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ABSTRACT

We investigate the connection between the trading of Forward Freight Agreements (FFAs) and its microstructure effects in the volatility of the spot freight market in the Capesize dry-bulk sector of oceangoing vessels. Conditional volatility models are used to capture the volatility effects in the freight market. A connection with the trading of FFAs is established by using dummy variables, while additional factors that affect global economy and consequently the volatility in shipping markets, West Texas Intermediate, Brent oil and S&P500 Commodity Index, are incorporated into the model. The empirical results are divided into two processes. In the first process, we isolate the effect of the FFAs in the volatility of the spot rates in the physical market, indicating that FFAs led to a rise in the volatility in the physical market for the 4 Time Charter Average (4TC) and the routes C3 and C5, increase though limited. In the second process, we identify the effect of FFAs in the asymmetric response of negative shocks or information to the volatility in the physical market. A positive impact of the FFAs was identified in the 4TC, while in the three other voyage routes examined no impact was established. The results provide complementary insights to a specific shipping market segment not examined by current literature, while identifying and enhancing our understanding of the actual volatility impact of hedging instruments to the physical market.

1. Introduction

A Forward Freight Agreement is a financial forward contract that allows ship-owners, charterers and speculators to hedge against the volatility of freight rates. It gives the contract owner the right to buy or sell the price of freight for future dates (Baltic Exchange Ltd, 2016). Essentially, an FFA is a contract for differences on freight costs (Simpson Spence and Young, 2015). Forward Freight Agreements are over the counter products made on a principal-to-principal basis and as such they are not traded on any Exchange. Settlement of these contracts is affected against the relevant route assessment and specific asset class, i.e. Capesize, Panamax etc. it refers to.

As FFAs cover a time-frame for settlements from a month up to seven years with many intervals, we consider that this tool may be used for future information regarding supply and demand in the shipping sector, increasing the transparency of the markets as well. However, entry to FFA market is open to investors that do not have exposure in the shipping market itself as it is easier to simply trade on FFAs than to actually own a ship, employ operations staff and manage the crew, fuel, supplies and charter it. Thus, the market is open to speculative positions about the movement of the industry, which may lead to excess volatility, transmitting a destabilizing effect in the spot market. Therefore, in this context, it is critical to identify whether this effect is present and whether it transposes the market to a "safer" or riskier environment, despite its forward-looking characteristics.

Information and volatility transmission between derivatives and underlying markets is a research area that is addressed for at least 40 years. Goss and Yamey (1978) evaluate this interrelation stressing that since a position in the forward market is of low cost and there are no entering boundaries, speculators can engage in the shipping market causing adverse effects on volatility. Derivatives markets are criticized to cause a rise in the volatility of the underlying market, despite improving the speed as well as the quality of information flowing to the spot market (Antoniou and Holmes, 1995).

On the contrary, other studies come to the conclusion that the involvement of speculators has indeed a stabilizing effect in the spot market. The work of Moriarty and Tosini (1985), Edwards (1988), and more recently by, Corredor and Santamaria (2002) for the Spanish Ibex-35 index, Thenmozhi (2002) for the NSE-50 Index in India, Dawson and Staikouras (2009) for the S&P500 index show that the inception of derivatives reduced the volatility of spot returns and led to a higher flow of information. This assertion is corroborated in the Hang Seng index as well. Fong and Han (2015) examine the impacts of derivatives markets on spot market volatility deducing that futures markets provide new and material information which leads to a reduction in spot market volatility. The same work concludes that on the other hand, the options market generates noisy information and distorts price, which is followed by an increase in volatility and a decrease in its sensitivity to price change. Shiqing and Jiajun (2014) observe mixed effects, in the sense that derivatives do not reduce the volatility but decrease sensitivity to new information, focusing on the China Securities Index (CSI) 300 index futures.

Steering our interest now in examining the shipping market, introduction of FFAs took place back in 1992, when trading of FFAs was still mostly an over-the-counter (OTC) product for more information on the FFA market (Kavussanos and Visvikis, 2006; Alizadeh and Nomikos, 2009). In the case of forward and spot market interrelations, Bachelor et al. (2004) investigate the impact of the introduction of FFAs trading on spot market price volatility in Panamax freight routes. The authors indicate that the onset of FFAs has a stabilizing effect on spot price volatility in all examined routes, as well as an impact on the asymmetry of volatility in most routes. Furthermore, forwards' trading improved the quality and speed of information flowing towards the spot market for the Panamax routes. After including other explanatory variables for volatility, Bachelor et al. (2004) show that the FFAs have a direct diminishing effect on spot price volatility only in some routes. In conclusion, the implementation of FFA trading led to an improvement to the flow of information into the spot price, however the overall effect was not detrimental. Chen and Wang (2004) apply the E-GARCH model to investigate the effect of asymmetric volatility using data for four time charter routes from April 1999 to July 2003. The results show existence of asymmetric effects, as positive shocks generated less volatility than negative shocks of the same magnitude. Taking into account more complex interrelations between shipping markets, Alexandridis et al. (2017) investigate interactions between time-charter rates, freight futures and freight options prices. The results point out that the freight futures market as far as information is concerned, leads the freight rate market, while freight options lag behind both futures and physical freight rates.

