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The Analysis of the Fluctuation of Shipping Prices——Based on the VaR-GARCH Model

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***Abstract*—As the fluctuations of shipping prices are affected by many factors, and the volatility is large, the measurement of the risk has become many shipping-price stakeholders' concern. Under the current background of Sino-US trade friction, international freight prices will face more and more factors which bring risks and the potential volatility in the future can be uncertain. Therefore, it is meaningful to explore the potential impact of trade friction between China and U.S. on the international shipping price fluctuations which the freight-price stakeholders care about. By establishing the VaR-GARCH model, this paper analyzes and measures the fluctuations and risks of the international freight price index of the Ningbo-U.S. East route.**

Keywords—VaR-GARCH model, Risk measure, Sino-U.S. trade friction, NCFI Index, shipping management

I. INTRODUCTION

The uncertainty of freight price fluctuation brings huge risks and opportunities to operators and investors in the market, which is the main reason for international market uncertainty. How to measure and utilize risks is the key to successful investment, avoiding risks and gaining profits for charterers, shipowners and market investors. Therefore, the management and control of freight price risk has become an important issue in shipping management.

A. NFCI Index

Ningbo export container Freight Index (NCFI) objectively reflects the freight price movements in international container liner shipping market, including comprehensive Index which is composed of Index 21 points and routes, by calculating and recording the export of Ningbo Zhoushan port in 21 international routes container freight price fluctuation information. At the same time, Ningbo export container freight price index was based on the 10th week of 2012 (March 3-9, 2012), with a base point of 1000.

The reasons for why this paper uses the index of Sino-US container freight export price index is that this index is relatively easy to obtain compared with other freight price indices such as CCFI and SCFI. On the other hand, it is also because Chinese exports to the United States is focused on the low-end manufacturing industry and the way for export trading is mainly by using container shipping.

As a result, compared to the dry bulk freight index and coal freight index which also show the price change tendency on the fright trade market, this index is more representative.

B. Ningbo-East of the United State Route

The paper will primarily measure freight price risks contained in the route between China and the United States in the context of trade frictions happening between China and the United States.

Due to source restrictions, we choose Ningbo port export freight price index to represent China's export freight price change tendency. Actually, there are two routes from Ningbo port to the United States, namely Ningbo-East America route and Ningbo-West America route. The built of New Panama Canal in 2016 positively makes the routes from Asia to the eastern ports of the United States gradually become active, and there is a tendency that the use frequency of the route of Asian-West America is to surpass the use frequency of the routes from Asia to the west America. In addition, compared with the route from Ningbo to west America, the route from Ningbo to east America has longer distance, which means higher risks are contained. As a result, based on the two reasons mentioned above, we choose to calculate the risk of the export container freight index of Ningbo-East America route.

C. Factors Affecting the Price of Export Container Freight

Maike (2007, p. 8) thinks export container freight price is mainly affected by the following four aspects' factors, respectively is: cost, supply and demand, international economy and trade and seasonal and stochastic factors. As the price of various scarce resources rises, the transportation cost is also in a steady state of rise, which will have an impact on the freight price. The change of supply and demand leads to the change of its equilibrium point which means the change of freight price. Changes in the world economy, international trade and other climatic factors will also affect changes in freight prices.

However, Li (2007) made an empirical analysis on ocean shipping prices in combination with theoretical, graphical and financial metrology methods, and believed that the sea shipping price volatility conforms to the characteristics of mean regression with the growth of time span. With the decrease of time span, the shipping price is more in line with the characteristics of random migration.

