu Cuilian, Liu Meijian, Yang Juan, etc. 2012: Assessment on The Volatility of CBCFI by ARCH Model, Wu Han University of Technology published, 2012 No. 36(3), p 445-449.

Freight Index (CBCFI) to show the intangible principle of the coastal coal transportation market.

What's more, study on the Auto-Regressive model has been never stopped. After being put forward in 1993, Engle used it in the inflation model, but also Bollerslev6 stated GARCH and TARCH model. And based on the TARCH, he figure out the exponential GARCH model, which shows the leverage effect from the market to the index.

In this dissertation, the author will concentrate on not only the volatility pattern of CCFI but also the characteristics of stability, heteroskedasticity and volatility for improve the forecasting reliability of China container transportation market.

1.3 The framework of the dissertation

The main goal of this dissertation is to use GARCH (Generalized Auto-Regressive Conditional Heteroskedasticity) model to analyze the volatility of the China Containerized Freight Index, risk of the container market and connect the statistics volatility and the reality factors. In this dissertation the author will collect the figures of CCFI from Jan 1st 1998 to Mar 16th 2012, analyzing, as well as testifying, their stability in time serial and heteroskedasticity. Then, using the GARCH model indicates the clustering and sensitivity of the index, and the EGARCH and TGARCH model figures out the effect of leverage and the asymmetry of the index. Finally, connect the market factors to the data volatility, give the characteristics for Chinese container market, and some author's recommendation to Chinese container shipowners. So the framework of the article is following:

Chapter one: Telling the background and the purpose of the research, summing up the research results in past decades, and briefly introducing the clue of the dissertation.

[6] Bollerslev T. 1986: Generalized Auto regression Conditional Heterroskedasticity, J Econometrics, 1986 No. 31, p 307-327.

Chapter two: Introducing the developing history of domestic container liner market, realizing the general situation of that market based on the statistics that has been collected, and giving the analysis of the characteristics of the Chinese container liner transportation market.

Chapter three: Analyzing CCFI, stating the development and the calculation of it, then, after the historical volatility analysis, summarizing the feature of the volatility.

Chapter four: Picking up series of CCFI data, and after the fitting test of the GARCH model, the model should be built. According to the GARCH(1,1) model, the sensitivity and persistency of CCFI could be concluded. Furthermore, the optimized model EGARCH and TGARCH will be used to figure out the unparallel leverage of the CCFI, the negative impact stronger than the positive one.

Chapter five: Based on the forecasting ,from the GARCH(1,1) model, of the yield of CCFI, giving a prediction to the movement of the future volatility of CCFI.

Chapter six: Conclusion and suggestion.

Chapter 2 General statement of China exporting containerized transportation market and CCFI

2.1 General statement of the China container liner transportation market

Retrospect the developing history of the container, that is beginning from the rail and the road. After the World War two, American military used it on the maritime transportation. That fact proved that the containerized transportation is much safer and more efficient than the transportation model ever before. So, when the war was ending, a new era started. While the recovery of the world economics and the trading volume in different countries, containerized transportation became the fist option to facilitate the efficiency of the loading and discharging and cut down the transportation costs. It is the most brilliant technical evolution in the domain of transportation, which not only changes the transportation itself, but also influences the world trading, finance, customs and the relevant apartments. Without an exaggeration, container triggers a revolution to the world transportation.

In China, the containerized transportation was firstly utilized in the railway, and after the virgin voyage of the ship carrying container, that was generalized. For the sake of catching up with the world transportation developments, in Sep 1973, Penavico, Sinotrans Group, and Cosco, as the representation of China, negotiated with the Naiko Kaiun and Nissin Corporation, commencing a testing container liner by general cargo ship carrying small containers between Shanghai and Yokohama, Osaka, or Kobe. Through nearly 40 years building, as well as the blooming of the international trading in China, China containerized transportation market is becoming the focus of the world. The exporting volume increasing rapidly and the optimized structure of cargo guarantee the rising demand of containerized transportation.

According to the statistics, by the first season of 2011, the value of China export container is $2.82 billion, comparing to 2010, which adds 317.5%, reaching the

summit of increasing percent. That reflects the upsizing of the container ships, as well as the value of the ship. At the same time, by the stably recovery of the world economics, the ships are becoming bigger and bigger. In Mar 2011, the volume of China exported container is 310 thousand, and the value of them is $1.12 billion. Because the price of ships is in the valley and the world economics is going up, the booking order in 2013 has increased 109% than 2012.

2.2 Analysis of the demand of China containerized transportation market

Demand of transportation is derivative form the trading. From the domestic perspective, containerized transportation can partly fulfill the demand of transportation, facilitating the international trading. Due to the exporting volume fluctuating by the economics change in the world, the demand is unbalance from time to time. When the demand is high, all the cargo owner fight for the limited room in the ship, but the depression season coming, it is totally contrary. And the supply of transportation capacity is always leg behind the market changing. Now the situation of China containerized transportation market will be introduced:

1. Nowadays Throughput

Affecting by the economic crisis, the throughput of China appeared first time decreasing in 2009. Entering the 2010, pulling by the highly developing economics and the exporting volume growing, domestic port throughput was uprising, higher than the foresee. From 2001 to 2013, except the 2009, the throughput of Chinese port is increasing stably, keep above 25%.

2. Containerizeable cargo

The containerized transportation market is determined by how much cargo can be containerizeable in the trading market. Containerizeable cargo means that the cargo can be fitted into a container, and transported in it.

In the statistics of transportation by water, there is only one kind of catalogue, published by Ministry of Communication. In that catalogue, they are classified into 12 kinds. But in the practice in the port, or the river transferring, there are 16 kinds. For

more precise, the dissertation will use the 16 kinds to classify the cargo, but it is only 8 kinds of them that can be containerizeable. And the percentage of transporting by containers is following:

Table 2-1 The percentage of cargo transporting by containers

Name	Percentage
Fertilizer	50%
Salt	5%
Mechanic equipments	65%
Raw chemical material	50%
Nonferrous metals	65%
Light industrial and medical products	70%
Agricultural and sideline products	60%
The others	50%

According to the past historical throughput statistics, the past volume of containerizeable cargo can be calculated, which is 73 million tons, 78.7 million tons, 122.5 million tons, 137.09 million tons, and 140.14 million tons. We can see that the demand of containerizeable cargo is still increasing.

3. Forecast of the demand of container liner carrying capacity

From the experts saying, generally, port throughput will keep uprising, but the increasing rate of international container liner will slow down. Because of the depression after world economic crisis, it is not easy to have a strong signal in the throughput increasing, especially in the far-east line.

2.3 Analysis of the supply of China containerized transportation market

1. Unbalance

The carrying capacity is unbalance between the busy season and the off season, so there is a gap between the summit and the valley, which means sometimes there are lots of spear carrying capacity, while there is not enough carrying capacity in the other time. In the other aspect, different regions, different routes, are has unbalance

situation. Even the same route, inbound and outbound is unbalance.

2. Forecast of the supply of container liner carrying capacity

Though there is a signal the world economics getting warming, the shipping market is still leg behind the economics. 2009, the demand of containerized transportation drop sharply, but the supply of that was going up. Figures from recently years, new carrying capacity in 2009 is approximately 1.71 million TEU, increasing 12.7%, and the supply is much over the demand in the market.

So far, the containerized market was in the bottom in Jun 2005, hence it seemed that there is no rooms for freight dropping again. However, the new ships are keeping putting into the market, and, to contrary, the restore of the demand is relatively slow, so it is the situation that the supply exceeds the demand will prolong for future years.

Table 2-2 Supply of containerized carrying capacity

Year	New carrying capacity (TEU)	Demolition (TEU)	Existing carrying capacity (TEU)	Increasing percentage
2006	1,380,000	30,000	9,470,000	16.70%
2007	1,370,000	30,000	10,810,000	14.10%
2008	1,580,000	70,000	12,310,000	14.00%
2009	1,710,000	15,000	13,880,000	12.70%
2010	1,440,000	15,000	15,170 ,000	9.30%
2011	1,260,0000	120,000	16,310,000	7.50%
2012	770,000	70000	17,010,000	4.30%
2013	1,160,000	90,000	18,090,000	6.30%

3. Risks of the container liner market

The goal of the cargo owners are to fix the freight to transport their cargo, whereas, it should have a reasonable way to stabilize the freight rate. After the promotion of the future, cargo owners can hedge the risks by using the future, fixing their transportation cost in a acceptable region to hold their international business moving. Hence, this dissertation will measure the freight risk as the main risk to the container liner companies. So, what is the advantage to promote the CCFI? That is will be

following.

2.4 Analysis of China Containerized Freight Index

2.4.1 The history and the evolution of CCFI

China Containerized Freight Index, short for CCFI, is one of the three famous shipping index in the world, like Baltimore Tanker Index and Baltic Dry Index. And it is the first index to reflect the freight volatility in containerized transportation market. State quo, UNCTAD has deemed CCFI as an authoritative figure in its annual shipping report. So, using the scientific method to analyze the volatility of CCFI, and digging out the internal rules, as well as the influencing reasons are sensible to container liner companies.

CCFI was published by Shanghai Shipping Exchange in Apr 1998, chosen the index of Jan 1st 1998 as the benchmark, 1000 points. It consists of 11 typical and consistent routes scattering in different district of the world, including Korean, European, Hong kong, Mediterranean, East Africa, West Africa, and West coast of American lines. And the base port in China are Dalian, Tianjian, Qingdao, Nanjing, Shanghai, Ningbo, Xiamen, Guangzhou, Shenzhen. All these data are calculated by Laspeyres' formula, and draw out the index. Therefore, it becomes a critical index to understand Chinese shipping market, not only to the shipping companies in daily running, but also to the press, research institutions, and the Chinese government.

2.4.2 Calculation formula of CCFI

1. Formula

Using the Laspeyres' formula, and the data of Jan 1st 1998 as the benchmark, 1000point, that is the beginning of the CCFI.

$$CCFI = \sum_{i=1}^{11} I_i = \sum_{i=1}^{11} \frac{P_{1i}}{P_{0i}} \times W_i \qquad (2\text{-}1)$$

$$W_i = \frac{p_{0i} q_{0i}}{\sum_{i=1}^{11} p_{0i} q_{0i}} \quad (2\text{-}2)$$

I_i : The parameter of the routes

P_{1i} : The freight rate of the route at that time

P_{0i} : The corresponding freight rate of the benchmark

W_i : Weight of the rout

q_{0i} : Cargo volume the route

2. The selection of the typical routes

As the typical, dispersive and relative principles, picking out the 11 routes as the samples, including Hong kong, Korean, Japan, Mediterranean, Europe, South Africa, South America, and West and East coast of America lines. And the base port in China are Dalian, Tianjian, Qingdao, Nanjing, Shanghai, Ningbo, Xiamen, Guangzhou, Shenzhen, Fuzhou. The freight rate, cargo volume will be as the data to calculate.

3. Data collecting

11 ship owner companies, domestic and international, which have good reputation, worldwide routes, high market occupation constitute to be a council, providing the data to Shanghai Shipping Exchange.

4. Publishing

CCFI is published by Shanghai Shipping Exchange every Friday, and the index of the 11 routes respectively.

2.4.3 The volatility characteristics of CCFI

For more persuasive of the volatility of the CCFI, the article will adopt series data in a rather long period, from Jan 1st 1998 to Mar 16th 2012, issued by Shanghai Shipping Exchange.

