https://doi.org/10.1016/j.tre.2020.101931

Quantile hedge ratio for forward freight market[1]

Yimiao Gu*, Zhenxi Chen[2]*†, Donald Lien‡, and Meifeng Luo§

* *School of Economics and Commerce, South China University of Technology*

† *Research Center of Financial Engineering, South China University of Technology*

‡ *Department of Economics, University of Texas at San Antonio*

§ *Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University*

Version: Feb 2020

Forward Freight Agreement (FFA) is used by shipping market players for hedging. We evaluate the hedging performance of the FFAs by comparing the conventional approach of minimum variance with the quantile regression. The quantile hedge ratios tend to be different from the conventional one, indicating the possibility of over- or under-hedge. Including the error correction term reduces the discrepancy between the quantile hedge ratios and the conventional one. The FFA of one-month horizon is more informative to the physical market than other FFAs of longer horizons. Overall, the Panamax sector has a better hedging performance than the Capesize one and the quantile hedge should be preferred for the Capesize sector.

JEL: G14; C32; R40

Keywords: Quantile Regression; Baltic Capesize Index; Baltic Panamax Index; Hedging effectiveness; Shipping Finance

[1]The authors are grateful for the stimulating and constructive comments of the editors and reviewers. This paper receives funding support from the Youth Foundation of the Humanities and Social Sciences Research of the Ministry of Education of China [grant no.17YJCGJW002], and the Development of Philosophy and Social Science of Guangzhou city [grant no.2018GZYB24].

[2]Corresponding author, email: zchen2@e.ntu.edu.sg

1. INTRODUCTION

The shipping industry plays an irreplaceable role in the modern economy by carrying around 80% of the world's merchandise trade (United Nations Conference on Trade and Development, 2008). Meanwhile, due to the sluggish adjustment in the shipping capacity as well as the uncertain demand for shipping service, the shipping market is characterized by large volatility in the freight rates (Alizadeh, Huang, and van Dellen, 2015). To hedge the price risk of the physical market, shipowners and charterers turn to freight derivatives, such as forward freight agreement (FFA) and freight futures. Among the various freight derivatives, FFA is the most popular one due to its flexibility in designing the contract details and the hedging performance of FFA becomes an important issue since it is related to the success of risk hedging (Kavussanos and Visvikis, 2010; Li et al., 2014). This paper contributes to the literature by investigating the hedging performance of FFA using the conventional OLS as well as the quantile regression approaches for Capesize and Panamax, the two important vessels in the dry bulk market.

FFAs are over-the-counter freight derivatives. They are agreements between two principals, usually through a broker. The FFAs would set a freight rate for a specified volume of cargo and vessel type on a particular route at a given date in the future. A shipowner would be the seller of an FFA to protect her from a potential decline in freight rates. Meanwhile, a charterer would be a purchaser of an FFA in order to cancel out the loss due to a potential rise in the physical market. In case there are over- or under-hedge, market players of FFA might incur unnecessary loss or make less profit. This paper contributes to the industry by comparing the hedge ratios of the conventional and the quantile approaches to judge the over- or under-hedge by the conventional hedge approach.

Many efforts have been devoted to studying the interactions between physical and FFA prices. Adland and Alizadeh (2018) report that time-charter (TC) freight rate has a cointegration relationship with FFA price with the TC rate higher than the one of FFA. They further claim that the time-varying TC-FFA freight rate differential can be explained by factors such as the level and slope of the term structure, economic condition, and default risk. Li et al. (2014) investigate the spillover effects and the dynamic correlations between the spot and FFA markets. They find evidence for the existence of the unilateral spillover in returns from FFA to spot markets and the bilateral spillover in volatility between the spot and FFA markets. In addition, they also detect persistent volatile correlations between the two markets. Yin, Luo, and Fan (2017) analyze the interactions between spot and FFA prices in the dry bulk shipping sector. It is found that market demand and supply influence the dynamics of the spot and FFA prices. Also, both prices would adjust to the long-run relationship between the two prices.

The interactions between the physical and FFA market provide a foundation to further investigate the forecasting performance of FFA price on the spot price as well as the performance of risk management for the shipping market. Kavussanos and Visvikis (2004) examine the market interactions in returns and volatilities between spot and forward shipping freight markets, finding that FFA prices contribute to the discovery of new information in the spot market. Zhang, Zeng, and Zhao (2014) examine the forecasting capability of FFA and TC contracts on the spot freight rate. They find the existence of cointegration between spot and FFA rates and between spot and TC rates. The inclusion of FFA and TC contracts together improves the forecasting performance of spot freight rates. Kasimati and Veraros (2018) examine the accuracy of FFA in forecasting the future freight rates and find that FFAs display limited usefulness in the prediction and also miss the turning points of the market cycles. However, the forecast performance becomes better for the shorter time horizon. Kavussanos and Visvikis (2010) evaluate the hedging performance of the Capesize forward freight market using the methods of constant and time-varying hedge ratios. They claim that the FFA contracts effectively reduce the freight rate risk. Alexandridis et al. (2018) develop a portfolio-based methodological framework including the physical diversification of freight rates and the financial hedging of freight derivatives. They report benefits of a decrease in freight rate risk by holding a diversified portfolio of freight rates and then further reduction of risk with futures contracts. Goulas and Skiadopoulos (2012) investigate the market efficiency of freight derivatives using data of the International Maritime Exchange (IMAREX) and report that IMAREX is not efficient over the shorter daily horizon.

Another way to evaluate hedging performance is the quantile regression approach. Ideally, the results of quantile regression should be the same across the quantiles. Otherwise, it is possible to have over- or under-hedge. The method of quantile regression has been applied to investigate the hedging performance for financial and commodities markets. Lien, Shrestha, and Wu (2016) estimate quantile hedge ratios for 20 different commodities and report that the quantile hedge ratios are generally smaller at the upper and lower tails of the spot distribution. This phenomenon is especially prominent for daily data such that the conventional hedge ratio would not be appropriate for short horizons at a daily level. Shrestha et al. (2018) use the similar quantile hedge ratio to evaluate the hedging performance of the derivatives of energy markets including crude oil, heating oil, and natural gas. It is found that price discovery mainly takes place in the futures market for natural gas. By including the error correction term, the hedging effectiveness improves significantly.

This paper contributes to the studies of hedging performance for the freight market by employing the quantile regression. Using the daily data, we estimate the quantile hedge ratio for FFA contracts with horizons of one-, two-, three- and four-month for both Capesize and Panamax vessels. It is found that the quantile hedge ratios tend to be inconsistent with the conventional hedge ratio. There are significant long-run relationships between the physical TC price and the FFA rates. By including the error-correction term, the discrepancy between the quantile hedge ratios and the conventional hedge ratios is reduced, especially for the Panamax vessels. The discrepancy between the quantile hedge ratios and the conventional hedge ratios implies that quantile hedge should be preferred for the Capesize vessels to avoid potential over- or under-hedge. In contrast, the conventional hedge is still valid for the Panamax sector.

