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The interaction between Forward Freight Agreements & Spot Freight Rates

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Abstract

Shipping Industry along with relevant freight markets are characterized by extreme volatility. For this reason, hedging tools might be vital for companies involved and their business activities.

The Forward Freight Agreements are financial forward contracts that can be used as hedging or speculation tools for principals involved in ship chartering and commodity trading, such as shipowners and charterers.

However, given the fact that freight rates regulate the industry, companies invest in market analysis in order to estimate future freight market activity. In addition, relevant analysis has attracted the interest of several researchers, who have also attempted to study the relation of the FFAs with the Spot Freight Rates.

The present thesis deals with the interaction of Forward Freight Agreements with the Spot Freight Rates for five sea routes of Panamax dry cargo vessels. We study whether FFAs prices with specific maturity can be used as unbiased estimators of spot prices in short term period.

The study is based in some tools of econometrics and data series analysis and the methodology is based on the published study of Professor, Mr. E. Kavussanos in 2004 with similar hypothesis.

Considering the final results, there is a strong evidence that FFAs prices can be used as unbiased estimators for Spot Prices. However, the opposite relationship cannot be ascertained.

Kea Words: Forward Freight Agreements, Shipping, Derivatives, Hedging, Freight, Regression, Cointegration, Heteroscedasticity, Homoscedasticity, Unbiasedness

Περίληψη

Η Ναυτιλιακή Βιομηχανία όπως και η Ναυλαγορά είναι ιδιαίτερα ευμετάβλητες αγορές. Για αυτόν τον λόγο, τα εργαλεία αντιστάθμισης κινδύνου ενδέχεται να είναι ζωτικής σημασίας για τις εμπλεκόμενες εταιρείες και τις επιχειρηματικές τους δραστηριότητες.

Τα προθεσμιακά συμβόλαια ναύλων είναι χρηματοοικονομικά παράγωγα που μπορούν να χρησιμοποιηθούν ως εργαλείο αντιστάθμισης κινδύνου ή κερδοσκοπίας για τους εμπλεκόμενους στη ναύλωση πλοίων και την εμπορία εμπορευμάτων, όπως οι πλοιοκτήτες και οι ναυλωτές.

Ωστόσο, δεδομένου ότι οι ναύλοι ρυθμίζουν την συγκεκριμένη βιομηχανία, οι εταιρείες επενδύουν στην ανάλυση της αγοράς προκειμένου να εκτιμήσουν τη μελλοντική δραστηριότητα των τιμών τους. Επιπλέον, παρόμοιες αναλύσεις έχουν αποτελέσει αντικείμενο έρευνας αρκετών ερευνητών, κάποιοι από τους οποίους έχουν επίσης μελετήσει τη σχέση των παραγώγων ναύλου με τις τρέχουσες τιμές τους.

Η παρούσα διατριβή ασχολείται με την αλληλεπίδραση των προθεσμιακών συμβολαίων ναύλων με τις τρέχουσες τιμές των ναύλων για πέντε συγκεκριμένες διαδρομές πλοίων ξηρού φορτίου τύπου Panamax. Μελετάμε εάν οι τιμές των παραγώγων ναύλου με συγκεκριμένη διάρκεια μπορούν να χρησιμοποιηθούν ως αμερόληπτοι εκτιμητές των τρεχουσών τιμών βραχυπρόθεσμα.

Η μελέτη βασίζεται σε ορισμένα εργαλεία οικονομετρίας και ανάλυσης χρονοσειρών και η μεθοδολογία βασίζεται στη δημοσιευμένη μελέτη του καθηγητή κ. Ε. Καβουσανού το 2004 με παρόμοια υπόθεση.

Λαμβάνοντας υπόψη τα τελικά αποτελέσματα, υπάρχουν ισχυρές ενδείξεις ότι οι τιμές προθεσμιακών συμβολαίων ναύλων προκαλούν τις τρέχουσες τιμές στο άμεσο μέλλον. Όμως, η αντίθετη σχέση δεν μπορεί να υποστηριχθεί.

Λέξεις Κλειδιά: Προθεσμιακά Συμβόλαια επί ναύλου, Ναυτιλία, Παράγωγα, Αντιστάθμιση Κινδύνου, Ναύλος, Παλινδρόμηση, Συνολοκλήρωση, Ετεροσκεδαστικότητα, Ομοσκεδαστικότητα, Αμεροληψία

Contents

INTRODUCTION

Shipping is a competitive market, characterized by significant changes which are closely connected with microeconomic, macroeconomic and geopolitical factors, governmental policies and plans, global organizations and unions along with the international relations between the countries. These changes have also a great influence on freight rates and vessel prices. In addition, shipping is derived demand, means that the demand for shipping services comes from the demand for products, goods or commodities. Thus, freight markets are characterized by high volatility. Shipping cycles combined with the seasonality observed in this market, make it imperative to explore alternative effective ways of risk management in shipping. Financial derivatives, which apply to markets of currencies, bonds, interest rates, etc., offer the opportunity for hedging and speculation, taking advantage of changes in the prices of underlying assets. The application of financial derivatives in the freight market is a new market which in recent years has attracted considerable interest from the shipping community and global markets.

Freight Forward Agreements (FFAs) were initially developed so as to manage the risks arising from fluctuations in freight rates, storage cost of commodities, vessel prices, vessel demolition market, bunker prices, interest and exchange rates more efficiently, in an economic, competitive and more flexible way. These products that were traded Over-the-Counter (OTC) in London market, slowly expanding to other centers, such as Oslo, Singapore, and other major shipping centers. Shipping companies as well as oil and gas or energy companies use shipping derivatives to manage fluctuations in freight prices and are now considered to be the most rapidly growing sector of the shipping industry. The first shipping derivative contracts appeared in 1985 with the creation of BIFFEX (Baltic International Freight Futures Exchange). It was a stock exchange with the BFI (Baltic Freight Index), index of the Baltic Exchange, as the underlying instrument, for the trading of freight future contracts. Gradually, due to market segmentation, many sub-BFI indices emerged. However, as private agreements between two counterparties traded over-the-counter they first appeared in 1992.

HISTORICAL REPORT ON DERIVATIVES

The first historical reference to our derivatives comes from "Aristotle's Politics" (Book I, chapter 11) where Thales the Milesian appears to predict an increased harvest next year and thus decided to buy the right to use the mills. The first attempt for organized trading of such products was made on the Amsterdam Stock Exchange in 1688 when the trading of the first options on the tulip bulb began. Thus, it took several years since 1973 in Chicago to operate the first organized derivatives exchange by the Chicago Board of Trades and the Chicago Mercantile Exchange. This was followed by the stock exchanges of New York, Montreal, Tokyo, etc. Over the last 20 years, derivatives markets around the world have grown. Under these circumstances, in 1999, the Greek Stock Exchange established the first organized derivatives market in Greece, the Athens Derivatives Exchange. The trading of the first products started in August of the same year. The derivatives market has flourished and experienced the greatest growth in recent years. It has established itself as the main factor, which contributes to the balance of the financial system and also as an important factor for the functioning of the economy. Apart from the importance of the derivatives market, few outside the market are aware of its operation and have a complete picture of the size, structure and market share it occupies. In fact, Thales paid a small down payment in advance to ensure the operation of the mills. If the harvest was sufficient, he would exercise his right and make a big profit, otherwise he would not exercise it. By today's definitions, Thalis created the first call option. The first record of an organized transaction with futures contracts dates back to the 17th century in Japan. Where Japanese feudal lords transported the surplus rice to warehouses and then distributed tickets. The tickets represented the receipt of a certain quantity of rice at a future date and a specific price. Rice sales tickets were created to "lock" the purchase price of the product and reduce its risk faced by traders or feudal lords. The importance around which the worldwide Maritime market unfolds, especially in the last twenty years, in combination with the cross-border growth of the world economy, with the main product being the transport of goods by sea to meet human needs, as well as the sharp change in values emerging over time due to the "economic volatility" (Shipping Cycles) was considered imperative to create an organized market the so-called Shipping market. Today, the Shipping Market consists of the Freight Market, the Sale and Purchase Market, the New Building Market and the Demolition Market. Specifically, in the Freight Market the product is the shipping service which is paid by the charterer with the freight rate in a voyage charter[1] or with the hire in a time charter[2]. This service legally concludes contract between the principals involved, Charterer and Shipowner. The Ship Sale and Purchase

[1] Voyage Charter: A charterer hires a vessel for a particular voyage for the purpose of transporting a specific commodity from load port to discharge port. Payment is the freight which is calculated by a rate of freight per-ton of cargo carried or the parties agree on a lump-sum amount in some cases. The charter party contains written terms of the agreement, the clauses, between the shipowners and the charterer.

[2] Time Charter: A time-bound agreement where the charterer hires a vessel for a specific period of time and the payment is calculated on a daily basis. The charterer takes the commercial control of the ship, can decide loading and discharge ports and preferable route, while leaves technical and other management duties to the shipowner. This form gives flexibility while charterer is responsible for certain costs (as bunkering) and may have pre-agreed restrictions according to charterparty. In some cases, the charterer may have the opportunity (according to the terms of the charter party) to sub-chartered the vessel to a third party on either a time or voyage charter basis.

market, where the asset traded is the vessel herself, is combined by three sectors, the sector for newbuilding vessels, the sales or purchases of secondhand vessels in the open market and the demolition or “scrap” market for the ships to be dismantled. All the cash flows that flow into these markets create the Maritime Cycles. As a consequence, all four sectors that make up the Shipping market, it is said that, in the short run tend to act differently but in the long run one begins to affect the other. Of course, when investing with a long-term horizon, it is necessary to study beyond the current profitability and history of each sector, business and industry lending, the size of orders in the shipyards (order book) and the financial health of the respective trade sector (Cinquegrana, 2008).

In 1979, Leif T. Loddesol, former president of Wilhelm Wilhelmsen, wrote an article about why some shipping companies fail while others succeed (1979). According to Loddesol, the spread of risk through a diversified fleet seems to be one of the five reasons some shipowners survive in such an unstable industry. According to Peter Lorange, "*many of the disasters at Scandinavian shipping companies in the early 1980s can be attributed to the confusion over risk exposure*". Covariation between shipping markets appears to have decreased over time. Therefore, the benefits of diversification could be more apparent than before. Thus, it is important for all those involved in the shipping industry to improve their knowledge of risk exposure (Lorange, 2009).

Although there are many studies analyzing the potential profitability through diversification using correlation and integration approaches in the stock markets, real estate markets and hedge funds, there are no similar surveys available for this market. Previous studies on shipping or investing in ships have generally focused on the effect of diversifying ship portfolios, consisting of different types, ages and sizes of vessels, on the part of shipping companies. However, the results of these studies were not consistent (Lee and Woo, 2015).

Magirou et al. (1997) investigated the benefit of diversifying hypothetical portfolios with dry bulk carriers and tankers based on Markowitz Theory and the Asset Valuation Model (CAPM), demonstrating the benefits of investing in a diverse portfolio. They also analyzed the correlation with the Dow Jones Industrial Average (DJIA) representatively for stocks and found low or negative volatility and b values between their proposed portfolio and DJIA, in support of its dynamic differentiation. Empirical results have shown that by using the optimal portfolio, an investor obtains a much better risk-return profile than that provided by limiting the investment to a single type of vessel.

In contrast, Jia & Adland (2002) investigated the correlations of five different types of ships based on the annual return on investment, calculated on a monthly chronological basis. Their results showed relatively high correlations, showing that the shipping industry in general seems to be positively correlated most of the time, which means that the operation of different types of ships is not justified in the context of diversification.

Veenstra & Franses (1997) examined the long-run relationships of dry bulk freight rates for three Capesize[3] and three Panamax[4] routes by applying integration

[3] The Capesize vessel is the largest type of dry bulk carrier that is unable to transit the Suez Canal or Panama Canal and therefore has to use the Cape of Good Hope or Cape Horn route. A Capesize bulk carrier typically has a deadweight in excess of 150,000dwt and typical dimensions: length overall 290m, breadth 45m and draught 18m.

[4] The Panamax bulk carrier is a mid-size vessel that has a deadweight of between 60,000 and 79,999dwt and is designed to travel through the present Panama Canal. This type of vessel can carry maximum amount of cargo within the constraints imposed by the locks of Panama Canal. The

analysis. The results showed that a general framework of freight rates cannot be predicted due to their stochastic behavior.

