UNIVERSITY OF PIRAEUS
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# FORWARD FREIGHT AGREEMENTS & MARKET TRANSPARENCY IN THE CAPESIZE SECTOR

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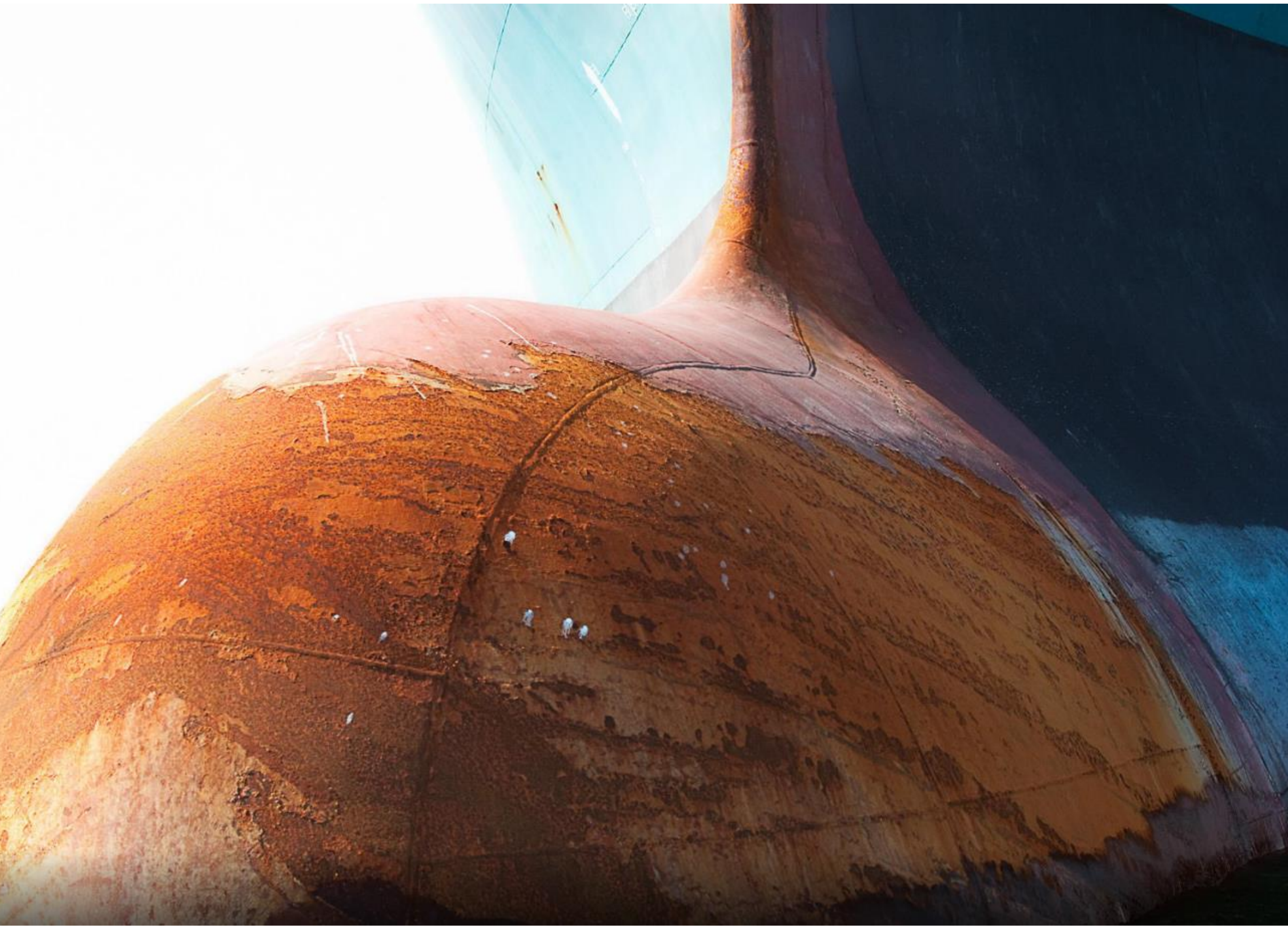

*"Paper is not transparent, you can't see through paper…"*

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This thesis was approved unanimously by the three-member Commission of Inquiry appointed by the “1ΓΣΕΣ” of the University of Piraeus Department of Maritime Studies, in accordance with the Management Regulations of the MSc in Shipping.

The Committee members were:

-Professor A. Merikas

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The approval of the thesis by the Department of Maritime Studies, University of Piraeus does not imply acceptance of the author's opinions.

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## Abstract

The current thesis intends to clarify the connection between the trade of Forward Freight Agreements and its ripple effects in the volatility of the spot freights in the physical market of Capesize vessels.

The analysis uses as a tool the GJR-GARCH econometric process to model the volatility of the spot freight rates in the routes C3, C5, C7 and the time charter average index 4TC. A connection with the trading of FFAs is established through the use of dummy variables, while additional factors that affect the whole economy, WTI, Brent and S&P500 Commodity Index, are incorporated into the model with the intention to take into account other variables that may affect volatility in shipping markets.

The results may be 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 of this specific sector. The empirical results for the 4TC and the routes C3 and C5 indicate that FFA led to a rise in the volatility in a small degree however. For the C7 Capesize route, the models produced where insufficient thus the results were of no use.

In the second process, the goal was to identify the effect of FFA in the asymmetric response of negative shocks or information to the volatility of the physical market. By dividing the data in pre and post-FFA samples we managed to have substantial results only for the 4TC, as for the voyage routes a comparison was not possible because of insufficient models produced. In the 4TC however, the introduction of the “paper” market had as a result the elimination of the effect of negative past information in the current volatility. That means that FFAs helped the more efficient incorporation of information in the physical market.

Keywords: Capesize, FFA, Volatility, GJR-GARCH

# Chapter 1: Introduction and scope of research

This thesis was written for the University of Piraeus, Department of Maritime Studies and on behalf of the Master of Science “MSc. in Shipping”. The goal of this thesis is to identify whether the forward freight agreements market had a stabilizing effect on volatility of the physical market, in the specific sector of Capesize vessels.

The scope of this research is to analyse the connection between the Physical market of the Capesize sector with the equivalent Forward Freight Market using econometric processes. This analysis will serve as a tool to identify whether the use of Forward Freight Agreements (FFAs) increased the flow of information into the physical market, increasing consequently the market transparency.

The analysis of the data generated and published by The Baltic Exchange Ltd., both the physical and forward market of the 5 Time Charter average (5TCavg), 4 Time Charter average (4TCavg), the route C3 (Tubarao to Qingdao) the route C5 (West Australia to Qingdao) and the route C7 (Bolivar to Rotterdam), the last three reported on US Dollars per tonne, will be associated with major drivers of the market. For that reason, additional factors, such as the S&P500 Commodity Index and crude oil price (Western Texas Intermediate and Brent), as a global commodity that affect directly and indirectly shipping, will be taken into account. These additional variables will be analysed in order to facilitate a link between the physical market of transporting goods via oceangoing vessels and the corresponding “paper” market.

The thesis will address allegations of the physical market members, who claim that the introduction of the forward freight agreements distort the market to an extent that all period fixtures and trip charters have a ceiling in freight rate marked by the corresponding FFA used to hedge the risk of the charterers. This of course is the general feeling of ship owners and of shipbrokers that have as their principals mainly owners, who always encounter a ceiling in their earnings set at the level of Forward Freight Agreements for the specific size of the dry bulk vessel for the duration of the charter and/or the distinct route the vessel will follow.

As this FFA price is referring to a future date months or even years later, when the picture of the shipping market can be completely different due to the high volatility of the sector, the question raised is whether the forward curves are serving towards a more transparent market, in which information is incorporated more effectively in freight rates.

As a former employee of a ship broking firm specialized in the dry bulk sector for all the vessel sizes of oceangoing vessels, from Handysizes up to Capesizes, this debate between owners and charterers on to what extent FFA rates were indicative of the current physical market was always a friction point.

For the ship-owners and ship brokers FFAs are an additional variable they must take into account alongside with the four shipping markets being the newbuilding market, the freight market, the second hand market and the demolition market. Traditionally, what an owner should account for was demand and supply of shipping services and in that essence the “paper” market had altered the industry.

On the other hand, for charterers, who because of their size can more easily and more effectively hedge their overall position in the shipping market, FFAs are a very useful tool. Their size makes them extremely vulnerable to steep changes in freight rates and therefore control of shipping risk is essential to their operation.

Therefore benchmarking of forward contracts via the Baltic Exchange Ltd was a positive development for charterers when introduced in the 1990s. Their evolution over the years and the development to trading via clearing houses or hybrid exchanges had a positive effect on the minimization of credit risk of over-the-counter contracts and the rise the liquidity of this market.

As until now limited research on the effect of FFAs in spot price volatility is made and only in the Panamax vessel class (Kavoussanos & Visvikis, 2004). This research showed that FFA trading had a stabilizing impact on the spot price volatility and among others FFAs substantially improved the quality and speed of information flow in routes P1, P1A and P2.

However, no research is existent for Capesize vessels, whose size and limitations of cargoes transported mainly to iron ore and coal, make their market extremely volatile to changes in demand and supply. This is the gap that this thesis intends to fill analyzing the market accordingly to E. Kavoussanos and I. Visvikis method.

## 1.1. Methodology, data collection and organization of the thesis

In order to fulfil the purpose of the thesis, we will use past research addressing the matter in hand, however we will use raw data to make the necessary crosschecks. These data are mainly derived from The Baltic Exchange (regarding physical and FFA market for the Capesize vessels) and Clarksons database. However, other major sources of data are reported in the main body and the bibliography of the thesis.

Consequently, the thesis is organized in the following major chapters:

Chapter 2 gives an introduction to the Forward Freight Agreements (FFAs). It gives a short historic review of their introduction in the shipping market, the way they are formulated and calculated, and finally how they are used in the shipping sector.

In Chapter 3, we emphasise in the sector of Capesize vessels in order to present useful information about the physical market and the FFA market.

In Chapter 4 we present the data used for the specific crosschecks we intend to make and in Chapter 5 we conduct the analysis of the volatility of the spot freight rates so as to understand the connection with the FFA market and FFA trading.

Finally, in Chapter 6 we conclude the results of the aforementioned analysis.

## Chapter 2: Introduction to Forward Freight Agreements (FFAs)

*"The history of the Baltic Exchange spans more the 250 years and traces its origins back to a coffee house – the traditional meeting place of merchants and sea captains – in the City of London.",* according to the Baltic Exchange as it describes its history through the years.

From the year 1744, when the Virginia and Maryland coffee house in Theadneedle Street changes its name to Virginia and Baltic, that reflects the business of the merchants and ship-owners who regularly gather there, until now, 2016, 272 years later, a lot have changed. The ships are bigger, fired by different fuels, carrying larger chunks of valuable commodities, technology has also played its role on every aspect of the trade and many other small or bigger things that over a such vast period of over 250 years where bound to change. However, what has not changed through the years is the need of an institution that can gather all information derived from reliable sources, and report it back to the market, that is desperate for insight. That is what the Baltic Exchange continues to do, even though the reported information nowadays is more vast and in more detail. A new "product" of the Baltic Exchange is the bellow analysed Forward Freight Agreements (FFAs).

Forward Freight Agreements operate in a market relatively new, keeping in mind the history of the Baltic Exchange, currently counting nearly three decades of life. From the early 1990s a new market for trading the forward value of freight emerged, primarily, as stated in literature, as a response to the need of market players who were aware of the deficiencies of the BIFFEX contract used as a hedging instrument (Alizadeh A. H. & Nomikos N. K., 2009). The players wanted a precise tool to implement hedging strategies, limiting the drawbacks from their exposure in the physical market. We have come to far as seeing in the past, when in 1992 the first trade of forward freight agreement (FFA) was recorded, the market has grown and reached a value of trades of US$ 125 billion (Financial Times, 2008) (further information about market volumes will be presented in chapter 3).

In this chapter, we will present the structure and function of the FFA market, the trading practices, documentation, and type of contract used in the trades, applications and uses of FFAs for risk management and speculation, all matters really important so that to get the fundamentals behind a derivative such as the one under study and scrutiny.

## 2.1. Forward Freight Agreement, definition

A forward freight agreement (FFA) is an agreement between two counterparties in order to settle a freight rate or a hire rate, regarding a specific quantity of cargo or vessel type, for one major shipping route or a basket of routes in the dry-bulk as well as the tanker market at a predefined date in the future (Alizadeh A. H. & Nomikos N. K., 2009). Every derivative has to have an underlying asset, and for the FFA contracts that is a freight rate assessment for an underlying shipping route, or a basket of routes corresponding to the aforementioned, which is generated by the Baltic Exchange in the dry-bulk market, or Platts regarding the tanker sector. Settlement for this kind of contracts is in cash and is calculated on the difference between the contract price and a settlement price derived from the physical market.

As stated by the Baltic Exchange, FFA contracts will normally be based on the terms and conditions of the FFABA (it stands for Forward Freight Agreement Brokers Association) standard contracts amended as agreed between the principals. The main terms of an agreement will cover:

a. The agreed route.

b. The day, month and year of settlement.

c. Contract quantity.

d. The contract rate at which differences will be settled.

Settlement is between counter parties in cash within five days following the settlement date (The Baltic Exchange, 2013), as referred in the Guide to Market Practice for the FFABA.

The settlement price mentioned earlier is not the price of the underlying asset the day of the settlement date. This practice is used to ensure that settlement rates are not susceptible to large moves due to very high volatility or market manipulation on any specific trading day.

In general, the calculation of the settlement price is different depending on the type of the contract being traded. More specifically, on individual routes, for the Baltic Capesize Index (from now on BCI) and for the Baltic Panamax Index (from now on BPI), the settlement rate is calculated as the average of the Time Charter Trip (TCT) of that route over the last seven trading days of a month. For the FFAs on the average indices of BCI, BPI, Baltic Supramax Index (from now on BSI) and Baltic Handysize Index (from now on BHSI-all the acronyms are quoted as reported in the market), the settlement price is the average of the month. The reasoning behind the different averaging periods used in the calculation of the settlement price is their need in usage of FFAs as a risk-management tool.

Shedding more light in the aspect of different settlement rates, we can examine the following: FFAs on individual routes are used to hedge risk on specific voyages, which are shorter in duration. Therefore the need is for a tool that has a better correlation with the underlying physical market over a shorter period of time, something that is accomplished by averaging the last seven days of the month as mentioned already. On the other hand, when hedging against a position in the physical market of a period charter, market participants use basket routes such as the BCI, BPI, BSI and BHSI, with intent to hedge their average monthly earnings, so these corresponding FFAs provide a better solution to the needs of traders (Alizadeh A. H. & Nomikos N. K., 2009).

However, the Baltic Exchange introduced a series of FFAs settled as a monthly average of the BCI C4 (Richards Bay-Rotterdam) and BCI C7 (Bolivar-Rotterdam), with the trading volume to be significantly lower.

## 2.2. The Baltic Code of Ethics and Market Practice

Having established a background on what FFAs are, and before focusing in more detail on how they work, in terms of reporting, and how they are used as hedging instruments, it is important, to the author's view, to present in this subchapter the general rules applied in this specialized market. For that reason, in the bellow few lines are listed the principles under which the Baltic Exchange and the market around it works, and which are included in a document called The Baltic Code.

This document was first produced in 1983 under the consolidated heading of the Baltic Code, and was substantially revised in 2012. It has now been divided into three main sections, namely an introduction to the Baltic Exchange, the Code of Ethics and Market Practice (the core Code) and an introductory guide to modern shipping practice and terminology.

Under this document, and the code of ethics that represents, a motto of the Baltic Exchange, which some could say concludes in just four words the whole meaning of the code, is present on the footer of every page of that document. The motto of the Exchange - “Our Word Our Bond” – captures the importance of ethics in the whole shipping sector. All members of this community have to rely on each other and, in turn, on their principals, for contracts verbally expressed and only subsequently confirmed in writing. The terms of a contract, whether oral or written, that are agreed between the counterparties are considered as binding, something that is an essential commitment of Baltic Members (The Baltic Exchange, 2014).

The standards set include, but are not limited to, the following basic principles:

*1. All market participants are required to honour their contractual obligations in a timely manner.*

*2. In the conduct of their profession, members must exercise reasonable care to avoid misrepresentation and shall be guided by the principles of honesty and fair dealing.*

*3. A broker must only offer or bid a ship or cargo when duly authorized by a principal or by a broker acting on the instructions of, and with the authority of, the principal. A broker must not purport to hold or make use of authority where that authority is not in fact held, nor may a broker alter the substance of any authority without the approval of the principal concerned.*

*4. An owner or owner’s broker may only offer his/her vessel “firm” for one cargo at a time. Similarly, a charterer or charterer’s broker may only offer his/her cargo “firm” to one vessel at a time.*

*5. A principal may receive multiple firm offers for a vessel or cargo but must always make it clear at the time if he is already out firm elsewhere.*

*6. An unsolicited offer or proposal does not necessarily establish the channel of negotiation.*

*7. Prior to quoting business from a principal previously unknown to him, a broker should take reasonable steps to obtain the background and reputation of the principal concerned. However, where this has not been possible, the situation should be clearly communicated to any counterparty.*

*8. All parties must ensure there is absolute clarity regarding the payment of broker commissions. In the event it is anticipated that commissions will be deducted from hire and paid to the broker by the charterer, then this must be expressly stated in both recap and charterparty. Any subsequent change must be similarly documented.*

*9. Brokers who act as Baltic panellists are required to pay careful attention to the guidance offered by the Guide to the Specification, Production and Management of Benchmarks. Impeccable standards of honesty and integrity are critical to this role.*

(The Baltic Exchange, 2014)

Additionally to the basic principles, the Baltic Exchange continues to issue and list unacceptable practices, which include, but are not limited to the following:

*1. It is unacceptable to offer named tonnage against tenders without the authority of owners or disponent owners.*

*2. Brokers must not imply that they hold a ship cargo firm or exclusively when they do not, in order to secure a response from another party.*

*3. A vessel must not be held on "subjects" for the purpose of determining market direction. Failing a vessel on "subjects" for such spurious reasons is unacceptable.*

*4. It is never acceptable to attempt to manipulate prices in the FFA (freight derivatives) market through the abuse of "subjects" in the physical market.*

*5. Except where expressly contemplated in the charterparty, the offsetting of other claims against hire or freight payments is unacceptable.*

*6. Where a principal operates a company (whether wholly, partially or separately owned), great care must be taken in considering the company name. Where the name is similar to that parent company, market participants are likely to associate the goodwill of the parent with the subsidiary or separate company. In these circumstances, whatever the precise legal position, it is unacceptable if the "subsidiary" fails to meet its obligations while the parent is in a position to meet those obligations or pay appropriate damages.*

*7. Withholding payment of undisputed sums, including commission to brokers, on any earnings received is unacceptable.*

*8. It is not acceptable for a charterer to fix two vessels or more for one cargo and then hold the vessels over a period of time on "subjects".*

*9. The distribution of route or index rates, produced by the Exchange from its panel reporting companies, for the purpose of pricing charters or contracts without an appropriate commission to a Baltic broker is unacceptable.*

*10. Redelivery of a vessel from timecharter at any time prior to the expiration of the minimum period, unless mutually agreed in advance with the owner, is unacceptable.*

*11. Failure to nominate cargoes or vessels when required under the terms of a Contact of Affreightment, is unacceptable.*

(The Baltic Exchange, 2014)

A member of the Exchange who fails to comply with any of the above terms or practices of this Code may be disciplined by the Directors under the Rules. The Directors have power to censure, suspend or expel an individual member and his/her company form the Exchange.

The Exchange has arrangements for investigating disputes between members, and between members and non-members, which arise from the breach of this code. Members are encouraged to bring such instances to the attention of the Exchange in writing so that they can be investigated (The Baltic Exchange, 2014).

## 2.3. European Commission Directorate General Internal Market and Services' Consultation Documents on the Regulation of Indices

In correlation to the above, we are now going to provide some interesting information derived from the European Commission. The Directorate of General Internal Market and Services, in its effort to increase information about the financial markets within the Eurozone, explores the possibility of policymaking. The regulation of indices, such as those produced by the Baltic Exchange, is a matter of continuous talks, and an insight from the providers of such indices is crucial for the European Commission.

Regarding our scope of the current thesis, we are going to provide the key points from the Consultation Document on the Regulation of Indices, provided by The Baltic Exchange on 14 November, 2012.

It is important to state before going into the specifics, that such a reform and a regulation of indices has not been effected, but according to the European Commission, an exploration of possible changes , after alleged manipulation of LIBOR, EURIBOR and TIBOR has highlighted the importance of indices and their vulnerabilities.

First of all, in this document, we can locate the amount of contracts traded for settlement on Baltic benchmarks, which are about 25 different freight derivatives contracts. In the FFAs dry bulk sector, market volumes averaged about 20.000 lots per week, which represent 20.000 days of time charter per week.

Furthermore, it is stated that it is impossible to quantify the amount of business conducted in the physical market based on Baltic benchmark rates and indices. One of the main appeals is that a floating rate charter carries with it only very modest credit risk and a party wishing to establish either fixed returns or fixed costs is usually able to do so by using the FFA market.

The benchmarks are used mainly by owning or chartering interests, both as indicators of returns and market trends and more specifically in contracts (charterparties) and FFAs. Heavy users are also operators of ships who are effectively traders who charter in vessels sometimes against cargo commitments they have made and sometimes on a more speculative basis. The large commodity trading interests which are now based in Switzerland, the USA and increasingly in Singapore, are significant users. Owners may operate from a variety of countries, including the UK, Denmark, Norway, Greece, Switzerland, Monaco, Germany, Singapore, China, Hong Kong, Japan, Korea etc.

The forward curve benchmarks are used for mark to market of both physical and derivative forward exposures, as well as for CCP margin calculation.

However, according to the answers by The Baltic Exchange, the shipping marketplace is problematic from the point of view of benchmark production. This is derived from many factors as every vessel is different in some small or large degree. From the aspect of design and efficiency, age, operating costs, management both of the ship and the management company, every vessel is not the same and attractiveness and perceived risks may vary. Furthermore, the vessel or owner may have a good or bad record with the Port State Control inspections and detentions. Load ports and cargoes vary in terms of their desirability from the point of view of the owner or their costs. Some cargoes are considered dangerous and of high risk (eg Nickel Ore, which has a tendency to liquefy in certain circumstances, or Cotton is flammable) while other cargoes, such as grain, may be more appealing to owners.

Due to the fact that the shipping marketplace is a private market, its participants do not have the obligation to report the fixtures they make. Thus, and because the Baltic Exchange is based on those reports by the market to issue the published indices, it is not suggested that the Baltic Exchange represents complete information about the market, however, it is stated that the information produced is "reasonably accurate". Moreover, on some occasions, the information produced is not entirely accurate and may be corrected later and not all routes will be fixed every day, or even have business quoted with any real reliability. The benchmarks generated though, are used for settling derivatives contracts and other benchmark-based transactions, which means that there may be an inconsistency with the real physical market.

Therefore, the Baltic Exchange has developed a carefully defined methodology for the production of its benchmarks, which reflects the difficulties in reporting this complex market and which exploits certain characteristics of it which allow the production of credible and reliable indices on an impartial basis.

The Baltic Exchange prices its benchmarks only on the basis of contributions from a panel of competitive shipbrokers who are members of the Baltic Exchange and who agree to provide their professional assessments of the market each day at the time of submission. The panellists have specific expertise on the routes they report and are able to assess the market rates, taking into considerations various factors that may apply. Such factors would include available vessels and cargoes, current negotiations, recent fixtures, market sentiment etc. The panellists selected have a wide range of business and clientele in order to provide independent assessments according to the Manual for Panellists, which provides the relevant guidance.

All submissions for each route are used by the Baltic to create and publish a mathematical average that will represent the market at each day. The highest and lowest submissions are not regarded so as to eliminate discrepancies. The submissions are reviewed on a daily basis and in case the rate contributed appears outside the range for the market, the contributors are contacted in order to clarify the submission.

Each panellist is visited by the Baltic staff once a year and a review of the quality of their inputs relative to other panellists is conducted. After this review and if they are deemed appropriate to continue their contribution, they are re-appointed as panellists. Once each quarter Moore Stephens checks the calculation of rates and indices to ensure that the computer system used is not introducing any errors. The above procedure ensures the integrity of the rates and indices calculated by the Baltic Exchange.

When asked about the possible advantages and disadvantages of making benchmarks a regulated activity we can quote the bellow:

"The introduction of regulation would presumably mean either that industry bodies and market participants would simply not create new indices because it would be a regulated activity, or the regulator would have to intervene at a later stage to impose regulation on a specific index. In any case, the vast majority of indices are produced with very little hope of significant financial return and the increased cost of regulation would be a further disincentive to create benchmarks. It must be recognized that there are vast numbers of benchmarks and indices produced, most of which are not used directly for any financial transaction. They survive or disappear based on whether they are perceived to be useful and whether the provider has any success in monetising them." (The Baltic Echange Ltd., 2012)

Therefore we can state that the Baltic Exchange is opposed to a possible regulation of the generating process that it conducts, as it may lead to worse results. Market drives are valued to be the reason that the Baltic produces useful indices with integrity and according to high standards. As it is stated while further reading the interview, the produced Baltic Exchange Dry Index is often cited as being a leading indicator of economic activity, however, it is dangerous for a regulator to assume the purpose to which an index is put is in some way the responsibility of the provider. In that case, the Baltic Exchange tries to steer clear of any accusations in its involvement of publishing such benchmarks.

In that purpose, Baltic Exchange, as an index provider has a normal commercial responsibility for the product. If the product is not of sufficient quality then it will not be widely used. The provider in any case will find that he has a responsibility to all users of the data to ensure that there is no negligence involved in the production of the rate. However, the responsibility of the provider must end with the production process. He cannot be held responsible for the uses to which his data is put, especially where there may not even be any licence arrangement in place between the provider and the user. Ultimately, the responsibility must be with the buyer and the seller to establish that the benchmark used reflects properly both in its specification and production method, the transaction they wish to conclude.

As such, the production of indices by the Baltic Exchange cannot be considered a public good, as they are not produced by governments and supragovernment bodies, but by normal commercially-run organizations in a competitive environment. Where the benchmarks are produced and selected in the normal commercial way, and are subject to normal rules of competition, there is no need for a role to be played by public institutions. Commercial and public users of benchmarks are free to select those which they feel meet their standards in terms of production process, benchmarking aim and commercial terms. It should be recognized here, that the barriers to entry in the production of all kinds of indices and benchmarks are extremely low. Therefore, the market itself can provide the governance of the members.

Overall, at least from the point of view of the Baltic Exchange, the regulation of the indices produced and according to which every Forward Freight Agreement is settled, will cause more problems that it may possibly resolve. As such, as the Exchange operates in a commercial way driven by market forces, as well as due to the particularities of the shipping market, the way the data is gathered and reported, and the faithful implementation of the Baltic Code by the members as briefly mentioned earlier, an overall proper function of the system is secured.

## 2.4. Forward Freight Agreement Brokers' Association (FFABA)

The Forward Freight Agreement Brokers' Association (FFABA) was formed in 1997 by members of the Baltic Exchange, and acts within the framework of the Baltic Exchange under the management of the Baltic. In 2006, a separation was conducted so that two Associations can service the wet and the dry markets. The Members that trade in the freight derivatives market are obliged to abide by the current Rules of the FFABA, as published and renewed from time to time by the FFABA Committee. Additionally to the Rules of the FFABA, any member must conform to the Baltic Code, as a prevailing to all code of conduct.

The FFABA has a goal to promote trading of Forward Freight Agreements, complying with the high standards required among the market participants. However, it is recognized that members of the FFABA, namely the brokers of this kind of transactions, cannot be held responsible for the performance of the contract.

The Members of the FFABA must:

1. Be members of the Baltic Exchange;
2. Be regulated by The Financial Conduct Authority (FCA) if resident in the UK, or if not resident in the UK, by an equivalent body if required by the authorities in the jurisdiction;
3. Have demonstrated they are active in promoting the use of the FFAs;
4. Contribute to the Baltic Forward Curve Assessment (BFA) if required to do so by the Baltic Exchange.

(The Baltic Exchange, 2014)

Furthermore, the FFABA requires from its members and staff to have a reasonable knowledge of all the routes as defined by the Baltic Exchange and all the FFABA standard contracts (The Baltic Exchange, 2014).