The rest of the paper is organized as follows. In Section 2, we briefly introduce the methodology for the empirical estimation. In Section 3, we present the data to be used for the estimation. Section 4 reports the estimation results. Lastly, Section 5 concludes the paper.

2. METHODOLOGY

For the physical TC and forward markets, we denote the natural logarithm of the TC and forward agreement freight rates at time t by s_t and f_t, respectively. Subsequently, returns on the TC and forward freight rates can be calculated according to $\Delta s_t = s_t - s_{t-1}$ and $\Delta f_t = f_t - f_{t-1}$. The TC and forward freight rates form a hedged portfolio, whose return is given by

$$R_{H,t} = \Delta s_t - H \Delta f_t \tag{1}$$

where H is the so-called hedge ratio that this paper intends to study.

Ederinton (1979) argues that the objective of hedging is to minimize the volatility of the portfolio. This objective means to optimize H such that the variance of R_H is minimized, leading to the so-called MV (minimum variance) hedge ratio, H_{MV} given by

$$H_{MV} = \frac{Cov\left(\Delta s_t, \Delta f_t\right)}{Var\left(\Delta f_t\right)}. \tag{2}$$

2.1. Conventional approach

The MV hedge ratio can be estimated from the below regression equation using the OLS method:

$$\Delta s_t = \alpha + \beta \Delta f_t + e_t \tag{3}$$

where the estimate of the coefficient, β is H_{MV}.

In case the two prices time series, s_t and f_t, are nonstationary such that they are cointegrated as defined by Engle and Granger (1987), the regression model given by Eq.(3) will be misspecified, rendering the estimated hedge ratio biased. To remedy the problem of mis-specification, the below error-correction model (ECM) can be used to estimate the MV hedge ratio in the presence of cointegration:

$$\Delta s_t = \alpha + \beta \Delta f_t + \gamma u_{t-1} + \sum_{i=1}^{m} \phi_{s,i} \Delta s_{t-i} + \sum_{j=1}^{n} \phi_{f,j} \Delta f_{t-j} + \epsilon_t \tag{4}$$

where error correction term u_t is the residual from the cointegration regression given by

$$s_t = a + b f_t + u_t \tag{5}$$

In the ECM regression, the estimate of β in Eq.(4) provides the estimate of the optimal hedge ratio which is denoted by H_{ECM}. The lag orders of Δs_t and Δf_t can be determined by using the Akaike information criterion (AIC). Therefore, there are two different estimates of the MV hedge ratio: (1) H_{OLS}, obtained by estimating Eq.(3) using the OLS method (referred to as OLS hedge ratio) and (2) H_{ECM}, obtained by estimating Eq.(4) with error-correction included (referred to as ECM hedge ratio).

2.2. Quantile hedge ratio

The quantile hedge ratio technique used in this paper is based on Lien, Shrestha, and Wu (2016). Quantile regression was introduced by Koenker and Bassett Jr

(1978) to investigate the relationship between quantiles of the conditional distribution of the response variable and the observed covariates. Suppose Y is a continuous random variable with cumulative density function $F(\cdot)$, then $\Pr(Y < y) = \Pr(Y \leq y) = F(y)$ for every y in the support and a τ-*th* quantile is any number ς_τ such that $F(\varsigma_\tau) = \tau$. If F is continuous and strictly increasing, then the inverse exists and $\varsigma_\tau = F^{-1}(\tau)$.

For a regression model

$$y_t = X_t\theta + \epsilon_t,$$

the OLS estimation relies on the quadratic loss function

$$L = \sum_{t=1}^{T} (y_t - X_t\theta)^2 . \tag{6}$$

the OLS estimator, $\widehat{\theta}$, is obtained by minimizing the quadratic loss function:

$$\widehat{\theta} = \arg\min_{\theta} L = \arg\min_{\theta} \sum_{t=1}^{T} (y_t - X_t\theta)^2 . \tag{7}$$

In contrast, instead of the quadratic loss function, the quantile regression for a given quantile τ uses the loss function with an absolute form,

$$L(\tau) = \sum_{t\in\{t:y_t\geq X_t\theta\}} \tau |y_t - X_t\theta| + \sum_{t\in\{t:y_t<X_t\theta\}} (1-\tau) |y_t - X_t\theta| . \tag{8}$$

The quantile estimator $\overline{\theta}(\tau)$ is the solution to the minimization problem:

$$\begin{aligned}\overline{\theta}(\tau) &= \arg\min_{\theta} L(\tau) \\ &= \arg\min_{\theta} \left[\sum_{t\in\{t:y_t\geq X_t\theta\}} \tau |y_t - X_t\theta| + \sum_{t\in\{t:y_t<X_t\theta\}} (1-\tau) |y_t - X_t\theta| \right] . \end{aligned} \tag{9}$$

Compared to the OLS estimation, the quantile regression has an important property that its estimators are less affected by outliers. Meanwhile, the OLS parameters and quantile parameters have a below relationship:

$$\widehat{\theta} = \int_0^1 \overline{\theta}(\tau)\, d\tau. \tag{10}$$

Similar to the conventional hedge ratio, the quantile hedge ratio could be estimated by two methods. The first method estimates the quantile hedge ratio, referred to as $\beta(\tau)$, by estimating Eq.(3) using the quantile regression method for quantile τ. We call the first method OLS-quantile method. The second method, referred to as ECM-quantile method, estimates the quantile hedge ratio $\beta(\tau)$ by estimating Eq.(4) using quantile regression where the cointegrating regression Eq.(5) is estimated by OLS. Quantile regressions would be conducted for various quantiles ranging from 0.05 to 0.95.

Regarding the hedging performance, the conventional hedge ratio is a constant while the quantile hedge ratio might vary with the quantile. In case the quantile hedge ratio is different from the conventional one, the conventional MV hedge ratio could result in over- or under-hedge. Using Eq.(3) as an example, we illustrate the difference between the conventional and the quantile hedge ratio. The conventional MV hedge ratio, H_{OLS} is equal to β while the quantile hedge ratio is $\beta(\tau)$ at quantile τ. Suppose that the MV hedge ratio is 1 and $\beta(\tau)$ at quantiles 0.1 and 0.9 is 0.8 and 1.2, respectively. That is $H_{OLS} = \beta = 1$, $\beta(0.1) = 0.8$ and $\beta(0.9) = 1.2$. With this setting, if the realized physical TC return is at the 10% quantile of the TC return, the MV hedge ratio causes over-hedging. In the same spirit, the MV hedge ratio leads to under-hedging when the realized TC return is at the 90% quantile. Such circumstances would be detrimental to the long hedgers while beneficial to the short hedgers when the MV hedge ratio is applied in place of the quantile hedge ratio. For the long hedgers such as ship lessee, they would be over-hedged in the lower quantile when they do not need the protection from the forward contracts while under-protected in the upper quantile when they need the protection. On the other hand, it would be beneficial to short hedgers such as shipowners because they are over-protected in the lower quantile when they need protection from the forward contracts while under-hedged in the upper quantile when they do not need the protection. In case the quantile hedge ratio is the same across the quantiles, it would be equal to the conventional MV hedge ratio, according to Eq.(10). Then, the hedgers do not need to worry about the over- or under-hedge arising from the difference between the two hedge ratios. In other words, when the discrepancy between the conventional hedge ratio and the quantile hedge ratio is small across the quantile, it is safe to use the conventional hedge ratio for hedging without taking into account the quantile distribution of the physical freight rate.

