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The dynamic relationship in returns and volatilities between Capesize and Panamax markets from 2008 to 2016.

by

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Abstract

This thesis investigates the relationship in earnings and volatilities of daily time charter rates in the dry Capesize and Panamax markets. The research is based on a quantitative analysis using 1,894 daily rates in the transatlantic, transpacific, fronthaul and backhaul routes. The sample analysed in this research is from 2 January 2009 to 7 July 2016 of the reported daily rates by the Baltic Exchange. A vector error correction model and a Granger causality test are used to analyse the relation in returns on each route. On the transatlantic and the backhaul routes there is a unidirectional influence in returns from the Panamax to the Capesize market. On the fronthaul and the transpacific routes there is a bidirectional influence between both markets. By applying an ECM-GARCH model, the volatility and the spill-over of information from one vessel category to the other is examined. Results show that in all routes volatility in the Panamax freight market is more impacted by new information. On the other hand, volatility in the Capesize freight market is more influenced by the variations of previous periods, old information. Results of the spill-over of information imply that market has changed since 2008 on the four major Capesize and Panamax trading routes. The outcome contains valuable information for ship-owner and charterers to manage risks and make extra profit through allocation of a vessel in the most profitable area.

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List of Abbreviations

ADF	Augmented Dickey-Fuller (1981) test
ARCH	Autoregressive Conditional Heteroskedastic model
BDI	Baltic Dry Index
BH_C	Backhaul Capesize
BH_P	Backhaul Panamax
BT	Billion Tonnes
Cape	Capesize
DWT	Deadweight Tons
FH_C	Fronthaul Capesize
FH_P	Fronthaul Panamax
FR	Freight Rates
FFA	Forward Freight Agreement
GARCH	General Autoregressive Conditional Heteroskedastic model
IMO:	Internationale Maritime Organisation
Mt	Million Tonnes
Pmax	Panamax
PP	Phillips and Perron (1988) test
TA_C	Transatlantic Capesize
TA_P	Transatlantic Panamax
TP_C	Transpacific Capesize
TP_P	Transpacific Panamax
VAR	Vector Autoregressive model
VLOC	Very Large Ore Carrier
4TC_C	4 Time Charter Average of Capesize
4TC_P	4 Time Charter Average of Panamax
5TC_S	5 Time Charter Average of Supramax
6TC_H	6 Time Charter Average of Handysize
5TC_C:	5 Time Charter Average (including longhaul) Capesize.

1. Introduction

1.1 Background

Transportation of products by sea has been in the centre of global economy since 3,000 BC, when the Ancient Egyptians used commercial ships in the Red Sea. Since then, the shipping industry has had a central role in global economy, facilitating international trade of vast variety of goods ranging from raw materials to finished products. Through this legacy the maritime world has gained knowledge and transmitted the know-how from generation to generation. The revolution in technology and construction technics, such as steam engines and steel hauls, played a large role in the industry growth at the end of the nineteenth and in the middle of the twentieth centuries. The vessel size increased and trade schedule became more accurate, enabling owners and charterers to increase efficiency. Moreover, vessels became specialized by cargo type, creating five shipping segments; liquid bulk, dry bulk, containers carriers, the Ro-Ro carriers and the passenger vessels. The first bulk carrier was built in 1852, followed by the first oil tanker in 1872. After the Second World War the chemical carriers, the liquefied gases carriers and the containers fleet emerged. The merchant fleet cost's decreased because of the economies of scale and specialisation, reducing the freight rates. On the other hand, the industry faced booms on different markets creating fortune for the investors and owners, e.g. during the shipping boom of 2003 to 2008. (Stopford , 2009).

The shipping market is highly fragmented as the shipping segments are reacting to their own factors such as the commodity price, the vessel basin, the vessel parcel, the crude oil price and the political environment. On the other hand, the sub-shipping sectors also need to be analysed together because of the strong links between each sector in the global economy. For example, a slowdown in the world GDP will negatively affect all the shipping segments. The aforementioned characteristics of the shipping sector generate large volatilities and uncertainties, causing financial distress and possible bankruptcy to the market players but generating excitement and interest of many economists.

In order to analyse and manage previous risks, shipping agents interact in the newbuilding, the second hand, the freight and the recycling ship markets. First, in the newbuilding market, the ship-owner interacts with a shipyard to build a vessel that will operate years later. The expectations of the owner will guide his decision as it is impossible to forecast the freight for the next years. Second, the second-hand market is framed by two identical agents that have opposite expectation of the market taking contrary positions. One ship-owner is selling his asset when the other is buying. Third, the freight market corresponds to the price of transportation decided between supply and demand for cargo transportation. It is negotiated between a cargo owner and a ship-owner. Finally, the recycling (scrap) market correspond to the sale of a vessel for its steel lightweight value. Scrapping companies buy the ship, to an owner, for the steel and recycle the vessel.

Following the overview of the different components of the shipping industry, we determine the elements of bulk shipping. Bulk shipping is the carriage of unpacked raw materials or commodities in specially designed ships. We distinguish between liquid and dry bulk. The liquid bulks (tankers) are the vessels carrying crude oil, refined petroleum and chemicals. The dry bulkers are vessels carrying all type of dry cargo, from grains to coal. For both cargoes, the agents are looking for the most suitable ship to take advantage of economies of scale and decrease fixed costs. Ships of more than 220,000 dwt, for example, have been built to carry exclusively iron ore, it is the Very Large Ore Carriers. Expansion of the ship size can help decrease the costs but may also raise such issues as port and canal infrastructures. Table 1 shows the actual classification in the dry bulk shipping sector.

Table 1

Ship Categories	Deadweight Tons
Handysize	10,000 to 39,999
Handymax	40,000 to 59,999
Panamax	60,000 to 82,999
Post Panamax	83,000 to 120,000
Capesize	120,000 to 220,000
VLOC	Larger than 220,000

Source: Lloyds list (2016)

Because the VOLC's are linked to long run contracts with a determined freight rate, Panamax and Capesize are the largest vessels in the dry bulk trade open on the spot market. They are linked by the commodities they carry (coal and iron ore), as well as by port restrictions. Since the industrial revolution, demand for both commodities has followed a steady growth. Due to different commodity quality around the globe, growth in international trade and demand for transportation followed the same path. In order to remain competitive owners had to ship at the lowest possible cost, putting the economies of scale in the centre of their decision-making. Vessels became standardized, creating a homogeneous market in which the owners can only compete on prices. Dry bulk vessels are carrying a single commodity, generating the same service for transportation. As a consequence, the vessels are considered as commodities. However, since 2012 ship-owners built eco-design vessels to lower the bunker costs and create an advantage from the competitors.

In 2008 the dry bulk market reached a peak, driven by the fast growing Chinese economy, with spot freight rates going up to 240,000 US dollars per day. The financial crisis affected the world global economy, with a large effect on the Capesize market influencing the smaller categories and putting the rates down.

1.2 Scope of Research

Owners, operators, charterers and shipping investors are earning part of their profits through freight rates which are highly volatile and very complex to forecast. The dry bulk assets involve large capital and operating investments which are of interest to different parties. All the interested parties are looking for the biggest profits in growing markets and for lowest costs in recession. Therefore, they have the possibility to operate the vessel on the spot market and accept the full risks for high profit opportunities. They can also enter a period charter agreement and secure profits for the medium to long run. However, in both cases there are risks of vessel unemployment and low freight rates.

In 2015 and half of 2016, ship-owners have faced the most depressed dry bulk market, resulting in many bankruptcies. Because of a big uncertainty in profitability, it is important to managed risks and build strategies to maintain profit in depressed markets. Thus, ship-owners have the possibility to charter majority of the fleet through 1-, 2-, or 3-years charter to guarantee earnings for the coming years. In addition, they can use the shipping derivative contracts such as freight forward agreements. The FFA market has increased a lot during the past decade as paper traders entered the market. The amount of paper counterparties increase, raising liquidity for physical participants such as owners and charterers.

The scope of this thesis is the fluctuation of the returns and the volatility in the Capesize and Panamax markets. To be more precise, we investigate the evolution of the relationship in returns and volatility between the Capesize and the Panamax freight rates on the transatlantic, fronthaul, transpacific and backhaul routes. We think it is important to bring up-to-date information on the interconnectivity and help actors in decision-making, in case they are interested in switching vessels or basins. As an illustration, market actors have the possibility to swap assets if the freight is more attractive. For example, a ship-owner facing low demand for Panamax cargo but very high demand for Capesize cargo may earn a higher profit by allocating two Panamax vessels on the Capesize route and using them to transport the Capesize’s commodities, than by leaving his Panamax on the low profitable trade. By managing assets and being pro-active regarding fleet allocation, different market actors can better handle risks and stabilise profitability.

1.3 Objective

The aim of this study is to provide an actual analysis and understanding of the volatility and returns in the dry bulk freight industry. We investigate the interconnectivity of the freight rate on four Panamax and Capesize main routes. More specifically, we research the price discovery and volatility transmission between the Capesize and the Panamax spot rates from 2009 to 2016 in order to see whether the Capesize (Panamax) market influences the returns and volatility of the Panamax (Capesize) market as well as whether the direction of the effect is affected. As the structure of the market changed after the financial crisis, our research will highlight the up-to-date dynamics of the Capesize and the Panamax markets. The explanation of the inter-relationship, knowledge of the potential of substitutability between the vessels in specific trading areas can be of interest to the ship-owners, charterers, investors and managers in the Capesize and Panamax markets. This research may be useful in creating strategies towards managing the fleet and take advantage of market situations.

1.4 Research Question

This research will be based on the interaction of the volatility of the freight rates between Capesize and Panamax. The analysis is focused on the mechanism of the markets. By focusing on the direction of the influence from one market to the other and the possible spill-over effects. The dynamics are analysed in specific trading routes, taking time charters. To understand the effects, we will answer the following main research question.

“What is the dynamic relationship in returns and volatilities between the Capesize and the Panamax spot market?”

In order to answer this question, we separated the main research question into three sub-research questions:

1. What is the effect relationship in the spot prices between the Capesize and the Panamax market?

2. What is the direction of the price influence between Capesize and Panamax markets?

3. What is the volatility of returns spill-over of both markets from 2008 to 2016?

1.5 Thesis structure

The remainder of this thesis is structured as follows.

Chapter two summarizes the literature review, discerning the scientific findings used in our research. In the first part of the literature review, we discuss the dry bulk market structure. In the second part, we highlight the main literature regarding volatility, covering the volatility and the interaction between the dry bulk spot and period charter market, between the spot and the FFA prices market as well as the spill-over effect in each inter-relationship. In the third part, we analyse the methodology used in articles researching co-integration and causality in the financial and shipping sectors. Next to this, we also describe the methodology employed in a similar research as this thesis.

Chapter three presents the framework of the dry bulk shipping market. It provides details on each vessel market, on the freight contracts, as well as the factors affecting the freight rate negotiation.

Chapter four explains the methodology implemented in this research. An overview of our data strategy and the statistical model is presented. The characteristics and design of the methodology concerning the econometrical model is demonstrated.

Chapter five covers our findings and provides an analysis of the results by answering the research questions. We highlight the relationship between the Capesize and the Panamax freight rates, focusing on the returns and volatility. Moreover, the positive or negative effect of one market on the other is argued and we determine the influenced market.

Chapter six is a review and a conclusion of the thesis. In addition, it considers the potential for further research and a possible evolution of the market.

2. Literature Review

International trade for ninety percent depends on the seaborne traffic, according to the IMO (2016). In other words, the demand for maritime transportation is directly derived from the demand for international trade influenced by world economy. The maritime sector is divided into five shipping segments, namely: liquid bulks, dry bulks, Ro-Ro carriers, container carriers and the passenger cruise vessels. In addition, each of these segments is characterised by four markets; the newbuilding, the recycling, the second-hand and the freight market (Stopford , 2009). Our research focuses on the freight market in the dry bulk segment. This segment is structured into different vessel sizes assigned to specific trade. First, the Handysize (up to 39,999 DWT), Handymax (up to 49,999 DWT) and the Supramax (up to 65,000dwt), which are carrying minor bulk such as agricultural products, cement minerals and aluminum. The major bulk products such as iron ore and coking coal are carried by the largest vessels, the Panamax (up to 120,000 DWT) and the Capesize (carrying more than 120,000 DWT) without considering the VLOC's as they are operating in a niche market.

The sea borne trade increased tremendously during the nineteenth century following the steam engine revolution. Ships became larger, creating economies of scale, resulting in a fall of the freight rates. Lundgren (Lundgren , 1996) explains that the freight rates had fallen by 65 percent during two periods: from 1880 to 1910 and from 1950 to 1980. This happened due to several reasons: first, because of the introduction of the new technology in the shipping sector; second, due to development of production process, enabling shipyards to build vessels from 20,000 dwt to more than a 120,000 dwt. In 1990 more than 70 percent of the iron ore in international trade was carried by vessels of more than 100,000 dwt called Capesize. The major bulk increased by 663 percent between 1950 and 1990. The market structure of the dry bulk shipping is very specific as on the one hand it can be highly competitive where ship-owners are the price takers. On the other hand, when a ship is the only one available in an area, with many demand for tonnage, there will be a monopolistic situation. Then the ship-owners become the price makers. For ship-owners it is a perquisite to know the market at every moment. The shipping market and the volatility of the freight rates have often been the subject of many scientific papers. Staring in the beginning of the twentieth century, with the explanation of the freight markets provided by Tinbergen (1934).

Dry bulk market structure

In addition, Zannetos (1966) highlights that the international shipping is perfectly competitive because of the mobility of the assets. It allows ship-owners to catch the best opportunity in a region. When extra profit is available in a specific basin, ships will move and the surplus of earning will disappear. (Zannetos, 1966). Moreover, as the tonnage moves from one region to the other to reach the equilibrium of supply and demand, the market can be seen as efficient.[(Evans, 1994) , (Berg-Andreassen, 1997)] More recently, the efficiency of the bulk shipping market has been researched by Adland and Strandenes (2006) who found that excessive profit has been made in the tanker market, which is at odds with the efficient market hypothesis. However, the freight market is described as semi-strong form of efficiency. (Adland & Strandenes, 2006). The efficient market hypothesis is directly related to the availability of information in the market (Fama , 1970). The most important principles are that the participants are rational, the prices are adjusted instantaneously and there is no arbitrage opportunity. From this analysis we can conclude that freight rates incorporate all publicly available information, resulting in an efficient market.

Stopford (1997) explains the factors affecting the freight rate market. The equilibrium is found through a negotiation process. The ship-owners and the shippers acknowledge the tonnage available and the amount of cargo. They express their needs at a specific location in time. Then the freight rate bargaining starts taking many factors into account, such as the world economic situation, the commodity prices and the international political events. The freight price reacts significantly to shocks in the market due to the large uncertainty of the previous factors. Freight markets are characterised as being very cyclical with 8 peaks for the dry bulk markets and 10 peaks for tankers since the Second World War. Moreover, the dry bulk freight cycles have a duration of 6.7 years on average. It is important to understand that freight rate cycles exist and that they are driven by different factors such as technology, political risk, commodity demand and the time needed to adapt the fleet to demand for transportation. (Stopford , 2009). Additionally, there is seasonality in the Baltic Freight Index and freight rates do not follow a random walk. (Denning, et al., 1994). Moreover, Kavussanos and Alizadeh (2001) demonstrate regular and deterministic seasonality across various vessel sizes. A large part of the seasonality is derived from the type of commodity transported on specific routes. Furthermore, the seasonal effect is more important during market recovery compared to recession (Kavussanos & Alizadeh-M, 2001).

When the trends in the shipping market are well known, ship-owner can create strategies in order to take advantage of each market and make profit. Alderton (Alderton, 2004) advises to put the assets on the spot market when it is growing and to sell or find a period charter when the market reaches its peak. However, as we mentioned previously and as maintained by Cufley (Cufley, 1972), the factors affecting the dry bulk market are highly unpredictable. The decision of buying and selling ships at the right timing is difficult for owners. The shippers do not know the amount of tonnage they will need in the coming years. Anyhow, it is the role of the ship-owner to forecast and take his position on the shipping market for the coming years. He has to position his fleet to respond correctly to the future demand. In order to take such decisions, the owner has to analyse the demand side and can do so by hiring highly specialized consultants. On the other hand, information about the tonnage supply on the market is easily available. All owners have the same information, nevertheless, many companies are getting bankrupt. Scarsi (Scarsi, 2007) explores the ship-owner source of mistakes during the cycles. She stressed five main points: “lack of experience”, “lack of managerial culture”, “mistakes connected to the decision making attitude”, “mistakes connected to the companies’ structure”, “Imitation and/or emulation”. We can see that aforementioned mistakes are directly linked to the personal intuition of the ship-owners. They are taking decisions based on their own feeling and not based on scientifically reasoned approach. Stefan Albertijn et al. (Albertijn, et al., 2011) express the current situation regarding the evolution of risk management for ship-owners. They underline the importance of operating cash flow risk and ship value risk due to high volatility in both markets. They point out the importance of risk management technics for shipping in the actual unpredictable environment. More recently, Guo et al. (Guo , et al., 2009) examine the factors impacting the dry bulk market with a SEM-structural equation modelling. They discover that the freight market is a seller’s market. There is significant evidence that the fleet supply has the largest effect on the freight rates. The supply side can more easily adapt and take advantage of a changing market. The fleet impacts negatively the freight rates as an oversupply of vessels results in a sharp fall of the transportation price. Batrinca and Cojanu (2014) detect that the main factor positively affecting the freight rate is the worldwide gross domestic product.

Volatility of the dry bulk market

Koopmans (Koopmans , 1939) is one of the first to analyse the volatility in the bulk sector, investigating the factors determining the freight rates in the supply and demand model. Other researcher, such as Zannetos (1966), Hawdon (1978), Wergeland (1981) and Beenstock (1985) analyse and try to model the freight variability. Kavussanos (Kavussanos, 1996) investigates the volatility in the dry bulk market, more precisely, the volatility of the spot and period charter rates. He concludes that, regarding the demand side, the world industrial production has a great positive effect. On the supply side, the bunker prices and the size of the fleet have a negative effect on returns. The research of Xu et al. (Xu, et al., 2011) determines with significant evidence that an increase of the dry bulk fleet will positively influence the volatility of the freight rate. The volatility follows the same behaviour in both spot and period charter markets. Moreover, they highlight that the Capesize rates are the most impacted by a change because of the restriction in alternative employment. Moreover, the risk of spot and period charter is constant over time and the volatility is clustered in each market, due to the commodities transported by each vessel category (Jing, et al., 2008). Furthermore, the volatility is larger when external shocks appears in the sector. In many cases the risk is higher for time charter than for the spot market. In addition, change of volatility has different impact on vessel category, because of the flexibility and the technical difference in loading and discharging. It is important to mention that risk premiums are higher for the large vessel class. Therefore, ship-owner may choose different ship size to hedge the risks.

The factor affecting the choice of different contracts has been researched by Pirrong (1993). Spot contracting is observed for grain and crude oil and long-term contracts are observed for special purpose vessels that are built to carry a specific commodity generally for industrial purposes (Pirrong, 1993). Zannetos (1966), Glen et al. (Glen , et al., 1981) and Kavussanos (1996) argue that the period charter rates are smoother than the spot rates because of the long term characteristics of the contract. The aggregation of spot contract over the period should represent the same trends as the period charter because they highlight the aggregate average. Industrial commodities such as coal and iron ore, following regular trends, will mainly be under period charter contract. Spot charter will be used for marginal necessity such as seasonal and cyclical extra demand. Econometric models have been developed to analyse and forecast the dry cargo shipping market by Beenstock and Vergottis (Beenstock & Vergottis, 1989). They find that the spot market determines significantly the period charter rates by using a Vector Autoregressive Model. Beenstock and Vergottis (Beenstock & Vergottis , 1993) investigate the spill-over effects, by using econometric models, between dry bulk and tankers. Furthermore, interdependence and spill-over of information has been researched between different types of ships. They find that a shock in one shipping market has an effect on the other shipping market and will generate a feedback to the original sector. More precisely, different vessel sizes may be switched according to their profitability.

A comparison of time and trip charter rate behaviour regarding different duration of the freight contract has been researched by Binkley and Bessler (Binkley & Bessler, 1983). They describe the importance of agent expectations for the long term in the formation of charter rates. The most important conclusion of the study is that analysing only historical data will not be sufficient to determine the time charter rates. It is important to understand the expectations of the ship-owners and charterers. When owners perceive a fall in rates, they will be interested in fixing their ship before the market changes. On the other hand, when they perceive an increase in the market they will have more incentive to wait for the market to go up and then fix their vessels. This effect is described as the “elastic expectation” (Zannetos, 1966). Following Zannetos (1966), Glen et al. (1981) who have researched the relationship between spot and time charter in the tanker market from 1970 to 1977, the price expectation can be explained on the “basis of exponentially declining weights” and the hypothesis of Zannetos is not created by “observed behaviour” (Glen , et al., 1981). Berg-Andreassen (1997) has tested the so called wisdom hypothesis and concludes that there is a significant relationship between spot rate and time charter rate. He emphasizes that the change in spot rates is relevant where the level is not. Veenstra (Veenstra, 1999) analyses the term structure and the hypothesis that period rate are expectations of the future spot rates. He concludes in an existing relationship between the spot and period freight rates. Alizadeh (Alizadeh-Masoodian, 2001) researches the dynamics and the spill over effect between spot 1-year, 2-year and 3-year long charter rates. He compares the spot and the period charter market. Furthermore, he investigates the possible transmission of the freight rate between two sub-sectors taking the same contracts.

As another risk management technique, ship-owners can use forward freight agreements. FFAs are contracts between two parties in which they agree in advance to pay a fixed price for the freight at the maturity of the contract. The relation between the future spot price and the FFA has been of interest to many researchers. Haigh (Haigh, 2000) applied co-integration techniques to find that the FFA price is the most reliable forecaster of the future spot rates for the next month. Kavussanos and Nomikos (Kavussanos & Nomikos, 1999) and Kavussanos et al. (Kavussanos , et al., 2004) tested the hypothesis that the FFA prices are an unbiased forecaster of the spot rates. They concluded that, one to two months before maturity of the future contract, the price is an unbiased estimator of the spot price. However, the three months’ maturity is biased, except for the Panamax pacific routes. This predictor is more reliable than the econometric technics such as “VECM, random walk, ARIMA, and the Holt-Winters models.”, moreover, the findings confirm the theory of efficient market hypothesis. (Kavussanos & Nomikos, 1999). The interactions in returns and volatilities between spot and futures markets have been research by Kavussanos et al. (2004) and Kavussanos et al. (Kavussanos , et al., 2003). In both studies they find that forward freight agreements are stabilizing the volatility of the spot market. FFA trading does not have any harmful effect on the spot market. On the opposite, it increases the information transmission speed, adjusting prices more efficiently. In their methodology they used a GJR-GARCH model (Glosten , et al., 1993), in order to catch both side effects. More recently, Kavussanos and Visvikis (Kavussanos & Visvikis, 2011) discover an extensive increase in the use of freight derivative by ship-owner and charterers. The actors of the freight market increased their interest for risk hedging in order to secure profit and decrease volatility.

Literature methodology

After analysing the papers regarding the behaviour of the freight rates, we look at the models used to describe the return and volatility. Risks are determined by the freight rate variance, known as the volatility. Mandelbrot (Mandelbrot, 1963) is the first to identify and model the volatility by analysing the variance of stock prices. Then, Engle (Engle, 1982) introduces a new class of models, the Autoregressive Conditional Heteroscedasticity (ARCH). In addition, co-integration has been introduced by Engle and Granger (Engle & Granger, 1987) and more studies on the models followed. Many time series models have been derived from this basis, such Johansen (Johansen, 1991) who introduced the likelihood analysis to investigate co-integration in the vector Autoregression models. The bivariate time series model can be written as:

$$y_t = \beta_0 + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \cdots + \beta_p x_{t-p} + \varepsilon_t$$

This distributed lag models need a constant variance over the sample period with the variance of the error equals 0 and normal distribution. With y_t the dependent variable and x_t all the past values being the independent variables.