Kavussanos (2003) investigates the risks associated with owning and operating tanker vessels of various sizes in voyage charter and time charter using ARCH integration models. In his study concludes that time charter contracts are more desirable than voyage charter in order to eliminate risk. Besides, the use of smaller vessels might be preferable than owning and operating larger vessels, in relation to the high risks involved

Grelck et al. (2009) analyzed the diversification properties of shipping investments for a period from January 1999 to December 2007. However, they focused on shipping companies and not the shipping sector in general and estimated the b's of shares of shipping companies. The empirical results showed that the shares of shipping companies do not have a very large b therefore they possessed the diversification properties desired by alternative investors.

In his dissertation, Tsolakis (2005) examined the possibilities of benefiting from diversification in the shipping market with the integration approach. It used Johansen's integration methodology to test the long-run freight rates of eight different types and sizes of vessels. The dissertation identified the situations in which there can be long-term benefits for risk reduction by investing in different types and sizes of vessels for the period 1979-2002. Investing in more than one type of bulk carrier was proved that does not bring risk-reduction benefits. However, the results also showed that it is possible to reduce the risk by investing in more than one type of tanker. In addition, the risk mitigation benefits decreased as diversification increased without the risk mitigation benefits when more than five different types and sizes of vessels participated in the investments.

Merikas et al. (2008) examining the age parameter, attempt to model the investment decision of the tanker sector, between the choice of buying secondhand and newbuilding ships, arguing that one of the main elements for the investment decision should not be the price of the vessel, second - hand (SH) or newbuilding (NB) but a) the relative ratio of second- hand price over newbuilding price (SH / NB) and (b) the variation of this ratio.

Stasinopoulos (2011), examining the risk-return profile of different sizes and ages of bulk carriers, supports the utility of modern portfolio theory in shipping risk management based on the generated risk-performance characteristics of individual composition of the fleet for each investment horizon, also taking into account the various operating strategies available. In addition, it indicates that the sequential portfolio leverage theory and the CAPM method provide market portfolios with the amounts of systematic and non-systematic risk of ships and their risk premiums.

In exploring the benefits of diversifying investment in bulk cargo ships, Köseoğlu & Karagülle (2013) applied the integration approach with ten different types of dry and wet bulk carriers.

According to Tsolakis (2005), only 74 of the 1,013 investment combinations provided the opportunity to reduce risk by investing in different types of ships. If the ships belong to the category of dry bulk carriers, then the diversification does not create a risk reduction. However, the results showed that there is a possibility of reducing the risk by investing in more than one type of tanker, but not in more than four different types and sizes.

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dimensions of a typical 70,000dwt Panamax bulk carrier will be: length overall 225m, breadth 32m and draught 12m.

Lian & Toften (2015), applying the theory of the modern portfolio, found differences in risk-performance characteristics between dry bulk cargo vessels, tankers and container vessels. The results also showed that the possession of a diversified portfolio statistically exceeds a portfolio of dry bulk carriers or containers, while the same cannot be concluded for a solid tanker portfolio due to its strong historical performance.

CHAPTER 1: FINANCIAL DERIVATIVES

1.1 Definition of financial derivatives

Financial derivatives are financial products whose value depends on or derives from the performance of an underlying asset. The most common underlying investment assets are stocks, bonds, commodities such as grain, gold, oil, gas, currencies, interest rates and market indices such as the Baltic Dry Index (BDI) or Baltic Dirty Tanker Index (BDTI). Derivatives are contracts between two or more parties. The most important types of derivatives are futures contracts, forwards contracts, options and swaps (Zhang, 2020).

1.2 Futures contracts

A futures contract is an agreement between two parties to buy or sell an asset at a predetermined date in the future and at a predetermined transaction price. Concerning the parties, the one who agrees to buy a certain quantity of a commodity at a certain price and date in the future takes a long futures position and the party who agrees to sell the commodity takes a short futures position. The futures contracts are traded on the stock exchange, either with the "open outcry" method, or electronically on electronic trading platforms. Trading through the electronic systems of stock exchanges, offers promptness in the registration and execution of trades, reliability and global connectivity. This method has attracted considerable interest in recent years, in relation to the traditional natural method of "open outcry" trading. Futures Contracts were originally designed to meet the needs of traders and farmers. The founding of the Chicago Board of Trade in 1848 marked the beginning of the negotiation of futures contracts, bringing traders in contact with farmers. Today the stock exchanges with the largest trading volume are the Chicago Mercantile Exchange (CME), Chicago Board of Trade and New York Mercantile Exchange (NYMEX), members of the CME Group and Eurex (Blums & Weigand, 2019).

1.3 Forward contracts

A forward contract is an agreement between two parties to buy or sell an investment property at a predetermined date in the future and at a predetermined transaction price. The difference with futures contracts is that forward contracts are traded outside the stock market. Such a trading is in the form of Over-the-Counter (OTC). An important advantage of OTC contracts is that the terms of the contract trading are not predetermined as in those which are traded on stock exchanges and market participants are free to trade any mutually attractive offer. However, their disadvantage is the credit risk, i.e the risk due to the inability of one of the contracting parties to fulfill the contractual obligation it has undertaken. The use of Clearing houses, as intermediaries between the parties to the OTC contracts, ensures that the transaction will be completed even if one party goes bankrupt. Following the crisis of 2008 and the collapse of the investment bank Lehman Brothers, the role of clearing houses became imperative. A typical example is the Forward Freight Agreements (FFAs) in the bulk dry cargo market, where in 2012, according to the Baltic Center, 99.51% of transactions were cleared (Ginsberg & Heaton, 2010).

1.4 Options

Options are a type of derivatives that offers the buyer the right, without obligation to buy or sell an underlying asset at a certain price on a specific date. There are two fundamental types of options: The rights of purchase (calls) and the rights of sale (puts). A call option gives the holder the right to buy an investment good at a

specific date and price. A put option gives the holder the right, but not the obligation, to sell an investment good at a specific date and price. The price stated in the contract is called the exercise price or strike price and the indicated date is called the expiration date or maturity date. In the case of a European option, it is exercised on its expiry date, while an American option is exercised at any time during its lifetime. Asian rights are exercised at an average price of the right price over a period of time. In order for an investor to acquire an option, he must pay the price of the option (option premium) to the seller. An option is "at the money", if the price of the underlying investment good is the same as the exercise price. A call option is "in the money" when the price of the underlying investment good (market price) is higher than the exercise price and "out of the money" when this price is lower than the exercise price. On the contrary, a put option is "in the money" when the price of the underlying good is lower than the exercise price and "out of the money" when this price is higher than the exercise price. Finally, an option is "deep in the money" when its exercise leads to high profits and futures contracts in which the holder is obliged to buy or sell an investment good at a predetermined time and at a predetermined price.
There are four types of participants in options trading:

- Call option Buyers
- Call option Sellers
- Put option Buyers
- Put option Sellers

Options are extensively used as hedging tools. Investors take advantage of the strategies they offer in order to eliminate risk. On the other hand, Options offer a less expensive way for traders to go long or short the market with specific risk and make certain profit. Thus, they are a popular tool for speculation. For instance, a speculator, can buy a call option instead of the stock which may cost considerably less compared to the stock price, and in case he/she can estimate the movements of the stock price then would make a riskless profit.
In terms of how these rights are traded, it is done both on the stock exchange, with the largest trading volume being carried out by the CME Group, as well as over-the-counter, in the market of over-the-counter traded contracts (Crama, De Reyck & Taneri, 2017).

1.5 Swaps

A swap is an agreement between two parties to exchange cash flows in the future. The agreement defines the date of payment of the cash flow and the way in which they will be calculated. Swaps are not traded on stock exchanges, but in the OTC market, where there is a risk of default by one of the parties (credit risk). In order to eliminate the credit risk, transaction clearing centers undertake the liquidation of these contracts. An example of a clearing house is LCH Clearnet with the Swap Clear platform which is the dominant interest rate clearing platform with a share of more than 50% in this market. The most common types of exchange contracts are "plain vanilla interest rate swaps" and "currency swaps". In the first case, one part of the transaction agrees to pay the other part a fixed interest rate on a notional principal for a period, receiving a floating interest rate for the same nominal capital and the same period. In the second case of "currency swaps", one part of the transaction agrees to pay interest to the other party in the nominal capital of one currency and receives from the other party an interest rate on the nominal capital of a different currency. The use of swaps is very popular because they offer the participants the possibility to use them for commercial needs and to exploit the comparative advantages they retain. For example, a bank that pays a floating interest rate on deposits and receives a fixed interest rate on the loans it offers. In order to cover this difference, participates in a swap, where pays a fixed interest rate and receives a floating one. In this way, it converts its loans from loans with fixed interest rates to loans with floating interest rates, bridging the initial difference between interest rates. Moreover, a company, A, which has a comparative advantage in floating rate lending over another company, B, which has a comparative advantage in lending at fixed interest rates. A will borrow at a floating interest rate and in case it wishes to convert this interest rate to a fixed one, it will participate in an interest rate swap with B, converting the floating interest rate to a fixed one (Rates & Market, 2018).

1.6 Categories of participants

There are three main categories of derivatives market participants: "hedgers", "speculators", "arbitragers". Hedgers use financial derivatives to reduce or eliminate the risk associated with changes in the price of an investment good. Their goal is to avoid the unfavorable changes of the underlying investor to which they are exposed. The "speculators" take a position in the derivatives market, betting on future changes of an investment good and their derivatives give the opportunity for more leverage. The leverage offered by financial products involves a higher risk, resulting in an increase in the potential profits and losses of each investor. Finally, arbitragers use financial derivatives to participate in two or more markets at the same time, taking advantage of price differences in different markets, taking offsetting positions to make a profit. The "arbitrage" method exists as a consequence of market inefficiencies. It offers a mechanism, which ensures that prices will not deviate significantly from their fair value for a long time. This method requires speed in the execution of transactions, as the opportunities for inefficiency presented in the markets last for a short time, eliminating the possibility of profit (Vikas, Srikanth & Scholar, 2019).

1.7 Risks in the shipping market

Over the years, shipping has verified its importance. Market fluctuations, combined with high capital and financing, have made market participants more cautious of underlying risks. The sources of risks faced by the shipping industry are divided into the following categories (Albertijn, Bessler & Drobetz, 2011):

a. Business-risk is the risk of loss due to adverse changes in EBIT (Earnings Before Interest and Taxes), therefore, the factors that affect EBIT are essentially the sources of business risk. That is, voyage expenses, operating expenses, freight, exchange rates.

b. Liquidity risk is the risk arising from the inability of the company to quickly carry out the transactions required for its operation.

c. Default risk is the risk of a company not completing its obligations.

d. Financial risk, which stems from the investment strategy followed by each company.

e. Credit risk is related to the reliability of the counterparties that are going to fulfill their part of the agreement.

f. Market risk, this form of risk stems from stock price volatility due to changes in the stock market.

g. Political risk is the risk that refers to political decisions or policy changes that distort the expected outcome of an economic action.

h. Technical and physical risk is the risk of technical damages or loss of the ship.

1.8 Hedging the risks in shipping

Shipping companies face a number of variable risks. The effect of freight derivatives may offset said risks to some extent. The analysis of shipping industry & related markets characteristics is vital for understanding the fluctuations in freight rates. Employment of a vessel, or in market terms "chartering", through voyage or time charter contracts, is a crucial part for the liability of the shipping company. Furthermore, the acquisition of a vessel is a capital-intensive investment, therefore companies need large cash flows, not only for the acquisition but also for the operation and maintenance as well. However, raising funds during recession plays fundamental role. Derivatives and futures, that are traded on the stock exchange, in commodities such as oil, grains, iron ore, corn etc., might increase demand for shipping services. Similarly, forwards, that unlike futures they are not traded on the stock exchange, offer analogous opportunities. Similar financial products are used by charterers in their efforts to minimize risk from fluctuations in the prices of commodities (Kavussanos & Visvikis, 2006).

Syriopoulos and Roumpis (2009) emphasize that the volatility of freight rates is the most important factor that affects the variability in the returns of shipping stocks. The risk of freight fluctuations can be offset through derivatives in the event of a possible fall. FFAs in the OTC market pose a credit risk. In the analysis of credit risk, especially in the shipping industry, it is found that the main and common component is the possibility of default. Carrying out transactions through the stock exchanges eliminates the risk of non-fulfillment of the obligations arising from these transactions, due to the liquidation houses. Hedging the risk of interest rate changes is imperative. Shipping companies are characterized by capital intensive investments (fleet) and large cash flows in order to support their day-to-day operations and business activities. Consequently, they might face liquidity problems, which may lead to loans, either with floating or fixed interest rates. In the second case, the costs of a loan are fixed, but in the first, the fluctuation of Libor, determines the cost of loans, with the result that many times the cost of interest rates reaches high levels for a company. The use of interest rate swaps may be an agreement between two parties to bear the risk of this fluctuation through the exchange of interest on credit instruments. More specifically, an agreement is made between two parties, e.g. between two loans, a floating and a fixed interest rate and agree on a specific interest rate price to be settled. In this way the company with the floating interest rate stabilizes the cost of its loans and the second, expecting that Libor prices will move downwards, gains from the interest rate difference.