Regarding now the charter market negotiations, the brokers of the FFA contracts have to conduct all the procedures with attention to detail and record their transactions and in any case have a filling system.

All the members have to distinct clearly market guidance given by brokers from indications derived from principals and firm offers. The latter should always have a time limit. Consequently, the practice of withdrawing an offer during the period that it is still valid is strongly discouraged and the FFABA should always have knowledge of this kind of misconduct. Additionally, all verbal communications are contractually binding and the motto mentioned earlier too, “Our Word Our Bond”, applies to the derivatives market as well the physical market (The Baltic Exchange, 2014). As already mentioned brokers must record their transactions and due to the fact that verbal agreements and negotiations have binding power, brokers are also encouraged by the FFABA to record their telephone conversations. For that reason, clients should be informed that conversations may be recorded (The Baltic Exchange, 2014).

As the settlement of the forward agreements is concerned, settlement procedures are clearly set out in the FFABA standard contracts. The principal is obliged to make sure that payment details are available to their counterparty in time, in order the settlement to be conducted. If the FFABA is contacted to provide a settlement rate under the terms of a contract, then the FFABA, after a written request from either principal, will appoint a panel of minimum three independent brokers which within two London business days will reply to the request. If either party fails to honour their agreement and this act is reported to the FFABA, then the association will inform its members, who may use this information as they see proper to their interests.

Furthermore, the FFABA will liaise with the Baltic Exchange to secure the required professional production and development of route indices for use as settlement mechanisms for the Forward Freight Agreement contracts. The FFABA monitors and publicises an annual calendar of Baltic Exchange publication days for the various route indices (The Baltic Exchange, 2013).

Concluding this relatively small subsection, we can say in general that the general rules of the Baltic Exchange as described by the Baltic Code of Ethics and Market Practice apply to the FFABA brokers too. As "old school" as all the above may seem and of no importance to a modern way of making business with many unknown counterparties, it seems that in shipping this Code has a meaningful value and sets the terms for multimillion dollar deals.

## 2.5. Trade of Forward Freight Agreements

Forward Freight Agreements can be traded either over the counter (OTC), or through a clearing house, an exchange. Trading in OTC markets is materialized through FFA brokers. There are two ways to trade FFAs. Firstly, they can be traded on the basis of principal-to-principal contract between the involved counterparties, which was until recently the traditional way of trading (Perrott, 2012). In these transactions, standard contract forms prevailed in the market, such as the FFABA 2007 and the ISDA Master Agreement which will be briefly presented in following chapters. Secondly, and nowadays almost exclusively (Perrott, 2012), the trades in the FFA market are cleared through clearing houses that provide services to the freight market. According to Alizadeh A. H. and Nomikos N.K. in their book "Shipping Derivatives and Risk Management (Alizadeh A. H. & Nomikos N. K., 2009) , and the Baltic Exchange Ltd. these clearing houses are the London Clearing House (LCH.Clearnet), the Singapore Exchange (SGX) Asia Clear Service, the Norwegian Futures and Options Clearing House (NOS) and the New York Mercantile Exchange

(NYMEX). Alternatively, FFAs can be also traded through a “hybrid” exchange, the most popular of which is the Imarex, which stands for International Maritime Exchange. Imarex provides a trading screen where standardized contracts are traded and are then cleared straight through the Norwegian Futures and Options Clearing House (NOS) (Alizadeh A. H. & Nomikos N. K., 2009).

### 2.5.1. Over-the-counter (OTC) FFA contracts.

When the counterparties negotiate in the over-the-counter (OTC) market, the two principals act through a broker, similarly to the negotiations conducted when chartering a vessel in the physical market. As mentioned in subsection 2.4, brokers are members of the FFABA and subsequently members of the Baltic Exchange.

The broker establishes a channel of communication between the two parties firstly by acquiring a firm “Bid” and “Offer” from the buyer and the seller respectively. Afterwards, and during the period of negotiation, in order to conclude the agreement the principals must agree all the term of the deal. The main terms of the contract include the agreed route; the day, month and year of settlement; the contract quantity i.e. the duration of the Time Charter (TC) routes and the contract rate at which differences will be settled. Until all points are agreed upon, brokers must not reveal the identity of their principals, unless they have the authority given from their principal. However, in some cases the approval of the counterparties is to be affected after the agreement of all the other terms and conditions. The approval of the counterparties has a time limit affected after the remaining contract terms have been agreed. In order for the contract to be concluded and be binding, both counterparties must give their express acceptance about the deal. For that reason, and according to the Baltic Code (The Baltic Exchange, 2014), during the negotiating process, brokers must keep an accurate record of all written exchanges and all telephone conversations must be recorded, with knowledge of their principals, as verbal agreements are binding too (Alizadeh A. H. & Nomikos N. K., 2009).

Continuously to the conclusion of the negotiations and the following agreement, a verbal trade confirmation is agreed and the broker, usually of the side of the seller, is responsible to issue a recap which contains in detail the main terms of the trade. According to this recap, the full contract is issued to be signed by the counterparties normally within two business days of the contract day. At the settlement day of the contract, typically the last trading day of the month, the settlement price is calculated as the average over a certain period which is specified in the contract and accordingly a settlement statement is issued. As a final step of conclusion of the contract, settlement funds are paid within five London banking days after the settlement date (Alizadeh A. H. & Nomikos N. K., 2009).

As OTC contracts are principal-to principal contracts, they are made directly between the two counterparties. For that reason, the broker acts only as an intermediate and therefore is not responsible if either principal fails to meet his/hers contractual agreements. This means, that credit risk and counterparty risk is evident and that market participants should exercise their due diligence to ensure that their counterparty will honour their obligations emanating from the FFA transaction they are in. A number of defaults in the FFA market showcases that a possibility of financial losses is existent. As mentioned above the broker does not have any exposure to a possible breach of contract and does not share any counterparty risk, however brokers have the obligation to not mislead the counterparties about the status and the capabilities of either principal. They are expected to exercise reasonable care of all pre-contract representations and not to withhold any material information. The details of each contract may vary, as the OTC forwards may be tailored to the needs of the two parties. Finally, the commission received by the brokers is agreed in advance with the principals and is typically 25 basis points (0.25%) from each party, calculated on the fixed or expected freight rate (Kavousanos & Visvikis, 2006).

After their introduction and in the end of the 1990s, FFA market developed leading to a subsequent need for a standardized contract form for trading FFAs. Accordingly, we had at first the creation of two main contract documentation to satisfy that need. Firstly there was a contract created by the FFA brokers and secondly, market users and traders who were active in the commodity and financial derivatives markets oriented themselves into utilising the contract they already used in those markets, into the FFA market (Alizadeh A. H. & Nomikos N. K., 2009). These two different types of contracts documentation have same similarities despite the different target groups that formulated them and they are namely the FFABA contract and the ISDA contract.

#### 2.5.1.1. The FFABA contract

The FFABA contract developed from the FFABA, is a standard contract used in FFA transactions (Alizadeh A. H. & Nomikos N. K., 2009). The first version of this contract contained the main terms of an FFA agreement (the contract route, duration, settlement dates etc.) and was known as the FFABA 2000 contract (Alizadeh A. H. & Nomikos N. K., 2009). However, and simultaneously with the development of the market for FFAs, this version found to be inadequate as it had deficiencies regarding provisions for counter-party credit risk, as the FFAs as mentioned extensively is an over-the-counter contract. As the main purpose of this chapter is to provide an overview of the structure of FFAs we will not analyse in specific the deficiencies. However, for the above main issue to be addressed the development led to the creation of the FFABA 2005 contract, that incorporated the 1992 International Swaps and Derivatives Association (ISDA) Master Agreement (Papacharalampous, 2013). This contract is mainly used from charterers and shipowners, while the ISDA contract is mainly used from banking institutions and trading houses (Papacharalampous, 2013).

The latest version is the FFABA 2007 contract, which is an update to the 2005 one and also incorporated the ISDA Master Agreement 1992. Improvements are related to the calculation of the contract quantity and settlement sum and the netting provisions and the early termination caused by default (Alizadeh A. H. & Nomikos N. K., 2009).

#### 2.5.1.2. The ISDA Master Agreement and Schedule

The ISDA Master Agreement is the most commonly used master service agreement for OTC derivatives transactions internationally. It is part of a framework of documents, designed to enable OTC derivatives to be documented fully and flexibly. The framework consists of a master agreement, a schedule, confirmations, definition booklets, and a credit support annex. The ISDA master agreement is published by the International Swaps and Derivatives Association (ISDA, 2016).

Companies from the energy and commodities sector use this kind of contract as it is used for trading derivatives, therefore from their point of view it is a tried-and-tested contract (Alizadeh A. H. & Nomikos N. K., 2009).

The ISDA form for swap transactions includes a Master Agreement which sets the terms of the legal and credit relationships between the counterparties. Any amendments to the Master Agreement are in an attached schedule (Alizadeh A. H. & Nomikos N. K., 2009). The advantage derived from an ISDA contract is that it has been used as the standard form of derivative contract for the majority of the traded commodities, therefore it is tested and it has been subject to judicial reviews and enforced in a number of international jurisdictions. This leads to a solid contract reducing uncertainty derived from misinterpretation of the terms (Zepeda, 2013).

### 2.5.2. Trading FFAs with Clearing Houses

Trading in the over-the-counter market entails credit risk derived from non-payment or bankruptcy of the counter-party. Although credit risk can be mitigated to some extent using the FFABA 2007 or the ISDA Master Agreement contracts, bank guaranties or letters of credit etc., perhaps the most effective method is clearing (Alizadeh A. H. & Nomikos N. K., 2009). Traditionally clearing houses were used for exchange traded contracts, however, since the late 1990s clearing houses were used for OTC contracts. Nowadays clearing for OTC contracts regarding freight is conducted by LCH.Clearnet, SGX, NOS and NYMEX (Papacharalampous, 2013).

Clearing houses are well capitalized financial institutions that have the ability to guaranty counter-party trade performance on both sides, eliminating restrictions of pre-approved counter-party limits, the need for bilateral credit arrangements, and the reliance on sleeving arrangements (Kavousanos & Visvikis, 2006).

The clearing house works between the buyer and the seller of an FFA assuming the position of the buyer to every seller and the position of the seller to every buyer, therefore eliminating the credit risk between the counter-parties. The clearing house has a balanced portfolio of long and short positions, however the possibility of losses in case of a default is substantial. Therefore, a margin account is needed in the sense that every time a trader either buys or sells a contract he needs to place a deposit on his account with his clearing member. This deposit (the initial margin) represent the potential loses on the position the trader has placed on mark-to-market basis. After the initial margin has been deposited at the end of each trading day the account is adjusted to represent the profit or loss from the position of the trade (Alizadeh A. H. & Nomikos N. K., 2009). If the account has an amount in excess of what is needed the trader can withdraw the balance and if the account is bellow a "maintenance margin" then the trader must deposit an amount. This process of marking to market lowers the exposure to credit risk as all losses are due to daily price fluctuations and are settled at the end of each day. Accordingly, the counter-party that has a profitable position, at the end of the day can acquire his gain without fear of a default from the side that has the losses.

### 2.5.3. Trading FFAs via a "hybrid" exchange

This form of trading is conducted through an electronic screen the most popular of which is the International Maritime Exchange (Imarex). Imarex is a publicly listed company, based in Oslo, offering an authorized and regulated marketplace for trading and clearing freight derivatives. The principals can trade freight derivatives electronically in real time or through an Imarex exchange broker. All principals trade anonymously, and all trades are automatically cleared through NOS in a process called "straight-through clearing" (Alizadeh A. H. & Nomikos N. K., 2009).

The NOS in that case operates a system of dynamic margining as the trader must maintain in his margin account a percentage of the value of the contract. Therefore, if the value of the position increases, the amount of the margin increases as well and vice-versa.

The Imarex is like an exchange, as it provides a regulated marketplace in which standardized contracts are traded, principals can trade either for their account directly, either via an Imarex broker and all trades are cleared through a clearing house. However, this market is not open to brokers outside Imarex. This means that FFA brokers cannot use the system neither to post prices nor to place trades for their clients. As the market is not open to all market participants, Imarex is a hybrid exchange.

### 2.5.4. FFAs as a hedging instrument

Having established the contracts used and the different forms of trading FFAs we are now going to focus on how they are used in the shipping market. Firstly, we must stress out that market participants in the shipping sector, like in all other markets of the economic life, confront risks that emanate from the ordinary conduct of business. Derivatives markets provide a mean to transfer these risks to other individuals whi are willing to bear them by means of hedging. (Alizadeh A. H. & Nomikos N. K., 2009) Depending on the position on the physical market that someone has, hedge can be either short or long. A short hedge involves selling FFAs as a protection against a possible fall in freight rates For example, a ship-owner or a ship operator in order to hedge their risk of falling freight rates, the can sell FFAs. If the freight rates indeed fall, they lose freight income, which is compensated through a gain from the forward market (Kavousanos & Visvikis, 2006).

The opposite position would be to use a long hedge, in order to be protected against a possible rise in freight rates. Users of a long position in FFAs can be charterers in order to protect themselves from future rise in freights causing them to pay higher freights to cover their needs of transportation services (Papacharalampous, 2013).

Although initially the main use of FFAs was the above procedure of hedging risks between ship-owners and charterers, nowadays there are used primarily in order to speculate the future direction of the freight markets (Alizadeh A. H. & Nomikos N. K., 2009).

In the shipping industry we can distinguish three different types of hedging using FFAs, regarding the kind of charter a vessel does. Therefore, it is possible to hedge a Time-Charter Trip (TCT), a Voyage Charter, or a Period Charter. In the next three subsections we are going to present how hedging is conducted in these three separate types of employment.

#### 2.5.4.1. Hedging a Time-Charter Trip (TCT)

In the Capesize sector FFAs are not produced regarding the routes contributing to the BCI index. These routes are the C8_14 Gibraltar/Hamburg TransAtlantic R/V, the C9_14 Continent/Mediterranean trip China-Japan, the C10_14 China-Japan TransPacific R/V, the C14 China-Brazil R/V and the C16 Revised backhaul (The Baltic Exchange Ltd., 2016). We can note that only in the Panamax sector the Baltic Exchange publishes FFA Assessments regarding the underlying routes P1A_03 Skaw-Gibraltar TransAtlantic R/V, P2_03 Skaw-Gibraltar trip Taiwan-Japan and P3A_03 Japan-S. Korea trip Skaw-Passero (The Baltic Exchange Ltd., 2016). Therefore, it seems there is no need analysing how hedging is conducted in TCT terms, as in our case is not applicable.

#### 2.5.4.2. Hedging a Voyage Charter

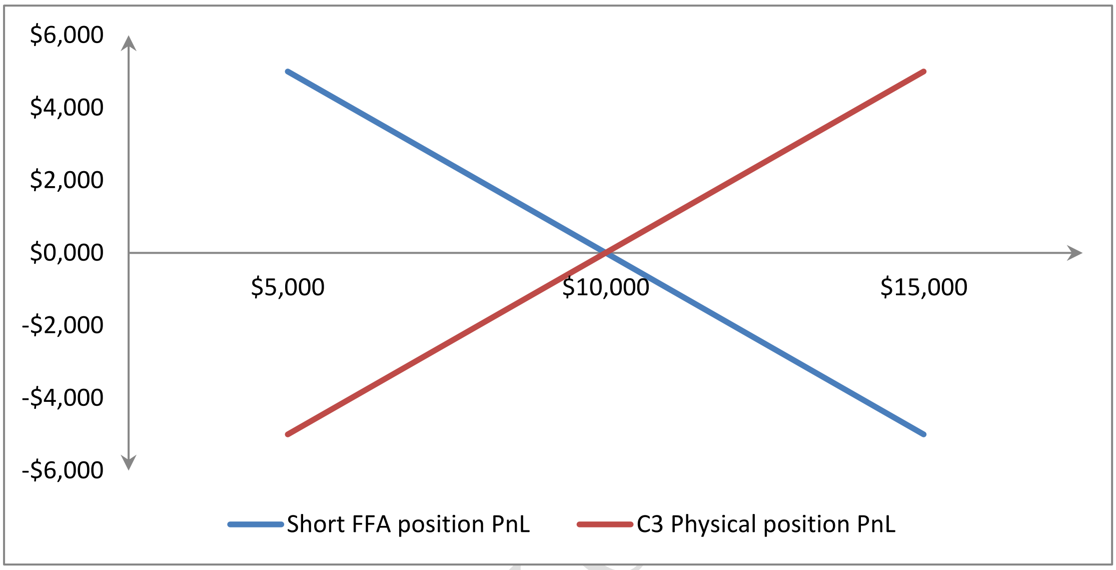
In this case, a ship-owner and a charterer are engaged in a contract where a good must be transported from a port of load to the port of destination in voyage terms. This means that payment to the ship-owner is conducted in dollar per ton of cargo terms and he is the one that has to cover all other costs of transportation, ie. Port dues, Canal dues, pilotage etc. (Kavousanos & Visvikis, 2006).

In this kind of employment the counterparties have the ability to hedge their risks in all voyage terms routes provided by the Baltic Exchange except two, the C2 Tubarao to Rotterdam (long tons) and the C15 Richards Bay to Fangcheng (The Baltic Exchange Ltd., 2016). In the remaining published voyage routes, the C3 Tubarao to Qingdao, C4 Richards Bay to Rotterdam, C5 West Australia to Qingdao and C7 Bolivar to Rotterdam hedging is possible through the corresponding FFAs (The Baltic Exchange Ltd., 2016).

Examining the side of the ship-owner first, an owner wishes to hedge against a decline in freight rates due to a possible downturn in market conditions of the specific route involved. Therefore a ship-owner is interested in locking future income in the level the FFA of the specific route. That means that through his FFA broker he needs to find a counter-party to take the opposite position (Alizadeh A. H. & Nomikos N. K., 2009). In economic terms the ship-owner is the seller of an FFA which means that he holds a short FFA position. FFA contracts based on the underlying voyage routes of the BCI are settled based on the average of the last month trading days at the end of the contract duration. If this settlement rate is below the locked price that the ship-owner has locked his earnings, then his is entitled of the difference times the number of tons transported he has hedged. The main difference that FFAs have compared to other forwards, as stated in previous sections, is that there is only a cash settlement and not a physical delivery of the good involved, in our case transportation services. This means that the owner is still operates his vessel in the physical market, in this case at lower levels, however, his is compensated through the FFA contract payoff, locking his freight income at the level of the FFA (Kavousanos & Visvikis, 2006).

On the contrary, if the settlement price calculated as stated above, is higher than the price of the FFA contract, which means that the market is at higher levels than the owner anticipated, he is the one that pays the counter-party the difference between the settlement price and the price of the contract. In the same sense as above, the owner now operates in a market that pays higher freight rates, however his gains are negatively impacted by the losses he has on the FFA market, keeping his earnings locked maintaining his hedged position (Alizadeh A. H. & Nomikos N. K., 2009).

*Diagram 2.1 Profit and Loss for a ship-owner in the physical and forward market in the C3 route.*



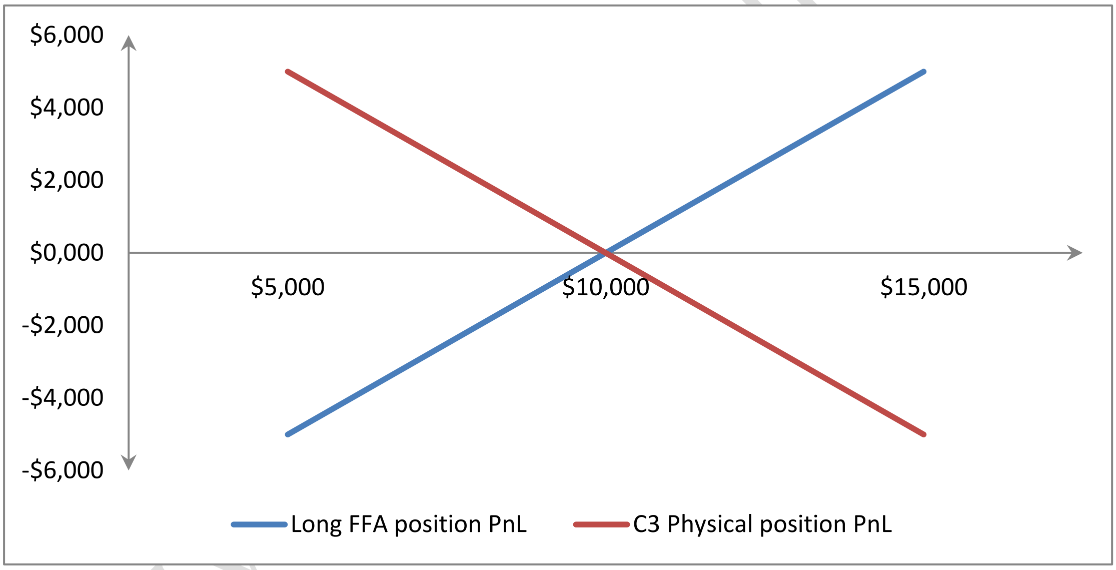

*Data and processing by the author, 2016*

The above diagram depicts the profit and loss for an owner hedging his position for hypothetical prices of settlement rates when he intends to lock his earnings at $10 per ton of transported cargo for the C3 Tubarao to Qingdao route. Above $10 per ton he is profitable in the physical market and "on the red" in the paper market, and the opposite when considering levels of freight below the $10 per ton mark.

A charterer, as a buyer of transportation services, has exactly the opposite position from a ship-owner. As a result, in order to hedge his risk as a buyer of transportation services, he needs to take an opposite position in the forward or "paper" market. A charterer intends to protect himself against a possible rise in freight rates maintaining a buying position of FFAs, or in derivatives terms a long position. Respectively to the above, he wants to lock the amount of money he needs to spend for the transportation of goods. Applying the same logic we have that when the settlement price is below the contract price he pays the difference to the counter-party losing on the FFA market. However, in the physical market the charterer can employ vessels at a lower rate gaining the difference and locking his expense at the levels of the FFA (Kavousanos & Visvikis, 2006).

Easily we can derive that when the settlement price, the average to the last month trading days, is above the price of the forward contract, the charterers receives the difference from the counter-party. However, because in the physical market he needs to pay higher freight rates to employ vessels for the intended transportation of goods, the overall position of the physical and "paper" market is locking his freight expenses at the price of the Forward Freight Agreement of the specific route (Kavousanos & Visvikis, 2006).

*Diagram 2.2 Profit and Loss for a charterer in the physical and forward market in the C3 route.*




*Data and processing by the author, 2016*

Respectively, the above diagram 2.2 is a graph interpretation of the profit and loss of a chartering trying to hedge his risk in the C3 Tubarao to Qingdao route. According to the analysis been made, as the market and equivalently the settlement rate rises above $10 per ton of cargo, the charterer has a gain from his long position as he has locked to pay a freight rate at $10 per ton as per FFA contract terms. However, in the physical market, and in order to actually transport the said cargo, he needs to pay more than $10 per ton of cargo, therefore the overall position has a result of locking freight rate payable at $10 per ton. Accordingly, when the market drops, the charterer is favoured in the physical market as he can employ a vessel in “cheaper” freight rates, however he has losses in the forward market as he has to pay the difference to his counter-party of the contract. Overall, this transaction will have the same result of locking freight rates at the level of $10 per ton of cargo.

#### 2.5.4.3. Hedging a Period Charter

In this kind of charter a vessel is employed basis a per day payment for a pre-agreed period of time. Freight is payable to the ship-owner in advance most commonly at a fifteen days intervals. Usually, depending the time period that a vessel is chartered, we can distinguish a short, medium and long period charter. For the duration of this charter fluctuation of freight rates is causing either one side, the ship-owner, or the other, the charterer, to be benefited or to be on the “loser’s” side. For this reason hedging of risk is pursued through a position in the forward market.

Accordingly to the above, we are going to mention hedging the risk of the ship-owner, who has already chartered his vessel, however at the end of the charter period volatility of freight rates urges him to hedge against a possible drop in his earnings. In this case, application of forwards quoted on specific routes is not appropriate as the trade the vessel will do will most probably be worldwide. This means that his has to hedge against the volatility of the whole Capesize sector instead of distinct routes. This possibility is provided through the FFAs on the 5TC_Average which is a basket of the five time charter routes C8_14 Gibraltar/Hamburg TransAtlantic R/V, C9_14 Continent/Mediterranean trip China-Japan, C10_14 China-Japan TransPacific R/V, C14 China-Brazil R/V and C16 Revised backhaul with weights 25%, 12.5%, 25%, 25%, and 12.5% respectively (The Baltic Exchange Ltd., 2016). These FFA contracts, as well as the contracts based on the specific routes, are applied for different time periods in order to cover different needs depending on the duration of the period charter. Therefore the owner can place a hedge strategy depending on when the current charter ends at the end of the current month, one month ahead and accordingly for two, three, four months, the end of the current quarter and the following six quarters and finally at the end of the first through the seventh calendar year (The Baltic Exchange Ltd., 2016).

The logic behind hedging the owner’s risk is equivalent to the one mentioned in the distinct routes. A ship-owner has a long position in the physical market, therefore he needs to have a short position in the forward market. This means that he has to sell FFAs, corresponding of course to the period he intends to hedge his risk covering possible losses from the physical charter of his vessel (Kavousanos & Visvikis, 2006). If the settlement price, calculated as an average of the last trading days corresponding to a month, which means that the physical market has risen, then the owner has a gain when chartering his vessel in higher freight rates, however in the forward market he has to pay the difference to his counter-party. Overall, he maintains his earnings in the level he locked them via the FFA. Accordingly, if the physical market has fallen, the owner has a loss from the physical market, hedge by a gain from the forward market (Papacharalampous, 2013).

A charterer in order to hedge the risk of having to pay more in the future to employ vessels for his cargoes, he needs to buy FFAs, or have a long position, as his position in the physical market is short. Without repeating the above, we can easily derive that when freights are above the level of the FFA price, then the charterer is paid from his counter-party, but he is forced to cover his transportation needs in higher levels. If the settlement price is lower, then the charterer loses on the forward market, but has the ability to charter vessels cheaply, maintaining his expense in freight paid to amount of the FFA contract (Alizadeh A. H. & Nomikos N. K., 2009).

### 2.5.5. Baltic Exchange Capesize vessel description

In order to standardize the procedure of publishing indices, vessel description of the benchmark vessel is reported and reviewed when necessary by the Baltic Exchange. Therefore we Forward Freight Agreements are based as of May 6th, 2014:

180.000mt dwt on 18.2m Summer Salt Water draft

Max age 10 years

198.000cbm grain

LOA 290m Beam 45m

15 knots ballast/14 knots on 62mt fuel oil (380 cst), no diesel at sea

When considering the prevailing timecharter market rate for the Baltic Capesize vessel, panellists should assume that, if steaming at 12 knots laden or 13 knots ballast, the vessel will consume 43mt fuel oil, no diesel at sea.

The commission basis on which panellists are asked to quote the routes has been amended to reflect current practice. The commission for the timecharter routes C8_14 (trans Atlantic round voyage); C9_14 (Continent trip Far East); C10_14 (Pacific round voyage) will be 5%. From May 6th 2014 all the Baltic timecharter routes are basis 5% commission. The commission on voyage routes C2. C3, C4, C5 and C7 remained unchanged at 3.75% total (The Baltic Exchange Ltd., 2014).

## 2.6. Hedging errors and risks

Hedging error derived from the strategy one follows to offset possible future losses, is existent using Forward Freight Agreements. The magnitude of the hedging error and equivalently the effectiveness of a hedging strategy, depends on a number of factors the main of which are presented below:

- Timing mismatch between paper and physical contracts: paper contracts are settled at the end of each month, whereas fixtures in the physical market can be concluded any time in that period. Depending on the volatility of the underlying market this mismatch can have an important effect on the performance of the hedge.

- Basis risk: basis risk arises due to the fact that the route underlying the FFA differs from the exposure in the market. Namely, the hedge conducted does not corresponds exactly to the trade that the vessel does, as possibly there is not an exact route for the trade, or possibly the FFA on the specific route has limited liquidity affecting the performance of the hedge.

- Size mismatch: when the vessel whose earnings we intend to hedge is different from the reference vessel used in the calculation of the underlying rates, basis risk can be generated. Benchmark vessel as described above is only a reference and the actual specifications vary from vessel to vessel.

- Relocation or non-earning-day mismatch: this may arise if, for example the vessel is off-hire for some days during the period. In this case there will be a mismatch because the earnings period hedged is different from the period over which earnings are received from the operation of the vessel.