Bollerslev (1987) introduced the General Autoregressive Conditional Heteroscedasticity model (GARCH). In this model the lagged squared error and the lagged value of variance are taken into account in the variance and they use a student-t distribution for the density function of the error term.

In the financial literature, research on the volatility and the spill-over of information between different markets has been conducted. Kutmos and Booth (Koutmos & Booth , 1995) used a EGARCH model to understand the effect of good and bad information on the stock price volatility. Using the same model research has been made regarding the relationship of stock price and futures, using the condition that there is a long-term equilibrium relation between both markets. This model allows to highlight the volatility spill-overs of the markets on one another (Koutmos & Tucker, 1996). Furthermore, Glosten et al. (1993) uses a CARCH-M model to investigate the direction of the variance between the conditional expected and conditional variance of stocks returns. They confirm the negative relationship. Advanced models have been developed to understand the volatility in the stock market and then used to determine and forecast the behaviour of the freight rate. Financial research underlines that variables containing all information publicly available, such as stock price, are the only ones needed to correctly forecast (Malkiel & Fama , 1970). Therefore, assuming that the freight rates contain all publicly available information, they are the only variables we can use to forecast the market volatility. Furthermore, the freight rates are stochastic in the bulk market sector according to Adland and Strandenes (Adland & Strandenes, 2007). The stationary pattern of the freight rates has been confirmed by Tvedt (2003). In their research they transform all observation from dollars to yen and find that the freight rates and the prices for all deep sea vessels are stationary and less volatile (Tvedt, 2003). Moreover, they confirm the classic research that the freight rates are mean revering (the prices and returns move back toward the mean). Zeng and Qu (Zeng & Qu, 2014) introduce a new method to forecast and analyse the volatility in the dry bulk sector, called the "*empirical mode decomposition".* The model is mainly used for machinery fault diagnosis, medical science, petroleum price forecasting and financial analysis. We could use the same model because of the similarity in the volatility through the nonstationary and nonlinear nature. They made the experiment on the Baltic Dry Index (BDI). The index is constructed by the equal weighted average of the Baltic Capesize Index (BCI), Baltic Panamax Index (BPI), Baltic Handysize Index (BHSI) and Baltic Supramax Index (BSI). The BDI is the main dry cargo shipping index, reflecting the overall dry cargo shipping market.

In order to represent the long-run pattern of the freight rates, other studies take the life expectancy indicator. The life expectancy effect is found negative in the short run (less than15 years) and positive for long run (more than 15 years) (Duru & Yoshida, 2011) .

Research findings presented above prove the high variability of the freight rate on different routes due to variety of commodities and due to the fact that port infrastructure varies from region to region. The inter-relationship between freight rates and shipping routes has been investigated by Veenstra and Franses (Veenstra & Franses, 1997). They used freight rate data in a multivariate time series model on six major Baltic Exchange routes. The idea is to build a model that is meaningful to represent the microeconomics. The Capesize and Panamax series are non-stationary at 1% and they have a unit root. The rates have a similar pattern, following a common trend. In addition, considerable deterministic relationship exists in the data set confirming co-integration. It can help forecast the "changes in freight rates over a short to medium period." Likewise, the freight rates are unpredictable; therefore, it is really complex to forecast. But there are stable long-run relationships between freight rates.

Based on the literature review on the dry bulk market structure and the freight rate volatility, we believe that ship-owners are interested in having a larger view on the market situation. To be more precise, they may be concerned about the possibility to substitute vessels of different sizes on specific routes. The study of Chen et al. (Chen , et al., 2010) analyses the inter-relationship between Capesize and Panamax vessels on four major trading routes. They divided their research into two different periods. The *first sub-period is from 1999 to 2002*. They found that Capesize and Panamax are co-integrated on all routes at 5% significance level. On all routes there is a spill-over from Panamax to Capesize, unidirectional at 5%. This may be explained by the economic situation during this period, "the dry bulk market was mostly oriented on large vessel". There was an "absence of real Capesize prices, the panellist of the Baltic Exchange may report prices that are more arbitrary arrived". Because of the low market transparency, the data for this period are non-trustworthy to generate a forecast. In this period the "seaborne trade for these cargoes tumbled during the economic recession in 2001. Therefore, ship-owners of Panamax vessels faced more risks and could be sensitive to market innovations. Panamax prices therefore, may convey more market information and react faster to market shocks."

In the second sub-period from 2002 to 2008 they used the following VECM model to get more insight into the short-run co-integration.

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{p} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t$$

With ΔX_t the first difference between the time charter rate of log-capesize and the log-panamax. ε_t represents the vector of error and Γ_i and Π are the coefficient matrices that have to be estimated.

They highlight that both series are co-integrated at conventional significance levels for all routes and thus have a long-run relationship between them. Which “implies that both Capesize and Panamax time charter rates respond to correct a shock to the system in order to reach the long-run equilibrium.

When the log “Cape/Pan ratio” is greater than the long-run average, then Capesize prices are over estimated in comparison with the panamax prices, resulting in panamax vessels participating in the transportation of large large consignment in the Capesize market, decreasing the Capesize prices. If the ratio is lower, the opposite situation is created when permitted by ports. “Capesize react quicker to information and reach equilibrium faster” (Chen et al. 2010, p. 82).

Then in order to examine the spill-over the use a GARCH (1,1) model is used with the following equation explaining the covariance.

$$Cov_t = E'E + F'\varepsilon_{t-1}\varepsilon'_{t-1}F + G'H_{t-1}G + H_1' e_{1t-1}e'_{1t-1}H_1 + H_2' e_{2t-1}e'_{2t-1}H_2$$

The vectors $H_1 and\ H_2$ are the coefficients of the spill-over effects.

In the first sub-period, there are no spill-over in the volatilities. In the second period, “there are bidirectional volatility spill-overs between both markets”. It is stronger from Panamax to Capesize, in other words the Capesize market leads to the Panamax. More precisely, when the Capesize prices are too high a charterer will prefer to hire two Panamax vessels. Moreover, in a weak Capesize market there are occasions where a Capesize owner will accept Panamax cargoes. These results are mainly observed on the transatlantic routes because of the higher trading activity of the Panamax vessels. On the fronthaul route, there is a “unidirectional volatility spill over from the Capesize to the Panamax sector”. For the transpacific route, the Capesize market leads to Panamax and there is a volatility spill-over from Capesize to Panamax. This unidirectional spill-over effect can be explained by the fact that the Capesize market is more sensitive to the news than the Panamax because of the restricted number of ports available for larger ships. Panamax are more flexible and will be able to carry more cargoes, therefore, shocks will be absorbed by trading on other routes. On the backhaul route there is no evidence of volatility spill over in either direction due to the lowest trading activities on those routes.

Co-integration and non-stationary models will highlight long-term inter-relationship as well as short-term spill-over effects.

The impact of shocks on different vessel sizes is researched by Lu Jing et al. (2008). Using a GARCH (1,1) model, they analyse the impact of new information on freight rate, during the period of 1999 to December 2005. An important outcome of the research is that shocks have different impacts on the volatility depending on the flexibility of the vessels. To investigate the impact of capacity of each vessel size Lu Jing et al.(2008) test an exponential GARCH model. The results show that the carrying capacity has a direct influence on the commodity transported by each vessel, influencing the returns. Moreover, the research of Beenstock and Vergottis (1996) determines three spill-over effect in the bulk shipping industry. First, there is an influence between newbuildings in tanker and dry bulk vessels. One type of vessel may be built at the cost of the other. Second, there is bidirectional influence between freight rates in the tanker and dry market, meaning that when the volatility of the tanker market increases, the volatility in the bulker will increase as well and vis-versa. Moreover, there is a feedback effect. The change in volatility will come back to the original market. Finally, there is also an impact in the scrapping market. A shock modifying tankers' scrapping price will increase the volatility for bulkers' scrapping price. To identify the changes in volatility, the above mentioned influences are important between tankers and dry bulk vessels ; they also may have changed since the financial crisis.

The effect of the 2008 crisis on the dry bulk market has been investigated by Chung and Ha (2010) where they analysed the effect on the Baltic Dry Index. They found co-integration relationship between the BDI and iron ore import in China (Chung & Ha, 2010). The BDI experienced a sharp fall in 2008 due to the financial crisis. Moreover, Zhang and Shen (Zhang & Shen , 2014), noted that 2008 has directly affected the international shipping profitability and that the sector is facing one of the longest downturn period of its history. In addition, Ko (Ko, 2011) found that after the financial crisis of 2008 the synchronicity of Panamax and Capesize has increased because of the common factors impacting both markets.

In conclusion, an extensive literature exists regarding the dry bulk freight rate market with strong focus on the volatility, interconnectivity and ship prices. The literature takes into account the dynamic structure of shipping prices. Many researchers try to model the interrelationship in order to forecast freight rate. An important aspect that we will try to model, in order to understand the freight formation, is the risks associated with the dynamic behaviour of the shipping framework. We believe that shipping agents take into account the aforementioned factors when negotiating contracts. Thus by researching freight volatility in different basins, we emphasize the dynamic risk behaviour of the shipping industry. In addition, Chen et al. (2010) find inter-connectivity in sub-sectors proving that a substitution effect between ship size exists on a different route. They explain that information transmission changes over time. The market framework has changed since 2010 and no further research has been made to understand the actual interconnectivity in the dry bulk sub-sector.

In our research we will try to investigate the effect relationship in the spot market between Capesize and Panamax. Our aim is to understand which freight market has influence on the other in order to discover the spill-over effect. In section 4 we discuss the methodology used based on the previous literature. We used advanced econometric models: a vector error correction model to discover the return dynamics, and a GARCH (1,1) model to catch the volatility spill-over effects of the freight rate from one vessel size to the other in the same trading area.

3. Dry Bulk Market Analysis

3.1 The Dry Bulk Market

The dry bulk shipping industry is divided in two categories: the major and the minor bulk, referring to the largest and smallest quantities transported by ships.

The major bulk are iron ore, coal and grains. These commodities represent the core of the modern society. Iron ore and coking coal are used in production of steel for construction, cars manufacturing and other industrial products. Grains are the base of the human's diet, being part of the bread and meat production. (Stopford, 2009). The total amount of grain increased by 37% since 2008 reaching 438 mt in 2015. The major bulk is the most important cargo of the dry bulk shipping industry. (Clarksons, 2016).

The minor bulk trades are a mix of commodities carried in smaller quantities. Therefore, smaller vessels or containerized shipment are used. Stopford (2009) proposed six categories, agribulks, sugar, fertilizer, metals and minerals, steel products and forest products. Each product has a specific market responding to their own factors. The highest freight volatility is found in the major bulk segment. Thus, the following parts explain the components of the major bulk trades with regards to each vessel category.

3.1.1 Capesize Market

The largest bulkers have a carrying capacity, starting from 120,000 dwt up to 404,000 dwt. This range can be divided into two sub-categories summarized in Table 2.

Table 2

Ship Categories	Deadweight (Tons)
Capesize	120,000 - 220,000
VLOC	220,000 - 404,000

Source: Author

Market actors name all the ships with the capacity from 120,000 (dwt) to 400,000 (dwt) Capesize. Both are too large to enter any canals and have to go through the Cape of Good Hope or the Cape Horn. Moreover, vessels of this capacity are mainly carrying iron ore on standard routes. The iron ore traffic is handled at 80% by Capesize to take advantage of economies of scale on specific basin (Stopford, 2009). Thus, the factors affecting the Capesize calls are linked to the iron ore supply and demand. The iron ore trade is characterised by loading in a port close to the mines and delivering to steel mills. The mines are located in the following countries; Australia, Brazil, South Africa and India. On the other hand, steel mills are located next to market seeking for steel, such as China, Japan, South Korea and North

West Europe. Table 3 summarizes the different origins and destinations for iron ore cargo.

Table 3

Trading Routes		
Origin	West Australia	Port Hedland
		Dampier
		Port Walcott
	Brazil	Tubarao
		Sepetiba
		Ponta da Madeira
	South Africa	Saldanha Bay
	India	Mormugao
		Vishakhapatnam
Destination		China
		Europe
		Japan
		South Korea

Source (Stopford , 2009)

To be more accurate, here are the important Capesize routes; from Australia: port Hedland, Dampier and port Walcott, to China. From Brazil: Ponta da Madeira, Tubarao and Sepetiba, to China. We also observe trade from Australia to the North West of Europe as well as from Brazil to the North West of Europe. Moreover, a smaller quantity of iron ore is transported from South Africa: Richards Bay, and India to the North West Europe.

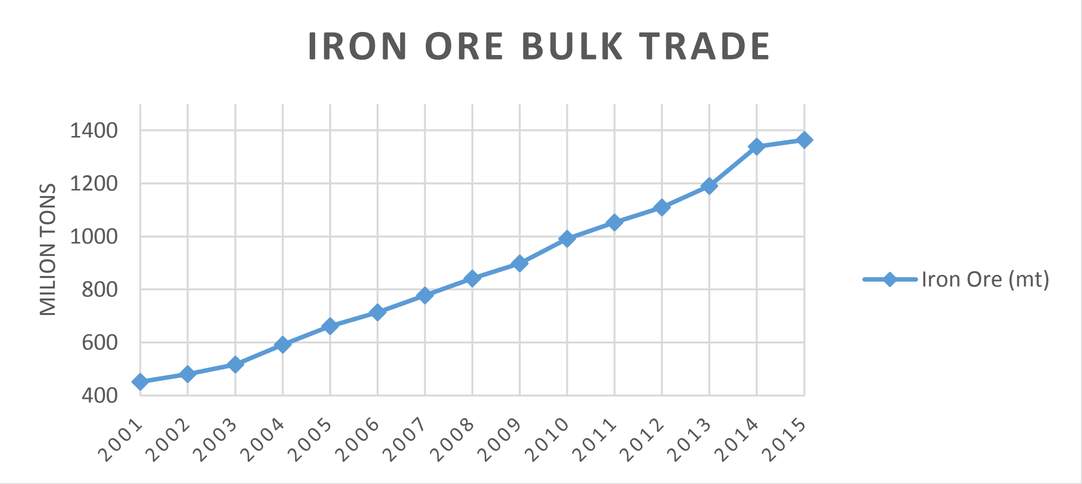


Figure 1: Iron Ore Bulk Trade (from 2001 to 2015)

Source: Clarksons (2016)

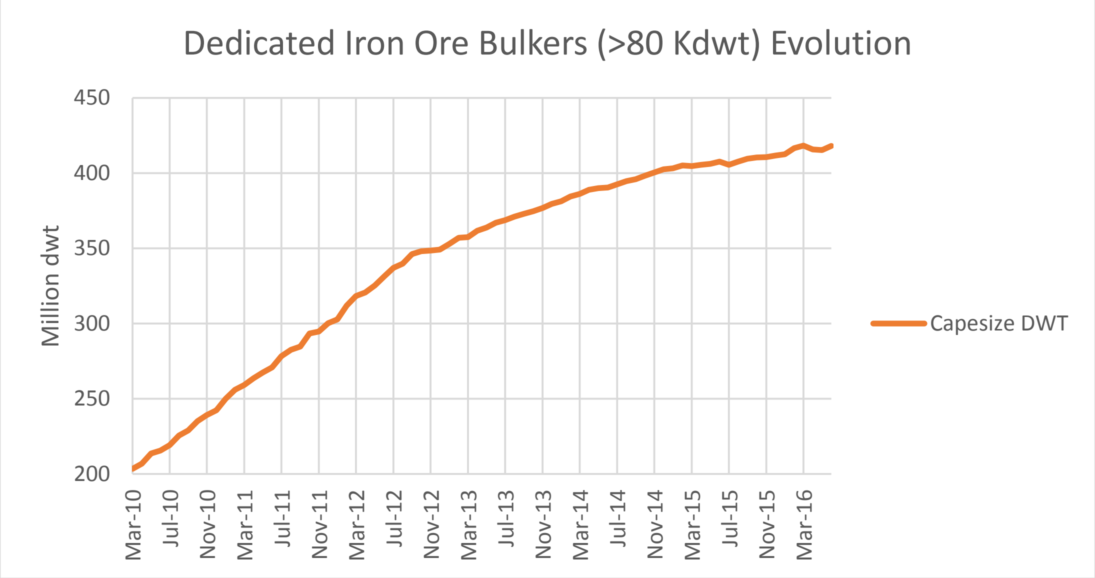


Figure 2: Dedicated Iron Ore Bulker Evolution

Source: Lloyd's (2016)

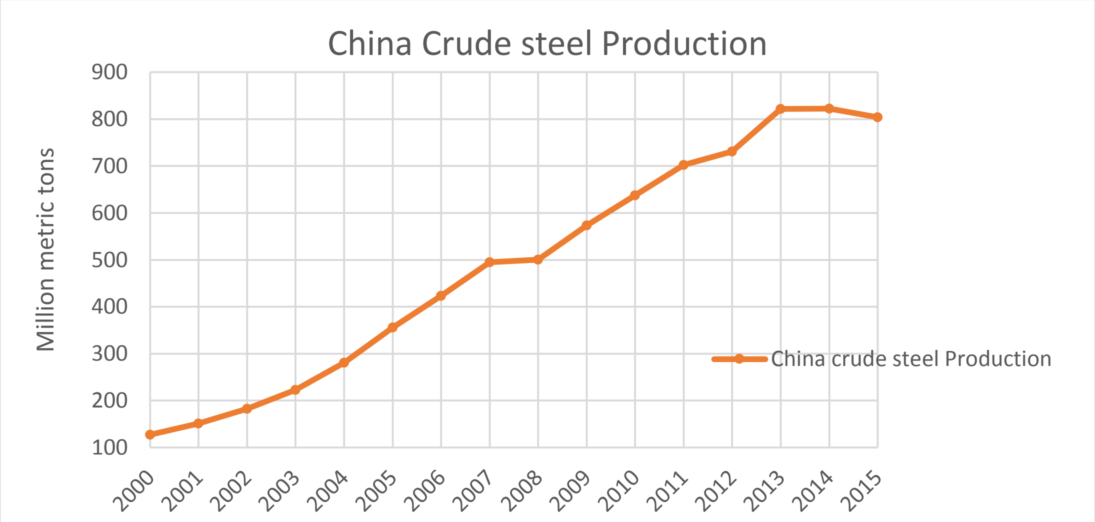


Figure 3: China Steel Production (from 2001 to 2015)

Source: mesteel.com (2016)

The previous graphs show the iron ore trade growth (Figure 1), the Capesize tonnage growth (Figure 2) and the chinses steel production growth. The three graphs are miles stones in the supply chain of raw material for steel production. We can observe a relationship between chinese steel production and the increase of the capesize tonnage. As we can see the two first lines are flattering in the past years following a decrease in steel production in China. It is interesting to compare the available tonnage with the iron ore seaborne trade at the end of 2015. The trade is equal to 1.3 (bt) where the tonnage on the market is 411.68 (mt). Resulting in an average fleet productivity of 3.16 tons per deadweight, being relatively low compared to 7.5 tons per deadweight of the world merchant fleet in 2004 (Stopford , 2009). Due to the strong increase in demand for iron ore from 2003 to 2008 many investors and ship-owners entered the Capesize market as the world economy saw no end to the growth in China. The Chinese construction market would keep growing, increasing the demand from the steel mills and the demand for iron ore could not stop. However, the ship-owners brought too much tonnage to the market, creating overcapacity and negatively affecting the freight rate. On the other hand, it is important to notice the constant growth of the iron ore seaborne trade from 2001 to 2015. Even with the financial crisis, the trade kept growing at a stable rate. We can derive this pattern form the industrial operating process of the steel industry, following the Chinese growing economy. Moreover, demand for iron ore in North West Europe and Japan remained steady for the past eight years. (Clarksons, 2016). Nonetheless, the Capesize fleet increased by 105% between 2010 and 2015 while iron ore seaborne trade increased by only 37% in the same period. Consequently, we observe an oversupply of vessels on the market. If the iron ore demand in China falls, the freight earnings are directly affected. In this situation owners and operators will look for other employment of their assets. Capesize could enter the coal market, being the main Panamax cargo. Under the following section the coal trading routes are analysed.

3.1.2 Panamax Market

Panamax vessels are the largest able to go through the locks of the Panama Canal (from 65,000 dwt to 120,000 dwt, as shown in Table 4). The main cargo is coal and grains but in some cases it can also be iron ore.

Table 4

Ship Categories	Deadweight (tons)
Panamax	65,000 - 82,999
Post-Panamax	83,000 - 120,000

Source: Author

The actual locks of the Panama canal are 320.04m long, 33.53m wide and 12.56m deep. In 2016 the expansion of the third lock should be finished, increasing the dimensions to 427m in length, 55m in width and 18.3m in depth. However, the exact bulk capacity able to pass the locks is still unclear. Two sub-categories are distinguished in the market. First, the actual Panamax of 65,000 dwt to 82,999 dwt enjoys flexibility as it can enter many ports and have no problems passing the canals. Moreover, the vessels are up to 82,999(dwt) corresponding to the maximum size allowed in the port of Kamsar in Guinea. These vessels are also called Kamsarmax. Second, the post-panamax is from 80,000 dwt to 120,000 dwt. The Panamax vessels are important in transporting coal and grain. According to Stopford (2009), coal is carried in smaller vessels than iron ore. It is due to the smaller demand as well as the risk of combustion of the cargo when carried in large quantities. There are two types of coal, the coking coal, used in steel production and the thermal coal for power generation. Coking coal is the second main material in steel production. The quality of the coal is very important to manufacture resistant steel. Therefore, coking coal comes from specific region, such as Australia and Indonesia, and is transported to steel mills. China has large reserves and exploits its own mines, lowering the demand for coking coal transportation. Thermal coal, used as a substitute to oil and gas for power generation, faced a sharp increase and became more significant for trade in the 90's because of its low price.

Table 5 presents the origins and destinations for coal cargo.

Table 5

Trading Routes		
Origin	East Australia	Hay Point
		Gladstone
		New Castle
		Port Kembla
	Indonesia	Tanjung Bara
		Balikpapan
		Banjarmasin
	Colombia	Bolivar
	Canada	Roberts Bank
		Seven Island
	South Africa	Richards Bay
Destination		China
		Europe
		Japan
		Korea

Source: (Stopford , 2009)

Major Panamax routes run from Australia, Indonesia and South Africa to China, Europe and Japan. Cargoes are also transported from Canada to Korea and China. The coal trade is under strong pressure for two main reasons. Firstly, the steel production has dramatically fallen in Europe and Japan, being the main importers. Secondly, power generated from coal is releasing sulphur emission in the atmosphere increasing the greenhouse effect. Therefore, developed countries are looking for alternative sources of energy.