Shipping operates in the global market, where transactions are mainly made in dollars. Nevertheless, other currencies can be used occasionally. In payments of freight or hire, transactions are made in dollars, however the purchase of a ship can also be effected in yen or euros. Therefore, shipping company faces the exchange rate risk due to exchange rate fluctuations. To hedge these risks, it can use either currency swaps, i.e. an agreement that provides for the exchange of a certain amount of foreign exchange against another currency, or options with underlying products exchange rates, such as dollar / yen or euro / dollar. In these cases, money is settled at regular payments, based on the exchange rate applicable at the time of concluding the contract (Alizadeh and Nomikos, 2009).

The price of crude oil drives the price of oil products & bunkers. Bunker costs account for 30% of a vessel's costs. Other operating or voyage expenses do not fluctuate as much as bunkers. Consequently, it is another variable of a vessel's costs. The following products have been created to compensate for this change: Forward Bunker agreements, Bunker Swaps, Options on bunker prices, Petroleum product future contracts. Forward Bunker agreements are futures agreements between a seller and a buyer for a specific quantity of fuel, at a predetermined price, at a specific delivery location (usually at the largest fuel ports of Rotterdam – Singapore – Houston). The settlement of this type of agreement is done either by monetary settlement in relation to the spot price, or by physical delivery. This product is traded on the OTC market. Respectively, the Bunker Swaps are agreements with money settlement based on the spot oil price. (Syriopoulos and Roumpis, 2009).

Finally, options on bunker prices are rights over fuel prices, the cost of which is limited to the purchase of the right, although the potential profit can be unlimited. Fluctuation in vessel prices has always been one of the key issues for shipping companies, banks and shipyards, as the ship is the main activity of a shipping company and the change in vessel prices has an impact on viability of the company. An increase in the price of a ship can affect the creditworthiness of shipowners and their ability to meet their debts. Therefore, volatility in vessel prices incorporates key information such as lending, investment, and decisions to decrease or enlarge a business. (Kavussanos & Visvikis, 2006).

Adland, Ameln & Børnes (2019) studied the hedge of vessels value with a portfolio of fixed-term FFA contracts covering the longest possible life of the vessel. As mentioned above, the risks of shipping market are various. However, said risks are known to analysts and are controllable. A key risk of the shipping market is the volatility of vessels prices, which has not yet been systematically analyzed to create the appropriate risk management tool. Diversification of vessel portfolio plays a major role in maintaining valuable balance in the income of a shipping company. Shipowners and investors maintain portfolios of vessels of different sizes, exchanging contracts of different duration and make use of tools such as forward freight contracts. (Syriopoulos and Roumpis, 2009).

Alizadeh and Nomikos (2009) proved that the prices of different types of ships are positive correlated with each other, i.e. the price fluctuations are similar, therefore the above method is ineffective. In addition, in the shipping market, the lack of liquidity as well as the occasional oversupply of available vessels, the high transaction costs and complex and time-consuming procedures of a ship sale & purchase procedure make the above method non-functional. In addition, managing a diversified portfolio has a particularly high level of difficulty in managing it. Each type of vessel has different technical, operation and commercial management and needs different high specialized shore & sea personnel, in order to be handled safely and adequately.

Finally, Adland, Ameln & Børnes (2019) studied the hedging of asset value risk for the dry cargo vessels through FFA contracts and concluded that the return of the value of ships is possible with a portfolio of fixed duration FFA contracts, that covers as long as possible the life of the ship. In addition, they have shown that the effectiveness of the returns increases in proportion to the age of the ships up to 15 years.

1.9 Purpose and use

The growth of stock derivatives is connected with the increased use of these products by governments, banks, international companies and private investors. These users exploit derivatives in order to provide better exchange rates, for the allocation of financing, for the improvement of risk management as well as for the elimination of price risk (price risk hedging). Fite and Pfeiderer (1995) have identified four uses of stock derivatives for traders / stockbrokers:

i. They enable the modification of the risk or risk of an investment portfolio, facilitating its efficient distribution to investors who "accept to bear it".
ii. They are given room to improve the expected return on a portfolio, depending on the risk-sharing efficiency of other investors.
iii. Reduction of transaction costs related to portfolio management.
iv. Finally, they bypass any regulatory barriers.

To understand the above, we need to consider the operation of a well-distributed stock portfolio. This function would be better served by buying shares on the stock exchange. However, transaction costs and risk monitoring costs limited the number of companies that could be part of a portfolio. The idea of concentrating intermediaries greatly reduced the aforementioned costs. Futures were then created based on various stock indices. These futures further reduced risk, as well as offering more flexibility in leverage and risk control. As far as society is concerned, there are two benefits that come from the use of derivatives:
i. Efficient way of risk management.
ii. Derivative trading provides us with information on the prices of assets / commodities / services.

The popularity of these stock market products is connected with the high degree of leverage they offer. Leverage is an economic term that refers to the multiplication that occurs when a small amount of money is used to control an item of much greater value. For example, the most common leverage method is the mortgage. In such a case, a party acquires control of a property of much higher value than the amount of money he has exchanged. Leverage technique of derivatives is similar to that of the mortgage, presented above. Investor has the ability to control higher value shares of the company in return of a small fee, something that could not be effected without the use of derivatives. Obviously, there are two versions with derivatives market:
i. If investor has precise estimations, then investment would be more profitable than the case same had been made through the company.
ii. The investor has misjudged, which means that the losses will be multiple.

CHAPTER 2: SHIPPING DERIVATIVES

2.1 Definition and types of shipping derivatives

Shipping derivatives are financial products whose value depend on or is derived from the value of freight indices and trade routes published daily by the Baltic Exchange and the S&P Global Platts for bulk dry and wet cargos along with the Shanghai Shipping Exchange and Drewry Shipping Consultants (in partnership with the Clear Trade Exchange), for containers. Shipping derivatives are financial contracts between two parties for the carriage of a cargo by sea at a predetermined price (voyage charter), or for a vessel employment for specific period of time (time charter). These contracts do not include the physical delivery of the underlying asset and the settlement involves the payment of cash settled contracts. This arrangement varies from contract to contract and depends on its maturity, which may be in a month, quarter or year, depending on the type of contract, which may be Time Charter or Voyage Charter, etc. and from the market, dry bulk or wet cargo, containers. The main types of shipping derivatives are Freight futures, which are traded on the stock exchange. Forward Freight Agreements (FFAs), which are traded over-the-counter and can be divided into "Over-The-Counter" FFAs and "cleared" FFAs, which are cleared by clearing centers. Freight options, which are traded both outside and inside the stock market. Container Freight Swap Agreements (CFSAs), which are traded outside the stock market (Adland & Alizadeh, 2018).

2.2 Participants in the market of shipping derivatives

Significant changes in freight rates compose the Baltic Dry Index (BDI), the Baltic Dirty Tanker Index (BDTI) and Baltic Clean Tanker Index (BCTI), respectively, have made it imperative to use financial instruments for more effective risk management for maritime market participants. More specifically, ship owners and charterers use these products to protect themselves from price fluctuations. Including brokers, these three categories are the traditional participants in the market of shipping derivatives. The increase in volume and value of world trade has led to an increased interest in shipping products, given the fact that a large quantity of commodities and goods is transported by sea. As a result, investment banks, hedge funds, financial institutions, mining companies, etc. entered said market. Furthermore, the financial collapse of 2008 made it imperative to liquidate the contracts that are traded off the stock exchange, with the clearing centers having a significant share in this market. Finally, the Baltic Exchange and the freight futures and freight options trading exchanges are the backbone of the market (Alexandridis, Sahoo & Visvikis, 2017).

2.3 Shipowners

Ship owners use freight derivatives to protect themselves from falling freight rates. They use them to stabilize their cash flows, choosing a freight level today, so as to protect themselves from future changes in the physical freight market. For example, a Cape-size ship owner operating the Tubarao – Rotterdam (BCI) C2 route believes that in June the freight rates in the Cape market will fall due to the seasonality of dry bulk market in the summer period. Selling a Forward Freight Agreement for the C2 route for July (sell July FFA), is protected from falling freight rates as expected. Hence, he/she takes a short position. Shipping companies with large fleets use these products for profit purposes, considering future changes in the freight rates, taking advantage of their market intelligence and internal information due to their significant size. For instance, a ship owner who owns one Panamax-type vessel does not have the same information as a shipping company that manages a fleet of 60 Panamax-type vessels. Additionally, it is important to note that participants in the market of freight derivatives are ship owners and managers with large fleets, such as Teekay, OSG, Swiss Marine, etc. Furthermore, a ship owner can take advantage of the time until the delivery of a newbuilding vessel, using effective maritime derivatives in order to ensure a continuous cash flow. The owner of a newbuilding VLCC of about 320,000 dwt in April, who expects to take delivery of the asset in June, fixing the ship in time charter for one year from June onwards, can purchase a futures contract for the months until delivery from NYMEX and ICE Futures Europe. Once his predictions are verified, he may secure continued cash flow from the derivatives market (Adland, Ameln & Børnes, 2020).

2.4 Charterers

The charterer of a vessel, who may be a commodity trader, or a company provides transportation services, aiming to protect himself from the rise of freight rates, takes the opposite position in a freight derivative transaction from a ship owner. Thus, the charterer secures the transportation cost for his cargo. The charterer in a transaction like the one mentioned above, would buy the July FFA, to protect himself from a possible price increase. Hence, he/she takes a long position. A charterer may choose a time charter contract for a tanker vessel for a two - year period, in order to protect himself against possible fluctuations of freight rates. To minimize the risk of time-lapse and exposure to a potential fall in rates, he/she can buy a sell-off or sell a buy-in right, offsetting its losses in the physical market with profit from buying that derivative. Finally, it is abundantly clear that both charterers and ship owners can use shipping derivatives to make a profit by taking offsetting positions, taking advantage of fluctuations in freight rates between vessels with similar carrying capacity, where one vessel might substitute the other, offering “arbitrage” opportunities. Examples of vessels that the one may be a substitute for the other are the Panamax and Supramax[5] dry cargo vessels. (Plomaritou & Nikolaides, 2016).

2.5 Brokers

The broker is actually an intermediary, who negotiates the contract between Sellers and Buyers in a possible transaction, trying to protect client’s interests. A broker focuses on searching the market for the best possible offers on behalf of his client. Payment for broker’s service is actually the commission (broker’s commission / brokerage fee). The major brokers in the shipping derivatives market are Clarksons Securities Ltd., Simpson Spence and Young Ltd., Freight Investor Services Ltd. The role of brokers is also expanding in the field of market intelligence. The FFABA forward curve is the official "forward curve" for the evaluation of FFAs, offering forward freight rates for different periods at any time. This curve is calculated by the largest groups of shipping brokers in the shipping derivatives market, which are members of the Forward Freight Agreement Brokers Association (FFABA). At the end of each working day - close of business time- (17:30 London time) the members of this organization give to the Baltic Exchange their estimates for the future fluctuations of the freight rates. The Baltic Exchange then publishes the FFABA forward curve, which is the average of brokers' daily estimations in the Forward Freight Agreements market.

[5] Supramax: type of mid -size dry cargo bulk carrier with carrying capacity of about 48,000 - 60,000dwt and typical dimensions: length overall 199m/ draught 12m.

This process is similar to the process of publishing spot freight indices. The Baltic Exchange issues future estimates for dry and wet sea routes. For example, in the dry cargo market, it offers future estimates for Capesize ships on routes C3, C4, C5, C7, C8_03, C9_03 and on average BCI time charter routes (BCIT / C average), for Panamax ships on P1A routes, P2A, P3A and average BPI (BPIT / C average) time charter routes. As regards wet cargos, it offers future estimates on clean petroleum products sea routes TC2_37, TC4, TC5, TC6, TC12, TC14 and on the sea routes of crude oil TD3, TD5, TD7, TD8, TD9, TD17, TD17. The demand for faster transactions, combined with the use of electronic centralized trading systems, has resulted in the gradual abolition of traditional telephone communication between broker and trader, as this process causes delays and entails risks. Besides, the growing trend for out-of-stock clearing contracts, the crucial role of clearing houses as well as the ability offered by both clearing houses, NYMEX and ICE Futures Europe stock exchanges to make any purchase opening using an online account on their platform (screen trading), might affect the role of brokers in shipping derivatives market. (Eba, Ifiok & Leonard, 2018).

