The Asymmetric Impacts on the Volatility of the shipping financial derivatives

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Abstract

Shipping freight forward agreements (FFA) is world's major shipping financial derivative. It is often used to hedge against the huge freight fluctuations by ship owners. The paper takes four shipping freight forward agreements with China factors as the research object, using the GARCH model to fit these four shipping price fluctuations and establish price volatility models; In order to reflect market fluctuations factors on the impact of price changes, uses TARCH models to analyze their asymmetric impacts. At last the paper provides decision-making references for Chinese ship owners participating in the FFA market transactions.

Keywords: shipping freight forward agreements (FFA); Volatility; GARCH models; TARCH models

1. INTRODUCTION

The main source of ship-owner enterprises' income is the freight earned by offering the service of shipping to the one who has transportation demand. The freight is always in a volatility due to the effect which exerted on shipping industry, such as world economy, trade and political situation etc. To take BDI (which reflects the freight of the international dry bulk shipping market) as an example, it reached its peak at 11793 points on 20th May 2008, while on 5th December 2008 it fallen onto 663 points, losing 94.4% of the freight. The index hovers around about 1000 points at the moment, which means that most ship-owner enterprises are in the state of break even or even under deficit. To avoid the risk resulted from the volatility of freight, financial derivative instruments emerge as the times require. FFA (forward freight agreement) is currently a financial derivative instrument with the biggest trading volume in the international shipping market, which annually covers over hundreds of billions of U.S. Dollars. FFA has already become the most critical instrument for risk management in shipping market. The physical volume of international trade and transportation capacity of China have a large share in the world market, which means that china is in an urgent need of the financial derivative instruments to hedge, and ultimately to stabilize the freight revenue. To understand the fluctuation of FFA will not only lead to better FFA trading but also reduce the operating risk of the enterprises.
The transactions of FFA mainly includes 4 kinds of contracts involving Capesize carrier route, Panamax carrier route, Handy-max carriers route, Handy-size carrier route and so on. The C3 contracts (range of route: Tubarao Port, Brazil-Beilun/Baoshan, China), C5 contracts (range of route: West Australia-Beilun/Baoshan, China) of Capesize carrier route and P2A contracts (range of route: Gibraltar–Far East), P3A contracts (The Pacific route) of Panamax carrier route involve Chinese factor among the above 4 contracts.

Currently, there are many studies about the fluctuation of BDI while FFA contract is involved little. Such as applying VAR model to the analyzing the volatility of BDI (Veenstra, 1997), using the ARCH models to examine the volatility and the time varying risks in the world tanker freight markets (Kavussanos, 1996; Kavussanos, 2003), studying long memory of volatility about the BDI index (Gu, 2009). The return series of BDI have the peak thick tail characteristics, which did not obey normal distribution (Li et al., 2006). There is a cointegration relationship between futures price and spot price of BDI through Granger causality test (Liu and Shi, 2005). There is a seasonal effect of yield rate of BDI (Gong, 2001), and the clustering character of the fluctuation of CCFI and BDI (Sun, 2005). Some scholars have studied on the trading rules, hedging effectiveness, forecasting and other risk management issues related to the shipping derivative contracts. For instance, grasping market timing rules and taking active trading strategies can profit from the FFA market (Nikos and Kaizad, 2013; Amir, 2013). Find that using ARIMA or VAR models to forecast is better than the VECM models in Freight forward market (Roy et al., 2007) and can use the VECM-GARCH to analyze the market interactions in returns and volatilities between spot and forward shipping freight markets (Kavussanos and Visvikis, 2004). The volatility of FFA market is more intense than the spot market as the reason of transaction costs (Manolis and Ilias, 2004; Jane et al., 2011).

The main differences of our research with previous studies rest with three aspects. Firstly, this paper focus on the Chinese factors of the shipping financial derivatives, we know that Chinese holds a great proportion in the shipping market, and more and more Chinese shipping companies and financial institutions involved in the transaction in FFA. Secondly, we choose the FFA price data after 2008. Since the financial crisis after 2008, shipping market has entered a new period. The analysis of data after 2008 is more close to the market situation. Thirdly, we focus on the asymmetric impacts of shipping financial derivatives. We want to find out how the shipping financial derivatives price changes when the market appeared new information.

