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'What is the influence of seasonality on the spot index freight rates for the dry bulk shipping market?

By

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Abstract

The dry bulk market has a leading role in the formation of trade market. However, it is mainly characterized by seasonality and volatile prices which may be caused by a variety of reasons such as weather conditions and local legislation. Therefore, the involved parties may take an economic risk attributed to the fluctuation in the value of freight rates. By understanding the seasonal pattern and business cyclicality with the use of shipping derivatives this risk may be eliminated as much as possible. In this thesis, the nature of seasonality (deterministic and/or stochastic) for four different types of dry bulk vessels (Capesize, Panamax, Supramax and Handysize) is examined for the period 2010-2016. The results do not reveal evidence of stochastic seasonality, while the deterministic seasonality varies from -44% to 29% in individual months for each year. Moreover, different vessel sizes showed differences in seasonal fluctuations, with bigger vessels being subjected to higher seasonal fluctuations compared to smaller ones.

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List of Abbreviations	
ARIMA model	Auto-Regressive Integrated Moving Average
ARMA	Auto-Regressive Moving Average
BCI	Baltic Capesize Index
BDI	Bulk Dry Index
BFI	Baltic Freight Index
BHSI	Baltic Handysize Index
BIFFEX	Baltic International Freight Futures Exchange
BPI	Baltic Panamax Index
BSI	Baltic Supramax Index
CAGR	Compounded Annual Growth
CAMP model	Capital Asset Pricing Model
CoA	Contracts of affreightment
CV	Coefficient Variation
DWT	Dead weight Tonnage
EOC	Economics Of Scale
FFA	Freight Forward Agreement
GARCH	Generalized Auto-Regressive Conditional Heteroscedacity
GDP	Gross Domestic Product
HEGY model	Hylleberg-Engle-Granger-Yoo model
IMAREX	International Maritime Exchange
IMF	International Monetary Fund
IPO	Initial Public Offering
KG	KommanditGessellschaft
NYMEX	New York Mercantile Exchange
TC	Time Charter
TCavg	Time Charter Average
VAR model	Vector Auto Regression
VLOCs	Very Large Ore Carriers

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Chapter 1: Introduction

1.1. The issue of seasonality in the dry bulk shipping industry

Sea transportation has arisen as the most fundamental part for the international trade. Over the last decade, there is an increase in the dry bulk demand; making this sector one of the longest sectors of the world's shipping market. The growth of the dry bulk transport is affected by global Gross Domestic Product (GDP). As the latter increases, the international trade also increases and this correlation is depicted to the dry bulk transportation.

The revenues that come from maritime services define the value of freight rate. Therefore, freight rate can be considered as a macroeconomic variable that is influenced by the demand and supply of maritime services. As a macroeconomic variable, it resembles the behaviour of other economic variables, such as the rate of unemployment, the percentage of interest rate, etc., which are characterized by an economical cyclicality. Understanding the cyclicality and recognizing its phases is critical in order for the investors, especially those who do not belong to the shipping market, to achieve a profitable investment with positive cash flow. By this way, changes and shocks can be implemented in the primary risk assessment, enabling a reliable forecasting scenario (Kavussanos &Visvikis, 2016).

However, there seems to be some confusion between the terms of cyclicality and seasonality. A seasonal pattern exists when a time series is influenced by seasonal factors. Therefore in the shipping market, seasonality is an outcome of fluctuations of demand. On the other hand, cyclicality does not refer to fluctuations of fixed period and it is largely driven by supply and external shocks to the demand (Kavussanos &Visvikis, 2016). The lack of this discrimination for an investor may cause excess capacity of supply, leading to the decrease of the already decreased value of freight rates, causing a rebound effect. A typical example of such a situation appeared in autumn 2013, when the seasonal upswing led to an excessive increase in the ordering activity, which resulted in further pressure in the already supplied market in 2015-2016, when these orders were delivered. In this case, when the balance between supply and demand is disturbed, the freight rates are significantly affected.

Asymmetries in seasonal fluctuations in freight rate market are of great importance in the strategy of shipping companies. The typical shipping operations of ship-owners and charterers are then influenced, including the selection of contracts and the switch of business orientation to other maritime markets, where the freight rate is increased when operating a vessel. The result of such a strategy is the achievement of economies of scale (EoC) and increased probability for the investor to maximize his profits. Other involved parties of the maritime sector, such as shipping agents, may also take advantage of the understanding of seasonality.

Moreover, the demand for sea transportation of dry bulk commodities may be affected by a variety of reasons, which are commonly connected to the legislation of each country. China, which is one of the largest importers in the dry bulk market, is a typical example. The increased demand for iron ore of China can be explained by strict environmental regulations regarding the production of iron ore, which led to the shrinkage of domestic production (Kavussanos & Visvikis, 2016). As a result, in 2014 China imported 1.3 times as much as the big four iron ore producers; Vale, Rio Tinto, BHP Billiton and FMG jointly produce (Zhang, 2014) (Kavussanos & Visvikis, 2016). Another reason is the increased need of construction materials in developed and developing countries, where massive building construction appears. Therefore, there is a gap which is not covered by local production creating favourable conditions for other countries to export, in order to restore the balance of supply and demand.

Furthermore, there is evidence that the sea transportation of other dry bulk products will be increased, thus the supply of the maritime services for these products must be able to cover the corresponding increasing demand.

Due to international financial crisis in 2008, the cyclicality of the shipping sector consolidated the interesting of investors, even of those who do not belong to maritime sector, as all investors aim to a significant yield of return in a short period of time. Particularly, investors are aiming to finance various investments in the shipping sector at a historical low point of the cycle and make an exit at the top of the cycle. Although the engagement of outside investors provides extra funds for the shipping industry, it could also lead to excess supply of capacity, due to increase in order book, abolishing the cyclical nature of shipping industry (Kavussanos & Visvikis, 2016).

1.2. Scope of Research

The 90% of global trade is serviced by the maritime transport, as it provides the lowest costs in international transport (Demeroukas, 2014). As word's gross domestic product keeps rising, the demand for maritime transport services is also increasing. This fact attracts new investors, who ignore the seasonal pattern of the prices charged for maritime services. Moreover, it affects the action of ship owners and charterers. Recognizing the general characteristics of shipping cycles gives a comparative advantage in decision-making for all involved parties who occupy with maritime sector.

Because of the volatility of the dry bulk shipping market, coming from the changes in geopolitical scene and ups and downs of economy, the investigation of shipping cycles has been indispensable (Scarci, 2007). However, it is very hard to define the shipping cycle and explore its characteristics. This can be explained by the irregularity of shipping cycles and the intervention of one cycle into one other. What should also be considered is the correlation of shipping cycles with different segments. For instance, when comparing the dry bulk sector with the container sector, one can observe that the latter could have quite different behaviour. This could also happen in related markets, where the same fluctuation in time series is expected.

In order to predict the future value of freight rates in the dry bulk shipping market, it is important to recognize the phases of shipping cycles. This fact plays a significant role, as it affects the decision-making of all involved parties especially of ship owners, not only for long-term decisions but also for short-term decisions. The cyclical pattern of the dry bulk shipping allows ship owners to avoid the undervaluation of market trends, taking into account available information in order to make effective decisions regarding the ship purchasing and ship chartering (Scarci, 2007). Furthermore, investors who aim to make investments in maritime sector have to identify the importance of seasonality, exploiting each phase of cycle with the optimal decision, in order to minimize the risk of loss and to achieve maximization of their profits.

1.3. Objective

The purpose of this study is to create a tool for other researchers and other business involved parties with up to date information related to the seasonality in the dry bulk shipping market. Proving the existence of seasonal pattern in dry bulk shipping freight rates and estimating the percentage of this, a beneficial consequence for all involved parties can be achieved. Furthermore, this study provides an incentive for the multi-vessel companies to diversify and extend their investments. This process would contribute to the reduction of their exposure to seasonal fluctuations of the freight market during the year. Moreover, ship owners could use the seasonal patterns of freight rates in order to make decisions, which would protect their investments. Additionally, it will provide a tool for ship operators, acting as a "forecasting" method between the four seasons. Lastly, it may contribute to better understanding of the global trade commodities market and how this pattern has changed over the last decades.

1.4. Research Question

This thesis is focusing on investigating the degree of seasonality that influences the spot charter freight rates for the dry bulk shipping market. In order to define the data for freight rates, in this thesis the indexes will be derived from Baltic Dry Index (BDI), where secondary data will be adopted. Thus, the main research question is:

‘What is the influence of seasonality on the spot index freight rates for the dry bulk shipping market?’

In order to efficiently answer to the main research question, a series of sub research questions have been posted. These sub research questions are:

Is the total impact of seasonality positive or negative?

Is the impact of seasonality statistically significant in handysize, panamax, supramax and capesize vessel market segments?

What type of seasonality can be traced on the indices (stochastic or deterministic)?

1.5. Thesis Structure

The remainder of this paper is structured as follows:

Chapter 2

In this chapter the main definitions of the market that will be used will be presented, as well as an overall description of the functions of the market.

Chapter 3

In this chapter the related literature regarding the background of freight rates will be examined. Finally, the reasons about choosing the appropriate model for analysing the seasonality of them in dry bulk shipping sector will be explained.

Chapter 4

The main target of this chapter is to provide information about the methodology used. Moreover, the basic points of our approach and the various characteristics of the econometric model that is used will be introduced.

Chapter 5

In this chapter the description of data used, as well as a preliminary statistical analysis will be provided.

Furthermore, in this chapter the final results will be analysed, aiming to give responses to the research question.

Chapter 6

In this final chapter a brief overview of this thesis will be presented. Finally, the limitations of this paper will be explored.