2.6 Central counterparties – Clearing houses

Clearing centers are the legal counterparties for both buyers and sellers in a transaction. Actually, they are the central counterparties (CCP), which act as buyers to each seller and as sellers to each buyer. In other words, mediation of Clearing houses eliminates counterparty risk, by ensuring that the transaction is completed even if one of the participants goes bankrupt. In this case, Clearing house takes over the market position of the party that went bankrupt, closing the open positions or transferring them to another member. Hence, none of the members are affected by this bankruptcy. Regarding the closing of open positions, the clearing house uses the initial margin of the party that went bankrupt. In case amount required is more than said initial margin, Central counterparty might use part of guarantee funds that maintains from clearing members for this reason. Clearing houses may enhance liquidity, eliminate the counterparty risk in transactions and increase the number and types of participants in the shipping derivative. They ensure execution of transactions and the daily settlement of open positions. Clearing centers with large volume of transactions in shipping derivatives are LCH Clearnet Group Ltd., NOS Clearing ASA, member of the group Nasdaq OMX Goup Inc., CME Clearport, member of CME Group Inc., ICE Futures Europe, member of Intercontinental Exchange, Inc. and ICE Clear Singapore, regulated by the Monetary Authority of Singapore. Clearing of Forward Freight Agreements, that were traded on a stock exchange, was a measure against counterparty risk. As a result, new contracts, combine the benefits of both futures and forward contracts created, called "hybrid" FFAs. Hybrid FFAs are OTC agreements with the additional benefit of clearing through LCH, eliminating the default risk and supporting their flexibility to the needs of participants (Loader, 2019).

2.7 LCH Clearnet

LCH Clearnet Group Ltd. is a multinational clearing house that offers a wide range of clearing assets for investments, such as bonds, common stock, stock market derivatives, shipping derivatives, currency derivatives, commodity derivatives, Credit Default Swaps (CDS). In the maritime derivatives market, LCH Clearnet offers clearing services for OTC FFAs on popular sea routes for dry and liquid cargos. Additionally, it offers options for dry cargo routes and has gained ground in container market since 2010, offering clearing to OTC Container Freight Swap Agreements (CFSAs) on major container shipping routes. The contracts are cleared through the ECS network program and are entered into this network in the Clear Way online system by authorized brokers or authorized members of the LCH Clearnet, from 07:00 to 18:00 London time. The Clear Way is open until 18:30 London time, for confirmation of transactions by authorized members. Approvals and receipts of successful ECS transactions are verified and must comply with LCH Clearnet regulations. Shipowners, charterers or anyone wishes to use the services of LCH Clearnet can do so through an authorized member or can be registered at this clearing house, meeting the minimum capital requirements depending on the products to be cleared. The authorized members consist of large financial institutions such as Goldman Sachs International, JP Morgan Securities, Barclays Bank plc, Merrill Lynch International, BNP Paribas Commodity Futures Ltd, Citigroup Global Markets Limited, Morgan Stanley & Co International Plc, Deutsche Bank AG, UBS Limited, etc. brokers and commodity houses (Alexandridis, Sahoo, Song & Visvikis, 2018).

2.8 Investment banks

Investment banks, as well as banks with shipping portfolios, are presently participating in the market of shipping derivatives more dynamically and especially in that of derivatives which are traded outside the stock market. Concerning clearing contracts, they show comparative advantages over clearing centers: A bank, acting as a General Clearing Member (GCM), enables, for example, the shipowner to maintain a margin account in it and offers access in any Clearing house he wishes. Otherwise, the shipowner would have to maintain different accounts at each of the clearing centers. Banks may can offer lower margin requirements, as they are well aware of the financial situation of their customers. On the contrary, clearing centers do not differentiate the margin requirements according to each client. Private companies, which are not listed in the stock exchange and wish to remain anonymous in clearing centers, prefer banks operating as GCMs for transactions in shipping derivatives. Banks use shipping derivatives for their own benefit. On the one hand, banks invest in derivatives whose underlying asset are freight indices or sea routes in order to expand their investment portfolios and achieve high returns from freight rate fluctuations. Such an investment does not involve exposure to physical ship - management expenses, such as cost for manning, supply, maintenance, repairs, etc. or any other fix or variable expense. On the other hand, they use derivatives as tools for hedging against risk associated with fluctuations in freight rates. A bank with a shipping portfolio (long position in physical market), in order to cover the risk of falling freight rates, that consequently may reduce the value of its vessels portfolio, participates in derivatives market by taking positions that will reduce this risk. An additional example of banks' participation in this market, is the provision of liquidity to shipowners for ship finance, by their acceptance of FFAs contracts with a freight index as underlying asset, in order to ensure stable cash flow unless a vessel is fixed under time-charter contract. Deutsche Bank AG, taking advantage of the above techniques and its strong connection with shipping community, maintains a significant share of shipping loans. In reference to FFAs, said bank completed on behalf of its customers 115,000 lots, more than any other organization, gaining a share of 15% in this market (Alexandridis et al., 2018).

2.9 Advantages of shipping derivatives

Derivatives are characterized by unique advantages (Dalheim, 2002):
i) They offer opportunities for multiple returns on invested capital (leverage), since only a percentage of the nominal value of the position is bound as protection margin.
ii) They enable the exploitation of all the trends of the stock market (up, down, or static trends). Moreover, they are simple and flexible in use with low transaction costs.
iii) Existing portfolio can be used as protection margin.
iv) Taking or compensating for a position can be closed at any time before the end of the contract, due to the liquidity provided in the market by special traders (Market Makers).
v). They create opportunities for various strategies, tailored - made according to the expectations and investment profile of each client.

In addition to the above benefits, which are exploited by shipowners and charterers, shipping derivatives are also valuable for (Dalheim, 2002):
i) Traders of energy and commodities, as they enable them to trade and offset transportation coast of their products.
ii) Financial institutions, which participate in private transactions market, so as to offer benefits to their clients.
iii) Energy companies / refineries / oil companies, to manage their cash inflows.

Moreover, shipping derivatives can be used as speculation tool. In practice, shipping derivative contracts can be used not only to meet the hedging needs set out above, but purely for investment purposes, i.e., for profit and as it is commonly called, speculation. According to their economic definition, derivative contracts are a means of speculation when they take a position in the unhedged derivative position. In this, after all, the speculative differs from the compensatory function. In that the user does not prepare the transaction to cover the market risk of the resulting liability or credit opening or investment, but to assume such risk for profit. For instance, Investor X, estimating that the prices of freight rates for a specific route of BPI will move upwards for the next five months, buys relevant stock options (call option) with the following terms: Quantity 55,000 tons, exercise price 16.00 $ / ton, and a price of $ 0.30 / ton immediately payable, i.e., a total amount payable of $ 16,000 (55,000 * 0.30). Given that the above transaction of the investor is purely for-profit, i.e., it is not carried out to cover the risk of liability or its opening in relation to the underlying market of the relevant derivative, the market, the investor is exposed by investing in the relevant market risk. This risk in this case is the risk of decreasing freight rates, while the investor maintains a position on them. Thus, if the relevant risk occurs, the investor will record a loss from his transaction. If, on the other hand, his expectation are verified, i.e., the freight rates move upwards, the investor will record a profit from the transaction, which he will be able to collect during the relevant settlement. Suppose that after two months from the day of the investor's transaction, the freight rate in relation to the specific route is reduced to 11.00 $ / ton. Given this reduction, the investor's position on the options is not profitable. For this reason, investor does not exercise the relevant rights, leaving the deadline for exercising them to expire. In this case, the investor has a loss from his investment of $16,000 which corresponds to the above cost of the purchase of the relevant rights (Kilian & Murphy, 2014).

CHAPTER 3: FREIGHT FUTURES

3.1 BIFFEX contracts

The Baltic International Freight Futures Exchange (BIFFEX) contract is the first futures contract in the shipping market. These contracts were traded on the London International Financial Futures and Options Exchange (LIFFE) from 1 May 1985 to April 2001 and were cleared by the LCH. BIFFEX had as its underlying asset the Baltic Freight Index (BFI) and its settlement was made on prices of this index at the end of the contract. The BFI index originally consisted of 13 sea trade routes. Specific weighting percentage was set depending on the importance of each route. On 29 October 1999 this index was replaced by the Baltic Dry Index (BDI). Since the end of 1999, BIFFEX has had the Baltic Panamax Index (BPI) as its underlying asset. In 1988, the trading volume of these contracts approached 100,000 contracts per year, declining in the following years, as the shipping market turned to the use of futures contracts that are traded on the stock exchange. The inability to adapt to stakeholder needs by limiting the effectiveness of reducing or eliminating risks from route changes, as well as their lack of liquidity and low marketability, led to the suspension of trading on the London International Financial Futures and Options Exchange in April 2001 (Sahoo, 2018).

3.2 International Maritime Exchange (IMAREX)

The International Maritime Exchange was founded in 2000 as a joint venture of Mr. Michelet, Frontline Ltd, I.M. Skaugen ASA, RS Platou Shipbrokers AS and NOS ASA. Headquartered in Oslo, Norway, it was an international shipping derivatives exchange, offering futures contracts as a measure of the indices issued by the Baltic Exchange and the brokerage firm Platts. These indicators concerned sea trade routes for dry bulk and liquid cargo. The Norwegian Futures and Options Clearing House (NOS) was in charge of clearing the contracts. In 2008 IMAREXA SA, a name acquired in 2007, acquired Spectron Group Limited. In 2011 the International Maritime Exchange ASA and its shipping business were restructured and incorporated into Spectron Group Limited, which was sold in 2011 to Marex Group Ltd. In 2012, NOS Clearing ASA, which had merged with IMAREX in 2006, was sold to NASDAQ OMX Stockholm AB. The process of restructuring and investing has resulted in the IMAREX ASA group including the futures exchange International Maritime Exchange (Imarex), the Norwegian Futures and Options Clearing House (NOS) and the international commodity exchange Fish Pool. (Goulas & Skiadopoulos, 2012).

3.3 New York Mercantile Exchange (NYMEX)

The New York Mercantile Exchange (NYMEX) started trading in shipping products in May 2005. In 2008 it became a member of the Chicago Mercantile Exchange (CME Group) offering futures contracts in agriculture, energy products, currencies and metals. These contracts are traded in two ways, through the electronic platform CME Globex and with the "open outcry" method. They are cleared through CME ClearPort. NYMEX offers ten freight futures contracts, which have as underlying investment goods indices from the Baltic Exchange and the brokerage firm Platts. These derivatives consist of three crude oil sea routes TD3, TD5, TD7, six oil products sea routes TC2, TC4, TC5, TC6, TC12, TC14 and the Supramax ship chartering arithmetic tool based on the B daily publications. Futures are available for trading on CME Globex and CME ClearPort Sunday through Friday from 6:00 pm New York time (5:00 pm –

4:15 pm Chicago time) with a break 45 minutes daily at 5:15 p.m. New York time (4:15 p.m. Chicago time). Trading with the "open outcry" method is possible Monday through Friday from 9:00 am to 2:30 pm New York time (8:00 am - 1:30 pm Chicago time). Each contract consists of 1,000 tons (mt) for sea routes TD3, TD5, TD7, TC2, TC4, TC5, TC6, TC12, TC14 and their prices are measured in US dollars (US $) per ton with a minimum change of US $ 0 ,0001 per ton. For the average Supramax time charter, the size of each contract is one day charter, the unit of measurement is US Dollars (US $) per day with a minimum change of US $ 1 per charter day. The settlement price (floating price) of each monthly contract is calculated as the arithmetic mean of the freight rates issued by the Baltic Center or the brokerage house Platts for the respective sea voyages during the month. If for any reason the Baltic Center and the brokerage firm Platts do not issue prices for the settlement price, then the guidance of the Forward Freight Agreement Brokers Association (FFABA) may be requested for the determination of the price. The settlement price for Supramax Time Charter Average contracts is calculated as the arithmetic average of the daily prices issued by the Baltic Center, starting from the first working day of the month until the last trading day. The trading day for Supramax Time Charter Average contracts is the last business day in the United Kingdom, except December, where the last day is December 24 or the previous day, if December 24 is a public holiday in the United Kingdom. The expiration of transactions in futures contracts for the aforementioned sea voyages is the last working day of the contract month. Freight futures for the 9 routes are available for trading for 36 consecutive months at CME Clearport and with the "open outcry" method and one month at CME Globex while for Supramax Time Charter Average contracts one month at CME Globex and each month for five consecutive months at CME Clearport and with the "open outcry" method. Finally, the execution and clearing costs of the transactions are differentiated based on the registration or not of the client as a member of the stock exchange and the clearing house, the product and the trading volume and based on the trading method, i.e., if the transactions are made electronically through its platform, CME Globex or with the "open outcry" method (Sclavounos, 2007).