Since the difference between the conventional hedge ratio and the quantile hedge ratio indicates the possibilities of over- or under-hedge, we calculate a discrepancy measure λ to gauge the overall difference between the two hedge ratios across the quantile for a particular FFA contract according to

$$\lambda = \sum_{\tau=0.05}^{0.95} \left| \overline{\theta}\left(\tau\right) - \widehat{\theta} \right| /N.$$

where N is the number of quantile evaluated. The larger the λ, the larger the discrepancy between the two ratios and then the larger chance of over- or under-hedge.

2.3. Hedging effectiveness

Since there are multiple hedging strategies, the comparisons of the hedging effectiveness of the strategies deepen the understanding of the hedge activities and have been studied intensively (Kavussanos and Nomikos, 2000; Lien, 2005, 2008, 2009). As the MV hedge ratio minimizes the variance of R_H, the return on the hedged portfolio as per Eq.(1), the hedging effectiveness is defined as the improvement in the variance following Shrestha et al. (2018),

$$HE_{mv} = 1 - \frac{Var\left(R_H\right)}{Var\left(\Delta s\right)},$$

where $Var\left(R_H\right)$ is the variance of the hedged portfolio while $Var\left(\Delta s\right)$ is the variance of the TC return or the variance of the un-hedged portfolio. With this setting, the highest hedging effectiveness is achieved when HE_{mv} approaches 1. In addition, HE_{mv} is equal to R^2 of the regression of Eq.(3). Therefore, a higher R^2 means better hedging effectiveness.

For quantile regression, the hedging effectiveness for a given quantile τ is measured in a similar way,

$$HE(\tau) = 1 - \frac{L_{unrest}(\tau)}{L_{rest}(\tau)}.$$

where $L_{unrest}(\tau)$ is the minimized loss function of Eq.(8) in the quantile regression while $L_{rest}(\tau)$ is the value of loss function with restriction that $\theta = 0$. Koenker and Machado (1999) and Shrestha et al. (2018) argue that the $HE(\tau)$ is analogy to R^2. Hence, following Shrestha et al. (2018), we use R^2 to measure the hedging effectiveness of both conventional and quantile regressions.

3. DATA

Capesize and Panamax are the two vessels delivering the largest freight volumes in the dry bulk markets. Meanwhile, from data of trading history, FFAs of Capesize and Panamax are the most traded, accounting for more than 35% of Baltic Exchange FFAs transaction, respectively (Alizadeh and Nomikos, 2009; Gong and Lu, 2016). Therefore, examining Capesize and Panamax FFAs helps reveal the hedging performance of the dry bulk market. Baltic Capesize index (BCI) is a daily average for shipping cost on a basket of time-charter (TC) and voyage routes in the dry bulk shipping market representative of Capesize vessels. At the same time, Baltic Panamax Index (BPI) indicates the cost of cargo movements of Panamax vessels. We abstract the relevant daily data of Capesize time-charter average (BCI 4TC average) and Panamax time-charter average (BPI 4TC) as well as their FFAs from the Baltic Exchange. The sample period is 01/04/2011 to 11/16/2017. In total, there are 1738 observations. The data include the physical TC price index, and the freight forward agreement price with horizons of one-, two-, three- and four-month[1]. The natural logarithm of the TC price indices at time t for BCI and BPI are denoted by s_t^c and s_t^p, respectively. Meanwhile, the natural logarithm of the BCI FFAs with horizons of one-, two-, three- and four-month are denoted by $f_t^{c,1}$, $f_t^{c,2}$, $f_t^{c,3}$, and $f_t^{c,4}$ respectively. Similarly, the natural logarithm of BPI FFAs are $f_t^{p,1}$, $f_t^{p,2}$, $f_t^{p,3}$, and $f_t^{p,4}$. The return of a time series is denoted by Δ. For example, Δs_t^c is the return on BCI freight rate. Fig. 1 plots the time series of TC rates and the FFAs rates. The FFA rates tend to fluctuate with similar trends with the corresponding TC rates. In addition, the FFAs of four-month horizon are the least volatile.

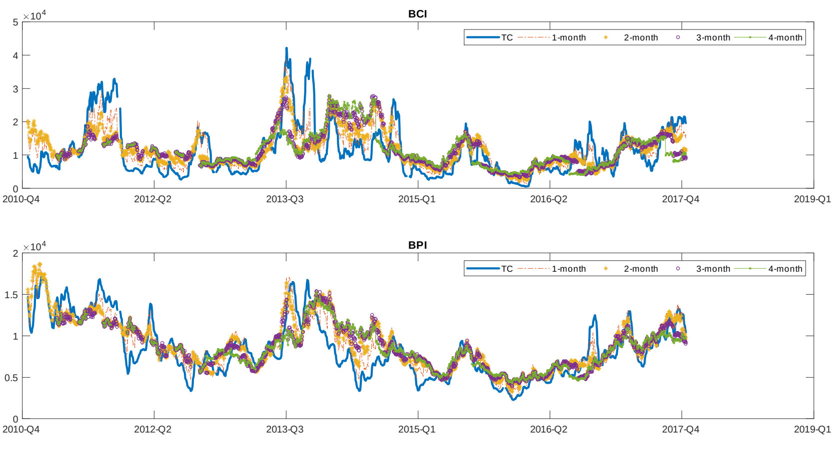

FIG. 1 Plot of the spot and FFAs rates.

Table 1 reports the descriptive summary of the variables. It is found that the average returns on the TC and forward rates are negligible, with no clear trend observed in the sample period. Based on the standard deviation, the FFAs have a comparable level of fluctuations to the TC rates. It is observed that the fluctuation of the FFAs tends to decrease with the horizon of the FFAs. All the returns display

[1] For the meaning of horizon, for example, one-month horizon denotes the contract that matures next month while two-month denotes the contract that matures in the following two months.

TABLE 1
Summary statistics (log returns).

	Δs_t^c	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$
Average	0.000	0.000	0.000	0.000	0.000
Maximum	0.411	0.477	0.328	0.264	0.200
Minimum	-0.321	-0.600	-0.552	-0.608	-0.629
Standard dev.	0.066	0.080	0.063	0.052	0.047
Skewness	0.791	-0.039	-0.863	-2.806	-4.688
Kurtosis	7.575	9.707	15.975	36.738	61.984
Jarque-Bera	1670***	3256***	12385***	73890***	206884***
	Δs_t^p	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$
Average	0.000	0.000	0.000	0.000	0.000
Maximum	0.138	0.373	0.294	0.201	0.142
Minimum	-0.119	-0.230	-0.218	-0.295	-0.186
Standard dev.	0.025	0.043	0.033	0.030	0.024
Skewness	0.508	1.159	0.444	-0.715	-0.320
Kurtosis	5.239	12.562	11.816	16.193	9.987
Jarque-Bera	430***	7006***	5682***	11123***	2854***

Notes: *** denotes significance at 1% level.

fat-tails and non-normality. Next, we conduct the cointegration test using the technique of Johansen (1991, 1995) to check any long-run relationship between the spot rate and its FFA rates. The cointegration equations based on Eq.(5) for TC rate with each FFA is reported in Table 2. Based on the cointegration equation, the corresponding error correction term u_t for each FFA is generated.