- Liquidity risk: If liquidity in the market is low, establishing a hedging position or unwinding a hedge will occur at a premium due to the non-availability of counter-parties to trade in the market at the specified rate. This can be the case on routes where there is little trading interest, or in cases when one trades at the far end of the forward curve where liquidity in general tends to be low.

(Alizadeh A. H. & Nomikos N. K., 2009)

## 2.7. Conclusions

The above introduction and analysis of the Forward Freight Agreements will serve, additionally to establishing the main knowledge about their use, as starting point and cause to the analysis of the following chapters. This analysis will focus on whether after the introduction of the FFAs in the Capesize sector the volatility of the market seemed to be lower or higher. Evidents of lower volatility, considering other restrictions that may arise, will lead us to conclude overall that the FFAs helped to market transparency and the integration of more information in the physical market freights.

Issues to support a possible positive effect of the use of FFAs in the physical market according to the aforementioned analysis of chapter 2 can be firstly that FFA assessments are derived from experienced market participants. Code of market practice and ethics involved in the everyday transactions in shipping according to the Baltic Exchange can guaranty an unbiased outcome. Additionally to that, as the Baltic Exchange states, all indices produced are subject to the end users' judgement that it serves his interests. As the Baltic Exchange acts in a free and competitive market, the users' support is a sign of trust that the data produced are unbiased and that the use of FFAs as a hedging tool provide the expected results. Furthermore, the enhanced liquidity that arises from clearing FFA contracts in daily basis and through clearing houses can be another positive aspect for their use.

On the contrary, talk on the market does not support that FFA improved the market as they distort the trade in the physical market and distances players in the physical market from the actual physical supply and demand. Moreover, someone can disagree that the power of ethics and the quote "Our Word, Our Bond" is powerful enough in a market that is so vast, as this may be criticized as utopic. Last but not least, as every vessel differentiates from the benchmark vessel as described in section 2.5.5, a question may arise regarding to what extend can a FFA assessment represent future earnings of vessels in the market, as it can clearly affect freights achieved in the physical market.

# Chapter 3: Market presentation of the physical and forward Capesize sector

In the current chapter we are going to present the key figures that represent the physical and forward market regarding the Capesize vessel sector. These numbers are going to help us understand the size of the market we are referring to and therefore its importance.

## 3.1. Physical market of Capesize vessels

Firstly we are going to start with the physical market of Capesize vessels as the forward market was of course subsequent to the physical. In the following pages we are going to provide a historical recursion to the Baltic Capesize routes published, as these are the routes and indices we are going to examine in chapter 5. Next to that, it seems necessary to have a background of the cargoes a Capesize transports and its importance to global economy so as to determine what can be the factors that have an effect on the Capesize physical market.

### 3.1.1. Chronology of the Capesize reported routes

Track log of the Capesize vessels started from the Baltic Exchange since 4th January 1985. At that time Capesize standard routes that contributed to the then published benchmark shipping index, the Baltic Freight Index (BFI), were three. The Hampton Roads to South Japan with 120.000 tons of coal and 5% weighting to the BFI (route 6), the Queensland to Rotterdam route with 110.000 tons coal (route 8) with 5% weighting and the Monrovia to Rotterdam route with 90.000 tons of iron ore (route 10) and 5% weighting to the BFI as well (The Baltic Exchange Ltd., 2016). On February 5th 1991 we have the amendment of the above routes. Firstly route 7 that until that time was referring to Panamax vessels transposed as 100.000 tons coal (from 65.000 tons) from Hampton Roads to ARA range (5% weighting). Route 6 as described above changed weighting to 7.5% and route 10 was transposed to 135.000 tons iron ore from Tubarao to Rotterdam.

Continuing our historical recursion and due to technological changes that augmented the carrying capacity of oceangoing vessels, route 8 now represented the transportation of 130.000 coal from 110.000 tons as of February 5th 1992 (The Baltic Exchange Ltd., 2016). On February 5th 1993 route 7 increased carrying capacity to 110.000 tons from 100.000 previously and on November 3rd 1993 weighting of routes 7, 8 and 10 increased to 7.5%. On August 2nd 1995 route 10 (Tubarao to Rotterdam) increased transported cargo from 135.000 tons to 150.000 tons of iron ore. On May 6th 1998 routes 6 and 8 cease publication and two new ones are introduced: route 14 Tubarao to Beilun-Baoshan with 140.000 iron ore and 7.5% weight to the BFI and route 15 with 140.000 tons coal from Richard's Bay to Rotterdam and equivalent weights. On March 1st 1999 trials begin for the Baltic Capesize Index (BCI). This compromises four timecharter and seven voyage routes and began at 1000 points. The routes corresponded to this index were the below:

C1: 120.000 tons coal Hampton Roads to Rotterdam with 5% weight

C2: 160.000 tons iron ore Tubarao to Rotterdam with 10% weight

C3: 150.000 tons iron ore Tubarao to Beilun-Baoshan with 10% weight

C4: 150.000 tons coal Richard's Bay to Rotterdam with 5% weight

C5: 150.000 tons iron ore West Australia to Beilun-Baoshan with 15% weight

C6: 120.000 tons coal Newcastle to Rotterdam with 10% weight

C7: 150.000 tons coal Bolivar to Rotterdam with 5% weight

C8: 161.000 dwt timecharter Delivery Gibraltar-Hamburg transatlantic round voyage, duration 30-45 days with 10% weight

C9: 161.000 dwt timecharter Delivery ARA or passing Passero redelivery China-Japan, duration about 65 days with 5% weight

C10: 161.000 dwt timecharter Delivery China-Japan, round voyage, durations 30-40 days with weight 20%

C11: 161.000 timecharter Delivery China-Japan, redelivery ARA or passing Passero, duration about 65 days and 5% weighting.

(The Baltic Exchange Ltd., 2016)

On April 26th 1999 the BCI index is first published on a daily basis. On November 1st 2002 the new Baltic Capesize is described as: 172.000mt dwt, not over 10 years of age, 190.000 cbm grain, max loa 289m, max beam 45m, draft 17.75m, 14.5 knots laden, 15.0 knots ballast on 56mts fuel oil, no diesel at sea (The Baltic Exchange Ltd., 2016).

Subsequently, on April 1st 2004 the following changes to the Capesize Index are made: the C1 route ceases publication, the C3 route 150.000 mt iron ore Tubarao to Beilun-Baoshan changes weighting to 15%, the C6 route ceases publication and a new route is introduced, the C12 with 150.000 mt from Gladstone to Rotterdam with 10% weighting (The Baltic Exchange Ltd., 2016).

On June 1st 2009, the size of the voyage routes C3 (Tubarao-Beilun/Baoshan) and C5 (West Australia-Beilun/Baoshan) is changed from 150.000/10 to 160.000/10 and the discharge is changed to Qingdao basis usual disbursements (The Baltic Exchange Ltd., 2016).

Additionally, announcement for changes effected on June 1st 2010 are made, with the voyage route C12 (Gladstone-Rotterdam) to be suspended and the weighting of the timecharter route C11_03 (172.000 mt China/Japan trip Mediterranean/Cont) to become 15% (The Baltic Exchange Ltd., 2016).

On June 1st 2010, the above changes are implemented and the newly derived Multiplier for C11 is 0.016850646. On March 1st 2012, the amended laycan of the C5 route West Australia to China is implemented. The successful feedback and consensus led to the previous laycan of 20/35 days to be changed to 10/20 days forward from the days of the Index. On October 1st 2012, following successful consultation and in accordance with all previous announcements, with the process for minor changes under paragraph 5,d of the manual for panellists, the following changed are implemented:

C3 and C5 Brazil and West Australia to China: the cargo size description is changed to “160.000 mt or 170.000 mt 10 per cent”

C8_03, C9_03, C10_03 and C11_03 (the 4 Time Charters): the laycans are changed to 3/10 days ahead of the index date.

On September 25th 2013, and after a recent announcement of restriction in the main channel sailing draft in Dampier, panellists are instructed to continue to the benchmark the route C5 West Australia to Qingdao basis normal drafts (The Baltic Exchange Ltd., 2016).

On February 3rd 2014, dual reporting of the current Baltic Capesize vessel routes as well as the new Baltic Capesize 2014 vessel routes started. The Capesize with carrying capacity of 172.000 mt dwt described as above is supplemented with the Capesize with carrying capacity of 180.000 mt dwt described in section 2.5.5 to be on trial basis. The applicable new routes for the new vessel description including revised 5 Time Charter routes would be the bellow:

C8_14 – TRIAL (renamed trans Atlantic round voyage). 5% total commission

C9_14 – TRIAL (renamed Cont trip Far East). 5% total commission

C10_14 – TRIAL (renamed Pacific round voyage). 5% total commission

C14 – TRIAL (new route) – Delivery Qingdao spot or retroactive up to a maximum 15 days after sailing from Qingdao, round voyage via Brazil, redelivery China-Japan range, duration 80-90 days. Basis the Baltic Capesize 2014 vessel. 5% total commission

C15 – TRIAL (new route) – Richards Bay to Fangcheng. 160.000 mt coal, 10% more or less in owner's option, free in and out trimmed, scale load / 30.000mt Sundays + holidays included, discharge 18 hours turn time at loading port, 24 hours turn time at discharge port. Laydays/cancelling 25/35 days from index date. Age max 15 years, 5% total commission.

C16 (new route) – Delivery North China-South Japan range, 3-10 days from index date for a trip via Australia or Indonesia or US west coast or South Africa or Brazil, redelivery UK-Cont-Med within Skaw-Passero range, duration to be adjusted to 65 days. Basis the Baltic Capesize 2014 vessel and 5% total commission.

(The Baltic Exchange Ltd., 2016)

As of May 6th 2014 the trial basis of the above change is lifted. The Baltic Exchange Capesize Index (BCI) is modified to take into account some re-weighting of routes, the change to the benchmark vessel for the timecharter routes, and the addition of certain new routes.

As stated by the Baltic Exchange in the history the Baltic Indices provided, an implementation of a change to an index is always necessary to ensure that the integrity of the time series is maintained (ie there are no spikes or shifts in the data). In order to achieve this, the new index is normally modelled on the last day of trading of the old index so it produces the same result. This implementation provides the necessary adjustment factor for the time series to continue correctly and permits the application of the desired weighting (The Baltic Exchange Ltd., 2016).

A new route is starting being reported on a trial basis, on 18th June 2014. The new route, C17, to be published at 11:00 hours London time together with all the other Cape routes and will not contribute to the BCI whilst on trial. This route would describe on voyage basis the Saldanha Bay to Qingdao, 170.000 mt iron ore 10% more or less in owner's option, free in and out trimmed, 90.000 Sundays + holidays included load / 30.000 Sundays + holidays included discharge. 18 hours turntime loading port, 24 hours turntime discharge port. Laydays/cancelling 20/30 days from index date. Max age 18 years, 5% total commission. Trial status of the abovementioned route C17 lifted on November 24th 2014 (The Baltic Exchange Ltd., 2016).

On July 31st 2015, Capesize reporting changed and following differentials were applied to generate the published value for the 172.000 4TC average. This change entailed that from August 3rd 2015 the differential to the 180.000 4TC average will be -$1.120, while form January 2nd 2017 the differential to the 180.000 5TC average will be -$1.064 (The Baltic Exchange Ltd., 2016).

In order to conclude and summarize all the above changes conducted to the index and routes of the Capesize vessel reported by the Baltic Exchange, we have the bellow:

C2 160.000 10% iron ore Tubarao to Rotterdam, 5% weighting

C3 160-170.000 10% iron ore Tubarao to Qingdao, 15% weighting

C4 150.000 10% coal Richards Bay to Rotterdam, 5% weighting

C5 160-170.000 10% West Australia to Qingdao, 15% weighting

C7 150.000 10% coal Bolivar to Rotterdam, 5% weighting

C8_14 Trans Atlantic round voyage, 5% weighting

C9_14 Fronthaul, 7.5% weighting

C10_14 Pacific round voyage, 15% weighting

C14 China Brazil round voyage, 15% weighting

C15 160.000 10% coal Richards Bay to China, 5% weighting

C16 Revised backhaul 65 days, 7.5% weighting.

(The Baltic Exchange Ltd., 2016)

Economics of the Capesize market

Overall, the shipping industry is considered one of the most volatile, in which the Capesize market is massively fluctuated. In June 5th 2008 the BCI 4TC index peaked with a value of $233.988 (The Baltic Exchange Ltd., 2016), while only six months later it backed up and accelerated into the greatest shipping crash in the history of shipping and while during 2016 and more specifically on 17th March 2016 the same index hit an all-time low of just $485 (The Baltic Exchange Ltd., 2016). Additionally one day before the BCI had recorded 172 basis points while at its peak the same value was approximately 17.000 (The Baltic Exchange Ltd., 2016).

Capesize vessels deal with the transportation of a vast majority of raw materials (such as iron ore and coal), which are inputs for the steel and power industry. This means that the fluctuations of the Capesize market have a relationship with the strength of the world production economy, as the commodities transported are considered as strategic goods for several countries (Kim, 2013).

Capesize ships led the historical boom in the shipping industry from 2000 to the peak in 2008. This is due to the fact that demand for iron ore and coal had increased in unprecedented levels, exceeding supply of vessels (Kim, 2013).

The Capesize market has a homogeneous service, and its nature is free to enter with perfect competition. Because the main cargoes are iron ore and coal as per table 1, the Capesize market is a perfect competition and it depends on the law of demand

and supply (Kim, 2013). Additionally, the market is easily affected by some internal and external variables such as political and economic issues.

*Table 1 Capesize main cargoes*

| Commodity | Iron ore | Coal | Grain |
|---|---|---|---|
| | 70~80% | 30~40% | 0~5% |

(Grammenos, 2010)

#### 3.1.1.1. Demand for Capesize vessels

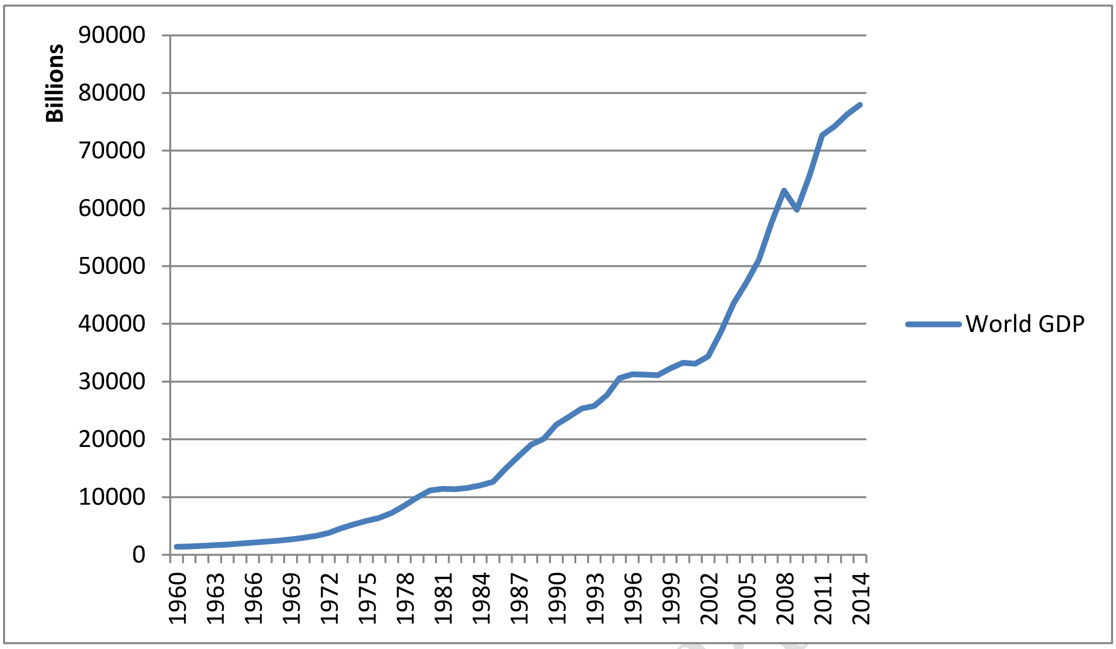
Demand for Capesize vessels can be described by various influential variables of which the major are analysed in short bellow.

##### 3.1.1.1.1. World economy

Shipping abides by the rule of derived demand (Stopford, 2009), as it is created by the trade between countries. Therefore the most crucial factor on ship demand is the global economy. According to Isserlis (1918), "there is similar timing of fluctuations in freight rates and cycles in the world economy". There should be a close relationship, since the world economy generates most of the demand for sea transport, through either the import of raw materials, such as iron ore and coal for the manufacturing industry or the trade in manufactured products (Stopford, 2009).

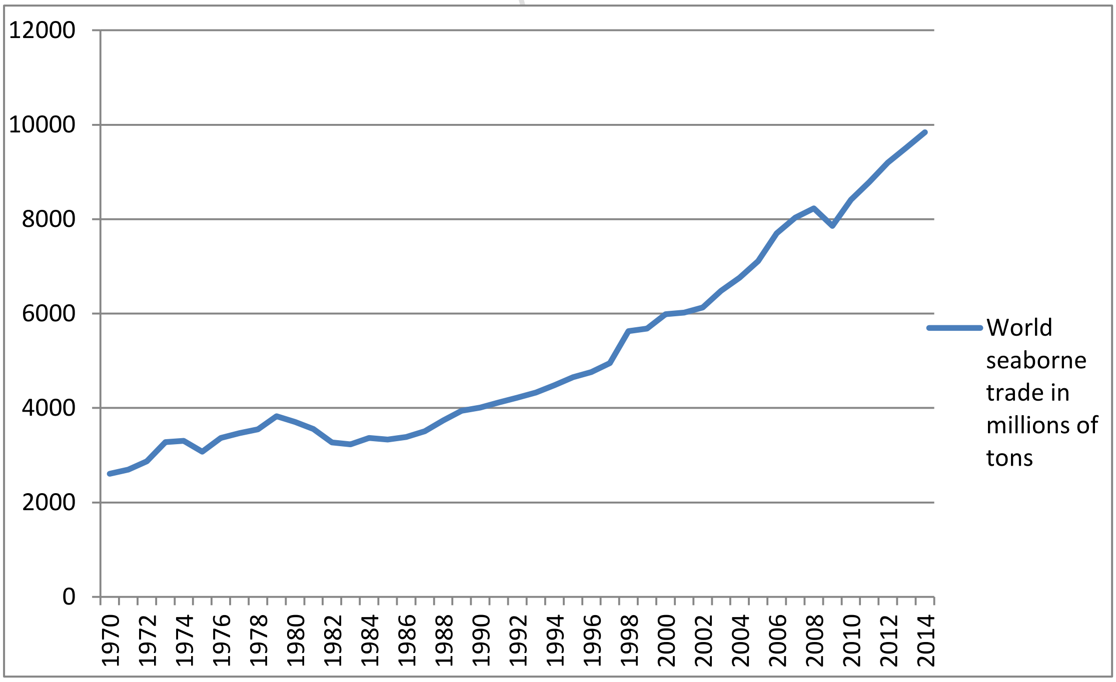
We can contrast data derived regarding world GDB and world seaborne trade for the last decades, with the conclusion to be made corresponding to the above.

*Chart 1 World Development Indicators, GDP at market prices US$ 1960-2014, in billion US$*




*Data from OECD, 2016*

*Chart 2 World seaborne trade in millions of tons, 1970-2014*




*Data from UNCTAD, 2016*

Therefore we can derive that as the world GDP increases the demand for seaborne trade increases as well, and in follows even the downwards direction of the

GDP as easily we can see during the 2008 economic crisis burst transferred into shipping as well.

Furthermore, and because of the globalization of the shipping industry, the market and the freight rates are affected by other macroeconomic variables, such as the exchange rate and global inflation (Kim, 2013). To conclude, there are various direct and indirect effects caused from a number of factors of the world economy, making it a very difficult task to identify possible relations between different factors and the shipping market that can be sometimes contradictory if considered together.

##### 3.1.1.1.2. Commodities

Commodities trade of course represent a factor of the demand side of the equation. Capesize vessels are mainly involved in the transport of raw materials for steel production and energy generation. The products derived are used construct apartments, rails, ports, and roads for infrastructures and various other aspects of the economic activity. These two raw materials as well as Capesize vessels are concerned are iron ore and coal.

Firstly, iron ore represents 70~80% of the cargoes transported by Capesize vessels as stated in table 1 (Grammenos, 2010). At the end of 2014 increased production and exports from Australia led the seaborne iron ore to grow by 12.4% compared to a year before, to a total of 1.34 billion tons (UNCTAD, 2015). At that time iron ore exporters and importers as per market share were formed as bellow table 2 shows:

*Table 2 Market share of iron ore exporters and importers in 2014, %*

| **Iron ore exporters** | **%** | **Iron ore importers** | **%** |
|---|---|---|---|
| Australia | 54 | China | 68 |
| Brazil | 25 | Japan | 10 |
| South Africa | 5 | Europe | 9 |
| Canada | 3 | Republic of Korea | 6 |
| Sweden | 2 | Other | 7 |

| | |
|---|---|
| Other | 12 |

*UNCTAD, Review of Maritime Transport 2015*

The above means that major routes are formed from major exporters like Australia and Brazil, to major importers in the Far East, with China representing about 68% of global imports. This means that China's economy has the biggest effect on the Capesize market and its freights.

Overall, iron ore and its volatility in terms of iron ore price and cargo demand can have a major impact to the Capesize freights.

The other major component of commodities demand is coal. As per table 1, it represents 30~40% of Capesize cargoes. Coal shipments according to UNCTAD Review of Maritime Transport 2015, decelerated to 2.8% comparing to 2013, with total volumes estimated at 1.2 billion tons. Thermal coal exports, which accounted for over two thirds of coal trade in 2014, are estimated to have increased by 3.8% and reached 950 million tons. Coking coal shipments fell marginally (-0.8%) to 262 million tons, owning mainly to reduced import demand from China (Dry Bulk Trade Outlook, 2015a). The total decrease of coal shipments can be explained by environmental reasons, as energy production with coal fired plants is harmful to the environment.

As with the iron ore, China was the main engine fuelling the rapid expansion of world seaborne coal trade over the past decade, with its share of global coal shipments reaching 20.0% in 2014 up from 2.0% in 2005. An estimated 10.0% drop in China's coal imports in 2014 may have a significant impact on dry bulk shipping demand. Factors contributing to the drop in China's imports include, among others, the falling import demand, which reflects China's regulations on saleable coal, a slowdown in steel production, coal import taxes and quality limits, efforts to protect the domestic coal mining industry, hydroelectric power production and government initiatives to reduce air pollution (UNCTAD, 2015).

Reflecting the global reclassifications regarding coal transportation, the main exporters and importers of the commodity, which form the various Capesize routes, had the bellow market share:

*Table 3 Market share of coal exporters and importers in 2014, %*

| Coal exporters | % | Coal importers | % |
|---|---|---|---|
| Indonesia | 34 | China | 20 |
| Australia | 31 | Europe | 19 |
| Russian Federation | 9 | India | 18 |
| Colombia | 6 | Japan | 15 |
| South Africa | 6 | Republic of Korea | 11 |
| Canada | 3 | Taiwan Province of China | 5 |
| Other | 12 | Malaysia | 2 |
| | | Thailand | 2 |
| | | Other | 9 |

*UNCTAD, Review of Maritime Transport 2015*

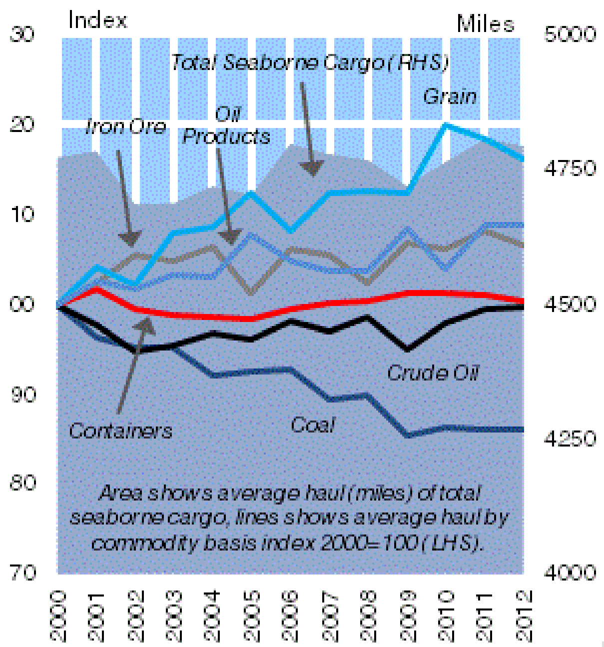


### 3.1.1.1.3. Average haul

Demand for transportation services for the raw materials the bulk carriers are transporting, is also a variable of voyage distances, voyage period, and ship's size. Average haul is generally defined as distance efficiency from Middle East to Western Europe (Kim, 2013). The average haul is calculated to measure ton-miles, namely it is measured as a cargo shipped tons, multiplied by its average transport distance. The average haul plays a very important role in calculating and forecasting the demand for sea transport services.

Between the years 2000 and 2012, the average haul for coal decreased by 14% to 3.961, as increasing Asian coal demand caused Australian and Indonesian exports, to China to accelerate (Clarksons, 2012). This reduction in the average haul for coal can be explained by the proximity of these two markets to the main importers in Far East. According to the same report by Clarksons, the average haul for iron ore shipments has risen by 7% as the boom of the Chinese market and economy, cause the main exporter Australia not to be able to cover the urge for iron ore. This gap was filled by other main iron ore exporters as Brazil and South Africa. Overall, the average dry bulk haul remained fairly steady at around 5.100 miles (Clarksons, 2012).

*Figure 1 The average haul of seaborne cargo*




*Clarksons Research Services, 2012*

#### 3.1.1.2. Variables of the supply of Capesize vessels

The supply side of the equation is consisted mainly by the number of ships available on the water, the ones that are going to be delivered from the shipyards, and of course the ones that are headed to the scrapyards for demolition after their economic life has ended, or the economics of the shipping market do not support their operation. Secondary variables can of course be “hot” or “cold” layup, that has a more immediate effect in the supply side, and the vessels’ operational speed.

##### 3.1.1.2.1. Historical growth of the Capesize merchant fleet

In terms of economics, every market development can be analysed by the law of supply and demand. Thus, the Capesize fleet development might affect the equilibrium leading to changes in freight rates and the market’s descriptive indices. Starting back in 1970, the Capesize fleet was about 1.29 million dwt (12 vessels), while in 1980 the volume increased to about 18.30 million dwt. Subsequently, and due to the fact that coal demand increased, the supply side tried to keep up with volume growth of over 10% (Clarksons Research, 2013). In 2000, Capesize fleet volume was about 80 million dwt worldwide. At that time, the economy experienced a boom in the period 2000-2008, leading to a dramatic increase in Capesize vessels, which at 2008 stood up at 143 million dwt, due to the expansion in demand of raw materials like iron ore and coal.

Looking between different time intervals we can see that volume increase between 1970 and 1980 was about 17 million dwt. During the next decade increase was about 30 million dwt the same during 1990 and 2000. After 2000, and due to the impact of China in the world economy, between 2000 and 2005 increase in volume was 26 million dwt, while between 2005-2008 we had a yearly increase of about 10 million dwt. From 2009 to 2013 the average increasing volume was about 34 million dwt yearly and at the end of 2013 it reached a total capacity of 279 million dwt and 1.505 vessels (Clarksons Research, 2013).

During 2014, the capacity of ordered in large and standard Capesize vessels was about 13.9 million dwt, due the extremely low newbuilding prices which at that time were thought to have bottomed out. In 2015 the deliveries were 13.8 million dwt and for the following years newbuilding deliveries were scheduled as follows: in 2016 31.8 million dwt, in 2017 4.2 million dwt, in 2018 0.4 million (Braemar, 2016).

## 3.2. Forward market of the Capesize vessels

After presenting the physical market of the Capesize vessels in chapter 3.1 and their historical evolution in subchapter 3.1.1, now its time to focus on the “paper” market from its introduction until today. Therefore we are going to do the same chronological presentation for the Forward Freight Agreements, from information derived from the Baltic Exchange Ltd (The Baltic Exchange Ltd., 2016).

### 3.2.1. History of the FFAs in the Capesize sector

Forward Freight Agreements for the Capesize vessels showed up later than that of the Panamax type vessels, despite the fact that Capesize vessels show an increased volatility due to their size and dependency in specific cargoes.