The paper mainly used the model of econometrics to study the fluctuation of FFA, which is a financial derivative products in shipping market mainly participated by Chinese ship-owner enterprises. The research includes the stability, heteroscedasticity and fluctuation of contract series, aiming at offering decision reference to Chinese ship-owner enterprises using FFA in hedging, arbitrage and speculation, etc.
2. Methodology

2.1 ARCH Model

Engle introduced the concept of conditional variance to analyze the reason of the change of variance and presented autoregressive conditional heteroscedasticity (ARCH) model (Engle, 1982). He pointed out that the conditional variance of financial time series varied with time, which could be seen as the function of the lag terms of stochastic error of the conditional mean equation. That is to say that the fluctuation of the yield rate depends on the antecedent information. The model of AR(p)-ARCH(q) can be written as follows.

\[
\begin{align*}
    y_t &= c + \sum_{i=1}^{q} \varphi_i y_{t-i} + \mu_t \\
    \mu_t &= \sqrt{h_t} \cdot v_t \\
    h_t &= \omega + \sum_{i=1}^{q} \alpha_i \mu_{t-i}^2
\end{align*}
\] (1)

The \(a_1, a_2...a_q, \omega\) in the equation (1) can be seemed as the undetermined parameter in the ARCH process, in which \(\{\mu_t\}\) obey the q order. To ensure that the conditional variance \(h_t>0\), the parameters in the model should meet that \(a_1, a_2...a_q \geq 0, \omega > 0\). If \(\sum_{i=1}^{q} \alpha_i < 1\), it means that the ARCH(q) process is steady. The parameters in the model show the effects of residual sum of squares with different lag terms which exerted on the variation of conditional variance. Generally, when \(i > j\), \(a_i < a_j\) shows that the earlier the news is, the less its effect on the fluctuation will be. The q value reflects the duration of a certain fluctuation of \(\{\mu_t\}\). Accordingly, the model can reflect the volatility clustering of time series.

2.2 GARCH Model

Due to the existence of conditional heteroskedasticity in some time series, especially when the higher-order ARCH effect exists, the parameters often can not be tested through significance. The generalized ARCH (p, q) model, namely GARCH (p, q) model should be adopted (Bollerslev, 1987). The basic representation of GARCH (p, q) is as follows.

\[
\begin{align*}
    h_t &= \omega + \sum_{i=1}^{q} \alpha_i \mu_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j}
\end{align*}
\] (2)

The \(\omega, a_1, a_2...a_q, \beta_1, \beta_2...\beta_q\) in the equation (2) are undetermined parameter. The necessary and sufficient condition of the stability of GARCH(p,q)process is that
\[
\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j < 1.
\]

If \( p=0 \), the GARCH\((p,q)\) process will degenerate into the ARCH\((q)\) process; when \( p>1, q>1 \), it is a high order GARCH \((p,q)\) process. Considering the flexibility and simplicity of the model, in most empirical research, people often use the simple model of GARCH \((1,1)\) to describe a great deal of time series, whose fundamental formula is:

\[
h_t = \omega + \alpha \mu_{t-1}^2 + \beta h_{t-1}
\] (3)

In the equation (3), \( \alpha \) is a return coefficient, which reflects the previous period of fluctuation through \( \mu_{t-1}^2 \). The larger the absolute value of \( \alpha \), the swifter the fluctuation reacts to the turn of the market. \( \beta \) is a lag coefficient, which reflects the duration of the effect of the fluctuation. The GARCH model overcomes the problem of testing of the parameter of high order ARCH model. But it cannot reflect the asymmetric effect of the fluctuation of time series as the ARCH model.

### 2.3 Asymmetry EGARCH Model

In order to reflect the asymmetric impact of new information on the market, Nelson (1990) proposed Exponential GARCH(EGARCH) model. The final designing equation is expressed as follows:

\[
\begin{align*}
\mu_t &= \sqrt{h_t} \cdot v_t \\
\ln h_t &= \omega + \sum_{i=1}^{q} \left( \theta_i \frac{\mu_{t-1}}{\sqrt{h_{t-1}}} + \gamma_i \frac{\mu_{t-1}}{\sqrt{h_{t-1}}} \right) + \sum_{j=1}^{p} \beta_j \ln h_{t-j}
\end{align*}
\] (4)