3.4 ICE Futures Europe (IFEU)

ICE Futures Europe (IFEU) has been the International Petroleum Exchange of London (IPE) since 1981 and was acquired by Intercontinental Exchange Group INC in 2001. It is the stock exchange with the largest trading volume in Europe and the second largest in the world in futures contracts, which are invested in energy products and maintain a share of more than 50% worldwide in the market for futures in crude oil and petroleum products. Concerning freight market, it offers futures contracts for maritime liquid cargo routes and the time charter indices issued by the Baltic Exchange for dry cargo ships. The settlement of contracts is undertaken by ICE Clear Europe. More specifically, in the freight market of liquid cargo, it offers four sea routes for crude oil transport and five routes for oil products transport. Each contract consists of 1,000 tons (mt) and their prices are measured in US dollars (US $) per ton (or World scale flat rates) with a minimum change of US $ 0.0001 per ton. Indicators are the future estimates of Platts (Platts Clean Tanker wire) for the Singapore – Japan (TC4) and Arabian Gulf – Japan (TC5) oil transport routes and the Baltic Exchange estimates for the remaining contracts. In reference to dry cargo future contracts, ICE Futures offers future contracts for Capesize, Handysize, Panamax, Supramax time charter contracts. The size of each contract is one day charter and the unit of measurement is US dollars (US $) per day with a minimum change of US $ 1 per charter day.

Futures contracts are available for trading for up to 48 consecutive months and trading hours are 00:50 –23:05 London time with the "pre-open" taking place 10 minutes in advance, excluding Saturday, when it is closed and Sunday where it takes place at 17:50 London time. Execution and clearing costs of transactions vary according to whether client is registered as a member of the stock exchange and clearing house or not, the product and the trading volume (Steffen, 2019).

CHAPTER 4: FORWARD FREIGHT AGREEMENTS

4.1 Definition and properties of FFAs

Forward Freight Agreements are negotiable contracts directly between two parties (principal-to-principal contracts), for the forward, offsetting settlement of freight for a certain quantity of cargo or hire for a specified type of ship, for a sea trade route or a combination of wet and dry cargo routes. They are traded outside the stock market (Over - The - Counter derivatives). They do not involve the physical delivery of cargo or ship, only the transfer of money between the parties to the transaction. The basic terms of an exchange arrangement, such as FFAs, include: the agreed sea route, the settlement date, the number of contracts, the price of the contract at which the profit or loss will be distributed among the participants. Forward Freight Agreements are contracts, whose trading terms are not predetermined, but are tailored to the needs of the participants. The documentation and records of these terms are based on the contracts created and issued by the independent organization Forward Freight Agreement Brokers Association (FFABA), consisting of members of the Baltic Exchange of London. The latest version of the FFABA contracts is the FFABA 2007 contract, which was issued in 2007 and includes elements and references, with suitable amendments, from the ISDA Master Agreement 1992, issued by the International Swap & Derivatives Association (ISDA). The FFABA 2007 contract is a continuation of the FFABA 2005 and FFABA 2000 contracts. These contracts are the standard contracts used in the Forward Freight Agreements industry and are used mainly by shipowners and charterers, while the contracts issued by International Swap & Derivatives Association are selected mainly by banks and trading houses. FFABA 2007 is an ISDA Master Agreement for the first time. English law applies to terms & conditions of said contract. FFABA Confirmations must be signed, but for practical reasons, in some cases they remain unsigned. The existence of FFABA Confirmations with the assistance and support of telephone records, prove the existence of an agreement. All payments are made in US Dollars, with the parties being able to agree later on the payment in a different currency. In cases where one of the parties does not make payments, then in 1992 the ISDA Master Agreement provides mechanisms for dealing with cases of insolvency by giving time for their payment. Once this period is over, the other party to the transaction may consider it bankrupt and demand payment of the amount owed. Then the overdue transactions in Forward Freight Agreements must be terminated and the next step is to compile the total net position (net financial position) (Alizadeh, Kappou, Tsouknidis & Visvikis, 2015).

4.2 Credit risk and the creation of cleared FFAs

The use of FFAs began in 1992, when ship broking company Clarksons innovating and promoting the use of more specialized shipping derivatives from BIFFEX stock exchange contracts. Forward Freight Agreements with underlying asset individual sea routes of the Baltic Freight Index was a more effective tool against risk from freight rates fluctuations, in contrast to BIFFEX contracts where underlying assets was the whole BFI index. The growing trading volume of FFAs against freight futures on the IMAREX and NYMEX stock exchanges, as well as the financial collapse of the market in 2008, made obvious the disadvantage of OTC contracts: the credit risk. This development resulted in a sharp drop in the trading of OTC FFAs and a massive shift to the use of "cleared" or "hybrid" FFAs which were cleared by a clearing house, eliminating the risk of non-fulfillment of these transactions. In 2007 the share of cleared FFAs in number of transactions approached 47%, while in 2008 the percentage rose to 79%. The value of these transactions increased from $ 3,345,291,182 to $ 6,181,045,551 in the corresponding years. The increase continued, with the share of cleared FFAs increasing from 88.68% in 2010 to 95.38% in 2011 and 98.95% in 2012 (Kavussanos & Tsouknidis, 2019).

4.3 Estimation of future prices with the use of FFAs

Forward Freight Agreements offer the ability to estimate future freight prices and reflect the future, expected balance of supply and demand for shipping services by sea. The research of Kavussanos & Alizadeh-M (2001), show that FFAs are unbiased estimators of spot values, with high correlation coefficients between FFAs and spot values on the sea routes under consideration. The high correlation between spot values and FFA forecasts observed on sea voyages of dry and wet cargo vessels referring to voyages and time - charter contracts.

The empirical analysis of Kavussanos et al (2004) and Bessler et al (2008) suggests that the estimation of freight rates is possible for a period of up to three and up to six months respectively. The results of their research indicate that the prices of FFAs are unbiased estimators of future freight rates in the near term and biased for longer periods of time, tending to devalue prices, making the derivatives market attractive to charterers. The reasons for the bias for more than six months are related to the low liquidity in the market of long-term FFAs and the reluctance of participants to pay the rising margin to protect themselves against the risk of future changes over long periods of time. In addition, Forward Freight Agreements can be used as tools for estimating freight rates, as they react faster to new market information than the spot market. The physical market requires higher transaction costs, whilst the use of FFAs allow more efficient risk management, vessel chartering and cargo transportation, as well as successful budgeting for shipowners or charterers. It should be noted that on several sea voyages, these contracts might have an effect on freight rates fluctuations in the physical market. Accordingly, companies keep a close eye on their market, so as to make an estimate about future price fluctuations.

4.4 Spot prices and FFAs

In reference to dry cargo market, time - charter prices for specific Baltic Exchange routes are quoted in USD / per day. Indices are calculated as weighted values of the individual routes that make up each index separately. When we say hire rate e.g., $ 40,000 / per Day, we mean that the shipowner's income will be the aforementioned price for a specific trip on the number of days the ship needs to make a round trip, adjusted for unforeseen events and additional costs. It is worth noting here that this method only applies to the current market (Spot market). It is the immediate delivery market or the cash market. Actually, it is a public financial market where commodities are traded for immediate delivery. On the other hand, in forward market delivery is due later. In a direct delivery market, the settlement usually takes place in T + 2 working days, i.e., the delivery of cash and goods must be made after two working days from the date of transaction. The high correlation between the monthly spot prices and the derivatives' forecasts for the current month is decreasing as the forecast period increases. Estimation of spot prices using derivatives varies significantly from the forecasts of four and five months ago, tending to underestimate freight rates, with the deviation of curves being smaller for one and two months before (Yin, Luo & Fan, 2017).

4.5 Hedging with the use of FFAs

Forward Freight Agreements, similar to all shipping derivatives, are used as financial instruments for physical market participants, such as shipowners and charterers, for hedging, profit and investment purposes, taking advantage of the high volatility in the freight market & opportunities for high returns. A shipowner, in order to protect himself from a possible decrease in freight rates, participates in the forward market by selling a Forward Freight contract for his vessel. The charterer in this transaction will take the opposite position in the contract, with the intention to protect himself from rising freight rates, that might increase the cost of cargo transportation accordingly. The following are examples of hedging risk using FFAs, cleared through the LCH Clearnet based on market data. On May 22, 2013, a Capesize shipowner expects his ship to be "open" in Bolivar, Venezuela in late July. In order to protect itself from a drop in freight rates due to the seasonality observed during the summer months in the dry bulk cargo market, he contacts a broker intending to sell a Forward Freight Agreement for the month of July on the Bolivar – Rotterdam (BCI route C7). A charterer shipping 150,000 tons (mt) of cargo from Bolivar to Rotterdam for July is monitoring future Baltic Exchange estimates, using the FFA curve C7 to forecast freight rates for this month at $ 8.96 / mt. With a current price of $ 8,225 / mt, the charterer will contact a broker to purchase a Forward Freight Agreement for July on the Bolivar – Rotterdam (BCI route C7) to protect himself against a possible freight increase. The forward freight is $ 8.96 / mt, the settlement date is July 31st, and the settlement price will be calculated as the arithmetic mean of sea freight rates for the last 7 business days of July. The broker's commission is 0.25%. On July 31, the settlement price is estimated at $ 10,116 / mt, while freight rates on the C7 route are higher and in line with the charterer's forecast. The following is the calculation of the shipowner and charterer positions, both in the physical market (spot) and in the forward market where they participated: The shipowner with the sale of the Forward Freight Agreement is required to pay the charterer $ 173,400 [= 150,000 mt * ($ 10.116 / mt– $ 8.96 / mt)]. Including broker’s commission of $ 3,360 (= 0.25% * 150,000 mt * $ 8.96 / mt), he is required to pay the total amount of $ 176,760 (= $ 173,400 + $ 3,360). However, he is compensated for said cost by chartering his ship in the spot market at a price of $ 10,116 / mt, a price higher than what he expected under the forward agreement. Revenues from this charter are $ 1,517,400 (= 150,000mt * $ 10,116 / mt). Therefore, he receives a total amount of freight increased by $ 173,400 [= 150,000 mt * ($ 10,116 / mt– $ 8.96 / mt)] from the amount he expected. The shipowner receives $ 1,340,640 from his participation in the contracts [= (150,000mt * $ 10,116) - $ 176,760]. The total cost for his positions is $ 3,360 (= $ 173,400 - $ 176,760). On the other hand, the charterer makes a profit from the purchase of the Forward Freight Agreement equal to $ 170,040 (= $ 173,400 - $ 3,360). The latter will use this flow to offset the losses from the rise in freight rates in the physical market. Charterer will pay $ 1,347,360 [= (150,000mt * $ 10,116 / mt) - $ 170,040]. If he did not participate in the forward market, he would pay the amount of $ 1,517,400 (= 150,000mt * $ 10,116 / mt). The two parties, agreeing to buy the forward contract at $ 8.96 / mt, so as to lock this level of freight, regardless of any fluctuations in the physical freight market, stabilizing their revenues or costs (Syriopoulos, Mermigas & Tsatsaronis, 2017).

CHAPTER 5: FREIGHT OPTIONS

5.1 Features and evolution

Freight options are the third type of financial derivatives that apply in the field of shipping. Their use provides more flexibility than FFAs and freight futures contracts, where the exercise is mandatory regardless of the direction of the freight market. Freight options allow for higher returns in case change in freight market trend is favorable for the user. In case freight market trend is reverse from the one received by the buyer of the option, the damage to be suffered is limited to the option price he is obliged to pay. European-style freight options trading began in 1991 on the London International Financial Futures and Options Exchange, with BIFFEX contracts as the underlying asset, but without gaining significant interest. In April 2002 LIFFE terminated their trading. One year earlier, in November 2001, Enron and Bocimar traded their first OTC option. It was in the form of "OTC zero-cost collar freight option" traded on the average of four time - charter contracts of the Baltic Capesize Index (BPI), with a maturity period of five years. On June 1, 2005, IMAREX introduced the first cleared tanker IFO option, with the TD3 (Middle East – China) oil sea route as underlying asset while was cleared by NOS clearing center. Then, in April 2006, the first IFO in the cleared dry-bulk IFO market was introduced with a "basket" of four time-charter routes for Panamax vessels (PM4TC) as underlying asset and NOS as clearing house. IFOs were Asian-style rights. Today, options are traded both inside and outside the stock market. The New York Mercantile Exchange offers European-style exchange-traded freight options for the same sea voyages as underlying assets for offered futures contracts. ICE Futures Europe offers FFA options on three TD3, TD5, TD7 and four T4 oil transportation routes TC5, TC6, TC14. In the over-the-counter market, individual sea routes, dry cargo time - charter "baskets" and Forward Freight Agreements are used as underlying assets for the options. The majority of future options are cleared. Options clearing services are offered by LCH Clearnet, NOS Clearing, CME Clearport, ICE Clear Europe and Asian Clear. (Geman & Smith, 2012).