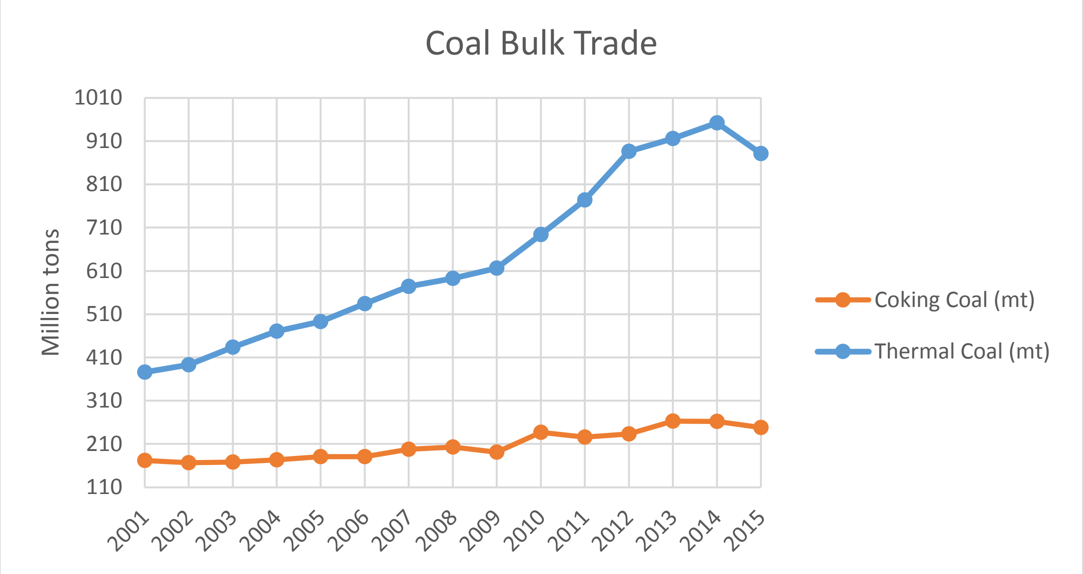


Figure 4: Coal Bulk Trade

Source: Clarksons (2016)

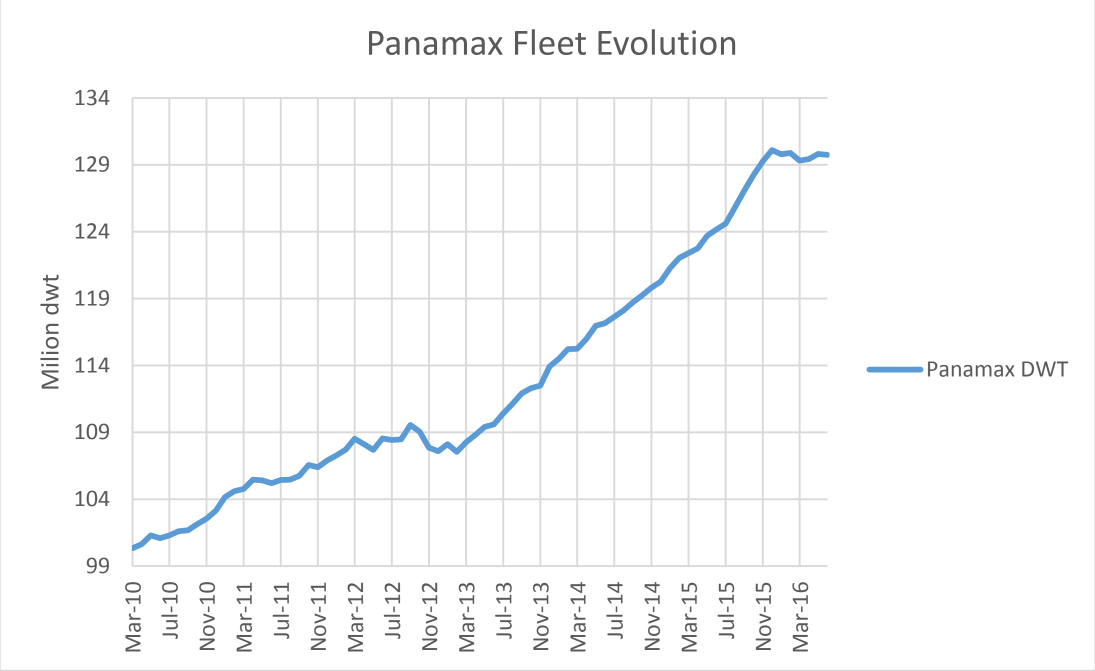


Figure 5: Panamax Fleet Evolution

Source: Lloyd’s (2016)

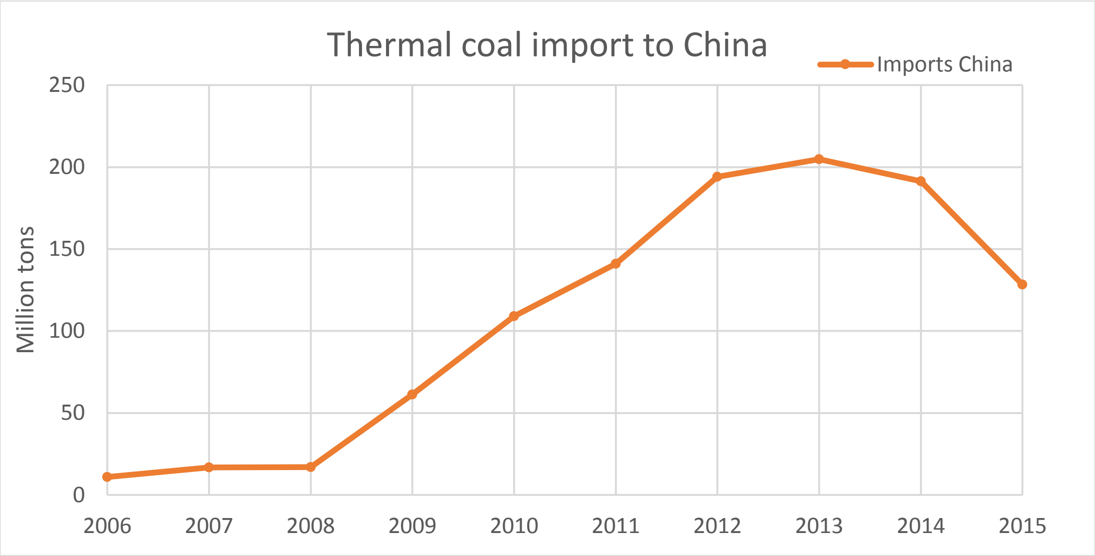


Figure 6: Chinese Thermal Coal Import (from 2006 to 2015)

Source: Clarksons (2016)

The three previous graphs show the relationship between the thermal coal trade, the panama fleet evolution and the Chinese thermal coal imports. We can see that China is given the rhythm to the all market. As the decreased imports in 2013, the global trade started to decline however the panama fleet kept rising. It only stabilised at the end of 2015, corresponding to the vessels ordered during 2013. Considering the fact that Panamax fleet, at the end of 2015, was mainly employed in coal trade, we can approximate the productivity. From Figure 3 and 4, the total coal trade is equal to 1.13 (bt) and the fleet tonnage is equal to 130 (Mtons), resulting in a productivity of 8.68. Besides, we notice that the Panamax fleet evolved by 29.3% between 2010 and 2016 pursuing the 31.5 % increase of thermal coal (26.9%) and coking coal (4.6%) together during the same period. There is a relationship between the Panamax fleet evolution and the coal trade. Although Capesize vessels can also transport coal as they are facing low levels of productivity, the consequence is a decrease in productivity in the Panamax market, which in turn affects freight rates. Following the aforementioned assumption, we found that the Capesize market has a negative effect on the Panamax market for the period from 2009 to 2016.

The Panamax vessels are also involved in grains transportation, nevertheless, grains trade requires different routes than the coal trades and more flexibility because of the seasonal behaviour. The largest exporter is the United States where there are various importers, such as the Far East, Africa and the Americas. Therefore, it is riskier and too far off for a Panamax vessel owner to catch cargo on the grain spot market, when compared to trying to enter into iron ore trade, especially when coal freight is not attractive.

3.1.3 Handy Market

The Handy ship market is divided into the following sub-categories.

Table 6

Ship Categories	Deadweight (Tons)
Handysize	10,000-39,999
Handymax	40,000-49,999
Supramax	50,000-59,999
Ultramax	60,000-65,000

Source: Author

The name of the main category comes from the high flexibility of the asset. Their low draft and convenient size give them access to a large number of commercial ports around the globe. Moreover, the vessels are equipped with cranes, allowing them to load and discharge cargo in low infrastructure ports. The smaller category is the Handysize from 10,000 (dwt) to 39,999 (dwt). Then we have the Handymax from 40,000 (dwt) to 49,999 (dwt). Followed by the Supramax from 50,000 (dwt) to 59,999 (dwt). Finally, the Ultramax from 60,000 (dwt) to 65,000 (dwt), with the most recent design going up to 66,000 (dwt). The Handy category is transporting the minor bulks. They are divided into six segments; Agribulk, Sugar, Fertilizer, Metals and Minerals, Steel products and Forest products.

Agribulk includes soya beans, soya meal and rice. The largest producers are the United States, Brazil, Argentina and China. The main importers are Europe, Thailand, and South Korea.

The dry bulk sugar trade cover two commodities, raw sugar and refined sugar. There are more than 90 countries exporting both commodities with a large majority located in the southern hemisphere. There are more than 140 importing countries such as Russia, Europe, Persian Gulf and Indonesia.

The Fertilizer trade includes four raw materials, potash, sulphur and urea. The exporters and importers are widely spread around the globe and depends on political and economic decisions.

The metals and minerals trade englobe bauxite, cement, steel scrap and salt. Bauxite is the raw material used to manufacture aluminium, it is mainly exported from the Caribbean to United States, Europe and Japan. Even if aluminium is used on an industrial scale, imports are shipped in small quantities because of the high value of the product and the low amount needed by the manufacturers. Cement trade is attached to construction project in different parts of the world. This linked creates high volatility in cement transportation. Steel scrap traffic corresponds to recycling steel from waste of steel production and old industrial material such as ships, engines and other steel products. This trade takes mainly place in developping economies such as the India, Bangladesh and Pakistan. Lastly the salt trades take place from Mexico and Australia to Japan.

The steel products trade is a mix of liner and tramp bulk shipping depending on the amount of steel to be transported.

Finally, the forest products are a high volume trade with very low value. It was mainly a backhaul cargo imported to Europe from developing countries. However, the demand increased and the trade became more important, developing specialized vessel with appropriate haul size called loggers with stanchions.

In conclusion, the handy market is divided into a large variety of cargo calling for smaller ship size. The market is more flexible and opens more opportunities for operating strategies. (Stopford , 2009).

3.1.4 Relationship between Capesize and Panamax markets

The three dry bulk shipping markets have been described in the previous section focusing on the routes and commodities. There is a clear distinction between the Handy market, mainly trading minor bulk cargoes, and the Capesize and Panamax markets, both catching major bulk cargoes. Even if the main commodity traded with Capesize is iron ore, the geographical distance between ore ports and coal ports in Australia, South Africa and from Brazil to Colombia can be acceptable. This ballast trips do not involve high cost for an owner and, in some circumstance, it can be more profitable to move the assets from a market to the other. Such situation appears when demand for a shipping market decrease. For example, vessels chartered on the spot market for thermal coal trade, from Colombia to Europe, are facing low demand because coal power plants are closing due to environment restrictions in Europe. Owners will be interested in ballast their ships from Colombia to Brazil to carry iron ore to Europe if the freight is profitable. In such situation, there will be price transmission form a market to the other. Furthermore, a shock in a market will impact the other and the freight rate will move in the same direction.

The literature highlights that there is a distortion in the dry bulk market by ship size because of the low level of vessel substitution. However, on specific route substitution between Panamax and Capesize exists. This effect is caused by the increase in demand for shipping in a market, making the segment profitable for other vessel size. The effect can be observed in both sides. On one hand, a ship-owner can choose to allocate ore carriers to coal market if infrastructure is available. On the other hand, a charterer can separate a large shipment of ore in several Panamax when the ore carrier freight rate is too expensive. Derived from the nature of the trade, the relationship between Capesize and Panamax market are related to similar routes but different commodities.

Moreover, the trading routes have an extended impact on determining the freight rate as we saw in Veenstra and Franses (1997). Panamax and Capesize vessels are associated by their cargo and by ports having the infrastructure to accept them. Therefore, there is a strong relationship between those two sub-sector in the following routes; Australia - Far East, South America – Far East, South Africa – Far East, Australia – Europe, South America – Europe, South Africa – Europe. The routes are summarized in the following matrix.

Table 7

	Trading Routes
Origin	Australia South Africa South America
Destination	China Japan - S. Korea - Taiwan Europe Others

Source: Author

3.2 The Shipping Freight Contracts

International shipping is framed around trip charter contracts and period charter contracts. Trip contracts correspond to short run contracts for a single voyage or trip from point a to point b. There are two types of such contracts, the single-voyage contract and the trip charter contract. Period charter contracts also have two different types, the so called time-charter and the bareboat charter. We can consider time charter contracts to be period charter when they refer a long period, from three to twenty years. The contract of affreightment is the last type which is related to a large amount of cargo to be transported. This section provides an overview of the shipping contracts.

Voyage Charter contracts

Under a single voyage contract, the charterer agrees with the ship-owner to buy a vessel transport capacity in a loading port and to give it back to an agreed port for a price determined in US-dollars per ton carried. The ship-owner is responsible for the cargo until he safely discharged it at destination. In the contract both parties agree to the time period in which the vessel has to be at the port of origin and the port of destination, as well as the number of hours to load/discharge the vessel. If the charterer causes delays, he has to pay the demurrage agreed in advance with the owner. On the other hand, if the ship-owner delivers the cargo earlier than agreed he has to compensate the charterer, it’s the dispatch. In addition, the ship-owner is responsible for all the costs made during the voyage such as, bunkering, cargo handling, port fees and canal dues, crew expenditures. (Alizadeh-Masoodian, 2001).

Time Charter trip contracts

Under a trip-charter agreement the charterer hires the vessel for a defined trip from the port(s) of loading to the port(s) of discharge. The ship-owner is responsible for the cargo until he discharges to the specified destination. The freight is agreed in US-dollar per day and the ship-owner pays for the operating costs, such as the costs for the crew, for example. The charterer pays for the voyage costs such as bunker and canal dues. In this agreement, as the rates are paid per day, the owner directly benefits from delays caused by the charterer. This contract is interesting for the charterer as he can benefit from the discounts agreed with bunkering companies and port terminals. He operates in the same way as under a time-charter contracts.

The trip-charter and the voyage charter contract are moving together as they are both offering a single voyage agreement. Therefore, under market efficiency hypothesis, there is no arbitrage opportunity. Contracts available on the same trade routes for the same commodity will not offer opportunity for arbitrage. (Alizadeh-Masoodian, 2001).

Period Charter contracts

Under a time-charter arrangement the charterer hires a vessel for an agreed period of time, in general from one year to twenty years. They agreed on specific clauses such as the place of delivery and redelivery of the vessel, the bunker and the trading area. As in a trip-charter the freight is paid in US-dollars per day. The ship-owner is only responsible for the capital cost, such as maintenance as well as for the financial expenses. This provides the owner with a secure cash flow which he can use to safely run his company. The charterer, on the other hand, has to pay for the operating, voyage, and handling costs. It gives him more flexibility regarding his trading routes and no risk of demurrage. As the charterer moves the assets freely in the agreed trading area for the same freight during the whole period, he takes the risk of paying a higher rate than the future spot price in the trading region. (Alizadeh-Masoodian, 2001).

Contracts of Affreightment

Under a contract of affreightment, the ship-owner agrees to transport a determined amount of cargo from a region or port of loading to a port/region of discharge. The ship-owner pays all the costs. Such contracts are agreed for the commodities transported in large amounts. For example, a power plant wants to guarantee the supply of coal with a low level of inventory. The freight is paid in US-dollars per ton which guarantees to the cargo owner a fixed cost for the amount to be transported. Therefore, he will be able the optimize his supply chain and minimize his costs. This contract is interesting for the ship-owner as he can play with his assets, increasing his flexibility to allocate vessels on other trading routes and brings him a secure cash flow as well. (Alizadeh-Masoodian, 2001)

Bare-boat charter contracts

Under a bare-boat charter contract the charter hires the vessels for a long period of time, it could be the economic life of the vessel. The owner is only responsible for the financial costs. The charterer is responsible for all the other costs, such as maintenance, crew, bunker, port fees and canal dues. The charterer agrees to this type of contract when he is interested in having the full control of the commercial operations of the vessel. This strategy enables him to get rid of the risks related to the fluctuation of the asset value, causing distortion on their balance sheet. In such situation the owners are shipping investors only interested in financing the asset but not in operating them.

Voyage-charter, trip-charter and time-charter are the most common contracts reported in the market and for which we have data. Because the period charter contracts are agreed between the owner and the charterer in private and the rates are not transparent it is hard to do research to calculate the spill-over effect and the price influence per route. Therefore, in our research we gather data on the spot market only, focusing on the agreed trading routes and on the main Capesize and Panamax time charter agreements.

3.3 The Freight Market

3.3.1 Shipping Cost structure

In this section, we investigate the different shipping costs as trade is significantly responsive to changes in charges. (Geraci & Prewo, 1977). In order to fully understand the incentive and the factors constituting the freight rates in the dry bulk market, we investigate the cost structure of a ship-owner.

First, the capital costs occur when acquiring a vessel and are composed of two main factors: repayment of the loan and the interest rate. The structure of the loan repayment and the interest margin of the bank will depend directly on the reputation of the ship-owner, the size of his fleet, operational and financial capabilities of the company. As an illustration, if we consider a well-known ship-owner with a large fleet that could be used as collateral. He will be able to ask for a lower interest rate and a longer debt repayment period, increasing his cash flow flexibility. (Alizadeh-Masoodian, 2001). Therefore, the capital costs differ from one shipping company to another, even if they are operating in the same market. They are the responsibility of the ship-owner.

Second, operating costs are the fixed costs of running a vessel. They include all expenses for the crew (provisions, stores), maintenance and insurance of the vessel. The abovementioned costs are directly related to the standards required by the flag on which the vessel is sailing. The operating costs are the responsibility of the ship-owner or the charterer under a bare boat contract.

Third, we have the cargo handling cost and the voyage costs. They are the variable costs occurring when the vessel is sailing and when it has a cargo. For example, bunker costs, canal dues, port charges and the stowing, loading and discharging of the vessel. The previous costs depend on the type of the contract. To be more precise, in a voyage charter and contract of affreightment the ship-owner is responsible for the voyage costs and the handling cost where under a time-charter the charterer has to pay for operating costs as well. (Stopford, 2009).

Shipping is a cash industry, therefore, handling expenses as efficiently as possible is a key for ship-owner and charterers. Benefiting from the most suitable type of contract at the correct timing brings serious advantage, resulting in better bargaining of the freight rate and surviving when the market is in a downturn. For example, a ship-owner taking long-term agreement with bunker companies with a fixed price, will keep low fuel cost when the oil market rises. Consequently, they will have more flexibility in the spot market to carry cargo for a lower rate and increase their market share.

3.3.2 Spot freight composition

The spot freight market is reported through two different types of contracts: the voyage charter, when the shipper has no intention to manage the vessel, and the time charter, arranged by ship operator when they are interested in the vessel operation. The original freight market is called the Baltic Shipping Exchange where the freight contracts were physically negotiated. Cargo-owner and ship-owner bargained in order to transport the cargo for the highest profit and agreed on the freight rate. Nowadays, there is no more physical market place, transactions and bargaining are done through email and phone calls. The Baltic exchange is a virtual market where traders, brokers and owners buy and sell transportation. The bargaining is organised between a cargo owner and a ship-owner by the intermediary of a broker. The broker is in the centre of the shipping market and knows all the information available on the market to fix the most profitable freight. They are supposed to have all the market knowledge, meaning they know where the ships and the cargo are to match them efficiently. In general brokers are specialized in a shipping market. As an illustration, there are capesize brokers, knowing where the fleet and the cargo are positioned at any time. They negotiate the freight based on the information they have. Brokers are gathering in shipping centres to be close to the market, increasing the possibility that they all have the same information. This could result in a movement of the market in one direction because they influence each other and decisions are not made independently from each other. Also feelings and expectations play a role (Stopford , 2009).

Each segment is influenced by their own factors and move according to individual determinants. For example, the tanker market will be directly affected by oil demand and geopolitical situation in the Middle East. On the other hand, dry bulk market will not be affected by those factors in the short run. However, in a segment the same factors applied to supply and demand. Shock in a shipping market in one region will be transmitted to other regions in the same shipping markets. Furthermore, the shock can be transmitted to other shipping market. Such phenomenon is driven by the fact that brokers in a market will advise the owner to move his assets in other regions or carry other cargo if the freight are better. It confirms the market efficiency hypothesis.

The five main factors affecting the demand for transportation are the world economy, the seaborne commodity trades, the average haul, the random shocks and the transport cost. On the other hand, the main factors affecting the supply of transportation are the world fleet, the fleet productivity, the shipbuilding production, the scrapping losses. The combination of the previous factors, through a broker, will determine the freight rate. Figure five models the supply and demand for freight determines by Koopmans (1939).

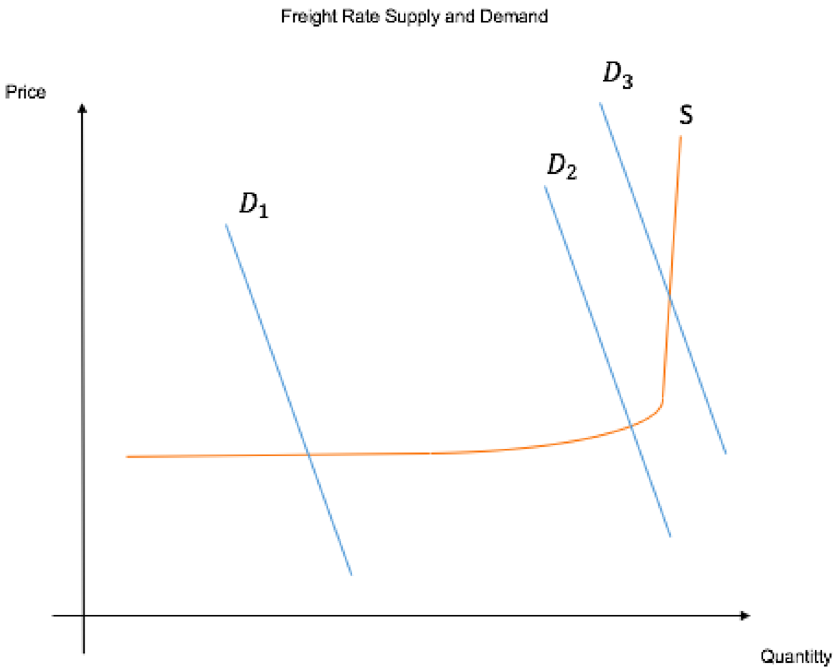


Figure 7: Freight Supply and Demand

Source: Koopmans (1939)

A low quantity of transportation volume results in a minimum level of freight rate because of oversupply of ships. In such situation the ship-owners decrease the speed of the vessels to lower the fuel costs and the productivity of each asset to create space for ship. If the freight is too low, they will lay-up the vessel. As the volume to be transported increase, the available number of vessels decrease and the freight rates start to increase. Then the owners increase the speed to optimize the level of productivity or bring laid-up ships back to trade. However, the volume to be transported by the fleet has to increase to a very high level to see the freight rate moving from D1 to D2. Then many vessels are taken into the market. Then only a small increase in cargo volume is needed to move from D2 to D3 but the freight rates explode.

The demand side reacts differently to the changes in volume and the freight price. Koopmans (1939) argued that the demand elasticity for freight is low. The demand in the freight market is independent from the price in dollar, charterer will pay the amount asked to transport their cargo and satisfy their demand. Finally, the freight rate will be determined at the equilibrium of supply and demand at a certain moment in time.

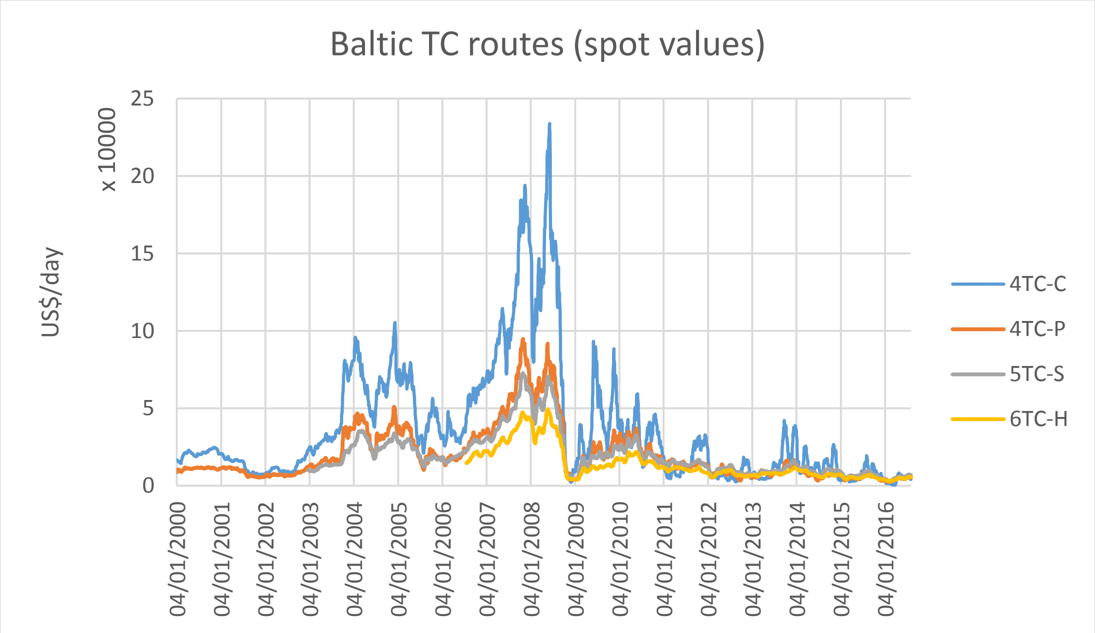


Figure 8: Baltic Time Charter values per routes

Source: Baltic Exchange (2016).