What is very interesting and justifies the expansion of the model presented in the following chapters with sources of additional volatility generators, is that information appears first in the returns and volatilities of the commodities futures markets, before it is spilled over into the freight derivatives market (Kavussanos et al., 2014). Additional drivers to include other volatility generators are justified by previous research as well, as Chou (2011) identifies the existence of a stage one lag effect between Capesize FFAs and the global oil index, by using VARMA (1,3) model.

Kassimati and Veraros (2017) find that FFAs display limited usefulness in predicting future freights, only slightly superior than simple naïve models. The shorter the contract period and the smaller the vessel the better the forecast. Furthermore, their work on FFAs show that these derivatives are a relatively good predictor of future market direction, but they are missing the turning points of the market cycles.

Debate on the matter of whether FFAs can truthfully be used to predict future freight rates, is not only an academic research area, but it does constitute a market concern too. Ship-owners feel that the "paper" market usually pushes the market downwards as it can cap freight rates only to the level charterers can hedge their exposure for the duration of the charter. Therefore, this study extends the empirical literature on the relationship between shipping derivatives trading and spot market price volatility in the Capesize sector, in continuance to the Panamax asset class analysis.

Rallies and slumps tend to be a very common phenomenon in the shipping market. As a global industry, shipping markets are affected by the global economy, where balances are extremely fragile. Even as we speak and during 2019, the freight rates are battered due to incidents that cannot be predicted by no FFA contract and the most insightful ship owner, ship broker or charterer. A burst dam in Brazil which is affecting directly the transport of iron ore via Capesizes, or a trade war between the two largest economies, the U.S.A. and China, which can have multiple impacts some not known even now, can destabilize a promising and recovering Capesize market from around $15,000 to $16,000 at the start of 2019 to a gloomy $4,000 during mid-March.

Furthermore, no market participant can predict mid-year spikes that can be caused by a bottleneck in a busy port, a cyclone in a loading area, or decisions to scrap vessels and tendencies to over ordering.

Therefore, in a market that recently experienced the worst crisis in its history, where Capesize 4TC earnings dropped to just USD 485 on 17/03/2016 well below operational (OPEX) and capital (CAPEX) expenses, this study can provide regulators, practitioners and market participants with important insights on the FFA trading – spot market volatility relationship.

FFA assessments are extrapolated through the contribution of Forward Freight Agreements Brokers Association (FFABA) participants, who daily submit their assessments of where the market stands at their honest opinion and abiding by the FFABA code of ethics and business conduct.

Therefore, the matter of the objectivity and accuracy of the current FFA assessments extrapolation can be tested and what can be the actual impact on the physical market of Capesize vessels.

Capesize vessels are mostly chartered for the transportation of iron ore and coal as their size is specifically designed to offer serious economies of scale. This means that cargo and port limitations can render this specific asset class riskier than smaller vessels, namely Panamaxes, Supramaxes and Handysizes. These three vessel types can be more flexible in the terminals they can serve as draft, beam and length restrictions can be mediated and can carry self-unloading equipment (for the case of Supramaxes and Handysizes, while limited geared Panamaxes are in service as well). Furthermore, additionally to smaller parcels of iron ore and coal, there is a wide range of cargoes they can carry, from different types of grains to fertilizers, phosphates, steel products etc. These limitations to the Capesizes, can create a more adverse economic environment that makes interesting to investigate what is contribution of FFAs as a stabilizing hedging instrument.

The above size related risk is addressed by economic literature, where Kavussanos (1996a) analyze the volatility of the dry cargo sector for spot and time charter contracts, and concludes that risk is higher in the time charter market and that the market of larger vessels is more volatile than that of smaller ones. Another study showed that even the price of larger vessels has higher volatility than the price of smaller ones (Kavussanos, 1997).

Lastly, our case to investigate the Capesize market and not smaller vessel types, is justified be the work of Fan et al. (2012) who study the volatility spillover effect among Capesize, Panamax and Handysize vessels using the multivariate GARCH. They conclude that Capesizes have volatility spillover effects on Panamaxes and Handysizes, while the reverse is not existent, which intensifies our need to investigate the Capesize market. Previous research between the same asset classes, Capesizes and Panamaxes, yielded mixed results for the cointegration and causality tests applied for two sub-periods, from 3 January 1999 to 24 December 2002 and from 2 January 2003 to 29 August 2008 using the ECM-GARCH model (Chen et al., 2010).

Our main scope with this paper is to model volatility and try to identify additional volatility generators. Therefore, our methodology, which is described in detail in the next chapter, will need to employ GARCH type models, either symmetric or asymmetric. According to Ching Mun Lim & Siok Kun Sek (2013), during normal periods (i.e. pre- and post-crisis) the symmetric GARCH model performs better than the asymmetric. However, for fluctuation periods asymmetric GARCH models are preferred. As stated above, and due to the highly volatile market in shipping, it seems that assymetric models are a better fit.

To our knowledge, the most commonly used asymmetric-GARCH models are the E-GARCH and the GJR-GARCH. The main advantage that both models share is that they incorporate asymmetrics related to the impact of negative return volatilities.