4. EMPIRICAL RESULTS

4.1. Hedge ratio

We estimate the conventional MV hedge ratio and the quantile hedge ratios across various quantiles for the four FFAs with horizons of one-, two-, three- and four-month, respectively. For Capesize vessels, the MV hedge ratio and the quantile hedge ratios for 19 different quantiles using the daily data for the four FFAs are reported in Table 3. All the estimated hedge ratios are significant at the level of 1% except for one estimate which is significant at 5% level. Without taking into

TABLE 2
Cointegrating equation for each FFA with the spot rate.

s_t^c	a	$f_t^{c,1}$	$f_t^{c,2}$	$f_t^{c,3}$	$f_t^{c,4}$
1	2.947***	-1.304***			
	(0.680)	(0.074)			
1	2.555		-1.260***		
	(2.065)		(0.222)		
1	1.670			-1.170***	
	(3.162)			(0.341)	
1	-0.284				-0.957**
	(3.903)				(0.422)
s_t^p	a	$f_t^{p,1}$	$f_t^{p,2}$	$f_t^{p,3}$	$f_t^{p,4}$
1	0.679	-1.067***			
	(0.581)	(0.064)			
1	-0.302		-0.957***		
	(1.269)		(0.140)		
1	0.638			-1.059***	
	(1.845)			(0.205)	
1	-0.819				-0.895***
	(1.792)				(0.200)

Notes: standard errors are in parentheses, ** and *** denote significance at 5% and 1% levels, respectively.

account the error-correction term, the OLS regression based on Eq.(3) shows that the conventional MV hedge ratio, H_{OLS}, is quite close to each other at value 0.29 for different FFAs. In contrast, the conventional MV hedge ratios are different from the quantile hedge ratios for all the four FFAs ranging from 0.201 to 0.389. The hedge ratios are plotted in Fig. 2. For FFAs of one- and two-month horizons, the quantile hedge ratio is smaller than the MV hedge ratio for quantile less than 0.6. With the increase in the quantile, the quantile hedge ratio becomes larger than the MV hedge ratio. For FFA of three-month horizon, the quantile hedge ratio tends to be smaller than the MV hedge ratio over the medium quantiles. Lastly, for FFA of four-month horizon, the relationship between the quantile and MV hedge ratios is irregular. The quantile hedge ratio is larger than the MV hedge ratio over different quantiles while it is smaller over other quantiles. The inconsistency between the quantile hedge ratio and the MV hedge ratio indicates that the conventional hedge could result in over- or under-hedge. Similar patterns of MV hedge ratio and quantile hedge ratios are observed for Panamax vessels as reported in Table 4.

As cointegration relationships between the TC and the forward freight rates exist, OLS regressions without including error-correction term would be misspecified. Now we check the regression results with error-correction term included based on Eq.(4). The estimated MV hedge ratio and the quantile hedge ratios for the Capesize and Panamax vessels are reported in Tables 3 and 4, respectively. The hedge ratios taking into account the error-correction term for the two vessels are plotted in Fig. 3. For Capesize vessels, the conventional hedge ratio of ECM regression, H_{ECM}, is comparable to its counterpart of the OLS regression, H_{OLS}, across the FFAs. For example, H_{ECM} for FFA of one-month horizon is 0.266, close to 0.294 of H_{OLS} of the same horizon. Meanwhile, the quantile hedge ratios are close to H_{ECM} for FFAs with horizons less than four-month as visualized in Fig. 3, indicating less over- or under-hedge by taking into account the error correction term while the

TABLE 3
MV and quantile hedge ratios for the BCI FFAs using OLS and ECM methods.

OLS based on Eq.(3)					ECM based on Eq.(4)				
Quantiles	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$	Quantiles	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$
0.05	0.247***	0.222***	0.275***	0.284***	0.05	0.218***	0.264***	0.326***	0.399***
0.10	0.220***	0.227***	0.292***	0.332***	0.10	0.220***	0.251***	0.335***	0.430***
0.15	0.210***	0.233***	0.252***	0.291***	0.15	0.226***	0.262***	0.352***	0.426***
0.20	0.222***	0.237***	0.254***	0.318***	0.20	0.246***	0.267***	0.350***	0.443***
0.25	0.218***	0.221***	0.214***	0.272***	0.25	0.246***	0.270***	0.315***	0.444***
0.30	0.251***	0.209***	0.201***	0.278***	0.30	0.237***	0.269***	0.322***	0.427***
0.35	0.267***	0.242***	0.232***	0.297***	0.35	0.249***	0.285***	0.333***	0.436***
0.40	0.263***	0.241***	0.210***	0.248***	0.40	0.253***	0.296***	0.340***	0.427***
0.45	0.264***	0.247***	0.215***	0.287***	0.45	0.263***	0.308***	0.349***	0.406***
0.50	0.272***	0.253***	0.248***	0.300***	0.50	0.268***	0.307***	0.344***	0.421***
0.55	0.278***	0.271***	0.259***	0.348***	0.55	0.267***	0.316***	0.359***	0.408***
0.60	0.288***	0.291***	0.241***	0.352***	0.60	0.272***	0.318***	0.348***	0.378***
0.65	0.307***	0.299***	0.220***	0.299***	0.65	0.281***	0.323***	0.335***	0.382***
0.70	0.326***	0.299***	0.229***	0.310***	0.70	0.285***	0.321***	0.330***	0.421***
0.75	0.330***	0.357***	0.228***	0.322***	0.75	0.281***	0.337***	0.323***	0.395***
0.80	0.344***	0.357***	0.230***	0.263***	0.80	0.281***	0.319***	0.301***	0.393***
0.85	0.389***	0.357***	0.258***	0.294**	0.85	0.290***	0.316***	0.313***	0.321***
0.90	0.385***	0.277***	0.244***	0.193***	0.90	0.295***	0.319***	0.304***	0.251***
0.95	0.329***	0.293***	0.278***	0.210***	0.95	0.270***	0.222***	0.184***	0.159***
H_{OLS}	0.294***	0.281***	0.281***	0.282***	H_{ECM}	0.266***	0.282***	0.300***	0.311***
λ	0.046	0.041	0.041	0.031	λ	0.019	0.029	0.036	0.099

Notes: H_{OLS} and H_{ECM} are conventional hedge ratio estimated by OLS and error-correction regressions, respectively. λ is the discrepancy measure. All the hedge ratios are significant at 1% level except for one marked by ** denoting significance level at 5%.

discrepancy between the conventional hedge ratio and quantile hedge ratios is still there. An impressive improvement in the alignment between the quantile hedge ratios and the conventional MV hedge ratio is observed in the Panamax vessels. The relatively close values of quantile hedge ratios and MV hedge ratio for Panamax vessels, as indicated by the relatively small λ in Tables 4, suggest stable hedging performance in the Panamax sector. For a short summary, even if we take into account the error correction term, the conventional hedge could still create over- or under-hedge, especially for Capesize vessels.