In the above formula, The conditional variance \( h_t \) of EGARCH model is expressed by exponential form. The parameter \( \gamma \) in the model can reflect the asymmetric effects. if \( \gamma \neq 0 \), the positive or negative of stochastic disturbance \( \frac{\mu_{t-1}}{\sqrt{h_{t-1}}} \) can influence the change of the conditional variance \( h_t \). The parameter \( \gamma \) is defined as the leverage factor, which can reflect the asymmetric effect of good news or bad news on volatility. If \(-1<\gamma<0\), it means that fluctuations caused bad news \( (\mu_t<0) \) is more acute than good news \( (\mu_t>0) \). If \( \gamma>0 \), it means that fluctuations caused bad news \( (\mu_t<0) \) is less acute than good news \( (\mu_t>0) \). If \( \gamma = 0 \), it means that fluctuations caused bad news \( (\mu_t<0) \) is equal to good news \( (\mu_t>0) \).
3 Empirical Analysis

3.1 Data description

Due to the large variety and quantity of FFA, and only the FFAs with Chinese factor have a close relationship with Chinese ship-owner enterprise. So in this thesis, the FFA with Chinese factor provided by The Baltic Exchange, namely, C3 (Brazil, Tubarao Port-Beilun/Baoshan), C5 (West Australia-Beilun/Baoshan), P2A (Gibraltar-Far East), P3A (The Pacific route) have been chosen as the subject line. The 1492 price data were got from between August 2009 and September 2014, among which the price data of C3, C5 route are the one-month voyage charter contract, and the price data of P2A and P3A are the one-month time charter contract. (see in figure 1, 2).

**Figure 1.** The price chart of C3, C5 route’s one-month voyage charter contract

**Figure 2.** The price chart of P2A, P3A route’s one-month time charter contract

As is shown in figure 1, 2, the price of the four kinds of FFAs with Chinese factor experienced a large fluctuation, whose trend is unsteady, and the fluctuation of the data
has an obvious volatility clustering. Compared with the price trend, the revenue attracts more attention of the FFA dealer. Therefore, the author has picked the logarithmic return series of these 4 routes to analyze the fluctuation of FFA market.

For the convenience of elaboration, we may use \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\} to respectively represent the yield rate series of the first order difference. (see in figure 3)

\[ \text{Figure 3. The yield curve of \{RC3\}, \{RC5\}, \{RP2A\}, \{RP3A\}} \]

As is shown in the chart, the yield rate time series of the dry bulk freight agreement were first order differenced hover around zero. The series of \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\} have the character of volatility clustering, and the fluctuation has clustered, which means that the series may have conditional heteroskedasticity.

**3.2 Descriptive Statistics of the Data**

After analyzing the basic statistic eigenvalue of the four groups of yield rate series by using Eviews 6.0, we have got 5 basic statistics of \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\} : mean value of series, variance, skewness, kurtosis and JB statistics. (see in table 1)
Table 1 The basic statistics table of \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\}

<table>
<thead>
<tr>
<th>Statistics</th>
<th>{RC3}</th>
<th>{RC5}</th>
<th>{RP2A}</th>
<th>{RP3A}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.000466</td>
<td>0.000199</td>
<td>0.00032</td>
<td>0.000312</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.297779</td>
<td>0.135284</td>
<td>0.209973</td>
<td>0.333489</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.146502</td>
<td>-0.182284</td>
<td>-0.12797</td>
<td>-0.25075</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.022528</td>
<td>0.026597</td>
<td>0.02645</td>
<td>0.038081</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.399527</td>
<td>-0.277213</td>
<td>0.814276</td>
<td>1.184781</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>28.53886</td>
<td>10.35228</td>
<td>9.444642</td>
<td>14.06714</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>41034.23</td>
<td>3379.589</td>
<td>2746.871</td>
<td>7963.328</td>
</tr>
<tr>
<td>Probability</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Observations</td>
<td>1492</td>
<td>1492</td>
<td>1492</td>
<td>1492</td>
</tr>
</tbody>
</table>

We may conclude from the table that the average yield rate series may be negative, which fully accords with the sluggish in the international market since the financial crisis in 2008. During this time, there is a persistent excess capacity in the dry bulk shipping market. But there is too little demand and the shipping market is in depression. As for the variance, the variance of \{RP3A\} is the largest, which means that the yield rate deviate from the average most. With respect to the skewness, \{RC3\} and \{RP3A\} skewed to right. That is to say, the skewness, to a relatively great extent, is less than the statistic of the average yield rate with a relatively thick right tail. \{RC5\} and \{RP2A\} skewed to left, whose skewness, to a relatively great extent, is larger than the statistic of the average yield rate with a relatively thick left tail. Concerning the kurtosis, the average of the kurtosis is larger than 3, which means that the yield rate of the 4 series has a peak thick tail. The kurtosis of \{RC3\} and \{RC5\} is relatively large, which means there exists an outlier which deviate from the average. The adjacent probability of the JB statistics is zero, which means the 4 groups of series do not obey normal distribution.