5.2 The use of freight options

The use of freight options offers following opportunities:

(a) Hedging opportunities to various market participants against freight rates fluctuations.

(b) Investment purposes, with potential users exercising these options without exposure to the underlying asset. There are two strategies for investment purposes:

i. First one concerns "spread strategies", including options of the same type with different strike prices or expiration dates. The most important strategies are Bull and Bear Spreads, Butterfly Spreads, Calendar (or Time) Spreads, Diagonal Spreads. In the case of Bull and Bear Spreads strategies the investor's portfolio includes two or more call or put options with different settlement prices and the same expiration date, Butterfly Spreads include three call or put options with three different prices and the same expiration date. Calendar (or Time) Spreads include call or put options with the same exercise price and different expiration dates. Finally, Diagonal Spreads include options with different exercise prices and different expiration dates.

ii. Second one concerns "combination strategies", where, such a portfolio includes options of different types, with the same or different exercise prices and the same or different expiration dates. The most important strategies are Bottom Straddles, Top Straddles, Bottom Strips, Top Strips, Bottom Straps, Top Straps, Bottom Strangles, Top Strangles. In Bottom Straddles strategy, a call and put option is traded simultaneously with the same trading date and the same exercise price and Top Straddles deals with the simultaneous sale of the aforementioned options. Bottom Strips strategies concern the simultaneous purchase of one call option and two put options with the same exercise date and price and Top Strips include the simultaneous sale of these options. Bottom Straps strategies include the simultaneous purchase of two call and one put option with the same exercise price and expiration date, while Top Straps include their simultaneous sale. Then, Bottom Strangles strategies involve the simultaneous purchase of one call & one put option with the same expiration date but at different strike prices, whereas Top Straddles concerns the sale of said options.

(c) Arbitrage purposes, where the most common strategies are conversions, reversals, boxes. Conversions take place with the purchase of a Forward Freight Agreement, the simultaneous purchase of a put option and the sale of a call option (synthetic FFA), which have as underlying asset the purchased FFA.
"Arbitrage" is achieved when the sale price of the Forward Freight Agreement is higher than its purchase price. The opposite (sell FFA, buy call option and sell put option) takes place in the case of reversals strategies where profit is gained by the reversal of trends in the market. The desired result is achieved when the purchase price of the Forward Freight Agreement is lower than its sale price. Finally, boxes strategies include the simultaneous purchase of a call option and the sale of a put option (synthetic long FFA position) as well as the sale of a call option and the purchase of a put option (synthetic short FFA position) (Nomikos, Kyriakou, Papapostolou & Pouliasis, 2013).

5.3 Hedging with freight options

A shipowner can protect himself against freight rate fluctuations by purchasing a put option with an underlying asset a sea route issued by the Baltic Exchange or the brokerage firm Platts. In case of rise in freight market, with the current price (spot price) being higher than the exercise price (strike price), the shipowner does not exercise the option. The shipowner makes a profit in the spot market and his loss is limited to the purchase price of the financial product. In contrary to the above, in case of decrease in freight rates, with the spot price being lower than the exercise price, shipowner exercises the option, with the profits from the purchase of the option being added to the shipowner's income from the vessel charter in the physical market. A charterer can be protected against changes in freight rates by purchasing a call option. In case of rise of the freight market, with the current price (spot price) being higher than the exercise price (strike price), the right is exercised. The profits that the charterer will make from the purchase of this derivative, will reduce the losses from the rise in rates in the physical market. Otherwise, in case of fall in freight rates, with the current price being lower than the exercise price, the right is not exercised. In continuation of the example described in subsection 4.5, assuming that the Capesize shipowner, in order to protect himself from a possible drop in freight rates, contacts his broker to purchase a put option at $ 8.96 / mt. Suppose the spot price on July 31 is $ 10,116 / mt and the cost of the option is $ 0.50 / mt. The following are the results of positions taken in the spot market and in the options market: In the spot market, the shipowner receives revenue equal to $ 1,517,400 (= 150,000mt * $ 10,116 / mt). This amount is $ 283,500 [= $ 1,517,400 - (150,000mt * $ 8,225 / mt)] higher than the revenue would have received on May 22nd. Owner does not exercise the option and the relevant loss is limited to the purchase price of the derivative $ 75,000 (= $ 0.50 / mt * 150,000mt), including the broker's commission ($ 3,360). His total loss is $ 78,360 (= $ 75,000 + $ 3,360). Total revenue from both markets is $ 1,439,040 (= $ 1,517,000 - $ 78,360). The charterer from this previous example communicates with the broker to purchase a call option at $ 8.96 / mt in order to protect himself from a potential freight increase. With the price reaching $ 10,116 / mt on July 31st, the results of the positions received are as follows: In the spot market he pays $ 1,517,400 (= 150,000mt * $ 10,116 / mt) to transport the cargo. This price is $ 243,650 [$ 1,517,400 - (150,000mt * $ 8,225 / mt)] higher than the price on May 22nd. The call option will be exercised with the charterer receiving a profit of $ 95,040 [= (($ 10,116 / mt– $ 8.96 / mt) * 150,000 mt) - $ 75,000 - $ 3,360]. The total cost is $ 1,422,360, down $ 95,040 from $ 1,517,400, which he would have paid if he had not participated in the options market (Sahoo, 2014).

CHAPTER 6: EMPRIRICAL RESULTS

The major goal of current chapter is to analyse the relationship between the following variables:

- Spot prices of freight market (panamax vessels)
- FFAs prices (panamax vessels – contracts with 1-month maturity)

It will be conducted a brief study of the following hypothesis: **FFAs prices (specific market and maturity) can be used as unbiased estimators of spot prices in short term period.**
Taking into consideration the above mentioned hypothesis, this study will be conducted by using several tools of econometrics and data series analysis. Moreover, the methodology used regarding the analysis of dataseries is based on a published survey, in which a similar hypothesis has already been analysed (Kavussanos, et al., 2004). Furthermore, data analysis has been conducted with the usage of econometric Software EVIEWS.

6.1 Data Presentation

Basic information regarding data used on current study are briefly presented in the following tables:

Table 1:Variable of Spot Prices

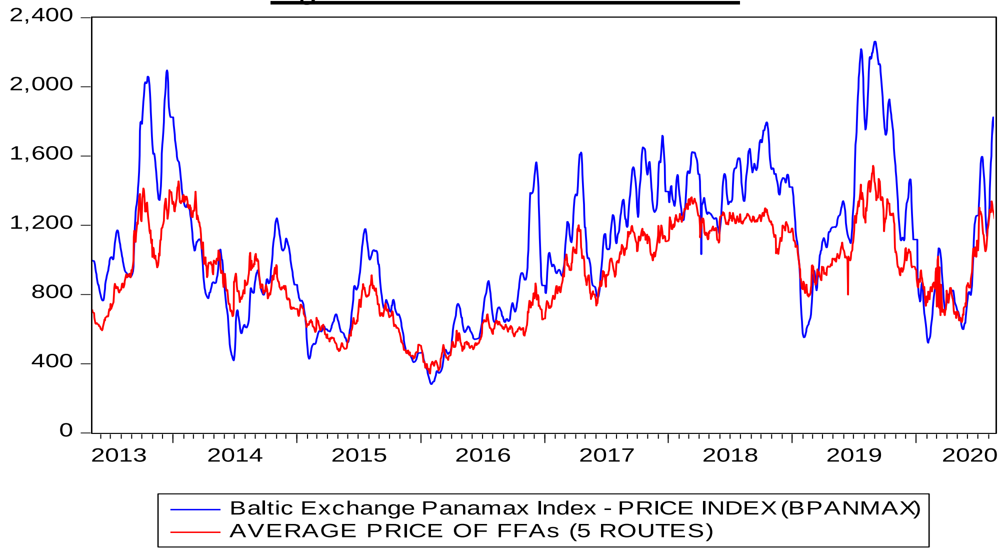
Description	Prices of Baltic Exchange Panamax Index (Average of 4 Time Charter routes in USD per day)
Range	7/5/2013 – 21/8/2020
Frequency	Daily Prices (Week of 5 working days)
Number of Observations	1904
Data Source	Datastream

Table 2: Variable of FFAs prices

Description	FFAs prices are composed by the average price of Baltic Panamax Time Charter FFA monthly futures of 5 different routes.
Maturity of Contract	1 month
Range	7/5/2013 – 21/8/2020
Frequency	Daily Prices (Week of 5 working days)
Number of Observations	1904
Data Source	Datastream

The following figure depicts the behaviour of two variables during the time-period related with current study (Figure 1). Moreover, a brief presentation of descriptive statistics regarding our variables is included in Annex Tables 1 & 2.

Figure 1: Data Series Presentation



Taking into account the above-mentioned information, it is obvious that there is a similar fluctuation of two variables during the reference period. However, the level of fluctuation of FFAs prices is much lower than the fluctuation of Spot prices (Std. Deviation FFAs prices: 272.85 – Std. Deviation Spot prices: 422.07).

6.2 Study of Initial Hypothesis (Simple Linear Regression – Ordinary Least Squares)

A common econometric technique so as to evaluate a possible relationship between two different variables is the application of simple linear regression with the method of Ordinary Least Squares (OLS).
A simple linear regression model, which can be applied so as to evaluate the initial hypothesis, can be expressed by the following equation:

$$S_t = \alpha + \beta * F_{t,t-n} + \varepsilon_t$$

Where:

- St: Spot price on t (BPI _ Panamax Vessels)
- α: Constant coefficient of the equation
- Ft, t-n: FFAs price on t-n (FFAs with 1-month maturity)
- β: Coefficient of independent variable
- Et: Residuals of regression (Real prices – Estimated prices of dependent variable of the model)

The main target of OLS method is to minimize the sum of squared prices of residuals. This method is expressed by the following equation:

$$\min SS = \sum_{i=1}^{n} \hat{\varepsilon}_i^2$$

If the coefficient of independent variable (β) is statistically significant, there is an evidence that the FFAs prices (with specific maturity date) may be used as unbiased estimators of spot prices respectively.

The results of OLS method are presented in the following table:

Table 3: Estimation of Simple Linear Regression Model (OLS method)

Dependent Variable: SPOT				
Method: Least Squares				
Date: 09/02/20 Time: 13:09				
Sample: 5/07/2013 8/21/2020				
Included observations: 1904				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-174.1261	15.67549	-11.10818	0.0000
FFA	1.371210	0.016419	83.51276	0.0000
R-squared	0.785723	Mean dependent var		1080.404
Adjusted R-squared	0.785611	S.D. dependent var		422.0793
S.E. of regression	195.4319	Akaike info criterion		13.38935
Sum squared resid	72644277	Schwarz criterion		13.39518
Log likelihood	-12744.66	Hannan-Quinn criter.		13.39150
F-statistic	6974.380	Durbin-Watson stat		0.047562
Prob(F-statistic)	0.000000			

Taking into account the above-mentioned results, the estimated equation of simple linear regression model has the following form:

SPOT = -174.126142118 + 1.37120952785*FFA

In other words, it is estimated that if the price of FFAs has an increase/decrease of **1 USD**, spot price will be increased/decreased approximately by **1.371** USD.
Moreover, it can be observed that the price R-squared coefficient (coefficient of determination) is in a satisfactory level (approximately 0.78 or 78%). This coefficient indicates that approximately 78% of total fluctuation of dependent variable (Spot Price) can be estimated by independent variable (FFAs price).

Furthermore, the coefficients of Spot and FFAs prices are **statistically significant** (separate test of statistical significance) because of zero prob.
However, it must be mentioned that if time-series which are related with two variables (spot and FFAs prices) are not stationary, the estimated coefficients of regression are inconsistent and they cannot be used for the evaluation of initial hypothesis (Kavussanos, et al., 2004, p. 244).