In our study presented below, we deem that the appropriate process to model spot volatility is the conditional variance GJR-GARCH process from Glosten et al. (1993). This will enable us to link conditional volatility to market dynamics and information and accounts for asymmetric volatility response. Furthermore, one additional advantage is that this enables us to have comparative results with previous papers for the Panamax asset class [see Bachelor et al. (2004)]

Elaborating on the above, in finance, risk management is all about negative returns as they represent future losses. Positive returns are to be suppressed as they bring profits and not part of risk. To capture the importance of negative returns GJR-GARCH model introduces leverage parameters.

The paper is structured as follows: After a brief review of the methodology in section two, section three provides some preliminary statistics of the main data used. Section four presents the empirical results derived from the quantitative analysis, while in the fifth and final section we conclude with the findings.

2. Methodology

By The methodology followed is based on the GJR-GARCH process (Glosten et al., 1993) as mentioned above. The model includes leverage terms for modeling asymmetric volatility clustering. In the GJR formulation, large negative changes are more likely to be clustered than positive changes.

The GJR-GARCH (p, q) model has p GARCH coefficients associated with lagged variances, q ARCH coefficients associated with lagged squared innovations, and q leverage coefficients associated with the square of negative lagged innovations. The process produces two equations, the mean equation and the variance equation. The first one can be defined by the following mathematical equation:

$$y_t = \mu + \varepsilon_t \quad (1)$$

where $\varepsilon t = \sigma t z t$ and the variance equation with the bellow form:

$$\sigma_t^2 = \kappa + \sum_{i=1}^{p} \gamma_i \sigma_{t-i}^2 + \sum_{j=1}^{q} a_j \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \xi_j I[\varepsilon_{t-j} < 0]\varepsilon_{t-j}^2 \quad (2)$$

The indicator $I[\varepsilon_{t-j} < 0]$ equals 1 if $\varepsilon_{t-j} < 0$ and 0 otherwise, thus the leverage coefficients are applied to negative innovations, giving negative changes additional weight (Glosten et al., 1993). This is the coefficient we check to make the relevant conclusions about the asymmetric response of volatility of the spot freight rates for the specific routes analyzed. To achieve this goal, we will divide our sample in two subsamples, one before and one after FFA introduction and compare the results. For stationarity and positivity, the GJR model has the following constraints:

- $\kappa > 0$
- $\gamma i \geq 0, \ \alpha j \geq 0$
- $\alpha j + \xi j \geq 0$
- $\sum_{i=1}^{p} \gamma_i + \sum_{j=1}^{q} a_j + \frac{1}{2} \sum_{j=1}^{q} \xi_j < 1$

The GARCH model is nested in the GJR model. If all leverage coefficients are zero, then the GJR model reduces to the GARCH model.

Furthermore, so as to measure the effect of the onset of FFA trading we are going to augment the variance equation incorporating a dummy variable D1 (for C7 route and 4TC index and D2 for C3 and C5 route) which takes the value zero before the introduction of FFAs and value 1 for the post-FFA period. Accordingly, and by simplifying the equation (2), we incorporate the dummy as bellow:

$$\sigma_t^2 = \kappa + \gamma_1 \sigma_{t-i}^2 + a\varepsilon_{t-j}^2 + \xi I[\varepsilon_{t-j} < 0]\varepsilon_{t-j}^2 + \beta D \quad (3)$$

A significant and positive β coefficient means that the introduction and trading of forwards in the shipping industry led to an increase in the volatility of the spot market. On the contrary, a significant negative β coefficient means that FFA trading reduced spot price volatility.

However, as shipping is a market in which various factors of global economy have a critical impact, a model with external variable only the dummy introduced for the start of FFA trading seem to be rather simplified. Volatility in the shipping market can be a result of the demand for shipping services to transport goods as well as other global variables affecting every aspect of human activity. These factors need to be incorporated into the model, so as not to address excess volatility produced by these external factors to FFA trading.

Therefore, additional variables of conditional volatility are incorporated into the model for some very critical economic indicators. At the demand side for shipping services we use the S&P500 Commodity Index, which is an index currently comprised by 24 commodities from all commodity sectors – energy products, industrial metals, agricultural products, livestock products and precious metals (S&P Dow Jones Indices, 2016). To insert volatility caused by the fluctuations of oil we are going to use the Western Texas Intermediate (WTI) crude oil benchmark and the London Brent crude oil index. With these additions we will manage to some extent isolate the effect on volatility caused by Forward Freight Agreements trading. The produced equations for each of the three additions will be the bellow:

$$\sigma_t^2 = \kappa + \gamma_1 \sigma_{t-i}^2 + a\varepsilon_{t-j}^2 + \xi I[\varepsilon_{t-j} < 0]\varepsilon_{t-j}^2 + \beta D + \delta 1\mathrm{WTI} \quad (4)$$

$$\sigma_t^2 = \kappa + \gamma_1 \sigma_{t-i}^2 + a\varepsilon_{t-j}^2 + \xi I[\varepsilon_{t-j} < 0]\varepsilon_{t-j}^2 + \beta D + \delta 2\mathrm{BRENT} \quad (5)$$

$$\sigma_t^2 = \kappa + \gamma_1 \sigma_{t-i}^2 + a\varepsilon_{t-j}^2 + \xi I[\varepsilon_{t-j} < 0]\varepsilon_{t-j}^2 + \beta D + \delta 3\mathrm{S\&P500CI} \quad (6)$$

Finally, Bollerslev & Wooldridge (1992) argue that excess kurtosis in the estimated standardized residuals, even after accounting for second moment dependencies, can invalidate traditional inference procedures. For that reason, the GJR-GARCH estimation is done with Quasi Maximum-Likelihood Estimation (QMLE), which estimates robust standard errors. For symmetric departures from conditional normality, the QMLE is generally close to the exact Maximum-Likelihood Estimation (MLE). The Berndt-Hall-Hall-Hausman (BHHH) optimization algorithm is employed to obtain maximum-likelihood estimates of each of the coefficients in the mean and variance equations (Bachelor et al., 2004).