Chapter 2: A brief description of dry bulk industry

2.1. Introduction

The market equilibrium of dry bulk shipping services is determined by the demand and supply for them. However, the previous year can be characterized as one of the worst years in the history of the dry bulk market. In this chapter, the indicators that affect the demand and determine the percentages of imports and exports of the sector will be explored. Some of them could be the world economic growth, the global steel production and the performance of the biggest importer of dry bulk products, namely China. Since 2004, the dry bulk shipments increased with a compounded annual growth rate (CAGR) of 5.6%, showing a respective growth with the development of global GDP. Since 2008, China has been importing more iron ore than all the other countries together (De la Rubia, 2014). In 2013, 75% of total iron ore shipments were directed to China. The main production and shipments for iron ore originated from Australia and Brazil (each of them holds the 20% of global production). These exporters tend to expand their business leading to the increase in global iron ore supply. Consequently, this fact created vital agreements between Brazilian suppliers and Chinese importer companies to coordinate the shipment of iron ore. (Kavussanos&Visvikis, 2016)

According to International Monetary Fund (IMF), the global GDP in 2015 was decreased by 1% and this fact can be useful in order to explain the reduction in demand for the freight market. Another reason could be the growth of dry bulk fleet, which was twice as big as the demand for maritime services for the same year. However, not only China's GDP had slightly increased in 2016, but also the rise of real estate sector led to the rise in iron ore trade, which increased by 5%. Moreover, the regulations in the Chinese coal production, which boosted the imports improving the values of freight rates in dry bulk sector is another reason to explain the positive signs. In 2017, the global GDP is expected to be raised by 3.4%, leading to a higher growth of economies and subsequently increasing the demand for dry bulk services. This expecting growth of global steel production tends to boost the imports of raw materials, like iron ore, coal and scrap.

The Economy of China appeared to be a vital player in the dry bulk market and its fiscal policy can affect the shipping sector. This can be proved by the fact that the global coal trade dropped by 7% in 2015 due to specific restrictions set by governmental policies of the domestic coal mines. (Kavussanos&Visvikis, 2016) However, there is some controversy about which industries will be affected. The change in price charged of domestic coal could affect the price from sources apart from China, making them more cost competitive, as the potential capacity for long-distance routes will be increased.

As a consequence, the ordering boom of 2010 resulted in the fleet growth over the next years. The high volume of scrapping could not balance the supply and demand, revealing the importance of new deliveries of dry bulk vessels. (Kavussanos&Visvikis, 2016)

2.2. The demand for maritime services

It is generally known that the demand of maritime transport is highly affected by GDP. In fact, the demand of cargo transport is not defined by the actual size of the GDP, but by the way the involved countries interact, giving rise to the global GDP. The latter is affected by different factors of the global market. It is stated that the growth of population in developing countries will lead to an extra demand, while in the developed countries the population declines but increases significantly in age (Fang et al., 2013) (Kavussanos&Visvikis, 2016). Moreover, political issues have a leading role in the trade market by determining the effect of the global megatrends on the trade and shipping. Through free trade agreements that are already applied, it is reassured that there will be a need for maritime services. Though, in the long term, there is a factor of uncertainty, since the global megatrends may change the terms of these agreements, affecting the demand of transported capacity. Furthermore, other factors, such as climate changes and environmental regulations should be considered when estimating the demand for sea transport.

By the end of 2030, it is expected that the GDP will double, with China driving the leading role of this increase. Since China is one of the biggest importers of dry bulk commodities, it is evident that the dry bulk market is developing in the shipping market. However, the increase of global indicator ensures the rise of seaborne trade. When it is observed with an holistic point of view, the correlation between GDP growth and trade growth is not exactly proportional. For instance, in 2012 3.4% increase of GDP led to 2.8% increase of the trade growth, while in 2017 a rise of 3.9% of GDP led to 5%-6% increase of global trade (Kounis, 2014) (Kavussanos&Visvikis, 2016). Therefore, the correlation between these two variables should be examined in detail. A specific perspective of each individual segment of the shipping market is needed to allow reliable forecasting. In this thesis, the factors which contribute to the demand of the dry bulk market will be examined.

2.3. The supply for maritime services

The supply of the shipping market is determined by the existing fleet, the construction of new buildings and the scrapping of the older vessels (Kavussanos&Visvikis, 2016). Moreover, infrastructural fluctuations, regulatory issues and factor costs have contributed to the increased demand for new buildings vessels and the scrapping of the older ones (Kavussanos&Visvikis, 2016). Considering the existing regulations, the environmental requirements have posed some limitations, causing the economic aging of older vessels which do not comply with the current requirements of global regulations. For example, the new ECO designs have forced the vessels of older construction to leave the market (Kavussanos&Visvikis, 2016).

Furthermore, the size of used vessels may have an impact in the supply. For example, using a more than adequate size of vessel will lead to a half-filled vessel for a specific route, with the costs outreaching the revenues. However, geopolitical issues, such as the extension of Panama Canal and the Suez Canal, may give rise to profitable conditions for vessels of bigger size, by lowering the operational costs.

2.4. Current state of shipping

Although maritime services are characterized by a constant increase in demand for sea transportation of about 4% per year, they are often suffering from strong cyclicality. Thus, cyclicality can be divided into three basic cycles of maritime economies: seasonality, mid-term cycles with duration of seven years and long term cycles with duration of thirty years or more (Stopford,2009) (Kavussanos&Visvikis, 2016). Seasonality originates from fluctuations in demand. That means that, while in a specific period of time the transport capacity is kept at a constant, the demand in sea transportation is altering, causing fluctuations of the freight rates. The mid-term cycles stand as a challenge for the current maritime investments and in contrast to the seasonality, they are largely supply driven with a few exceptions of external shocks to the demand (Kavussanos&Visvikis, 2016). The above supply, which is characterized by cyclicality, is not in alignment with a stable background of a constant and safe increase. This cyclicality may originate from endogenous factors.

Moreover, there is a time gap between the ordering of a new vessel and its delivery, which varies from two to three years. This fact leads to over ordering of new vessels when the freight rate values are favourable, and when delivered, the vessel services a growth in the capacity of cargo for the next thirty years. Although a market collapse leads to a decrease in the ordering of vessels, the excess capacity may take years to be absorbed by the global trade growth. In conclusion, when the seasonality is studied, the different cycles and their impact on the demand, rather than the supply, should be taken into account.

2.5. The dry bulk market

2.5.1. The development of dry bulk market

The dry bulk shipping market consists of about 10.000 vessels, with an overall capacity of four million gross tonnage, covering the 36% of the total number of vessels. The main products of the dry bulk market is coal, iron ore and grain, while the minor bulks commodities are rice, sugar, fertilisers and cement.

The major commodities of the dry bulk market are usually used for production of steel, cement production and for generation of electricity. Thus, these materials, which are used for construction and manufacturing reasons, play a significant role in the primary stage of the production cycle. In 2013, the global dry bulk shipping reached the 4.3 billion tonnes, with 29% share of coal, 27% iron ore, 14% grain and 30% of minor bulks. (Torp, 2014)(Kavussanos & Visvikis, 2016).

By 2004, the transportation of dry bulk commodities revealed a good correlation between the dry bulk trade growth and the increase of global GDP, with the first sharing a compounded annual growth of 5.6%. In 2013, the 40% share of global transport of the dry bulk sector is attributed to the imports of China. The 67% of these imports was iron ore and 27% was coal (Kavussanos&Visvikis, 2016).From 2013 to 2017, the Chinese imports of iron ore was expected to rise from 800 billion tonnes to 900 billion tonnes (Kavussanos&Visvikis, 2016). This increased demand in iron ore transportation caused a corresponding increase in iron ore exports, with Australia and Brazil driving the leading role. As a result, companies located in these two countries planned an increase of iron ore production, making sure that there will be available cargo to be transported by dry bulk carriers.

The companies responsible for the transportation of iron ore from both the importer and exporter (e.g. China and Brazil respectively) have to conduct an agreement regarding the transportation of dry bulk commodities, formalizing the relation between these two countries.

As far as the coal is concerned, which is a vital type for dry bulk transportation; it owns the biggest share of dry bulk vessel's capacity. India and China appear to be the biggest importers while Australia and Indonesia appear to be the main exporters. (Kavussanos&Visvikis, 2016)

Lastly, in the grain market an increase is also expected. Forecasting reveals a 50% growth of grain transportation from 2010 to 2030, with US and Russia remaining the biggest exporters and mid-East and Southern Asia the main importers.

2.5.2. The description of dry bulk carriers

The dry bulk market is composed of different vessel designs like Capesize, Post Panamax, Panamax, Supramax, Handymax and Very Large Ore Carriers (VLOCs) and is controlled by five main types of bulk, iron ore, coal, grain, phosphate and bauxite or alumina. A brief explanation of the above types of dry bulk vessels will be provided below.

Handysize vessels are able to carry up to 64.000 tons and usually are made to carry minor bulk cargo. The sub-segments of this category are the Supramax, the Handymax and Handy vessels. Supramax vessels have capacity from 50,000 to 64,000 Dead Weight Tonnage (DWT), while Handymax vessels provide a capacity from 36,000 to 49,000 DWT. The last sub-segment, Handy vessels are the smallest and able to carry until 35,000 DWT. Usually, all the vessels of this category are equipped with cranes. (Kavussanos&Visvikis, 2016)

As far as the Panamax vessels are concerned, they are designed to pass through Panama Canal locks. The limitations of Panama Canal include maximum length of 275 meters and breadth 32.31 meters. This type of vessels is able to serve a capacity of 65,000 tons to 100,000 tons.

In contrast, the Post-Panamax vessels cannot pass through Panama Canal, as they are larger than Panamax vessels and their capacity varies from 87,000 to 115,000 DWT. (Kavussanos&Visvikis, 2016)

Capesize vessels are capable of carrying from 120,000 to 200,000 DWT. Their name comes from the Cape of Good Hope due to the inability to pass the Panama Canal and the option of Cape of Good Hope seems to be the most efficient for routes from Australia and Brazil to Europe and Asia. (Kavussanos&Visvikis, 2016))

The last category is the Very Large Ore carriers (VLOCs). These ships have a capacity from 250,000 up to 400,000 and are specialized to serve the Chinese market from imports that come usually from Brazil. (Kavussanos&Visvikis, 2016)

Table 2-1 Vessel size, deadweight capacity and types of cargo in dry bulk market

Sub-segment	Capacity (Dead Weight Tonnage)	Type of Cargo
Handysize	10,000-40,000 dwt	Minor bulk, bauxite
Handymax/ Supramax	40,000-65,000 dwt	Bauxite, phosphate
Panamax	65,000-100,000 dwt	Iron Ore, coal
Post-Panamax	87,000-115,000 dwt	Grain
Capesize	120,000-200,000 dwt	Iron Ore, coal
Very large ore/bulk carrier (VLOC/VLBC)	250,000-400,000 dwt	Iron Ore

2.6. *The Baltic Dry Index (BDI)*

The Baltic Dry Index is an indicator that is issued daily by London Baltic Exchange. The Baltic Dry Index owes its name to the Baltic Coffeehouse where captains and merchants gathered in order to negotiate the price charged for shipping services. It contains the value of freight rates between different vessel sizes and different dry bulk goods. Moreover, the Index estimates the demand for shipping services in relation to supply of dry bulk capacity. The reliability and independency of the index makes the involved parties to consider it as a permanent source of information. Baltic Dry Index (BDI) sets different categories for the dry cargo indices. Each segment has its index. Thus, we can introduce the indexes of our research that will be the Handysize Index (BHSI), the Baltic Panamax Index (BPI), the Baltic Capesize (BCI) and the Baltic Supramax Index (BSI).