TABLE 4

MV and quantile hedge ratios for the BPI FFAs using OLS and ECM methods.

OLS based on Eq.(3)					ECM based on Eq.(4)				
Quantiles	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$	Quantiles	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$
0.05	0.075***	0.109***	0.119***	0.227***	0.05	0.072***	0.105***	0.125***	0.176***
0.10	0.100***	0.118***	0.099***	0.187***	0.10	0.074***	0.099***	0.114***	0.154***
0.15	0.089***	0.095***	0.107***	0.169***	0.15	0.075***	0.107***	0.110***	0.143***
0.20	0.118***	0.109***	0.122***	0.137***	0.20	0.081***	0.102***	0.118***	0.151***
0.25	0.118***	0.126***	0.112***	0.136***	0.25	0.083***	0.095***	0.115***	0.143***
0.30	0.133***	0.139***	0.099***	0.128***	0.30	0.083***	0.099***	0.111***	0.137***
0.35	0.135***	0.131***	0.091***	0.108***	0.35	0.087***	0.105***	0.111***	0.143***
0.40	0.135***	0.133***	0.087***	0.122***	0.40	0.101***	0.111***	0.107***	0.149***
0.45	0.144***	0.136***	0.083***	0.141***	0.45	0.104***	0.117***	0.120***	0.147***
0.50	0.148***	0.132***	0.096***	0.165***	0.50	0.102***	0.119***	0.121***	0.144***
0.55	0.159***	0.143***	0.107***	0.166***	0.55	0.101***	0.118***	0.119***	0.145***
0.60	0.173***	0.165***	0.117***	0.155***	0.60	0.101***	0.119***	0.115***	0.144***
0.65	0.193***	0.185***	0.135***	0.189***	0.65	0.100***	0.122***	0.109***	0.148***
0.70	0.187***	0.204***	0.152***	0.206***	0.70	0.104***	0.119***	0.108***	0.154***
0.75	0.188***	0.200***	0.169***	0.242***	0.75	0.107***	0.123***	0.105***	0.145***
0.80	0.194***	0.193***	0.180***	0.234***	0.80	0.104***	0.127***	0.110***	0.135***
0.85	0.201***	0.199***	0.148***	0.233***	0.85	0.117***	0.136***	0.118***	0.152***
0.90	0.182***	0.178***	0.135**	0.239***	0.90	0.120***	0.135***	0.090***	0.137***
0.95	0.176***	0.196***	0.123***	0.203***	0.95	0.119***	0.139***	0.085***	0.138***
H_{OLS}	0.141***	0.157***	0.131***	0.194***	H_{ECM}	0.095***	0.123***	0.118***	0.164***
λ	0.033	0.033	0.025	0.039	λ	0.013	0.012	0.008	0.018

Notes: H_{OLS} and H_{ECM} are conventional hedge ratio estimated by OLS and error-correction regressions, respectively. λ is the discrepancy measure. All the hedge ratios are significant at 1% level except for one marked by ** denoting significance level at 5%.

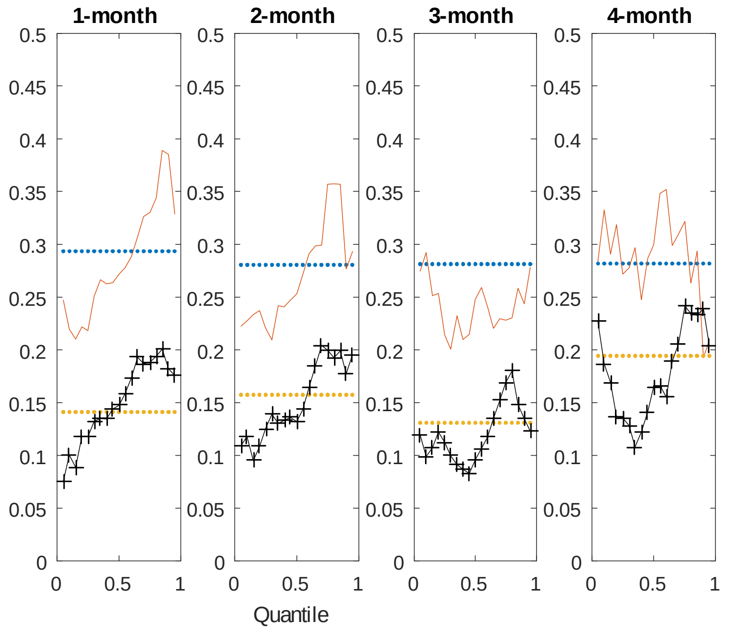

FIG. 2 MV hedge ratio (dotted line) and quantile hedge ratios for the four FFAs with different horizons based on OLS Eq.(3). The upper and lower dotted lines are the MV hedge ratios for BCI and BPI FFAs, respectively. The upper smooth lines and the lower smooth lines with markers are the quantile hedge ratios for BCI and BPI FFAs, respectively.

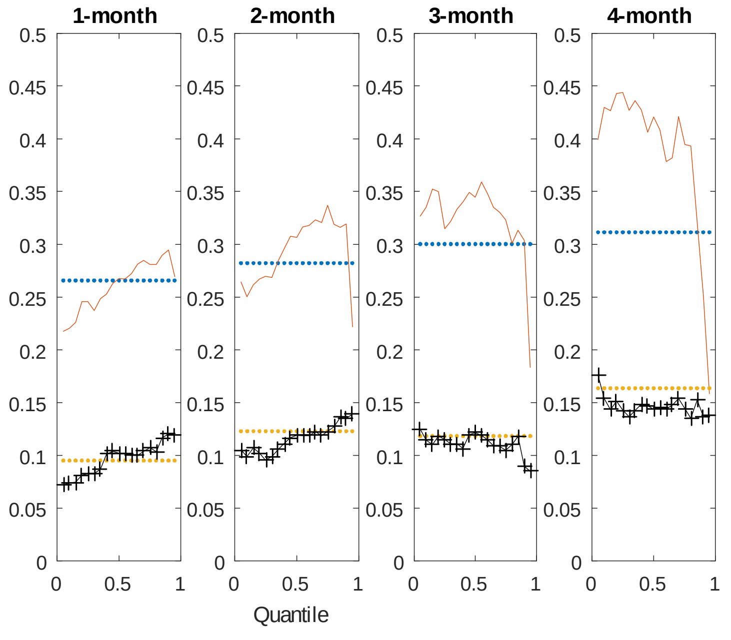

FIG. 3 MV hedge ratio (dotted line) and quantile hedge ratios for the four FFAs with different horizons based on ECM Eq.(4). The upper and lower dotted lines are the MV hedge ratios for BCI and BPI FFAs, respectively. The upper smooth lines and the lower smooth lines with markers are the quantile hedge ratios for BCI and BPI FFAs, respectively.