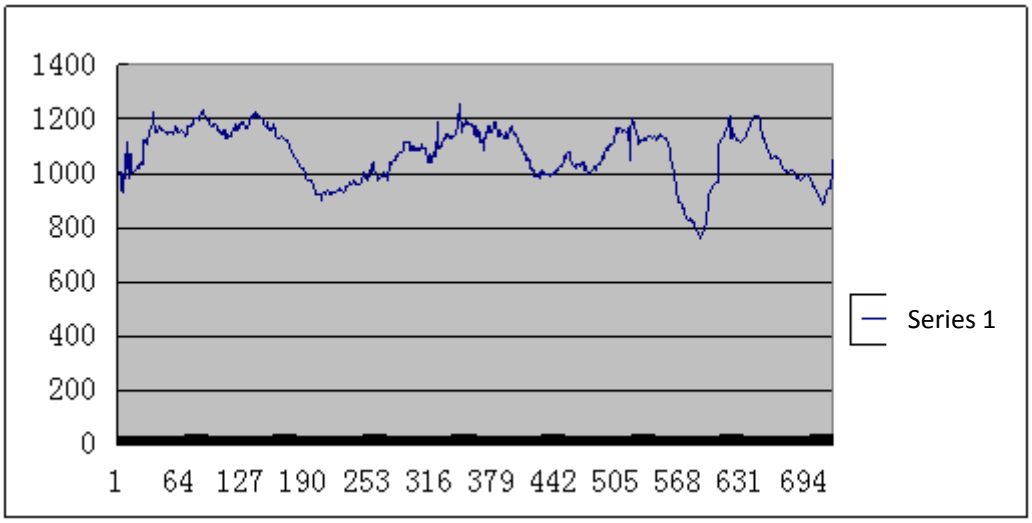


Figure 2-1 Movement of CCFI

In the dissertation, the sample contains 721 days index figures, and we can see how the CFFI went in the Grape 2-1. From the view of whole sample period, CCFI has strong volatility, the highest point, 1221.5, in May 1995, the lowest point, 777.04, in Jun 2009. What's more, we can see CCFI in some period may has strong volatility than the other time in the sample. By realizing the historical data and movements of CCFI, connecting with the economic and political power changes in the world, we may find some rules.

1. Declining slowly in a long time period

On the above Figure, adding an unary linear regression line, it finds out the tangent is negative, which shows CCFI descends in a long period, at least in the sample. The reasons come from two perspectives. One is because of the government. It drafted rules to confine the competition between the conference. Apparently, that is not real. The reason form container liner market is much more rational. For cutting down the cost, getting lower each unit cost, all the container liner companies starting building large-size container ships. Cost descends, freight rate drops as well. At the same, large-size container ships lead to surplus carrying capacity in the market, which is negative to the market. Not Sufficient profit holds the market in fierce competition.

2. Influenced by world economic cycle

There are four stages in the volatility movements, ascent-shock-descent-shock, if we see CCFI from section to section. Recently, CCFI is shocking in relative low

position still under the shadow of world economic crisis. Contrarily, CCFI incents the world economics reversely. The strong volatility of CCFI indicates the freight rate fluctuates severely in the containerized transportation market, which is exposing neither consignor or consignee to huge risks.

3. Seasonality

Result from the natural climate and social factors, CCFI fluctuates as the season change. We change the weekly data into monthly data in the sample in order to figure out the seasonality. The summit occurs in September and October, while valley appears in March and April. The main reason is that Spring Festival and Christmas pushed demands in that period in advance. Consequently, two reasons cause the seasonality: one is the seasonal demand, tow is the seasonal carrying capacity change.

2.5 Reasons of the volatility

2.5.1 Direct reasons

1. Demand and supply

International container liner shipping market supply refers to, a certain period of time, the container liner ship owners are willing and able to provide standard transportation volume, under the condition of all kinds of freight. The realization of the containerized transportation supply has to meet two requests: one is the container transportation producers have a willingness to provide the services; second, the producer has the ability to provide containerized transportation service. Quantity of the supply depends on many factors, the influence of the freight rate, the mainly one, and the cost of transportation, technology level, market structure and others. In recent years the supply of containerized carrying capacity presents the following features: (1) as the international container trade increased year by year, that promoted the containerized carrying capacity growing, result to the market in a long term supply glut. (2) operational ships are bigger and bigger. (3) the international container liner market has more exit obstacles than entry.

2. Transportation cost

The transportation cost, the mainly body of the freight rate of containerized transportation, is the determinative cause to the freight rate. Transportation costs almost includes: fixed investment of ships and containers, operational cost, management expenses and financial expenses.

Generally speaking, freight rate comprises transportation cost, taxes and profit. And transportation cost occupies large proportion of it, 90% or even more, therefore, transportation cost directly affect the freight rate. Digging into the transportation cost, fuel cost is a huge part of it. We can see it from Table 2-3:

Table 2-3 Containerized transportation cost

Name	Proportion（%）
Total cost：	100
Operational cost：	58.61
Cargo cost:	20.18
Transfer:	18.81
Fuel cost:	16.13
Disbursement:	6.43
Others:	0.06
Fixed cost of ships:	17.56
Fixed cost of containers:	16.51
Administration:	4.8
Financial cost:	2.52

From the table, sailing cost is the main part of the operational cost, and the fuel cost takes up 16.13% of the sailing cost, relatively large proportion. Meanwhile, fuel cost, connecting with the oil price in the world, is very unstable, so this makes the fuel cost fluctuate often. Shipping companies also shall change the freight rate according to the fuel prices from time to time.

Consequently, international crude oil price and container ship fuel prices has a strong connection. Once oil price rises, for avoiding losses, liner companies shall increase the freight rate correspondingly. Even the freight rate might not rise in a short

term, the companies will use the crude oil futures to hedge the risks from oil market. If oil price rise consistently in a long term, container liner companies must adjust the freight rate to compensate for rising fuel cost.

As a result, CCFI basically has the same movement as the WTI (West Texas Intermediate, which is a typical figure to indicate the crude oil market), but because of CCFI restricted by many factors, coupled with its cyclical fluctuations and the characteristics of seasonality, CCFI creates volatility in the period, at the same time CCFI movements are lagging behind the crude oil fluctuation, so the change of international crude oil price will not lead to the change of container freight immediately.

3. Exchange rate

US dollar devaluation also contributed to the increase of operational cost to the container liner companies. According to Chinese Foreign Exchange Administration, the Yuan central parity rate compared to $682.81 in Jan 2010 to 662.47 in Dec 2010, devaluation about 2.98%. The falling of dollar makes the price of commodities, raw material, wages keep rising, elevating the cost of fuel, disbursement, terminal handling cost, agent fees and transfer fees as well, result in an increase to the container liner companies' cost. Dollar depreciation will give rise to the ships maintenance, materials, spare parts, survey, crew wages, and administration cost in a certain extent. And the revenue of container liner companies are settled in US dollar, the devaluation of dollar cased the net profit reduction after currency exchange.

2.5.2 Indirect reasons

1. World economics

World economics effect the container freight rate mainly by influencing the demand. International containerized transportation market is closely related to the world economics, and world economics fluctuations has a strong impact to world trading volume, thus the world trading volume implies the demand of international containerized transportation, and the demand will affect the freight rate. All this shape

a chain that how world economics effects containerized transportation freight rate.

The growth of the world economics and world trading growth are basically consistent, same rise, same fall. The decline of world economics triggers the reduction of container transportation volume, while the upside of the world economics brings the growth of container transportation volume. So the world economics is the engine of international containerized transportation market. Once the engine slows down, the whole transportation market will collapse. In 2008, the world economic crisis hit the world fiercely, and the shipping industry is one of the first to be affected. Under the could of the crisis, container freight rate fell down again and again. Into the end of that year, freight index fell to 978.12.

2. Emergencies

Emergencies contain unexpected problems in politics, military event and natural disasters, which leave a strong impact to world economics, changing the commodity trading, so to the containerized transportation demand, such as the “911” in 2001. From the point of container freight rate in 2001, after “911”, freight index fell to 932.35 at the end of 2001. Same situation happened in 2005. After the hurricane “Katrina” hit America, the container freight rate dropped shapely again.

Chapter 3 Analysis of GARCH model and the adaptability

3.1 The development and application of GARCH model

Traditional econometric model assumes that the sample variance remains the same, keeping a constant variance in different periods. However, more and more researcher find out that the expression of the uncertainty and risks decision making of variance is changing with time, and depend on the degree of the change of the error in the past. So, traditional model about independent with variance assumption is not suitable for the development of financial theory now. For example, the inflation rate, foreign exchange rates, stock prices and the other areas of the finance often come across the heteroscedasticity problems in data analysis.

To solve the problem of heteroscedasticity, American economist Engle[7] proposed ARCH model in 1982, for analysis of the time series heteroscedasticity. Later, because the model can comprehensively describe the volatility of financial assets, it is widely used in financial domain. Then, Bollerslev, T. put forward the GARCH model that is a specific regression model for financial data. Except the common features as ordinary regression model, GARCH model builds another further part for error variance, especially suitable for the analysis of volatility and forecast. The precision of it plays a very important role in guiding for the decision making to enterprise investor. In 1991, Nelson[8] presented the EGARCH model to depict the asymmetric reaction of conditional variances to the positive and negative interference in the market. People, like Engle, drew out the asymmetric information curve, the good news and the bad news, indicating that shocks in the capital market often show an asymmetry. After that, Glosten, Jagannathan and Runkel proposed the asymmetric TGARCH model that points out that different model will cause positive or negative

[7] Engle R F. 1982: Autoregressive Conditional Heteroskedasticity with Estimate of the Variance of United Kingdom Inflation, Econometrica No. 50, p 987-1007.

[8] Nelson D B. 1991:Conditional heteroskedasticity in Asset Returns: A New Approach, Econometrica, 1991 No.59, p 347-370.

impact to the yield by different conditional heteroscedasticity setting. With constantly developing in ARCH model, gradually forming a huge ARCH model family, these models constitute a relatively completed set of conditional heteroscedasticity regression theory, attracting high attention and received widely range of applications in economic and financial field. Nonlinear theory applied, it becomes the most classic part of the price fluctuation.

3.2 Classification of GARCH model

3.2.1 Symmetric GARCH model

1. GARCH model

Bollerslecv, T.[9] considered the conditional variance equation is the variance of distribution lag model, and one or two of variance lag value can instead of many residual square lag ,which is the basic idea of GARCH model. GARCH model is one kind of ARCH family model with different variance of time series modeling method. In GARCH model, two different settings should be considered: one is the average condition, the other is conditional variances. Standard GARCH model can be expressed as:

$$Y_t = c + \theta' \times X' + u_t \tag{3-1}$$

$$\sigma_t^2 = \omega + \alpha \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2 \tag{3-2}$$

Among them, $X' = (X_1, X_2, \cdots, X_k)'$ is to interpret the variable vector, and $\theta' = (\theta_1, \theta_2, \cdots, \theta_k)'$ is the coefficient vector. Formula (3-1) is an average equation with a disturbance of exogenous variables function. Since it, based on the previous information, issues the forecasting variance, so σ_t^2 is called conditional variances, formula (3-2) called the conditional variance equation. Formula (3-2) consists of three parts of conditional variance: ω, constant; u_{t-1}^2, ARCH part, measuring the volatility

[9] Bollerslev T. 1987: Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return, Rev Econ & Stat, 1987 No.69, p 542-547.

of information from the early stage by the lagging behind of the disturbance square of mean equation; σ_{t-1}^2, GARCH part, forecasting variance of former period.