Indirectly, the BDI reflects the global demand and supply of materials and products transported by dry bulk vessels (McMorris, 2009). Hence, the BDI is calculated by the below formula:

$$BDI = \left(\frac{BCITCavg + BPITCavg + BSITCavg + BHSITCavg}{4}\right) * 0.11034533$$

Where

BCI=Baltic Capesize Index

BPI=Baltic Panamax Index

BSI=Baltic Supramax Index

BHSI=Handysize Index

TCavg=Time Charter Average

The calculation of the current BDI (19^{th} July 2017) is presented in the following table:

Table 2-2 Calculation of BDI for the 19^{th} July 2017

BCI TCavg	BPI TCavg	BSI TCavg	BHSI TCavg	BDI
9439 $/day	11280 $/day	9564 $/day	9536 $/day	1098

2.6.1. The Baltic Capesize Index (BCI)

Baltic Capesize panel contains the time charters and voyage charters contracts, which are presented in Table 2.3. The weight factor is based on the significance of the route, the capability of each vessel, the type of the contract and the type of cargo transported.

Table 2-3 The Baltic Capesize Index as determined by the different routes. Source: The international handbook of shipping finance

Baltic Capesize Index				
Routes	**Vessel Size (metric tons)**	**Route description**	**Cargo**	**Weight Factor (%)**
C2	160.000	Tubarao (Brazil)- Rotterdam (Netherlands)	Iron Ore	5
C3	160.000-170.000	Tubarao-Qingdao (China)	Iron Ore	15
C4	150.000	Richards Bay (S. Africa)-Rotterdam	Coal	5
C5	160.000-170.000	W. Australia-Qingdao	Iron Ore	15
C7	150.000	Bolivar (Colombia)-Rotterdam	Coal	5
C8_14	180.000	Transatlantic round voyage, redelivery Gibraltar-Hamburg range	TC	5
C9_14	180.000	ARA (Amsterdam-Rotterdam-Antwerp) or passing Passero (Mediterranean), redelivery China-Japan	TC	7.5
C10_14	180.000	Pacific Round Voyage, delivery and re-delivery China-Japan Rage	TC	15
C14_14	180.000	Qingdao-Brazil round voyage, redelivery China-Japan range	TC	15
C15	160.000	Richard's Bay-Fangcheng	Coal	5
C16	180.000	North China-South Japan range, trip via Australia or Indonesia or US West Coast or South Africa or Brazil,	TC	7.5

		redelivery UK/Continent/Mediterranean within Skaw Passero (North West Europe-Mediterranean)		
C17	170.000	Saladha Bay (South Africa) – Qingdao	Iron Ore	0

2.6.2. *The Baltic Panamax Index (BPI)*

BPI is designated by four time charter routes with equal weight factors. The time charter rates are calculated by dollars per day. The following table shows the determination of the BPI according to the selected routes, the vessel capacity and the type of contract.

Table 2-4 The Baltic Panamax Index as determined by the different routes. Source: The international handbook of shipping finance

Baltic Panamax Index				
Routes	**Vessel Size (metric tons)**	**Route description**	**Cargo**	**Weight Factor (%)**
P1A_03	74.000	Transatlantic Round Voyage	TC	25
P2A_03	74.000	Skaw-Gibraltar range to Far East, redelivery Taiwan-Japan range	TC	25
P3A_03	74.000	Japan-South Korea range to Pacific round voyage redelivery Japan-South Korea range	TC	25
P4_03	74.000	Japan-South Korea range, redelivery Skaw-Passero range	TC	25

2.6.3. *The Baltic Supramax Index (BSI)*

The BSI contains six time charter routes with different weight factors, which define the level of the index. The prices of contract are calculated in dollars per day. Table 2.5 presents the BSI, with respect to the selected routes, the vessel capacity and the type of contract.

Table 2-5 The Baltic Supramax Index as determined by the different routes. Source: The international handbook of shipping finance

Baltic Supramax Index				
Routes	**Vessel Size (metric tons)**	**Route description**	**Cargo**	**Weight Factor (%)**
S1A	52.454	Antwerp (Belgium)/ Skaw trip Far East, redelivery Singapore-Japan	TC	12,5
S2	52.454	Canakkale (Turkey) trip Far East, redelivery Singapore-Japan	TC	12,5
S3	52.454	Japan-South Korea trip, redelivery Gibraltar-Skaw range	TC	25
S4A	52.454	US Gulf, redelivery Skaw-Passero range	TC	12,5
S4B	52.454	Skaw-Passero range, redelivery US Gulf	TC	12,5
S5	52.454	Delivery West Africa (Dakar-Douala range), trip via east coast South America, redelivery North China (Shanghai-Dalian range)	TC	0

2.6.4. The Baltic Handysize Index (BHSI)

The BHSI contains six time charter routes with different weight factors. The BHSI with respect to the selected routes, the vessel capacity and the type of contract is presented in Table 2.6.

Table 2-6 The Baltic Capesize Index as determined by the different routes. Source: The international handbook of finance

Baltic Handysize Index				
Routes	**Vessel Size (metric tons)**	**Route description**	**Cargo**	**Weight Factor (%)**
HS1	28.000	Skaw-Passero trip, redelivery Recalada (Argentina)-Rio de Janeiro (Brazil) range	TC	12,5
HS2	28.000	Skaw-Passero trip,	TC	12,5

		redelivery Boston-Galveston (USA) range		
HS3	28.000	Recalada-Rio de Janeiro range, redelivery Skaw-Passero range	TC	12,5
HS4	28.000	US Gulf trip via US Gulf or North Coast South America, redelivery Skaw-Passero	TC	12,5
H5S	28.000	Southeast Asia trip via Australia, redelivery Singapore-Japan range	TC	25
HS6	28.000	South Korea-Japan via North Pacific, redelivery Singapore-Japan	TC	25

2.7. Shipping Freight Contracts

A shipping freight contract is the agreement between the ship-owner and the charterer, which allows the use of the ship for transportation services. The amount charged for the use of the ship is called freight rate. The formal contract between the two parties is called charter party and contains specific contractual agreements. The types of charter contracts are:

Voyage charter contracts

Time charter contracts

Trip charter contracts

Contracts of affreightment (CoA)

Bareboat charter contracts

2.7.1. Voyage Charter

A voyage charter or spot contract is an agreement between the ship-owner and the charterer, so as the latter to transport the shipment from the port of loading to the port of discharge. As it is perceived, this validation of contract is based on the agreement between ship-owner and charterer. For this service, the ship-owner charges the charterer a specific amount of money for each ton that is transported. In this type of contract, the ship-owner is responsible to cover all the expenses that will occur during the route. These expenses could be the operating costs, the voyage costs, the capital costs and the cargo handling costs.

2.7.2. Time Charter

In this type of agreement, the charterer hires the vessel for a specific period. Most of time contracts last from 6 months to 10 years. Again the ship-owner is responsible to find the proper crew and to take care for the maintenance of the vessel as well as for the supervision of the cargo. However, the charterer is liable for costs resulting from the use of the vessel, as voyage costs and cargo handling costs. There is no limitation in the number of voyages that charterer will choose as long as he pays the agreed amount of money to the ship-owner. Usually the ship-owner charges the charter in daily basis and the freight rate is defined per day.

In financial terms, if we want to compare the voyage charter and time charter we have to transform the freight rate from dollars per ton to dollars per day. In order to accomplish this transformation the use of the Time Charter Equivalent is indicated. Hence, the Time Charter Equivalent is calculated by dividing the total earnings of a voyage by the days spent in the voyage.

2.7.3. Trip Charter

Unlike the previously mentioned types of contract, in this type of contract the ship-owner agrees with the charterer for a specific route. The expenses for handling and voyages costs are paid by the charterer. The ship-owner is only responsible for the non-operational costs including the fluctuations in the bunker price. The agreement is upon a dollar per day basis ensuring that if any delay occurs the charterer will pay the extra hours of delay.

2.7.4. Contracts of affreightment (CoA)

Under a contract of affreightment, the ship-owner agrees with the charterer to transport a specific amount of cargo for a standard price per ton. The period for this contract is indeterminate and is defined by the agreement between the ship-owner and the charterer. A contract of affreightment occurs when the charterer needs to transport a vast amount of cargo which is impossible to carry with a single voyage. This type of contract provides flexibility to the ship-owner, as he can then arrange a series of voyages, allowing him to reduce costs and to achieve economies of scale. This type of contract mainly facilitates the transport of iron ore and coal to the steel mills in Europe and Far East (Stopford, 1997).

2.7.5. Bareboat Charter

The last contract is the bareboat charter which ensures the total control of the vessel to the charterer, without any title of ownership. Hence, the charterer is responsible for all costs during the trip apart from the capital costs. The bareboat charter is ideal for investors who occupy with maritime sector and do not have any experience on it. The freight rate is determined by the method of a dollar per day and usually is paid monthly. However, the bareboat charter does not affect the freight market, as it is a kind of financial agreement.

2.8. Shipping Derivatives

The maritime sector is characterized by economic cycles, seasonality and volatility which are the results of fluctuations of freight rates, the bunker prices and the price of the vessels, interest rate and interest exchange rate. These fluctuations cause instability between revenues and costs. Therefore, the use of financial derivatives is critical in order for the investment to be protected and to present a positive cash flow. With the use of these derivatives, ship-owners and charterers are able to protect the future income by ensuring stability and reducing the uncertainty in the fluctuation of freight rates.

From 1970 to 1980, the derivatives that were commonly used in commodities until then, expanded to the financial market. Hence, for instance agents of shipping industry were using currency swaps to secure against fluctuations in foreign currencies for the payment of new building vessels (Kavussanos & Visvikis, 2006). This risk of currency is driven by the fact that the income of the ship-owner is measured in dollars, while the payments for purchasing a new vessel are estimated by the local currency of the shipyard. Therefore, the reduction of freight rate risk for the incomes that are directly affected is succeeded by tools that ensure stability, such as freight futures, Freight Forward Agreements (FFAs) and freight options contracts. In this thesis, these tools will be analysed, so as to reveal the options to protect the maritime investment from fluctuations caused by seasonality, volatility and cyclicality.