4.2. Error correction effect

The error correction term has an impact on the estimation inferences of the conventional and quantile regressions. Comparing Fig. 2 and 3, we can observe that regardless of the vessels type, for FFA of one-month horizon, the inclusion of the error term makes the quantile hedge ratios as well as the MV hedge ratio slightly smaller. Moreover, the quantile hedge ratios are closer to the conventional hedge ratio, evidenced by the smaller λ, suggesting that conventional MV hedge ratio has less possibilities to result in over- or under-hedge. In contrast, for FFA of four–month horizon, the inclusion of error-correction term overall increases the magnitudes of quantile hedge ratios, making the difference between the quantile hedge ratios and MV hedge ratio larger, rendering the inappropriate application of the conventional method in hedging.

To further evidence the effect of the error-correction term, we report the estimated coefficient for the error-correction term in Table 5. The negative coefficients for the error-correction term are highly significant for most of the regressions. The larger the magnitude of the coefficient, the more sensitive of the TC price to the price deviation from the FFA rate. Fig. 4 plots the estimates of the coefficient for the error-correction term. For all the four FFAs of Capesize vessels, the strength of error-correction is larger in the upper quantiles. Overall, the FFA of one-month horizon exhibits the largest strength of error-correction for both conventional and quantile regressions, indicating that the TC rate is more sensitive to the deviation from the long-run relationship with the FFA of one-month horizon. Similar result is found for Panamax. That is, the FFA of one-month horizon displays the largest strength of error-correction for both conventional and quantile regression. The result that TC is more sensitive to pricing error from FFA of short horizon means that FFA of short horizon tends to lead the TC price and contains more information for the trend of the TC price compared to FFA of longer horizons. For FFAs of long horizons, their pricing process is subject to more uncertainty and potential shocks due to their long maturity. Comparing between the two vessels, the Panamax vessels tend to show comparable level of error correction with relatively smaller magnitudes based on the quantile regressions, indicating mild sensitivities of the TC price to the pricing error in the Panamax sector.

TABLE 5

Estimates of the coefficient for error correction term for the four FFAs.

ECM based on Eq.(4) for BCI					ECM based on Eq.(4) for BPI				
Quantiles	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$	Quantiles	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$
0.05	-0.018*	-0.012*	-0.004	0.006**	0.05	-0.001	-0.001	-0.001	-0.001
0.10	-0.018***	-0.009***	-0.007**	0.005**	0.10	0.000	0.001	0.001	0.000
0.15	-0.018***	-0.009***	-0.007***	0.003	0.15	-0.003	0.000	0.000	-0.001
0.20	-0.019***	-0.010***	-0.009***	0.002*	0.20	-0.005**	-0.001	-0.002	-0.002
0.25	-0.019***	-0.009***	-0.008***	0.002*	0.25	-0.006***	-0.002*	-0.002*	-0.001
0.30	-0.022***	-0.008***	-0.007***	0.001	0.30	-0.007***	-0.003***	-0.002**	-0.002**
0.35	-0.021***	-0.007***	-0.005***	0.001	0.35	-0.007***	-0.003**	-0.002**	-0.002**
0.40	-0.020***	-0.008***	-0.005***	0.001	0.40	-0.007***	-0.003***	-0.003***	-0.003***
0.45	-0.020***	-0.007***	-0.005***	0.000	0.45	-0.008***	-0.004***	-0.003***	-0.004***
0.50	-0.020***	-0.006***	-0.005***	0.000	0.50	-0.008***	-0.004***	-0.003***	-0.005***
0.55	-0.020***	-0.007***	-0.005***	-0.002	0.55	-0.008***	-0.004***	-0.003***	-0.004***
0.60	-0.022***	-0.007***	-0.006***	-0.002	0.60	-0.009***	-0.005***	-0.004***	-0.004***
0.65	-0.023***	-0.009***	-0.007***	-0.002	0.65	-0.009***	-0.005***	-0.004***	-0.004***
0.70	-0.025***	-0.011***	-0.008***	-0.003**	0.70	-0.010***	-0.006***	-0.004***	-0.003***
0.75	-0.023***	-0.011***	-0.010***	-0.003**	0.75	-0.012***	-0.007***	-0.004***	-0.004***
0.80	-0.021***	-0.010***	-0.008***	-0.004**	0.80	-0.012***	-0.007***	-0.005***	-0.004***
0.85	-0.021***	-0.010***	-0.008***	-0.005**	0.85	-0.013***	-0.008***	-0.004**	-0.004***
0.90	-0.026***	-0.007	-0.008***	-0.008**	0.90	-0.013***	-0.008***	-0.005***	-0.005***
0.95	-0.029***	-0.014***	-0.009*	-0.013***	0.95	-0.013***	-0.007***	-0.007***	-0.007***
conventional γ	-0.021***	-0.009***	-0.007***	-0.002	conventional γ	-0.009***	-0.004***	-0.003***	-0.004***

Notes: all the hedge ratios are significant at 1% level except those marked by * and ** denoting significance level at 10% and 5%, respectively.

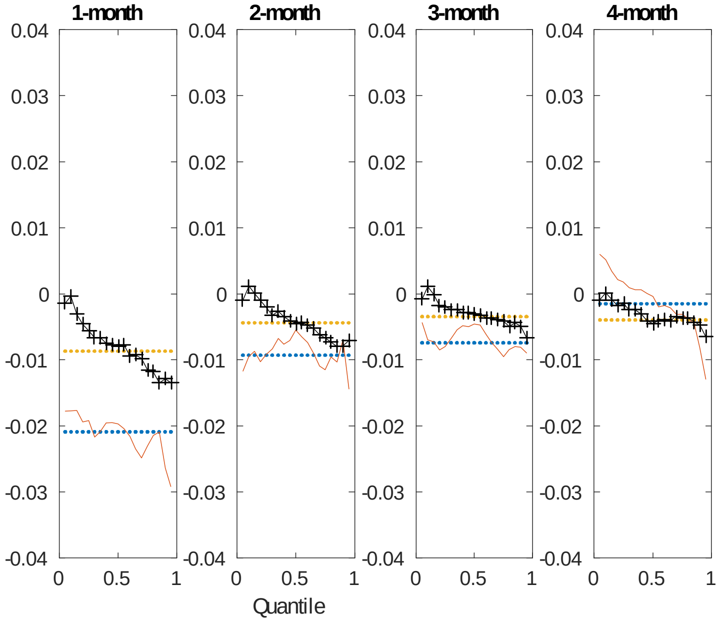

FIG. 4 Estimates of the coefficient for error correction term using conventional (dotted line) and quantile regressions for the four FFAs. The upper and lower dotted lines are for BCI and BPI FFAs, respectively. The lower smooth lines and the upper smooth lines with markers are for BCI and BPI FFAs, respectively.