In here, h_t can be understood as the weighted average of the all past residual error, which consistent with the volatility clustering effect, example: the big volatilities are followed by the greater volatility, but the small ones are followed by the small one. Since GARCH model is the extension of ARCH model, GARCH (p, q) has the same characteristics as ARCH (q) model. Not only is GARCH model of conditional variances lagged residual square linear function, but it is lagging conditional variance of linear function. GARCH model is good at small amount of calculation, describing the higher-order process of ARCH model conveniently. However, it is defective in application to reflect the freight earning's volatility.

Firstly, GARCH model cannot explain the between the freight revenue and the earning change, there is a negative correlation in fluctuation. GARCH model assumes that conditional variances is lagged residual square function, so the plus-minus of residual error does not effect the volatility that imply that it is symmetric to the reaction of the conditional variances whether the price changes positively or negatively. Nevertheless, in empirical research, it found that when band news appeared, expected freight revenue fell, strong volatility, when good news came, expected yield rose, weak volatility. GARCH model cannot explain this asymmetric phenomenon, namely GARCH model cannot depict the asymmetry of yield under the conditional variance volatility.

Secondly, in order to ensure σ_t^2 is nonnegative, GARCH model presumes that all the coefficients in formula (3-2) is positive. These constraints implied that any lag of u_t^2 will increase the σ_t^2, which exclude the random volatility of σ_t^2, making oscillation phenomena when we estimate GARCH model.

2. GARCH-M model

On the basis of GARCH model, Engle, Lilien Robins (1987) proposed the average GARCH model (GARCH-in-mean, GARCH-M). The conditional variance of return

on assets joins in the mean equation, for describing the relationship between the financial assets return and risks, and it can be expressed:

$$Y_t = c + \rho \times h_t + \theta' \times X' + u_t \tag{3-3}$$

$$\sigma_t^2 = \omega + \alpha \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2 \tag{3-4}$$

In these formulas, σ_t^2 obeys GARCH model, ρ is measured by conditional variances, and the impact from observable expected risks in fluctuations to y_t, it represents a balance between the risks and benefits. Under the hypothesis that the model try to explain a freight revenue returns, the reason why we increase σ_t^2 is that every investor has expectations that return rate is closely connected with risks, and conditional variances is on behalf of the magnitude of the expected risks. So, GRCH-M model is appropriate for describing the expected return rate is tightly bound to the expected risks.

3.2.2 Asymmetric GARCH model

1. TGARCH model

TGARCH model (Threshold ARCH) was proposed by Zakoian, Glosten and Runkle, which is to use virtual variable to set a threshold, to distinguish the positive and negative impact of conditional variance. The form of conditional variances:

$$\sigma_t^2 = \omega + \alpha \times u_{t-1}^2 + \gamma \times u_{t-1}^2 d_{t-1} + \beta \times \sigma_{t-1}^2 \tag{3-5}$$

d_{t-1}, a virtual variable: $d_{t-1} = \begin{cases} 1 & u_{t-1} < 0 \\ 0 & u_{t-1} \geq 0 \end{cases}$ (3-6)

In formula (3-6), $\gamma \times u_{t-1}^2 d_{t-1}$, in conditional variance equation, is called asymmetric effect item or TARCH item. Conditional variance equation shows that σ_t^2 relies on the residual error square of prophase u_{t-1}^2 and the size of the conditional variance σ_{t-1}^2. Due to d_{t-1}, the good news ($u_{t-1} > 0$) and bad news ($u_{t-1} < 0$) effect conditional variance differently. The hitting level of good news is α,

namely $u_{t-1} > 0$, $d_{t-1} = 0$, no asymmetric item in formula (3-6). Contrarily, the level of bad news is $(\alpha + \gamma)$, for $u_{t-1} < 0$, $d_{t-1} = 1$, the impact of asymmetric item. So, only is there a γ, there is a leverage. If $\gamma > 0$, the impact of asymmetry will enhance the volatility, and if $\gamma < 0$, the volatility is weakened. Consequently, when receiving a hit in the same level, bad news is much stronger than good news.

2. EGARCH model

EGARCH (Exponential GARCH) model, proposed by Nelson (1991), aims to depict the σ_t^2, conditional variances, responses asymmetrical to the positive and negative interference. The conditional variances σ_t^2 is the anti-symmetric function of delayed disturbance u_t, so the conditional variance equation is:

$$\ln(\sigma_t^2) = \omega + \alpha \left| \frac{\hat{u}_{t-1}}{\sqrt{\sigma_t^2}} \right| + \gamma \frac{u_{t-1}}{\sqrt{\sigma_t^2}} + \beta \ln(\sigma_{t-1}^2) \qquad (3\text{-}8)$$

Conditional variances in the model adopted natural logarithm form, which means that the leverage effect is exponential, rather than square, so the conditional variance forecast must be negative. The existence of leverage effect is inspected by the assumption $\gamma < 0$. If $\gamma \neq 0$, the asymmetry of information impact exists; if $\gamma < 0$, the leverage effect is remarkable. Hence, EGARCH model can describe the asymmetry well in shipping market. In addition, due to σ_t^2 be represented as index form, the variance σ_t^2 is positive itself. So, without any constraint to the parameter in the model, the solving process is more simple and flexible, which is a huge advantage of EGARCH model.

3.2.3 Analysis of GARCH model adaptability

Through the analysis of the past CCFI, in the first chapter, we summarized the freight index has characteristics, like long-term downward trend, seasonal fluctuations, cyclicity, similar with volatility characteristics of Chinese stock market, but these

characteristics is external manifestation of freight rate volatility. If want to explore the inner source of freight rate fluctuations, we need a relevant mathematical model, through the surface to study the deep of volatility. Domestic and foreign experts have achieved numerous research results that can be reference in stock market. Stock index, as well as freight index, both belong to the financial time series that generally has “leptokurtosis and fat tail”, ARCH effect, cluster, and leverage.

By above model introduction, GARCH model is especially designed for financial data regression. Expect ordinary regression model’s features, GARCH model is devoted the model of variance error. Furthermore, classified the symmetry and asymmetry, the model can not only analyze the cluster of the sequence, but also be able to depict the asymmetry of the conditional variance volatility. These features are especially suitable for the analysis and forecast the volatility of the time series that play an important role in guiding or making decision to investors, which is more significant than analyzing and predicting the data itself. Nowadays, most empirical studies of volatility in stock market have shown the unique advantages of GARCH model, therefore, GARCH model in shipping freight index volatility research has strong adaptability, and the following will utilize the model in the volatility study in CCFI to confirm the advantage of it.

Chapter 4 Empirical study of CCFI

4.1 Selection and process of sample data

In this paper, we use CCFI data, publishing by Shanghai Shipping Exchange, to build a model. Given CCFI begun on April 3rd 1998, this article selects the data from April 3rd 1998 to Mar 16th 2012, if it is not issued in some weeks, we deed that it is same as the previous one in default, total of 730 raw data. And we will use Eviews6.0 and Excel to do the analysis.

For the better reflection of volatility of CCFI, and CCFI raw data fluctuated strongly, week yields is regarded as the variable by logarithmic difference method. The reason is following: one is the logarithmic can change the growth curve of assets sequence trend into linear trend, and difference can eliminate some non-stationary of the sequence; Second is the index sequence, expressed by logarithmic difference, can describe the index difference yields well, in order to analyze the index changes form the yield curve.

We make CCFI to represent the index value of the t week, and get the sequence of CCFI week yield after processing first order difference to original data, as R_t, namely the t week yield of index:

$$R_t = log_{10}(CCFI_t) - log_{10}(CCFI_{t-1}) \quad (4\text{-}1)$$

The movement of CCFI yield sequence is following:

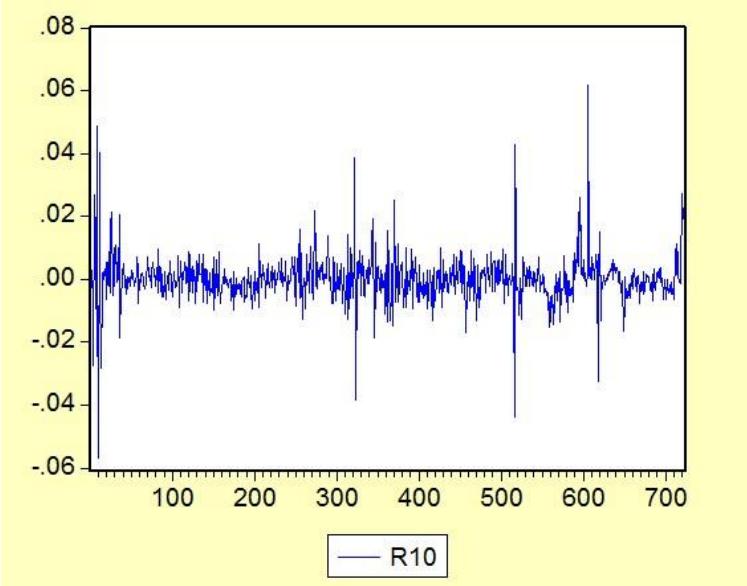


Figure 4-1 The movement of CCFI yield sequence

From the Figure 4-1, we can see that the yield is fluctuating up and down around the zero, large volatility is followed by the large one, an the small volatility is followed by the small one; sometimes it continuously stay high in a certain period, and in another continuous period, it is in the low side. When time goes on, there is no tendency that the amplitude decreases. Primarily estimation, the yield sequence is stable with cluster and sustainable.

4.2 Analysis of basic statistical characteristics

4.2.1 Introduction of the basic statistics

To realize basic statistical characteristics of CCFI weekly yield series, we need to calculate the sequence of the mean value, standard deviation, skewness, kurtosis, and Jarque-Bera normal distribution test statistics, including:

1) Mean value, to describe average volatility of the sequence in a period;
2) Standard deviation, to describe the discrete degree of the sequence. Greater standard deviation, stronger volatility;
3) Skewness, to reflect the symmetric distribution of the sequence (skewness of normal distribution is zero (symmetric). Greater the absolute value of skeness, greater deviation degree;

4) Kurtosis, to indicate the sequence distribution curve steep. As a result, normal distribution kurtosis is 3. The steeper the kurtosis, the greater the distribution curve; on the contrary, more smooth;
5) Jarque-Bera statistics, mainly for testing whether the sequence is normal distribution.

4.2.2 Analysis of the basic statistics

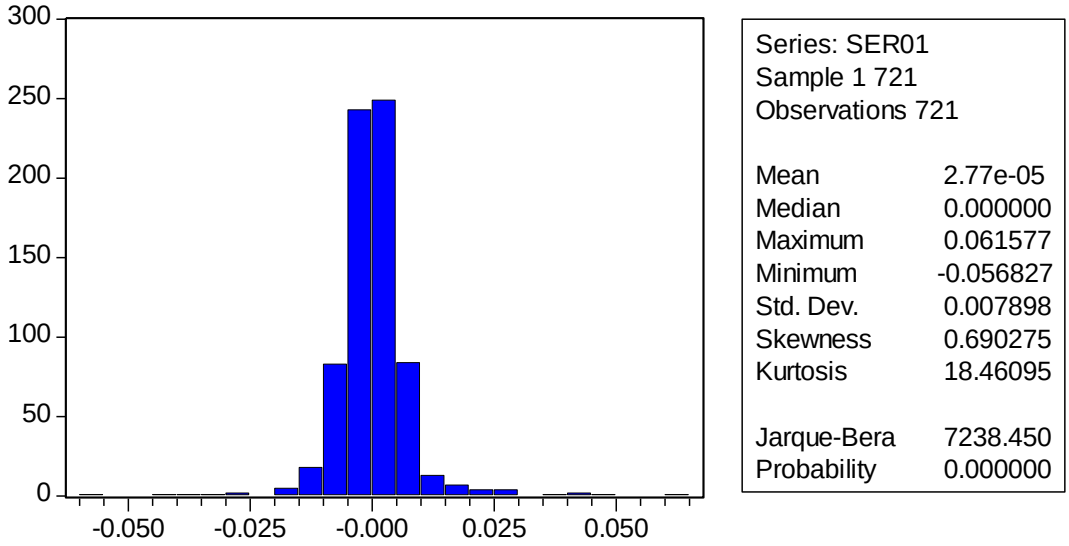


Figure 4-2 The statistics of CCFI yield based on $\log_{10}$

From the Figure 4-2, the standard deviation is 0.018187, the skewness of R_t is 0.690275, different from zero, so it is right distribution (or positive distribution). Kurtosis is 18.46095, higher than the normal distribution kurtosis value 3, and the tail is thick than normal distribution. The feature—"leptokurtosis and fat tail", now, has been proved in statistics. Jarque-Bera test whose result is 7238.450 also comfirms this point, and the associated probability is 0.0000, which means that the yield sequence is significantly different from normal distribution.