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D. Impact Analysis of Freight Price Changes in Export Containers

From ship management point of view, the shipping price fluctuations for shipping companies having ships and for traders to use the ships to take business have different effects, for which reason the freight price fluctuation will bring owners and users different risks and benefits (Xu, 1996). Li (2009) analyzed the change of ship operating income under the fluctuation of ocean shipping price through the risk measurement of sea shipping price fluctuation. He believes that shipping companies face the same international shipping market environment and the same risk of freight fluctuation in ownership and control of ships. From the perspective of ship ownership management, the change in freight rate has a greater impact on ship operators than the risk of ship investment and financing, and the uncertainty of income is much higher than the uncertainty of cost. To control the operation of ships, operators are sensitive to the fluctuation of freight rates and can quickly adjust the fleet structure to adapt to the changes in the shipping market. But fluctuations in freight rates and the rent is synchronous, freight charges are high, the rental rate is also high, if shipping companies can't grasp for shipping market to make a good prediction, chartering business is working for shipping company.

E. Overview of Model Applications

In the existing literature, the most comprehensive VaR study is the book VaR: A New Criterion for the Management of Risk Value-Financial Risk, written by Philippe Jolly (2000). In addition, many foreign scholars also conduct relevant research on VaR from different perspectives. Scholars such as Beder (1995), Jorion (1996), and Boudoukh (1997) used the VaR standard method to measure the market risk faced by securities companies. Meanwhile, Shams M. F. et al. (2012) studies the application of VaR methodology to risk management in the stock market in Iran.

However, at present, there are not many such literatures on the measurement of sea freight price fluctuations. In China, Wang Hui (2012) evaluated the international dry bulk shipping market risk by calculating the VaR of international dry bulk freight index. The samples used were: BCI (Baltic Freight Capesize Index); BPI (Baltic Freight Panamax Index) and BHMI (Baltic Freight Handymax Index). Li (2010) used the threshold model (POT) in the extreme value theory to measure the VaR and CVaR of sea freight price loss volatility, and concluded that the sea freight price loss rate under the POT was greater than the normal distribution assumption of the value of the risk. At the same time, Jin Yan (2010) used the VaR risk measurement method to measure the fluctuation risk of oil tanker freight rates.

Since the GARCH model was put forward, it has been widely quoted by the academic community in terms of measurement condition volatility. The most recent applications of the extended model for the GARCH model are Lombardi and Gallo (2001), Giot and Laurent (2004), and Ricardo (2006). , Cifter and Ozun (2007) et al. At the same time, the GARCH model has also been introduced into the measurement of VaR in the field of financial risk management as a main analysis algorithm for predicting VaR. In foreign countries, literatures on the calculation of VaR for financial assets based on ARCH models are Billio and Pelizzon (2000), Vari and Sosa (2000), Guermat and Harris (2002). In China, Qiu Peiguang (2004) applied the GARCH model (Generalized ARCH Model) to VaR calculations and empirically analyzed the closing index of the Shanghai Stock Exchange. Hu Yuehui and Ye Jun (2004) used the GARCH-M model for VaR calculations. An empirical analysis of the six indices of the SSE was conducted; Yan Haiyan (2006) used the ARCH model to discuss the volatility of the Chinese stock market; Gong Ni (2006) combined the GARCH model with the VaR method to discuss its externalities.

Due to the nature of the GARCH model, most of the GARCH models are not used on their own. Previous scholars have chosen the GARCH model to test most of the VaR risk of shipping prices. However, as research on the volatility of the price of export freight, the previous literature about GARCH model used in this aspect is rare.

However, we can refer to the literature about the measure of oil price by GARCH model, as oil price volatility is related closely with the freight price and there are some similarities between these two prices function mechanism. In order to measure the oil market risk, Feng Chunshan (2003) established the ARCH model for international oil prices, and Cortazar (2003) established a stochastic volatility model for oil futures prices. David (2003) adopted the normal distribution model. The GARCH model estimates the value atRisk (VaR) of the international oil market. Giot (2003) uses the semi-parametric method such as the GARCH model with t-distribution and Feng Chunshan (2004) to calculate the oil market. VaR. Cabedo and Moya (2003) studied the international crude oil price using the HSAF method that combines the historical simulation (HS) method of VaR and the ARMA model.