3.3 Estimation of the Steadiness of the Series of Yield Rate

The author adopted ADF to conduct the estimation of the steadiness on the yield rate series of the 4 kinds of contracts. As is shown in chart 3, the 4 kinds of yield rate series of dry bulk FFA hover around zero at random with no persistent increase or decrease. The outcome of the Augmented Dickey-Fuller (ADF) is shown in table 2.

From the perspective of the outcome of the estimation, the statistics of yield rate series of the 4 groups of contracts are all smaller than the critical value of ADF, rejecting the null hypothesis, which means that the yield rate series of the 4 groups of contracts do not have unit root. That is to say, it is a steady time series.
### Table 2 ADF test results of \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\}

<table>
<thead>
<tr>
<th>ADF statistics</th>
<th>{RC3}</th>
<th>{RC5}</th>
<th>{RP2A}</th>
<th>{RP3A}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significance</td>
<td>t-statistic</td>
<td>Prob.</td>
<td>t-statistic</td>
<td>Prob.</td>
</tr>
<tr>
<td>-24.4190</td>
<td>0</td>
<td>5</td>
<td>-26.2411</td>
<td>0</td>
</tr>
<tr>
<td>Significance</td>
<td>1%</td>
<td>3.43453</td>
<td>0</td>
<td>-3.43453</td>
</tr>
<tr>
<td>5%</td>
<td>2.86327</td>
<td>-2.86327</td>
<td>0</td>
<td>-2.86327</td>
</tr>
<tr>
<td>10%</td>
<td>2.56774</td>
<td>-2.56774</td>
<td>0</td>
<td>-2.56774</td>
</tr>
</tbody>
</table>

### 3.4 GARCH Analysis on Yield Rate Series

By using LBQ to conduct an estimation of correlation on the 4 groups of yield rate, the author has found that along with the increase of the lag phase, the adjoint possibility corresponds to LBQ, as they are all approximate to zero. It means that there exists autocorrelation in the yield rate series of the 4 contracts. \{RC3\}, \{RC2\}, \{RP2A\}, \{RP3A\} are the process of AR (2), AR (1), ARMA (1, 1), ARMA (2,2). Therefore, a corresponding fitting equation can be established on the yield rate series on the 4 contracts by using Eviews 6.0. And through the estimation of heteroscedasticity of the fitting equation, the author finds that the 4 series has volatility clustering and high order ARCH effect. To conduct fitting on the series with ARCH model requires a relatively large lag. Therefore, the former ARCH model should be replaced by GARCH model. The thesis adopts the common GARCH (1,1) model to fit on the above 4 yield rate series and got the relevant parameters in table 3.

#### Table 3. The parameter estimation results of GARCH(1,1)

<table>
<thead>
<tr>
<th>Parameter Series</th>
<th>{RC3}</th>
<th>{RC5}</th>
<th>{RP2A}</th>
<th>{RP3A}</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>0.01279</td>
<td>-0.00502</td>
<td>-0.01767</td>
<td>0.131848</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.92108</td>
<td>0.907667</td>
<td>1.013797</td>
<td>0.578151</td>
</tr>
<tr>
<td>(\alpha + \beta)</td>
<td>0.93388</td>
<td>0.902651</td>
<td>0.996123</td>
<td>0.709999</td>
</tr>
</tbody>
</table>

As is shown in table 3, we may draw a conclusion about FFA voyage charter party from the \(\alpha\) after the market impact: the FFA price of C3 route reacts more fleetly than that of the C5 routes. And by comparing \(\beta\): the author finds that the duration of the effect suffered from the fluctuation of the market of C3 route lasts longer than that of C5. As for the FFA time charter, after the market impact, we may see from \(\alpha\) that: P3A route reacts more fleetly than P2A; and from \(\beta\), the author finds: the FFA price of P2A route suffers from a longer period of effect from the market fluctuation than that of P3A route.
3.5 Analysis of Asymmetric TARCH Model on Yield Rate Series