3. Data Presentation

The data used for the analysis cover the period 1/12/1998 to 29/4/2016. In order to have a smoother sample and abiding by common practice used in econometrics, we are transposing the spot rates to physical logarithm returns. This will allow us to keep in the sample periods during the boom in the shipping market where freight rates had an enormous fluctuation leading to the following crisis. Additionally, we are going to calculate the same statistics for these routes for two subsamples, one before the introduction of the FFAs and one after. For the 4TC and the route C7 the pre-FFA sample will be from 1/12/1998 to 6/5/2004 while the post-FFA sample will range from the introduction of the FFAs in 7/5/2004 until 29/4/2016. Regarding the routes C3 and C5 for which FFAs started trading on 1/9/2005, the pre-FFA sample will be from 1/12/1998 to 31/8/2005 and the post-FFA from 1/9/2005 until 29/4/2016. The additional data used to represent other market factors, S&P500 Commodity Index, the Western Texas Intermediate (WTI) and the Brent spot rates, will have the same duration and characteristics.

The necessary tests for the implementation of the GJR-GARCH model are the examination of the Jarque and Bera (1980) statistic, to determine departure from normality and existence of stationarity via the Augmented Dickey-Fuller test (Dickey & Fuller, 1981) (ADF). ADF tests the null hypothesis of whether a unit root is present in a time series sample against the alternative hypothesis of stationarity.

Table 1
Main statistics of 4TC, C7, C3, C5 for the whole sample, pre and post FFA trading respectively

	Std. Dev.	Skewness	Kurtosis	JB	Prob.
4TC	0.047437	0.922096	14.22607	22870.62	0
	0.016869	2.177962	23.8931	25052.27	0
	0.056017	0.814581	10.56632	7290.747	0
C7	0.023795	0.15637	11.8759	13938.65	0
	0.012524	1.693473	20.95384	18359.65	0
	0.027399	0.112891	9.392312	4979.408	0
C3	0.022607	0.142303	12.02994	14423.09	0
	0.028277	0.233265	11.84094	13850.38	0
	0.014561	0.418765	10.59793	3997.586	0
C5	0.034216	0.219833	8.803526	3668.296	0
	0.012364	1.031025	14.7307	9705.668	0
	0.027144	0.119315	9.045995	3964.666	0

Source: Baltic Exchange Ltd, Clarksons

Results summarized in table 1 indicate that at a significance level of 1% we can accept the data used in order to continue with our GJR-GARCH analysis for C3, C5, C7 and the 4TC, therefore no additional transposition except the initial modification to physical logarithm returns is needed.

Taking a closer look to each set of data we can highlight here bellow the statistics that encourage us to proceed with our main goal of examining volatility. First, in the 4TC index, the pre-FFA period shows lower standard deviation compared to the post-FFA, as well as the whole period examined (0.016869 compared to 0.056017 and 0.047437 respectively). As long as higher moments are concerned, the pre-FFA period has a higher positive skewness 2.177962 compared to 0.814581 of the post-FFA and 0.922096 of the whole sample (longer right tail) and higher kurtosis (higher peak) 23.89310 (10.56632 and 14.22607 respectively).

In the case of the C7 route Bolivar to Rotterdam, the whole period from 1/12/1998 to 29/4/2016, we can see a standard deviation of 0.023795, a positive skewness close to zero (0.15637) which corresponds to no significant effect in the tails of the distribution and a kurtosis over 3 (11.8759) and as a result a leptokurtic distribution. In the pre-FFA sample the standard deviation is lower (0.012524 compared to 0.23795), there is a positive skewness over 1 (1.693473 compared to 0.15637) and a higher kurtosis (20.95384 compared to 11.8759). In the post-FFA period the standard deviation is higher from the two samples mentioned above (0.27399) the skewness is lower (0.112891) as well as the kurtosis (9.392312).

For the C3 voyage route the undivided sample has a standard deviation of 0.022607 compared to 0.012364 in the pre-FFA period and 0.027144 in the post-FFA, which again shows a lower divergence from the mean before trading of forwards was adopted. Additionally, skewness for the whole sample is 0.142303 (1.031025 and 0.119315 for pre- and post-FFA) and kurtosis of 12.02994 (14.73070 and 9.045995 respectively).

Last but not least, for the C5 the whole sample has a standard deviation of 0.028277 (0.014561 and 0.034216 for pre- and post-FFA samples), a skewness of 0.233265 (0.418765 and 0.219833 accordingly) and kurtosis of 11.84094 (10.59793 and 8.803526 for the subsamples.