The main types of shipping derivatives are presented and analysed below:

Freight Futures

Freight Futures consist of the International Maritime Exchange (IMAREX) and New York Mercantile Exchange (NYMEX). IMAREX was established in 2000 and provides information about shipping freight derivatives. Moreover, IMAREX facilitates the trade between participants providing a trading screen with all important features which can be useful for third party freight derivatives, like brokers.

NYMEX was founded in May 2005, offering freight derivatives on tanker freight futures contracts via its electronic platform. NYMEX handles energy and metal carriers such as other commodities that being sold or bought on its trading platform.

Forward Freight Agreements (FFAs)

The shipping market is considered as a very competitive market. Both ship-owner and charterer have to cope with the volatility and seasonality, which are observed in freight rates. For the ship-owner, the risk involved in the decrease of freight rates leads to the decrease of his income. On the contrary, for the charterer a decrease in the value of freight rates implies lower cost. Thus, to secure this risk, FFAs should be used. Forward Freight Agreement is an agreement to buy or sell a freight rate (contract price) today for a future date whereby the payment (settlement price) is based upon an agreed route or an index prevailing at the time of shipping (Lafranca, 2014). According to Baltic Exchange, an FFA is a swap agreement between two principals, where agreement is struck for the value of the contract on an agreed future date (Exchange, 2014). Therefore, the settlement price depends on the adopted contract and FFAs can facilitate short and long terms contracts. These contracts include information about the quantity of cargo, the type of the vessel and the duration of leasing. The charterer expects that the price of an agreed freight route at an agreed time will be higher than the current level and buys FFA contract while the ship-owner takes the opposite position and sells FFAs contracts. (Kavussanos & Visvikis, 2006)

Specifically, in the dry bulk market voyage contracts are determined by the difference between the contracted price and the average spot price of the index over the last seven working days of the month, while time charter contracts are determined by the difference between the contracted price and the average price over the calendar month. Thus, in case that the price of seller is lower than the final determination of freight rate, the seller pays the remaining difference between the current price and the price of the Freight Forward Agreement.

The establishment of Baltic International Freight Futures Exchange (BIFFEX) in 1985 resulted in the appearance of first freight derivatives contracts. The BIFFEX contract consisted of Baltic Freight Index (BFI). Due to the market segmentation of the dry bulk industry, a number of different sub-indices were introduced in order to present more reliable results for each sub-market. Thus, the BFI was categorized in the following indices: the Baltic Panamax Index (BPI) (1998), the Baltic Capesize Index (BCI) (1999), the Baltic Handymax Index (BHI) (2000) and the Baltic Supramax Index (BSI) (2005).The daily movement in rates across dry bulk spot voyage and time charter rates is monitored by the aforementioned indices, without describing neither the specific cargo nor the tonnage requirements .Each route has its own weighting factor, which reflects its international importance in the freight market. In order to ensure the reflection of these indices to reality, these routes are reviewed on a regular basis.

Freight Options

The last tool for risk management is the freight options. This type of financial derivatives contracts has been used extensively in finance on a number of underlying instruments, including exchange rates, interest rates, etc. (Kavussanos & Visvikis, 2006).

2.8.1. Participants in freight derivatives market

The fluctuating value of freight rates sets the use of financial tools as an inseparable component for the analysis of risk management and for the efficiency of investments in maritime sector. Particularly, the involved parties, such as the ship-owner and the charterer, use these financial tools in order to cover their investment against shipping seasonality and in cooperation with brokers compose the freight derivative market. The increase of the volume and the value of the international trade led to the increase of interest in the shipping derivatives because the majority of the goods are transported by sea (Chatman et al., 2013).

Ship-owners

With the use of the shipping derivatives, ship-owners tend to protect themselves from the decline of freight rates. Hence, in order to balance their cash flows, they aim to choose a freight rate in particular moment and to avoid the future fluctuations in the freight rates. For instance, due to the seasonality in dry bulk market on summertime, the ship-owners tend to prevent the decrease in their cash flow and with Freight Forward Agreement protect themselves from expected decrease in the value of freight rates.

Charterers

In contrast to the ship-owner, the charterer acts differently in a transaction of shipping derivatives. His target is to get covered against possible increases in the price of freight rates and to minimize his total costs. Hence, most of the time, the charterer chooses to buy a Freight Forward Agreement which lasts for a long period. Again the enemy of charterer is the seasonality of freight rates and especially the decrease of them in a specific time during the year. The charterer may choose to buy a put option or to sell a call option in order to moderate his losses in case of a possible decrease in the value of freight rates. As we understand, both the ship-owner and the charterer can take advantage of the fluctuation of freight rates and switch to targeted market, which will be a substitute but without being affected by the decrease of freight rates.

Brokers

The broker behaves as an intermediate between the seller of the cargo and the buyer. The broker aims to find the appropriate offer of the market for the client in order to gain a brokerage fee from this transaction. For this reason, the broker should have insight for all factors that determines the shipping market. These factors could be the selling cargo and its characteristics, ship's specifications, market trends and fluctuations. Another clue of a successful shipbroker is to have negotiating skills, an issue that is highly important in order to persuade his clients.

Clearing Houses

Clearing houses act like a buyer for each seller and like a seller for each buyer. This states the role of clearing houses as highly important due to the fact that less and less contracts are available in the stock exchange market. The role of clearing houses has tremendous advantages, as they ensure liquidity and their proposals are characterized by low risk decisions. Their ability to eliminate credit risk in case of default, results in the attraction of future investors. Moreover, the clearing houses provide anonymity and restrict the need of credit evaluations of the various involved parties. Finally, they offer transparency and consistency of pricing for margin and funds settlements as the price is same for all contracts (Culp, 2010).

2.9. The stages of shipping cycle

A short shipping cycle can be defined as the mechanism of coordinating supply and demand in the shipping market (Stopford, 1997). Thus, a complete short shipping cycle contains four stages:

- Trough: The period of cycle where a surplus of shipping capacity pulls down the value of freight rate, approaching the value of operating costs. Thus, ship-owners attempt to sell vessels while the quantity of new shipbuilding vessels is reduced.
- Recovery: The period of cycle where the supply and demand balances, leading to the value of freight rate exceeding the operating costs.
- Peak: The period of cycle where the value of freight rate is relatively high and ship-owners are motivated to expand their fleet due to the liquidity coming from the increased revenues.
- Collapse: The period of cycle where the supply for shipping services overtakes the demand, resulting in the fall of the price of freight rate.

As it is perceived, decisions about ship purchasing - selling and ship chartering have major importance. Ship owners must choose the appropriate moment to buy or sell ships, taking into account the sovereign correlation between ship prices and the value of freight rate. Another important factor in purchasing a vessel is to examine options of second hand market, where sometimes there are good occasions without being subordinated to the rhythm of the shipbuilding market (Scarci, 2007).

The gap between the time of ordering and the time of delivery of a new building ship is the main reason for the existence of cyclical pattern in the value of freight rates. The delivery of a new ship varies between two and four years. In this interval, market conditions are changing, causing uncertainty in the future process of repayment of investment. Thus, when the market is already depressed and the delivery of new vessels concurs, the market will deteriorate due to the existence of oversupply for maritime capacity. Therefore, the decision of ship owners about the kind of contract charged is very crucial, as time charter guarantees a stable freight rate for a determined period, while voyage charter allows the exploitation of the positive trends of the spot market. Although, it is visible that there is a risk of sudden freight rates decreasing (Scarci, 2007). The usual optimal solution for ship owners to minimize their risk is to diversify their fleet between time charter and voyage charter. In time charter they can cope with operating costs by the regulation of cash flow and the remuneration of capital. On the other hand, with voyage charter ship owners perceive a margin of flexibility. The determination of the exact proportion between these two management instruments demands full awareness of shipping cycles in the dry bulk market.

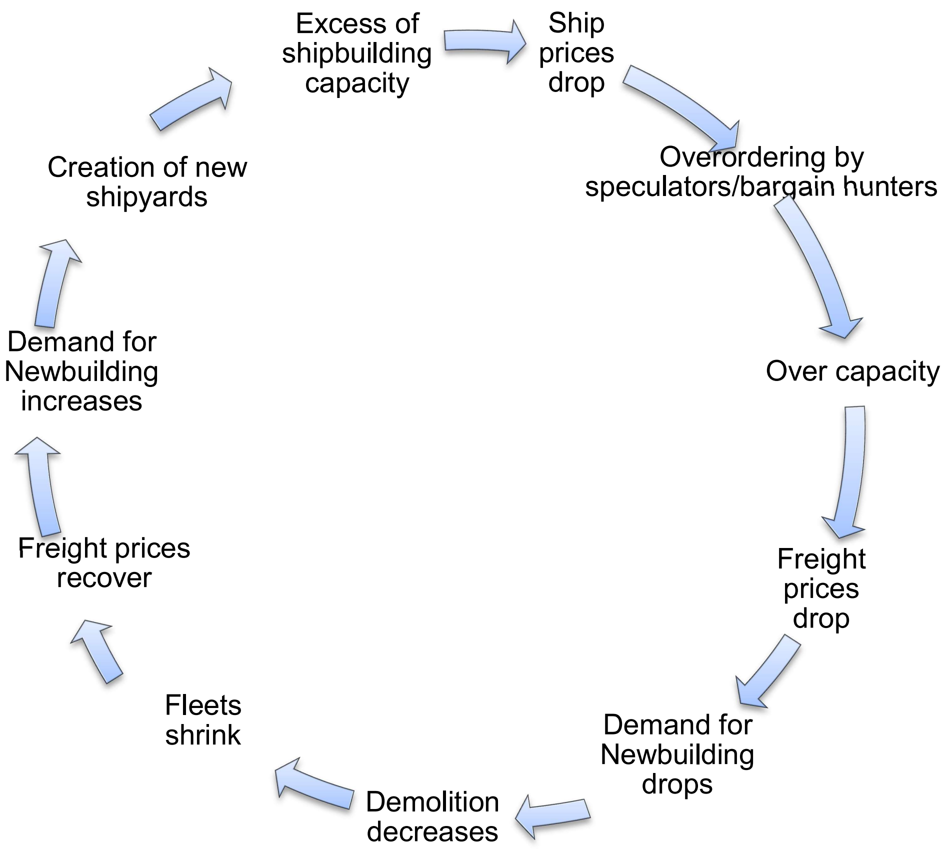

Figure 2-1 Stages of the shipping cycle. Source: DVB Bank AG

2.10. Freight Rates

As freight rate is defined the price charged for sea transport for a cargo transported from one point to another. The freight rate is determined by the demand and supply for maritime services. In the following figure 2.2, we can observe the determination of freight rate value. In many macroeconomic variables, deterministic seasonal coefficients depend on the phase of the business cycle. Similarly, in the cyclical shipping freight market, the elasticity of supply curve is presented as high during troughs and low during peaks, as shown in the shape of supply curve of the following figure. (Stopford,1997). Hence, when the freight rates are low, the less efficient vessels are laid up and the existing vessels at sea operate at slow speed. With the improvement of market conditions, freight rates start rising, as a result, more and more ships are taken out of lay-up. In the peak of shipping cycle, all vessels are active and operate at full speed, creating a vertical supply curve. Concerning the demand for dry bulk services, it is characterized as inelastic due to the minimum proportion of transportation costs in the final value of good. Consequently, changes in demand at the recovery point of the shipping cycle demonstrate stronger reactions in the value of freight rates compared to market downturns. (Kavussanos & Alizadeh, 2002).