II. EMPIRICAL ANALYSIS

This article uses the 325 weekly freight index of 2012.3.9-2018.5.25 of the Ningbo Export Container Freight Index (NCFI) as the analyzed data. Meanwhile, the determination of whether to join data of the freight index in the period of the Sino-US trade friction (2018.3.9-2018.5.25) is seen as control variable, which constructs the data of the freight price index into two series, which are the series with data of trade friction period (seen as series 1) and series without the data in trade friction time period (seen as series 2).

In this paper, the logarithmic rate of return of the freight index is used as an index to measure the market index. This is because the price of freight is a discrete variable which is generally unstable and inconvenient for modeling, but the logarithmic rate of return can overcome the early data’s shortcomings while at the same time it can reflect the volatility of freight prices. In addition, this article uses eviews8.0 and excel2016 to analyze and organize the data and all the conclusions come from the statistics results.

A. Construct a GARCH Model

The GARCH model is structured as:

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2;$$

Using Eviews to model GARCH(2,1), GARCH(1,2), E-GARCH and T-GARCH respectively, by comparing, only all the coefficients of GARCH(1,1) pass the t-test, which is the best. Select the model GARCH(1,1) and the result is:

TABLE I. MODEL GARCH(1,1) FOR SERIES 1

Parameter	Ω	A	B	α+β
GARCH(1, 1)	4.33E-05	0.09234	0.90286	0.9952

B. VaR Calculation and Back Test

Under a certain confidence level, using the conditional variance equation obtained above, the estimated value of the conditional variance can be calculated, and then the estimated value of the standard deviation can be calculated. The VaR value can be calculated by using the variance covariance model. The expression formula is:

$$VaR = P_{T-1}\sigma_T Z_\alpha$$

Therefore, the VaR can be calculated. When α = 0.05, Zα = 1.65.

VaR estimates can be tested using a variety of methods, such as failure frequency tests, interval tests, distribution tests, etc. This article uses the failure frequency method to test. The principle of failure frequency test is to compare VaR estimates and actual profit and loss values. If VaR is greater than the absolute value of the real profit and loss value, there is a success, otherwise it is a failure. After the actual failure probability is obtained, taking it compared with the expected failure probability under a certain confidence level. The actual profit and loss in this paper can be calculated with the formula MT = PTYT. As the result shows, the actual profit and loss and VaR comparison is at 5% confidence level.

Using the Kupiec failure frequency test method, LR∈ [10,24] is obtained, which means that in more than 300 measurements, the VaR may fail 10 to 24 times with a failure rate of 3.08% to 7.38%.

C. Model Construction and Inspection

Through the same steps as above, we performed the test of stationarity and normality, ARCH effect, and GARCH (1, 1) modeling and VaR risk measurement for sequence 2, the conclusions are as follows:

a. Sequence 2 is a stationary time series but does not satisfy the normality test;

b. After the sequence 2 was whitened, the sequence showed an ARCH effect;

c. The result of GARCH(1, 1) modeling is:

TABLE II. MODEL GARCH(1,1) FOR SERIES 2

Parameter	Ω	A	B	α+β
GARCH(1, 1)	4.22E-05	0.10251	0.8953	0.99781

d. Through VaR estimation, the VaR calculated by Sequence 1 is greater than Sequence 2, but the difference is not vary large, and the failure rate of Sequence 2 measurement is between 3.52% and 7.92%, which is similar to Sequence 1.

III. THEORETICAL ANALYSIS

A. Analysis of Empirical Results.

Through the calculation of the previous VaR index, we have found that the VaR indexes calculated by the two sequence are different, but the difference is not large. Therefore, we believe that so far, Sino-US trade friction has not yet had a significant impact on freight price fluctuations. At the same time, the failure rates of the two sequences measured in sequence 1 and sequence 2 are relatively low, so we can consider that VaR can more accurately predict the potential risks of freight prices. In addition, the GARCH(1, 1) model and VaR used in this paper have passed the back test, so the model used in this paper can be used to measure the international container freight price index.