First trials for the Capes introduced in February 2nd 2003 for the route C4 (Richards Bay to Rotterdam), for which assessments were on the basis of the current month and one and two months forward and were produced on a weekly basis (The Baltic Exchange Ltd., 2016). On May 7th 2004 the BFA commenced trials on a number of heavily traded dry and tanker routes on a daily basis. Among the dry routes these were the C4, the C7 (Bolivar o Rotterdam) and the Capes 4TC. On September 1st 2005, a change is effected on the BFA reporting. Firstly, the C3 and C5 routes are introduced and secondly the rollover date, for all routes, is set as the first working day of each month.

On April 6th 2009, two extra calendar years are added to BFA routes C4 and C7, following market requests and will also match the number of calendar years reported for the Capesize Timecharter BFA. The codes of the new periods added for the two mentioned routes are: C4+4CAL, C4+5CAL, C7+4CAL, C7+5CAL. Continuously, on September 10th 2009, an extra period of +1 month is added on all Dry Time Charter Forward Curves, therefore for the Capesize regarding the 4TC (The Baltic Exchange Ltd., 2016).

On March 1st 2010, there are a series of changes to the BFA reporting. C3+5MON and C5+5MON period are added to C3 and C5 respectively. The periods C3_1M1QNR, C3_1M2QNR, C3_1M3QNR, C4_1M1QNR, C4_1M2QNR, C5_1M1QNR, C5_1M2QNR, C5_1M3QNR, C7_1M1QNR, C7_1M2QNR are no longer reported and are replaced with full quarters as bellow:

C3CURQ, C3+1Q, C3+2Q, C3+3Q, C3+4Q

C4CURQ, C4+1Q, C4+2Q, C4+3Q, C4+4Q

C5CURQ, C5+1Q, C5+2Q, C5+3Q, C5+4Q

C7CURQ, C7+1Q, C7+2Q, C7+3Q, C7+4Q

Additionally, 4TC_C+2MON period will be added to Capesize time charter and as a result 4TC_CCURQ will be mathematically derived (The Baltic Exchange Ltd., 2016).

On June 30th 2010, calendar year 11 (CAL11) is added to the forward curves of the C3 and C5 routes. On May 9th 2011, Dry forward curve assessments include additional periods of plus 3 and plus 4 months and on June 6th of the same year, settlement prices for the C4 and C7 routes are reported basis entire month settlement instead of 7 days until that date. This means that all cape routes are currently reported basis entire month settlement (The Baltic Exchange Ltd., 2016). On August 23rd 2011, additional calendar years are added to the C3 route which were the C3+2CAL and the C3+3CAL. On November 10th, the Baltic Exchange Ltd. commenced reporting new curves for Capesize routes C8 and C9 for entire month as bellow:

| | |
|---|---|
| C8_03CURMON | C9_03CURMON |
| C8_03+1MON | C9_03+1MON |
| C8_03+2MON | C9_03+2MON |
| C8_03+3MON | C9_03+3MON |
| C8_03+4MON | C9_03+4MON |
| C8_03CURQ | C9_03CURQ |
| C8_03+1Q | C9_03+1Q |
| C8_03+2Q | C9_03+2Q |
| C8_03+3Q | C9_03+3Q |
| C8_03+4Q | C9_03+4Q |
| C8_03+1CAL | C9_03+1CAL |
| C8_03+2CAL | C9_03+2CAL |

On July 16th 2012, more quarters are added to the Cape TC which will be the 4TC_C+5Q and the 4TC_C+6Q. Additionally, as no open interest and Clearing houses were listing some of the routes assessed from February 1st 2013 the forward curves of the C8 route (Cape transatlantic round voyage) will be suspended.

All the above changes and alterations bring us to today, where Forward Freight Agreements are daily assessed for the C3, C4, C5, C7 and the BCI_4TC for periods of the current month the least and up to seven calendar years in the future (The Baltic Exchange Ltd., 2016).

### 3.2.2. The size of the forward freight market

Regarding now the size of the market this is quantified by a unit of measurement called "lot". In general, any group of goods or services making up a transaction is called a lot. In the financial markets, a lot represents the standardized quantity of a financial instrument as set by an exchange or similar regulatory body. For exchange-traded securities, a lot may represent the minimum quantity of that security that may be traded (Investopedia, 2016).

The concept of lots allows the financial markets to standardize price quotes. For example in the case of stocks, equity options are prices such that each contract (or lot) represents exercise rights for 100 underlying shares of common stock. With such standardization, investors always know exactly how many units they are buying with each contract and can easily assess what price per unit they are paying. Without such standardization, valuing and trading options would be needlessly cumbersome and time consuming (Investopedia, 2016).

In the case of the shipping Forward Freight Agreements, the market convention is to measure the volume of trades in terms of lots where one lot represents a one-day unit of trip-charter hire or 1000 mt of voyage-based ocean transportation. In each case a single transaction, although having a buyer and a seller, is counted for one lot (Alizadeh A. H. & Nomikos N. K., 2009).

According to data provided for the Baltic Exchange Ltd. we can present the volume of lots traded for over the counter and cleared contracts of Capesize vessel forward freight agreements. In 2007 the weekly data provided show that the size of the market for Capes was 315.415 lots, in 2008 the market augmented to 757.527 lots, however, after the burst of the shipping crisis there was a two consecutive year reduction in the trade of FFAs. In 2009, market size stood up at 540.325 lots and the decrease continued in 2010 when the number of lots traded was 456.329. In 2011 FFAs showed an increase in usage with 509.344 lots, which however did not hold in 2012 with a volume of 461.240 lots. The following years and until a year ago, i.e. 2015, the market had some ups and downs with the volume recording 591.755 in 2013, 635.674 in 2014 and 608.328 in 2015. Even though the FFA market recovered after the 2008 shock, it never reached again the levels of that year, and the volatility may show slight improvements and deterioration of the physical market. The failure of the market to recover in 2015, after many predictions and reports leading to that assumption, may be the reason behind the drop reported in 2015 comparing to a year before (The Baltic Exchange Ltd., 2016).

According to the above explanation of the meaning of the lot, in 2015 and in the paper market owners, charterers and speculators, namely market participants, traded 608.328 days of time charter in Capesize vessels, or on voyage terms 608.328.000 mt of cargo.

In order to have a more common understanding of the size of the market, we asked for the Baltic Exchange to provide some information of the dollar market value of forwards. The data were calculated by taking the forward curves and applying the number of lots traded; therefore the figures presented are estimations and cannot be broken down to vessel asset class.

In 2012, where dry lots where 929.686 the estimation of the forward dry market value in U.S. dollars was $7.322.295.536. In 2013, the trade of 1.154.873 lots led to a market valuation of $13.975.705.172. Continuously, in 2014 market size was 1.186.152 lots with a value of $13.035.266.273 and in 2015 market size of 1.240.121 lots with a value of 8,33 billion (estimation) (The Baltic Exchange Ltd., 2016).

All the above can give us the essence of the importance of the Forward Freight Agreements market, as its size can have a possible impact on the physical market. A comparison of the size of the physical and forward market would give us a better understanding of the above, however the Baltic Exchange does not have a database recording the dollar value for the physical market fixtures.

# Chapter 4: Methodology and data presentation

In this section of the thesis we are going to present the methodology used to produce the main conclusions, as well as the dataset used. The purpose of this study as mentioned in the introductory part is to ruling to whether the introduction of the FFAs provided transparency in the Capesize physical market. According to previous literature see (Kavoussanos & Visvikis, 2004) the impact of FFAs in the physical market can be located in the volatility of the underlying physical routes. In their article "Over-the-Counter Forward Contracts and Spot Price Volatility in Shipping" the authors Mr Kavoussanos and Mr Visvikis are studying the impact of the introduction of Forward Freight Agreements to the volatility of the physical market of the Panamax type vessels and the underlying specific routes P1, P1A, P2, P2A.

The results in the Panamax sector are in accordance with the results of most futures markets, suggest that the onset of FFA trading has had (i) a stabilizing impact on the spot price volatility in all routes; (ii) an impact on the asymmetry of volatility in routes 2 and 2A; and (iii) substantially improved the quality and speed of information flowing in routes 1, 1A and 2. After the inclusion of other explanatory variables set by the authors (S&P500 Composite index, S&P500 Commodity Index, London Brent crude oil Index and West Texas Intermediate) the results indicate that only in voyage routes 1 and 2 the reduction in volatility may be a direct consequence of FFA trading. Furthermore, the results do not present a clear answer as to whether reduction in spot volatility, in routes 1A and 2A, is a direct consequence of FFA trading (Kavoussanos & Visvikis, 2004).

The findings of this study are that the introduction of FFA contracts has not had a detrimental effect on the underlying Panamax spot market. On the contrary it appears that there has been an improvement in the way that news is transmitted into prices following the onset of FFA trading. Thus even those market agents who do not directly use the FFA market have benefited from the introduction of FFA trading (Kavoussanos & Visvikis, 2004).

To test the impact of the introduction of FFA contracts in the Panamax sector, this paper uses a GARCH model modified along the lines of the GJR-GARCH model of (Glosten, Jagannathan, & Runkle, 1993), which allows for asymmetric impact of news (positive or negative) on volatility.

## 4.1. The GARCH model

The previous model called ARCH (Autoregressive Conditional Heteroskedastic) (Engle, 1982) explicitly recognizes the difference between the unconditional and the conditional variance allowing the latter to change over time as a function of past errors. The statistical properties of this parametric class of models have been studied further in Weis (1982) and in Milhoj (1984).

Let εt denote a real-valued discrete-time stochastic process, and ψt the information set (σ-field) of all information through time t. The GARCH(p,q) process is then given by

εt | ψt-1 ~ N (0, ht) (1)

ht = a0 + $\sum_{t=1}^{q}$ atεt-12 + $\sum_{t=1}^{p}$ βtht-1 = a0 + A(L)εt2 + B(L)ht (2),

where

p ≥ 0, q > 0

a0 > 0, ai ≥ 0, i=1,………,q

βi ≥ 0, i=1,…………,q

For p = 0 the process reduces to the ARCH (q) process, and for p = q = 0 εt is simply white noise. In the ARCH (q) process the conditional variance is specified as a linear function of past sample variances only, whereas the GARCH (p, q) process allows lagged conditional variances to enter as well. This corresponds to some sort of adaptive learning (Bollerslev, 1986).

The GARCH (p, q) regression model is obtained by letting the εt 's be innovations in a linear regression,

εt = yt – xt'b (3)

where yt is the dependent variable, xt a vector of explanatory variables, and b a vector of unknown parameters.

If all routes of 1-B(z) = 0 lie outside the unit circle, (2) can be rewritten as a distributed lag of past εt2's,

$ht = a0(1-B(1))-1 + A(L)(1-B(L))-1\varepsilon t2 = a0(1-\sum_{i=1}^{p} \beta i)-1 + \sum_{i=1}^{\infty} \delta i\varepsilon i-12$ (4)

which together with (1) may be seen as an infinite-dimensional ARCH (∞) process. The δi's are found from the power series expansion of D(L) = A(L)(1-B(L))-1,

$\delta i = ai + \sum_{j=1}^{n} \beta j\delta i-j$, i= 1,………..,q,

$= \sum_{i=1}^{n} \beta j\delta i-j$, i = q+1,…………… (5)

Where n = min(p, i-1). It follows that if B(1) < 1, δi will be decreasing for i greater than m = max{p, q}. Thus if D(1) < 1, the GARCH(p, q) process can be approximated to any degree of accuracy by a stationary ARCH (Q) for a sufficiently large value of Q. But as in the ARMA analogue, the GARCH process might possibly be justified through Wald's decomposition type of arguments as a more parsimonious description.

From the theory on finite-dimensional ARCH(q) processes it is to be expected that D(1) < 1, or equivalent A(1) + B(1) < 1, suffices for wide-sense stationarity; cf. Milhoj (1984).

Theorem 1. The GARCH(p, q) process as defined in (1) and (2) is wide-sense stationary with E(εt) = 0, var(εt) = a0(1-A(1)-B(1))-1 and cov(εt, εs) = 0 for t ≠ s if and only if A(1) + B(1) < 1.

As pointed out by Sastry Pantula and an anonymous referee, an equivalent representation of the GARCH (p, q) process is given by

$\varepsilon t2 = \alpha 0 + \sum_{t=1}^{q} \alpha t\varepsilon t-12 + \sum_{j=1}^{p} \beta t\varepsilon t-j2 - \sum_{j=1}^{p} \beta tvt-j + vt$ (6)

and

$vt = \varepsilon t2 - ht = (\eta t2 - 1)ht$, (7)

where

ηt ~i.i.d. N(0,1)

Note, by definition vt is serially uncorrelated with mean zero. Therefore, the GARCH (p, q) process can be interpreted as an autoregressive moving average process in εt2 of orders m = max{p, q} and p, respectively. Although a parameterization along the lines of (6) might be more meaningful from a theoretical time series' point of view, (1) and (2) are easier to work with in practice (Bollerslev, 1986).

The simplest but often very useful GARCH process is of course the GARCH (1, 1) process given by (1) and

ht = α0α1εt-12 + β1ht-1, α0 > 0, α1 ≥ 0, β1 ≥ 0 (8)

From Theorem 1, α1 + β1 < 1 suffices for wide-sense stationarity, and in general we have:

Theorem 2. For the GARCH (1, 1) process given by (1) and (6) a necessary and sufficient condition for existence of the 2mth moment is

$\mu(\alpha 1, \beta 1, m) = \sum_{j=0}^{m} \binom{m}{j}$ αjα1jβ1m-j < 1 (9)

where

α0 = 1, αj = $\prod_{i=1}^{j}$ (2j-1), j = 1…… (10)

The 2mth moment can be expressed by the recursive formula

E(εt2m) = αm[$\sum_{n=0}^{m-1}$ αn-1E(εt2n)α0m-n$\binom{m}{m-n}$μ(α1, β1, n)] x [1-μ(α1, β1, m)]-1 (11)

It follows by symmetry that if the 2mth moment exists, E(ε2m-1) = 0.

For β1 = 0, (9) reduces to the well-known condition for the ARCH (1) process, αmα1m < 1; cf. Engle (1982). Thus if α1 > (αm)-1/m in the ARCH(1) process, the 2mth moment does not exist, whereas even if $\sum_{i=1}^{\infty}$ δ1 = α1(1-β1)-1 > (αm)-1/m in the GARCH (1, 1) process, the 2mth moment might very well exist because of the longer memory in this process.

In the GARCH (1, 1) process the mean lag in the conditional variance equation is given by

$\zeta = \sum_{i=1}^{\infty} i\delta i / \sum_{i=1}^{\infty} \delta i = (1\text{-}\beta 1)\text{-}1$,

and the median lag is found to be

$\nu = \text{-}\log 2/\log\beta 1$,

where $\sum_{i=1}^{\nu} \delta i / \sum_{i=1}^{\infty} \delta i = ½$ and the δi's are defined in (5); cf (Harvey, 1982).

If 3α 12 + 2 α1β1 + β12 < 1, the fourth-order moment exists and by Theorem 2

$E(\varepsilon i2) = \alpha 0(1\text{-}\alpha 1\text{-}\beta 1)\text{-}1$,

And $E(\varepsilon_t^4) = 3\,\alpha_0^2(1+\alpha_1+\beta_1)[(1-\alpha_1-\beta_1)(1-\beta_1^2-2\alpha_1\beta_1-3\alpha_1^2)]^{-1}$.

The coefficient of kurtosis is therefore

$K = (E(\varepsilon_t^4) - 3E(\varepsilon_t^2)^2)E(\varepsilon_t^2)^{-2} = 6\alpha_1^2(1-\beta_1^2-2\alpha_1\beta_1-3\alpha_1^2)^{-1}$,

Which is greater than zero by assumption. Hence the GARCH(1, 1) process is leptokurtic (heavily tailed), a property the process shares with the ARCH(q) process (Bollerslev, 1986).

### 4.2.Data presentation

In this section we are going to analyse the main statistics that will be used to the econometric model, so as to identify possible signs that lead to either accept or diminish the use of FFAs as a stabilizing tool to the spot Capesize rates.

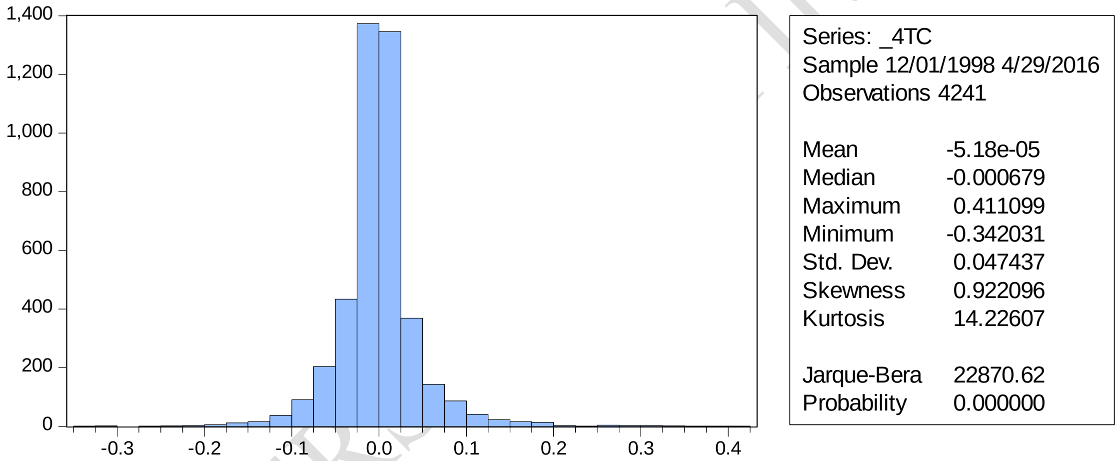
Therefore we are going to present the routes covered from FFA contracts which are the C3, C5, C7 and the time charter average index 4TC_avg with a timeframe covering the period from 1/12/1998 to 29/4/2016. In order to have a more smooth sample and abiding by common practice used in the econometrics, 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.

Lastly, additional data will be used so as to construct a model that better fits the distribution of the spot freight rates. These are the S&P500 Commodity Index, the Western Texas Intermediate (WTI) and the Brent spot rates.

#### 4.2.1. 4TC index

Firstly, for the 4TC and for whole period the use of EViews gives the bellow information:

*Figure 4.1 Descriptive statistics and histogram of 4TC for the whole period*




*Source: The Baltic Exchange, processing via Eviews from the author*

From the above what is of importance is the standard deviation of 0.047437 which we are going to compare with the two subsamples as well as the positive skewness of 0.922096, which means that the distribution has longer right tail and the mass of the distribution is concentrated in the left, and kurtosis of 14.22607 (rule of thumb over 3) which means that the distribution is leptokurtic comparing to normal distribution with a higher peak.

Additionally to the above, in order to proceed with our analysis we need to conduct some tests that are necessary for the implementation of the GARCH analysis introduced above.

First of all, we are examining the Jarque-Bera (Jarque & Bera, 1980) statistic viewed in the above table which shows whether the data are following a normal distribution in terms of skewness and kurtosis. The null hypothesis of skewness to be zero and excess kurtosis to be zero is rejected due to the probability of the Jarque-Bera statistic which is zero with a six decimal accuracy, supporting the skewness and kurtosis statistics mentioned above. Therefore, we can assume a departure from normality for the returns of the 4TC index of the Capesize vessels.

Secondly, a prerequisite for continuing the suggested method is stationarity. This means that the data have a probability distribution that do not change over time. The test used is called Augmented Dickey-Fuller test (Dickey & Fuller, 1981) (ADF) and tests the null hypothesis of whether a unit root is present in a time series sample against the alternative hypothesis of stationarity. Using the Eviews econometric program we can apply the ADF test, which gives the bellow results:

*Table 4.1: Augmented Dickey-Fuller test for the 4TC*

Null Hypothesis: D(_4TC) has a unit root
Exogenous: Constant
Lag Length: 14 (Automatic - based on SIC, maxlag=30)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -26.06502 | 0.0000 |
| Test critical values: | 1% level | -3.431714 | |
| | 5% level | -2.862028 | |
| | 10% level | -2.567073 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(_4TC,2)
Method: Least Squares
Date: 09/04/16 Time: 15:59
Sample (adjusted): 12/24/1998 4/29/2016
Included observations: 4223 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(_4TC(-1)) | -3.603980 | 0.138269 | -26.06502 | 0.0000 |
| D(_4TC(-1),2) | 2.398272 | 0.133138 | 18.01341 | 0.0000 |
| D(_4TC(-2),2) | 2.066375 | 0.127189 | 16.24644 | 0.0000 |
| D(_4TC(-3),2) | 1.742093 | 0.120083 | 14.50736 | 0.0000 |
| D(_4TC(-4),2) | 1.526961 | 0.111889 | 13.64716 | 0.0000 |
| D(_4TC(-5),2) | 1.316845 | 0.103155 | 12.76570 | 0.0000 |
| D(_4TC(-6),2) | 1.065498 | 0.093842 | 11.35423 | 0.0000 |
| D(_4TC(-7),2) | 0.898668 | 0.084235 | 10.66862 | 0.0000 |
| D(_4TC(-8),2) | 0.722320 | 0.074425 | 9.705381 | 0.0000 |
| D(_4TC(-9),2) | 0.534143 | 0.064200 | 8.319995 | 0.0000 |
| D(_4TC(-10),2) | 0.409934 | 0.054233 | 7.558808 | 0.0000 |

| | | | | |
|---|---|---|---|---|
| D(_4TC(-11),2) | 0.283842 | 0.044185 | 6.424009 | 0.0000 |
| D(_4TC(-12),2) | 0.193779 | 0.033833 | 5.727510 | 0.0000 |
| D(_4TC(-13),2) | 0.105648 | 0.024248 | 4.357045 | 0.0000 |
| D(_4TC(-14),2) | 0.050119 | 0.015497 | 3.234172 | 0.0012 |
| C | 3.57E-05 | 0.000546 | 0.065380 | 0.9479 |

| | | | |
|---|---|---|---|
| R-squared | 0.603749 | Mean dependent var | -4.13E-06 |
| Adjusted R-squared | 0.602337 | S.D. dependent var | 0.056230 |
| S.E. of regression | 0.035459 | Akaike info criterion | -3.837092 |
| Sum squared resid | 5.289664 | Schwarz criterion | -3.813039 |
| Log likelihood | 8118.019 | Hannan-Quinn criter. | -3.828589 |
| F-statistic | 427.3346 | Durbin-Watson stat | 2.004120 |
| Prob(F-statistic) | 0.000000 | | |

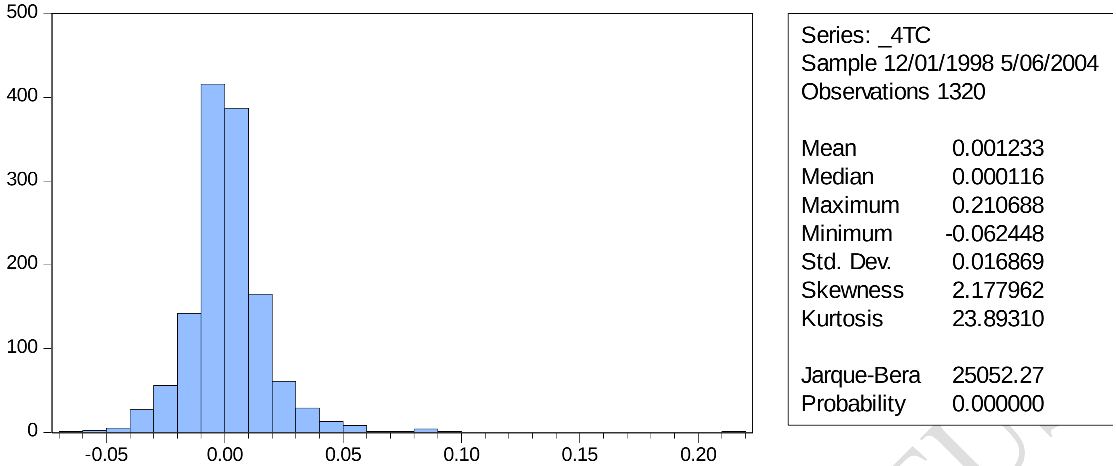
*Source: The Baltic Exchange, processing via Eviews from the author*

Therefore even at a significance level of 1% we reject the null hypothesis H0 and we cannot reject the H1, meaning that data is stationary, doing so with low probability of making an error as the probability of the Augmented Dickey-Fuller t-statistic is 0 with four decimals accuracy. This stationary process is applied for the first difference of the 4TC variable, which means that parameters such as mean and variance do not change when shifted in time. As stationarity is an assumption underlying many statistical procedures used in time series analysis (as we are doing in this thesis), no-stationary data often need to be transformed to become stationary, therefore in our case a procedure like this is of no need.

Both Jarque-Bera (Jarque & Bera, 1980) and ADP (Dickey & Fuller, 1981) tests have the same result to earlier study for the Panamax vessel sector (Kavoussanos & Visvikis, 2004).

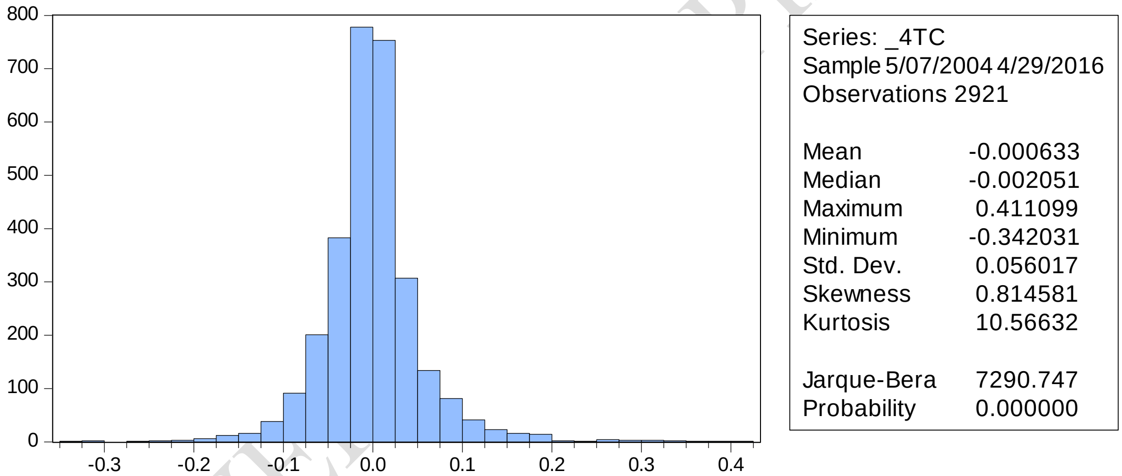
Now, in order to make our case stronger, we divide the sample in pre- and post-FFA periods and analyse the main results comparing to the whole period of our sample. The descriptive statistics for the pre-FFA and post FFA subsamples are calculated respectively:

*Figure 4.2 Descriptive statistics and histogram of 4TC for the pre-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.3 Descriptive statistics and histogram of 4TC for the post-FFA period*

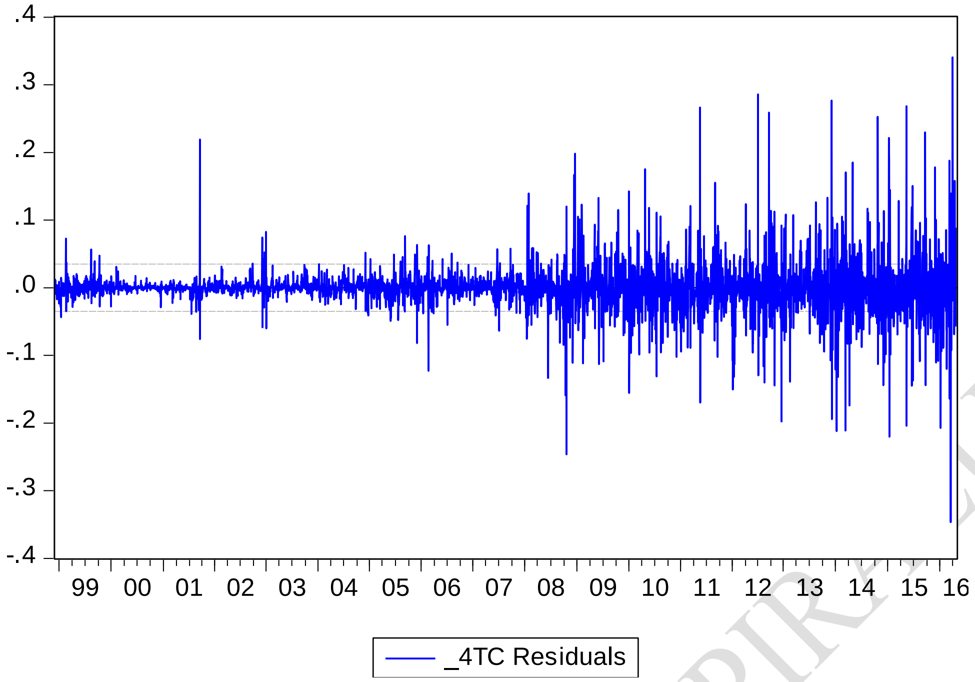



*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

The above show that in the pre-FFA period the standard deviation is lower from the post-FFA period and the whole sample. Furthermore, in the pre-FFA there is 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).