4.3 Analysis and test the features of CCFI yield series

4.3.1 Analysis the stability of the series

The premise of using GARCH family model is that the series must be stable. It is difficult to reflect the time series of the past and future with unstable random process. In general, if the mean value and variance of time series do not change by time changing, it is stable, otherwise, it is unstable. The test method, commonly used, in time series stability are DF test, ADF test, F test. And in this dissertation, we will use ADF test (unit root test) to prove the stability of R_t time series. Lagging differential order, namely i the number, which is determined by empirical research, is to make error sequence is not related. When AIC and SC10 is minimize, the i is decided. By Eviews6.0, i can be optimized automatically, and in this model, according to the AIC and SC, maximum lagging behind for 10, we can get the optimal i is 3, mean i =3. Test results are shown in Figure 4-3.

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-30.75283	0.0000
Test critical values:	1% level	-3.439205	
	5% level	-2.865338	
	10% level	-2.568849	

Figure 4-3 Test results of ADF

Under the confidence level of 1%, the t statistic in ADF test of yield R_t is 30.75283, less than the 1%, 5%, 10% corresponding critical value, and the probability of a unit root is zero. As the result, under these three confidence level, yield R_t declined random move hypothesis, which is a stable time series.

4.3.2 Correlation test of the yield series

The correlation testing method has two kinds: firstly, by autocorrelation function (ACF) and partial autocorrelation function diagram (PACF) into general qualitative judgment,; secondly, Ljung-Box Q test. Hypothesis is that there is no serial correlation, then we construct a statistic $Q = N(N+2)\sum_{k=1}^{p} \frac{r_k^2}{N-K}$, freedom degree

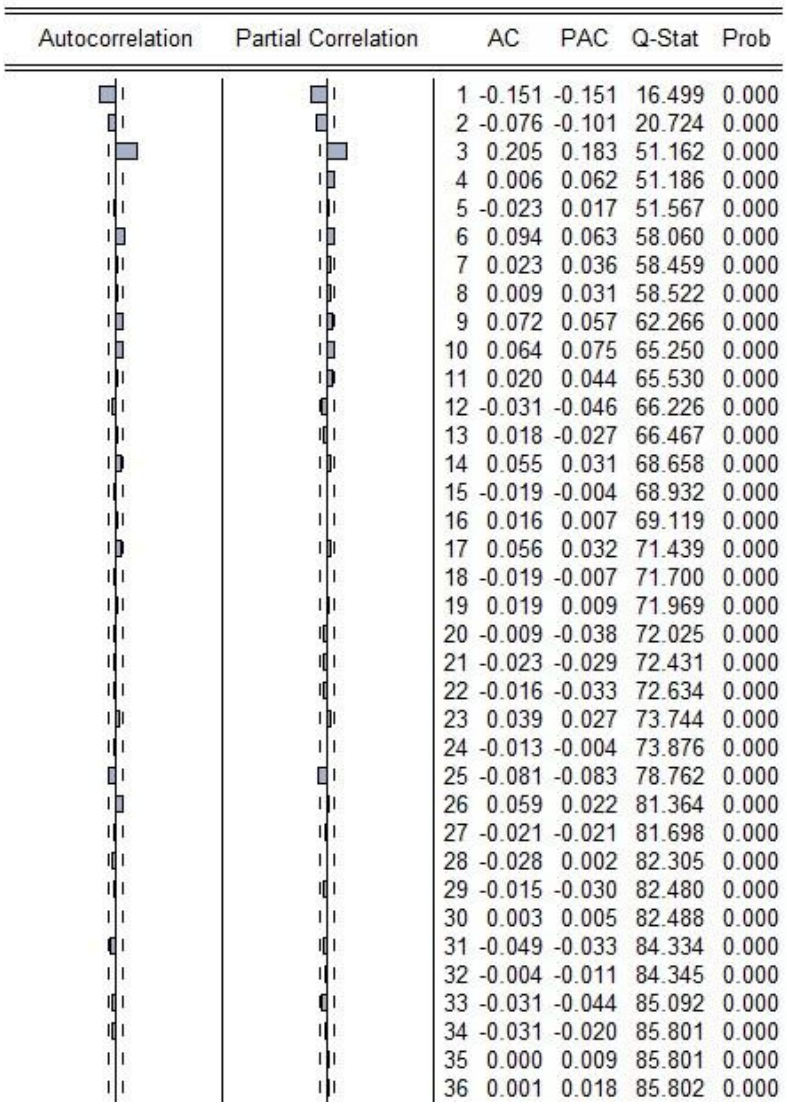
[10] AIC: Akaike information criterion. SC: schwarz information criterion.

of p, and obey the χ^2 distribution, where N is the sample volume and r_k^2 is the correlation coefficient square of the yield in k level. If the original hypothesis is true, Q approximately obey the χ^2 distribution. When the Q statistics is higher than the critical value under the significant level, as well as the concomitant probability value is less than that level, we suggest that it should refuse the null hypothesis, namely there is significant correlation. Since the correlation test of yield R_t, choosing the biggest lag behind order 35, we can get:

Table 4-1 The result of correlation test of yield R_t

	Q(15)	Prob	Q(25)	Prob	Q(35)	Prob
Critical value	18.307		31.410		43.772	
CCFI	68.932	0.000	78.762	0.000	85.801	0.000

From the table 4-1, when the freedom degree of yield R_t is 15, 25, and 35, the Q statistic value is greater than the corresponding critical value, refusing the null hypothesis under the 5% significance level, correlation of the series obviously. Hence, the volatility of weekly index yield has transitivity, meaning that the yield in one period may be related to earlier yields. When the external information hitting the market, the volatility of yield increases obviously, and the yields after that will also stay in a higher level. So large shocks are often together in a certain time period, and the same theory, the low points of volatility are gathered at another time. That is the cluster characteristics of the yield series.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.151	-0.151	16.499	0.000
		2	-0.076	-0.101	20.724	0.000
		3	0.205	0.183	51.162	0.000
		4	0.006	0.062	51.186	0.000
		5	-0.023	0.017	51.567	0.000
		6	0.094	0.063	58.060	0.000
		7	0.023	0.036	58.459	0.000
		8	0.009	0.031	58.522	0.000
		9	0.072	0.057	62.266	0.000
		10	0.064	0.075	65.250	0.000
		11	0.020	0.044	65.530	0.000
		12	-0.031	-0.046	66.226	0.000
		13	0.018	-0.027	66.467	0.000
		14	0.055	0.031	68.658	0.000
		15	-0.019	-0.004	68.932	0.000
		16	0.016	0.007	69.119	0.000
		17	0.056	0.032	71.439	0.000
		18	-0.019	-0.007	71.700	0.000
		19	0.019	0.009	71.969	0.000
		20	-0.009	-0.038	72.025	0.000
		21	-0.023	-0.029	72.431	0.000
		22	-0.016	-0.033	72.634	0.000
		23	0.039	0.027	73.744	0.000
		24	-0.013	-0.004	73.876	0.000
		25	-0.081	-0.083	78.762	0.000
		26	0.059	0.022	81.364	0.000
		27	-0.021	-0.021	81.698	0.000
		28	-0.028	0.002	82.305	0.000
		29	-0.015	-0.030	82.480	0.000
		30	0.003	0.005	82.488	0.000
		31	-0.049	-0.033	84.334	0.000
		32	-0.004	-0.011	84.345	0.000
		33	-0.031	-0.044	85.092	0.000
		34	-0.031	-0.020	85.801	0.000
		35	0.000	0.009	85.801	0.000
		36	0.001	0.018	85.802	0.000

Figure 4-4 Correlation and partial correlation of the yield

In the Figure, the bar of Autocorrelation and Partial correlation exceed the dotted line, so we can estimate the basic form for fitting equation of CCFI yield series is:

$$R_t = c_1 R_{t-1} + c_2 R_{t-2} + c_3 R_{t-3} + \varepsilon_t \tag{4-2}$$

To test whether the fitting equation of residual series has heteroscedasticity, we do least square (OLS) estimates again:

Dependent Variable: RT
Method: Least Squares
Date: 04/15/12 Time: 15:34
Sample (adjusted): 5 722
Included observations: 718 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RT(-1)	-0.136495	0.036957	-3.693304	0.0002
RT(-2)	-0.071024	0.037605	-1.888691	0.0593
RT(-3)	0.186845	0.037274	5.012685	0.0000

R-squared	0.062594	Mean dependent var	8.08E-05
Adjusted R-squared	0.059972	S.D. dependent var	0.018207
S.E. of regression	0.017653	Akaike info criterion	-5.231643
Sum squared resid	0.222816	Schwarz criterion	-5.212521
Log likelihood	1881.160	Durbin-Watson stat	2.002610

Figure 4-5 OLS of series fitting equation

In Figure, The t-statistic of RT(-2) , whose concomitant probability is 0.0593, higher than 5%, is not significant enough. We should delete this item in the fitting equation, so the formula will become:

$$R_t = c_1 R_{t-1} + c_3 R_{t-3} + \varepsilon_t \tag{4-3}$$

And we fit the equation based on the above formula again:

Dependent Variable: RT
Method: Least Squares
Date: 04/15/12 Time: 15:44
Sample (adjusted): 5 722
Included observations: 718 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RT(-1)	-0.124754	0.036496	-3.418286	0.0007
RT(-3)	0.198785	0.036800	5.401729	0.0000

R-squared	0.057918	Mean dependent var	8.08E-05
Adjusted R-squared	0.056602	S.D. dependent var	0.018207
S.E. of regression	0.017685	Akaike info criterion	-5.229452
Sum squared resid	0.223928	Schwarz criterion	-5.216704
Log likelihood	1879.373	Durbin-Watson stat	2.023860

Figure 4-6 OLS of series refitting equation

We get the new equation of the model:

$$R_t = -0.124754 R_{t-1} + 0.198785 R_{t-3} + \varepsilon_t \tag{4-4}$$

R2 = 0.057918, Log likelihood is 1879.373, AIC = -5.229452, SC = -5.216704

4.3.3 Test of ARCH effect

Before analyze ARCH effect of the residual error series, we should look into the residual error series of volatility characteristics. In the Figure:

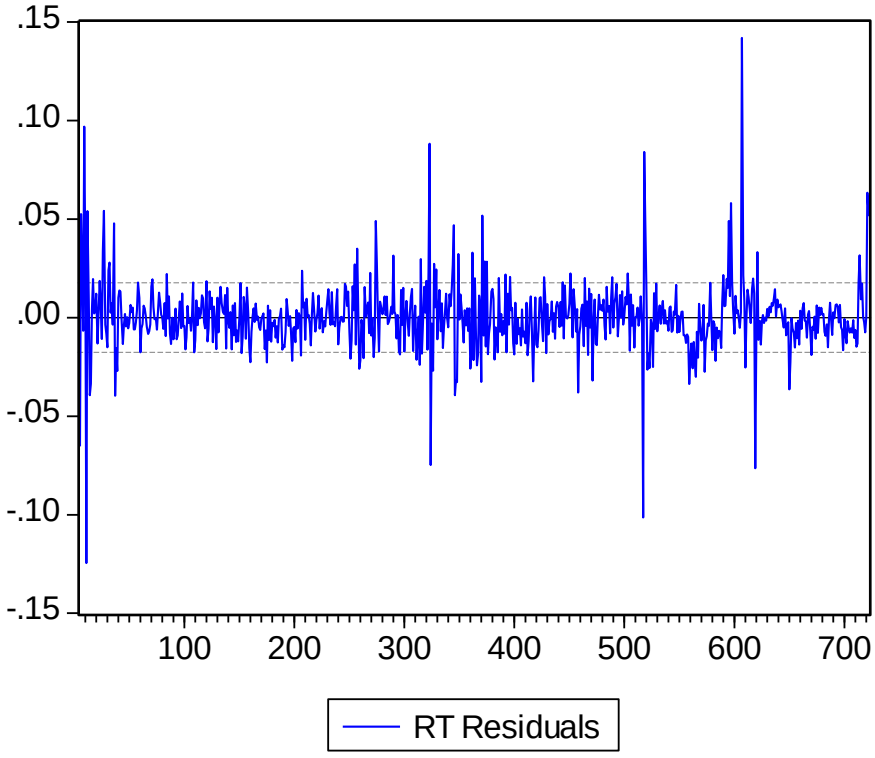
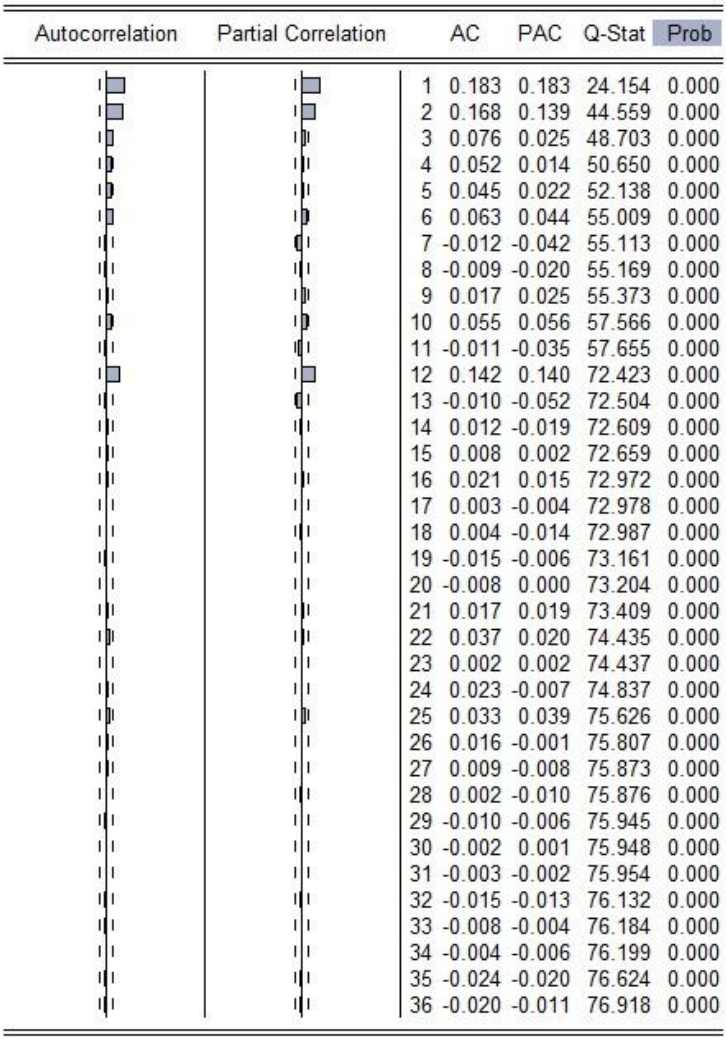


Figure 4-7 moving characteristics of the residual error series

As the Figure, we can see that the regression formula of the residual error series shows special characteristic—cluster that means strong volatility is always followed by strong volatility, and the weakness is often accompanied by the weakness. This situation imply that regression formula of the residual error series may have the conditional heteroscedasticity feature, which is ARCH effect. Next, we will use the autocorrelation Figure of residual square regression to judge whether the regression formula has ARCH effect.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.183	0.183	24.154	0.000
		2	0.168	0.139	44.559	0.000
		3	0.076	0.025	48.703	0.000
		4	0.052	0.014	50.650	0.000
		5	0.045	0.022	52.138	0.000
		6	0.063	0.044	55.009	0.000
		7	-0.012	-0.042	55.113	0.000
		8	-0.009	-0.020	55.169	0.000
		9	0.017	0.025	55.373	0.000
		10	0.055	0.056	57.566	0.000
		11	-0.011	-0.035	57.655	0.000
		12	0.142	0.140	72.423	0.000
		13	-0.010	-0.052	72.504	0.000
		14	0.012	-0.019	72.609	0.000
		15	0.008	0.002	72.659	0.000
		16	0.021	0.015	72.972	0.000
		17	0.003	-0.004	72.978	0.000
		18	0.004	-0.014	72.987	0.000
		19	-0.015	-0.006	73.161	0.000
		20	-0.008	0.000	73.204	0.000
		21	0.017	0.019	73.409	0.000
		22	0.037	0.020	74.435	0.000
		23	0.002	0.002	74.437	0.000
		24	0.023	-0.007	74.837	0.000
		25	0.033	0.039	75.626	0.000
		26	0.016	-0.001	75.807	0.000
		27	0.009	-0.008	75.873	0.000
		28	0.002	-0.010	75.876	0.000
		29	-0.010	-0.006	75.945	0.000
		30	-0.002	0.001	75.948	0.000
		31	-0.003	-0.002	75.954	0.000
		32	-0.015	-0.013	76.132	0.000
		33	-0.008	-0.004	76.184	0.000
		34	-0.004	-0.006	76.199	0.000
		35	-0.024	-0.020	76.624	0.000
		36	-0.020	-0.011	76.918	0.000

Figure 4-8 Autocorrelation of residual error square

From the Figure, we can see that the autocorrelation coefficient and partial autocorrelation coefficient in the 1, 2, 12 order of residual error square exceed 95% confidence region, and Q statistic is also very significant, which shows that residual square series has autocorrelation, namely, ARCH effect exists in residual error series. Test for ARCH effect in residual error of the regression formula, we shall use Lagrange multiplier LM method. The ARCH LM test statistics is calculated by an auxiliary regression test. The null hypothesis: residual series, until p order does not have ARCH effect, then we need to undertake the following regression:

$$\hat{u}_t^2 = \alpha_0 + \left(\sum_{s=1}^{p} \alpha_s \hat{u}_{t-s}^2 \right) + \varepsilon_t \tag{4-5}$$

$\hat{u}_t$ is the residual error, and this formula says $\hat{u}_t$ does a regression to a constant

and the residual square that lagging behind p order. The test regression has two statistics: 1) F statistics is an variable omitted test for all lag residual square joint significant; 2) $T \times R^2$ is Engel's LM statistics, which is the observation number T multiplies the R^2 in regression test.

Under the null hypothesis, F statistics is a exact finite sample but distribution unknown, and in general situation, LM statistics is gradually obeyed the $\chi^2(p)$ distribution. Given the significant level and degree of freedom p, when LM > $\chi^2(p)$, it shows the series has ARCH effect, otherwise, it is not.

According to the theory mentioned above, we do the ARCH LM test on the conditional heteroscedasticity of the residual series, setting the length of the lag 7, ARCH LM test results are accessed in Figure 4-9:

ARCH Test:

F-statistic	9.651965	Probability	0.000000
Obs*R-squared	62.34792	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 04/15/12 Time: 15:58
Sample (adjusted): 11 722
Included observations: 712 after adjustments

Figure 4-9 Results of ARCH LM test

In the results, *F* statistics is 9.651965, the probability value *p* is extremely small, so the residual square in the auxiliary regression formula is joint significant. Obs*R^2 is the statistics of ARCH effect, which is 62.34792, and its concomitant probability is really small, so the original hypothesis "there is no ARCH effect in residua error" is refused, and we deem that ARCH effect exists in residual error series.

When checking out the random error item in the regression formula has ARCH effect, or the existence of residual heteroscedasticity, we can use autoregressive conditional heteroscedasticity (ARCH) model and generalized ARCH model (GARCH) to fitting the random error of variance, to depict ARCH effect

characteristics of the residual error.

4.4 Analysis the sensitivity and consistency of CCFI

4.4.1 Building GARCH (1,1) model

Considering the residual error series has advanced ARCH effect and the yield series has "Leptokurtosis and Fat Tail" characteristics, the GARCH family model can avoid the too much parameter to be estimated. In time series analysis, one of the Log likelihood, AIC, and SC can be chosen to be a principle to build an appropriate GARCH model.

Akaike Information Criterion: $AIC = -2l/T + 2(k+1)/T$ (4-6)

Schwarz Criterion: $SC = -2l/T + [(k+1)\ln T]/T$ (4-7)

Log Likelihood: $l = -\frac{T}{2}[1+\ln(2\pi)+\ln(\hat{u}'\hat{u}/T)]$ (4-8)

In the model, Log likelihood is a balance between bias and the variance, or commonly saying, a balance between the accuracy and complexity of the model. AIC criterion is not a hypothesis test for the model but a tool for option to the model. For the given data, similar models can be sorted by AIC value, the lower, the better. The different estimation model, the optimized one should has the lowest SC value.

In previous section, we have concluded that the residual series has ARCH effect, then GARCH model is applied to fitting the conditional heteroscedasticity of the random error item. Since GARCH model covers more widely range, this article selects GARCH model to build. And the general form of GARCH (p,q) model is:

$$r_t = \mu_t + u_t \tag{4-9}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2 + \cdots + \beta_p \sigma_{t-p}^2 \tag{4-10}$$

In GARCH (p, q) model, p is the order of autoregressive ARCH item, and q is the order of ARCH item. From the simplicity and the significance of the parameters in the model, we choose GARCH (1, 1) from GARCH (1, 1) , GARCH (1, 2), GARCH (2,

1), GARCH (2, 2). Main steps for building the model is following: 1) Test of stable and correlation; 2) Identify the AR model by Figure and Q statistics; 3) Test of ARCH effect; 4) Establish GARCH (1, 1) model mean value formula and variance formula; 5) Estimate the parameter of the model.