Figure 6 represents the evolution of the spot charter rates of the Capesize, the Panamax, the Supramax and the Handysize vessels category. The data is taken from the Baltic Exchange and gives codes to each route. The freight volatility has been impressive between 2003 and 2011 corresponding with the sharp rise of the Chinese economy. Moreover, we observe that all the rates are driven by the Capesize. They move in sync with the Capesize market: they rise when the Capesize rises and fall when the Capesize falls. Moreover, co-integration can be observed in all routes with a higher volatility on the Capesize. In order to visualize the trends between Capesize and Panamax freight rates, we draw two of them in Figure 7.

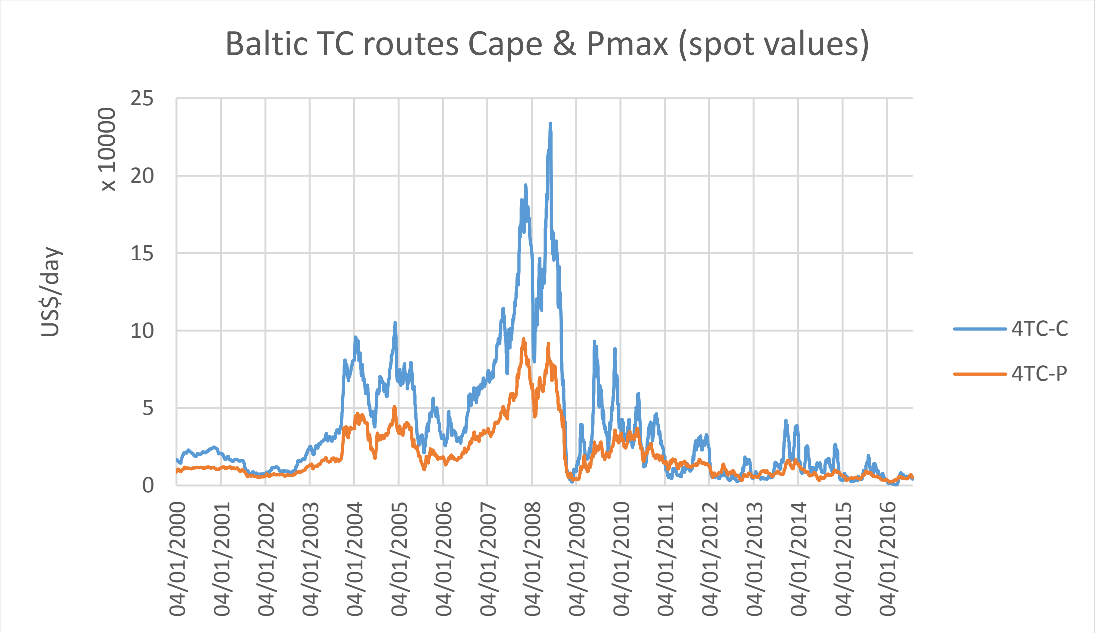


Figure 9: Baltic 4 Time Charter Average for Capesize and Panamax

Source: Baltic Exchange (2016).

Figure 7 illustrates the spot charter rate from 2000 to 2016 of the Capesize and Panamax. Both trends are moving in the same direction with peaks in 2007 and 2008 pushed by the strong demand for coal and iron ore in China. It suggests that co-integration and information spill-over exist. Furthermore, there is a change in trend after the financial crisis. We can observe two different patterns from 2008. First, between 2009 to 2010 with a large volatility. (the Capesize had peaks at 93,197 (US$/day) followed by the Panamax with peaks around 35,007 (US$/day)), and then between 2011 and 2016, when the volatility decreases and both market are flattering.

3.3.3 Period charter rate composition

The time-charter rates are modelled on the same supply and demand theory of Koopmans (1939). However, they include market expectations of ship-owners regarding the coming months or years. As the period charter covers a longer period, both charterer and owners are taking risks. The charterer takes a speculative position, thinking that the market will increase and, therefore, he lowers his cost by having booked his contracts. In addition, he can charter the vessel again making a marginal profit from his first contract. The ship-owner is facing opportunity cost as he could charter his vessel for a higher price if he waits for the market to rise or operates on the spot market. Nevertheless, the period rate guarantees a revenue for the time laps. Thus, ship-owners are willing to accept a discount on freight to fix a charter on a longer period. (Alizadeh-Masoodian, 2001). Because both agree on a period charter, the freight reflects both players' expectations for the contracting period. Under the efficient market hypothesis, the freight should be a relevant predictor of the future spot freight rates.

3.3.4 Seasonal behaviour of freight rates and dry bulk cycles.

The demand for shipping is a derived demand for the commodity transported, therefore, a direct relationship exists between the freight rate and the commodity prices, which are subject to seasonality and cyclicality. As mentioned in section 2, the major bulk are iron ore, coal and grains, corresponding to the Capesize and Panamax cargoes. Two out of three are subject to seasonal patterns. First, coal, more precisely thermal coal faces a larger demand during winter months as the days are shorter and people spend more time inside using more power than during the summer months. Additionally, grain trade such as wheat and crop are highly seasonal by nature. The last years' charterer and owner had to manage strong cyclones and typhoons. Their directions are highly unpredictable, making the shipping operations complicated and creating large delays. To handle seasonality, charterers are looking for available ships on the spot market as it is very complex to determine the amount of cargo to be transported and they benefit from more flexibility implementing this strategy. Accordingly, freight rates of large ships are influenced by the seasonality. This pattern may influence interconnectivity and spill-over between the Capesize and Panamax rates. For instance, the cyclical pattern of coal trade may create a rise in demand for transportation during the winter months (more power needed), increasing Panamax spot rates and pushing Capesize to take part of the market.

4. Methodology

In our methodology, we analyse freight rate data to understand the dynamic interrelationship between the Capesize and Panamax market since the financial crisis of 2008. The literature review helps us determine the appropriate statistical and econometrical models to use. Moreover, it helps emphasize the main trading route, creating connectivity between both markets. It is the transatlantic, the transpacific, the fronthaul and the backhaul routes. The results of this section will answer the main research question and the sub-research questions of the thesis. We are using time series models to catch the behaviour of the freight rate over time. First, we construct a statistical analysis on each route separately to understand the distribution, the correlation and the stationary pattern of the data. Then, we compute a Johansen test (1981) to investigate co-integration. The co-integrating vector is used in the vector error correction model (VECM) to highlight dynamics of the returns. Finally, we develop a general autoregressive conditional heteroscedasticity (GARCH (1,1)) to understand the volatility and the spill-over effect on each route.

4.1 Data Analysis

4.1.1 The Baltic Exchange

The Baltic Exchange is the shipping market where merchant and ship-owner meet to buy and sell freight. It all started in London in the nineteenth century. The company started to publish freight index to help actors of the market understand the shipping supply and demand situation. In 1985, they published the first Baltic freight Index, which became the Baltic Dry index in 1999. Then the Baltic Capesize index, Baltic Panamax index, Baltic Supramax Index and finally, the Baltic Handysize Index.

Following the indices, they publish the Time Charter Average per ship category. It is a weighted average of daily time charter for the main shipping routes per vessel size. As an illustration the 4 Time Charter Capesize average is computed as follow.

$$4TC\_C = 0.25 * TA + 0.25 * FH + 0.25 * PA + 0.25 * BH$$

The $4TC\_C$ is the 4 time charter average of the capesize market. TA corresponds to the transatlantic route also code as C8-03 by the Baltic. It is the round voyage from Europe to South America. The time charter rate is compute via a standard ship of 172 Kdwt, going at an agreed speed, carrying an agreed cargo, fuelled with accepted oil. FH is the fronthaul route also code as C9-03. It is the most profitable route, the highest paying leg, with delivery in Amsterdam-Rotterdam-Antwerp range and redelivery of the vessel in China-Japan range. Like the transatlantic route, it is based on a standard vessel and contract clauses. PA is the transpacific route also code as C10_03. The vessel is delivered in China-Japan range and does a round voyage through Australia to be redelivered 30 to 40 days later in China-Japan range. The charter contract is agreed on a standard vessel with the same clauses as in the previous contracts. Ship-owners are trying to forecast the most paying basin between the transatlantic and transpacific to position their vessels. It is variable and depends on demand for transportation. Finally, BH is the backhaul route also code as C11_03. It is the less paying leg. The vessel is delivered in

China-Japan range and has to be redelivered in Amsterdam-Rotterdam-Antwerp range. It has the same characteristic as the previous routes.

To continue, in May 2014 the Baltic Exchange introduced a new Capesize time charter average; the 5TC, with an increased Baltic type of 180 Kdwt. Because the 4TC on the basis of a 172 Kdwt did not represent the Capesize market accurately, mainly because of the lack of the longhaul component. They made the following weighing.

$$5TC\_C = 0.25 * TA + 0.125 * FH + 0.25 * PA + 0.25 * LH + 0.125 * BH$$

The LH has been introduce in the equation and is taking 25% of the market according to the Baltic panel list. It corresponds to the round voyage from China to Brazil. The vessels are ballasting from China to Brazil to take iron ore and come back full, with a profitable leg to China. It is based on a standard 180 Kdwt Capesize with the same charter clauses as previously, only the period is longer.
The Panamax 4TC, Supramax 5TC and Handysize 6TC are computed the same way as the Capesize time charter average with their corresponding routes. The Panamax 4TC has exactly the same routes as the Capesize 4TC. Using the average and by isolating each route from both markets, we are able to investigate the dynamic inter-relationship of both markets globally and on each trade route.

4.1.2 Data sources and data collection

The dataset is composed by daily spot rate given by The Baltic Exchange. We gathered data from the main routes. First, we took the data from the 4TC Capesize (172 Kdwt) average, being an equally weighted average of the transatlantic (C8_03), the fronthaul (C9_03), the transpacific (C10_03) and the backhaul (C11_03) Capesize routes. Second, we took the data from the new 5TC Capesize (182 Kdwt) average. The Batlic Exchange started to publish the 5TC Capesize in May 2014, restricting our sample. Third, we took the 4TC Panamax (74 Kdwt) average routes. The underlying routes are the same as for Capesize and are equally weighted as well.

The period of research starts on 1 January 2009 and ends in the second quarter of 2016. Our sample has 1,895 observations. All the data of our thesis is secondary as we gathered them from the Baltic Exchange database. From the literature review we understood that the Capesize and Panamax markets are crossing each other on the coal and iron ore trading routes. In a more general way, we may find relationship on the route presented in Table 8. The transatlantic, transpacific, fronthaul and backhaul are standard routes from the Baltic exchange. Transportation on this route is mainly agreed on time charter rate in US-dollar per day.

Table 8

Market	Route	Description	Main Cargoes
Capesize	Transatlantic	Europe to Americas and return	Coal and Iron Ore
	Fronthaul	Europe to Fare East	Coal and Iron Ore
	Transpacific	North Pacific to North America, return voyage	Coal and Iron Ore
	Backhaul	Fare East to Europe	Coal
	Longhaul	Round voyage from China to Brazil	Iron Ore
Panamax	Transatlantic	Transatlantic round trip from Europe to Europe	Coal, Iron Ore and Grain
	Fronthaul	Europe Fare East time charter	Coal, Iron Ore and Grain
	Transpacific	North pacific to North America return voyage	Coal, Iron Ore and Grain
	Backhaul	North pacific to Europe	Coal, Cement

Source: Baltic Exchange (2016)

After defining the main trading routes whereCapesize and Panamax vessels are overlapping each other, we investigated the freight rates. First, we analysed the time charter on the 4 different routes. As can be seen in Figure 8, during 2008 the freight rates fell dramatically and never returned back to the level of mid-2008. Therefore, we excluded the data from January to December 2008 from our sample. By including the aforementioned data, we would have the problem of serial correlation and non-stationarityy in the sample. Before that, we investigated the Baltic Capesize and Panamax routes to understand if the situation changed since the inter-market relationship that existed from 2003 to 2008. (Chen , et al., 2010)

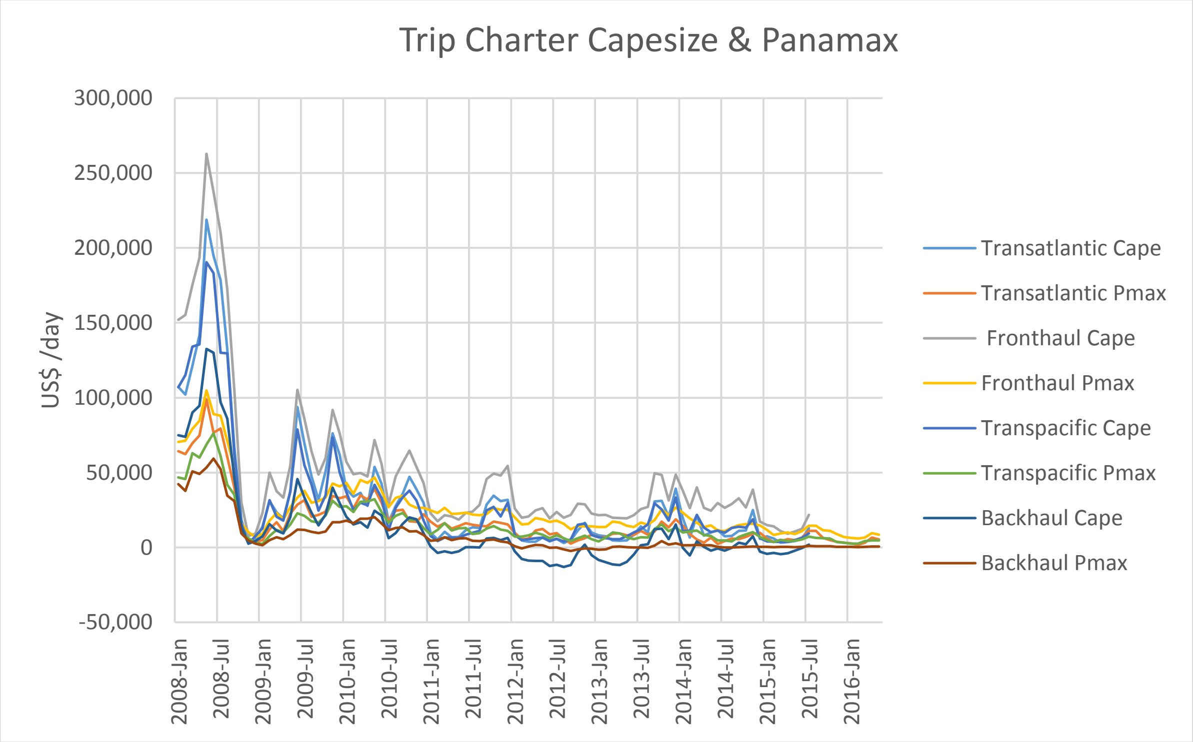


Figure 10: Trip Charter Rates for Capesize and Panamax (from 2008 to 2016)

Source: The Baltic Exchange (2016)

The spot rates on the overlapping routes also faced a sharp decrease in 2008 and therefore, we did not consider them in our sample. We investigate the time charter freight rate because it gives spot rate representing the information in the market at a definite moment in time. When the period charter contracts are long term agreements and represent the expectations of the ship-owners regarding the coming market, such contracts are considered to be out of the scope of our research. In addition, it is important to have comparable data to analyse, therefore, we took spot rate in US$/day for the different voyage and trip charter.

Following the high volatility of the rate and the strong difference from one period to the other, we divided and analysed two periods: from 2009 to 2011 and from 2011 to 2016. Furthermore, it is important to chase the rates from period to period and to understand the drivers in each sub-division.

First, the shock of the fast growing Chinese economy pushed the demand for raw material at the highest levels from 2003 to middle 2008 as we can see it in Figure 9.

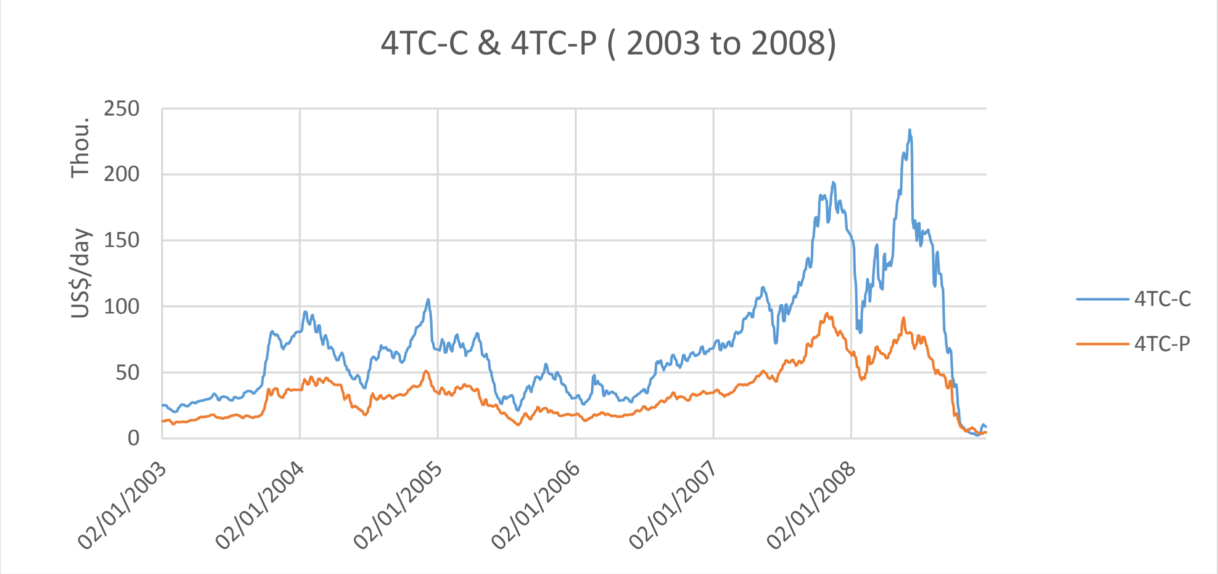


Figure 11: 4 Time Charter Av. for Capesize and Panamax (from 2003 to 2008)

Source: Baltic Exchange (2016)

Between 2003 and 2008 there is a strong co-integrating effect between Capesize and Panamax on the four time charter average as it is found by Chen et al. (2010). Both are peaking and falling together. We can observe a constant spread between the two markets, with a clear symmetry. After the financial crisis shock, the co-integration and the symmetry is less clear. As we can see it in Figure 10, between 2009 and 2011 the Capesize faces strong volatility where the Pananax is not peaking or falling sharply.

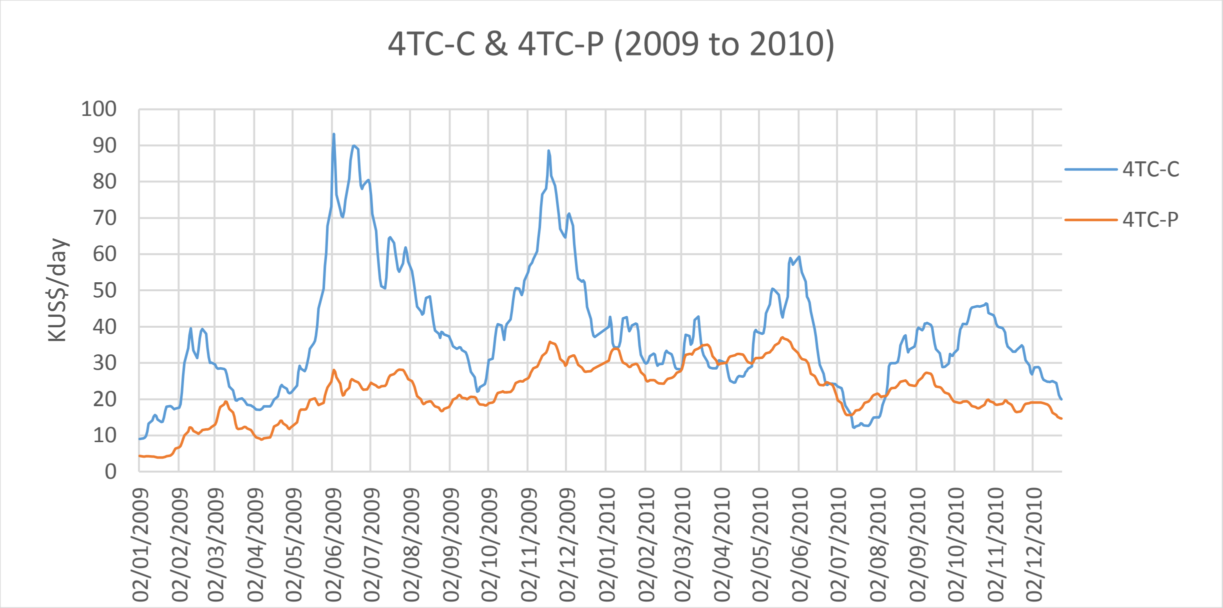


Figure 12: 4 Time Charter Av. for Capesize and Panamax (from 2009 to 2010)

Source: Baltic Exchange (2016)

The volatility in the Capesize market decreases after 2012. In 2009 the Capesize market peaked at 93,197 US$/day and in 2010 at 59,324 US$/day. Where the highest peak between 2012 and 2016 is at 42,211 US$/day in 2013. We can observe a decreasing volatility in the Capesize and Panamax in the last period. Moreover, co-integration and symmetry is hard to distinguish as we can see it on Figure 11. Moreover, the longhaul route started to be more important from 2011 to 2016 disturbing the market and making the 4TC less representative of the actual situation. Increasing the ton/miles for the Capesize market, raising fleet productivity. In addition, in 2011, ship-owners were facing large bunker costs and low freight rate. Therefore, they had to sail on eco-speed in order to remain profitable. The longhaul and the eco-speed may have changed the interrelationship of both markets.

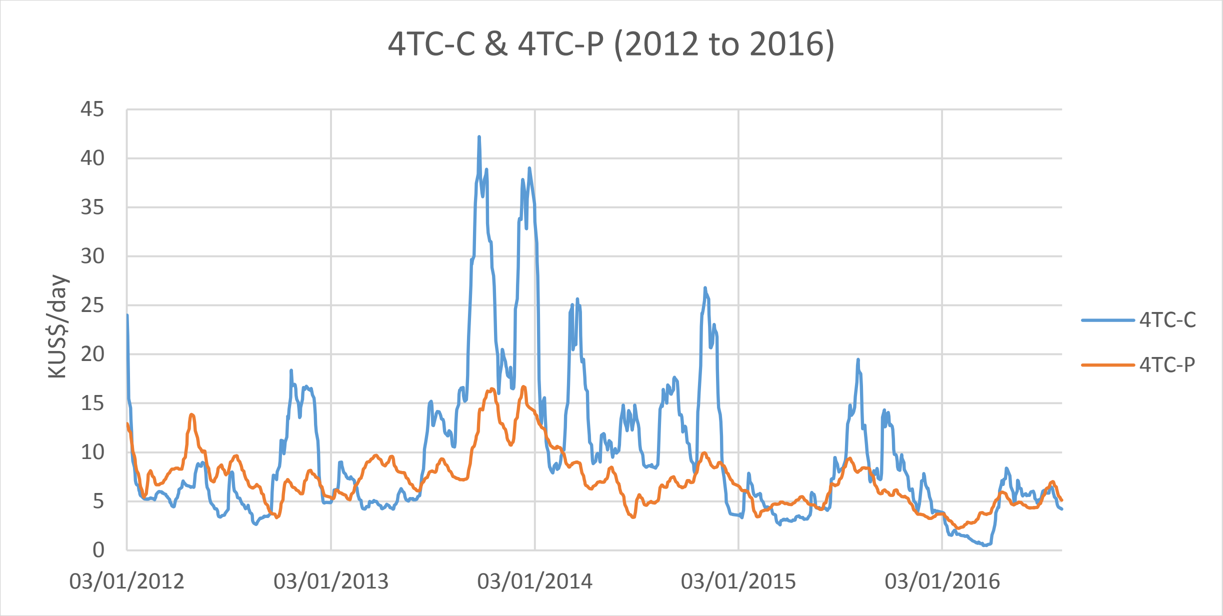


Figure 13: 4 Time Charter Av. for Capesieze and Panamax (from 2012 to 2016)

Source: Baltic Exchange (2016)

The main aspect to consider after financial crisis is the Capesize volatility from 2009 to 2011 and the creation of the longhaul route from 2011 to 2016.