Lastly, we present a graph of the residuals of the 4TC index as derived from Eviews, which so an intense volatility after the crash of the shipping market in order to make our case stronger.

*Figure 4.4 Residuals of the 4TC*

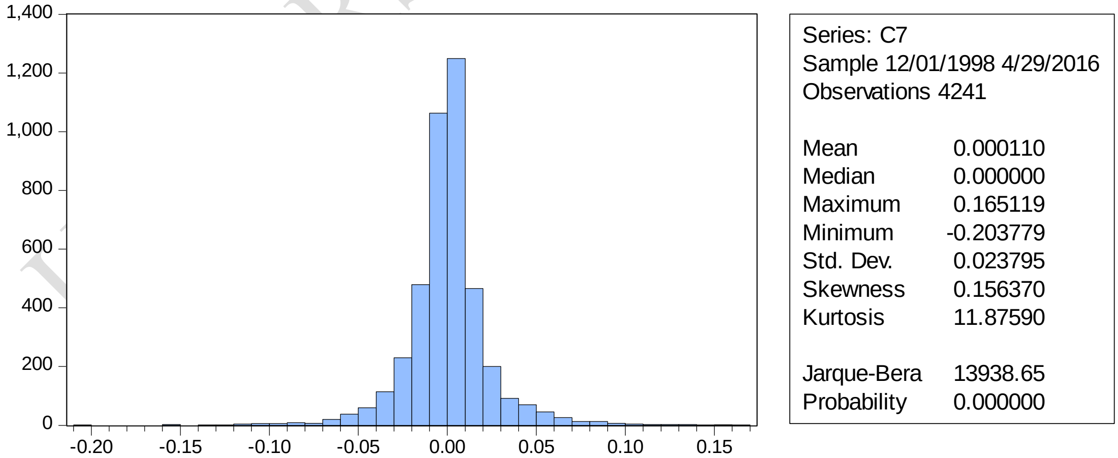



*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

### 4.2.2. C7 route Bolivar to Rotterdam

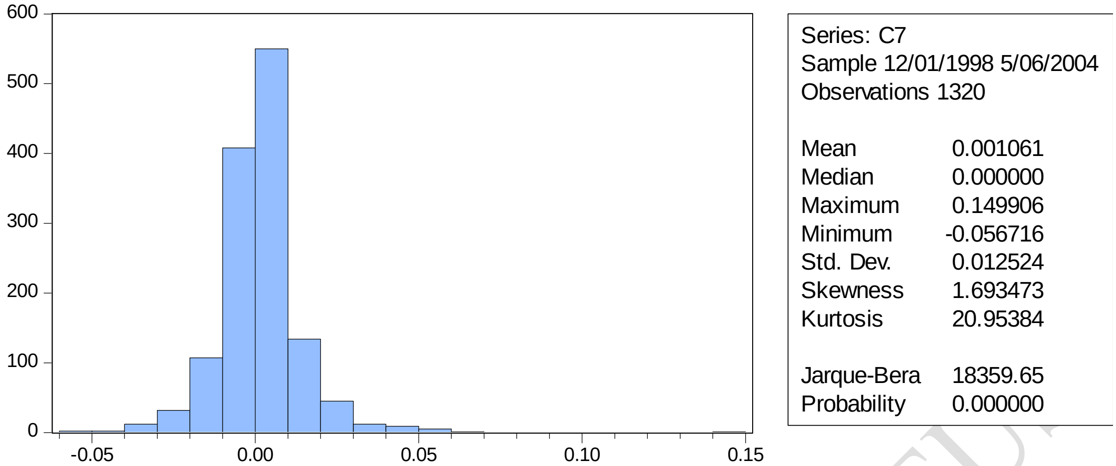
For the C7 route we have the below statistics for the whole period, the pre-FFA and the post-FFA period respectively:

*Figure 4.5 Descriptive statistics and histogram of C7 for the whole period*



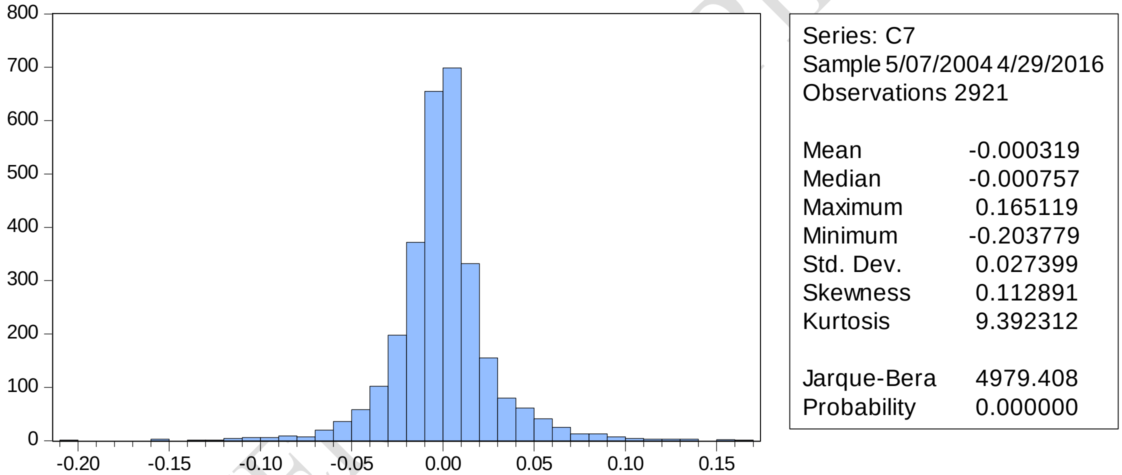

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.6 Descriptive statistics and histogram of C7 for the pre-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.7 Descriptive statistics and histogram of C7 for the post-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

In this case, for the route C7 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).

Same as for the case of the 4TC index, we will run some additional tests to identify the distribution of the data regarding the whole dataset. Firstly, we can detect the Jarque-Bera statistic which has a probability of 0.0000%, which means we can reject the null hypothesis of the data following a normal distribution and consequently not reject the hypothesis of departure from normality in terms of skewness and excess kurtosis.

Next step is to apply the Augmented Dickey-Fuller test (Dickey & Fuller, 1981) for the stationarity of the probability distribution.

*Table 4.2 Augmented Dickey-Fuller test for the C7*

Null Hypothesis: D(C7) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -27.66174 | 0.0000 |
| Test critical values: | 1% level | -3.431714 | |
| | 5% level | -2.862028 | |
| | 10% level | -2.567073 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(C7,2)
Method: Least Squares
Date: 09/05/16 Time: 23:12
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(C7(-1)) | -3.603964 | 0.130287 | -27.66174 | 0.0000 |
| D(C7(-1),2) | 2.261873 | 0.124869 | 18.11401 | 0.0000 |
| D(C7(-2),2) | 1.958061 | 0.117921 | 16.60484 | 0.0000 |
| D(C7(-3),2) | 1.603019 | 0.109810 | 14.59810 | 0.0000 |
| D(C7(-4),2) | 1.347130 | 0.100489 | 13.40577 | 0.0000 |
| D(C7(-5),2) | 1.091489 | 0.090578 | 12.05024 | 0.0000 |
| D(C7(-6),2) | 0.849371 | 0.080155 | 10.59660 | 0.0000 |
| D(C7(-7),2) | 0.657112 | 0.069237 | 9.490758 | 0.0000 |
| D(C7(-8),2) | 0.480427 | 0.058275 | 8.244082 | 0.0000 |
| D(C7(-9),2) | 0.318973 | 0.047314 | 6.741607 | 0.0000 |
| D(C7(-10),2) | 0.198206 | 0.036165 | 5.480577 | 0.0000 |
| D(C7(-11),2) | 0.110054 | 0.025888 | 4.251112 | 0.0000 |
| D(C7(-12),2) | 0.054618 | 0.015491 | 3.525850 | 0.0004 |
| C | 1.59E-05 | 0.000295 | 0.054062 | 0.9569 |

| | | | |
|---|---|---|---|
| R-squared | 0.650717 | Mean dependent var | -2.14E-06 |
| Adjusted R-squared | 0.649639 | S.D. dependent var | 0.032371 |
| S.E. of regression | 0.019161 | Akaike info criterion | -5.068588 |
| Sum squared resid | 1.546017 | Schwarz criterion | -5.047551 |
| Log likelihood | 10721.39 | Hannan-Quinn criter. | -5.061152 |

| | | | |
|---|---|---|---|
| F-statistic | 603.4724 | Durbin-Watson stat | 2.003950 |
| Prob(F-statistic) | 0.000000 | | |

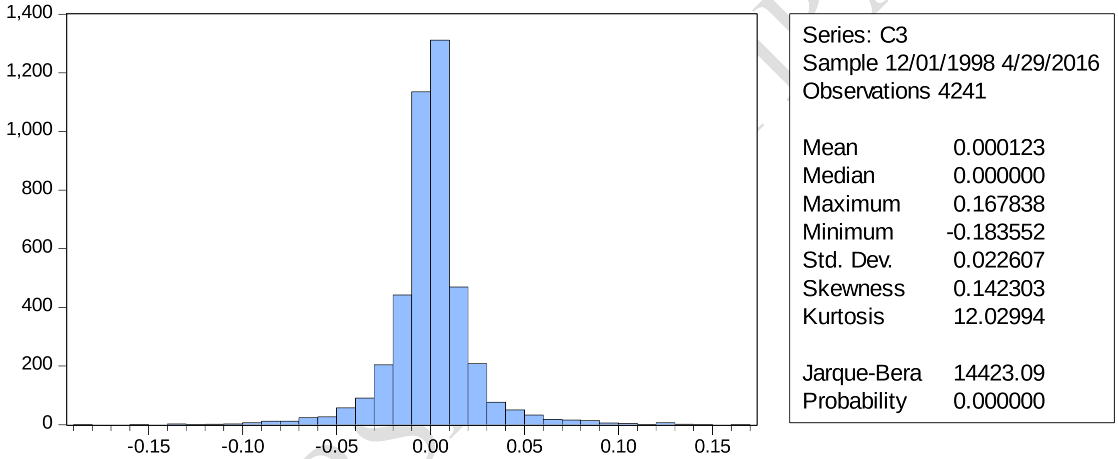
*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

We can come to the conclusion that with a test statistic of -27.66174 and probability 0.0000, the null hypothesis is rejected and we can suppose stationarity to the mean and variance, with a low probability of error.

### 4.2.3. C3 route Tubarao to Qingdao

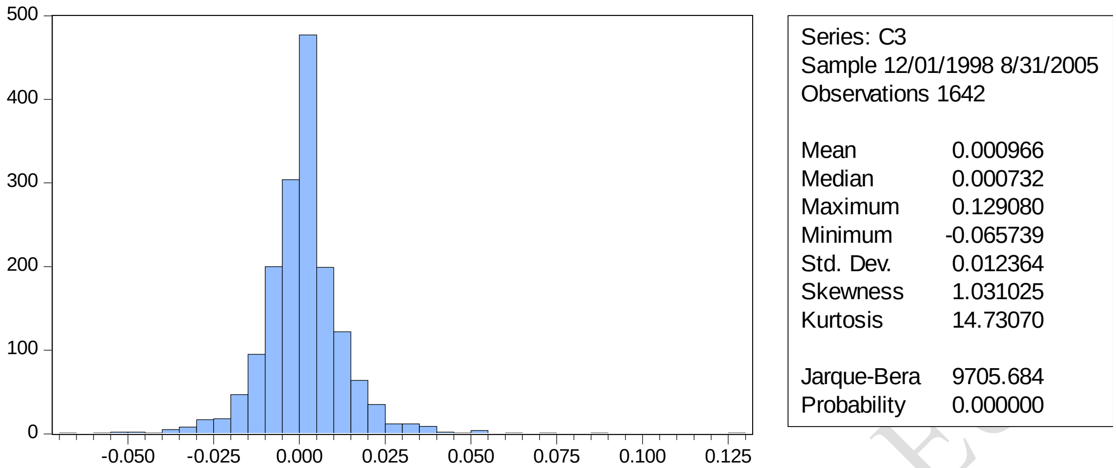
Continuously we are analysing the route C3 Tubarao to Qingdao with the same samples, however with a change point for pre- and post-FFA samples set on 1/9/2005:

*Figure 4.8 Descriptive statistics and histogram of C3 for the whole period*



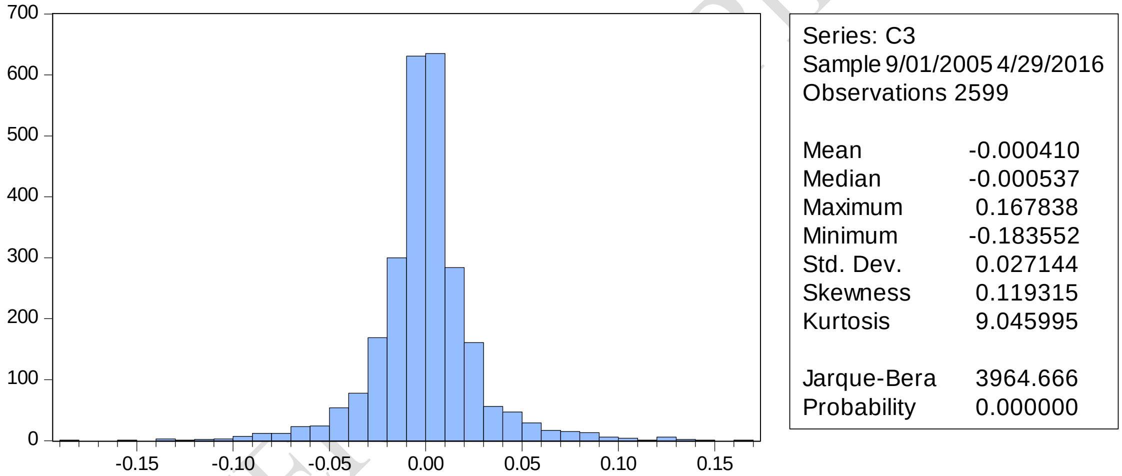

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.9 Descriptive statistics and histogram of C3 for the pre-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.10 Descriptive statistics and histogram of C3 for the post-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

In the first case we have a standard deviation of 0.022607 compared to 0.012364 in the pre-FFA period and 0.027144 in the post-FFA. 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).

In this route the Jarque-Bera statistic, as in the two previous cases shows departures from normality (14412.09, probability 0.000000). As long as the stationarity is concerned, the bellow table supports that mean and variance are stationary:

*Table 4.3 Augmented Dickey-Fuller test for the C3*

Null Hypothesis: D(C3) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -28.07944 | 0.0000 |
| Test critical values: | 1% level | -3.431714 | |
| | 5% level | -2.862028 | |
| | 10% level | -2.567073 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(C3,2)
Method: Least Squares
Date: 09/12/16 Time: 21:54
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(C3(-1)) | -3.751055 | 0.133587 | -28.07944 | 0.0000 |
| D(C3(-1),2) | 2.465739 | 0.128015 | 19.26136 | 0.0000 |
| D(C3(-2),2) | 2.134371 | 0.121146 | 17.61823 | 0.0000 |
| D(C3(-3),2) | 1.764414 | 0.112800 | 15.64199 | 0.0000 |
| D(C3(-4),2) | 1.444890 | 0.103308 | 13.98620 | 0.0000 |
| D(C3(-5),2) | 1.162486 | 0.092911 | 12.51183 | 0.0000 |
| D(C3(-6),2) | 0.867172 | 0.081707 | 10.61319 | 0.0000 |
| D(C3(-7),2) | 0.658443 | 0.069794 | 9.434043 | 0.0000 |
| D(C3(-8),2) | 0.488972 | 0.058132 | 8.411365 | 0.0000 |
| D(C3(-9),2) | 0.326429 | 0.046560 | 7.010902 | 0.0000 |
| D(C3(-10),2) | 0.179128 | 0.035388 | 5.061837 | 0.0000 |
| D(C3(-11),2) | 0.106932 | 0.025155 | 4.250958 | 0.0000 |
| D(C3(-12),2) | 0.049152 | 0.015485 | 3.174172 | 0.0015 |
| C | 1.95E-06 | 0.000278 | 0.007018 | 0.9944 |

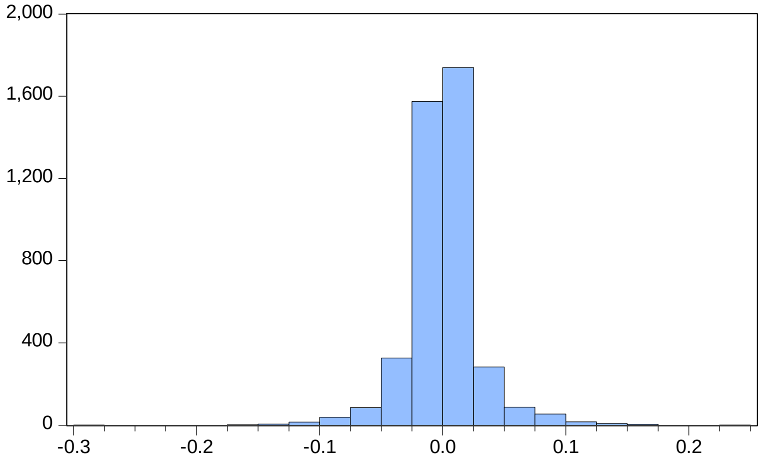
| | | | |
|---|---|---|---|
| R-squared | 0.628615 | Mean dependent var | 2.66E-06 |
| Adjusted R-squared | 0.627469 | S.D. dependent var | 0.029598 |
| S.E. of regression | 0.018065 | Akaike info criterion | -5.186328 |
| Sum squared resid | 1.374297 | Schwarz criterion | -5.165291 |
| Log likelihood | 10970.12 | Hannan-Quinn criter. | -5.178892 |
| F-statistic | 548.2808 | Durbin-Watson stat | 2.002453 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

### 4.2.4. C5 route West Australia to Qingdao

Below are the descriptive statistics for the route C5 West Australia to Qingdao:

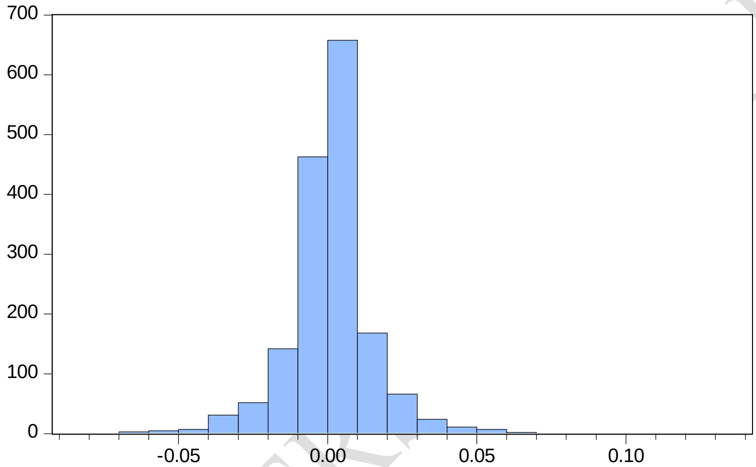
*Figure 4.11 Descriptive statistics and histogram of C5 for the whole period*




| Series: C5 | |
|---|---|
| Sample 12/01/1998 4/29/2016 | |
| Observations 4241 | |
| Mean | 1.64e-05 |
| Median | 0.000000 |
| Maximum | 0.244593 |
| Minimum | -0.277580 |
| Std. Dev. | 0.028277 |
| Skewness | 0.233265 |
| Kurtosis | 11.84094 |
| Jarque-Bera | 13850.38 |
| Probability | 0.000000 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

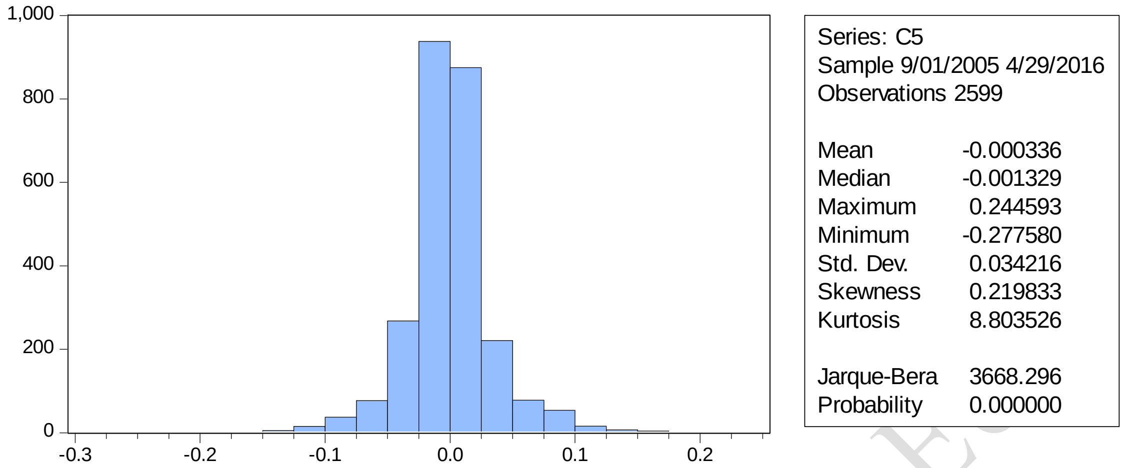
*Figure 4.12 Descriptive statistics and histogram of C5 for the pre-FFA period*




| Series: C5 | |
|---|---|
| Sample 12/01/1998 8/31/2005 | |
| Observations 1642 | |
| Mean | 0.000574 |
| Median | 0.000000 |
| Maximum | 0.131928 |
| Minimum | -0.080322 |
| Std. Dev. | 0.014561 |
| Skewness | 0.418765 |
| Kurtosis | 10.59793 |
| Jarque-Bera | 3997.586 |
| Probability | 0.000000 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Figure 4.13 Descriptive statistics and histogram of C5 for the post-FFA period*




*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

For this route, 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.

For the West Australia to Qingdao route, regarding normality the Jarque-Bera statistic concludes to the same results of non-normality (13850.38, probability 0.000000) for the whole sample (note that both subsamples give the same results).

Furthermore, the ADF test show that stationarity of mean and variance is existent even at a 1% significance level:

*Table 4.4 Augmented Dickey-Fuller test for the C5*

Null Hypothesis: D(C5) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -30.29335 | 0.0000 |
| Test critical values: | 1% level | -3.431714 | |
| | 5% level | -2.862028 | |
| | 10% level | -2.567073 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(C5,2)
Method: Least Squares

Date: 09/12/16 Time: 22:00
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(C5(-1)) | -4.765504 | 0.157312 | -30.29335 | 0.0000 |
| D(C5(-1),2) | 3.347961 | 0.151140 | 22.15133 | 0.0000 |
| D(C5(-2),2) | 2.898408 | 0.143331 | 20.22181 | 0.0000 |
| D(C5(-3),2) | 2.417201 | 0.133526 | 18.10283 | 0.0000 |
| D(C5(-4),2) | 1.984108 | 0.121951 | 16.26970 | 0.0000 |
| D(C5(-5),2) | 1.604766 | 0.109128 | 14.70532 | 0.0000 |
| D(C5(-6),2) | 1.273867 | 0.095644 | 13.31879 | 0.0000 |
| D(C5(-7),2) | 1.000108 | 0.081429 | 12.28200 | 0.0000 |
| D(C5(-8),2) | 0.716905 | 0.067032 | 10.69501 | 0.0000 |
| D(C5(-9),2) | 0.490563 | 0.052693 | 9.309821 | 0.0000 |
| D(C5(-10),2) | 0.313263 | 0.038962 | 8.040249 | 0.0000 |
| D(C5(-11),2) | 0.195289 | 0.026663 | 7.324260 | 0.0000 |
| D(C5(-12),2) | 0.054400 | 0.015477 | 3.514866 | 0.0004 |
| C | 8.77E-06 | 0.000385 | 0.022770 | 0.9818 |

| | | | |
|---|---|---|---|
| R-squared | 0.676571 | Mean dependent var | 7.28E-06 |
| Adjusted R-squared | 0.675572 | S.D. dependent var | 0.043942 |
| S.E. of regression | 0.025029 | Akaike info criterion | -4.534290 |
| Sum squared resid | 2.637892 | Schwarz criterion | -4.513253 |
| Log likelihood | 9592.688 | Hannan-Quinn criter. | -4.526854 |
| F-statistic | 677.6031 | Durbin-Watson stat | 2.004399 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

Concluding, the above results are a prerequisite to form the model presented in the next chapter. Mostly because we can naively detect a higher volatility during the period after the use of FFAs as a financial hedging tool, which gives us grounds for further investigation. Furthermore, important tests are implemented, the results of which so that the data need no further modification except for the common transpose to physical logarithms. Last but not least, we need to mention here that the WTI, Brent and S&P 500 Commodity Index variables are not tested and analysed, as according to our model they are going to be used as independent variables to show a possible effect on volatility of the spot Capesize rates.

# Chapter 5: The impact of FFAs in physical market volatility

After introducing the scope and the purpose of the thesis in chapter 1, presenting Forward Freight Agreements in chapter 2 and the physical and forward market of the Capesize vessels in chapter 3 and lastly by presenting the main idea of our econometric model and the data used, we can now proceed with the formulation of the model itself and the presentation of the results.

In order to test the repercussions of the introduction of FFAs the GARCH model presented in chapter 4 is modified according to the model of (Glosten, Jagannathan, & Runkle, 1993) named GJR-GARCH. This model allows for asymmetric impact of news (positive or negative) on volatility (Kavoussanos & Visvikis, 2004). Additionally, as stated by Kavoussanos et al. (2004) the GJR-GARCH model is the best among other GARCH models. Among those models, the symmetric GARCH (Bollerslev, 1986) 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).

To capture numerically the impact of FFA trading we introduce a dummy variable which will take the value of zero before the onset of FFAs and one for the post-FFA period. As for the 4TC and the C7 route the FFA introduction is different as that for the C3 and C5 routes, we will use the dummy D1 for the first case and the dummy D2 for the latter.

Using the Eviews econometric model we can calculate the estimators for the mean and variance equations. In the mean equation we have the dependent variable followed by the constant and only an AR(1) term. However, for the variance equation, which will give us the results in question, we are going to use as regressors the dummy that applies for the dependent variable (D1 and D2 as described above) and the other three variables mentioned on the previous chapter i.e. WTI, Brent and S&P500 Commodity Index.

Further to our introduced variables, the model itself generates an estimation for a dummy represented as RESID(-1)^2*(RESID(-1)<0, which assess if FFA trading has led to changes in the asymmetric response of volatility (Kavoussanos & Visvikis, 2004). This coefficient takes the value 1 for a negative shock and 0 otherwise. When the coefficient is equal to zero, the model becomes the symmetric GARCH model. However, a negative shock (value 1) can generate an asymmetric response. If the estimator of this coefficient is positive (negative), the model produces a larger (smaller) response for a negative shock compared to a positive shock of equal magnitude (Kavoussanos & Visvikis, 2004). To compare if the onset of FFA trading had an effect on the asymmetric impact of news, we need to calculate the GJR-GARCH model for pre- and post-FFA periods and compare the results.

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%.

This chapter is organized in two subsections: in the first we are going to 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). In the second subsection, we will run the model the for the pre- and post-FFA periods comparing the results for a possible asymmetric effect of FFAs.