Concluding the above results, the prerequisites to form the model are existent and we can naively detect a higher volatility during the post-FFA period, which gives us grounds for further investigation.

4. Empirical Results

As stated in the previous chapters, we use the GJR-GARCH process (Glosten et al., 1993). This model allows for asymmetric impact of news (positive or negative) on volatility (Kavussanos and Visvikis, 2004). Additionally, as stated by Kavussanos et al. (2004) the GJR-GARCH model is the best among other GARCH models. Among those models, the symmetric GARCH (Bollerslev T., 1986; Autoregressive Conditional Heteroskedasticity), and the asymmetric EGARCH (Nelson, 1991) have inferior results comparing to the GJR-GARCH process. As long as the GJR-GARCH (p, q) process is concerned, V-Lab uses p=1 and q=1, because this is usually the option that best fits financial time series (The Volatility Laboratory of the NYU Stern Volatility Institute, 2016).

It is highly important to set the significance level for which we are going to assess the models produced. Therefore, and as a common practice, this significance level is set at 5%. Furthermore, in order to recognize whether we produce a model that has the appropriate specification, for every GJR-GARCH process we run, we conduct an ARCH-LM test (Engle, 1982) to check for existence of heteroscedasticity.

This chapter is organized in two subsections: in the first we run the model for the 4TC, C7, C3, C5 for the whole period, using the dummies D1, D2 and for each of the variance regressors (WTI, Brent, S&P500 Commodity Index) and comment the results. The additional variables are derived from Federal Reserve Bank of St. Louis, (2016) and Bloomberg Professional Services (n.d.). In the second subsection, we run the model the for the pre- and post-FFA periods comparing the results for a possible asymmetric effect of FFAs. All the results produced and presented in the following subsections are summarized in the tables 2 through 9.

4.1. *Impact of the onset of FFA trading in the actual conditional volatility*

4.1.1 4TC index results

Firstly, we calculate the results for the dummy D1, as this applies to the 4TC, and for WTI as a variance regressor. Before presenting the findings of the regression we need to mention that a satisfactory model has coefficients for the variance equation that are not significantly different than zero. This implies that the variance of the dependent variable's (in the first case 4TC spot rates) residuals is rather stable and therefore no heteroscedasticity is present. This will have effect for the entirety of the regressions conducted bellow and this issue will be addressed by making all necessary tests.

The F-statistic and the probability produced means that we cannot reject the null hypothesis and thus our GJR-GARCH model has captured the ARCH effects (the same results are extracted when calculating for 1 up to 14 lags).

Table 2 summarizes the results of the GJR-GARCH process. We can see that for the variance equation most of the coefficients are statistically important at a 5% level, except from the coefficient C(5) that depicts the asymmetry of negative news. Furthermore, the WTI coefficient is statistically important which means that the volatility has an impact on the volatility of Capesize 4TC spot rates. For the FFAs, our dummy with a probability of 0.0005 is significant at the predefined level, which means that the implementation of FFAs had an influence at spot freight volatility. As the C(7) coefficient is positive (0.000116), FFA trading led to a rise in the spot freight volatility although the effect was small.

If we replace WTI with Brent in the variance estimation, we produce a model that although has captured the ARCH effects, it has made an additional coefficient not significant. That is for the variable inserted, Brent. However, in this case too, our dummy D1 is still significant with a small positive effect on volatility (2.21E-05 prob. 00031).

The last test for the 4TC will be using the volatility of S&P500 Commodity Index and our D1 dummy so as to model the volatility in spot rates. The results bellow show that the D1 is not significant and therefore FFA had no effect on spot freight volatility. However, as the ARCH test conducted and presented on the appendix has a probability of the F-statistic of 0.0000, the whole model has not implemented all the ARCH effects and therefore heteroscedasticity is persistent and the whole model void.

Table 2
4TC Index results

4TC	WTI		BRENT		S&P500	
	Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
C	5.03E-05	0.0000	2.40E-06	0.0124	0.000527	0.3147
RESID(-1)^2	0.930659	0.0000	0.423182	0.0000	0.921440	0.3091
RESID(-1)^2*RESID(-1)<0	-0.319026	0.0922	-0.041468	0.7780	-0.399441	0.2087
GARCH(-1)	0.424691	0.0000	0.732253	0.0000	0.183417	0.8276
D1	0.000116	0.0005	2.24E-05	0.0031	4.37E-05	0.8765
WTI/BRENT/S&P	0.001041	0.0000	1.02E-05	0.8669	-0.11821	0.0000
ARCH test (F-stat)	0.228688	0.9987	0.388697	0.0000	5.226856	0.0000

Source: Baltic Exchange Ltd, Clarksons

4.1.2 C7 route results

Same as for the 4TC we conduct the same tests for the C7 route (Bolivar to Rotterdam) and taking into considerations our three variance variables (WTI, Brent, S&P500) (results in Table 3).

While using WTI for the variance equation, we can see a significant D1 coefficient (probability 0.0031) and positive (3.59E-05), however ARCH test shows the existence of heteroscedasticity with F-statistic probability of 0.0042, way bellow from our set limit of 5%. Therefore, a not sufficient model cannot provide reliable results, so we continue to the second test using Brent.