B. Possible Explanations

As for the results obtained in this paper, the trade friction between China and the United States has not yet had a significant impact on the fluctuation of international freight prices. We believe that there may be several reasons.:

Firstly, because the current trade frictions have been temporarily stabilized through bilateral government negotiations, which boosted the confidence of traders and shipowners, and there were not substantial harm caused in the physical trade;

Secondly, as we have mentioned above, although related regulations are put forward in the United States, as there is no substitute for the traders in the line of Pacific Ocean, there are still large demand for the freight ship for the line of Ningbo-East America, therefore, according to the supply-demand curve, the equilibrium price is still high;

Thirdly, it may be because the sea freight price has its own characteristics which is up or down according to the free season and the busy season of trade, and it was subject to greater volatility.

Therefore, due to politics put forward, the special fluctuations brought about by the political factors are just offset by the original seaborne price fluctuations, making the calculated VaR value relatively small. Finally, due to the way that the freight price index is recorded once a week, though the data calculated by this paper has large time span, there are still defects in the amount of data, leading to possible biases in the results.

IV. Conclusion and Suggetsiongs

A. Conclusion

The conclusion reached by this paper is that Sino-US trade friction, so far, has not yet had a significant impact on freight price fluctuations. At the same time, VaR can more accurately predict the potential risks of shipping prices. On the one hand, this result has a positive impact on the ship's investors and can boost its investment confidence. On the other hand, this result will also help ship investors, owners and traders better predict risks, control risks and reduce unnecessary losses.

B. Suggestions for Stakeholders in the Shipping Business.

Firstly, for ship investors, the current Sino-US trade friction has no significant impact on freight prices, so shipowners can still choose vessels as investment targets, but because the current situation is still unclear, it is recommended to wait and see;

Secondly, for shipowners, shipowners are the biggest victims of the trade frictions between China and the United States. Therefore, the empirical results are beneficial to such groups of people. However, ship owners should always observe the fluctuation of shipping prices. Potential risks should be forecasted and controlled in a timely manner;

Thirdly, the impact of Sino-U.S. trade frictions, if they affect freight prices, are most favorable to traders with unrestricted trade. Therefore, traders should always pay attention to the forecast of freight prices and they can do hedges in advance to avoid possible risks and bring greater benefits.

V. Summary and recommendations

This paper uses the VaR-GARCH model to explore the risk of fluctuations in the container freight price index from Ningbo to the United States on the trade friction between China and the United States. The data used in this paper is the Ningbo container export freight price index. The sample period is from March 9, 2012 to May 25, 2018. In order to explore the impact of the Sino-US trade friction on the freight price index, this article takes the participation of the freight price index in the Sino-US trade friction period as a control variable and divides the sequence into with prices within the period of trade friction or not. The sequence 1 of the index is with the prices data within the period of trade friction and for the sequence 2, the data of period of trade friction are not included, and they are analyzed and tested separately.

The two sequences examined in this paper have obvious statistical characteristics of spikes and thick tails, all of which have strong autocorrelation, and the autoregressive model residual sequence has ARCH effect. The GARCH model can be used to fit the fluctuation characteristics of each series of the test difference, and a VaR model is established on the basis of this model, so that the risk value of the yield series can be calculated, and the calculation result is based on the failure rate VaR test.

There are also many imperfections in this article. Due to the limitations of conditions and the habits of weekly freight statistics, although the data collected in this paper has a long span in time, there is still a shortage of data, which may cause some bias in the results. In addition, as the new Sino-U.S. trade frictions have just begun, many policies have yet to be implemented and the statistics are relatively small, which may also be the cause of biased conclusions. However, the test shows that the model used in this paper can be used to measure the international container freight price index, so the value of this paper is also to provide reliable models and research methods for later measurers.

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