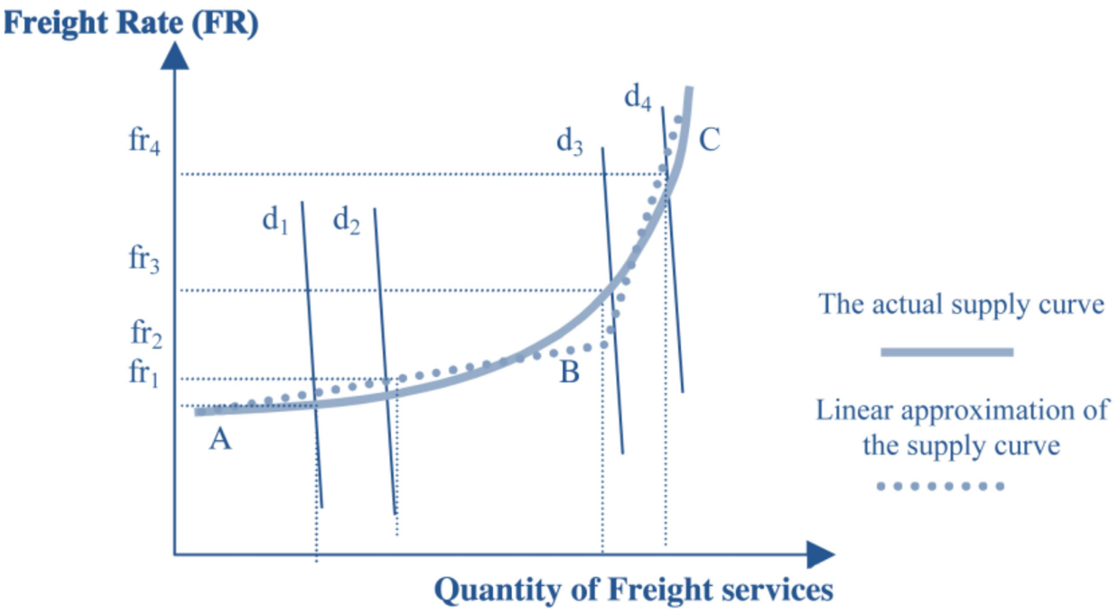

Figure 2-2 The shipping freight market, source: Stopford, Maritime Economics 1997

According to the Baltic Exchange, the freight market is affected by the below factors (Kavussanos & Visvikis, 2006):

Fleet Supply

The fleet supply consists of the total number of dry bulk vessels which are available for transport. The fleet size depends on the amount of the delivered vessels and of the scrapped vessels. When there is an excess capacity in the dry bulk market, the value of freight rate would decrease, as the supply exceeds the demand for transport services. While, in case of increased demand the value of freight rate tends to increase, increasing the revenues for the ship-owner and the costs for the charterer.

Commodity Demand

The industrial production affects the commodity demand. The industrial production is affected by the decision of each country regarding the increase or decrease in the amount of steel production, for instance. An increasing production demands shipping services in order to transport raw materials that are used in the different phases of production.

Bunker Prices

Freight rates are heavily affected by oil prices as the bunker costs occupy from 50% to 60% the operating costs of a ship. The fact that there is no alternative way to power a ship proves that the bunker costs have a significant role in the determination of freight rates.

Crucial Points

The Panama Canal, Suez Canal and the street of Malacca can be characterized as the most important shipping lanes. Therefore, with these waterways, shipping companies save a big amount of time passing through these lanes and keep in low rates the value of price charged form maritime transport. Thus, if one of these lanes are blocked due to for example a terrorist attack, the duration of route is changed, increasing the price of freight rate.

Market Sentiment

The economic growth is the driver for shipping services. Hence, the indications of economic growth can affect the production of raw materials and consequently the demand for maritime services.

Finally, Denning et al (1994) added other factors that may affect the value of freight rate. These factors could be political factors including wars, revolutions, and national crises, changes in currency value that affect the shipping costs for a foreign ship-owner and lastly average haul that refer to extra shipping service demand.

2.11. Seasonality in dry bulk commodities

The grain trade has always been one of the main drivers in freight rate seasonality, creating larger variances between high and lows in freight market noted during the course of the year. (http://www.hellenicshippingnews.com/dry-bulk-seasonality-comes-into-play-as-ship-owners-rely-more-on-grain-trades-to-offset-losses-elsewhere/). The grain trade is characterized by unpredictability because the weather factor plays an important role in the effectiveness of the production of grain. Planting and harvesting periods determine the supply in grain market, therefore the demand for sea transportation of grain is highly affected. Moreover, grain inventories decline after harvest, compromising to the seasonal pattern of the value of freight rate. Hence, it is usually observed that the routes which serve the transportation of grain show an increasing trend concerning the freight rates after the period of harvest, while in the winter months decreased trends are common.

In the period from November to February, an increase in the values of iron ore usually appears since this period shows seasonal supply disruptions. Consequently, the law of seasonal demand can be verified. China has a leading role in the iron ore market and belongs to one of the biggest importers of iron ore, as previously mentioned. The increased demand of China is served by exports of other countries such as Brazil and Australia. This excessive need for imports of iron ore derives from the attempt to fulfil its infrastructure projects in combination with the strict environmental regulations that cause the local production to shrink. However, a seasonal pattern in demand is also shown in iron ore imports due to the fact that holiday periods and other seasonal reasons seem to be critical for this specific route. (Kavussanos & Visvikis, 2016)

Furthermore, it is generally known that coal is used for heating in the winter months and power demand growth in the summer. These are the two main seasonal factors that have an impact in the coal prices. Therefore, the demand in maritime transport of coal rises from January to April and declines from April to October (WU Lixin et al, 2016). Another reason that contributes to the seasonality pattern of coal could be the end of the fiscal year in Japan at the end of March as Japan is a major player in the coal imports (Kavussanos & Alizadeh, 2001).

In order to avoid problems regarding to spurious results when modelling the seasonality, it is important to distinguish the difference between stochastic and deterministic seasonality.

A time series with stochastic seasonality is characterized by the fact that its behaviour is changing while the time passes by and does not follow a unique seasonal pattern, while a time series of deterministic seasonality follows the same seasonal behaviour every year. Another difference between these two types of seasonality is that the first is affected by the shock for a larger duration of time in contrast to the second one, where the shock is eliminated in a relatively recent period. As for the economic impact of the types of seasonality is concerned, the ability of recognising each type would improve the effectiveness of decision-making and policies. If the pattern changes, which is the case of a stochastic behaviour, a periodic revision of the policies is necessary (Kavussanos & Alizadeh, 2002). Examples of deterministic behaviour could be the increase in seasonal consumption of heating at every winter and the respective decrease every summer or, in the case of the dry bulk market, the start of the harvest period and the corresponding increase in demand in the following month. On the other hand, a stochastic behaviour includes the transition of the summer peaks to winter months, and the transition of winter troughs to summer months.

The aforementioned discrimination of seasonality pattern should be taken into account when modelling seasonality, as it may lead to incorrect results regarding the impact of seasonality on the freight rates. The type of seasonality can be investigated with the use of different models which examine the existence of stochastic and/or deterministic time series, such as HEGY model which will be discussed in the following chapters.

Overall, in this chapter, the main definitions of the maritime market were examined, as well as the main functions of them, emphasizing in the Baltic Dry Index. The latter was presented with the description of the selected routes and the respective weight factors and will enable us to examine the seasonal pattern of the dry bulk sector. Some examples of shipping derivatives were also presented, in order for the ship-owners to cope with the existence of the seasonal pattern and cyclicality. Furthermore, we defined the meaning of freight rate and analysed the factors that mainly affect the establishment of its values. In addition, we described a variety of commodities of the dry bulk market, in order to prove the seasonal component in the demand and supply and the fundamental causes of its existence. The following figure presents the possible conditions that may overlap with seasonality in the dry bulk market. These can be diversified into two categories: The first applies for conditions that affect the demand for imports of dry bulk commodities (e.g. national political issues) and the second for those conditions that affect the supply of maritime services. The latter emerged from the rise of new vessels' orders, leading to their delivery when the market is pressured and causing additional capacity, which results in the fall in values of dry bulk freight rates.

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Figure 2-3 Factors that may contribute to the seasonal pattern observed in the dry bulk market.

In the following chapter, we will analyse the related literature regarding the background of freight rate and the reasons that led us to choose the selected model as the most suitable for the examination of seasonality in the dry bulk sector. The selection of an appropriate model will help us to investigate the nature of the data, allowing us to proceed through the seasonality model, which will prove the degree of seasonality in dry bulk market.

As shown in Figure 2.3, the organizational structure of the process of this thesis includes the transformation of the Baltic Capesize Index, Supramax Index, Baltic Handysize Index and Baltic Supramax Index into their logarithmic returns, the application of the HEGY model, which allows the examination of the deterministic and/or stochastic pattern of seasonality and the selection of the appropriate model of seasonality.