For the Brent model ARCH test shows that the null hypothesis of no heteroscedasticity is rejected against the alternative of at least one of past residuals affecting today's volatility. Consequently, the model, which shows a significant coefficient for the D1 dummy of the onset of FFA trading with a small positive effect on volatility, does not have the appropriate specification.

Finally, Using the S&P500 Commodity Index and even though the significance of most of the coefficients of the variance equation, including that of D1 below the threshold of 5% (with almost the same results as above, small but positive value), ARCH effect is still present.

Resulting from the above for the C7 Capesize route we could not have a clear image whether FFA trading helped to lower or increase volatility of the spot market. However, in all cases we had statistically significant coefficients for the introduced dummy, which showed a small increase in volatility however economically not significant.

Table 3
C7 route results

C7	WTI		BRENT		S&P500	
	Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
C	6.38E-06	0.0001	6.39E-06	0.0000	7.05E-06	0.0000
RESID(-1)^2	0.249432	0.0000	0.244814	0.0000	0.264924	0.0000
RESID(-1)^2* RESID(-1)<0	0.003178	0.9620	0.000615	0.9923	-0.017410	0.7832
GARCH(-1)	0.696485	0.0000	0.700258	0.0000	0.684807	0.0000
D1	3.59E-05	0.0031	3.57E-05	0.0034	3.78E-05	0.0021
WTI/BRENT/S&P	0.000109	0.1414	0.000213	0.0000	-0.000339	0.0033
ARCH test (F-stat)	2.281658	0.0042	2.373452	0.0027	1.956445	0.0174

Source: Baltic Exchange Ltd, Clarksons

4.1.3 C3 route results

We continue the presentation of the results with the C3 Tubarao to Qingdao route (Table 4). Firstly, we use Western Texas Intermediate as an independent variable for the variance equation

Table 4
C3 route results

C3	WTI		BRENT		S&P500	
	Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
C	5.72E-06	0.0000	5.90E-06	0.0000	5.48E-06	0.0002
RESID(-1)^2	0.685627	0.0000	0.687352	0.0000	0.658096	0.0000
RESID(-1)^2* RESID(-1)<0	-0.192731	0.2729	-0.198054	0.2637	-0.212839	0.2207
GARCH(-1)	0.586178	0.0000	0.583538	0.0000	0.608334	0.0000
D2	1.63E-05	0.0003	1.66E-05	0.0003	1.49E-05	0.0005
WTI/BRENT/S&P	0.000125	0.0504	0.000123	0.0002	-0.000222	0.3416
ARCH test (F-stat)	0.538246	0.9119	0.524771	0.9203	0.599693	0.8675

Source: Baltic Exchange Ltd, Clarksons

The ARCH test for the residuals of the GJR-GARCH process shows that the variance equation is valid. Therefore, we can assess the D2 dummy variable (D2 is used because of the different date that FFAs were introduced in the market). The coefficient of the D2 is strongly significant, which means that there is an effect from FFA trading (positive effect), however the economic significance is rather small because of the value of the coefficient (1.63E-05).

As the probability of the F-statistic of the ARCH test for the Brent produced model has a value of 0.9203, heteroscedasticity is not present for the residuals of the variance equation. While using Brent instead of WTI the results for our dummy are almost the same with the previous test, with a significant coefficient (prob. 0.0003) and a small positive value (1.66E-05). The last test to prove a statistical relation between FFAs and C3 spot prices, incorporates the S&P500 Commodity Index volatility. The results are almost identical (ARCH test is supporting our model).

Concluding for the C3 route we proved that FFAs trading contributed to a rise in the volatility of spot freight rates. This effect was limited and ranged from 0.010039 to 0.01098.

4.1.4 C5 route results

Finally, we are computing the same results for the C5 route (West Australia to Qingdao) for the three independent variables (WTI, Brent, S&P500) and for the dummy variable D2, as FFAs for the underlying C3 and C5 routes where introduced at the same time (table 5).

Table 5
C5 route results

C5	WTI		BRENT		S&P500	
	Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
C	0.000123	0.9526	7.13E-06	0.0023	6.46E-06	0.0043
RESID(-1)^2	0.657360	0.9271	0.418054	0.0000	0.401166	0.0000
RESID(-1)^2* RESID(-1)<0	-0.172007	0.9271	-0.118251	0.3096	-0.120933	0.2539
GARCH(-1)	0.352156	0.9698	0.690927	0.0000	0.706044	0.0000
D2	5.66E-05	0.9648	3.03E-05	0.0001	2.88E-05	0.0001
WTI/BRENT/S&P	0.001536	0.4581	0.000199	0.1667	-0.000396	0.4404
ARCH test (F-stat)	4.655786	0.0000	0.624963	0.8465	0.783068	0.6888

Source: Baltic Exchange Ltd, Clarksons

Firstly, using WTI as an additional variable for volatility we produce the below depicted results. However, remaining ARCH effect means that the model is inefficient and conclusions for the volatility of the spot market are not possible.

For the Brent the same procedure creates an important model in terms of ARCH effect. Therefore, analyzing the D2 is meaningful as we lead to the conclusion that FFA trading led to an increase in spot freight volatility with a small effect however.