4.1.2 Capesize spot rate.

As in the research study conducted by Chen et al. (2010), we investigated the time charter rates of the Capesize vessels. We transformed the data into their first logarithm difference to understand the change in percentage from one year to the other. Moreover, the log first difference enables us to use autoregressive models to investigate trends in the data.

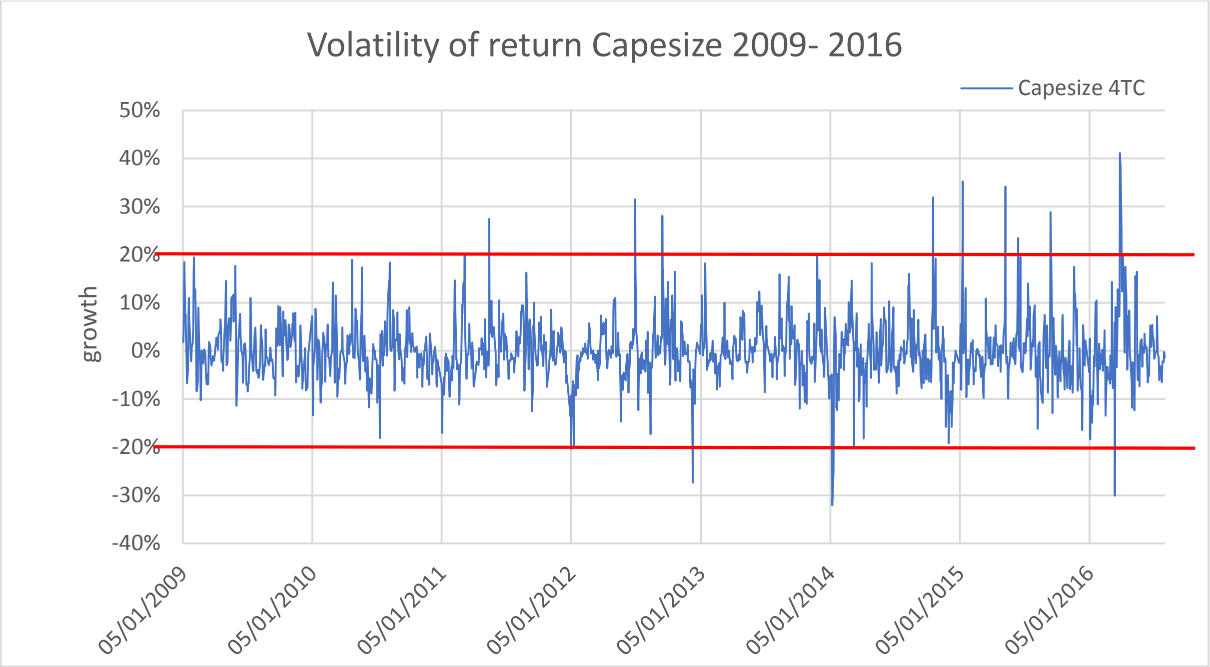


Figure 14:Capesize 4 Time Charter Average Volatility of returns

source: Baltic Exchange (2016)

On figure 12 we can see the percentage variation of the Capesize time charter average rate from the end of 2009 to July 2016. The graph shows the average of the four abovementioned Baltic exchange routes. We observe large variations from + 40% to -32%. However, the majority of the volatility is bound between $\pm 20\%$. We can observe it in the next figure on the variation of the transpacific, transatlantic and fronthaul routes.

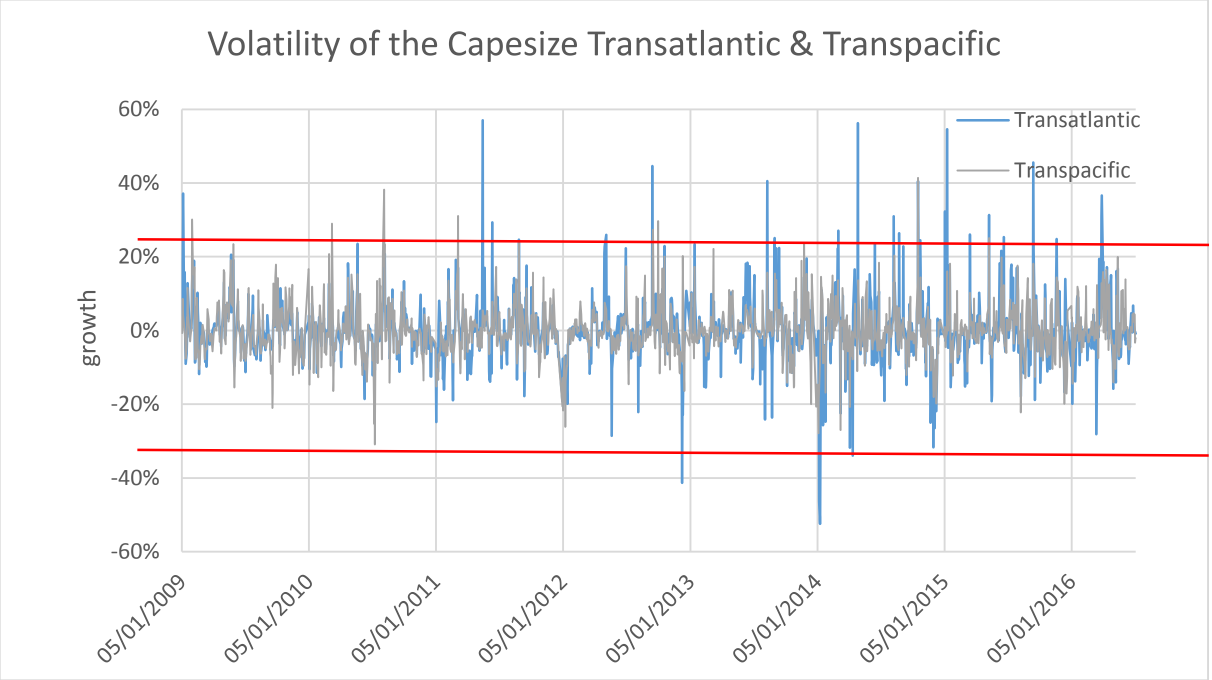


Figure 15: Capesize Transatlantic and Transpacific Volatility of returns

source: Baltic Exchange (2016)

Figure 13 highlights the percentage variation of the transatlantic and transpacific Capesize routes. The majority of the variation is in the interval of $\pm 30\%$ between 2009 and 2016. We observe a strong asymmetry in the variation. When the transatlantic is growing, the transpacific is falling. This phenomenon is called the "basin spread". The following graph expresses the volatility in the fronthaul and the backhaul routes. The volatility is larger in the backhaul route and completely random. It is built with large positive and negative peaks in a flat environment. On the other hand, the fronthaul is fluctuating between $\pm 15\%$.

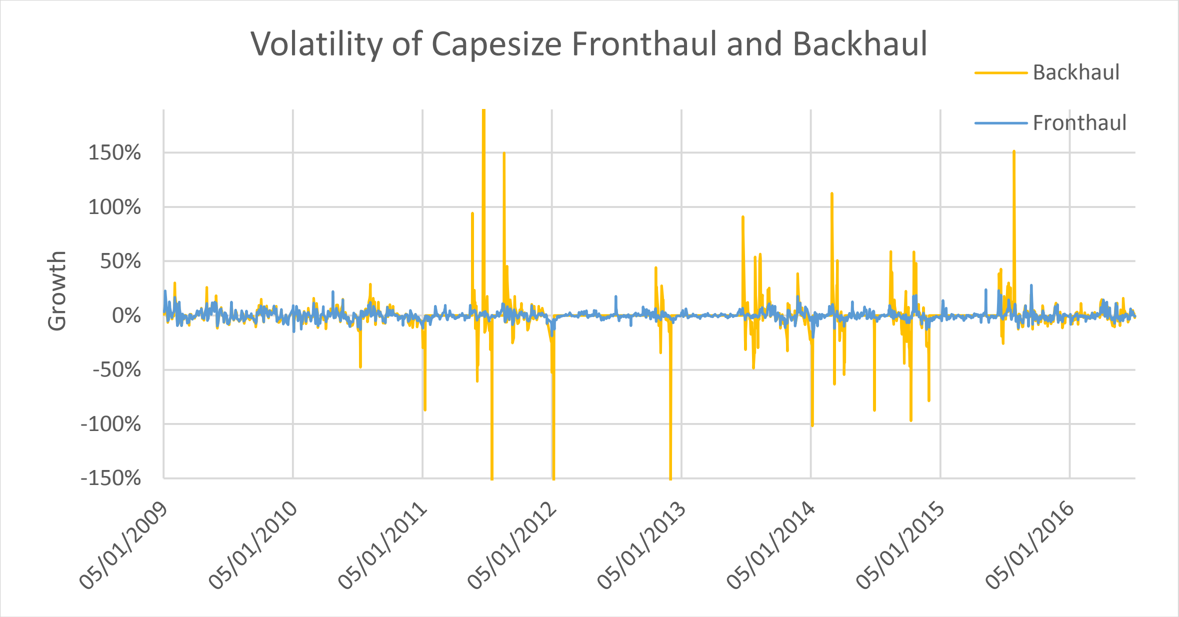


Figure 16: Capesize Fronthaul and Backhaul Volatility of returns

Source: Baltic Exchange (2016)

The arrival of the longhaul in 2011 changed the dynamics of the Capesize market. The ton mile increased, raising the vessel productivity. The vessels are doing a round trip from China to Brazil, to load iron ore and back to China to discharge. It has a direct impact on the rates and volatility as the vessel supply decreases. Figure 15 highlights the volatility on the longhaul route. It is in the interval of -10% and +20%, fluctuating from one day to the other.

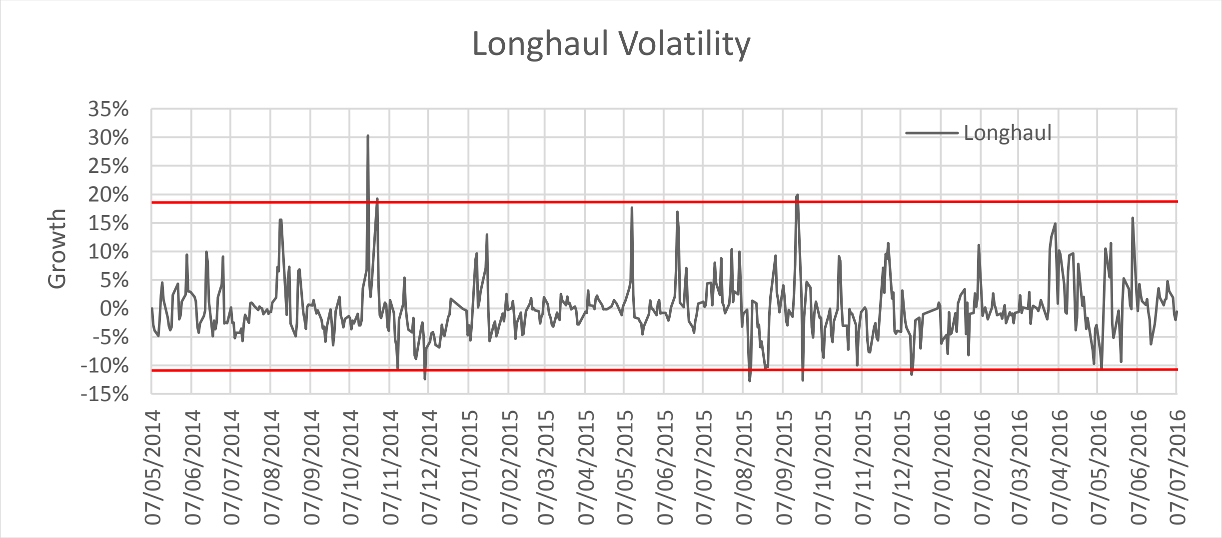


Figure 17: Capesize Longhual Volatility of returns

Source: Baltic Exchange (2016)

The Capesize market is driven by extremely high volatility even after the financial crisis of 2008. The variation is following a random walk, making the forecasting of the future rates by the past rates impossible in the Capesize market. As a final point the variation of the 4TC average is not expressing the volatility of each route. It is better to understand the dynamics of each seaborne trade separately.

4.1.3 Panamax time charter and spot rate.

The Panamax and the Capesize vessels are trading on the same routes when they are carrying coal and iron ore. In order to understand the dynamics, we analyse the freight volatility on the time charter routes. First, we investigate the volatility on the Panamax 4TC average between 2009 and 2016. There is a strong volatility during the first half of 2016. Afterwards the volatility is bound between -7% and + 8%. The volatility of the Panamax average is lower than the volatility of the Capesize.

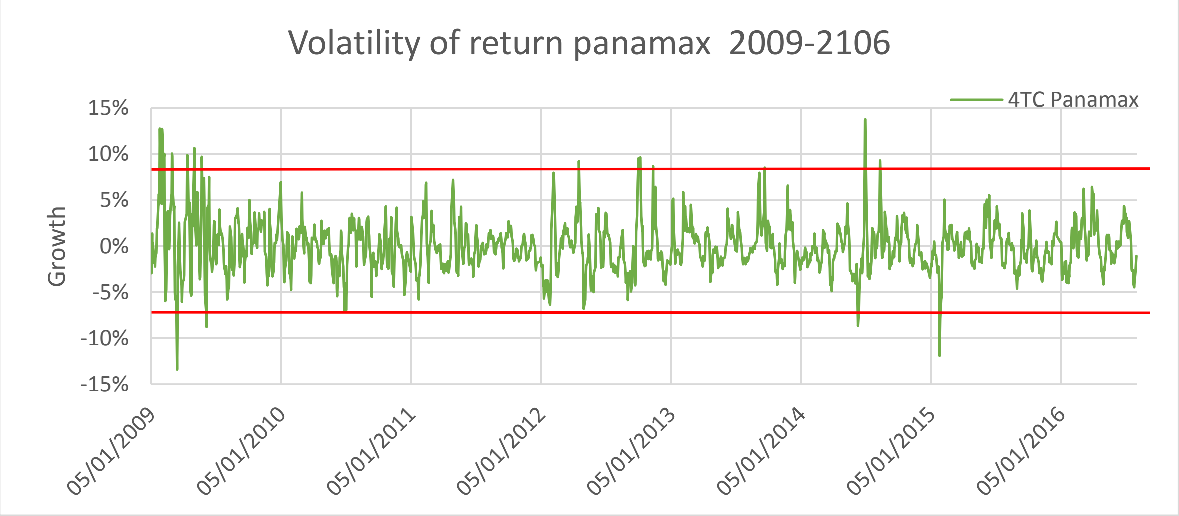


Figure 18: Panamax 4 Time Charter Average Volatility of returns

Source: The Baltic Exchange (2016)

In order to get more details about the impact of each route volatility on the 4TC average, we research the volatility on each route. We first compare the transatlantic and the transpacific routes to visualise the "basin spread" in the Panamax fleet. We can see a larger volatility in the transatlantic route. It may be explained by the uncertain economic environment in Europe and the low growth since the financial crisis. Moreover, northern countries are concerned about the environmental impact of coal and try to reduce their coal power generation decreasing coal imports. The transpacific route has a constant volatility between -8% and +11%. The coal market between Australia and the North Pacific is steady, flattering the volatility in the transpacific route.

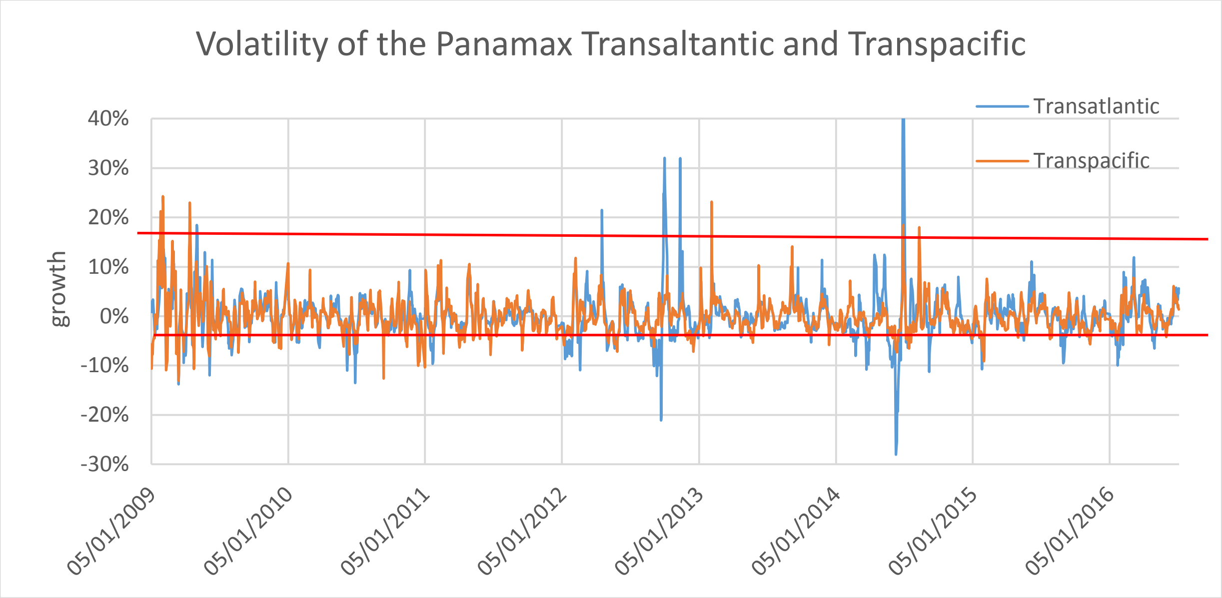


Figure 19: Panamax Transatlantic and Transpacific Volatility of returns

Source: The Baltic Exchange (2016)

The dynamics on the fronthaul and the backhaul routes of the Panamax and Capesize markets looks the same. There is a large volatility on the backhaul route and the fronthaul route volatility is more flat. The fronthaul varies between ±5%, being less than for the Capesize but following the same trends.

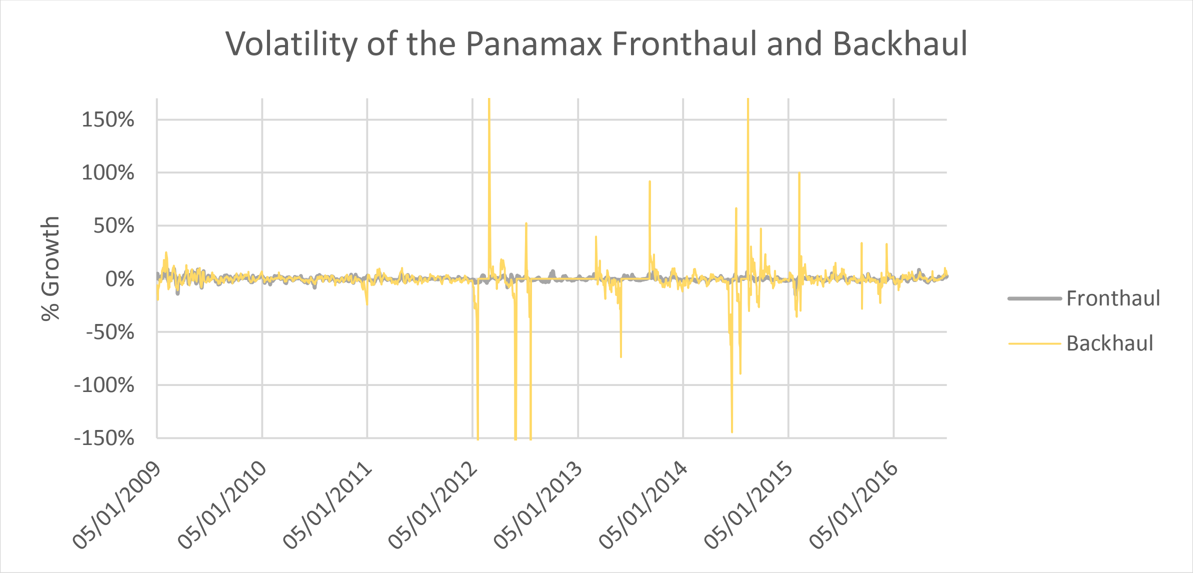


Figure 20: Panamax Fronthaul and Backhaul Volatility of returns

Source: The Baltic Exchange

Finally, the 4TC average expresses a broader image of the four routes, therefore it is important to investigate each of them independently to understand the dynamics of each vessel in different markets. In both cases, the transatlantic and transpacific are very volatile where the fronthaul and backhaul are more flat with random peaks.

4.2 Descriptive Statistics

In order to get more inside information of the returns, we compute the descriptive statistics of both markets. We investigate the distribution of Panamax and Capesize markets, the volatility around the mean and the possible autocorrelation, heteroscedasticity around the mean. The results are summarized in Table 9.

4.2.1 Variability Measurements

The descriptive statistics of our data are discussed in the following section. In order to measure the volatility, we computed quantitative models described in the literature review. The earlier literature has mainly studied the level of the freight rate using econometrical techniques. The most important statistics to understand are the mean, the standard deviation, the distribution of the variables, the autocorrelation and stationarity of the variable. The following sections explain the use of the methods in detail, as well as present the results received during the analysis. The objective of studying each variable is to perceive the stationarity of the time series to process with the appropriate co-integration test.

The following statistics helps the forecast the movements of a variable. First, the variance. It is the measure of average dispersion of variables from their mean in a sample. Mathematically, it is the squared difference of a variable to its mean.

The alternative to the variance is the standard deviation being the most common measure of dispersion of the data. The standard deviation is more understandable as it has the same unit as the variable. Mathematically, it is the squared root of the variance. (Wooldridge, 2013)

Table 9 presents the standard deviation of the Baltic. The Backhaul trading route is facing the largest volatility with 0.22 for Capesize and 0.16 for Panamax. This high volatility compared to the other routes is due to the large difference of cargoes on this route. Ship-owners will accept all possible cargoes to limit their loss. Moreover, the standard deviation on the other route is high as well. The high volatility may be due the uncertainty in demand fundamentals for raw materials as well as the slowdown of the world economy from 2008 up to now.

Second, to investigate for normality of a variable we compute the coefficient of Skewness and Kurtosis followed by the Jarque-Bera test. The coefficient of skewness or the third “moment measure” indicates if a distribution is symmetric around the value of its mean. For our sample the mathematical formula is the following:

$$\widehat{\alpha_3} = \frac{\sum_{i=1}^{n}(x_i - \bar{\bar{x}})/(n-1)}{s^3}$$

If the coefficient $\widehat{\alpha_3}$ is bigger than zero, the distribution is more important on the right of the mean, the tail on the right is larger compared to the left hand of the mean. On the contrary if $\widehat{\alpha_3}$ is smaller than zero, the distribution on the left is larger and longer than on the right hand of the mean. Logically, if $\widehat{\alpha_3}$ is equal to zero then the distribution is symmetric around the mean. (Alizadeh & Nomikos, 2009). Table 9 shows that all the routes have a negative coefficient expressing that the distribution

of returns is lower than the mean. Only the skewness of the transpacific and backhaul Panamax are positive.
The coefficient of Kurtosis or “fourth moment” indicates the pointed summit of a distribution. The larger the coefficient, the sharper is the distribution with a point summit. The mathematical formula used in our sample is the following:

$$\widehat{\alpha_4} = \frac{\sum_{i=1}^{n}(x_i - \overline{x_4})/(n-1)}{s^4}$$

Usually the coefficient of Kurtosis of a distribution is compared to the coefficient of Kurtosis of the normal distribution. It is equal to 3. Therefore, when $\widehat{\alpha_4}$ is smaller the distribution is flat. On the other hand, if the coefficient $\widehat{\alpha_4}$ is larger than 3 it is consider to be sharp. Lastly, if the coefficient is equal to 3 then the distribution has the same peak as the normal distribution. (Alizadeh & Nomikos, 2009).Table 9 highlights the coefficient of kurtosis of our dataset under the column Kurtosis.