In order to investigate the fluctuations in freight rate dry bulk market, we have to define the reasons. These fluctuations emerge from the general world activity and seasonal factors. It is important to depict the seasonal behaviour of freight rates as it affects the formation of transport policy. As we have mentioned above, the demand for dry bulk transport derives from the world economic activity and the related macroeconomic variables of economies. These macroeconomic variables have been shown to be non-stationary with deterministic seasonal components. Hence, it is possible that these seasonal characteristics in the variables will be shifted to the dry bulk freight rates. The detection of seasonal fluctuations in dry bulk freight rates can be valuable for the decisions of ship owners and charterers. For ship owners such decisions include the budget planning that depends on annual cash flow, as well as the time of dry docking, the selection of speed and vessel repositioning. In respect to charterers, the use of information about seasonal fluctuations in dry bulk freight rates could optimize their cost by adjusting their inventory. The latter will ensure that chartering requirements will be reduced during high seasons by building up sufficient inventory (Kavussanos & Alizadeh, 2002). To conclude, additional information about potential market conditions, such as seasonality measurements, can be useful in operational decisions and strategic business plans. In the following figure, the framework that will be used in order to examine the degree of seasonality in the dry bulk shipping sector is presented.

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Figure 2-4 The process of the examination of seasonality followed in this thesis is presented in this figure. The inputs inserted in the HEGY model are the logarithmic returns of the Baltic Capesize Index, Baltic Panamax Index, Baltic Handysize Index and Baltic Supramax Index for the respective type of vessel. The model examines whether there is a deterministic or stochastic pattern of seasonality. Finally, the existence of seasonality is checked with the appropriate model.

Chapter 3: Literature Review

3.1. *The need for forecasting in the shipping market*

The interaction between supply and demand for freight services determines the price of freight rates. The supply of shipping services depends on the available fleet, the price of second-hand vessels, the price of new building vessels, the percentage of scrapping and the offshore market. On the contrary, the demand for maritime transport services depends on world's gross domestic product, that affects the growth trade, as well as on other macroeconomic variables and characteristics of the market, that allow the free movement of products. Therefore, the freight rate can be described as the macroeconomic variable that is derived from interdependence of demand and supply. Moreover, as it is reasonable, ship-owners tend to increase the demand for new vessels, when the value of freight rates is relatively high. This is a process that affects the financing part due to the fact that the order of new building ships is characterized as a highly capital-intensive project (Goulielmos&Psifia, 2006). Banks play a crucial role in the finance of the vessel, resulting in the adaption of specific percentage of investment's risk. Because of the required security of the loan, ship-owners use to put the vessel as collateral for the repayment. Coincidentally, the financing of new vessel is based on the assessment of the current and future value and the liquidity of the asset. (Kavussanos & Visvikis, 2016). This can be separated from corporate funding, where the security of loan is based on corporate credit evaluation. Therefore, in the shipping sector, the credit evaluation process is related to value and the liquidity of the asset today and in the future. In contrast with other industries, in shipping industry, financing has been served from the industry itself and private investors, as well as institutional investors, who are looking for an incentive in order to participate in financing of the shipping industry. An exception of the above is KommanditGessellschaft (KG) fund, participating in the equity for the purchase of new vessels, as well as the purchase of second-hand vessels. This participation is raised principally from private resources. The limited access to financing and limited speculative investments prevents the investors, who do not deal with shipping investments to invest their money in the shipping industry.

However, after the breaking out of international financial crisis of 2008, the global excess supply of liquidity was looking for an advantageous return of investment and found it in the cyclicality of shipping sector, attracting private equity funds and hedge funds. Investors intended to make investments at a low cyclical point in order to make an exit in a short time of period, located in the peak of shipping cycle. This strategy represented a generous yield of return proportionally in a very short time. The exit would be succeeded by a sale of asset, when the prices of second hand vessels would have been relatively high. Alternatively, with an initial public offering (IPO) the market would price the investment according to expected improved market sentiment. Nevertheless, the exit was too difficult to be accomplished, as the cyclicality of shipping sector and offshore industries has not rebounded to the expected extent (Kavussanos&Visvikis, 2016).Thus, the above reinforce the argument that this extra access to funding for the shipping industry has led to over-ordering and to excess supply of capacity, causing the involved investors to be critical about the disappearance of the shipping cyclicality. On the other hand, many researchers acknowledge that the institutional investors are just using a self-inflicted (by the industry) opportunity in the sector (Kavussanos&Visvikis, 2016). But if it is indeed self-inflicted, a question will be raised regarding the importance of the cyclical nature of the industry, when the investors evaluate the asset risk and when they are doing asset backed financing. With this study, we will try to prove that when we are able to forecast the shipping market and risks, the potential investment in shipping industry tends to be characterized as successful.

3.2. The use of models in forecasting

The history of researches concerning the freight rate is too much extended and tries to explain the process of determination of the value of the freight rate over the years. Even Nobel Prize winners like Koopmans (1939) and Tinbergen (1959) had the incentive to explore the shipping industry. However, the determination of freight rate has not been accomplished with the use of dynamic models like GARCH, which stands for generalized auto-regressive conditional heteroskedasticity and is used for data whose variability changes in time, like freight rate. As a result, researchers like Koopmans and Tinbergen have been criticized, as they use an inelastic demand instead of a constant freight rate elasticity function. The latter is used by Wergeland (1981) and also by Kavussanos, graphing a totally inelastic demand in the short run. It is generally observed that the macroeconomic variables do not appear to be stationary and are characterized by deterministic seasonal patterns (Osborn, 1990; Beaulieu and Miron, 1992; Dickey 1993; Canova and Hansen, 1995; Kavussanos & Alizadeh, 2001). This fact can be justified in several bulk market commodities, as the petroleum and grain. These seasonal elements may have an impact in freight rates and prices. Apart from this, there are other reasons that can influence this coexistence and are usually referring to exogenous factors (war, oil prices, geopolitical issues etc.).

Moreover, Evans (1994) examined the efficiency of bulk shipping markets in the short term and in the long term and he found that in the short term, ship-owners are maximizing their profit, equalizing the marginal cost with the value of freight rate. On the other hand, in the long run the market is less efficient because of the imbalance between supply and demand and the outcome of overcapacity, leading to the malfunction of the market and eliminating the return on capital. However the theory of Evans was indeed opposed to the common sense because of the using of non-critical terms of short run and long run. This could be justified if we take into account that the shipping companies make decisions affecting the capital, like the sale of the vessel, the purchase of a new vessel and the scrapping, decisions that belong to the long run. Hence, the correlation between the values of current freight rate with the massive orders can be explained. Dijk et al (2012) established a model which proved the nonlinearity between freight rate and its determinants, like the size of the ship, the distance and the age of the ship. Moreover, Li and Parsons (1997) with the use of ARMA (autoregressive moving average) investigated the neutrality of networks for short- to long-term in order to predict the monthly tanker freight rates for the period of 1980-1995. They ended up that this neutrality of networks can outperform time series, especially for forecasts, where longer-term is concerned. Furthermore, they accepted that interactions of individual or aggregate economic variables are not purely linear.

Kavussanos and Marcoulis (1997) posed as main research the stock returns of water transportation companies using the CAPM model (Capital Asset Pricing Model). Their findings prove that the average betas, which were quantitatively smaller and stable, have many similarities with the beta of average company. In order to estimate the under-pricing, they calculated alpha which stands for the measure of the peak of the probability density function and beta for the estimation of systematic risk. (Goulielmos&Psifia, 2006). However, their last statement was controversial, as they stated that smaller companies present higher returns at higher risk in the middle of crisis. Nevertheless, Mandelbrot and Hudson (2004) rushed to notice the latter finding is due to the anomalies of CAPM model, namely capital asset pricing model.

Veenstra (1999) examined the relationship between spot and period freight rates in bulk market confirming its existence, but he concluded that no clear statement can be made regarding the efficiency of the voyage market. Moreover, for the examined period (1980-1993), he supported that the dry bulk shipping market tends to be perfectly competitive. Furthermore, with the use of his Campbell-Shiller test, Veenstra recognized that the expectation hypothesis of the term structure of freight rates is built on an inconvenient formulation, providing a no risk premium model.

Denning et al. (1994) also pointed out the existence of seasonality in Baltic Freight Index but not in the individual futures contracts on the index. In another paper Kavussanos and Alizadeh (2002), with the use of Markov switching models, explored the seasonality in the tanker market for the years 1978-1996 and they found that the use of nonlinear model is the most appropriate in order to present elements of seasonality and forecasting. Moreover, the existence of negative coefficients of excess kurtosis leads to distributions with fat tails. This is in parallel with another paper of Kavussanos (2003), where it was found that the main characteristic in tanker spot market is leptokurtosis and excess skewness, indicating again the adoption of nonlinear dynamic model. Kavussanos and Alizadeh (2001) investigated the nature of seasonality in dry bulk freight rates, measuring and comparing freight rates of different sizes in different market contracts. They proved the existence of deterministic monthly seasonality, combined with the high and low elasticities of supply. However, with the use of EGARCH-M model which is the ARCH model generalized by Nelson(1991), they did not support the Expectations Hypothesis of the term structure of freight rates for dry bulk ships, due to the existence of negative time varying risk premium. Undoubtedly, this finding is in contrast with the action of ship-owners, who are prepared to incur a loss for securing contract with longer duration. Therefore, when the prospects of market are uncertain, they must disregard the sale of vessel and the cross-subsidization between vessels of the same company, as this would reduce the importance of a company's reputation to banks, suppliers and charterers (Goulielmos&Psifia, 2006).

Most of the studies try to verify the seasonal pattern of economic series, by attempting to analyse and to compare this pattern between different sub-sectors and types of freight contracts. This interest can be explained by the importance of the seasonal pattern in econometric time series modelling, such as forecasting, which has significantly been the centre of research for economists. Moreover, studying the seasonal behaviour of the data demands a better model specification which will lead to reliable forecasts, as we have already taken into account the distortion of model's dynamics and biased results caused by this behaviour.

There are three forms of seasonal behaviour: stochastic, deterministic or a combination of the two. Time series with stochastic seasonal behaviour do not follow a unique seasonal pattern, in contrast to series with deterministic seasonality, which present the same seasonal pattern every year (Kavussanos & Alizadeh, 2001). Furthermore, stochastic seasonal series retain the shocks for a long time, while the deterministic seasonal series reduce the duration of shocks. It is crucial to distinguish the type of seasonality and particularly the stochastic seasonality, otherwise spurious regression results can be appeared (Hylleberg et al, 1990). In our literature review, we investigate whether ARIMA model (Auto Regressive Integrated Moving Average) or cointegrating VAR model (Vector Auto Regression) should be used, in order to avoid problems linked with spurious regressions results and inferences. The authors in literature review conclude that these models are helping us in order to avoid problems when we examine non-stationary time series. Distinguishing the type of seasonality can improve the forecasts and the effectiveness of econometric models. Moreover, the ability to separate the deterministic seasonality from stochastic would improve the decisions, regarding policies which are based on the seasonal behaviour of the series. For example, when a stochastic pattern exists, the policies should be revised periodically.