## 5.1. Impact of the onset of FFA trading in actual conditional volatility

### 5.1.1. 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.

*Table 5.1 4TC index results for volatility with WTI as an independent variable*

Dependent Variable: _4TC

Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/12/16 Time: 23:15
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*D1 + C(8)*WTI

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000339 | 0.000840 | 0.403541 | 0.6866 |
| AR(1) | 0.792424 | 0.022274 | 35.57543 | 0.0000 |
| | | Variance Equation | | |
| C | 5.03E-05 | 8.06E-06 | 6.246857 | 0.0000 |
| RESID(-1)^2 | 0.930659 | 0.175818 | 5.293296 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.319026 | 0.189476 | -1.683729 | 0.0922 |
| GARCH(-1) | 0.424691 | 0.050744 | 8.369276 | 0.0000 |
| D1 | 0.000116 | 3.34E-05 | 3.465974 | 0.0005 |
| WTI | 0.001041 | 0.000205 | 5.070050 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.440840 | Mean dependent var | -5.19E-05 |
| Adjusted R-squared | 0.440708 | S.D. dependent var | 0.047474 |
| S.E. of regression | 0.035504 | Akaike info criterion | -4.637219 |
| Sum squared resid | 5.340747 | Schwarz criterion | -4.625231 |
| Log likelihood | 9836.585 | Hannan-Quinn criter. | -4.632982 |
| Durbin-Watson stat | 2.031407 | | |
| Inverted AR Roots | .79 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

Before commenting the above, we need to check whether the model captures ARCH heteroscedasticity effects, which would mean that the variance equation does not explain the residuals produced. For that reason, an ARCH LM Test is affected to the residuals which give us the bellow results:

*Table 5.2 4TC index ARCH test for the residuals*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.228688 | Prob. F(14,4210) | 0.9987 |
| Obs*R-squared | 3.210604 | Prob. Chi-Square(14) | 0.9986 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/13/16 Time: 00:05
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| C | 0.908079 | 0.092490 | 9.818144 | 0.0000 |
| WGT_RESID^2(-1) | -0.008590 | 0.015412 | -0.557354 | 0.5773 |
| WGT_RESID^2(-2) | -0.010705 | 0.015412 | -0.694559 | 0.4874 |
| WGT_RESID^2(-3) | -0.011137 | 0.015413 | -0.722543 | 0.4700 |
| WGT_RESID^2(-4) | -0.005727 | 0.015414 | -0.371546 | 0.7102 |
| WGT_RESID^2(-5) | 0.002130 | 0.015414 | 0.138201 | 0.8901 |
| WGT_RESID^2(-6) | 0.006605 | 0.015413 | 0.428521 | 0.6683 |
| WGT_RESID^2(-7) | -0.002692 | 0.015412 | -0.174688 | 0.8613 |
| WGT_RESID^2(-8) | 0.013270 | 0.015412 | 0.860979 | 0.3893 |
| WGT_RESID^2(-9) | 0.011896 | 0.015413 | 0.771793 | 0.4403 |
| WGT_RESID^2(-10) | -0.001266 | 0.015414 | -0.082151 | 0.9345 |
| WGT_RESID^2(-11) | 0.005462 | 0.015414 | 0.354379 | 0.7231 |
| WGT_RESID^2(-12) | 0.002623 | 0.015417 | 0.170125 | 0.8649 |
| WGT_RESID^2(-13) | -0.000580 | 0.015416 | -0.037598 | 0.9700 |
| WGT_RESID^2(-14) | 0.004815 | 0.015416 | 0.312336 | 0.7548 |

| | | | |
|---|---|---|---|
| R-squared | 0.000760 | Mean dependent var | 0.913622 |
| Adjusted R-squared | -0.002563 | S.D. dependent var | 4.900898 |
| S.E. of regression | 4.907174 | Akaike info criterion | 6.022817 |
| Sum squared resid | 101378.3 | Schwarz criterion | 6.045357 |
| Log likelihood | -12708.20 | Hannan-Quinn criter. | 6.030785 |
| F-statistic | 0.228688 | Durbin-Watson stat | 2.000129 |
| Prob(F-statistic) | 0.998652 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

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 as depicted above).

Regarding the first table with the results from 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).

*Table 5.3 4TC index results for volatility with Brent as an independent variable*

Dependent Variable: _4TC
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/14/16 Time: 22:20
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*BRENT + C(8)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000750 | 0.000748 | -1.003009 | 0.3159 |
| AR(1) | 0.789952 | 0.013871 | 56.94973 | 0.0000 |
| | | Variance Equation | | |
| C | 2.40E-06 | 9.61E-07 | 2.500064 | 0.0124 |
| RESID(-1)^2 | 0.423182 | 0.074244 | 5.699858 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.041468 | 0.147115 | -0.281878 | 0.7780 |
| GARCH(-1) | 0.732253 | 0.023569 | 31.06840 | 0.0000 |
| BRENT | 1.02E-05 | 6.10E-05 | 0.167544 | 0.8669 |
| D1 | 2.24E-05 | 7.57E-06 | 2.960361 | 0.0031 |

| | | | |
|---|---|---|---|
| R-squared | 0.441411 | Mean dependent var | -5.19E-05 |
| Adjusted R-squared | 0.441279 | S.D. dependent var | 0.047474 |
| S.E. of regression | 0.035485 | Akaike info criterion | -4.748185 |
| Sum squared resid | 5.335296 | Schwarz criterion | -4.736197 |
| Log likelihood | 10071.78 | Hannan-Quinn criter. | -4.743948 |
| Durbin-Watson stat | 2.028503 | | |
| Inverted AR Roots | .79 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

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 5.4 4TC index results for volatility with S&P500 as an independent variable*

Dependent Variable: _4TC
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/14/16 Time: 22:28
Sample: 12/02/1998 4/29/2016

Included observations: 4239
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*S_P500 + C(8)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.002392 | 0.004063 | -0.588603 | 0.5561 |
| AR(1) | 0.752598 | 0.025785 | 29.18772 | 0.0000 |
| | | Variance Equation | | |
| C | 0.000527 | 0.000524 | 1.005469 | 0.3147 |
| RESID(-1)^2 | 0.921440 | 0.906026 | 1.017013 | 0.3091 |
| RESID(-1)^2*(RESID(-1)<0) | -0.399441 | 0.317758 | -1.257060 | 0.2087 |
| GARCH(-1) | 0.183417 | 0.842122 | 0.217804 | 0.8276 |
| S_P500 | -0.011821 | 0.002717 | -4.350197 | 0.0000 |
| D1 | 4.37E-05 | 0.000281 | 0.155414 | 0.8765 |

| | | | |
|---|---|---|---|
| R-squared | 0.448509 | Mean dependent var | -5.19E-05 |
| Adjusted R-squared | 0.448379 | S.D. dependent var | 0.047474 |
| S.E. of regression | 0.035259 | Akaike info criterion | -4.282222 |
| Sum squared resid | 5.267500 | Schwarz criterion | -4.270234 |
| Log likelihood | 9084.169 | Hannan-Quinn criter. | -4.277985 |
| Durbin-Watson stat | 1.980106 | | |
| Inverted AR Roots | .75 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

### 5.1.2. 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). The ARCH tests for the three models produced will be presented in the appendix.

*Table 5.5 C7 index results for volatility with WTI as an independent variable*

Dependent Variable: C7
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/14/16 Time: 22:43
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 289 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| C | 0.000897 | 0.000525 | 1.707351 | 0.0878 |
| AR(1) | 0.748024 | 0.015062 | 49.66325 | 0.0000 |
| | | Variance Equation | | |
| C | 6.38E-06 | 1.60E-06 | 3.998778 | 0.0001 |
| RESID(-1)^2 | 0.249432 | 0.053161 | 4.691988 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.003178 | 0.066651 | 0.047679 | 0.9620 |
| GARCH(-1) | 0.696485 | 0.038547 | 18.06834 | 0.0000 |
| WTI | 0.000109 | 7.45E-05 | 1.470702 | 0.1414 |
| D1 | 3.59E-05 | 1.21E-05 | 2.961808 | 0.0031 |

| | | | |
|---|---|---|---|
| R-squared | 0.361841 | Mean dependent var | 0.000110 |
| Adjusted R-squared | 0.361690 | S.D. dependent var | 0.023807 |
| S.E. of regression | 0.019021 | Akaike info criterion | -5.677483 |
| Sum squared resid | 1.532868 | Schwarz criterion | -5.665495 |
| Log likelihood | 12041.42 | Hannan-Quinn criter. | -5.673246 |
| Durbin-Watson stat | 2.237520 | | |
| Inverted AR Roots | .75 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

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.

*Table 5.6 C7 index results for volatility with Brent as an independent variable*

Dependent Variable: C7
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/14/16 Time: 23:38
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 269 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*BRENT + C(8)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000682 | 0.000520 | 1.312123 | 0.1895 |
| AR(1) | 0.746548 | 0.015412 | 48.43943 | 0.0000 |
| | | Variance Equation | | |
| C | 6.39E-06 | 1.53E-06 | 4.187907 | 0.0000 |
| RESID(-1)^2 | 0.244814 | 0.054000 | 4.533578 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.000615 | 0.064173 | 0.009588 | 0.9923 |
| GARCH(-1) | 0.700258 | 0.040033 | 17.49220 | 0.0000 |
| BRENT | 0.000213 | 3.75E-05 | 5.674525 | 0.0000 |

| | | | | |
|---|---|---|---|---|
| D1 | 3.57E-05 | 1.22E-05 | 2.933201 | 0.0034 |

| | | | |
|---|---|---|---|
| R-squared | 0.362261 | Mean dependent var | 0.000110 |
| Adjusted R-squared | 0.362111 | S.D. dependent var | 0.023807 |
| S.E. of regression | 0.019014 | Akaike info criterion | -5.681174 |
| Sum squared resid | 1.531858 | Schwarz criterion | -5.669186 |
| Log likelihood | 12049.25 | Hannan-Quinn criter. | -5.676937 |
| Durbin-Watson stat | 2.235626 | | |
| Inverted AR Roots | .75 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

For the above 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. As a consequence, the above model, which shows a significant coefficient for the D1 dummy of the onset of FFA trading with a small positive effect on volatility, has not the appropriate specification.

Using the S&P500 Commodity Index the results are summarized below:

*Table 5.7 C7 index results for volatility with S&P500 as an independent variable*

Dependent Variable: C7
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/14/16 Time: 23:57
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 364 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*S_P500 + C(8)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000857 | 0.000534 | 1.605252 | 0.1084 |
| AR(1) | 0.750634 | 0.014836 | 50.59488 | 0.0000 |
| | | Variance Equation | | |
| C | 7.05E-06 | 1.72E-06 | 4.096157 | 0.0000 |
| RESID(-1)^2 | 0.264924 | 0.051805 | 5.113887 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.017410 | 0.063284 | -0.275110 | 0.7832 |
| GARCH(-1) | 0.684807 | 0.039898 | 17.16373 | 0.0000 |
| S_P500 | -0.000339 | 0.000115 | -2.934399 | 0.0033 |
| D1 | 3.78E-05 | 1.23E-05 | 3.080089 | 0.0021 |

| | | | |
|---|---|---|---|
| R-squared | 0.361153 | Mean dependent var | 0.000110 |
| Adjusted R-squared | 0.361002 | S.D. dependent var | 0.023807 |
| S.E. of regression | 0.019031 | Akaike info criterion | -5.680274 |
| Sum squared resid | 1.534521 | Schwarz criterion | -5.668286 |
| Log likelihood | 12047.34 | Hannan-Quinn criter. | -5.676037 |

| | |
|---|---|
| Durbin-Watson stat | 2.241069 |
| Inverted AR Roots | .75 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

Despite the significance of most of the coefficients of the variance equation, including that of D1 (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.

### 5.1.3. C3 route results

We continue the presentation of the results with the C3 Tubarao to Qingdao route. Firstly, we use Western Texas Intermediate as an independent variable for the variance equation, which gives the bellow results:

*Table 5.8 C3 index results for volatility with WTI as an independent variable*

Dependent Variable: C3
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/15/16 Time: 00:05
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000286 | 0.000533 | 0.537057 | 0.5912 |
| AR(1) | 0.721280 | 0.047572 | 15.16196 | 0.0000 |
| Variance Equation | | | | |
| C | 5.72E-06 | 1.32E-06 | 4.323340 | 0.0000 |
| RESID(-1)^2 | 0.685627 | 0.126493 | 5.420281 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.192731 | 0.175792 | -1.096357 | 0.2729 |
| GARCH(-1) | 0.586178 | 0.038932 | 15.05629 | 0.0000 |
| WTI | 0.000125 | 6.36E-05 | 1.956301 | 0.0504 |
| D2 | 1.63E-05 | 4.51E-06 | 3.606317 | 0.0003 |

| | | | |
|---|---|---|---|
| R-squared | 0.375875 | Mean dependent var | 0.000123 |
| Adjusted R-squared | 0.375727 | S.D. dependent var | 0.022676 |
| S.E. of regression | 0.017917 | Akaike info criterion | -5.928757 |
| Sum squared resid | 1.360083 | Schwarz criterion | -5.916769 |
| Log likelihood | 12574.00 | Hannan-Quinn criter. | -5.924520 |
| Durbin-Watson stat | 2.057977 | | |
| Inverted AR Roots | .72 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

The ARCH test for the residuals of the above GJR-GARCH process shows that the above 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).

Using Brent in the place of WTI gives the results presented in the next table:

*Table 5.9 C3 index results for volatility with Brent as an independent variable*

Dependent Variable: C3
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 20:22
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 245 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*BRENT + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000502 | 0.000557 | 0.901108 | 0.3675 |
| AR(1) | 0.721009 | 0.047312 | 15.23931 | 0.0000 |
| Variance Equation | | | | |
| C | 5.90E-06 | 1.33E-06 | 4.418873 | 0.0000 |
| RESID(-1)^2 | 0.687352 | 0.126869 | 5.417801 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.198054 | 0.177204 | -1.117661 | 0.2637 |
| GARCH(-1) | 0.583538 | 0.039264 | 14.86203 | 0.0000 |
| BRENT | 0.000123 | 3.28E-05 | 3.746517 | 0.0002 |
| D2 | 1.66E-05 | 4.59E-06 | 3.608092 | 0.0003 |

| | | | |
|---|---|---|---|
| R-squared | 0.375910 | Mean dependent var | 0.000123 |
| Adjusted R-squared | 0.375763 | S.D. dependent var | 0.022676 |
| S.E. of regression | 0.017916 | Akaike info criterion | -5.931145 |
| Sum squared resid | 1.360005 | Schwarz criterion | -5.919157 |
| Log likelihood | 12579.06 | Hannan-Quinn criter. | -5.926908 |

| | |
|---|---|
| Durbin-Watson stat | 2.057541 |
| Inverted AR Roots | .72 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

With the probability of the F-statistic of the ARCH test with a value of 0.9203, heteroscedasticity is not present for the residuals of the above equation. However, while using Brent instead of WTI the results for our dummy is almost the same with the previous test, with a significant coefficient (prob. 0.0003) and a small positive value (1.66E-05).

As a last test to prove a statistical relation between FFAs and C3 spot prices, we are using S&P500 Commodity Index.

*Table 5.10 C3 index results for volatility with S&P500 as an independent variable*

Dependent Variable: C3
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 20:31
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 264 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*S_P500 + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000431 | 0.000554 | 0.778019 | 0.4366 |
| AR(1) | 0.719524 | 0.049393 | 14.56743 | 0.0000 |
| | | Variance Equation | | |
| C | 5.48E-06 | 1.48E-06 | 3.699483 | 0.0002 |
| RESID(-1)^2 | 0.658096 | 0.121439 | 5.419151 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.212839 | 0.173781 | -1.224754 | 0.2207 |
| GARCH(-1) | 0.608334 | 0.037324 | 16.29881 | 0.0000 |
| S_P500 | -0.000222 | 0.000233 | -0.951104 | 0.3416 |
| D2 | 1.49E-05 | 4.26E-06 | 3.492216 | 0.0005 |

| | | | |
|---|---|---|---|
| R-squared | 0.376212 | Mean dependent var | 0.000123 |
| Adjusted R-squared | 0.376065 | S.D. dependent var | 0.022676 |
| S.E. of regression | 0.017912 | Akaike info criterion | -5.928301 |
| Sum squared resid | 1.359348 | Schwarz criterion | -5.916313 |
| Log likelihood | 12573.03 | Hannan-Quinn criter. | -5.924064 |
| Durbin-Watson stat | 2.055499 | | |
| Inverted AR Roots | .72 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

The results are almost identical (ARCH test is supporting our model), therefore to conclude for the C3 route we proved that FFAs trading contributed positively in the volatility of spot freight rates. This effect was limited and ranged from 0.010039 to 0.01098.

### 5.1.4. C5 route results

Last but not least, we are computing the same results using the econometric program Eviews 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.

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 is no possible.

*Table 5.11 C5 index results for volatility with WTI as an independent variable*

Dependent Variable: C5
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 20:42
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000350 | 0.005471 | -0.064003 | 0.9490 |
| AR(1) | 0.626729 | 0.989133 | 0.633614 | 0.5263 |
| | | Variance Equation | | |
| C | 0.000123 | 0.002073 | 0.059491 | 0.9526 |
| RESID(-1)^2 | 0.657360 | 7.187432 | 0.091460 | 0.9271 |
| RESID(-1)^2*(RESID(-1)<0) | -0.172007 | 1.880654 | -0.091461 | 0.9271 |
| GARCH(-1) | 0.352156 | 9.313279 | 0.037812 | 0.9698 |
| WTI | 0.001536 | 0.002070 | 0.741926 | 0.4581 |
| D2 | 5.66E-05 | 0.001282 | 0.044168 | 0.9648 |

| | | | |
|---|---|---|---|
| R-squared | 0.228745 | Mean dependent var | 1.64E-05 |
| Adjusted R-squared | 0.228563 | S.D. dependent var | 0.028328 |
| S.E. of regression | 0.024881 | Akaike info criterion | -5.071521 |
| Sum squared resid | 2.622969 | Schwarz criterion | -5.059533 |

| | | | |
|---|---|---|---|
| Log likelihood | 10757.09 | Hannan-Quinn criter. | -5.067284 |
| Durbin-Watson stat | 2.133077 | | |
| Inverted AR Roots | .63 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

For the Brent the same procedure create an important model in terms of ARCH effect. Therefore analysing the D2 value we see that it is significant in our level of 5% and that FFA trading in the C5 route led to an increase in spot freight volatility with a small effect however.

*Table 5.12 C5 index results for volatility with Brent as an independent variable*

Dependent Variable: C5
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 20:44
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 428 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1) + C(7)*BRENT + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -2.78E-05 | 0.000626 | -0.044422 | 0.9646 |
| AR(1) | 0.653062 | 0.020141 | 32.42441 | 0.0000 |
| | | Variance Equation | | |
| C | 7.13E-06 | 2.34E-06 | 3.042099 | 0.0023 |
| RESID(-1)^2 | 0.418054 | 0.092553 | 4.516904 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.118251 | 0.116384 | -1.016037 | 0.3096 |
| GARCH(-1) | 0.690927 | 0.038958 | 17.73517 | 0.0000 |
| BRENT | 0.000199 | 0.000144 | 1.382792 | 0.1667 |
| D2 | 3.03E-05 | 7.60E-06 | 3.985212 | 0.0001 |

| | | | |
|---|---|---|---|
| R-squared | 0.221185 | Mean dependent var | 1.64E-05 |
| Adjusted R-squared | 0.221001 | S.D. dependent var | 0.028328 |
| S.E. of regression | 0.025003 | Akaike info criterion | -5.278628 |
| Sum squared resid | 2.648680 | Schwarz criterion | -5.266640 |
| Log likelihood | 11196.05 | Hannan-Quinn criter. | -5.274391 |
| Durbin-Watson stat | 2.168985 | | |
| Inverted AR Roots | .65 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

Last but not least, as with the above cases we run the last test with S&P500 Commodity Index with the above results:

*Table 5.13 C5 index results for volatility with S&P500 as an independent variable*

Dependent Variable: C5
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 20:52
Sample: 12/02/1998 4/29/2016
Included observations: 4239
Convergence achieved after 332 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*S_P500 + C(8)*D2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.68E-06 | 0.000601 | 0.002802 | 0.9978 |
| AR(1) | 0.653612 | 0.020467 | 31.93445 | 0.0000 |
| | | Variance Equation | | |
| C | 6.46E-06 | 2.26E-06 | 2.854717 | 0.0043 |
| RESID(-1)^2 | 0.401166 | 0.077135 | 5.200854 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.120933 | 0.105992 | -1.140970 | 0.2539 |
| GARCH(-1) | 0.706044 | 0.035858 | 19.68985 | 0.0000 |
| S_P500 | -0.000396 | 0.000513 | -0.771489 | 0.4404 |
| D2 | 2.88E-05 | 7.49E-06 | 3.848448 | 0.0001 |

| | | | |
|---|---|---|---|
| R-squared | 0.221012 | Mean dependent var | 1.64E-05 |
| Adjusted R-squared | 0.220828 | S.D. dependent var | 0.028328 |
| S.E. of regression | 0.025005 | Akaike info criterion | -5.279062 |
| Sum squared resid | 2.649269 | Schwarz criterion | -5.267074 |
| Log likelihood | 11196.97 | Hannan-Quinn criter. | -5.274825 |
| Durbin-Watson stat | 2.169705 | | |
| Inverted AR Roots | .65 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

ARCH test for the presence of heteroscedasticity in the residuals, show that the results are robust and the coefficient of D2 is positive and significant in the 5% level. This leads to the same conclusion as above as FFA trading had a negative effect on spot freight volatility causing an increase to uncertainty.

## 5.2.Tests for the asymmetry effect of FFA trading

As described in the introduction of chapter 5, in this section we are going to calculate the effect (if any) of FFA trading in the asymmetry cause 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.

### 5.2.1. Tests for the asymmetry effect in 4TC

The first two tables display the results for the two subsamples of the 4TC spot rates, while ARCH tests are included in the appendix. 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.

Period from 2/12/1998 to 6/4/2004

*Table 5.14 4TC index results for the asymmetry effect pre-FFA period results*

Dependent Variable: _4TC
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 21:51
Sample: 12/02/1998 5/06/2004
Included observations: 1320
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000417 | 0.002112 | -0.197347 | 0.8436 |
| AR(1) | 0.868863 | 0.029742 | 29.21368 | 0.0000 |
| Variance Equation | | | | |
| C | 9.98E-05 | 1.64E-05 | 6.070996 | 0.0000 |
| RESID(-1)^2 | 0.831585 | 0.201852 | 4.119773 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.756491 | 0.219127 | -3.452290 | 0.0006 |
| GARCH(-1) | 0.226782 | 0.021994 | 10.31125 | 0.0000 |
| WTI | 0.001239 | 0.000174 | 7.132656 | 0.0000 |
| S_P500 | -0.000721 | 0.001189 | -0.606515 | 0.5442 |

| | | | |
|---|---|---|---|
| R-squared | 0.508818 | Mean dependent var | 0.001233 |
| Adjusted R-squared | 0.508446 | S.D. dependent var | 0.016869 |
| S.E. of regression | 0.011827 | Akaike info criterion | -6.284903 |
| Sum squared resid | 0.184364 | Schwarz criterion | -6.253477 |
| Log likelihood | 4156.036 | Hannan-Quinn criter. | -6.273121 |
| Durbin-Watson stat | 2.349804 | | |
| Inverted AR Roots | .87 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

ARCH test shows no problem in our model so we calculate for the period from 7/5/2004 to 29/4/2016:

*Table 5.15 4TC index results for the asymmetry effect post-FFA period*

Dependent Variable: _4TC
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/17/16 Time: 22:07
Sample: 5/07/2004 4/29/2016
Included observations: 2919
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.001221 | 0.001424 | 0.857384 | 0.3912 |
| AR(1) | 0.717709 | 0.020632 | 34.78602 | 0.0000 |
| | | Variance Equation | | |
| C | 1.49E-06 | 9.81E-07 | 1.523480 | 0.1276 |
| RESID(-1)^2 | 0.024163 | 0.008907 | 2.712969 | 0.0067 |
| RESID(-1)^2*(RESID(-1)<0) | 0.018045 | 0.016068 | 1.123023 | 0.2614 |
| GARCH(-1) | 0.970263 | 0.006424 | 151.0307 | 0.0000 |
| WTI | -0.000452 | 0.000227 | -1.987052 | 0.0469 |
| S_P500 | -0.000163 | 0.000883 | -0.185056 | 0.8532 |

| | | | |
|---|---|---|---|
| R-squared | 0.449556 | Mean dependent var | -0.000633 |
| Adjusted R-squared | 0.449367 | S.D. dependent var | 0.056067 |
| S.E. of regression | 0.041605 | Akaike info criterion | -3.942630 |
| Sum squared resid | 5.049149 | Schwarz criterion | -3.926243 |
| Log likelihood | 5762.268 | Hannan-Quinn criter. | -3.936727 |
| Durbin-Watson stat | 1.922659 | | |
| Inverted AR Roots | .72 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

In this case 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 and with the bellow results:

*Table 5.16 4TC index results for the asymmetry effect post-FFA period (until end 2007)*

Dependent Variable: _4TC
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)

Date: 09/17/16 Time: 22:08
Sample: 5/07/2004 12/24/2007
Included observations: 887
Convergence achieved after 60 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000296 | 0.001903 | 0.155646 | 0.8763 |
| AR(1) | 0.786875 | 0.025379 | 31.00443 | 0.0000 |
| | Variance Equation | | | |
| C | 8.78E-05 | 1.47E-05 | 5.991442 | 0.0000 |
| RESID(-1)^2 | 0.474999 | 0.112607 | 4.218193 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.157851 | 0.224071 | 0.704466 | 0.4811 |
| GARCH(-1) | 0.182409 | 0.085190 | 2.141199 | 0.0323 |
| WTI | 0.000653 | 0.000470 | 1.388998 | 0.1648 |
| S_P500 | -0.001001 | 0.001198 | -0.835820 | 0.4033 |

| | | | |
|---|---|---|---|
| R-squared | 0.577877 | Mean dependent var | 0.001252 |
| Adjusted R-squared | 0.577400 | S.D. dependent var | 0.024161 |
| S.E. of regression | 0.015706 | Akaike info criterion | -5.676073 |
| Sum squared resid | 0.218322 | Schwarz criterion | -5.632891 |
| Log likelihood | 2525.338 | Hannan-Quinn criter. | -5.659566 |
| Durbin-Watson stat | 1.700984 | | |
| Inverted AR Roots | .79 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

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 effected 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 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.

### 5.2.2. 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. 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, as for the second sample the generated model until 29/4/2016 is significant we are presenting the results.

*Table 5.17 C7 index results for the asymmetry effect post-FFA period*

Dependent Variable: C7
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 20:17
Sample: 5/07/2004 4/29/2016
Included observations: 2919
Convergence achieved after 321 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000944 | 0.001000 | 0.943820 | 0.3453 |
| AR(1) | 0.731724 | 0.018056 | 40.52459 | 0.0000 |
| Variance Equation | | | | |
| C | 5.68E-05 | 1.70E-05 | 3.339295 | 0.0008 |
| RESID(-1)^2 | 0.320697 | 0.066694 | 4.808507 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.070616 | 0.081382 | -0.867708 | 0.3856 |
| GARCH(-1) | 0.632287 | 0.053106 | 11.90610 | 0.0000 |
| WTI | -0.000291 | 0.000480 | -0.606301 | 0.5443 |
| S_P500 | -0.000490 | 0.001510 | -0.324746 | 0.7454 |

| | | | |
|---|---|---|---|
| R-squared | 0.353280 | Mean dependent var | -0.000320 |
| Adjusted R-squared | 0.353059 | S.D. dependent var | 0.027417 |
| S.E. of regression | 0.022052 | Akaike info criterion | -5.112882 |
| Sum squared resid | 1.418506 | Schwarz criterion | -5.096495 |
| Log likelihood | 7470.251 | Hannan-Quinn criter. | -5.106979 |
| Durbin-Watson stat | 2.214903 | | |
| Inverted AR Roots | .73 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

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.

### 5.2.3. 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. While trying including all three independent variables, a combination of two, only one of them or even with no independent the results where the same. For easy reference the results with WTI and S&P500 as independents are the bellow (ARCH test showed no heteroscedasticity existent).