Steps 1 to 3 has been done in above sections, so we do the rest now. For mean value formula, same as the AR formula procession, we estimate the basic form of it:

$$R_t = c_1 R_{t-1} + c_3 R_{t-3} + \varepsilon_t \qquad 4\text{-}11)$$

And the conditional formula of GARCH (1, 1) is:

$$\sigma_t^2 = \omega + \alpha \times u_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad (4\text{-}12)$$

As GARCH (1,1) model, under the Student's distribution, the estimation results of CCFI yield volatility model is:

Dependent Variable: RT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/15/12 Time: 16:21
Sample (adjusted): 5 722
Included observations: 718 after adjustments
Convergence achieved after 58 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
RT(-1)	-0.108405	0.034316	-3.158979	0.0016
RT(-3)	0.137445	0.053986	2.545934	0.0109
Variance Equation				
C	1.59E-05	2.06E-06	7.696295	0.0000
RESID(-1)^2	0.099040	0.014985	6.609299	0.0000
GARCH(-1)	0.847747	0.015543	54.54145	0.0000
R-squared	0.053818	Mean dependent var		8.08E-05
Adjusted R-squared	0.048510	S.D. dependent var		0.018207
S.E. of regression	0.017760	Akaike info criterion		-5.472829
Sum squared resid	0.224902	Schwarz criterion		-5.440960
Log likelihood	1969.746	Durbin-Watson stat		2.056513

Figure 4-10 Coefficient of GARCH (1, 1)

According to the Figure, the mean value formula is:

$$R_t = -0.108405 R_{t-1} + 0.137445 R_{t-3} + \varepsilon_t \qquad (4\text{-}13)$$

Z = -3.158979 2.545934

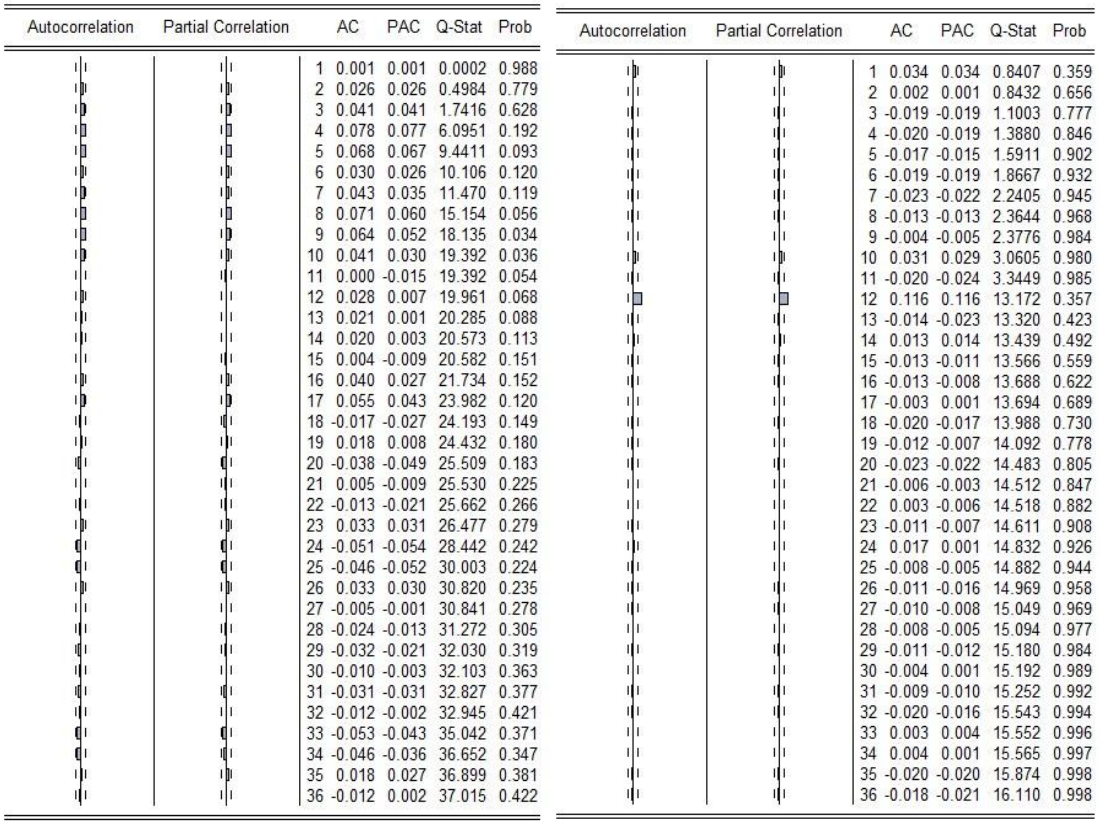
$$\sigma_t^2 = 1.59 \times 10^{-5} + 0.099040 \varepsilon_{t-1}^2 + 0.847747 \sigma_{t-1}^2 \qquad (4\text{-}14)$$

Z = 7.696295 6.609299 54.54145

The estimated parameter, in the conditional variance formula, Z statistics is very significant and the concomitant probability is so tiny, which all show that the estimated parameter is significant. And all these parameter are positive, so as to ensure the conditional variance of nonnegative requirements, all requests of the model satisfied. The coefficient of ARCH and GARCH item estimation are 0.099040 and 0.847747 respectively, proving the stability GARCH (1, 1) model. The model is fitting the weekly yield series of CCFI quite well.

4.4.2 GARCH (1, 1) model testifying

Because each coefficient of the model is significant, the following, we are going to testify the autocorrelation and heteroscedasticity of the residual error series in the fitting GARCH model. Above all, do the Q test to the residual error and residual square series, after that, ARCH-LM test for heteroscedasticity to the residual series. If the Q test tell that the residual series and the residual square series are not correlated, as well as there is no heteroscedasticity in the residual series by ARCH-LM test, which means that the model fits the data quite well. Otherwise, we should choose another model again. Through the Q test observation of residual and residual square series, the autocorrelation and partial correlation can we see following:



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.001	0.001	0.0002	0.988
		2	0.026	0.026	0.4984	0.779
		3	0.041	0.041	1.7416	0.628
		4	0.078	0.077	6.0951	0.192
		5	0.068	0.067	9.4411	0.093
		6	0.030	0.026	10.106	0.120
		7	0.043	0.035	11.470	0.119
		8	0.071	0.060	15.154	0.056
		9	0.064	0.052	18.135	0.034
		10	0.041	0.030	19.392	0.036
		11	0.000	-0.015	19.392	0.054
		12	0.028	0.007	19.961	0.068
		13	0.021	0.001	20.285	0.088
		14	0.020	0.003	20.573	0.113
		15	0.004	-0.009	20.582	0.151
		16	0.040	0.027	21.734	0.152
		17	0.055	0.043	23.982	0.120
		18	-0.017	-0.027	24.193	0.149
		19	0.018	0.008	24.432	0.180
		20	-0.038	-0.049	25.509	0.183
		21	0.005	-0.009	25.530	0.225
		22	-0.013	-0.021	25.662	0.266
		23	0.033	0.031	26.477	0.279
		24	-0.051	-0.054	28.442	0.242
		25	-0.046	-0.052	30.003	0.224
		26	0.033	0.030	30.820	0.235
		27	-0.005	-0.001	30.841	0.278
		28	-0.024	-0.013	31.272	0.305
		29	-0.032	-0.021	32.030	0.319
		30	-0.010	-0.003	32.103	0.363
		31	-0.031	-0.031	32.827	0.377
		32	-0.012	-0.002	32.945	0.421
		33	-0.053	-0.043	35.042	0.371
		34	-0.046	-0.036	36.652	0.347
		35	0.018	0.027	36.899	0.381
		36	-0.012	0.002	37.015	0.422

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.034	0.034	0.8407	0.359
		2	0.002	0.001	0.8432	0.656
		3	-0.019	-0.019	1.1003	0.777
		4	-0.020	-0.019	1.3880	0.846
		5	-0.017	-0.015	1.5911	0.902
		6	-0.019	-0.019	1.8667	0.932
		7	-0.023	-0.022	2.2405	0.945
		8	-0.013	-0.013	2.3644	0.968
		9	-0.004	-0.005	2.3776	0.984
		10	0.031	0.029	3.0605	0.980
		11	-0.020	-0.024	3.3449	0.985
		12	0.116	0.116	13.172	0.357
		13	-0.014	-0.023	13.320	0.423
		14	0.013	0.014	13.439	0.492
		15	-0.013	-0.011	13.566	0.559
		16	-0.013	-0.008	13.688	0.622
		17	-0.003	0.001	13.694	0.689
		18	-0.020	-0.017	13.988	0.730
		19	-0.012	-0.007	14.092	0.778
		20	-0.023	-0.022	14.483	0.805
		21	-0.006	-0.003	14.512	0.847
		22	0.003	-0.006	14.518	0.882
		23	-0.011	-0.007	14.611	0.908
		24	0.017	0.001	14.832	0.926
		25	-0.008	-0.005	14.882	0.944
		26	-0.011	-0.016	14.969	0.958
		27	-0.010	-0.008	15.049	0.969
		28	-0.008	-0.005	15.094	0.977
		29	-0.011	-0.012	15.180	0.984
		30	-0.004	0.001	15.192	0.989
		31	-0.009	-0.010	15.252	0.992
		32	-0.020	-0.016	15.543	0.994
		33	0.003	0.004	15.552	0.996
		34	0.004	0.001	15.565	0.997
		35	-0.020	-0.020	15.874	0.998
		36	-0.018	-0.021	16.110	0.998

Figure 4-11 Autocorrelation and partial correlation of the residual and residual square

In the Figure, when th lagging order is 10,20, and 30, Q statistics of residual series and residual square series are less than critical value significantly, and the concomitant probability is higher than the significant level, so we can tell that the residual series and residual square series have no autocorrelation.

Then, conditional heteroscedasticity of residual error series by ARCH effect test, under the lagging order 6, the results of ARCH-LM test is shown in Figure 4-12:

ARCH Test:

F-statistic	0.341958	Probability	0.934571
Obs*R-squared	2.412733	Probability	0.933524

Test Equation:
Dependent Variable: STD_RESID^2
Method: Least Squares
Date: 04/15/12 Time: 16:41
Sample (adjusted): 12 722
Included observations: 711 after adjustments

Figure 4-12 ARCH-LM test results of residual error series

In the results, F statistics is 0.341958, and its concomitant probability is 0.934571,

nearly to 1, which indicate that all lagging residual item in the auxiliary regression formula is not significant. Statistics of ARCH effect is Obs*R^2 whose value is 2.412733, and the probability of it is also closely to 1, consequently, we accept the original hypothesis: there is no ARCH effect in residual series. It also suggests that GARCH (1, 1) model eliminates the conditional heteroscedasticity of residual series. As a result, GARCH (1, 1) model is eligible to fit the yield series of CCFI and reflex it volatility excellently, and explain the phenomenon of "leptokurtosis and fat tail" at the same time.

4.4.3 Analysis the parameter of GARCH (1, 1)

In the GARCH (1, 1) model based on the yield series, the return rate α is the affected level of containerized transportation market as external shocks happening. While the α is bigger, the market is more sensitive to the volatility. The α of CCFI is 0.099040, saying that the external elements affecting the containerized transportation market level is medium. The lagging value β means that how long the market will memorize the volatilities, in other words, how long the market will keep reaction to the volatilities. The bigger β value, the stronger the memory of the market, volatility continues longer. β, in this model, is 0.8477496, which shows that containerized transportation market is sensitive to external shocks. This conclusion is consistent our previous analysis of container liner market, influenced by outside elements easily, having relatively high risks.

$\alpha+\beta$ can be deemed as a criterion whether the time series is stable, and in the financial market, that could be interpreted as the volatility persistency weak or strong. After market is shocked, conditional variance gradually restore to the mean value by the time. That series is stable. $\alpha+\beta$ of CCFI is 0.946789, indicating that the yield series of China containerized transportation market has strong persistency to volatilities. Easily speaking, characteristics of the past volatility are inherited by the current moment, and the high inheritance makes China containerized transportation

market fluctuating dramatically, $\alpha+\beta$ closely to 1. That hints us that the impact of volatilities may stay longer than we thought, which is coincident to the characteristics of CCFI, long volatility period. Additionally, despite $\alpha+\beta$ closely to 1, but $\alpha+\beta$ is less than 1, implying that the impact of volatilities to conditional variance of the yield is limited, or random shocks have limited persistency to the fluctuation of CCFI. This conclusion is consistent with the seasonal characteristics of CCFI, and it will not keep rising or declining because of external shocks.