Hylleberg et al.(1990) as well as Beaulieu and Miron (1993) examined monthly time series and concluded that in these time series unit roots at frequencies other than zero are observed, which is a characteristic for the existence of stochastic seasonality. In order to investigate the existence of stochastic seasonality in time series, the implementation of an appropriate model is essential. Kust and Franses (2011) in their research with title ‘Testing for seasonal unit roots in monthly panels of time series’, verified the use of cross-sectional augmented Hylleberg-Engle-Granger-Yoo (CHEGY) model, when the existence of seasonality in a monthly base is examined. Moreover, Pons (2006) suggested a method that tests the seasonal unit roots in monthly US Industrial Production. This method contained the combination of quarterly and monthly seasonal unit root tests through the use of the HEGY test, that is the most appropriate when we test the existence of both monthly and quarterly seasonal unit roots.

3.3. The selection of the appropriate model

The aim of this paper is to investigate the seasonal pattern in Baltic Dry Index for monthly time series. Therefore, based on the above literature, the use of HEGY test is considered as the most suitable. The HEGY model is the one widely used to test seasonal and non-seasonal unit roots in a time series (Tasseven, 2009). With HEGY test, we will check the nature of data series, proving that these follow a deterministic seasonal pattern rather than stochastic. Hence, the null hypothesis will be accepted in case that time series has a unit root and is non-stationary. Otherwise the null hypothesis will be rejected; proving that time series follows a deterministic seasonal pattern.

The research of Frances et al. (1995) is also emphasizing the importance to investigate stochastic seasonality in a time series, before testing these series for deterministic elements. Using the Beaulieu and Miron (1993) method, logarithms of freight rates are ideal to investigate the existence of stochastic seasonality. There are models with different deterministic components, like intercept only, intercept and trend, and intercept, trend and seasonal dummies. Although constant and terms are important in regression equation, conclusions can be formulated with the regressions in all deterministic components. In order to examine the existence of stochastic seasonality, using seasonal unit roots, the most appropriate method is F statistics. The frequencies of unit roots which are zero or one are tested at the 5% level of significance. As a result, the existence of seasonal unit root at the frequencies other than zero and one is rejected and overall the nonexistence of stochastic seasonality for each freight rate series is proven. Thus, the deterministic seasonal variation is measured by regressing changes in freight rate series ΔXt, against a constant βo and a set of seasonal dummies:

$$\Delta Xt = \beta o + \sum_{i=2}^{12} \beta i Qit + \varepsilon t$$

, where βi are the parameters that display the seasonal change in the growth rates compared to the monthly average of the sample.

The seasonal dummies contain monthly prices of freight rates in order to extract the coefficient for the base month $\beta 1$ and to estimate the standard error of this coefficient. Furthermore, εt stands for a white noise error term and represents the growth rate of the ΔXt series. Hence, the importance of a dummy coefficient indicates a change in the series in specific month compared to the previous month.

Generally, in the dry bulk shipping sector, the seasonality in freight rates is deterministic rather than stochastic. The rejection of stochastic seasonal behaviour of freight rates indicates that the pattern of seasonal demand for shipping services has not changed. Consequently deterministic seasonal patterns indicate the result of weather and calendar effects, namely harvest seasons, holiday periods and change of accounting year in countries that are concerned as vital players in demand and supply for dry bulk shipping services.

Table 3-1: Literature Review

Researchers	Objective
Koopmans (1939) and Tinbergen (1959)	Investigation of shipping industry with the use of inelastic demand instead of constant freight rate elasticity.
Osborn (1990), Beaulieu and Miron (1992), Dickey (1993)	The demand for maritime services depends on the economics of the commodities transported, world economic activity and the related macroeconomic variables. These variables appear to be non-stationary with deterministic seasonal components. This seasonality is affecting the value of freight rate.
Evans (1994)	In short-run, ship-owners adjust the value of freight rate in the value of marginal cost. In long-run, it is observed inefficiency of the market due to the imbalance between demand and supply.
Denning et al. (1994)	Confirmation of seasonal pattern in the Baltic Freight Index
Li and Parsons (1997)	With the use of ARMA model, they proved the neutrality of networks which can lead to the prediction of monthly freight rates that affected by the non-linearity of economic variables.
Veenstra (1999)	The Examination of relationship between spot and freight rates leads to the adaption of non-risk premium model.
Kavussanos and Alizadeh (2001)	Time series have a deterministic seasonal component; leading to the effectiveness of policies due to the pattern of seasonality does not change over time.
Kavussanos and Alizadeh (2002)	The examination of seasonality in tanker market through the use of non-linear model can lead to the observation of seasonality and forecasting.
Dijk et al (2012)	Confirmation of non-linearity of freight rates and its determinants (vessel size, distance of route)

Tasseven (2009)	The HEGY model is the one widely used to test seasonal and non-seasonal unit roots in a time series
Kust and Frances (2011)	The use of HEGY test is applied when we examine the existence of seasonality in monthly base.
Franses et al (1995)	Logarithmic returns are used to examined the existence of stochastic seasonality in time series
Kavussanos and Alizadeh (2001)	The ensuring of the non-existence of stochastic seasonality leads to the implementation of the seasonality model.

To conclude, the examination of the kind of seasonality though the HEGY model is the first step in order to apply the model of seasonality and draw conclusions about the existence of seasonality in Baltic Dry Index for the period 2010-2016. After the presentation of theoretical part of HEGY model in chapter four we test the null and alternative hypothesis through the F statistics and the results are presented in chapter five. Therefore, the null and the alternative hypothesis can be formulated as follows:

$H_{0=}$ The time series is a random walk sequence around a stochastic tension and the freight rate level, therefore, there is a unit root and the series is non-stationary

$H_1 =$ We reject the null hypothesis; therefore tie series follows a deterministic seasonal pattern around the freight rate level,

Where, the dependent variable is the freight rate level while the independent variable is time series for the examined period January 2010 to December 2016.

Chapter 4: Methodology

In this chapter, we present tools, which will help us to approach statistical characteristics of our macroeconomic variable, namely the freight rate, in order to explore the seasonal pattern of this variable. This can be achieved through the use of descriptive statistics, giving us information about its distributional properties. Some examples of descriptive statistics are the mean, the median, the mode, the variance and the standard deviation, coefficient of skewness, coefficient of Kurtosis and coefficient of variation. Furthermore, after the description of these meanings, we will analyse in detail the appropriate model, which enables us to estimate efficiently the existence of seasonality in freight rates of the dry bulk market. Lastly, our data were obtained from Clarkson's Intelligence Database and will be transformed to logarithmic returns in order to examine the deterministic seasonality in Baltic Dry Index for the period January 2010 to December 2016.

4.1. The HEGY model

The HEGY model developed by S. Hylleberg, R.F. Engle, C.W.J. Granger and B.S. Yoo tests the existence of unit roots in time series corresponding to seasonal frequencies. With this model, authors aimed to examine the cointegration at different frequencies between consumption and income in the United Kingdom (Hylleberg et al, 1990). Moreover, there are other models that intend to test seasonal unit roots, like Dickey et al. (1984), Osborn et al. (1988), Canova and Hansen (1995) although the HEGY model is the one widely used to test seasonal and non-seasonal unit roots in a time series. (Tasseven, 2009). The first stage is to consider a time series variable X that is available at monthly frequency for period t=1,. . . ,T. The problem is to determine whether the autoregressive operator Φ in:

$$\Phi(B)X_t = \varepsilon_t \; (1)$$

contains roots exp (ikπ/6) for k=0,. . ., 6. Hylleberg et al. (1990) drew attention to the fact that all of these roots appear in the polynomial Φ if, under some conditions, in the equivalent representation

$$\Delta_{12}X_t = \alpha'(X_{t-1},\ldots,X_{t-12})' + \gamma'\left(\Delta_{12}X_{t-1},\ldots,\Delta_{12}X_{t-p}\right)' + \varepsilon_t \; (2)$$

the 12-vector α is a zero vector. The symbol Δ_{12} denotes the seasonal differencing operator. The condition α=0 can be checked by a corresponding least-squares regression or by considering the F-statistic on α, which has an asymptotic non-standard distribution.

The representation can be more informative by applying an additional transformation to the vector of level lags $X_t = (X_{t-1}, \ldots, X_{t-12})'$. In order to define that transformation matrix, we consider the 12-vectors $c_k, k = 0, \ldots, 6$, filled by $\cos(\frac{lk\pi}{6})$ for l=1,. . . ,12. Then, we consider the 12-vectors $d_k, k = 1, \ldots, 5$, filled by $\sin(\frac{lk\pi}{6})$ for l=1, . . . ,12. These are used to define a transformation matrix M by

$$M = (c_0, c_1, d_{1,} c_2, d_2, \ldots, d_5, c_6),$$

in this order. The matrix is non-singular and $(Y_t)' = (X_t)' M$ can serve as an alternative regression in the specification

$$\Delta_{12} X_t = \beta' Y_t + \gamma' (\Delta_{12} X_{t-1}, \ldots, \Delta_{12} X_{t-p})' + \varepsilon_t \ (3)$$

Γ is identical to the equation (2) and ε_t is identical to equation (1) and to equation (2). In the form (3), the entries β_k in $\beta = (\beta_1, \ldots, \beta_{12})'$ correspond to unit root events as follows. If $\beta_1 = 0$, there is a unit root at +1 and if β_{12}=0, there is a unit root at -1. If $\beta_{2k} = \beta_{2k+1} = 0$, there is a unit root at exp(ikπ/6).

Thus the null and alternative hypotheses can be formulated as follows:

$$[H_o: \alpha = 0],$$

$$[H_1: \alpha < 0]$$

The use of F-test is appropriate for the hypothesis, because the pairs of complex roots cannot be distinguished and they always operate together (Kavussanos & Alizadeh, 2002). The non-rejection of the first hypothesis would mean a unit root at the zero frequency or a non-seasonal unit root in the series.

Therefore, by checking the $F_{i,i+1}$ statistics we test the existence of seasonal unit roots at the frequencies other than zero and one and we reject the hypothesis at the 5% level of significance. With this we can infer that the existence of stochastic seasonality is rejected including all sub-markets in the dry bulk market for the period 2010-2016.