The simplest method applied so as to recognize if time series are stationary or not, is the observation of correlograms. A correlogram represents the progress of autocorrelation function. If the prices of autocorrelation function remain stable at a statistically significant level with a simultaneous increase of lags, there is a strong evidence that time series are **non-stationary.** On the other hand, if the prices of autocorrelation function decrease with an accelerated rate and approach zero with a simultaneous increase of lags, there is a strong evidence that time series are **stationary**. (Dimeli, 2003, p. 39)

The figures 2 & 3 in Annex describe the progress of autocorrelation function for the time series of spot and FFAs prices.
It can be observed that there is **a strong evidence of non-stationary time series because autocorrelation remain at a statistically significant level given that the number of lags increases**.

Besides correlograms, Augmented Dickey – Fuller (ADF) test can be applied in order to examine if time series have a unit root (property of non-stationary time series). Null and alternative hypothesis can be expressed as follows:

H_o: Time Series has a Unit Root (Non-Stationary Time Series)
H_1: Time Series has no Unit Root (Stationary Time Series)

H_o cannot be rejected if test's probability is **greater than** the selected level of significance (1%, 5% or 10%). On the other hand, **H_o can be rejected** if test's probability is **less than** the selected level of significance. It is needless to say that a level of significance at 1% is linked with a confidence interval of 99%.
The results of Augmented Dickey Fuller Test for the time series of spot and FFAs prices are presented in the Annex tables 4 & 5.

Taking into consideration the above-mentioned results, it's observed that in both cases, the Augmented Dickey – Fuller Test has similar results. Null hypothesis cannot be rejected because test's probability is greater than significance levels (1%, 5% or 10%). So, the time-series have a unit root and are **non-stationary.**
By ending this segment, it is crucial to examine if the proposed simple linear regression model is consistent related with specific theoretical properties. These properties are related with the residuals (E_t) of the regression. More specifically (Agiakloglou & Benos, 2007, pp. 27-28):

i. Variance of residuals must be stable for all the prices of residuals (homoscedasticity):

$$\mathrm{Var}(E_i) = E(E_i^2) = \sigma^2$$

ii. There is no dependence between each and every price of residuals (i, j):

$$E(E_i * E_j) = 0$$

If the above -mentioned properties are violated, the proposed regression model cannot be used so as to estimate the behavior of dependent variable (Spot prices).
The violation of the first property is related with the problem of **heteroscedasticity** and the violation of the second property is related with the problem of **autocorrelation**. Two (2) different statistical tests are conducted in order to check the proposed linear regression model.

Heteroscedasticity Test

The existence of heteroscedasticity can be checked with the application of **White test**. This test is based on the following multiple regression model:

$$\hat{\varepsilon}_i^2 = a_o + a_1 * FFA_t + a_2 * FFA_t^2 + u_t$$

The dependent variable of the above multiple regression model is the residuals of initial regression and the independent variable is the FFAs prices (similarly with the initial model). White test examines the following alternative hypotheses:

$$H_0 : a_1 = a_2 = 0\_(Homoscedasticity)$$

$$H_1 : At\_least\_a_1\_or\_a_2 \neq 0\_(Heteroscedasticity)$$

The results of White Test are presented in the Annex Table 6.

According to the aforementioned results, it is obvious **that null hypothesis** of White Test **is rejected** because test's probability is zero and less than 1%, 5% or 10% levels of significance. As a result, the property of homoscedasticity is violated regarding the initial regression model.

Autocorrelation test

A statistical test, which is applicable, so as to detect the problem of autocorrelation in a simple linear regression model is Durbin – Watson Test. This test is based on the following equations (Agiakloglou & Benos, 2007, pp. 413-415):

$$S_t = \alpha + \beta * F_{t,t-n} + \varepsilon_t \quad (1)$$

$$\varepsilon_t = \rho * \varepsilon_{t-1} + u_t \; \varepsilon_t = \rho * \varepsilon_{t-1} + u_t \quad (2)$$

$$d = \frac{\sum_{t=2}^{n} (\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum_{t=1}^{n} \hat{\varepsilon}_t^{\,2}} \; \square \; 2*(1-\hat{\rho}) \quad (3)$$

$$0 \leq d \leq 4 \quad (4)$$

The price of d (Durbin – Watson Test) is an evidence regarding the presence of autocorrelation. If the price of d is between the prices (0 – 2), there is a positive autocorrelation among the residuals. If the price of d is approximately 2, there is a strong evidence that there is no autocorrelation. Furthermore, if the price of d is in the arithmetic interval (2 – 4), there is a negative autocorrelation among the residuals.
The result of Durbin-Watson test is presented with the other results of simple regression model (Table 3 – Durbin – Watson Stat: 0.0476). It is needless to say that there is **positive autoregression among the prices of residuals**.

6.3 Study of initial hypothesis (Vector Autoregression (VAR) – Granger Causality)

As it was ascertained in the previous section, the results of simple linear regression (OLS Method) could not be used so as to study our initial hypothesis due to violation of basic properties related with residuals of regression and the fact that that time-series are non-stationary.
In many cases, it has been observed that high level of correlation between two economic variables is not necessarily related with a causality relationship. In other words, a high price of coefficient of independent variable of a simple linear regression (FFAs prices)

is not a strong evidence that independent variable causes the fluctuation of dependent variable (Spot Prices) respectively.
Granger (1969) has developed a statistical test so as to evaluate causality among economic variables (Dimeli, 2003, pp. 205-206). Let's suppose that it must be conducted a survey so as to examine the relationship between two economic variables (X_t and Y_t). According to Granger, X_t causes Y_t if the latest and previous observations of X_t give us the ability to make forecasts of Y_t.
According to the above-mentioned definition X_t causes Y_t if the forecast of Y_t for one time-period (based on previous observations of Y_t and X_t) has lower Mean Squared Errors (MSE) price than prediction of Y_t (based on previous observations of Y_t). A mathematical approach of the above description can be expressed as follows

$$MSE(\bar{Y}/\bar{U}) \prec MSE(\bar{Y}/\bar{U}-\bar{X})$$

$$where$$

$$\bar{Y}: Forecast\_of\_Y_t$$

$$\bar{U}: \mathrm{Pr}evious\_Information\_based\_on\_observations\_of\_Y_t, X_t$$

$$\bar{X}: \mathrm{Pr}evious\_Information\_based\_on\_observations\_of\_X_t$$

Before conducting the above -mentioned statistical test, it is crucial to mention that this test is based on Vector Autoregression (VAR) model. VAR model is a system of equations, where all variables are endogenous. The price of each and every variable can be estimated by the previous prices of other endogenous variables included in the system. An application of VAR model can be implemented in the following theoretical example with 2 endogenous variables and 2 lags for each variable (X_t and M_t):

$$X_t = a_{10} + a_{11} * X_{t-1} + a_{12} * X_{t-2} + \beta_{11} * \mathrm{M}_{t-1} + \beta_{12} * \mathrm{M}_{t-2} + e_{t1}$$

$$M_t = a_{20} + a_{21} * X_{t-1} + a_{22} * X_{t-2} + \beta_{21} * \mathrm{M}_{t-1} + \beta_{22} * \mathrm{M}_{t-2} + e_{t2}$$

The above-mentioned system of 2 equations can be described with the usage of matrices as follows:

$$\begin{pmatrix} X_t \\ M_t \end{pmatrix} = \begin{pmatrix} a_{10} \\ a_{20} \end{pmatrix} + \begin{pmatrix} a_{11} & \beta_{11} \\ \alpha_{21} & \beta_{21} \end{pmatrix} * \begin{pmatrix} X_{t-1} \\ M_{t-1} \end{pmatrix} + \begin{pmatrix} a_{12} & \beta_{12} \\ \alpha_{22} & \beta_{22} \end{pmatrix} * \begin{pmatrix} X_{t-2} \\ M_{t-2} \end{pmatrix} + \begin{pmatrix} e_{t1} \\ e_{t2} \end{pmatrix}$$

So, the VAR model in vector form can be described by the following equation:

$$Y_t = \delta + A_1 * Y_{t-1} + A_2 * Y_{t-2} + e_t$$

where

$$\delta : \begin{pmatrix} a_{10} \\ a_{20} \end{pmatrix}, A_1 : \begin{pmatrix} a_{11} & \beta_{11} \\ \alpha_{21} & \beta_{21} \end{pmatrix}, Y_{t-1} : \begin{pmatrix} X_{t-1} \\ M_{t-1} \end{pmatrix}, A_2 : \begin{pmatrix} a_{12} & \beta_{12} \\ \alpha_{22} & \beta_{22} \end{pmatrix}$$

$$Y_{t-2} : \begin{pmatrix} X_{t-2} \\ M_{t-2} \end{pmatrix}, e_t : \begin{pmatrix} e_{t1} \\ e_{t2} \end{pmatrix}$$

Taking into consideration the theoretical framework of VAR models and Granger causality test, the initial hypothesis can be examined with Granger Causality Test. In other words, it can be conducted a statistical test so as to examine the following hypothesis: FFAs prices may cause Spot prices and Spot Prices may cause FFAs prices respectively. Granger Causality Test is applicable to this occasion.

Presentation of VAR model

In this case, a VAR model can be described by the following equations:

$$Spot_t = a_{10} + a_{11} * Spot_{t-1} + a_{12} * Spot_{t-2} + \beta_{11} * FFA_{t-1} + \beta_{12} * FFA_{t-2} + e_{t1}$$

$$FFA_t = a_{20} + a_{21} * FFA_{t-1} + a_{22} * FFA_{t-2} + \beta_{21} * Spot_{t-1} + \beta_{22} * Spot_{t-2} + e_{t2}$$

Presentation of Null and Alternative Hypothesis

Taking into account the equations of VAR model, null and alternative hypothesis can be expressed as follows:

- **FFAs prices cause Spot Prices**

$$H_o : \beta_{11} = \beta_{12} = 0$$
$$H_1 : \beta_{11} \neq 0 \_ or \_ \beta_{12} \neq 0$$

- **Spot prices cause FFAs Prices**

$$H_o : \beta_{21} = \beta_{22} = 0$$
$$H_1 : \beta_{21} \neq 0 \_ or \_ \beta_{22} \neq 0$$

Results of Pairwise Granger Causality Test

The results of Granger Causality Test are presented in Annex Table 7.
Taking into account the above results, **it is a strong evidence that FFAs prices cause Spot Prices because null hypothesis can be rejected on significance level 1% (probability of test approximately 0)**. On the other hand, Spot Prices don't cause FFAs prices because null hypothesis cannot be rejected on significance level 1% (probability of test is greater than 1%).

6.4 Study of initial hypothesis (Vector Error Correction Model – Johansen Cointegration Test).

According to Granger Causality Test, there is a strong evidence that FFAs prices cause Spot Prices. However, the previous statistical test does not take into consideration the fact that time-series are non-stationary. **That's why, Granger (1981) developed the meaning of cointegration**. The definition of cointegration was described as follows: Let's suppose that a study must be conducted so as to examine the relationship between two non-stationary I(1)[6] variables (X_t, Y_t). If the linear combination of those variables is a stationary variable I(0), they can be characterized as cointegrated variables CI (1, 1). Furthermore, the meaning of cointegration is related with long-term equilibrium level of compared variables. A practical example of cointegrated variables is related with the relationship of Consumption (C) and Disposable Income (Y). The relationship between two variables is described by the following equations:

$$C_t = a + \beta * Y_t + u_t$$
$$u_t = C_t - a - \beta * Y_t$$

Taking into consideration the economic theory, disposable income is equal with consumption (C) and Savings (S). IF consumption and disposable income are cointegrated non-stationary variables, residuals can be characterized as a stationary variable with expected value approximately zero. If the variables were not cointegrated, there will be a crucial problem in long – term period regarding the equilibrium between consumption and savings. (Dimeli, 2003, pp. 211-212).
The existence of cointegration between Spot Prices and FFAs prices will be tested with the usage of **Johansen methodology** (Dimeli, 2003, pp. 224-225).
First of all, it is crucial to examine if two variables, which are non-stationary, can be converted to stationary by calculating first differences. So, it will be conducted the Augmented Dickey-Fuller Test for the first differences of Spot and FFAs prices (DSpot and DFFA respectively. Augmented Dickey-Fuller Test will examine the following alternative hypotheses:

H_o: Time Series has a Unit Root (Non-Stationary Time Series)
H_1: Time Series has no Unit Root (Stationary Time Series)

[6] Two non-stationary variables which can be converted to stationary variables with the calculation of first differences. Generally, I(d) are two non-stationary variables which can be converted to stationary variables with the calculation of d differences.

The results of Augmented Dickey-Fuller Test are presented inAnnex Tables 8 & 9.