Last but not least, as with the above cases we run the last test with S&P500 Commodity Index. ARCH test for the presence of heteroscedasticity in the residuals, show that the results are robust. Coefficient of D2 is positive and significant in the 5% level, therefore FFA trading had a negative effect on spot freight volatility causing an increase to uncertainty.

4.2. *Tests for the asymmetry effect of FFA trading*

In this subsection we calculate the effect (if any) of FFA trading in the asymmetry effect of positive and negative information. By dividing the data into to subsamples, one before the introduction of Forward Freight Agreements and one after, we can compare the results produced from the GJR-GARCH process regarding the coefficient of RESID(-1)^2*(RESID(-1)<0) variable of the variance equation. In this case the dummies D1 and D2 are no longer needed and consequently not included.

4.2.1 Tests for the asymmetry effect in 4TC

Table 6 displays the results for the two subsamples of the 4TC spot rates, as well as the ARCH tests. For the variance equation we are including all the independent variables, however as the use of WTI and Brent in the same equation causes both coefficients of the estimators to be non-significant we choose to remove Brent and use only WTI and S&P500. This will be the case for the routes C7, C3 and C5 as well.

Table 6
4TC asymmetric response on volatility tests

4TC	Pre-FFA		Post-FFA	
	Coefficient	Probability	Coefficient	Probability
C	9.98E-05	0.0000	8.78E-05	0.0000
RESID(-1)^2	0.831585	0.0000	0.474999	0.0000
RESID(-1)^2* RESID(-1)<0	-0.756491	0.0006	0.157851	0.4811
GARCH(-1)	0.226782	0.0000	0.182409	0.0323
WTI	0.001239	0.0000	0.000653	0.1648
S&P500	-0.000721	0.5442	-0.001001	0.4033
ARCH test (F-stat)	0.129219	1.0000	0.624122	0.8465

Source: Baltic Exchange Ltd, Clarksons

For the pre-FFA period from 2/12/1998 to 6/4/2004 ARCH test shows no problem, however in the post-FFA period we encounter a problem with the ARCH test which shows that significant volatility of residuals is not incorporated. Therefore, we modify the second subsample in order to end before the burst of the shipping crisis at the end of 2007 which produces a significant model according to ARCH test.

The pre-FFA sample has a significant coefficient for the asymmetry dummy with probability of 0.0006. Furthermore, the value of the estimation of -0.756491 can be interpreted as follows: a negative shock (negative information) has a diminishing impact on the variance of the 4TC spot rates as it tends to reduce the variance by -0.756491 (note that the dummy for negative shocks has the value 1, consequently the value of the estimator of the coefficient is the exact impact on the variance model). This may mean that the spot market may have overreacted in anticipation of negative information and when this information is known a correction to the market is affected by the negative coefficient of the asymmetry dummy. In general, the negative sign would not be what we expected for the coefficient, as what we stated in theory was that it is common that negative news to have a greater effect than positive news of the same scale. However, in the post-FFA period the limited sample until the end of the year 2007 generates a non-significant estimator for the coefficient of the asymmetry dummy. This sift means that after FFA trading began, negative news (or negative past residuals more specifically) had no effect on the variance of 4TC spot rates. Therefore, the forward market may have operated positively in a better assimilation of current and future information in the physical market, leading to more transparency.

4.2.2 Tests for the asymmetry effect in C7

With the above assumptions in place we conduct the same two GJR-GARCH processes for the subsamples of C7 route (Table 7). For the first sample until 6/5/2004 the produced model has not incorporated ARCH effects for heteroscedasticity, which means that conclusions cannot be made for the C7 route as a comparison is not possible. However, for the second sample the generated model until 29/4/2016 is significant.

As in the case of the 4TC we can see the non-significance of the estimator for the coefficient of the asymmetry dummy, which indicates that negative shocks have no excess effect on the variance of the dependent. This may have resulted, as with above findings, from the use of FFAs for hedging and the better understanding that these instruments may offer to its users for future market conditions.

Table 7
C7 asymmetric response on volatility tests

C7	Pre-FFA		Post-FFA	
	Coefficient	Probability	Coefficient	Probability
C	4.38E-06	0.0085	5.68E-05	0.0008
RESID(-1)^2	0.172806	0.0403	0.320697	0.0000
RESID(-1)^2* RESID(-1)<0	0.085036	0.4474	-0.07616	0.3856
GARCH(-1)	0.758475	0.0000	0.632287	0.0000
WTI	0.000101	0.0276	-0.000291	0.5443
S&P500	-0.000204	0.0784	-0.000490	0.7454
ARCH test (F-stat)	6.526025	0.0000	0.755511	0.7187

Source: Baltic Exchange Ltd, Clarksons

4.2.3 Tests for the asymmetry effect in C3

For the C3 Tubarao to Qingdao voyage route the results indicate that the independent variables have no effect in the variance equation for the pre-FFA period from 1/12/1998 until 31/8/2005 (Table 8). While trying to include all three independent variables, a combination of two, only one of them or even with no independent the results where the same.