Above situation is mainly caused by many factors, including world politics, world economics and trade, regionalization of international trade, etc. At the same time, international conventions, legislation, operation preference, market strategies of shipping companies, especially the seasonality are all the elements influence the containerized transportation market. For a better analysis of CCFI, based on the GARCH model, we support by Eviews6.0 to generate the series of conditional standard deviation. Following is the Figure of conditional standard deviation:

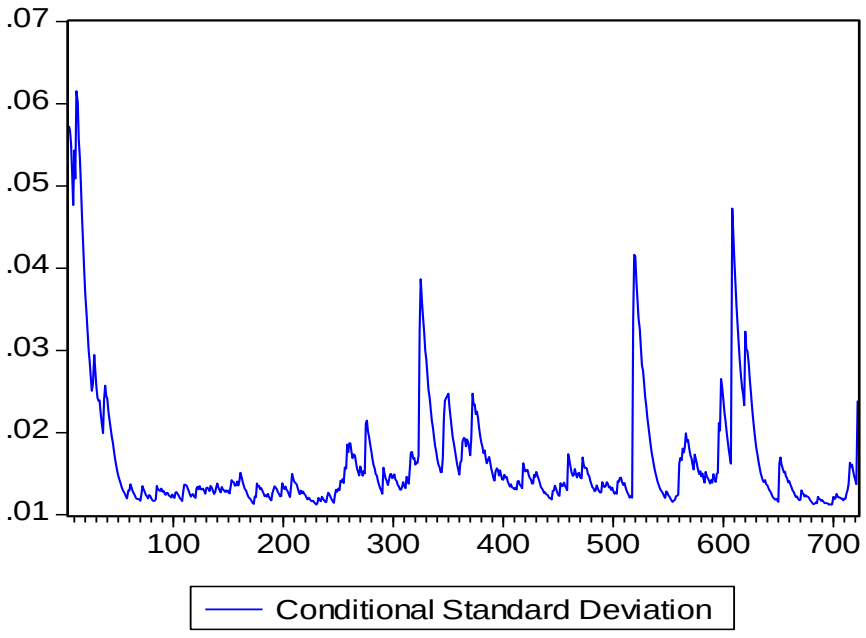


Figure 4-13 Conditional standard deviation of CCFI

As the Figure, there are some extreme phenomenon in the conditional standard deviation. In some moment, conditional standard deviation fell or rose dramatically, like booming or collapsing in a short time. As the time went by, strong volatility

appeared more frequently, strong volatility followed by the strong one, small volatility followed by the small one. In a few time, series stayed in high position continuously, and the rest of time, staying in low points.

And there are four period in the Figure showing the extreme value of conditional standard deviation: Jan 1998 to Jan 2002, Feb 2002 to Apr 2006, May 2006 to Jun 2009, and July 2009 to Mar 2012.

Jan 1998 to Jan 2002: The whole world is getting recovery from the Asian economic crisis, and the international trade is rebounding. That is the time when CCFI appeared. Under this favorable circumstance, CCFI developed fast, and reach the peak in Jan 1999, but when encountered “911”, CCFI collapsed, hitting the bottom in Jan 2002.

Feb 2002 to Apr 2006: Because China was approved to join WTO, that began the economics booming in China. CCFI rose sharply, and the summit of this period is Oct 2004. Since the SARS explosion, CCFI drop again, the valley in Apr 2006.

May 2006 to Jun 2009: CCFI went up and down like roller coaster in this period. Start is the growth of global economics, international trade recovery, but the critical point is the surge of crude oil price pushed CCFI to summit. However, subprime mortgage crisis burst in America, and it is a chain action, spreading to whole world quickly. International trade volume declined, container volume shrunk, and global container shipping market were in extremely panic. At that time, Jun 2009, CCFI was at the lowest point from which published.

July 2009 to Mar 2012: CCFI turned sharply in this period. As the rescue plan from different countries, global economics restored gradually. Chinese government announced investment plan to incent the market, expanding domestic demand to draw international trade activities. So CCFI rebounded in 2009. Although CCFI rose steadily, different routes of CCFI has diverse situation. The Mediterranean, European and American routes are quite popular, the opposite side, Japanese routes is so dull. In Aug 2010, CCFI reach 1215, the highest point after world economic crisis. At this point, the recovery of global economics does not go so well, especially in America, unemployment rate ascending, real estate market in a downturn. And China canceled

the special tariff policy for export. Those factors cooled down the containerized transportation market in a short term.

4.5 Analysis of the leverage effect based on asymmetric GARCH model

Previous section, according to weekly yield series of CCFI, we analyze the volatility cluster and persistency of yield series. After that, we continue fitting the mean value formula by TGARCH and EGARCH model to interpret the leverage effect of CCFI.

4.5.1 Fitting results of asymmetric GARCH model

1. TGARCH model

TGARCH model (Threshold ARCH) was proposed by Zakoian, Glosten and Runkle, which is to use virtual variable to set a threshold, to distinguish the positive and negative impact of conditional variance. The form of conditional variances:

$$\sigma_t^2 = \omega + \alpha \times u_{t-1}^2 + \gamma \times u_{t-1}^2 d_{t-1} + \beta \times \sigma_{t-1}^2 \tag{4-15}$$

d_{t-1}, a virtual variable: $d_{t-1} = \begin{cases} 1 & u_{t-1} < 0 \\ 0 & u_{t-1} \geq 0 \end{cases}$ (4-16)

For the virtual variable d_{t-1}, the impact of good news or bad news from markets is different. When the index is ascending, good news shows up, $u_{t-1} > 0$, and $\gamma u_{t-1}^2 d_{t-1} = 0$, influence coefficient is $\sum_{i=1}^{p} \alpha_i$. When the index is descending, bad news shows up, $u_{t-1} < 0$, and $\gamma u_{t-1}^2 d_{t-1} = \gamma u_{t-1}^2$, influence coefficient is $\sum_{i=1}^{p} \alpha_i + \gamma$. If $\gamma \neq 0$, the impact of market information is symmetric, otherwise, if $\gamma > 0$, the impact is asymmetric.

Dependent Variable: RT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/15/12 Time: 17:43
Sample (adjusted): 5 722
Included observations: 718 after adjustments
Convergence achieved after 45 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0)
+ C(6)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
RT(-1)	-0.114799	0.038750	-2.962552	0.0031
RT(-3)	0.163352	0.051270	3.186132	0.0014
Variance Equation				
C	1.65E-05	2.25E-06	7.349611	0.0000
RESID(-1)^2	0.195870	0.034315	5.707942	0.0000
RESID(-1)^2*(RESID(-1)<0)	-0.150830	0.037163	-4.058590	0.0000
GARCH(-1)	0.828614	0.017786	46.58755	0.0000

R-squared	0.056537	Mean dependent var	8.08E-05
Adjusted R-squared	0.049912	S.D. dependent var	0.018207
S.E. of regression	0.017747	Akaike info criterion	-5.504370
Sum squared resid	0.224256	Schwarz criterion	-5.466126
Log likelihood	1982.069	Durbin-Watson stat	2.043426

Figure 4-14 Parameters of TGARCH

In TGARCH (1, 1) model, as the Figure, $\omega = 1.65 \times 10^{-5}$, $\alpha = 0.195870$, $\gamma = -0.150830$, $\beta = 0.828614$, we find that parameters of the yield series, or the model, is significant under the confidence level of 95%. After the correlation Figure and Q statistics of residual error series of TGARCH model, we discover that the lag order statistics are not significant, and there is no autocorrelation in the residual error series. At the end, ARCH-LM test shows there is no ARCH effect either, the concomitant probability higher than the significant level, so the results of TGARCH model is accurate.

2. EGARCH model

Nelson put forward EGARCH model in 1991, aiming at solving some problems of GARCH model, such as nonnegative coefficient of parameter, too much limitation of dynamic change of conditional heteroscedasticity, etc. EGARCH has variety expressions, and this dissertation will adopt the normal one:

$$\ln(\sigma_t^2) = \omega + \alpha \left| \frac{\hat{u}_{t-1}}{\sqrt{\sigma_t^2}} \right| + \gamma \frac{u_{t-1}}{\sqrt{\sigma_t^2}} + \beta \ln(\sigma_{t-1}^2) \qquad (4\text{-}17)$$

Conditional variances in the model adopted natural logarithm form, which means

that the leverage effect is exponential, rather than square, so the conditional variance forecast must be negative. The existence of leverage effect is inspected by the assumption $\gamma < 0$. If $\gamma \neq 0$, the asymmetry of information impact exists; if $\gamma < 0$, the leverage effect is remarkable. Hence, EGARCH model can describe the asymmetry well in shipping market. In addition, due to σ_t^2 be represented as index form, the variance σ_t^2 is positive itself. So we establish EGARCH (1, 1) model fitting the mean value error, and the result is following:

Dependent Variable: RT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/15/12 Time: 17:55
Sample (adjusted): 5 722
Included observations: 718 after adjustments
Convergence achieved after 82 iterations
Variance backcast: ON
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

	Coefficient	Std. Error	z-Statistic	Prob.
RT(-1)	-0.113005	0.034202	-3.304008	0.0010
RT(-3)	0.133937	0.048598	2.756055	0.0059
Variance Equation				
C(3)	-0.518998	0.079810	-6.502933	0.0000
C(4)	0.195196	0.018570	10.51128	0.0000
C(5)	0.080940	0.017212	4.702457	0.0000
C(6)	0.953944	0.009055	105.3461	0.0000

R-squared	0.053551	Mean dependent var	8.08E-05
Adjusted R-squared	0.046905	S.D. dependent var	0.018207
S.E. of regression	0.017775	Akaike info criterion	-5.496750
Sum squared resid	0.224966	Schwarz criterion	-5.458506
Log likelihood	1979.333	Durbin-Watson stat	2.047980

Figure 4-15 Parameters of EGARCH

As the result, $\omega = -0.518997737$, $\alpha = 0.1951964075$, $\gamma = 0.08093958769$, $\beta = 0.9539440081$. After the test, autocorrelation and ARCH effect do not exist in residual error series. The model is correct.

4.5.2 Analysis leverage effect of volatility

Generally speaking, the disturbance to the shipping market can be divided into two

kinds: one is good news, for example, a surge demand in the market is a positive interference to freight rate; another kind is bad news, such as a large number of new ships is going to put in to operation, or the cargo source of some container liner routes decline severely. All these factors are in the range of negative interference. In order to better illustrate the leverage effect of the yield series volatility, we choose the parameter that can reflex leverage effect in TGARCH and EGARCH model, γ and θ, and compare the estimating parameter and significant level between them.

From the result above, leverage parameter of TGARCH γ is -0.150830, highly significant. When market falls down, its coefficient is $\alpha+\gamma=0.195870-0.150830=0.04504$. This coefficient is smaller than the original α value, which imply that there is leverage effect in CCFI that is more sensitive to good news rather than bad news.