*Table 5.18 C3 index results for the asymmetry effect pre-FFA period*

Dependent Variable: C3
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 20:34
Sample: 12/02/1998 8/31/2005
Included observations: 1642
Failure to improve likelihood (non-zero gradients) after 249 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.001246 | 0.002751 | 0.452905 | 0.6506 |
| AR(1) | 0.642881 | 0.191053 | 3.364930 | 0.0008 |
| Variance Equation | | | | |
| C | 9.40E-05 | 0.003263 | 0.028808 | 0.9770 |
| RESID(-1)^2 | 0.168577 | 44.78580 | 0.003764 | 0.9970 |
| RESID(-1)^2*(RESID(-1)<0) | -0.216442 | 44.68420 | -0.004844 | 0.9961 |
| GARCH(-1) | 0.454552 | 23.17463 | 0.019614 | 0.9844 |
| WTI | 0.001050 | 0.017831 | 0.058868 | 0.9531 |
| S_P500 | -0.001014 | 0.027549 | -0.036805 | 0.9706 |

| | | | |
|---|---|---|---|
| R-squared | 0.537185 | Mean dependent var | 0.000966 |
| Adjusted R-squared | 0.536903 | S.D. dependent var | 0.012364 |
| S.E. of regression | 0.008414 | Akaike info criterion | -6.415728 |
| Sum squared resid | 0.116100 | Schwarz criterion | -6.389401 |
| Log likelihood | 5275.313 | Hannan-Quinn criter. | -6.405965 |
| Durbin-Watson stat | 1.903827 | | |

| | |
|---|---|
| Inverted AR Roots | .64 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

For the post-FFA period the results were the bellow:

*Table 5.19 7C3 index results for the asymmetry effect post-FFA period*

Dependent Variable: C3
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 20:35
Sample: 9/01/2005 4/29/2016
Included observations: 2597
Convergence achieved after 125 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000254 | 0.000898 | -0.282804 | 0.7773 |
| AR(1) | 0.713909 | 0.028628 | 24.93703 | 0.0000 |
| | | Variance Equation | | |
| C | 2.11E-05 | 3.92E-06 | 5.379606 | 0.0000 |
| RESID(-1)^2 | 0.651222 | 0.138831 | 4.690762 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.184518 | 0.167376 | -1.102417 | 0.2703 |
| GARCH(-1) | 0.599624 | 0.033280 | 18.01753 | 0.0000 |
| WTI | -0.000206 | 0.000344 | -0.600437 | 0.5482 |
| S_P500 | -8.86E-05 | 0.000876 | -0.101154 | 0.9194 |

| | | | |
|---|---|---|---|
| R-squared | 0.354871 | Mean dependent var | -0.000411 |
| Adjusted R-squared | 0.354622 | S.D. dependent var | 0.027241 |
| S.E. of regression | 0.021884 | Akaike info criterion | -5.286938 |
| Sum squared resid | 1.242791 | Schwarz criterion | -5.268880 |
| Log likelihood | 6873.089 | Hannan-Quinn criter. | -5.280395 |
| Durbin-Watson stat | 2.044508 | | |

| | |
|---|---|
| Inverted AR Roots | .71 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

In this case too, 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.

### 5.2.4. Tests for the asymmetry effect in C5

In the last case of the C5 route West Australia to Qingdao, 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 affect the variance of the physical market. The Eviews calculated GJR-GARCH models for pre- and post-FFA trading are presented bellow respectively:

*Table 5.20 C5 index results for the asymmetry effect pre-FFA period*

Dependent Variable: C5
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 21:03
Sample: 12/02/1998 8/31/2005
Included observations: 1642
Failure to improve likelihood (non-zero gradients) after 337 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 7.48E-05 | 0.001475 | 0.050690 | 0.9596 |
| AR(1) | 0.786803 | 0.213069 | 3.692707 | 0.0002 |
| | | Variance Equation | | |
| C | 4.14E-05 | 0.000694 | 0.059617 | 0.9525 |
| RESID(-1)^2 | 0.941599 | 9.786597 | 0.096213 | 0.9234 |
| RESID(-1)^2*(RESID(-1)<0) | -0.558961 | 0.754008 | -0.741320 | 0.4585 |
| GARCH(-1) | 0.153630 | 16.45497 | 0.009336 | 0.9926 |
| WTI | 0.000480 | 0.021652 | 0.022164 | 0.9823 |
| S_P500 | -0.000202 | 0.077435 | -0.002605 | 0.9979 |

| | | | |
|---|---|---|---|
| R-squared | 0.477562 | Mean dependent var | 0.000574 |
| Adjusted R-squared | 0.477243 | S.D. dependent var | 0.014561 |
| S.E. of regression | 0.010528 | Akaike info criterion | -6.540019 |
| Sum squared resid | 0.181783 | Schwarz criterion | -6.513692 |
| Log likelihood | 5377.356 | Hannan-Quinn criter. | -6.530256 |
| Durbin-Watson stat | 2.330083 | | |
| Inverted AR Roots | .79 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 5.21 C5 index results for the asymmetry effect post-FFA period*

Dependent Variable: C5
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 21:04
Sample: 9/01/2005 4/29/2016
Included observations: 2597
Convergence not achieved after 500 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.001112 | 0.000822 | 1.353340 | 0.1759 |
| AR(1) | 0.576395 | 0.027822 | 20.71701 | 0.0000 |
| | | Variance Equation | | |
| C | 2.98E-05 | 8.12E-06 | 3.669461 | 0.0002 |
| RESID(-1)^2 | 0.350343 | 0.059417 | 5.896322 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.076360 | 0.113936 | -0.670203 | 0.5027 |
| GARCH(-1) | 0.730269 | 0.039757 | 18.36854 | 0.0000 |
| WTI | 0.000629 | 0.000973 | 0.646040 | 0.5183 |
| S_P500 | 0.001652 | 0.000969 | 1.704998 | 0.0882 |
| R-squared | 0.212547 | Mean dependent var | | -0.000336 |
| Adjusted R-squared | 0.212243 | S.D. dependent var | | 0.034289 |
| S.E. of regression | 0.030433 | Akaike info criterion | | -4.518403 |
| Sum squared resid | 2.403406 | Schwarz criterion | | -4.500345 |
| Log likelihood | 5875.146 | Hannan-Quinn criter. | | -4.511860 |
| Durbin-Watson stat | 2.072237 | | | |
| Inverted AR Roots | .58 | | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

# Chapter 6: Conclusions

In this thesis we tried to facilitate a spherical analysis of the Capesize forward freight agreements market. By introducing what the FFAs are, how they are used in the market, generally for hedging exposure in the physical Capesize market, how they are regarded in terms of lack of regulation and what are the possible errors and risks of this financial instrument, this thesis analyses the matter from different point of views. This is why subsequently to the theoretical analysis a presentation of the physical and forward market is given as well as a historical retrospection of both spot and paper market.

However, as the main intent of this thesis was to discover the effect of the introduction of FFAs to the volatility of the physical market, we followed past academic research on the same topic regarding the Panamax vessel market (Kavoussanos & Visvikis, 2004). The best fitting model as per the research was the GJR-GARCH, which accounts for asymmetric impact of news and allows for the addition of other independent variables so as to construct a variance equation for the spot freight rates in the physical market.

In our first case and by introducing a dummy variable indicating the specific period when the forwards commenced trading, we located the effect of FFA use to the variance of the specific indexes (4TC) and routes (C3, C5, C7). The results showed 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 rose, however the effect was limited. 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 of the study, we focused on the asymmetry effect of negative news on volatility. In theory and for other financial time series, negative shocks have a greater effect comparing to positive shocks of the same magnitude. Therefore we separated the sample into pre-FFA and post-FFA subsamples and applied the same GJR-GARCH process in order to assess the effect on asymmetry of the introduction of FFAs.

The empirical results showed that for the 4TC in the pre-FFA period negative shocks tended 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 had a positive effect in terms of no effect of negative news in spot rates, as possibly they helped to a better flow and integration of information into the physical market. In the C7 we could not have a clear comparison between current and past results, however post-FFA asymmetry of negative shocks was not present. Last but not least, for the C3 and C5 routes, the econometric analysis implied that the use of FFAs had 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.

## 6.1. Limitations of research

The current research thesis has some limitation mainly provided from the lack of data directly related to the cargoes transported by Capesize vessels. Iron ore data series are not a public time series and as the main transported cargo as stated in previous chapter of the thesis should have added important information to our produced models. Additionally, the second main transported cargo, coal data series, could not be found and incorporated in the model. As we used daily data for the spot freight rates and the remaining variables equivalent data is difficult to be found. Since the data for the spot freight rates go back as long as 1998, finding additional descriptive variables of the same range is a demanding task.

Furthermore, seasonality of Capesize trade is not incorporated in the models. Big holidays related to religion in the importing or exporting nations can distort the smoothtransportation of goods. This effect is steady every year and may cause seasonality to the data and volatility that is not connected to FFA trading. Additionally, seasonality of other sizes of vessels like Panamaxes that take part into coal trade, may affect Capesize market. A big seasoned effect for these vessels is the grain season, however a provision for such effects is not regarded.

## 6.2. Future research

As this was the first attempt in economic literature modelling volatility of the spot freight rates of Capesize vessels and establishing a connection with FFA trading, there is ample space for additional research on this topic.

Firstly, the limitations of the current thesis can be addressed with additional tests using different data so as to specify better what was the effect of FFA trading. Accounting for seasonality effects can also be included in future research.

Additionally alternative models can be tested and the results can be compared to the GJR-GARCH process used in this thesis. One possible model used can be the E-GARCH.

Lastly, as forwards are published for the remaining two vessel sizes, namely Handysize and Supramax vessels, the same research is possible and an overall comparative result of FFAs across vessel sizes can be made.

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# Appendix

*Table 1 4TC Index ARCH test (Brent)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.388697 | Prob. F(14,4210) | 0.9786 |
| Obs*R-squared | 5.454097 | Prob. Chi-Square(14) | 0.9784 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/14/16 Time: 22:27
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.131112 | 0.100889 | 11.21144 | 0.0000 |
| WGT_RESID^2(-1) | -0.000142 | 0.015412 | -0.009236 | 0.9926 |
| WGT_RESID^2(-2) | -0.010952 | 0.015411 | -0.710681 | 0.4773 |
| WGT_RESID^2(-3) | -0.015617 | 0.015411 | -1.013361 | 0.3109 |
| WGT_RESID^2(-4) | -0.011333 | 0.015412 | -0.735362 | 0.4622 |
| WGT_RESID^2(-5) | -0.003988 | 0.015411 | -0.258749 | 0.7958 |
| WGT_RESID^2(-6) | -0.007726 | 0.015411 | -0.501361 | 0.6161 |
| WGT_RESID^2(-7) | -0.011709 | 0.015410 | -0.759817 | 0.4474 |
| WGT_RESID^2(-8) | -0.011556 | 0.015410 | -0.749895 | 0.4534 |
| WGT_RESID^2(-9) | -0.006037 | 0.015411 | -0.391761 | 0.6953 |
| WGT_RESID^2(-10) | -0.010980 | 0.015411 | -0.712441 | 0.4762 |
| WGT_RESID^2(-11) | -0.011771 | 0.015411 | -0.763826 | 0.4450 |
| WGT_RESID^2(-12) | -0.011626 | 0.015411 | -0.754434 | 0.4506 |
| WGT_RESID^2(-13) | -0.009040 | 0.015411 | -0.586611 | 0.5575 |
| WGT_RESID^2(-14) | -0.007766 | 0.015411 | -0.503913 | 0.6143 |

| | | | |
|---|---|---|---|
| R-squared | 0.001291 | Mean dependent var | 1.000707 |
| Adjusted R-squared | -0.002030 | S.D. dependent var | 5.221260 |
| S.E. of regression | 5.226557 | Akaike info criterion | 6.148927 |
| Sum squared resid | 115004.2 | Schwarz criterion | 6.171467 |
| Log likelihood | -12974.61 | Hannan-Quinn criter. | 6.156894 |
| F-statistic | 0.388697 | Durbin-Watson stat | 2.000021 |
| Prob(F-statistic) | 0.978587 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*



*Table 2 4TC Index ARCH test (S&P500)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 5.226856 | Prob. F(14,4210) | 0.0000 |
| Obs*R-squared | 72.18207 | Prob. Chi-Square(14) | 0.0000 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/14/16 Time: 22:31
Sample (adjusted): 12/22/1998 4/29/2016

Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.456627 | 0.054362 | 8.399707 | 0.0000 |
| WGT_RESID^2(-1) | -0.012842 | 0.015410 | -0.833380 | 0.4047 |
| WGT_RESID^2(-2) | 0.001964 | 0.015408 | 0.127450 | 0.8986 |
| WGT_RESID^2(-3) | 0.003703 | 0.015401 | 0.240416 | 0.8100 |
| WGT_RESID^2(-4) | 0.016567 | 0.015396 | 1.075997 | 0.2820 |
| WGT_RESID^2(-5) | 0.034859 | 0.015392 | 2.264780 | 0.0236 |
| WGT_RESID^2(-6) | 0.042729 | 0.015367 | 2.780584 | 0.0055 |
| WGT_RESID^2(-7) | 0.028323 | 0.015365 | 1.843322 | 0.0654 |
| WGT_RESID^2(-8) | 0.047083 | 0.015365 | 3.064324 | 0.0022 |
| WGT_RESID^2(-9) | 0.069175 | 0.015369 | 4.500843 | 0.0000 |
| WGT_RESID^2(-10) | 0.030844 | 0.015397 | 2.003278 | 0.0452 |
| WGT_RESID^2(-11) | 0.023153 | 0.015402 | 1.503268 | 0.1328 |
| WGT_RESID^2(-12) | 0.031968 | 0.015465 | 2.067078 | 0.0388 |
| WGT_RESID^2(-13) | 0.020280 | 0.015473 | 1.310679 | 0.1900 |
| WGT_RESID^2(-14) | 0.018533 | 0.015480 | 1.197267 | 0.2313 |

| | | | |
|---|---|---|---|
| R-squared | 0.017085 | Mean dependent var | 0.707717 |
| Adjusted R-squared | 0.013816 | S.D. dependent var | 2.766430 |
| S.E. of regression | 2.747253 | Akaike info criterion | 4.862624 |
| Sum squared resid | 31774.55 | Schwarz criterion | 4.885164 |
| Log likelihood | -10257.29 | Hannan-Quinn criter. | 4.870592 |
| F-statistic | 5.226856 | Durbin-Watson stat | 2.002313 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 3 C7 ARCH test (WTI)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 2.281658 | Prob. F(14,4210) | 0.0042 |
| Obs*R-squared | 31.81563 | Prob. Chi-Square(14) | 0.0043 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/14/16 Time: 23:30
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.971935 | 0.084111 | 11.55539 | 0.0000 |
| WGT_RESID^2(-1) | 0.039487 | 0.015412 | 2.562156 | 0.0104 |
| WGT_RESID^2(-2) | -0.013713 | 0.015424 | -0.889074 | 0.3740 |
| WGT_RESID^2(-3) | -0.014257 | 0.015415 | -0.924877 | 0.3551 |
| WGT_RESID^2(-4) | -0.015398 | 0.015416 | -0.998831 | 0.3179 |
| WGT_RESID^2(-5) | 0.058575 | 0.015417 | 3.799331 | 0.0001 |
| WGT_RESID^2(-6) | -0.013236 | 0.015443 | -0.857036 | 0.3915 |
| WGT_RESID^2(-7) | -0.016081 | 0.015444 | -1.041237 | 0.2978 |
| WGT_RESID^2(-8) | -0.009787 | 0.015444 | -0.633720 | 0.5263 |
| WGT_RESID^2(-9) | 0.004986 | 0.015443 | 0.322888 | 0.7468 |
| WGT_RESID^2(-10) | -0.011094 | 0.015417 | -0.719565 | 0.4718 |
| WGT_RESID^2(-11) | -0.004762 | 0.015416 | -0.308888 | 0.7574 |
| WGT_RESID^2(-12) | 0.038126 | 0.015417 | 2.473026 | 0.0134 |

| | | | | |
|---|---|---|---|---|
| WGT_RESID^2(-13) | -0.008044 | 0.015425 | -0.521497 | 0.6020 |
| WGT_RESID^2(-14) | -0.006213 | 0.015414 | -0.403081 | 0.6869 |

| | | | |
|---|---|---|---|
| R-squared | 0.007530 | Mean dependent var | 1.000499 |
| Adjusted R-squared | 0.004230 | S.D. dependent var | 4.070168 |
| S.E. of regression | 4.061551 | Akaike info criterion | 5.644551 |
| Sum squared resid | 69448.98 | Schwarz criterion | 5.667091 |
| Log likelihood | -11909.11 | Hannan-Quinn criter. | 5.652518 |
| F-statistic | 2.281658 | Durbin-Watson stat | 1.999951 |
| Prob(F-statistic) | 0.004183 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 4 C7 ARCH test (Brent)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 2.373452 | Prob. F(14,4210) | 0.0027 |
| Obs*R-squared | 33.08558 | Prob. Chi-Square(14) | 0.0028 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/14/16 Time: 23:40
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.970040 | 0.083964 | 11.55306 | 0.0000 |
| WGT_RESID^2(-1) | 0.040946 | 0.015412 | 2.656784 | 0.0079 |
| WGT_RESID^2(-2) | -0.013646 | 0.015425 | -0.884630 | 0.3764 |
| WGT_RESID^2(-3) | -0.014693 | 0.015416 | -0.953129 | 0.3406 |
| WGT_RESID^2(-4) | -0.015322 | 0.015418 | -0.993787 | 0.3204 |
| WGT_RESID^2(-5) | 0.060663 | 0.015419 | 3.934389 | 0.0001 |
| WGT_RESID^2(-6) | -0.013034 | 0.015447 | -0.843820 | 0.3988 |
| WGT_RESID^2(-7) | -0.016315 | 0.015447 | -1.056180 | 0.2909 |
| WGT_RESID^2(-8) | -0.009713 | 0.015447 | -0.628771 | 0.5295 |
| WGT_RESID^2(-9) | 0.003956 | 0.015447 | 0.256075 | 0.7979 |
| WGT_RESID^2(-10) | -0.009812 | 0.015418 | -0.636371 | 0.5246 |
| WGT_RESID^2(-11) | -0.006068 | 0.015418 | -0.393556 | 0.6939 |
| WGT_RESID^2(-12) | 0.037541 | 0.015418 | 2.434870 | 0.0149 |
| WGT_RESID^2(-13) | -0.007653 | 0.015426 | -0.496113 | 0.6198 |
| WGT_RESID^2(-14) | -0.006345 | 0.015414 | -0.411617 | 0.6806 |

| | | | |
|---|---|---|---|
| R-squared | 0.007831 | Mean dependent var | 1.000521 |
| Adjusted R-squared | 0.004532 | S.D. dependent var | 4.065308 |
| S.E. of regression | 4.056087 | Akaike info criterion | 5.641858 |
| Sum squared resid | 69262.25 | Schwarz criterion | 5.664398 |
| Log likelihood | -11903.43 | Hannan-Quinn criter. | 5.649826 |
| F-statistic | 2.373452 | Durbin-Watson stat | 1.999954 |
| Prob(F-statistic) | 0.002745 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 5 C7 ARCH test (S&P500)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 1.956445 | Prob. F(14,4210) | 0.0174 |
| Obs*R-squared | 27.31015 | Prob. Chi-Square(14) | 0.0175 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/14/16 Time: 23:58
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.980787 | 0.083009 | 11.81543 | 0.0000 |
| WGT_RESID^2(-1) | 0.039884 | 0.015412 | 2.587857 | 0.0097 |
| WGT_RESID^2(-2) | -0.014241 | 0.015425 | -0.923267 | 0.3559 |
| WGT_RESID^2(-3) | -0.014144 | 0.015420 | -0.917248 | 0.3591 |
| WGT_RESID^2(-4) | -0.015668 | 0.015421 | -1.016021 | 0.3097 |
| WGT_RESID^2(-5) | 0.053708 | 0.015422 | 3.482533 | 0.0005 |
| WGT_RESID^2(-6) | -0.012165 | 0.015444 | -0.787704 | 0.4309 |
| WGT_RESID^2(-7) | -0.015400 | 0.015444 | -0.997154 | 0.3187 |
| WGT_RESID^2(-8) | -0.010632 | 0.015444 | -0.688413 | 0.4912 |
| WGT_RESID^2(-9) | 0.005960 | 0.015444 | 0.385931 | 0.6996 |
| WGT_RESID^2(-10) | -0.011026 | 0.015422 | -0.714985 | 0.4747 |
| WGT_RESID^2(-11) | -0.004390 | 0.015421 | -0.284666 | 0.7759 |
| WGT_RESID^2(-12) | 0.029541 | 0.015422 | 1.915527 | 0.0555 |
| WGT_RESID^2(-13) | -0.006406 | 0.015426 | -0.415249 | 0.6780 |
| WGT_RESID^2(-14) | -0.005369 | 0.015414 | -0.348326 | 0.7276 |

| | | | |
|---|---|---|---|
| R-squared | 0.006464 | Mean dependent var | 1.000432 |
| Adjusted R-squared | 0.003160 | S.D. dependent var | 3.959022 |
| S.E. of regression | 3.952762 | Akaike info criterion | 5.590250 |
| Sum squared resid | 65778.43 | Schwarz criterion | 5.612790 |
| Log likelihood | -11794.40 | Hannan-Quinn criter. | 5.598218 |
| F-statistic | 1.956445 | Durbin-Watson stat | 1.999938 |
| Prob(F-statistic) | 0.017382 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*



*Table 6 C3 ARCH test (WTI)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.538246 | Prob. F(14,4210) | 0.9119 |
| Obs*R-squared | 7.548775 | Prob. Chi-Square(14) | 0.9115 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/15/16 Time: 00:06
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| C | 1.137543 | 0.092942 | 12.23930 | 0.0000 |
| WGT_RESID^2(-1) | -0.008676 | 0.015411 | -0.562939 | 0.5735 |
| WGT_RESID^2(-2) | -0.015447 | 0.015411 | -1.002339 | 0.3162 |
| WGT_RESID^2(-3) | -0.019484 | 0.015411 | -1.264276 | 0.2062 |
| WGT_RESID^2(-4) | -0.012742 | 0.015414 | -0.826659 | 0.4085 |
| WGT_RESID^2(-5) | -0.016233 | 0.015415 | -1.053031 | 0.2924 |
| WGT_RESID^2(-6) | -0.014477 | 0.015417 | -0.939030 | 0.3478 |
| WGT_RESID^2(-7) | 0.003040 | 0.015418 | 0.197170 | 0.8437 |
| WGT_RESID^2(-8) | -0.011132 | 0.015418 | -0.722024 | 0.4703 |
| WGT_RESID^2(-9) | -0.007949 | 0.015417 | -0.515611 | 0.6062 |
| WGT_RESID^2(-10) | -0.000778 | 0.015408 | -0.050516 | 0.9597 |
| WGT_RESID^2(-11) | -0.000405 | 0.015407 | -0.026260 | 0.9791 |
| WGT_RESID^2(-12) | -0.014451 | 0.015407 | -0.937938 | 0.3483 |
| WGT_RESID^2(-13) | -0.013054 | 0.015407 | -0.847302 | 0.3969 |
| WGT_RESID^2(-14) | -0.006312 | 0.015408 | -0.409675 | 0.6821 |

| | | | |
|---|---|---|---|
| R-squared | 0.001787 | Mean dependent var | 0.999446 |
| Adjusted R-squared | -0.001533 | S.D. dependent var | 4.507640 |
| S.E. of regression | 4.511093 | Akaike info criterion | 5.854500 |
| Sum squared resid | 85673.33 | Schwarz criterion | 5.877040 |
| Log likelihood | -12352.63 | Hannan-Quinn criter. | 5.862468 |
| F-statistic | 0.538246 | Durbin-Watson stat | 2.000050 |
| Prob(F-statistic) | 0.911916 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 7 C3 ARCH test (Brent)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.524771 | Prob. F(14,4210) | 0.9203 |
| Obs*R-squared | 7.360120 | Prob. Chi-Square(14) | 0.9199 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 20:23
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.133837 | 0.093043 | 12.18621 | 0.0000 |
| WGT_RESID^2(-1) | -0.009177 | 0.015411 | -0.595497 | 0.5515 |
| WGT_RESID^2(-2) | -0.015467 | 0.015411 | -1.003626 | 0.3156 |
| WGT_RESID^2(-3) | -0.019104 | 0.015411 | -1.239651 | 0.2152 |
| WGT_RESID^2(-4) | -0.012379 | 0.015414 | -0.803084 | 0.4220 |
| WGT_RESID^2(-5) | -0.015817 | 0.015415 | -1.026112 | 0.3049 |
| WGT_RESID^2(-6) | -0.014129 | 0.015417 | -0.916490 | 0.3595 |
| WGT_RESID^2(-7) | 0.003617 | 0.015417 | 0.234577 | 0.8145 |
| WGT_RESID^2(-8) | -0.010375 | 0.015417 | -0.672937 | 0.5010 |
| WGT_RESID^2(-9) | -0.007208 | 0.015417 | -0.467532 | 0.6401 |
| WGT_RESID^2(-10) | -0.000457 | 0.015408 | -0.029661 | 0.9763 |
| WGT_RESID^2(-11) | -6.89E-05 | 0.015407 | -0.004474 | 0.9964 |
| WGT_RESID^2(-12) | -0.014789 | 0.015407 | -0.959899 | 0.3372 |
| WGT_RESID^2(-13) | -0.012846 | 0.015407 | -0.833788 | 0.4044 |

| | | | | |
|---|---|---|---|---|
| WGT_RESID^2(-14) | -0.006252 | 0.015408 | -0.405792 | 0.6849 |

| | | | |
|---|---|---|---|
| R-squared | 0.001742 | Mean dependent var | 0.999391 |
| Adjusted R-squared | -0.001578 | S.D. dependent var | 4.521189 |
| S.E. of regression | 4.524754 | Akaike info criterion | 5.860548 |
| Sum squared resid | 86193.02 | Schwarz criterion | 5.883088 |
| Log likelihood | -12365.41 | Hannan-Quinn criter. | 5.868515 |
| F-statistic | 0.524771 | Durbin-Watson stat | 2.000045 |
| Prob(F-statistic) | 0.920340 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 8 C3 ARCH test (S&P500)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.599693 | Prob. F(14,4210) | 0.8675 |
| Obs*R-squared | 8.408845 | Prob. Chi-Square(14) | 0.8670 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 20:32
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.148132 | 0.092373 | 12.42935 | 0.0000 |
| WGT_RESID^2(-1) | -0.007461 | 0.015411 | -0.484120 | 0.6283 |
| WGT_RESID^2(-2) | -0.016201 | 0.015410 | -1.051320 | 0.2932 |
| WGT_RESID^2(-3) | -0.020456 | 0.015411 | -1.327414 | 0.1844 |
| WGT_RESID^2(-4) | -0.012478 | 0.015414 | -0.809538 | 0.4183 |
| WGT_RESID^2(-5) | -0.017536 | 0.015415 | -1.137566 | 0.2554 |
| WGT_RESID^2(-6) | -0.015546 | 0.015417 | -1.008345 | 0.3133 |
| WGT_RESID^2(-7) | 0.002071 | 0.015417 | 0.134350 | 0.8931 |
| WGT_RESID^2(-8) | -0.013542 | 0.015417 | -0.878325 | 0.3798 |
| WGT_RESID^2(-9) | -0.008875 | 0.015417 | -0.575648 | 0.5649 |
| WGT_RESID^2(-10) | -0.001899 | 0.015408 | -0.123276 | 0.9019 |
| WGT_RESID^2(-11) | -0.000474 | 0.015407 | -0.030775 | 0.9755 |
| WGT_RESID^2(-12) | -0.015536 | 0.015407 | -1.008377 | 0.3133 |
| WGT_RESID^2(-13) | -0.013377 | 0.015407 | -0.868290 | 0.3853 |
| WGT_RESID^2(-14) | -0.007312 | 0.015407 | -0.474587 | 0.6351 |

| | | | |
|---|---|---|---|
| R-squared | 0.001990 | Mean dependent var | 0.999509 |
| Adjusted R-squared | -0.001329 | S.D. dependent var | 4.446514 |
| S.E. of regression | 4.449467 | Akaike info criterion | 5.826990 |
| Sum squared resid | 83348.56 | Schwarz criterion | 5.849530 |
| Log likelihood | -12294.52 | Hannan-Quinn criter. | 5.834957 |
| F-statistic | 0.599693 | Durbin-Watson stat | 2.000054 |
| Prob(F-statistic) | 0.867505 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 9 C5 ARCH test (WTI)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 4.655786 | Prob. F(14,4210) | 0.0000 |
| Obs*R-squared | 64.41592 | Prob. Chi-Square(14) | 0.0000 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 20:44
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.574010 | 0.061084 | 9.397017 | 0.0000 |
| WGT_RESID^2(-1) | -0.010390 | 0.015406 | -0.674379 | 0.5001 |
| WGT_RESID^2(-2) | -0.008045 | 0.015406 | -0.522181 | 0.6016 |
| WGT_RESID^2(-3) | -0.008430 | 0.015403 | -0.547268 | 0.5842 |
| WGT_RESID^2(-4) | 0.006005 | 0.015401 | 0.389885 | 0.6966 |
| WGT_RESID^2(-5) | 0.007036 | 0.015398 | 0.456971 | 0.6477 |
| WGT_RESID^2(-6) | 0.045439 | 0.015410 | 2.948752 | 0.0032 |
| WGT_RESID^2(-7) | 0.093213 | 0.015422 | 6.044244 | 0.0000 |
| WGT_RESID^2(-8) | 0.022398 | 0.015427 | 1.451839 | 0.1466 |
| WGT_RESID^2(-9) | 0.027415 | 0.015416 | 1.778346 | 0.0754 |
| WGT_RESID^2(-10) | 0.020421 | 0.015421 | 1.324244 | 0.1855 |
| WGT_RESID^2(-11) | 0.020237 | 0.015423 | 1.312123 | 0.1896 |
| WGT_RESID^2(-12) | 0.019879 | 0.015428 | 1.288522 | 0.1976 |
| WGT_RESID^2(-13) | 0.014006 | 0.015431 | 0.907668 | 0.3641 |
| WGT_RESID^2(-14) | 0.027595 | 0.015432 | 1.788200 | 0.0738 |

| | | | |
|---|---|---|---|
| R-squared | 0.015246 | Mean dependent var | 0.792483 |
| Adjusted R-squared | 0.011972 | S.D. dependent var | 2.985924 |
| S.E. of regression | 2.967997 | Akaike info criterion | 5.017196 |
| Sum squared resid | 37085.92 | Schwarz criterion | 5.039736 |
| Log likelihood | -10583.83 | Hannan-Quinn criter. | 5.025164 |
| F-statistic | 4.655786 | Durbin-Watson stat | 2.001613 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*