To reflect the asymmetric influence of good news and bad news of shipping market on FFA, the thesis analyse the asymmetric volatility of the 4 groups of contracts through TARCH model. The outcome is as follows in table 4:

Table 4. The parameter estimation results of TGARCH model

<table>
<thead>
<tr>
<th>Parameter Series</th>
<th>{RC3}</th>
<th>{RC5}</th>
<th>{RP2A}</th>
<th>{RP3A}</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.038484</td>
<td>0.063995</td>
<td>0.042521</td>
<td>-0.03783</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>-0.06943</td>
<td>-0.0737</td>
<td>-0.01923</td>
<td>0.317932</td>
</tr>
<tr>
<td>$\alpha + \gamma$</td>
<td>-0.03095</td>
<td>-0.0097</td>
<td>0.023296</td>
<td>0.2801</td>
</tr>
</tbody>
</table>

From table 4, the author finds that the $\gamma$ of contract C3, C5 and P2A are negative, which means that to the 3 kinds of contracts, good news has a greater effect on price than bad news. $\gamma$ of P3A is positive, which means good news has a smaller effect on price than bad news. Among the 4 FFA contracts, the asymmetry of P3A route is the greatest and that of C5 route is the smallest. Shipping companies and financial institutions joining into FFA transaction should wisely choose the relevant type and quantity of the contracts according to the different reaction of the 4 contracts upon the market information, so as to reduce the operation risk of the company.

4. CONCLUSION

The paper analyses the FFA products which are the main type among international shipping financial derivatives. And take 4 groups of FFA contracts with Chinese factor as an example to analyse the fluctuation of the 4 kinds of Forward Freight Agreement, the main conclusion is as follows:

Firstly, the basic statistic of the yield rate series shows that: the 4 groups of yield rate series do not obey normal distribution, with the character of peak thick tail and volatility clustering, heteroscedasticity and large market fluctuation. Form the outcome of the analysis of GARCH model, the regular of fluctuation of the 4 groups of FFA are of great differences. Take comparison between C3 route contract and C5 route contract as an example, the price of C3 route are more sensitive and lasts a longer time. This is because that C3 route (Brazil, Tubarao Port-Beilun/Baoshan) has a longer route distance than C5 (West Australia-Beilun/Baoshan), with vessels of large tonnage. Therefore, the vicarism of shipping capacity is inferior. When being exposed to market impact, the freight will more easily to experience volatility. Therefore, the ship-owner enterprise joining the transaction of these derivatives need to grasp the regular of fluctuation and take a proper control of the holdings of FFA to reduce the risk of investment.

Secondly, after analysing the asymmetric fluctuation of the 4 groups of FFA contracts, the author finds that GARCH model can well grasp the effect which is exerted by good news and
bad news on C3, C5, P2A, P3A contracts. The good news has a greater effect on the price of FFA of C3, C5, P2A, which means when the market is in prosperity, the price will increase in a great amplitude and the increase will last longer, and when the market is in sluggish, it has a good capacity of resilience. This is because that the vessels of these routes all belong to great ship-owners or cargo owners, and they tend to enter into joint monopoly, to avoid the rapid decrease in price and ultimately to gain the greatest benefit. The effect exerted by P3A routes on good news is smaller than that of bad news, with the greatest asymmetry, which means the price of P3A route decreases rapidly in market sluggish. So the dealer should sensibly choose transaction of these routes. Due to the different asymmetry of the contract of all kinds of routes. When dealing under FFA contract, the dealer should choose a suitable financial derivative in shipping market and the trading direction to achieve a stable income.

Thirdly, FFA is a high-end financial derivative in shipping market, which is currently a mainstream managerial instrument of freight risk in the world. Though there is few shipping company joining the FFA transaction, but with the rapid growth of the shipping industry, the Chinese shipping companies and financial institutions are sure to join into more and more transaction of financial derivatives. Shanghai Shipping Exchange rolled out in succession the derivatives of freight transaction on Chinese export container and coastal coal in 2011. Though there are only a few participants and trading volume, it is a huge supplement to the financial derivatives of our country. Therefore, the Chinese ship-owner enterprises need to understand more about the fluctuation regular of these derivatives and take relevant risk-management measures so as to reduce operation risk and to raise the competitiveness of enterprises.

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