The abovementioned measures of dispersion of the variable are considering a separate trend. Skewness is underlying the tail around the mean where kurtosis is focusing on the peak length. The coefficient of variation will take both into consideration. A high coefficient of variation indicates a large dispersion of the data around the mean. To compute it, we use the following formula:

$$CV = s/\bar{x}$$

It is the ratio of the standard deviation to the mean of the sample. The Sharp ratio is the inverse of the coefficient of variation which stresses the return to risk of an asset. We do not compute this ratio in table 9 because it is not in the interest of our co-integrated models.

After computing the previous coefficient and understanding the dispersion of our data, we conduct a Jarque-Bera test for normality. The null hypothesis corresponds to the normal distribution where the first hypothesis is a non-normal hypothesis. This test is done as a chi-squared test with 2 degrees of freedom. The test is calculated using the following formula (Jarque & Bera , 1980):

$$JB = n * \left[\frac{s^2}{6} + \frac{(EK)^2}{24}\right]$$

Table 9 presents the descriptive statistics found on the Baltic routes from 2008 to 2016. We found that none of the route are following a normal distribution. All the p-value are lower than the 1% significance level. Therefore, we reject the null hypothesis of normal distribution of the data.

The Ljung and Box (1978) test, also called “portmanteau”, analyse for autocorrelation in time series. The experiment is computed on a definite number of lags. It tests the randomness of the all sample based on the number of lags. We searched for autocorrelation on the 36 first lags. The null hypothesis corresponds to independency in the distribution, correlation is equal to zero. The alternative hypothesis highlights no independence in the data distribution. The mathematical formula of the test can be written as follows (Ljung & Box, 1978):

$$Q = n(n+2)\sum_{K=1}^{h}\frac{\widehat{\rho_k^2}}{n-k}$$

With n the number of observation, ρ_k^2 is the autocorrelation in the sample at lag k and h is the lags being tested, in our case 36. If H_0 is true then Q is following a χ_h^2 distribution. The critical values of 1 percent and 5 percent significance level are 58.11 and 51.48 respectively. (Chen , et al., 2010). In table 9 under the column $Q(36)$ and $Q^2\ (36)$ are the results of our test. Furthermore, all the p-value are larger than 1 and 5 percent significance level. Therefore, we do not have sufficient statistical evidence to reject the independence pattern of the variables (Keller, 2014). Having found no autocorrelation may be due to an increase in transparency and an increase in information exchange from ship-owners to the Baltic Exchange.

4.2.2 Unit root tests

The literature highlights two major unit root tests: Dickey and Fuller test (Dickey & Fuller, 1979) and Phillips and Perron test (Phillips & Perron, 1988).
Understanding that the Capesize and the Panamax freight market are independent and following a moving average pattern we have to use the Augmented Dickey & Fuller test (1984) and the Phillips & Perron test (1988). First, we test our data with the Augmented Dickey-Fuller test. The null hypothesis is that the data have a unit root I(1). The alternative is that the data are stationary I(0). The regression has no clear time trend and intercept; it is computed as follows:

$$\Delta y_t = \alpha + \Theta y_{t-1} + \gamma_1 \Delta y_{t-1} + e_t$$

We computed the lags number by minimizing the Akaike information criterion and Schwarz information criterion. With the appropriate lags of Δy_{t-h} we clean the serial correlation in Δy_t. (Wooldridge, 2013). Moreover, we conducted the Phillips and Perron (1988) test for unit root. The Phillips and Perron (1988) test does not require that the errors are conditionally homoscedastic which can bring another results in our sample. The PP regression can be written as follows:

$$y_t = \alpha + \beta t + \rho y_{t-1} + \varepsilon_t$$

On the descriptive statistics of Table 9, the results show that the Capesize and Panamax rates are following a random walk and each one is non-stationary. The column ADF Lev shows that the data is non-stationary. Because the p-values are larger than the 5 percent significance level, therefore, we don't have sufficient evidence to reject H0. We call them I(1) variables. On the other hand, the ADF 1st difference column shows that the series are stationary as the p-values are smaller than the 5 percent significance level. Therefore, we reject the null hypothesis of non-stationarity of the first difference variables.

Time series data are considered to be stationary, when after a shock they return to their mean in the short run and the variance is constant over time, concluding that the autocovariance depends only on the distance between the two observations. Nonstationary series keep the effect of shocks over a long period of time. They are considered to be following a random walk. It is important to test for the stationary because if the data are non-stationary the results of the models can give significant errors.

As our data are non-stationary, we implement the Johansen (1988) co-integration test between both markets for each route. The most popular tests for co-integration and volatility spill-over are the GARCH and the ECARCH models (Glen, 2006). New models following the VAR models developed by Chang et al. (2014) outperform the previous ones in terms of forecasting (Chang, et al., 2014).

4.3 Co-integration in returns between capesize and panamax.

From the augmented Dickey-Fuller test, we know that the prices are non-stationary and have a unit root. Moreover, the logarithm first difference is stationary. Therefore, we can conduct a co-integrating test between Capesize and Panamax to find their co-integrating vectors.

4.3.1 The Co-integration

Co-integration corresponds to a long run relationship and identical movement of data over time. Meaning that the difference between the data is stationary. Two time series are co-integrated when they are non-stationary (I(1)) and a relation of the type $y_t - \beta x_t = \varepsilon_t$ exist with ε_t being stationary. In this case the two series are co-integrated in order (1,1). The co-integrated vector is then written as (1, -β).
In order to investigate the impact of the financial crisis of 2008, we analysed the co-integration relation of the 4TC Capesize and Panamax vessels starting in 2009. We understood that no co-integration exists from 2009 to the end of 2012 between both markets. However, we observed a relation between 2009 and 2013 and between 2009 and 2016. We concluded that a long run relationship exists between 2009 and 2016. Figure 19 shows the logarithm returns of both markets. We can see that the pattern of the Panamax is more flat and does not follow strictly the movements of the Capesize.

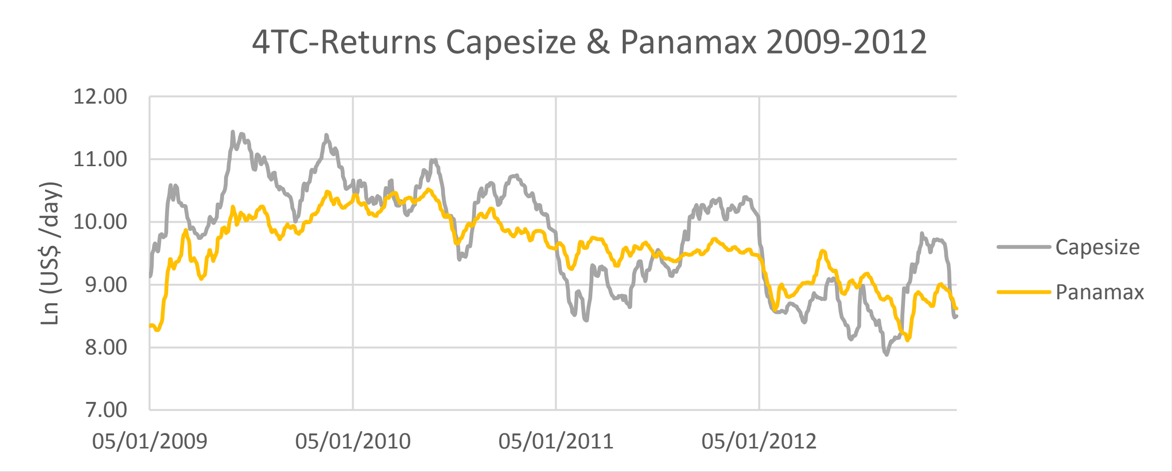


Figure 21:Cape and Pmax Logarithm of returns from 2009 to 2012

Source: Baltic Exchange (2016)

The following figure draws the logarithm relation of both markets from 2009 to 2016. There is a long run relation as both markets are following the same trends by peaking at the same dates and falling simultaneously.

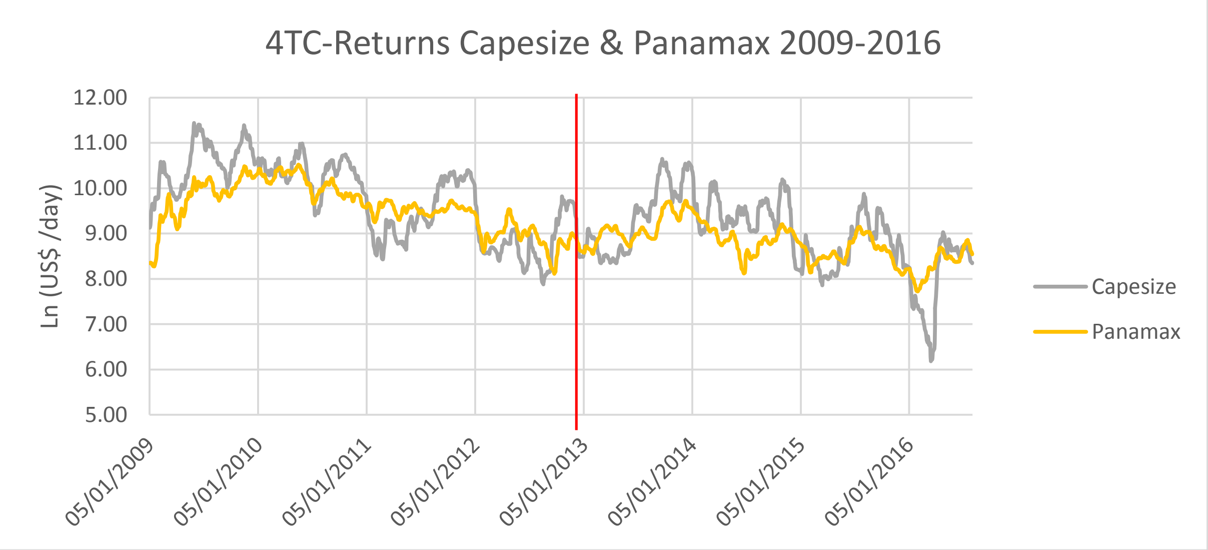


Figure 22: Cape and Pmax Logarithm of returns from 2009 to 2016

Source: The Baltic Exchange

In order to confirm co-integrating patterns between both markets, we conducted the Johansen (1988) test on each route. Table 10 highlights the co-integration relation between Capesize and Panamax freight rates. There is one co-integration relation on each route, showing a long run relationship between both markets. However, no co-integration relation exists on the backhaul route. There is no long run relationship between both markets.

4.3.2 VAR models

Many econometric models are used to make forecast such as the Vector Autoregressive models in the research of Chen et al. (2010). It is computed to understand the dynamics and relationship in time series data. The model can be written as follows:

$$y_t = \alpha + \rho_1 y_{t-1} + \rho_{t-2} y_{t-2} + u_t$$

The VAR models are estimating the actual value of a variable by computing a regression using the past values of the same variable. It uses the hypothesis of efficient market. It is widely used in finance to forecast stock prices, considering that prices combine all available information in the market. VAR models are criticised because they are only reflecting predictive movements. However, using the family of vector autoregressive models, we are able to investigate the relation and the impact of variables on one another. Using autoregressive models, help us to quantify the short run and long run relationship between Capesize and Panamax freight rates.

4.3.3 VECM models

As our data are time dependent and co-integrated, we use a specific vector autoregressive model called: Vector Error Correction Model. This model enables us to estimate the short run and long run relationship of a variable on the other. The model is based on an equilibrium long run relation given by the Johansen co-integration test. The error correction term will estimate the speed at which the dependent variable will come back to the long run equilibrium, after a market shock in the short run. Chen et al. (2010) describe the VECM as follows:

$$\Delta C_t = \sum_{i=1}^{p-1} a_{c,i}\, \Delta C_{t-i} + \sum_{i=1}^{p-1} b_{c,i}\, \Delta P_{t-i} + w_c Z_{t-i} + \varepsilon_{c,t}$$

$$\Delta P_t = \sum_{i=1}^{p-1} a_{p,i}\, \Delta C_{t-i} + \sum_{i=1}^{p-1} b_{p,i}\, \Delta P_{t-i} + w_p Z_{t-i} + \varepsilon_{c,t}\, , \varepsilon_t = \begin{pmatrix} \varepsilon_{c,t} \\ \varepsilon_{p,t} \end{pmatrix} |\Omega_{t-1} \sim dist(0, H_t)$$

Chen at al. (2010) estimated a VECM using seemingly unrelated equations to provide short run coefficient. The SURE is important in order to gain more information in relation of the system. (Zellner, 1962).$\Delta C_t$and $\Delta P_T$are the day to day logarithm variation of the Capesize and Panamax time charter rates. a_{ii} and b_{ii} represents the coefficients of past lags variation of the capesize and panamax respectively. $w_i$is the error correction term, giving the speed at which the freight rate will come back to the long run equilibrium after a shock.

The coefficient of the previous system describes the relationship and the influence between the markets. However, in order to gain more information on the influence between the variables, we research the Granger causality.

4.3.4 The Granger test

The Granger causality test shows the possibility that a variable (y) could be forecast by the past values of another variable (x). Using the lag values of y and the lag values of x the equation could explain the dependent variable. The equation could be written as follows:

$$Y_t = a + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1 x_t + \cdots + \beta_p x_{t-p} + \varepsilon_t$$

The test evaluates the null hypothesis that there is no causality between the variables. As a result, it computes the direction of the influence. It is important to highlight that the Granger causality is computed only with past variable. Knowing the past rarely predict the future many scientists highlight that Granger test will only express “predictive causality”.

VECM and Granger test explain the relationship in returns and the influence of one market on the other. In order to understand the volatility, we need to compute the family of General Autoregressive Conditional Heteroscedasticity models.

4.4 Volatilities Relationship Analysis.

Actors of the shipping industry are interested in the future risks in order to make decisions. They want to know the factors impacting their risks. To express it in a mathematical way, statisticians derive the volatility/the variance of a given variable. Recent studies highlight that the level of freight rate is not important and that only variation matters. (Berg-Andreassen, 1997). Therefore, we used dynamics time series models to investigate the volatility of both markets. By taking the logarithm first difference, we underline the changes in percentage to compare both markets. Moreover, the variance of a variable can be impacted by the variance of another variable. Using ARCH and GARCH models we are able to express the volatility spill-over effect between the Capesize and the Panamax rates.

4.4.1 ARCH and GARCH models

To model the volatility in time series, we use the Autoregressive Conditional Heteroscedasticity (ARCH) family model. It explains the variance of the error term at a certain period as a function of the error variance in the past periods. The freight rates are not constant and follow a moving average pattern we need to use the General Autoregressive Conditional Heteroscedasticity (GARCH) model. To be more precise we are using an ECM-GARCH model following Chen et al. (2010).

We estimated separately the Capesize and Panamax equations as previously using the error correction term. Then we calculated the GARCH equation as follows: (Chen , et al., 2010).

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + G'H_{t-1}G + D1'e_{1t-1}e'_{1t-1}D1 + D2'e_{2t-1}e'_{1t-1}D2$$

We computed the equation for the Capesize and the Panamax markets. The dependent variable is the volatility observed in each market respectively. C is the constant represented by a triangular matrix. A is the coefficient of the residuals and G is the coefficient of the past volatilities. D1 and D2 represent the effect of the volatility of one market on the other. It is characterised by the spill-over effect. e_{1t-1} and e_{2t-1} are the error terms from the Capesize and Panamax equations respectively. In order to estimate the ECM-GARCH model we used the quasi-maximum likelihood covariance and standard error of Huber and White.

5. Results and analysis

5.1 Descriptive Statistic

We analysed the daily time charter price for each Capesize and Panamax routes to understand their distribution. We transform the variables into natural logarithms and into first differences to visualize the day to day percentage growth. The results are presented in Table 9. The data is all following a normal distribution as we are rejecting Jarque-Bera null hypothesis for all routes. In addition, the variables, in levels, are all non-stationary at the 1% significance level from the Phillipps-Perron test. Where their first difference is stationary at 1% significance level resulting from, augmented Dickey-Fuller and Philipps-Perron tests. Transforming the data into their log first difference is making them independent over time. The descriptive statistics are in accordance with the statistics of Chen et al. (2010). Therefore, we can proceed to the Johansen (1988) co-integration test.

Descriptive Statistics for the logarithm first difference of the Capesize and Panamax from 2009 to 2016.

Route	N	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Q(36)	ADF Lev	PP Lev	ADF 1st Diffs.	PP 1st Diffs.
4TC_C	1894	0.0004	0.06	-0.85	8.05	2248.4	1682.3	-0.237	-0.1851	-14.88	-19.82
p-value						[0.0]	[0.0]	[0.6]	[0.61]	[0.0]	[0.0]
4TC_P	1894	0.00009	0.027	-0.67	5.69	715.34	3154.6	-0.2	-0.2	-15.87	-7.83
p-value						[0.0]	[0.0]	[0.6]	[0.61]	[0.0]	[0.0]
TA_C	1875	0.0000613	0.08	0.8359	11.08	5317.56	1305.5	-0.35	-0.33	-22.33	-22.49
p-value						[0.0]	[0.0]	[0.55]	[0.56]	[0.0]	[0.0]
TA_P	1874	0.00029	0.047	2.21	24.39	37286.59	3272.4	-0.3	-0.328	-15.34	-9.17
p-value						[0.0]	[0.0]	[0.57]	[0.56]	[0.0]	[0.0]
FH_C	1874	7.29E-05	0.041	0.93	8.13	2333.179	1463.3	-0.22	-0.21	-21.05	-19.39
p-value						[0.0]	[0.0]	[0.6]	[0.61]	[0.0]	[0.0]
FH_P	1874	0.00019	0.02	0.13	7.7	1736.98	2655.6	-0.22	-0.26	-15.87	-10.3
p-value						[0.0]	[0.0]	[0.6]	[0.58]	[0.0]	[0.0]
TP_C	1874	-2.10E-04	0.068	0.54	6.28	933.48	956.14	-0.21	-0.21	-22.48	-21.53
p-value						[0.0]	[0.0]	[0.6]	[0.61]	[0.0]	[0.0]
TP_P	1874	0.000424	0.036	1.21	8.76	3063.8	2611.9	-0.31	-0.39	-16.02	-9.54
p-value						[0.0]	[0.0]	[0.57]	[0.54]	[0.0]	[0.0]
BH_C	1158	-0.00034	0.22	6.39	161.18	1215182	167.07	-2.24	-0.55	-15.85	-16.8
p-value						[0.0]	[0.0]	[0.02]	[0.47]	[0.0]	[0.0]
BH_P	1574	-0.007	0.16	-5.35	152.47	1472908	484.91	-1.8	-0.22	-6.32	-29.8
p-value						[0.0]	[0.0]	[0.06]	[0.6]	[0.0]	[0.0]

Notes: All the time series are in natural logarithm first difference. TAC and TAP are transatlantic Capesize and Panamax respectively. FHC and FHP are fronthaul Capesize and Panamax. TPC and TPP and transpacific Capesize and Panamax. Finally, BHC and BHP are backhaul Capesize and Panamax. N is the number of observation in our sample. Skewness (third moment) and Kurtosis (fourth moment) measure the centralized distribution of the series. The Jarque-Bera test is a measure of normality distribution. The Ljung and Box test is conduct: Q(36),on the 36 first lags of the sample. ADF (4) Lev corresponds to the Dickey-Fuller test on the natural logarithm of the data, the (4) is the lags used. PP (3) Lev is the Phillips and Perron test on 3 lags of the natural log of the data. ADF (4) 1st Diff and PP(3) 1st are the same test but conducted on the log first difference of the data. ADF and PP test for unit root of the series.

Table 9

5.1.1 Co-integration of both markets

Following the non-stationarity of the daily time charter rates the Johansen (1988) test for co-integration is employed, between the Capesize and Panamax market for all routes, we received results that are reported in Table 10. First, there is one co-integrating relation between the 4TC average of the Capesize and Panamax returns. As the 4TC is the equally weighted average of all the 4 routes, each route should have a co-integrating relation. We found co-integration on the transatlantic, the transpacific and the fronthaul routes at the 5% significance level. However, there is no long run relationship on the backhaul route between both markets at the 5% significance level.

The co-integration on the transatlantic and transpacific is driven by the stable iron and coal market between 2009 and 2016. On the transatlantic route, Capesize vessels carry iron ore from Brazil to Antwerp-Rotterdam-Amsterdam range. Panamax vessels are also employed on this route to carry iron ore or coal. The transpacific route is focused around the Australian Chinese trades. Capesize vessels are loading iron ore in Westernest Australia and delivering it to China, while the Panamax vessels are loading coal in Eastern Australia and delivering it to China-Japan range. In this basin Capesize vessels will never load coal because the Australian ports do not have the infrastructure to host vessels of more than 100k dwt. Therefore, on the transpacific basin we can emphasize that the long run relationship is not derived from the commodity transported.

The long run relation on the fronthaul route is more complex to highlight as vessel are carrying different commodities. We can imagine that the profitability of the fronthaul is directly driven by the global macroeconomics. The vessel is on the most profitable basin with the high shipping demand. Therefore, he chooses the most paying cargo. The relationship has a direct relation on the carried commodity. Also, it depends on the vessel location and port accessibility.

The non-co-integration found on the backhaul route is explained by the low-profit shipping environment and small amount of cargo in this basin. To reposition their asset, ship-owners are taking whatever cargo they can find. In some case owners will ballast on the entire route and pay the full operating costs from their pocket. In such situation the data reported by the Baltic Exchange will be negative. Such rate disturbs the sample and the results of the long run relationship between the two vessel sizes. To find if the relationship that comes from the ship economics we calculate the influence of one market on the other.

Table 10

Results of the Johansen test for co-integration between Capesize and anamax from 2019 to 2016

	Lags	Hypothesis (eigen)		Test statistic	Hypothesis (trace)		Test statistic	95% critical values		cointegrating vector
		h_0	h_1	λ_{max}	h_0	h_1	λ_{trace}	λ_{max}	λ_{trace}	$\beta' =$(1, β_1 , β_2)
4TC	8	r=0	r=1	25.51	r=0	r=1	26.6	11.44	12.53	(1, -0.009, 0.0004)
		r<=1	r=2	0.09	r<= 1	r=2	0.09	3.84	3.84	
Note: There is one co-integration relation on the 4TC Capesize and Panamax for the period 2009 to 2016.										
TA	5	r=0	r=1	42.05	r=0	r=1	42.11	11.22	12.32	(1, -1.612, 1.652)
		r<=1	r=2	0.06	r<= 1	r=2	0.06	4.12	4.12	
Note: There is one co-integrating relation on the transaltantic route between Capesize and Panamax for the period 2009 to 2016.										
FH	15	r=0	r=1	26.97	r=0	r=1	27	11.22	12.32	(1, -0.012, -0.00067)
		r<=1	r=2	0.03	r<= 1	r=2	0.03	4.12	4.12	
Note: There is one co-integrating relation on the fronthaul route between Capesize and Panamax for the period 2009 to 2016.										
TP	3; 8	r=0	r=1	18.55	r=0	r=1	18.61	11.22	12.32	(1, -1.8234, 1.8834)
		r<=1	r=2	0.06	r<= 1	r=2	0.06	4.12	4.12	
Note: There is one co-integrating relation on the transpacific route between Capesize and Panamax for the period 2009 to 2016.										
BH	8	r=0	r=1	8.85	r=0	r=1	12.47	11.22	12.32	(1, -0.64, 0.78)
		r<=1	r=2	3.72	r<= 1	r=2	3.72	4.12	4.12	
Note: The max-eigenvalue test indicates no cointegration between Capesize and Panamax on the backhaul.										