Table 8
C3 asymmetric response on volatility tests

C3	Pre-FFA		Post-FFA	
	Coefficient	Probability	Coefficient	Probability
C	9.40E-05	0.9770	2.11E-05	0.0000
RESID(-1)^2	0.168577	0.9970	0.651222	0.0000
RESID(-1)^2* RESID(-1)<0	-0.216442	0.9961	-0.184518	0.2703
GARCH(-1)	0.454552	0.9844	0.599624	0.0000
WTI	0.001050	0.9531	-0.000206	0.5482
S&P500	-0.001014	0.9706	-8.86E-05	0.9194
ARCH test (F-stat)	0.369687	0.9830	0.810111	0.6589

Source: Baltic Exchange Ltd, Clarksons

For the post-FFA period, the independent variables of WTI and S&P500 are not significant. However, the previous residual, the constant C and the GARCH(-1) term are significant. For the asymmetry we can see that the coefficient is not significant in the 5% level, which means that negative shocks have no excess effect.

4.2.4 Tests for the asymmetry effect in C5

In the last case of the C5 route West Australia to Qingdao (Table 9), the generated models are both "ARCH-efficient", however the coefficient for the RESID(-1)^2*(RESID(-1)<0), i.e. the asymmetric information impact is in both samples not significant. Thereafter, FFA trading did not change how negative information affects the variance of the physical market.

Table 9
C5 asymmetric response on volatility tests

C5	Pre-FFA		Post-FFA	
	Coefficient	Probability	Coefficient	Probability
C	4.14E-05	0.9525	2.98E-05	0.0002
RESID(-1)^2	0.941599	0.9234	0.350343	0.0000
RESID(-1)^2* RESID(-1)<0	-0.558961	0.4585	-0.076360	0.5027
GARCH(-1)	0.153630	0.9926	0.730269	0.0000
WTI	0.000480	0.9823	0.000629	0.5183
S&P500	-0.000202	0.9979	0.001652	0.0882
ARCH test (F-stat)	0.312152	0.9927	0.972394	0.4792

Source: Baltic Exchange Ltd, Clarksons

5. Conclusion

In this paper we facilitate a spherical analysis of the implications of the Capesize forward freight agreements market to the underlying spot market. We extend the already existing literature on the same topic regarding the Panamax vessel market (Kavussanos and Visvikis, 2004). This study contributes to further understanding the interrelationship between forward and spot market of a non-storable commodity as that of transportation services in a highly cyclical industry.

In our first case and by introducing a dummy variable indicating the specific period when the forwards commenced trading, we locate the effect of FFA use to the variance of the specific indexes (4TC) and routes (C3, C5, C7). The results show that for the 4TC index there is indeed a positive impact of FFAs on volatility, while using WTI or Brent as independent variables (for S&P500 the model was not applicable). Same results were existent for the C3 and C5 routes for which all tests implied that after the introduction of FFAs the variance of the spot market increased, however the effect was mild. For the remaining voyage route C7, the same model did not have the appropriate specification as ARCH effects on the residuals were detected.

In the second case study, we focus on the asymmetry effect of negative news on volatility. The theoretical approach for financial time series states that negative shocks have a greater effect comparing to positive shocks of the same magnitude. Therefore, we separate the sample into pre-FFA and post-FFA subsamples and apply the same GJR-GARCH process in order to assess the effect on asymmetry of the introduction of FFAs.

The empirical results show that for the 4TC in the pre-FFA period negative shocks tend to have a diminishing effect on volatility indicating that the spot market overreacted the first day of the negative news and corrected the following. However, FFAs have a positive impact in terms of no effect of negative news in spot rates, which translates to a more efficient flow and integration of information into the physical market. This fact augments the quality of the market itself as it has already absorbed information connected to future market fundamentals alterations, rather than reacting or even overreacting to only current events. In the C7 we could not have a clear comparison between current and past results; however post-FFA asymmetry of negative shocks is not present. For the C3 and C5 routes, the econometric analysis implies that the use of FFAs has no effect in the asymmetry of negative news and their impact on the spot market variance as this asymmetry was not existent in the pre-FFA period as well.

The findings we present, can have some implications on the way the FFA market is viewed both from the side of speculators eager to get exposure in the shipping market and to traditional market participants, either these are charterers hedging their long position or to shipowners that are negotiating higher charter rates.

Thereupon, while we would expect that the use of FFAs would result in a less turbulent physical market the effect is not in fact that straightforward. If we consider the positive impact on the asymmetric effect of negative information, we could support an argument that while FFAs could not have eliminated volatility of the physical market entirely, they assisted on keeping uncertainty in lower levels, during the years of extraordinary contraction and expansion of the shipping market super-cycle we are experiencing from 2007-2008.

The results of this paper add up to existing literature by extending knowledge to an asset class that is not examined in depth, however its risk/return profile deems that necessary for the market players in place.

Building up to further enhancing understanding on volatility in shipping, future studies can address the remaining two major dry-bulk asset classes, i.e. Handysize and Supramax/Ultramax, as well as the tanker market. Comparative analysis of the established dry bulk and the newly created LNG shipping spot market in terms of volatility could be a topic of growing concern, as the spot market for LNG carriers is gaining participants and fluctuations and seasonality seem that will be of greater importance in the future. Furthermore, other methodologies can enhance the results generated, by utilizing time-varying volatility models that account for structural breaks.

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