4.3. Hedging effectiveness

Based on the conventional and quantile regressions, we evaluate the hedging effectiveness using the R^2. The result of hedging effectiveness for Capesize vessels is reported in Table 6. Using the OLS regression based on Eq.(3), the hedging effectiveness is very small. The largest one with value 0.127 is obtained for FFA of one-month horizon using the conventional approach. All the quantile regressions have hedging effectiveness less than 0.1. It is also observed that the hedging effectiveness decrease with the horizons of the FFA from one month to four months. The decrease in hedging effectiveness with the length of horizon might be because FFAs with longer horizons are subject to more uncertainty and noises given the longer maturity and, therefore, have a relatively weak explanatory capability for the TC market.

By including the error correction term, the hedging effectiveness improves dramatically to the level of around 0.4 for both the conventional and quantile regressions. FFA of one-month horizon still has the highest hedging effectiveness, followed by FFAs of longer horizons. A similar improvement upon the inclusion of the error correction term in the hedging effectiveness is also observed in Panamax vessels. From the results reported in Table 7, the hedging effectiveness can even reach above 0.6 for the quantile regression with the inclusion of error correction, much higher than the one of 0.4 for Capesize vessels. In addition, the hedging effectiveness is close to each other for FFAs across different horizons. Overall, the Panamax vessels are more suitable for hedging than the Capesize ones given the larger hedging effectiveness.

Note that the quantile regressions have lower hedging effectiveness compared to the conventional regressions. The low hedging effectiveness might be due to the different objective functions utilized as the conventional regressions estimate the parameters by maximizing the R^2 while the quantile regressions by minimizing the

TABLE 6
Hedging effectiveness for the BCI FFAs using OLS and ECM methods.

OLS based on Eq.(3)					ECM based on Eq.(4)				
Quantiles	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$	Quantiles	$\Delta f_t^{c,1}$	$\Delta f_t^{c,2}$	$\Delta f_t^{c,3}$	$\Delta f_t^{c,4}$
0.05	0.054	0.028	0.019	0.016	0.05	0.345	0.306	0.295	0.288
0.10	0.053	0.029	0.017	0.016	0.10	0.363	0.331	0.315	0.313
0.15	0.053	0.034	0.022	0.022	0.15	0.376	0.343	0.324	0.317
0.20	0.052	0.033	0.020	0.021	0.20	0.383	0.350	0.331	0.323
0.25	0.052	0.032	0.018	0.020	0.25	0.388	0.357	0.337	0.329
0.30	0.053	0.030	0.016	0.017	0.30	0.394	0.363	0.342	0.334
0.35	0.057	0.031	0.018	0.018	0.35	0.400	0.368	0.347	0.337
0.40	0.058	0.033	0.021	0.020	0.40	0.404	0.372	0.350	0.338
0.45	0.061	0.036	0.021	0.020	0.45	0.408	0.376	0.352	0.339
0.50	0.063	0.037	0.021	0.021	0.50	0.411	0.379	0.354	0.341
0.55	0.067	0.039	0.022	0.022	0.55	0.415	0.383	0.355	0.343
0.60	0.070	0.040	0.022	0.021	0.60	0.420	0.388	0.357	0.345
0.65	0.072	0.038	0.021	0.019	0.65	0.425	0.391	0.358	0.345
0.70	0.075	0.039	0.023	0.020	0.70	0.430	0.394	0.360	0.346
0.75	0.079	0.042	0.022	0.017	0.75	0.434	0.395	0.362	0.347
0.80	0.081	0.043	0.023	0.016	0.80	0.436	0.395	0.361	0.347
0.85	0.081	0.042	0.027	0.015	0.85	0.436	0.392	0.357	0.340
0.90	0.078	0.039	0.032	0.020	0.90	0.428	0.381	0.342	0.325
0.95	0.067	0.037	0.029	0.020	0.95	0.411	0.359	0.321	0.313
HE_{mv}	0.127	0.072	0.049	0.038	HE_{mv}	0.627	0.574	0.535	0.506

Notes: HE_{mv} is the hedging effectiveness using the conventional approaches.

absolute form loss function. In addition, factors such as the nature of the data (due to structural change) and the estimation issue (due to nonlinear effect of regressors) can contribute to the low hedging effectiveness. We will further explore the hedging effectiveness issue in our future research.

5. CONCLUSION

In this paper, we investigate the hedging performance of the forward freight agreements (FFAs) of different time horizons, focusing on the Capesize and Panamax vessels which are the most important carriers in the dry bulk sector. We compare the conventional hedge approach with the quantile regressions.

TABLE 7
Hedging effectiveness for the BPI FFAs using OLS and ECM methods.

OLS based on Eq.(3)					ECM based on Eq.(4)				
Quantiles	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$	Quantiles	$\Delta f_t^{p,1}$	$\Delta f_t^{p,2}$	$\Delta f_t^{p,3}$	$\Delta f_t^{p,4}$
0.05	0.020	0.018	0.016	0.027	0.05	0.588	0.572	0.561	0.565
0.10	0.027	0.021	0.014	0.017	0.10	0.610	0.603	0.587	0.592
0.15	0.027	0.019	0.015	0.016	0.15	0.621	0.615	0.602	0.604
0.20	0.025	0.015	0.011	0.012	0.20	0.630	0.624	0.609	0.611
0.25	0.026	0.015	0.008	0.011	0.25	0.640	0.633	0.617	0.618
0.30	0.025	0.014	0.006	0.008	0.30	0.646	0.639	0.623	0.624
0.35	0.026	0.015	0.008	0.009	0.35	0.652	0.645	0.627	0.629
0.40	0.026	0.014	0.007	0.008	0.40	0.656	0.648	0.628	0.631
0.45	0.027	0.014	0.007	0.009	0.45	0.659	0.651	0.630	0.633
0.50	0.029	0.017	0.008	0.012	0.50	0.662	0.654	0.630	0.636
0.55	0.033	0.019	0.010	0.014	0.55	0.664	0.657	0.632	0.638
0.60	0.037	0.022	0.010	0.015	0.60	0.665	0.658	0.632	0.638
0.65	0.041	0.027	0.011	0.019	0.65	0.666	0.659	0.631	0.638
0.70	0.043	0.029	0.014	0.021	0.70	0.665	0.659	0.629	0.635
0.75	0.044	0.029	0.016	0.024	0.75	0.663	0.657	0.626	0.631
0.80	0.046	0.031	0.016	0.025	0.80	0.660	0.654	0.621	0.626
0.85	0.048	0.034	0.019	0.028	0.85	0.658	0.651	0.613	0.620
0.90	0.039	0.029	0.013	0.019	0.90	0.655	0.646	0.604	0.611
0.95	0.027	0.025	0.014	0.015	0.95	0.652	0.638	0.596	0.604
HE_{mv}	0.058	0.043	0.026	0.034	HE_{mv}	0.852	0.846	0.821	0.823

Notes: HE_{mv} is the hedge effectiveness using the conventional approaches.