*Table 10 C5 ARCH test (Brent)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.624963 | Prob. F(14,4210) | 0.8465 |
| Obs*R-squared | 8.762442 | Prob. Chi-Square(14) | 0.8460 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 10/16/16 Time: 15:14
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| C | 1.140883 | 0.087927 | 12.97540 | 0.0000 |
| WGT_RESID^2(-1) | 0.007317 | 0.015412 | 0.474777 | 0.6350 |
| WGT_RESID^2(-2) | -0.014730 | 0.015411 | -0.955781 | 0.3392 |
| WGT_RESID^2(-3) | -0.019556 | 0.015413 | -1.268815 | 0.2046 |
| WGT_RESID^2(-4) | -0.019385 | 0.015415 | -1.257531 | 0.2086 |
| WGT_RESID^2(-5) | -0.018664 | 0.015416 | -1.210685 | 0.2261 |
| WGT_RESID^2(-6) | -0.010130 | 0.015422 | -0.656872 | 0.5113 |
| WGT_RESID^2(-7) | -0.007786 | 0.015422 | -0.504891 | 0.6137 |
| WGT_RESID^2(-8) | -0.009749 | 0.015422 | -0.632133 | 0.5273 |
| WGT_RESID^2(-9) | -0.011744 | 0.015422 | -0.761482 | 0.4464 |
| WGT_RESID^2(-10) | -0.012708 | 0.015421 | -0.824082 | 0.4099 |
| WGT_RESID^2(-11) | -0.010011 | 0.015417 | -0.649377 | 0.5161 |
| WGT_RESID^2(-12) | -0.005364 | 0.015415 | -0.347995 | 0.7279 |
| WGT_RESID^2(-13) | -0.012283 | 0.015414 | -0.796876 | 0.4256 |
| WGT_RESID^2(-14) | 0.004560 | 0.015414 | 0.295838 | 0.7674 |

| | | | |
|---|---|---|---|
| R-squared | 0.002074 | Mean dependent var | 1.000611 |
| Adjusted R-squared | -0.001245 | S.D. dependent var | 4.067471 |
| S.E. of regression | 4.070001 | Akaike info criterion | 5.648708 |
| Sum squared resid | 69738.27 | Schwarz criterion | 5.671248 |
| Log likelihood | -11917.89 | Hannan-Quinn criter. | 5.656675 |
| F-statistic | 0.624963 | Durbin-Watson stat | 1.999935 |
| Prob(F-statistic) | 0.846550 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 11 C5 ARCH test (S&P500)*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.783068 | Prob. F(14,4210) | 0.6888 |
| Obs*R-squared | 10.97344 | Prob. Chi-Square(14) | 0.6881 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 20:53
Sample (adjusted): 12/22/1998 4/29/2016
Included observations: 4225 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.157575 | 0.086294 | 13.41431 | 0.0000 |
| WGT_RESID^2(-1) | 0.010305 | 0.015412 | 0.668635 | 0.5038 |
| WGT_RESID^2(-2) | -0.014899 | 0.015411 | -0.966779 | 0.3337 |
| WGT_RESID^2(-3) | -0.022661 | 0.015413 | -1.470247 | 0.1416 |
| WGT_RESID^2(-4) | -0.021711 | 0.015416 | -1.408334 | 0.1591 |
| WGT_RESID^2(-5) | -0.020037 | 0.015418 | -1.299632 | 0.1938 |
| WGT_RESID^2(-6) | -0.011901 | 0.015423 | -0.771597 | 0.4404 |
| WGT_RESID^2(-7) | -0.009101 | 0.015424 | -0.590070 | 0.5552 |
| WGT_RESID^2(-8) | -0.010198 | 0.015424 | -0.661154 | 0.5085 |
| WGT_RESID^2(-9) | -0.013833 | 0.015424 | -0.896852 | 0.3698 |
| WGT_RESID^2(-10) | -0.014300 | 0.015422 | -0.927251 | 0.3538 |
| WGT_RESID^2(-11) | -0.011093 | 0.015418 | -0.719465 | 0.4719 |
| WGT_RESID^2(-12) | -0.006881 | 0.015415 | -0.446392 | 0.6553 |
| WGT_RESID^2(-13) | -0.013693 | 0.015414 | -0.888380 | 0.3744 |

| | | | | |
|---|---|---|---|---|
| WGT_RESID^2(-14) | 0.003064 | 0.015415 | 0.198750 | 0.8425 |

| | | | |
|---|---|---|---|
| R-squared | 0.002597 | Mean dependent var | 1.000592 |
| Adjusted R-squared | -0.000720 | S.D. dependent var | 3.897828 |
| S.E. of regression | 3.899230 | Akaike info criterion | 5.562979 |
| Sum squared resid | 64008.81 | Schwarz criterion | 5.585519 |
| Log likelihood | -11736.79 | Hannan-Quinn criter. | 5.570947 |
| F-statistic | 0.783068 | Durbin-Watson stat | 1.999950 |
| Prob(F-statistic) | 0.688838 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 12 4TC ARCH test post FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 4.064578 | Prob. F(14,2890) | 0.0000 |
| Obs*R-squared | 56.09493 | Prob. Chi-Square(14) | 0.0000 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 22:08
Sample (adjusted): 5/27/2004 4/29/2016
Included observations: 2905 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.917238 | 0.083108 | 11.03670 | 0.0000 |
| WGT_RESID^2(-1) | 0.118994 | 0.018598 | 6.398218 | 0.0000 |
| WGT_RESID^2(-2) | 0.033825 | 0.018729 | 1.805996 | 0.0710 |
| WGT_RESID^2(-3) | -0.017518 | 0.018737 | -0.934954 | 0.3499 |
| WGT_RESID^2(-4) | 0.017222 | 0.018737 | 0.919117 | 0.3581 |
| WGT_RESID^2(-5) | 0.008575 | 0.018736 | 0.457667 | 0.6472 |
| WGT_RESID^2(-6) | -0.000964 | 0.018731 | -0.051448 | 0.9590 |
| WGT_RESID^2(-7) | -0.000755 | 0.018726 | -0.040341 | 0.9678 |
| WGT_RESID^2(-8) | -0.022465 | 0.018726 | -1.199676 | 0.2304 |
| WGT_RESID^2(-9) | 0.024846 | 0.018731 | 1.326477 | 0.1848 |
| WGT_RESID^2(-10) | -0.020667 | 0.018736 | -1.103074 | 0.2701 |
| WGT_RESID^2(-11) | -0.015610 | 0.018735 | -0.833178 | 0.4048 |
| WGT_RESID^2(-12) | -0.017849 | 0.018732 | -0.952871 | 0.3407 |
| WGT_RESID^2(-13) | -0.003365 | 0.018725 | -0.179723 | 0.8574 |
| WGT_RESID^2(-14) | -0.020095 | 0.018593 | -1.080819 | 0.2799 |

| | | | |
|---|---|---|---|
| R-squared | 0.019310 | Mean dependent var | 1.001498 |
| Adjusted R-squared | 0.014559 | S.D. dependent var | 3.089185 |
| S.E. of regression | 3.066615 | Akaike info criterion | 5.084176 |
| Sum squared resid | 27177.92 | Schwarz criterion | 5.115023 |
| Log likelihood | -7369.765 | Hannan-Quinn criter. | 5.095290 |
| F-statistic | 4.064578 | Durbin-Watson stat | 2.000136 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 13 4TC post FFA period until end 2007*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.624122 | Prob. F(14,858) | 0.8465 |
| Obs*R-squared | 8.800836 | Prob. Chi-Square(14) | 0.8436 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/17/16 Time: 22:08
Sample (adjusted): 5/27/2004 12/24/2007
Included observations: 873 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.977932 | 0.150109 | 6.514821 | 0.0000 |
| WGT_RESID^2(-1) | -0.016830 | 0.034125 | -0.493178 | 0.6220 |
| WGT_RESID^2(-2) | -0.027072 | 0.034126 | -0.793310 | 0.4278 |
| WGT_RESID^2(-3) | -0.032916 | 0.034134 | -0.964313 | 0.3352 |
| WGT_RESID^2(-4) | 0.007707 | 0.034074 | 0.226193 | 0.8211 |
| WGT_RESID^2(-5) | 0.014248 | 0.034062 | 0.418300 | 0.6758 |
| WGT_RESID^2(-6) | 0.022318 | 0.034062 | 0.655223 | 0.5125 |
| WGT_RESID^2(-7) | 0.026744 | 0.034069 | 0.785015 | 0.4327 |
| WGT_RESID^2(-8) | -0.003667 | 0.034069 | -0.107627 | 0.9143 |
| WGT_RESID^2(-9) | 0.006146 | 0.034057 | 0.180466 | 0.8568 |
| WGT_RESID^2(-10) | 0.024658 | 0.034054 | 0.724098 | 0.4692 |
| WGT_RESID^2(-11) | 0.066748 | 0.034066 | 1.959369 | 0.0504 |
| WGT_RESID^2(-12) | -0.011575 | 0.034122 | -0.339228 | 0.7345 |
| WGT_RESID^2(-13) | -0.014607 | 0.034112 | -0.428207 | 0.6686 |
| WGT_RESID^2(-14) | -0.027729 | 0.034109 | -0.812962 | 0.4165 |

| | | | |
|---|---|---|---|
| R-squared | 0.010081 | Mean dependent var | 1.012232 |
| Adjusted R-squared | -0.006071 | S.D. dependent var | 2.244740 |
| S.E. of regression | 2.251544 | Akaike info criterion | 4.478143 |
| Sum squared resid | 4349.590 | Schwarz criterion | 4.560135 |
| Log likelihood | -1939.709 | Hannan-Quinn criter. | 4.509510 |
| F-statistic | 0.624122 | Durbin-Watson stat | 1.997139 |
| Prob(F-statistic) | 0.846469 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 14 C7 GJR-GARCH for pre FFA period*

Dependent Variable: C7
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 09/18/16 Time: 20:15
Sample: 12/02/1998 5/06/2004
Included observations: 1320
Convergence achieved after 268 iterations
Coefficient covariance computed using Bollerslev-Wooldridge QML
sandwich with expected Hessian
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*WTI + C(8)*S_P500

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000293 | 0.000691 | 0.423759 | 0.6717 |

| | | | | |
|---|---|---|---|---|
| AR(1) | 0.774328 | 0.023606 | 32.80214 | 0.0000 |
| Variance Equation | | | | |
| C | 4.38E-06 | 1.66E-06 | 2.633537 | 0.0085 |
| RESID(-1)^2 | 0.172806 | 0.084283 | 2.050310 | 0.0403 |
| RESID(-1)^2*(RESID(-1)<0) | 0.085036 | 0.111929 | 0.759734 | 0.4474 |
| GARCH(-1) | 0.758475 | 0.059449 | 12.75849 | 0.0000 |
| WTI | 0.000101 | 4.59E-05 | 2.203341 | 0.0276 |
| S_P500 | -0.000204 | 0.000116 | -1.760043 | 0.0784 |

| | | | |
|---|---|---|---|
| R-squared | 0.489522 | Mean dependent var | 0.001061 |
| Adjusted R-squared | 0.489135 | S.D. dependent var | 0.012524 |
| S.E. of regression | 0.008952 | Akaike info criterion | -6.942346 |
| Sum squared resid | 0.105617 | Schwarz criterion | -6.910920 |
| Log likelihood | 4589.949 | Hannan-Quinn criter. | -6.930564 |
| Durbin-Watson stat | 2.289666 | | |

| | |
|---|---|
| Inverted AR Roots | .77 |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 15 C7 ARCH test pre FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 6.526025 | Prob. F(14,1291) | 0.0000 |
| Obs*R-squared | 86.31722 | Prob. Chi-Square(14) | 0.0000 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 20:16
Sample (adjusted): 12/22/1998 5/06/2004
Included observations: 1306 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.844041 | 0.130150 | 6.485149 | 0.0000 |
| WGT_RESID^2(-1) | 0.021342 | 0.027824 | 0.767044 | 0.4432 |
| WGT_RESID^2(-2) | 0.009595 | 0.027829 | 0.344801 | 0.7303 |
| WGT_RESID^2(-3) | -0.008326 | 0.027522 | -0.302526 | 0.7623 |
| WGT_RESID^2(-4) | -0.021922 | 0.027522 | -0.796527 | 0.4259 |
| WGT_RESID^2(-5) | 0.210243 | 0.027471 | 7.653282 | 0.0000 |
| WGT_RESID^2(-6) | -0.031501 | 0.028087 | -1.121555 | 0.2623 |
| WGT_RESID^2(-7) | -0.060404 | 0.028098 | -2.149763 | 0.0318 |
| WGT_RESID^2(-8) | -0.013811 | 0.028097 | -0.491533 | 0.6231 |
| WGT_RESID^2(-9) | -0.005354 | 0.028085 | -0.190649 | 0.8488 |
| WGT_RESID^2(-10) | -0.063219 | 0.027470 | -2.301393 | 0.0215 |
| WGT_RESID^2(-11) | -0.000295 | 0.027519 | -0.010709 | 0.9915 |
| WGT_RESID^2(-12) | 0.148457 | 0.027519 | 5.394803 | 0.0000 |
| WGT_RESID^2(-13) | -0.007151 | 0.027814 | -0.257096 | 0.7971 |
| WGT_RESID^2(-14) | -0.020884 | 0.027808 | -0.751008 | 0.4528 |

| | | | |
|---|---|---|---|
| R-squared | 0.066093 | Mean dependent var | 1.001367 |
| Adjusted R-squared | 0.055965 | S.D. dependent var | 3.305093 |
| S.E. of regression | 3.211277 | Akaike info criterion | 5.182633 |

| | | | |
|---|---|---|---|
| Sum squared resid | 13313.18 | Schwarz criterion | 5.242067 |
| Log likelihood | -3369.259 | Hannan-Quinn criter. | 5.204928 |
| F-statistic | 6.526025 | Durbin-Watson stat | 2.000452 |
| Prob(F-statistic) | 0.000000 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 16 C7 ARCH test post FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.755511 | Prob. F(14,2890) | 0.7187 |
| Obs*R-squared | 10.59329 | Prob. Chi-Square(14) | 0.7176 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 20:17
Sample (adjusted): 5/27/2004 4/29/2016
Included observations: 2905 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.042591 | 0.102446 | 10.17693 | 0.0000 |
| WGT_RESID^2(-1) | 0.042543 | 0.018602 | 2.287044 | 0.0223 |
| WGT_RESID^2(-2) | -0.017760 | 0.018620 | -0.953833 | 0.3402 |
| WGT_RESID^2(-3) | -0.018034 | 0.018622 | -0.968384 | 0.3329 |
| WGT_RESID^2(-4) | -0.010681 | 0.018626 | -0.573437 | 0.5664 |
| WGT_RESID^2(-5) | -0.017750 | 0.018627 | -0.952944 | 0.3407 |
| WGT_RESID^2(-6) | 0.002061 | 0.018626 | 0.110648 | 0.9119 |
| WGT_RESID^2(-7) | -0.012237 | 0.018624 | -0.657040 | 0.5112 |
| WGT_RESID^2(-8) | -0.011956 | 0.018624 | -0.641937 | 0.5210 |
| WGT_RESID^2(-9) | 0.020419 | 0.018625 | 1.096297 | 0.2730 |
| WGT_RESID^2(-10) | -0.004270 | 0.018626 | -0.229220 | 0.8187 |
| WGT_RESID^2(-11) | -0.001486 | 0.018626 | -0.079786 | 0.9364 |
| WGT_RESID^2(-12) | -0.005374 | 0.018627 | -0.288505 | 0.7730 |
| WGT_RESID^2(-13) | -0.005284 | 0.018625 | -0.283720 | 0.7766 |
| WGT_RESID^2(-14) | 0.001102 | 0.018608 | 0.059202 | 0.9528 |

| | | | |
|---|---|---|---|
| R-squared | 0.003647 | Mean dependent var | 1.003972 |
| Adjusted R-squared | -0.001180 | S.D. dependent var | 4.000399 |
| S.E. of regression | 4.002758 | Akaike info criterion | 5.616995 |
| Sum squared resid | 46303.79 | Schwarz criterion | 5.647842 |
| Log likelihood | -8143.685 | Hannan-Quinn criter. | 5.628109 |
| F-statistic | 0.755511 | Durbin-Watson stat | 2.000038 |
| Prob(F-statistic) | 0.718688 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 17 C3 ARCH test pre FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.369687 | Prob. F(14,1613) | 0.9830 |
| Obs*R-squared | 5.207040 | Prob. Chi-Square(14) | 0.9827 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 20:35
Sample (adjusted): 12/22/1998 8/31/2005
Included observations: 1628 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.348439 | 0.061173 | 5.695951 | 0.0000 |
| WGT_RESID^2(-1) | 0.040451 | 0.024899 | 1.624598 | 0.1044 |
| WGT_RESID^2(-2) | 0.005677 | 0.024919 | 0.227816 | 0.8198 |
| WGT_RESID^2(-3) | -0.004657 | 0.024918 | -0.186891 | 0.8518 |
| WGT_RESID^2(-4) | 0.033726 | 0.024918 | 1.353499 | 0.1761 |
| WGT_RESID^2(-5) | -0.004718 | 0.024932 | -0.189250 | 0.8499 |
| WGT_RESID^2(-6) | -0.007126 | 0.024930 | -0.285820 | 0.7751 |
| WGT_RESID^2(-7) | 0.005705 | 0.024931 | 0.228838 | 0.8190 |
| WGT_RESID^2(-8) | -0.000452 | 0.024942 | -0.018127 | 0.9855 |
| WGT_RESID^2(-9) | 0.011878 | 0.024941 | 0.476243 | 0.6340 |
| WGT_RESID^2(-10) | 0.002472 | 0.024937 | 0.099123 | 0.9211 |
| WGT_RESID^2(-11) | 0.006873 | 0.024923 | 0.275767 | 0.7828 |
| WGT_RESID^2(-12) | -0.010300 | 0.024923 | -0.413278 | 0.6795 |
| WGT_RESID^2(-13) | 0.000931 | 0.024924 | 0.037366 | 0.9702 |
| WGT_RESID^2(-14) | 0.002387 | 0.024906 | 0.095836 | 0.9237 |

| | | | |
|---|---|---|---|
| R-squared | 0.003198 | Mean dependent var | 0.379919 |
| Adjusted R-squared | -0.005453 | S.D. dependent var | 2.069240 |
| S.E. of regression | 2.074874 | Akaike info criterion | 4.306849 |
| Sum squared resid | 6944.133 | Schwarz criterion | 4.356559 |
| Log likelihood | -3490.775 | Hannan-Quinn criter. | 4.325292 |
| F-statistic | 0.369687 | Durbin-Watson stat | 2.000052 |
| Prob(F-statistic) | 0.983044 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 18 C3 ARCH test post FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.810111 | Prob. F(14,2568) | 0.6589 |
| Obs*R-squared | 11.35763 | Prob. Chi-Square(14) | 0.6577 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 20:35
Sample (adjusted): 9/22/2005 4/29/2016
Included observations: 2583 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.210478 | 0.106797 | 11.33434 | 0.0000 |
| WGT_RESID^2(-1) | -0.010246 | 0.019696 | -0.520212 | 0.6030 |
| WGT_RESID^2(-2) | -0.028511 | 0.019690 | -1.448012 | 0.1477 |
| WGT_RESID^2(-3) | -0.027904 | 0.019694 | -1.416844 | 0.1566 |
| WGT_RESID^2(-4) | -0.027361 | 0.019701 | -1.388839 | 0.1650 |
| WGT_RESID^2(-5) | -0.018314 | 0.019707 | -0.929332 | 0.3528 |
| WGT_RESID^2(-6) | -0.015688 | 0.019710 | -0.795935 | 0.4261 |

| | | | | |
|---|---|---|---|---|
| WGT_RESID^2(-7) | -0.008746 | 0.019709 | -0.443770 | 0.6572 |
| WGT_RESID^2(-8) | -0.018806 | 0.019709 | -0.954195 | 0.3401 |
| WGT_RESID^2(-9) | -0.007548 | 0.019710 | -0.382934 | 0.7018 |
| WGT_RESID^2(-10) | 0.011476 | 0.019707 | 0.582354 | 0.5604 |
| WGT_RESID^2(-11) | -0.011401 | 0.019700 | -0.578737 | 0.5628 |
| WGT_RESID^2(-12) | -0.018478 | 0.019706 | -0.937690 | 0.3485 |
| WGT_RESID^2(-13) | -0.027873 | 0.019701 | -1.414761 | 0.1573 |
| WGT_RESID^2(-14) | -0.002478 | 0.019708 | -0.125715 | 0.9000 |

| | | | |
|---|---|---|---|
| R-squared | 0.004397 | Mean dependent var | 0.998202 |
| Adjusted R-squared | -0.001031 | S.D. dependent var | 3.469110 |
| S.E. of regression | 3.470897 | Akaike info criterion | 5.332494 |
| Sum squared resid | 30937.02 | Schwarz criterion | 5.366505 |
| Log likelihood | -6871.915 | Hannan-Quinn criter. | 5.344821 |
| F-statistic | 0.810111 | Durbin-Watson stat | 2.002879 |
| Prob(F-statistic) | 0.658906 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 19 C5 ARCH test pre FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.312152 | Prob. F(14,1613) | 0.9927 |
| Obs*R-squared | 4.398853 | Prob. Chi-Square(14) | 0.9925 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 21:03
Sample (adjusted): 12/22/1998 8/31/2005
Included observations: 1628 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.933217 | 0.133356 | 6.997950 | 0.0000 |
| WGT_RESID^2(-1) | -0.013605 | 0.024897 | -0.546447 | 0.5848 |
| WGT_RESID^2(-2) | -0.010860 | 0.024899 | -0.436148 | 0.6628 |
| WGT_RESID^2(-3) | -0.003563 | 0.024890 | -0.143158 | 0.8862 |
| WGT_RESID^2(-4) | -0.002413 | 0.024889 | -0.096957 | 0.9228 |
| WGT_RESID^2(-5) | -0.002260 | 0.024889 | -0.090792 | 0.9277 |
| WGT_RESID^2(-6) | 0.015424 | 0.024889 | 0.619708 | 0.5355 |
| WGT_RESID^2(-7) | 0.018174 | 0.024883 | 0.730369 | 0.4653 |
| WGT_RESID^2(-8) | 0.026256 | 0.024883 | 1.055185 | 0.2915 |
| WGT_RESID^2(-9) | 0.004425 | 0.024889 | 0.177806 | 0.8589 |
| WGT_RESID^2(-10) | -0.005850 | 0.024898 | -0.234946 | 0.8143 |
| WGT_RESID^2(-11) | 0.004067 | 0.024845 | 0.163697 | 0.8700 |
| WGT_RESID^2(-12) | 0.029268 | 0.024844 | 1.178055 | 0.2389 |
| WGT_RESID^2(-13) | -0.006600 | 0.024853 | -0.265539 | 0.7906 |
| WGT_RESID^2(-14) | 0.013322 | 0.024858 | 0.535924 | 0.5921 |

| | | | |
|---|---|---|---|
| R-squared | 0.002702 | Mean dependent var | 0.999056 |
| Adjusted R-squared | -0.005954 | S.D. dependent var | 3.865638 |
| S.E. of regression | 3.877129 | Akaike info criterion | 5.557238 |
| Sum squared resid | 24246.82 | Schwarz criterion | 5.606947 |
| Log likelihood | -4508.592 | Hannan-Quinn criter. | 5.575680 |
| F-statistic | 0.312152 | Durbin-Watson stat | 2.000132 |
| Prob(F-statistic) | 0.992708 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*

*Table 20 C5 ARCH test post FFA period*

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.972394 | Prob. F(14,2568) | 0.4792 |
| Obs*R-squared | 13.62083 | Prob. Chi-Square(14) | 0.4783 |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 09/18/16 Time: 21:04
Sample (adjusted): 9/22/2005 4/29/2016
Included observations: 2583 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1.183241 | 0.100954 | 11.72060 | 0.0000 |
| WGT_RESID^2(-1) | 0.020822 | 0.019731 | 1.055300 | 0.2914 |
| WGT_RESID^2(-2) | -0.018918 | 0.019733 | -0.958703 | 0.3378 |
| WGT_RESID^2(-3) | -0.035881 | 0.019732 | -1.818379 | 0.0691 |
| WGT_RESID^2(-4) | -0.022452 | 0.019744 | -1.137185 | 0.2556 |
| WGT_RESID^2(-5) | -0.030586 | 0.019748 | -1.548842 | 0.1215 |
| WGT_RESID^2(-6) | -0.013126 | 0.019766 | -0.664072 | 0.5067 |
| WGT_RESID^2(-7) | -0.008825 | 0.019763 | -0.446515 | 0.6553 |
| WGT_RESID^2(-8) | -0.020173 | 0.019765 | -1.020631 | 0.3075 |
| WGT_RESID^2(-9) | -0.018593 | 0.019767 | -0.940605 | 0.3470 |
| WGT_RESID^2(-10) | -0.009443 | 0.019762 | -0.477826 | 0.6328 |
| WGT_RESID^2(-11) | -0.010706 | 0.019755 | -0.541941 | 0.5879 |
| WGT_RESID^2(-12) | -0.019311 | 0.019745 | -0.978018 | 0.3282 |
| WGT_RESID^2(-13) | -0.015012 | 0.019745 | -0.760278 | 0.4472 |
| WGT_RESID^2(-14) | 0.016075 | 0.019742 | 0.814232 | 0.4156 |

| | | | |
|---|---|---|---|
| R-squared | 0.005273 | Mean dependent var | 0.997858 |
| Adjusted R-squared | -0.000150 | S.D. dependent var | 3.107244 |
| S.E. of regression | 3.107476 | Akaike info criterion | 5.111289 |
| Sum squared resid | 24797.66 | Schwarz criterion | 5.145300 |
| Log likelihood | -6586.230 | Hannan-Quinn criter. | 5.123616 |
| F-statistic | 0.972394 | Durbin-Watson stat | 1.999571 |
| Prob(F-statistic) | 0.479209 | | |

*Source: The Baltic Exchange, Clarksons processing via Eviews from the author*