In EGARCH model, when there is a good news, leverage parameter $\alpha-\gamma=0.195-0.081=0.114$, and when the bad one comes, the parameter is $\alpha+\gamma=0.195+0.081=0.276$. But the leverage parameter of TGARCH $\gamma=-0.131820<0$, it proves the asymmetric volatility in domestic containerized transportation. Good news causes stronger volatility than ban news in the same shocks level, which is contrary to the "leverage effect" we often talk about. The fundamental reason is that containerized transportation market is distinct from the other transportation market. Although nowadays the number of container liner companies is still growing, the market is trapped in a intense competition, but compared to other transportation market, line market is still a oligopoly shipping market, that is controlled by a few large container liner companies. Normally, operation container liner needs huge investments, therefore, only a handful companies are able to enter this market, being a survivor. They are the freight rate deciders rather than the price recipients. When bad news appears, due to the characteristics of container liner market—oligopoly, low profit and low return, the possibility of freight rate further reduction from the container liner companies is much smaller than the other kinds

transportation market. In the other side, huge container liner companies are always making alliances to resist low freight rate shocks from small container liner companies. So bad news do not bring huge volatility easily. But when there is good news, container liner companies may be into alliances to react rapidly, taking an advantage of this good news to promote the freight rate, earning higher profit. Under this situation, good news will incur greater volatility than the bad one in containerized transportation market, if strength of the shocks is the same.

Chapter 5 Forecast

Aim for capturing a more accurate prediction after good news and bad news, we choose EGARCH (1, 1) model to do the forecast. Though the leverage effect and the cluster of yield series have been analyzed, it is still far away from the precisely fitting yield series, and the volatility of yield also should be predicted. Based on EGARCH (1, 1) model and Eviews6.0, it concludes fitted yield series of CCFI and the actual series, in Figure 5-1:

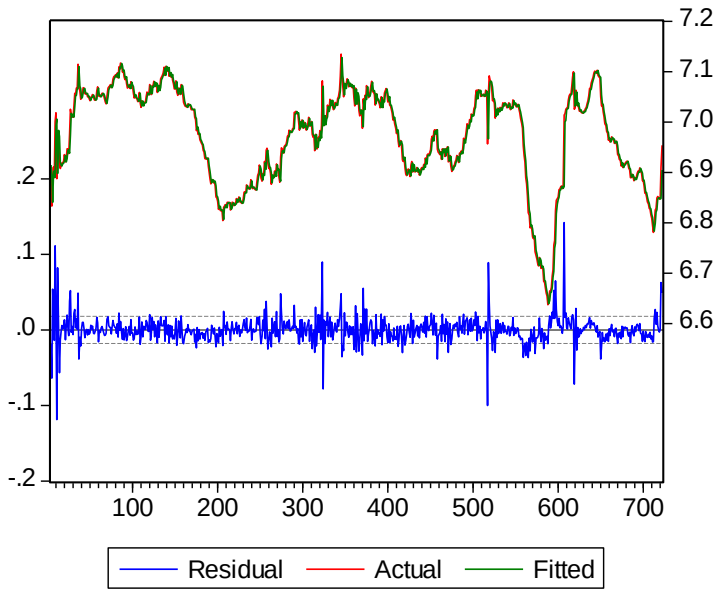


Figure 5-1 Fitted yield series of CCFI and the actual series

From Figure 5-1, conspicuously, there are still some differences between the fitted series and actual series, but the basic movement tendency is the same. And we will select a time period, comparing tow series.

obs	Actual	Fitted	Residual	Residual Plot
624	-0.00707	0.00437	-0.01144	
625	-0.00712	-0.00328	-0.00384	
626	0.00267	0.00116	0.00152	
627	-0.00446	-0.00125	-0.00321	
628	-0.00089	-0.00045	-0.00045	
629	-0.00090	0.00046	-0.00136	
630	0.00358	-0.00050	0.00407	
631	0.00000	-0.00052	0.00052	
632	0.00534	-0.00012	0.00546	
633	0.00266	-0.00012	0.00279	
634	0.00706	-0.00030	0.00736	
635	0.00614	-8.2E-05	0.00622	
636	0.00957	-0.00034	0.00991	
637	0.01461	-0.00014	0.01475	
638	0.00000	-0.00083	0.00083	
639	0.01103	0.00128	0.00975	
640	0.00673	0.00071	0.00602	
641	0.00502	-0.00076	0.00578	
642	0.00831	0.00091	0.00740	
643	0.00330	-3.7E-05	0.00334	
644	-0.00082	0.00030	-0.00112	
645	-0.00331	0.00121	-0.00451	
646	0.00578	0.00082	0.00496	
647	-0.00993	-0.00076	-0.00916	
648	-0.00333	0.00068	-0.00401	
649	-0.00083	0.00115	-0.00198	
650	-0.03829	-0.00124	-0.03705	
651	-0.01838	0.00388	-0.02226	
652	0.00177	0.00197	-0.00020	
653	-0.01332	-0.00533	-0.00799	

Figure 5-2 Fitted series and actual series (Mar 12th 2010 to Oct 29th 2010)

Again, we use Eviews6.0 to testify the prediction results from EGARCH (1, 1). In the testify of model prediction, it is used to applying former data to establish the model, and rest of them to testify. Technically, 85%～90% of the data will be utilized in the model, and 10%～15% of them for testify. So we use the data from May 23rd 2007 to Apr 20th 2011 to do the static forecast.

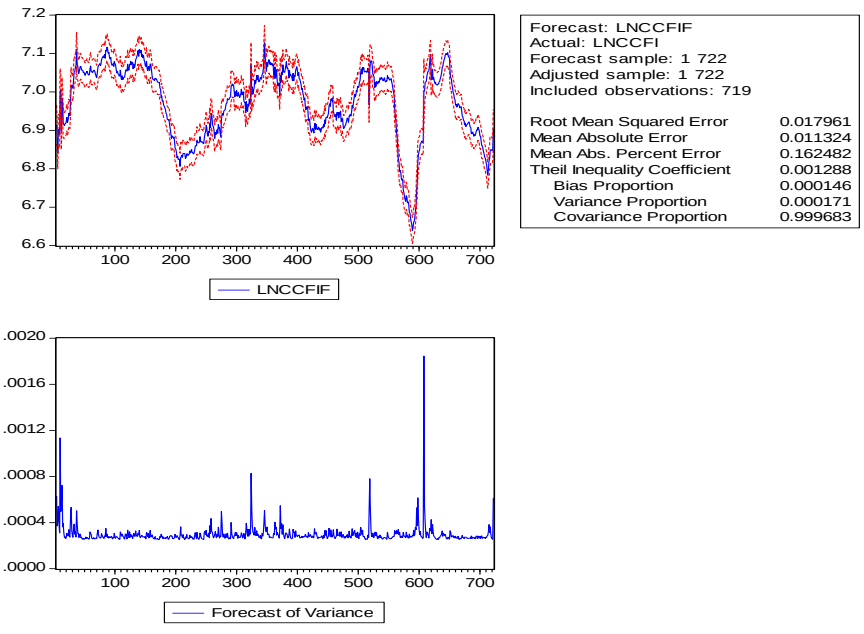


Figure 5-3 Static forecast result of EGARCH (1, 1) model

In the Figure, RMSE, MAE and Theil inequality coefficient is relatively small, showing that the model has good prediction accuracy. In addition, Bias proportion and Variance proportion is tiny too, and the fitted mean value and deviation are all smaller than the actual one. We can see from Figure 5-3. All these figures prove that the model has perfect forecasting ability.

Since the prediction predictive results of yield series, we use the reverse method on the formula $R_t = \log_\alpha(CCFI_t) - \log_\alpha(CCFI_{t-1})$, so we can infer the connection between CCFI and the yield series:

$$CCFI_t = CCFI_{t-1}e^{R_t} \tag{5-1}$$

Considering the relationship between CCFI and yield series R_t, and the seasonality of CCFI, we pick the data from Oct 7th 2011 to Mar 16th 2012 as the sample to calculate the differences between the fitted value and the actual value:

Table 5-1 Difference between the fitted CCFI and the actual CCFI

Date	Fitted yield	Estimate CCFI	Actual CCFI	Differences
10/07/2011	0.000938761	976.9165661	976	0.916566
10/14/2011	-0.000809292	976.1263568	966	10.12636
10/21/2011	-0.000743776	975.4006829	952	23.40068
10/28/2011	0.001649736	977.0109973	952	25.011
11/04/2011	-0.001379389	975.6643879	945	30.66439
11/11/2011	-0.001121338	974.5710648	936	38.57106
11/18/2011	0.001081395	975.6254216	932	43.62542
11/25/2011	-0.000504511	975.1333829	924	51.13338
12/02/2011	-0.000307522	974.8335853	922	52.83359
12/09/2011	-0.000328744	974.5132	912	62.5132
12/16/2011	7.77E-05	974.588919	906	68.58892
12/23/2011	0.000455687	975.0330821	893	82.03308
12/30/2011	0.000172609	975.201379	881	94.20138
1/6/2012	0.000644759	975.8302867	897	78.83029
1/13/2012	-0.00396965	971.9646602	921	50.96466
1/20/2012	-0.004795835	967.3149188	924	43.31492
2/03/2012	0.002043142	969.2930958	943	26.2931
2/10/2012	0.001236383	970.4921298	946	24.49213
2/17/2012	7.66E-05	970.5664971	944	26.5665
2/24/2012	0.002965355	973.4485439	941	32.44854

3/02/2012	0.000785121	974.2130399	942	32.21304
3/09/2012	-0.000403492	973.8200727	1003	-29.1799
3/16/2012	-0.007516877	966.5281835	1047	-80.4718

As Table 5-1, the mean difference of fitted CCFI and actual CCFI is 94.201, so we can forecast CCFI in the same period, Oct 7th 2012 to Mar 16th 2013, will fluctuate between 1047 ± 94.201, namely 953～1141.

Comparing with the actual CCFI in Oct 7th 2012 to Mar 16th 2013 that is following:

Table 5-2 Actual CCFI of Oct 7th 2012 to Mar 16th 2013

Date	Forecasting CCFI
2012-10-12	1187.72
2012-10-19	1177.71
2012-10-26	1166.05
2012-11-02	1159.62
2012-11-09	1155.9
2012-11-16	1152.85
2012-11-23	1144.98
2012-11-30	1129.9
2012-12-07	1106.28
2012-12-14	1101.46
2012-12-21	1107.55
2012-12-28	1113.58
2013-01-04	1109.89
2013-01-11	1122.36
2013-01-18	1125.21
2013-01-25	1132.27
2013-02-01	1142.4
2013-02-08	1144.55
2013-02-22	1152.47
2013-03-01	1134.82
2013-03-08	1110.77
2013-03-15	1090.92

From the table, we can see the highest point of this period is 1187, and the lowest one is 1090. Comparing our forecasting, there is not a big gap between them.

Chapter 6 Conclusion

After the qualitative and quantitative analysis above chapter, we can draw several conclusion about the volatility characteristics of CCFI.

1) Weekly yield series of CCFI does not obey the normal distribution, and it has the financial time series characteristics—cluster, “leptokurtosis and fat tail”, and strong volatility of the market.
2) GARCH model describes the sensitivity and persistency of CCFI outstandingly, and it can capture the time-vary of the yield series. When external shocks strengthen freight index fluctuation, CCFI is sensitive to the market volatility, and it will last a relatively long period. The conditional variance of yield series has time-varying feature, and has extreme value.
3) Through fitting the containerized transportation market reflection from good news and bad news by TGARCH and EGARCH model, we find out the leverage effect of container exporting market, which is the information asymmetric phenomenon. Market is more sensitive to good news, namely, in the same strength level, the positive shocks can cause greater volatility than the negative shocks. That is different from the past leverage effect, which is mainly forged by the imperfect completion of containerized transportation market.
4) The forecast results of EGARCH model, basically, is accurate. That proves the theory and the calculation process is effective. We can use it for further analysis and forecast, or in the other transportation market.

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