We estimate quantile hedge ratios for four FFAs with horizons of one-, two-, three- and four-month, respectively, using 19 quantiles from 0.05 to 0.95 with 0.05 increments. Using the daily data, we find that the quantile hedge ratio depends on the quantile of the TC return and is generally not equal to the conventional MV hedge ratio. With the inclusion of error correction term, the discrepancies between the quantile hedge ratios and the conventional hedge ratios are reduced, especially for the Panamax vessels. The relatively large discrepancy between the quantile hedge ratios and the conventional hedge ratios for the Capesize vessels implies the possibilities of over- or under-hedge using the FFAs. Therefore, quantile hedge ratio is preferred. In contrast, the relatively small discrepancy for the Panamax vessels suggests that the conventional hedge taking into account the error correction term is valid in practice for the Panamax sector in some instances.

Among the four horizons of FFAs, the physical TC return is more sensitive to the deviation of the TC rate from the long-run relationship with FFA of one-month horizon, suggesting that the FFA of one-month horizon is more informative than other FFAs of longer horizons. The result that FFA of short horizon is more informative is because the pricing process of FFA is subject to more uncertainty and potential shocks for FFA of longer horizons. Therefore, FFAs of short-horizon tend to get close to the TC market with fewer noises in the prices.

Regarding the hedging effectiveness, including the error correction term improves the hedging effectiveness impressively for both conventional and quantile regressions. Among the four FFAs of different horizons, the FFA of one-month has the largest hedging effectiveness. Comparing with the Capesize vessels, the Panamax vessels have better hedging effectiveness. We further split the sample into two subsamples and there is no prominent time-varying effect in the hedge ratios and hedging performance. These results are available upon request.

In terms of policy implications and suggestions to market practitioners, our result of minimizing the variance of the portfolio consisting of TC and FFA rates over different horizons supports the argument of Alexandridis et al. (2018) that proper portfolio could be utilized to reduce the freight risk. For the Capesize sector, we recommend to use the quantile hedge by taking into the quantile of the physical TC rates for risk management. The FFA market has a long-run relationship with the physical freight market and then manages to discover the moving trend of the TC rate, especially for the one-month horizon. Given that time-charter contracts usually refer to long horizons, often from 6 months to even 5 years, market participants should adjust their positions in the FFA market and put more weight on FFA of one-month horizon when their contracts approach the maturity, especially for the Panamax type vessels given its relatively better hedging effectiveness. However, we should be cautious for the hedging approaches as the practitioners would consider a lot of factors including the operational strategies, cargo type & vessel type, trade route, demand for and supply of bulk carriers, economic perspective, speculation and so on[2].

REFERENCES

Adland, Roar, and Amir H. Alizadeh. 2018. "Explaining price differences between physical and derivative freight contracts." *Transportation Research Part E: Logistics and Transportation Review* 118: 20 – 33.

Alexandridis, George, Satya Sahoo, Dong-Wook Song, and Ilias Visvikis. 2018. "Shipping risk management practice revisited: A new portfolio approach." *Transportation Research Part A: Policy and Practice* 110: 274 – 290.

Alizadeh, A., and N. Nomikos, eds. 2009. *Shipping Derivatives and Risk Management.* Palgrave Macmillan.

Alizadeh, Amir H., Chih-Yueh Huang, and Stefan van Dellen. 2015. "A regime switching approach for hedging tanker shipping freight rates." *Energy Economics* 49: 44 – 59.

Ederinton, Louis H. 1979. "The Hedging Performance of the New Futures Markets." *Journal of Finance* 34 (1): 157 – 170.

[2] We are grateful for one of the reviewers for pointing out the decision factors taken by practitioners.

Engle, Robert F., and C. W. J. Granger. 1987. "Cointegration And Error-Correction: Representation, Estimation And Testing." *Econometrica* 55 (2): 251 – 276.

Gong, Xiaoxing, and Jing Lu. 2016. "Volatility Spillovers in Capesize Forward Freight Agreement Markets." *Scientific Programming* 1 – 8.

Goulas, Lambros, and George Skiadopoulos. 2012. "Are freight futures markets efficient? Evidence from IMAREX." *International Journal of Forecasting* 28 (3): 644 – 659.

Johansen, Søren. 1991. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica* 59 (6): 1551–1580.

Johansen, Søren. 1995. *Likelihood-based Inference in Cointegrated Vector Autoregressive Models.* Oxford: Oxford University Press.

Kasimati, Evangelia, and Nikolaos Veraros. 2018. "Accuracy of forward freight agreements in forecasting future freight rates." *Applied Economics* 50 (7): 743 – 756.

Kavussanos, Manolis G., and Nikos K. Nomikos. 2000. "Futures hedging when the structure of the underlying asset changes: the case of the BIFFEX contract." *Journal of Futures Markets* 20 (8): 775 – 801.

Kavussanos, Manolis G, and Ilias D Visvikis. 2004. "Market interactions in returns and volatilities between spot and forward shipping freight markets." *Journal of Banking & Finance* 28 (8): 2015 – 2049.

Kavussanos, Manolis G, and Ilias D Visvikis. 2010. "The hedging performance of the Capesize forward freight market." *(In Eds.) Cullinane, K., The International Handbook of Maritime Economics and Business, Edward Elgar Publishing* .

Koenker, Roger, and Gilbert Bassett Jr. 1978. "Regression quantiles." *Econometrica* 33–50.

Koenker, Roger, and José A. F. Machado. 1999. "Goodness of Fit and Related Inference Processes for Quantile Regression." *Journal of the American Statistical Association* 94 (448): 1296–1310.

Li, Kevin X., Guanqiu Qi, Wenming Shi, Zhongzhi Yang, Hee-Seok Bang, Su-Han Woo, and Tsz Leung Yip. 2014. "Spillover effects and dynamic correlations between spot and forward tanker freight markets." *Maritime Policy & Management* 41 (7): 683 – 696.

Lien, Donald. 2005. "A note on the superiority of the OLS hedge ratio." *Journal of Futures Markets* 25 (11): 1121–1126.

Lien, Donald. 2008. "A further note on the optimality of the OLS hedge strategy." *Journal of Futures Markets* 28 (3): 308 – 311.

Lien, Donald. 2009. "A note on the hedging effectiveness of GARCH models." *International Review of Economics & Finance* 18 (1): 110 – 112.

Lien, Donald, Keshab Shrestha, and Jing Wu. 2016. "Quantile estimation of optimal hedge ratio." *Journal of Futures Markets* 36 (2): 194 – 214.

Shrestha, Keshab, Ravichandran Subramaniam, Yessy Peranginangin, and Sheena Sara Suresh Philip. 2018. "Quantile hedge ratio for energy markets." *Energy Economics* 71: 253 – 272.

United Nations Conference on Trade and Development. 2008. "Review of Maritime Transport." In *United Nations Publications*, Genava.

Yin, Jingbo, Meifeng Luo, and Lixian Fan. 2017. "Dynamics and interactions between spot and forward freights in the dry bulk shipping market." *Maritime Policy & Management* 44 (2): 271 – 288.

Zhang, Jiao, Qingcheng Zeng, and Xiaofeng Zhao. 2014. "Forecasting spot freight rates based on forward freight agreement and time charter contract." *Applied Economics* 46 (29): 3639 – 3648.