Notes: We used logarithm of the daily time charter rates to compute the cointegration statistic for all routes. The restrictions of the cointegration vector are imposed on beta 1 which is a constant, representing the long-run ratio C/P. Beta2 is the coefficient of the Panamax. All the restriction are accepted at the 5 percent significance level. 4TC , TA, FH, TP and BH are the 4 time charter average, Transatlantic, Fronthaul, Transpacific and the Backhaul respectively. The lags are computed by minimizing the Akaike and Schwarz criterion. r is the number of cointegrated vectors. Langda max is the maximum eigenvalue and langda trace is the estimated eigenvalue.

5.2 VECM-SURE estimation

The relationship of returns between each market is estimated using a Vector Error correction model. Adding a seemingly unrelated equation system brings precise information on the short run coefficients of both equations. Table 11 illustrates the results of our estimation.

First, we analyse the dynamics on the 4 time charter average between both markets. The error correction term (Wc) of the Capesize estimation is negative and significant at the 1% significance level. On average, in the four main routes, in the long run, the Capesize rate adjust to equilibrium relatively fast. With a coefficient equal to -0.223 at the 1% significance level. In addition, the Panamax freight has no significant influence on the Capesize rates on average. Regarding the Panamax equation, we estimate that the error correction term is neither negative, nor significant, meaning that it does not adjust to the equilibrium in the long run. Furthermore, we find that the Capesize rates have a negative influence on the Panamax with a coefficient that is equal to -0.06, at significance level of 1%. While the Panamax rate has no significant influence on the Capesize. Then we analyse each route to understand the relations in each trading area separately.

Second, on the transatlantic route, we measure a negative and significant speed of adjustment on the Capesize equation but the Panamax equation remains positive and not significant. Therefore, only the Capesize freight rate adjusts to equilibrium in the long run on the transatlantic route. Moreover, we find no significant connectivity between the markets. It is explained by the very specialized trades of each vessel size on the transatlantic route. Capesize vessels are only carrying iron ore from Brazil to Europe, while Panamax vessels are loading a large panel of commodities such as grain, and coal. It allows more flexibility for the Panamax owners and creates individual economics for each vessel size

.

Third, on the fronthaul route, we find a negative and significant error correction term for Capesize market, while the Panamax error correction is not significant. Thus, only the Capesize freight rate adjusts to the equilibrium in the long run. Moreover, we compute a positive and significant Panamax influence on the Capesize market at the 5% significance level. But we do not have sufficient evidence to conclude that the Capesize market has a significant influence on the Panamax freight rate. It may be explained by the arrival of the longhaul route on the Capesize market. It is more profitable for Capesize owner to fix their vessels on a longhaul route as the period is longer. Therefore, we observe less Capesize vessels on the fronthaul leg and more Panamax vessels which are driving the market. This results in an influence of the Panamax rates on the Capesize market.

Fourth, on the transpacific route, the Capesize ECT is negative and significant, while the Panamax ECT is not significant. Only the Capesize adjusts in the long run to equilibrium. Besides, we estimate that the Panamax freight rate has a positive and significant impact on the Capesize returns with a coefficient of 0.38 at the 1% significance level. The coefficient of the Capesize influence on the Panamax rate, however, is not significant. We cannot conclude that the Capesize has an impact on the Panamax. The transpacific route is mainly driven by export from Australia to the North Pacific. Panamax rates have a more important influence on the Capesize because of the larger flexibility of the vessels, resulting in less volatility of its rates.

Therefore, the Capesize rates have a higher tendency to be influenced by Panamax rates.

Knowing that there is no long run co-integration relation on the backhaul route, we still calculated it in the VECM-SURE equation. Confirmed by the Johansen (1988) test, we find no significant ECT in both markets.

To conclude, the ECT of the Capesize equation is larger for all routes. It explains that the Capesize freight rate reacts faster to the shocks in the market. It comes back to his long run equilibrium quicker than the Panamax freight rate.

5.2.1 Granger causality

In order to get more detailed information about the dynamics relation of returns, we compute a Granger causality test. The results highlight the direction of influence of the variable.

The estimates of the Granger causality test are presented in Table 11. We can observe that the results are different and more accurate with the Granger causality than with the VECM. On the 4TC average, there is a bidirectional relationship. The same influence appears on the fronthaul and transpacific routes at the 1% significance level. It is explained by the similar market environment of both routes. The transpacific and the fronthaul routes are delivering raw materials to the Far East. Thus, they are impacted by the same economics. Capesize and Panamax influence each other because of the similar shipping demand they face. Nonetheless, on the transpacific route there is unidirectional influence from the Panamax market to the Capesize market. The unidirectional impact from Panamax to Capesize is explained by the slowdown of the economic growth in Europe. The effects of the financial crisis remain, decreasing steel demand. Moreover, European steel makers are facing large competition from manufacturers in China offering lower price to increase their market share. Therefore, shipments of iron ore have been directly impacted. Many ship-owners preferred to fix a long run agreement at a lower rate to ensure revenue which resulted in a smaller volume of Capesize spot contracts and more Panamax spot contracts.

Table 11

VECM-SURE

4TC Capesize & Panamax				Transatlantic Capesize & Panamax				Fronthaul Capesize & Panamax				Transpacific Capesize & Panamax				Backhaul Capesize & Panamax			
ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt	
Panel A: VECM model estimation				Panel A: VECM model estimation				Panel A: VECM model estimation				Panel A: VECM model estimation				Panel A: VECM model estimation			
Wc	-0.223***	***W***p	0.05***	***W***c	-0.01***	***W***p	0.0019**	***W***c	-0.012***	***W***p	-0.000875	***W***c	-0.01***	***W***p	0.00014	***W***c	0.0098*	***W***p	-0.001
	(-9.46)		(7.98)		(-5.9)		(2.2)		(-5.26)		(-1)		(-4.48)		(0.17)		-2.8		(-0.8)
ac,1	0.035	***a*** p,1	-0.06***	***a***c,1	0.57***	***a***p,1	-0.009	***a***c,1	0.71***	***a*** p,1	-0.0081	***a***c,1	0.62***	***a***p,1	-0.007	***a***c,1	0.79***	***a*** p,1	-0.0053
	(-1.2)		(-7.71)		(25.05)		(-1.12)		(30.60)		(-0.96)		(26.98)		(-0.90)		(11.99)		(-0.43)
bc,1	0.06	***b*** p,1	0.325***	***b***c,1	0.08	***b***p,1	1.033***	***b***c,1	0.21**	***b*** p,1	0.99***	***b***c,1	0.38***	***b***p,1	1.0***	***b***c,1	0.20*	***b*** p,1	1.06***
	(0.7)		(13.05)		(1.36)		(44.62)		(3.23)		(42)		(6.07)		(43.31)		(1.76)		(22.58)
Note: The error correction term is negative and significant at the 1% significance level on the Capesize equation. Meaning that the Capesize adjusts to the equilibrium in the long run. On the other hand, the Panamax error correction term is not significant. It does not significantly come back to the equilibrium.				Note: The error correction term of the Capesize equation is negative and significant at the 1% significance level. There is a long run relationship in the fronthaul basin. However the coefficient on the transatlantic route is not negative, therefore it does not adjust in the long run.				Note: The speed of adjustment to equilibrium is significant on the Capesize market. Moreover, the coefficient of Panamax is significant in the Capesize equation. Meaning that and on the fronthaul route the Panamax has a real impact on the Capesize. There is no significant coef. in the Panamax equation.				Note: In the transpacific basin the Capesize go back to equilibrium with a speed of 0.01 at a significance level of 1%. Furthermore, the Panamax rate has a significant impact on the Capesize.				Note: The speed of adjustment is not significant on the backhaul route for the Capesize and the Panamax vessel. The Panamax has a significant impact on the Capesize rates at the10% significance level.			

	4TC Capesize & Panamax				Transatlantic Capesize & Panamax				Fronthaul Capesize & Panamax				Transpacific Capesize & Panamax				Backhaul Capesize & Panamax			
	ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt	
Panel B: residual diagnostics																				
J-B test	4104.22	[0.0]	3765	[0.00]	12687.6	[0.0]	10940	[0.0]	4866.5	[0.0]	12630.5	[0.0]	2016.04	[0.0]	11049.16	[0.0]	6231052	[0.0]	963904	[0.0]
Q(36)	32.63	[0.62]	40.99	[0.26]	50.277	[0.05]	67.058	[0.001]	28.408	[0.812]	33.89	[0.56]	21.98	[0.96]	42.62	[0.207]	22.45	[0.962]	52.52	[0.037]
Q^2 (36)	191.9	[0.0]	879	[0.0]	77.36	[0.0]	206.7	[0.0]	209.51	[0.0]	687.66	[0.0]	74.19	[0.0]	749.19	[0.0]	1.1	[1.0]	34.035	[0.56]
R^2					0.36		0.74		0.47		0.71		0.39		0.7		0.16		0.43	

Table 12

Granger Causality Test														
4TC	Statistics		Transaltantic	Statistics		Fronthaul	Statistics		Transpacific	Statistics		Backhaul	Statistics	
	F-Stat.	Prob.		F-Stat.	Prob.		F-Stat.	Prob.		F-Stat.	Prob.		F-Stat.	Prob.
ΔC_t -> ΔP_t	10.1	0.0	ΔC_t -> ΔP_t	1.72	0.12	ΔC_t -> ΔP_t	2.63	0.006	ΔC_t -> ΔP_t	2.88	0.0034	ΔC_t -> ΔP_t	1.53	0.14
ΔP_t -> ΔC_t	3.35	0.0008	ΔP_t -> ΔC_t	8.07	2.E-07	ΔP_t -> ΔC_t	2.63	2.00E-13	ΔP_t -> ΔC_t	9.33	1.00E-12	ΔP_t -> ΔC_t	3.26	1.10E-02
Note: On the 4TC average of Capesize and Panamax during the period from 2009 to 2016, there is Granger causality in both directions.			Note: We observe that the Panamax Granger caused the Capesize for this period.			Note: We observe that the Panamax Granger caused the Capesize for this period, meaning that Panamax prices affect positively Capsize prices. It is also shown that the Capesize Granger causes the Panamax at the 1% significance level.			Note: We observe that the Panamax Granger caused the Capesize for this period. It is also shown that the Capesize Granger causes the Panamax at the 1% significance level. In other words, both market prices influence the other.			Note: The capesize Granger causes the Panamax at the 1% significance level. In other words, the Panamax prices have a positive impact on the Capesize prices.		

5.3 ECM-GARCH (1,1) Results

We tested the General Autoregressive Conditional Heteroscedasticity model using the previous error correction system as mean equations. The results are reported in Table 12. The first portion of the table is the estimates of the mean equation and the second part are the variance estimates. The last part explains the diagnostic tests of the residuals. In this part we observe that all the routes are normally distributed. The Autocorrelation and heteroscedasticity test, Q(36) and Q(36) squared emphasize that there is no autocorrelation in the residuals. Moreover, the ARCH test rejects the null hypothesis, meaning that there is volatility clustering in our residuals for all routes. In order to estimate correctly the variance, it is important that the persistence of volatility is lower than one. It is measured by $a_{ii} + g_{ii}$ on each route. In all routes it is lower than 1, therefore the unconditional variance is stationary.

To get a global image of the volatility between each market, we first investigate the 4TC average of Capesize and Panamax freight rate. The coefficient of ECT is larger in the Capesize variance equation (0.54) than in the Panamax equation (0.36). It highlights that past shocks have on average larger impact on the Capesize rate. However, the past volatility has a larger impact on the Panamax rates (0.61) compared to the Capesize rates (0.06). The coefficient of spill-over effect of both markets is not significant on the 4 time charter average. The computation of the average may have lowered the impact of the volatility of one market on the other. Thus, it is important to investigate the volatility in each route separately.

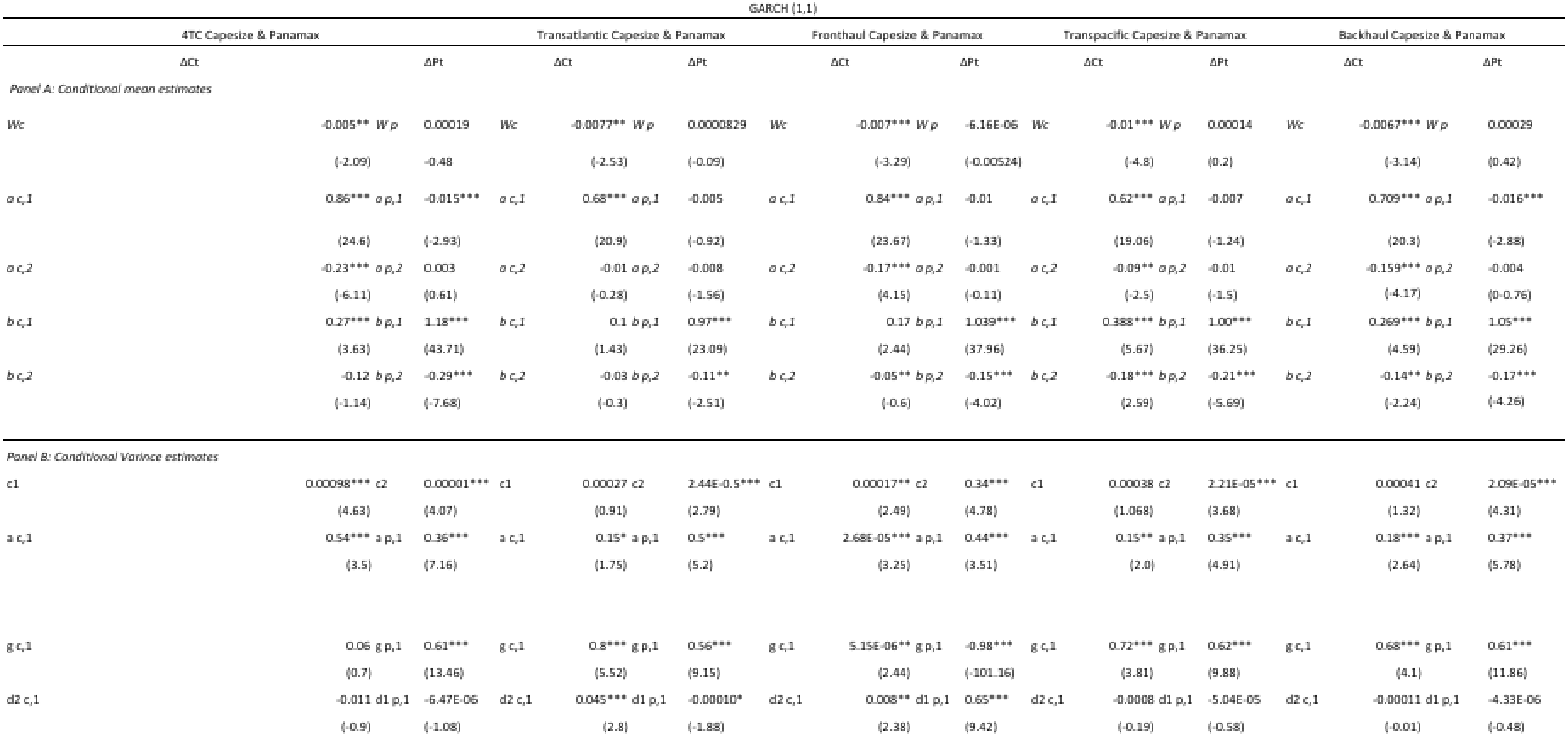
In the transatlantic route we can observe that past shocks in the market have more impact on the Panamax rate (0.5) compared to the Capesize rate (0.15). The past volatility, on the contrary, has more influence on the Capesize market (0.8) than on the Panamax market (0.56). Shocks in the market can be interpreted as new information where the past volatility corresponds with the old information. The fact that new information has more impact on the Panamax freight rate occurs because the transatlantic basin is more active for Panamax vessels since the financial crisis. As we said before, the majority of the Capesize vessel is fixed on long run agreement on the transatlantic route. Thus, past volatility is more important for the Capesize. In addition, there is bidirectional volatility spill-over effect. To be more precise, the volatility of the Capesize has a significant impact on the Panamax volatility with a coefficient of 0.045. While the Panamax volatility also has a significant impact on the Capesize volatility with a coefficient of -0.0001, the effect is stronger from the Panamax to the Capesize.

On the fronthaul route the new information plays a more important role on the Panamax market, with a coefficient of 0.44 compared to 2.68E-0.5 for the Capesize. On the other hand, the old information plays a leading role in the Capesize volatility where it is less important in the Panamax estimation. We observe the same pattern as on the transatlantic route. The economics in both areas are the same which explains the observed behaviour. There is a significant bidirectional spill-over effect, but it is stronger from Capesize to Panamax. The Capesize market is more sensitive to new information than the Panamax.

In the transpacific route, shocks in the market have more effect on the Panamax than on the Capesize freight rate. However, the past information has a greater impact on the Capesize. Additionally, there is no significant volatility spill-over between both markets on the transpacific route. It implies that when there is a shock on the transpacific route, it is not transmitted to other vessel sizes. It illustrates the highly specialized Capesize and Panamax markets in the transpacific. As mentioned in the previous section, in Australia, Capesize vessels are too large to enter a coal port therefore they can only carry iron ore. When a shock in the iron ore transportation occurs in the transpacific, Capesize cannot enter another trade and need to absorb the shock or move to another location.

The results of the backhaul route are similar to the transpacific route. But as there is no long run relationship, we do not discuss these results in detail.

Table 12



GARCH (1,1)

4TC Capesize & Panamax				Transatlantic Capesize & Panamax				Fronthaul Capesize & Panamax				Transpacific Capesize & Panamax				Backhaul Capesize & Panamax			
	ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt		ΔCt		ΔPt
Panel A: Conditional mean estimates																			
Wc	-0.005**	*W p*	0.00019	*Wc*	-0.0077**	*W p*	0.0000829	*Wc*	-0.007***	*W p*	-6.16E-06	*Wc*	-0.01***	*W p*	0.00014	*Wc*	-0.0067***	*W p*	0.00029
	(-2.09)		-0.48		(-2.53)		(-0.09)		(-3.29)		(-0.00524)		(-4.8)		(0.2)		(-3.14)		(0.42)
a c,1	0.86***	*a p,1*	-0.015***	*a c,1*	0.68***	*a p,1*	-0.005	*a c,1*	0.84***	*a p,1*	-0.01	*a c,1*	0.62***	*a p,1*	-0.007	*a c,1*	0.709***	*a p,1*	-0.016***
	(24.6)		(-2.93)		(20.9)		(-0.92)		(23.67)		(-1.33)		(19.06)		(-1.24)		(20.3)		(-2.88)
a c,2	-0.23***	*a p,2*	0.003	*a c,2*	-0.01	*a p,2*	-0.008	*a c,2*	-0.17***	*a p,2*	-0.001	*a c,2*	-0.09**	*a p,2*	-0.01	*a c,2*	-0.159***	*a p,2*	-0.004
	(-6.11)		(0.61)		(-0.28)		(-1.56)		(4.15)		(-0.11)		(-2.5)		(-1.5)		(-4.17)		(0-0.76)
b c,1	0.27***	*b p,1*	1.18***	*b c,1*	0.1	*b p,1*	0.97***	*b c,1*	0.17	*b p,1*	1.039***	*b c,1*	0.388***	*b p,1*	1.00***	*b c,1*	0.269***	*b p,1*	1.05***
	(3.63)		(43.71)		(1.43)		(23.09)		(2.44)		(37.96)		(5.67)		(36.25)		(4.59)		(29.26)
b c,2	-0.12	*b p,2*	-0.29***	*b c,2*	-0.03	*b p,2*	-0.11**	*b c,2*	-0.05**	*b p,2*	-0.15***	*b c,2*	-0.18***	*b p,2*	-0.21***	*b c,2*	-0.14**	*b p,2*	-0.17***
	(-1.14)		(-7.68)		(-0.3)		(-2.51)		(-0.6)		(-4.02)		(2.59)		(-5.69)		(-2.24)		(-4.26)
Panel B: Conditional Varince estimates																			
c1	0.00098***	c2	0.00001***	c1	0.00027	c2	2.44E-0.5***	c1	0.00017**	c2	0.34***	c1	0.00038	c2	2.21E-05***	c1	0.00041	c2	2.09E-05***
	(4.63)		(4.07)		(0.91)		(2.79)		(2.49)		(4.78)		(1.068)		(3.68)		(1.32)		(4.31)
a c,1	0.54***	a p,1	0.36***	a c,1	0.15*	a p,1	0.5***	a c,1	2.68E-05***	a p,1	0.44***	a c,1	0.15**	a p,1	0.35***	a c,1	0.18***	a p,1	0.37***
	(3.5)		(7.16)		(1.75)		(5.2)		(3.25)		(3.51)		(2.0)		(4.91)		(2.64)		(5.78)
g c,1	0.06	g p,1	0.61***	g c,1	0.8***	g p,1	0.56***	g c,1	5.15E-06**	g p,1	-0.98***	g c,1	0.72***	g p,1	0.62***	g c,1	0.68***	g p,1	0.61***
	(0.7)		(13.46)		(5.52)		(9.15)		(2.44)		(-101.16)		(3.81)		(9.88)		(4.1)		(11.86)
d2 c,1	-0.011	d1 p,1	-6.47E-06	d2 c,1	0.045***	d1 p,1	-0.00010*	d2 c,1	0.008**	d1 p,1	0.65***	d2 c,1	-0.0008	d1 p,1	-5.04E-05	d2 c,1	-0.00011	d1 p,1	-4.33E-06
	(-0.9)		(-1.08)		(2.8)		(-1.88)		(2.38)		(9.42)		(-0.19)		(-0.58)		(-0.01)		(-0.48)

4TC Capesize & Panamax			Transatlantic Capesize & Panamax			Fronthaul Capesize & Panamax			Transpacific Capesize & Panamax			Backhaul Capesize & Panamax		
	ΔCt	ΔPt		ΔCt	ΔPt		ΔCt	ΔPt		ΔCt	ΔPt		ΔCt	ΔPt
Panel C: Diagnostic tests on standardized residuals														
J-B test	3490.2	166.69	J-B test	12526.65	3133.18	J-B test	3576.97	281.71	J-B test	2631.25	240.13	J-B test	2714.021	242.04
	[0.0]	[0.0]		[0.0]	[0.0]		[0.0]	[0.0]		[0.0]	[0.0]		[0.0]	[0.0]
Q(36)	32.65	194.5	Q(36)	43.37	63.38	Q(36)	36.65	31.85	Q(36)	69.85	48.66	Q(36)	23.78	48.22
	[0.62]	[0.0]		[0.18]	[0.003]		[0.43]	[0.66]		[0.001]	[0.077]		[0.94]	[0.084]
Q^2(36)	193.62	35.6	Q^2(36)	19.57	22.99	Q^2(36)	63.605	67.84	Q^2(36)	20.96	45.39	Q^2(36)	20.83	44.83
	[0.0]	[0.48]		[0.98]	[0.95]		[0.003]	[0.001]		[0.978]	[0.136]		[0.98]	[0.14]
ARCH(36)	1.004	0.96	ARCH(36)	0.007	0.005	ARCH(36)	0.046	1.56	ARCH(36)	0.27	0.007	ARCH(36)	0.03	0.0039
	[0.46]	[0.525]		[0.92]	[0.94]		[0.8]	[0.21]		[0.6]	[0.93]		[0.85]	[0.95]
Pers. (a+g)	0.06	0.61	Pers. (a+g)	0.80	0.56	Pers. (a+g)	0.0002	-0.64	Pers. (a+g)	0.72	0.620	Pers. (a+g)	0.680	0.610029
Log-like.	3212	5814	Log-like.	2568	4910	Log-like.	4075	6217	Log-like.	2838	5181	Log-like.	2882	5182
AIC	-3.38	-6.14	AIC	-2.73	-5.23	AIC	-4.34	-6.65	AIC	-3.02	-5.53	AIC	-3.06	-5.53
SBIC	-3.32	-6.08	SBIC	-2.69	-5.19	SBIC	-4.24	-6.61	SBIC	-2.96	-5.47	SBIC	-3	-5.47

We can observe that the transatlantic, the fronthaul and the transpacific routes are reacting to market information in the same way. The Panamax is more influenced by shocks where the Capesize is more impacted by the past volatility. It is justified by the lower flexibility of the Capesize fleet. The number of the ports and the commodity carried by the fleet is restricted, creating standardized route and lower the reactivity. Asymmetrically the volatility of the Capesize rate is highly impacted by the previous volatility or past market information on all routes.