It is obvious that the null hypothesis can be rejected for both variables. So, Spot and FFAs prices are non-stationary I(1) variables.
In order to estimate the level of cointegration between the examined variables, it will be applied an alternative form of VAR model, which is called Vector Error Model (VECM). Besides the endogenous variables, a VECM incorporates possible relationships of cointegration between the examined variables.
A general form of VECM is described by the following equations:

$$\Delta \mathrm{Y}_t = \Pi \mathrm{Y}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathrm{Y}_{t-1} + BX_t + \varepsilon_t$$

$$where$$

$$\Pi = \sum_{i=1}^{p} \mathrm{A}_i - \mathrm{I}, \Gamma_i = -\sum_{j=i+1}^{p} A_j$$

$$p : endogenous\_\mathrm{var}iables$$

$$\Pi : Matrix\_of\_parameters, which\_multiply\_Y_{t-1}$$

$$X_t : Vector\_of\_\mathrm{var}iables\_related\_with\_trend\_seasonality$$

The rank[7] of matrix Π is related with the existence of cointegration. The rank of matrix Π may have the following prices:

- r(Π)=0 (All the elements of Π are zero, so the VEC model is converted to VAR Model. As a result, there is no cointegration among variables)
- r(Π)=p (All the variables included in the vector of Y_t are stationary variables, so there is no reason to estimate VEC model. VAR model is appropriate in this occasion)
- r(Π)<p (All the columns of Matrix Π are not linear independent. So, there is a cointegration relationship among variables).

VECM based on the examined variables has the following form:

$$\Delta \mathrm{Y}_t = \Pi \mathrm{Y}_{t-1} + \Gamma_1 * \Delta \mathrm{Y}_{t-1} + BX_t + \varepsilon_t$$

$$where$$

$$\Pi = A_1 + A_2 - I, \Gamma_1 = -A_2$$

The detailed results of VECM are presented in Annex Table 10.

Taking into account the above-mentioned results, it can be observed that the R-squared coefficient of VECM's equation where DSPOT is independent variable has a satisfactory level (approximately 60%). In other words, DSPOT prices could be estimated by 2-time lags of DSPOT prices and 2-time lags of DFFA prices. On the other hand, DFFAs prices could not be estimated by 2- time lags of DFFA prices and 2 -time lags of DSPOT prices due to the minimum price of R-squared (approximately 3%). Furthermore, the prices of Akaike and Schwarz criteria in the first equation (DSPOT independent variable) are **less than** the second equation (DFFA independent variable).

[7] Rank of a matrix is equal with number of linear independent row or columns

By ending Johansen methodology, it is crucial to estimate the cointegration grade of two variables. The cointegration grade is evaluated by applying the following tests (Dimeli, 2003, pp. 230-231):

- Trace test:

H_o: There are h vectors of cointegration in VECM (where h=0,1,2,...,p-1)
H_1: h=p (The variables are stationary)
Where:
p: number of endogenous variables on VECM

- λ-max test:

H_o: There are h vectors of cointegration in VECM (where h=0,1,2,...,p-1)
H_1: There are h+1 vectors of cointegration in VECM
The results of the above tests are presented in Annex Table 11.

It can be observed that both tests reject null hypothesis for h=0 (p-value:0) and accept null hypothesis for h=1 (p-value:0.0366 greater than 1% level of significance). Thus, it is obvious that SPOT and FFAs variables are cointegrated CI (1,1).

Conclusions

By ending the current chapter, it is crucial to sum up the major conclusions of the above analysis:

- In many cases, a simple linear regression model cannot be used so as to estimate the relationship between two variables (non-stationary variables, various problems regarding the violation of basic properties of a simple linear regression model).
- According to Granger Causality Test there is a strong evidence that FFAs prices (Panamax vessels, 1-month maturity) cause the Spot Prices (BPI Index).
- The meaning of cointegration is crucial in order to investigate the relationship of two economic variables, which are non-stationary.
- FFAs and Spot prices are cointegrated C (1,1). In other words, there is a long-term equilibrium level of compared variables. Moreover, there is a linear combination of those variables, which is a stationary variable.
- According to the results of VECM, FFAs prices contribute to the estimation of Spot Prices. The opposite relationship cannot be ascertained. So, the initial hypothesis is ascertained based on above mentioned results. However, the initial hypothesis is related with the specific market of Vessels (Panamax) and specific maturity of FFAs contracts (1-month).

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ANNEX (EXPORTED REPORTS BY EVIEWS)

Table 1: Descriptive Statistics (Spot Prices)

Date: 08/26/20 Time: 15:15	
Sample: 5/07/2013 8/21/2020	
	SPOT
Mean	1080.404
Median	1052.000
Maximum	2262.000
Minimum	282.0000
Std. Dev.	422.0793
Skewness	0.433777
Kurtosis	2.595761
Jarque-Bera	72.67400
Probability	0.000000
Sum	2057090.
Sum Sq. Dev.	3.39E+08
Observations	1904

Table 2: Descriptive Statistics (FFAs Prices)

Date: 08/26/20 Time: 15:21	
Sample: 5/07/2013 8/21/2020	
	FFA
Mean	914.9080
Median	911.0000
Maximum	1544.940
Minimum	341.8000
Std. Dev.	272.8507
Skewness	-0.018681
Kurtosis	1.970598
Jarque-Bera	84.17781
Probability	0.000000

Sum	1741985.
Sum Sq. Dev.	1.42E+08
Observations	1904

Figure 2: Correlogram of Spot Prices (Lags: 25)

Date: 08/26/20 Time: 16:21
Sample: 5/07/2013 8/21/2020
Included observations: 1904

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.997	0.997	1896.4	0.000
		2	0.991	-0.593	3770.9	0.000
		3	0.982	-0.245	5613.0	0.000
		4	0.971	-0.019	7415.4	0.000
		5	0.959	0.039	9173.0	0.000
		6	0.946	0.033	10883.	0.000
		7	0.932	0.045	12544.	0.000
		8	0.918	0.046	14158.	0.000
		9	0.904	0.017	15724.	0.000
		10	0.891	-0.013	17245.	0.000
		11	0.878	-0.026	18722.	0.000
		12	0.865	0.010	20157.	0.000
		13	0.853	0.021	21552.	0.000
		14	0.841	0.026	22909.	0.000
		15	0.829	0.018	24230.	0.000
		16	0.818	-0.008	25517.	0.000
		17	0.808	-0.013	26771.	0.000
		18	0.797	-0.003	27994.	0.000
		19	0.787	0.003	29187.	0.000
		20	0.777	-0.015	30351.	0.000
		21	0.768	0.012	31487.	0.000
		22	0.758	0.018	32595.	0.000
		23	0.749	0.007	33677.	0.000
		24	0.740	0.010	34734.	0.000
		25	0.731	0.013	35766.	0.000

Figure 3: Correlogram of FFAs Prices (Lags: 25)

Date: 08/26/20 Time: 16:31
Sample: 5/07/2013 8/21/2020
Included observations: 1904

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.994	0.994	1884.7	0.000
		2	0.987	-0.069	3745.2	0.000
		3	0.982	0.127	5587.4	0.000
		4	0.977	-0.073	7408.8	0.000
		5	0.970	-0.051	9206.6	0.000
		6	0.963	-0.006	10981.	0.000
		7	0.957	0.033	12734.	0.000
		8	0.951	-0.048	14465.	0.000
		9	0.944	0.008	16172.	0.000
		10	0.938	0.023	17857.	0.000
		11	0.932	-0.016	19521.	0.000
		12	0.925	-0.023	21163.	0.000
		13	0.918	-0.043	22780.	0.000
		14	0.911	0.014	24374.	0.000
		15	0.905	0.032	25946.	0.000
		16	0.898	0.004	27498.	0.000
		17	0.892	0.014	29028.	0.000
		18	0.886	-0.028	30538.	0.000
		19	0.880	0.019	32027.	0.000
		20	0.873	-0.009	33496.	0.000
		21	0.867	-0.011	34945.	0.000
		22	0.861	-0.000	36374.	0.000
		23	0.855	0.026	37784.	0.000
		24	0.849	-0.028	39174.	0.000
		25	0.842	-0.008	40544.	0.000

Table 4: Augmented Dickey – Fuller Test (FFAs Prices)

Null Hypothesis: FFA has a unit root				
Exogenous: None				
Lag Length: 3 (Automatic - based on SIC, maxlag=25)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-0.157073	0.6294
Test critical values:	1% level		-2.566180	
	5% level		-1.940990	
	10% level		-1.616587	
*MacKinnon (1996) one-sided p-values.				

Table 5: Augmented Dickey – Fuller Test (Spot Prices)

Null Hypothesis: SPOT has a unit root				
Exogenous: None				
Lag Length: 4 (Automatic - based on SIC, maxlag=25)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.190415	0.2144
Test critical values:	1% level		-2.566180	
	5% level		-1.940990	
	10% level		-1.616587	
*MacKinnon (1996) one-sided p-values.				

Table 6: White Test (Heteroscedasticity)

Heteroskedasticity Test: White			
F-statistic	65.71471	Prob. F(2,1901)	0.0000
Obs*R-squared	123.1244	Prob. Chi-Square(2)	0.0000
Scaled explained SS	156.0777	Prob. Chi-Square(2)	0.0000

Table 7: Granger Causality Test

Pairwise Granger Causality Tests			
Date: 09/06/20 Time: 17:33			
Sample: 5/07/2013 8/21/2020			
Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
FFA does not Granger Cause SPOT	1902	90.0191	4.E-38
SPOT does not Granger Cause FFA		0.51344	0.5985

Table 8: Augmented Dickey-Fuller Test (DFFA)

Null Hypothesis: D(FFA) has a unit root				
Exogenous: Constant				
Lag Length: 2 (Automatic - based on SIC, maxlag=25)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-24.86871	0.0000
Test critical values:	1% level		-3.433591	
	5% level		-2.862858	
	10% level		-2.567518	
*MacKinnon (1996) one-sided p-values.				

Table 9: Augmented Dickey-Fuller Test (DSPOT)

Null Hypothesis: D(SPOT) has a unit root				
Exogenous: Constant				
Lag Length: 3 (Automatic - based on SIC, maxlag=25)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-14.26360	0.0000
Test critical values:	1% level		-3.433593	
	5% level		-2.862859	
	10% level		-2.567519	
*MacKinnon (1996) one-sided p-values.				

Table 10: Estimation of VECM

Vector Error Correction Estimates		
Date: 09/06/20 Time: 21:52		
Sample (adjusted): 5/10/2013 8/21/2020		
Included observations: 1901 after adjustments		
Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Eq:	CointEq1	
SPOT(-1)	1.000000	
FFA(-1)	-1.260125	
	(0.11387)	
	[-11.0663]	
@TREND(5/07/13)	-0.032905	
C	104.1028	
Error Correction:	D(SPOT)	D(FFA)
CointEq1	-0.014021	-0.003616
	(0.00218)	(0.00329)
	[-6.44233]	[-1.09901]
D(SPOT(-1))	0.409478	0.127409
	(0.02212)	(0.03344)
	[18.5158]	[3.81042]
D(SPOT(-2))	0.267798	-0.068990
	(0.02093)	(0.03165)
	[12.7941]	[-2.17997]
D(FFA(-1))	0.216787	0.066066
	(0.01566)	(0.02368)
	[13.8399]	[2.78957]
D(FFA(-2))	0.157204	-0.178309
	(0.01599)	(0.02418)
	[9.82876]	[-7.37341]
C	-0.122940	0.105661
	(0.83674)	(1.26512)
	[-0.14693]	[0.08352]
@TREND(5/07/13)	0.000111	0.000222
	(0.00076)	(0.00115)
	[0.14542]	[0.19266]

R-squared	0.593939	0.036756
Adj. R-squared	0.592653	0.033704
Sum sq. resids	627651.2	1434817.
S.E. equation	18.20410	27.52379
F-statistic	461.7205	12.04536
Log likelihood	-8209.926	-8995.807
Akaike AIC	8.644846	9.471654
Schwarz SC	8.665283	9.492091
Mean dependent	0.346134	0.306228
S.D. dependent	28.52244	27.99969
Determinant resid covariance (dof adj.)		223823.8
Determinant resid covariance		222178.5
Log likelihood		-17096.63
Akaike information criterion		18.00382
Schwarz criterion		18.05054

Table 11: Johansen Cointegration Tests

Included observations: 1899 after adjustments				
Trend assumption: Linear deterministic trend				
Series: SPOT FFA				
Lags interval (in first differences): 1 to 4				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.018934	40.66963	15.49471	0.0000
At most 1 *	0.002299	4.369899	3.841466	0.0366
Trace test indicates 2 cointegratingeqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.018934	36.29973	14.26460	0.0000
At most 1 *	0.002299	4.369899	3.841466	0.0366
Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				