In Table 14, we illustrate the difference in returns and volatilities between the Capesize and the Panamax from the period analysed by Chen et al. (2010) and the actual period.

<table>
<tr><th rowspan="3"></th><th colspan="4">2003-2008</th><th colspan="4">2009-2016</th></tr>
<tr><th colspan="2">Prices</th><th colspan="2">Volatilities</th><th colspan="2">Prices</th><th colspan="2">Volatilities</th></tr>
<tr><th>Capesize</th><th>Panamax</th><th>Capesize</th><th>Panamax</th><th>Capesize</th><th>Panamax</th><th>Capesize</th><th>Panamax</th></tr>
<tr><td>Transatlantic</td><td colspan="2">→
←</td><td colspan="2">→
←</td><td colspan="2">⇢
←</td><td colspan="2">→
←</td></tr>
<tr><td>Fronthaul</td><td colspan="2">→
←</td><td colspan="2">→
⇠</td><td colspan="2">→
←</td><td colspan="2">→
←</td></tr>
<tr><td>Transpacific</td><td colspan="2">→
←</td><td colspan="2">→
⇠</td><td colspan="2">→
←</td><td colspan="2">⇢
⇠</td></tr>
<tr><td>Backhaul</td><td colspan="2">→
←</td><td colspan="2">⇢</td><td colspan="2">⇢
←</td><td colspan="2"></td></tr>
<tr><td colspan="9">Note: A dashed arrow shows that the relationship exist but is not significant at 5% significant level. Where the full arrow indicate a relationship at 5% significant level. The relationship from 2003 to 2008 are taken from Chen et al. (2010).</td></tr>
</table>

Table 13

Source: Chen et al. (2010)

→: There is a significant relationship in the direction of the arrow.
⇢: There is a non-significant relationship in the direction of the arrow.
“ “ : There is no relationship.

Regarding the prices relationship, the major difference occurs on the transatlantic and the backhaul routes. There, Capesize impact on the Panamax is not significant at the 5% as it was between 2003 and 2008. For the volatility, the spill-over of the Capesize on the transpacific route is not significant anymore. Furthermore, there is no volatility spill-over on the backhaul route.

6. Conclusions

The seaborne raw material trade is divided into three major vessel categories: Capesize, Panamax and Handysize. Each category of the vessels is impacted by individual factors, making the relationship of vessel category more complex with every year. This thesis conducted research on the evolution of interconnectivity between the Capesize and the Panamax market from 2009 to 2016. More precisely, it highlighted the changes in returns and volatility of the 4 time charter average, as well as the developments on the transatlantic, transpacific fronthaul and backhaul routes between the Capesize and the Panamax vessels.

In the first chapter we presented an introduction to the shipping market, providing more details on the historical evolution of the dry bulk segments. In the second chapter, we described the scientific methodology used in peer papers related to our research. We provided an analysis of the previous research on the freight rate behaviour and the possibility for the forecasting of the movements. In the third chapter analysed the dry bulk market as it is functioning in 2016. We put particular emphasis on the important factors that have had an impact on the Capesize and the Panamax markets. Moreover, we paid special attention of the reader to different freight contracts and geographical trade of Capesize and Panamax vessels. In section four we examined the methodology used to quantify the interrelation between both markets. It highlighted the data used and the econometrical models computed. In the fifth chapter, we presented the results and the economic analysis. At first, the descriptive statistics indicated that the data were non-stationary in levels but when transformed into the first difference, they were stationary. Then, we find that both series are co-integrated on all routes except the backhaul one. Then, the VECM indicate that the Panamax has a significant influence on the Capesize earnings on the transatlantic and the backhaul routes. To continue, it was clear that there is a bidirectional influence on the fronthaul and the transpacific routes between the returns. However, in both cases we found the Panamax has a larger impact on the Capesize rates compared to the opposite. Then we investigated the volatility association. On the transatlantic and the fronthaul routes we observed that there is bidirectional spill-over effect, meaning that an increase in volatility in one market will pass to the other, which will be influenced by this shock. There is no spill-over effect on the transpacific route at the 5% significance level and there is no spill-over effect on the backhaul route. Table 13 illustrates the changes in the dynamic interrelationship of the Capesize and Panamax return and volatility between 2003 and 2008 and between 2009 and 2016.

We can now answer our research questions.

1. What is the effect relationship in the spot prices between the Capesize and the Panamax market?

The co-integration test showed us that there is a long-run relationship between Capesize and Panamax 4-time charter rates, as well as on all routes, except in the backhaul one. Meaning that both prices are moving together on average in the long run.

2. What is the direction of the price influence between Capesize and Panamax markets?

The Granger and the VECM-SURE tests indicate that, on the transatlantic and on the backhaul routes, Panamax has a significant influence on the Capesize market. In addition, on the fronthaul and transpacific routes there is a bidirectional influence, however it is larger from Panamax to Capesize returns. It means that in the four main basins Panamax returns have a stronger influence on Capesize returns.

3. What is the volatility of returns spill-over of both markets from 2008 to 2016?

There is a bidirectional volatility spill-over effect on the transatlantic and on the fronthaul routes. Meaning that a shock in the Capesize market will increase the volatility of the Panamax market and vis-versa. To continue there is no significant volatility spill-over on the transpacific and backhaul routes.

Following, we answer the main research question

What is the dynamic relationship in returns and volatilities between the Capesize and the Panamax spot market?

There is a long run relation between both markets with an influence from Panamax to Capesize freight rates, on average. Furthermore, there is a long run relationship on the main Baltic routes except on the backhaul. To continue, there is volatility spill-over from Capesize to Panamax as well as from Panamax to Capesize, on the transatlantic and fronthaul route. On the transpacific route there is bidirectional spill-over, but it is not siginificant at 5%. There is no spill-over on the backhaul route. Resulting in the fact that a shock only on the transatlantic and fronthaul routes will increase the volatility of the Capesize and Panamax freight rates.

Although results are significant, research focuses only on the four major routes of the Baltic Exchange, taking the daily time charter rates. It would be interesting to analyse similar voyage rate to better understand the dynamic interrelation between Capesize and Panamax.

Changes in the dynamics are related to five major factors. First factor refers to the changes in the world macro-economy. The old continent has not recovered from the financial crisis, investors and financial institutions are scared to invest large amounts in projects, resulting in a flat growth. In addition, there is an uncertainty regarding the Chinese economy while it is actually growing at 7.7% per year. However, because of the large corruption, investors do not trust the numbers. Second factor is closely related to the bunker cost which has been fluctuating a lot during this period. From nearly 750 ($/ton) to actually 220 ($/ton). The actual low level has a large impact on the freight rate. Having low bunker cost enables owners to accelerate when the rate is more attractive, bringing more vessels on the market, creating over-supply and impacting negatively the returns. This effect increases the volatility in the market. Third factor is linked to the commodity market which is facing big uncertainties as well. The iron ore is at 92% export to China. The slowdown of the Chinese economy has a direct impact on the demand for iron ore. Additionally, the coal demand is falling because of its negative environmental impact. Fourth factor that influences the changes in the dynamics is that fact that in 2011 the world dry bulk fleet started to decrease the sailing speed because of the high bunker costs. Nowadays the fleet is still sailing at eco-speed even with low bunker costs which affected the relationship between the Capesize and the Panamax. Finally, the fifth factor is the longhaul route which had a major impact on the Capesize fleet. It brought a new profitable route to the Capesize owners. They are now able to charter the vessel for a high ton/mile ratio, increasing their revenue. Thus, a large number of actors entered this market which is still poorly represented by the Baltic Exchange.

All these factors played a significant role in the shipping industry between 2009 and 2016. Quantifying their impact on the Capesize and Panamax relationship should be the subject for further research.

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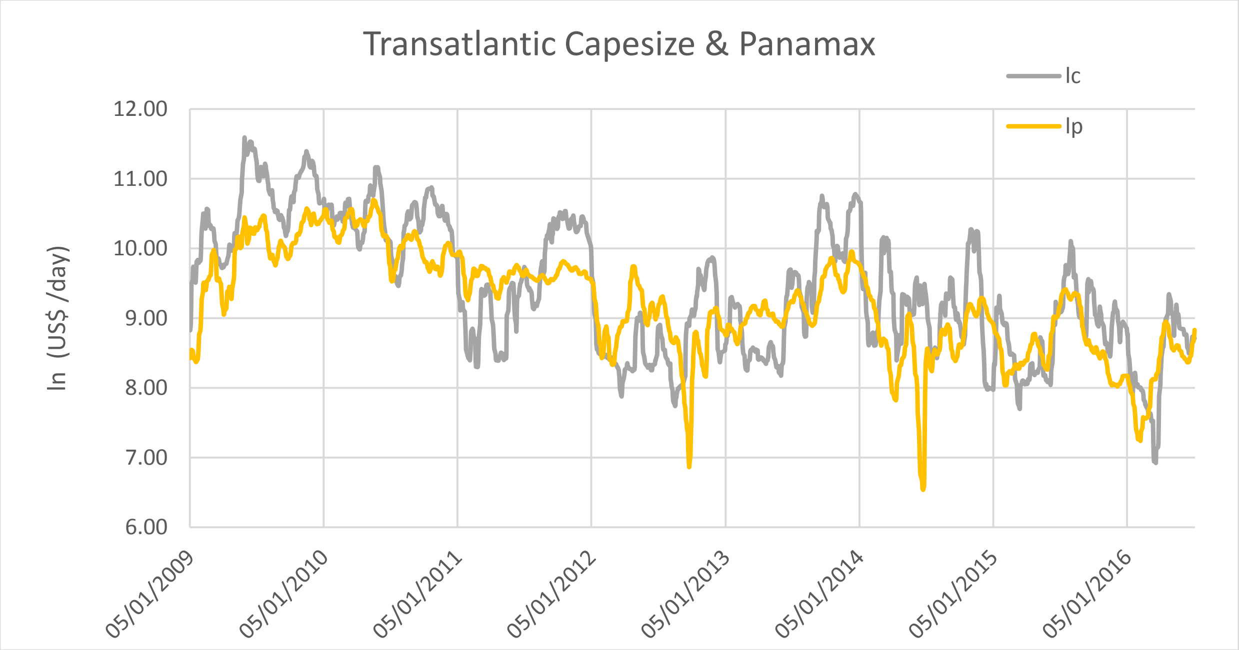
Appendices



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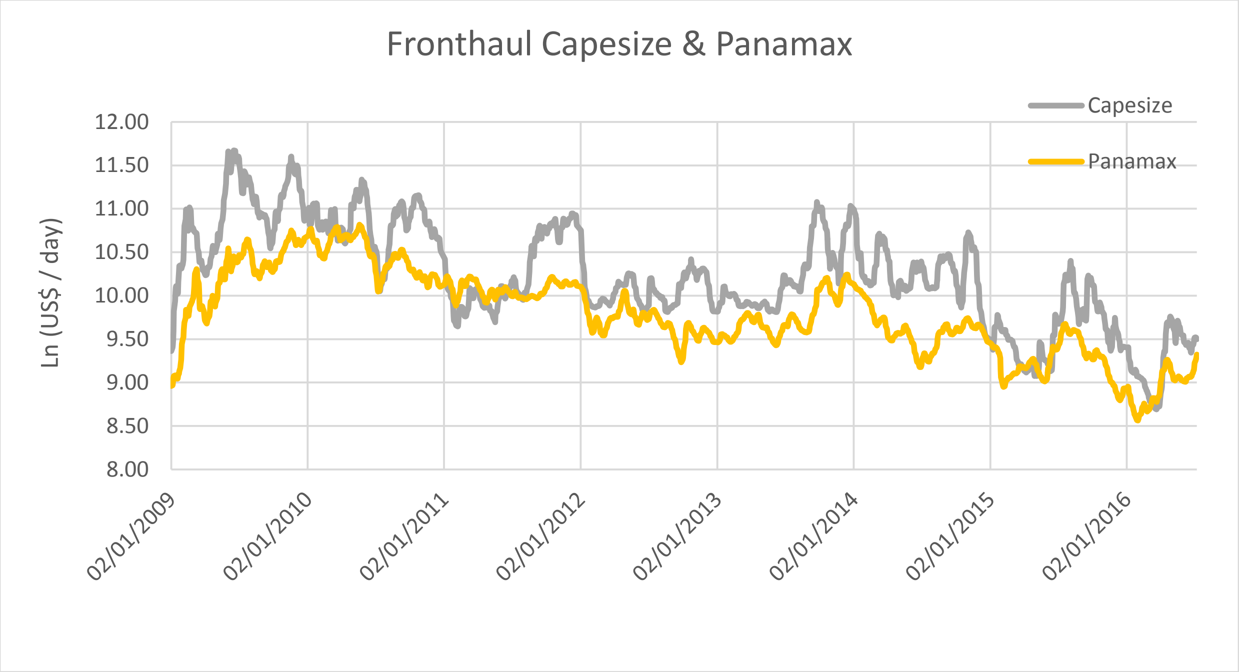

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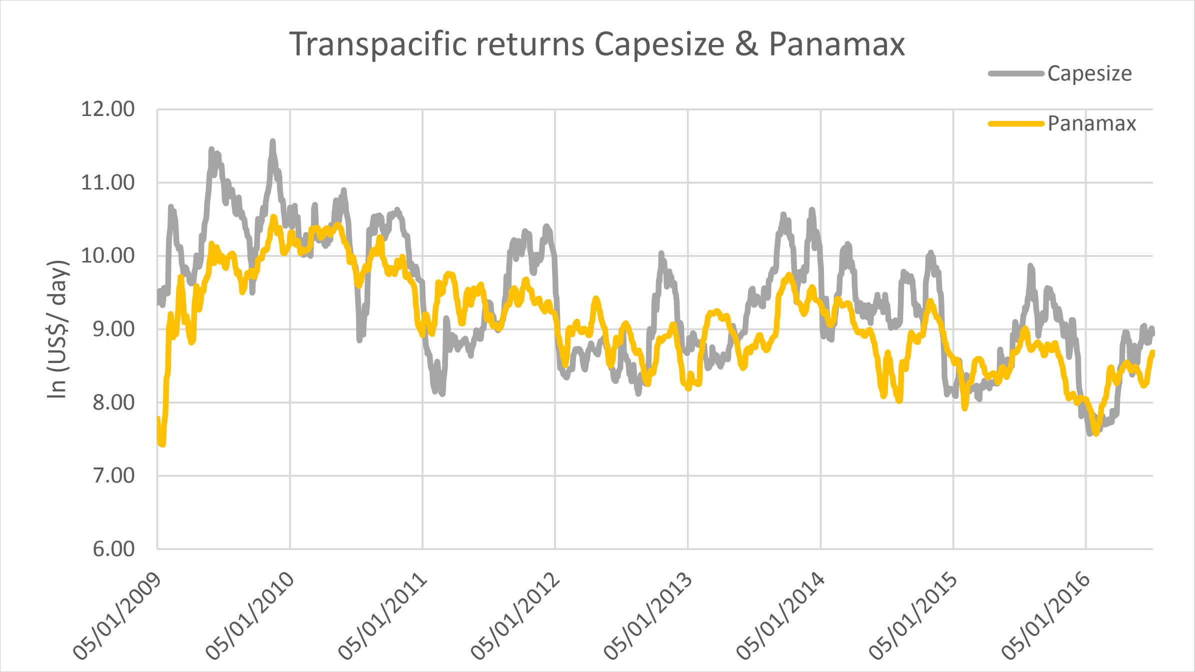
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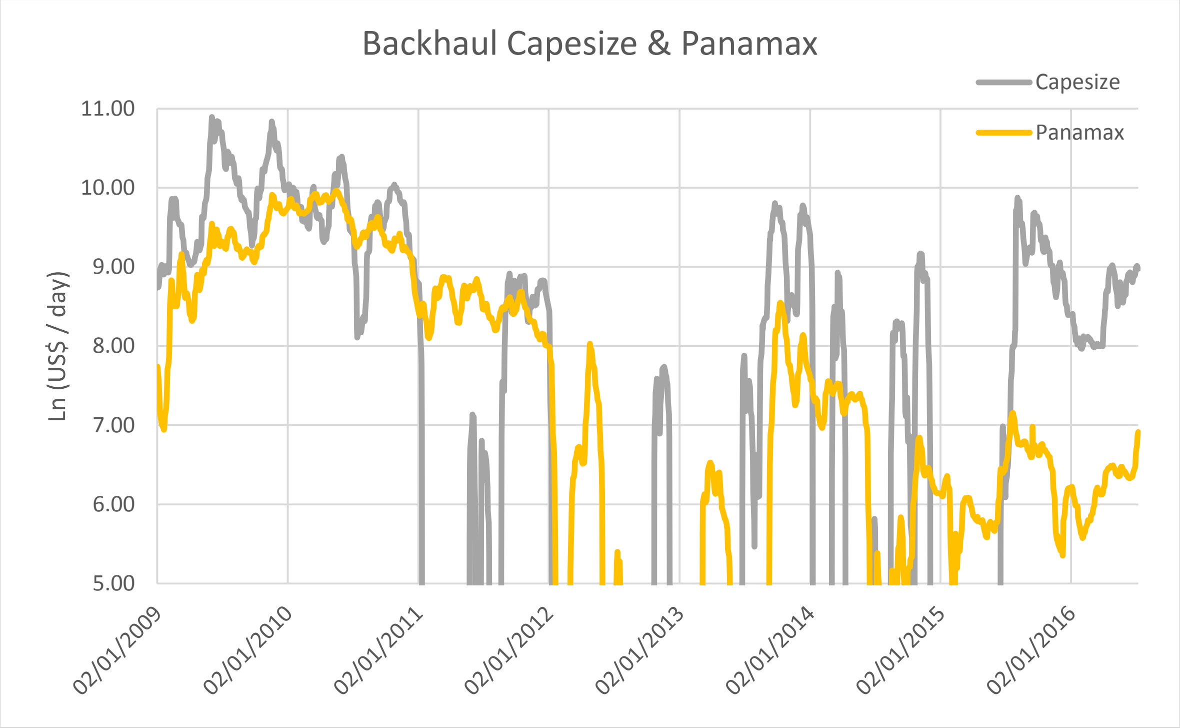
Backhaul Capesize & Panamax
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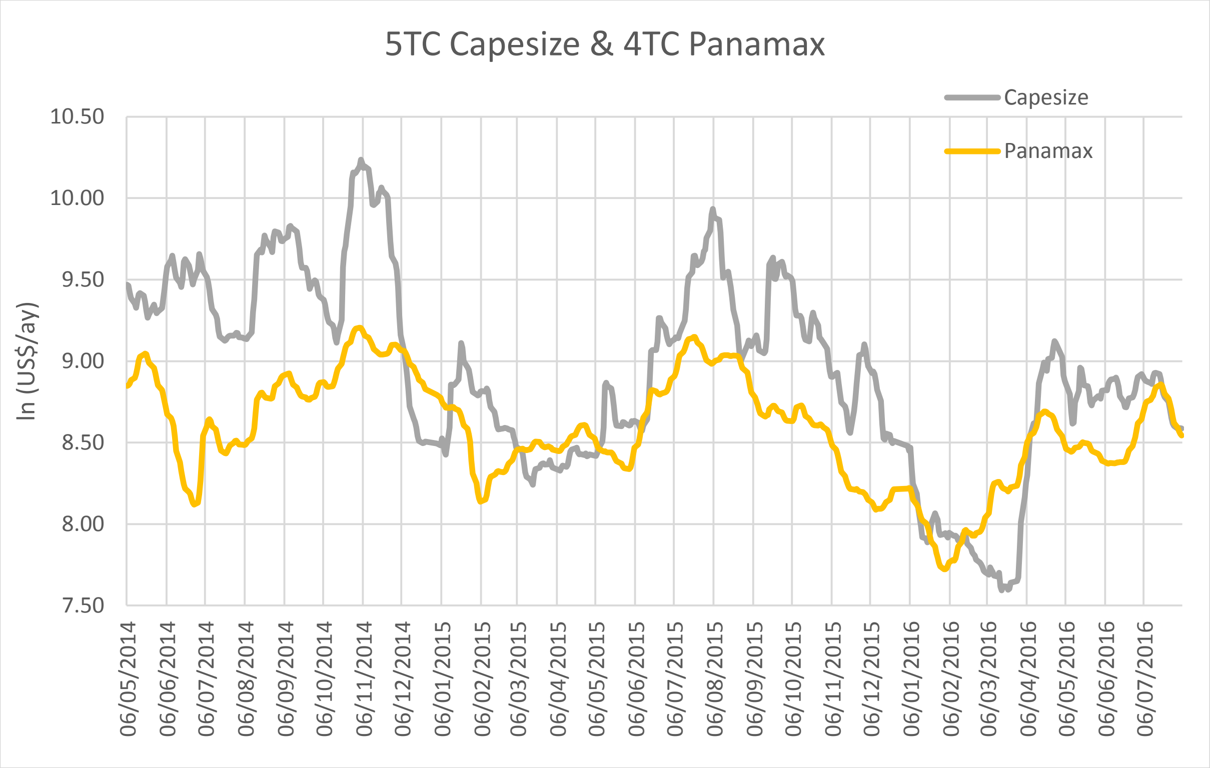
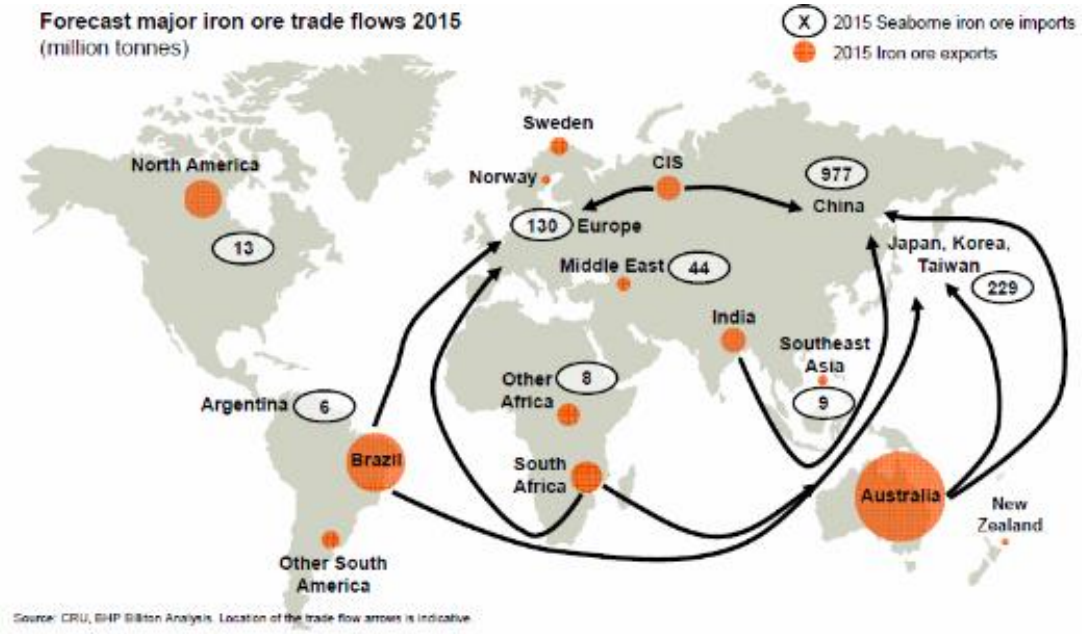


Iron ore Trades in 2015.



Source: CRU, BHP Billiton Analysis. Location of the trade flow arrows is indicative

Coal Trades in 2015.