Thus, the estimation of deterministic seasonal variations in time series is succeeded by regressing changes in freight rates ΔX_t, against a constant $\beta_0$and a set of seasonal dummy variables, as in the following equation:

$$\Delta^s X_t = \beta_0 + \sum_{i=2}^{12} \beta_i Q_{it} + \varepsilon_t$$

Where $\Delta^s X_t$=$X_t - X_{t-s}$

And β_i are the parameters of interest which show us the seasonal increase or decrease in the freight rates compared to the monthly average of the sample

$Q_{i,t}$ are the relative seasonal dummies,

i= 2, …,12 is the range of the number of periods that the variable is measured over the year. 12 is used because of our monthly data series.

And ε_t which is the white noise error term.

With the application of the t-statistic, we indicate the significant increase or decrease in monthly freight rate growth at a specific month compared to the average of the sample period. Moreover, we try to explain the cause of the variability in the values of freight rates and prove that the aggregate demand for international transport is responsible for the existence of co-movements between time series in the long run while some distinct factors, like the trade in commodities, create these fluctuations in the behaviour of freight rates in the short run.

4.2. Location Measurements

The location measurements contain the arithmetic mean, the median and the mode. The arithmetic mean represents the average value of returns of time series. The median defines the middle number of time series while the mode shows the value with the highest frequency in time series.

4.2.1. The arithmetic mean

In statistics, the population mean represents the value that provides the average value of probability distribution or of the random variable. For instance, for a random variable X, the arithmetic mean is calculated by the sum of each possible value x of X and its probability, namely:

$$\mu = \frac{\sum_{i=1}^{n} x_i}{n}$$

On the contrary, for a data set, the mean is called sample mean and is calculated from a group of random variables drawn from the population. It is definitely used to estimate the population mean when the population mean is unknown and holds the same expected value. The sample mean is defined by the following formula:

$$\chi = \frac{\sum_i^N x_i}{N}$$

4.2.2. The median

The median represents the middle number in a list of numbers and can be used to define an average value. In order to determine the value of median in a sequence of numbers we have to arrange the numbers from the lowest to the highest. If the numbers of list constitute an odd number, the value of median is the middle number. On the contrary, if there is an even amount of numbers in a list, we have to add the middle pair and divided by two in order to determine the median value.

4.2.3. The mode

When we examine a sample or a population, the value that has the highest frequency is called the mode. In case of none number in a list occurs more than once that means there is no mode number. While, when two or more numbers of a set have the same frequency these numbers are modes of the set.

4.3. Variability Measurements

In order to estimate the variability of a data set it is important to calculate the variance, the standard deviation, the coefficient of kurtosis, the coefficient of skewness and the Jarque-Bera test which checks the normality of the data set.

4.3.1. The Variance

The main characteristic of the variance is that it measures the average of squared deviations from their mean. In case of population, the calculation of the variance succeeded by taking the differences between each number and the arithmetic mean, squaring them and dividing the sum of the squares by the total number of observations. In case of a sample, the only difference is that the sum of squares is divided by the number of observations minus one. This occurs in order to avoid statistical errors for a small sample. Then, we present the equations of population variance and of sample variance:

Population Variance: $\sigma^2 = \frac{\sum_{i=1}^{N}(\chi_i - \mu)^2}{N}$

Sample Variance: $S^2 = \frac{\Sigma_{i=1}^{n}(x_i - \overline{x})^2}{n-1}$

4.3.2. The Standard Deviation

The standard deviation measures the dispersion of the data set from its mean and is calculated as the square root of the variance. Moreover, the standard deviation has the same unit of measurement as the data set. The formula that determines the standard deviation is the following:

Population Standard Deviation: $\sigma = \sqrt{\sigma^2}$

Sample Standard Deviation: $s = \sqrt{s^2}$

In this thesis, we use the percentage changes of BDI Index and not the index itself. This allows us to have more reliable results when we estimate the variance and the standard deviation. There are two ways (periodic returns and logarithmic returns) to estimate the returns (Salkind & Rasmussen, 2007):

Periodic Returns: $\frac{P_t - P_{t-1}}{(P_{t-1})} = \frac{P_t}{(P_{t-1})} - 1$

Logarithmic Returns: $r_t = \ln(\frac{P_t}{P_{t-1}}) = \ln(P_t) - \ln(P_{t-1})$

4.3.3. The Coefficient of skewness

The coefficient of skewness is used to describe the asymmetry of a distribution around the mean, giving information about the shape of distribution. The forms of a distribution are symmetrical, left skewed and right skewed. When the distribution of a data set is skewed to the right, the mean and the median are both greater than the mode. While, the distribution where a data set is skewed to the left the mode is smaller than the mean and the median. In case of a symmetric distribution the mode is equal with the mean and the mode. The formula that defines the coefficient of skewness is presented below:

Coefficient of skewness: $\gamma_{1=} E\left[(\frac{X-\mu}{\sigma})^3\right]$

When $\gamma_1 = 0, mean = median = mode$

$$\gamma_1 < 0, mean < median < mode$$

$$\gamma_1 > 0, mean > median > mode$$

4.3.4. The Coefficient of kyrtosis

The coefficient of kyrtosis measures the peakedness of a distribution. When the coefficient of kurtosis is high, the values close to the mean are more frequent, while the low coefficient of kyrtosis ensures that the distribution is less peaked and has thinner tails. The coefficient of kyrtosis is calculated by the following formula:

$$K = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^4}{\left[\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2)}\right]^4}$$

When K=3, the distribution is similar to the normal distribution

K< 3, the distribution is called platykurtic and the variables that found around the mean are small

K> 3, the distribution is called leptokurtic and most of the variables are found around the mean.

4.3.5. The Coefficient of Variation

The coefficient of variation measures the dispersion of a data set, either a population or a sample. The higher the coefficient of a variation the more dispersed the data is around the mean (Herve, 2010). It is calculated by dividing the standard deviation by the mean. Usually, the coefficient of variation is expressed as a percentage and given by the following formula

$$CV = \frac{\sigma}{\mu} * 100$$

With the help of Eviews software, we will present on the next chapter the results in the returns of each index.

4.3.6. The Jarque-Bera test

The Jarque-Bera test is similar with the Lagrange multiplier test and tests through the skewness and kurtosis the normality of data series. Usually, the Jarque-Bera test is run before the t-test and F-test in order the normality of test to be confirmed. The Jarque-Bera test is recommended for a large sample. Moreover the Jarque-Bera test can be applied without knowing the mean and standard deviation, creating an extra advantage for this model. The null hypothesis is that the data have normal distribution while the alternative hypothesis is that the data do not follow a normal distribution. The formula for the Jarque-Bera test is presented below:

$$JB = n[\frac{\sqrt{b_1}]^2}{6} + (\frac{b_2 - 3)^2}{24}]$$

Where n is the sample size

$\sqrt{b_1}$ Is the sample coefficient of skewness

b_2 Is the sample coefficient of kurtosis

In this chapter we presented the HEGY test that is used to investigate the nature of the data, which can be deterministic or stochastic or a combination of two. The determination of the kind of seasonality is critical for avoiding problems regarding spurious regression results, and by taking into account the deterministic seasonality, we can improve the results of the adopted econometric model. Moreover, our data have been converted to logarithmic returns of the monthly values of freight rates as Frances et al (1995) proposed, when we examine the existence of seasonal pattern in time series. Then we presented some of the descriptive statistics that will be useful for the description of characteristics of these returns. In the following chapter, we will present the results of seasonality and will examine the descriptive statistics of logarithmic returns of monthly spot rates for the period January 1st 2010 to December 31st 2016 in all examined vessels' size of dry bulk global market.

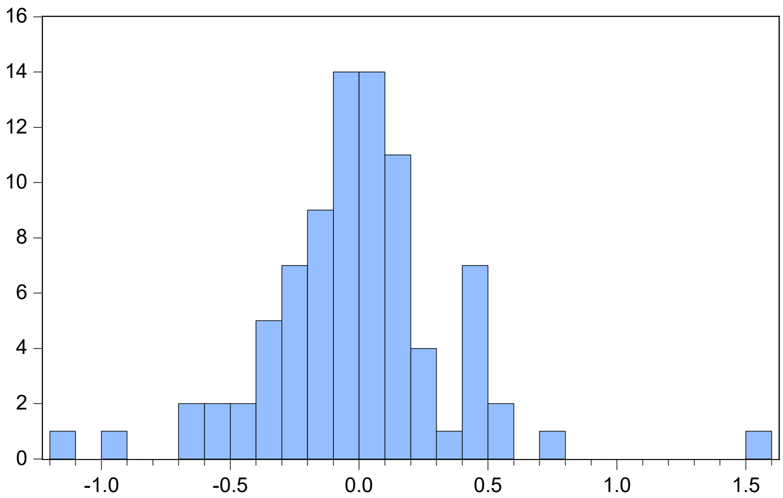
Chapter 5: Data Analysis and presentation of descriptive statistics

Our data set comprises monthly observations of the dry bulk freight rates for four vessels' size sub-indices, Capesize, Handysize, Panamax and Supramax. The data was obtained from January 1st 2010 to December 31st 2016, when the bursting of financial crisis of 2008 occurred, letting us form the opinion that shipping companies have altered their strategies and have been adapted in the new facts of shipping sector. Furthermore, the data have been taken from the Clarkson Shipping Intelligence Database and have been transformed to the percentage of logarithmic returns. Hence, in this chapter, the logarithmic returns will be tested though the HEGY test to check whether they are stochastic or deterministic. Finally, the selection of the aforementioned categories of vessel size covers almost the whole specific sector and we hope that will let us form an overall display of the seasonality pattern in the values of freight rates.

(Note A: for HEGY test results see appendix 1)

5.1. Descriptive Statistics

In this chapter, we will present and will analyse the descriptive statistics of logarithmic returns of monthly spot rates for the period January 1st 2010 to December 31st 2016 in all examined vessels' size of dry bulk global market.



Series: RETURNS	
Sample 2010M01 2016M12	
Observations 84	
Mean	-0.011653
Median	-0.002922
Maximum	1.509296
Minimum	-1.176800
Std. Dev.	0.359690
Skewness	0.307444
Kurtosis	6.836713
Jarque-Bera	52.84460
Probability	0.000000

Figure 5-1 Capesize Descriptive Statistics

In figure 5.1, we can observe that the values of Baltic Capesize Index fluctuate from 150% to -117%. The standard deviation is 35.9%. The skewness of this index is slightly negatively skewed. Moreover, the distribution can be characterized as leptokurtic because its value is bigger than 3.

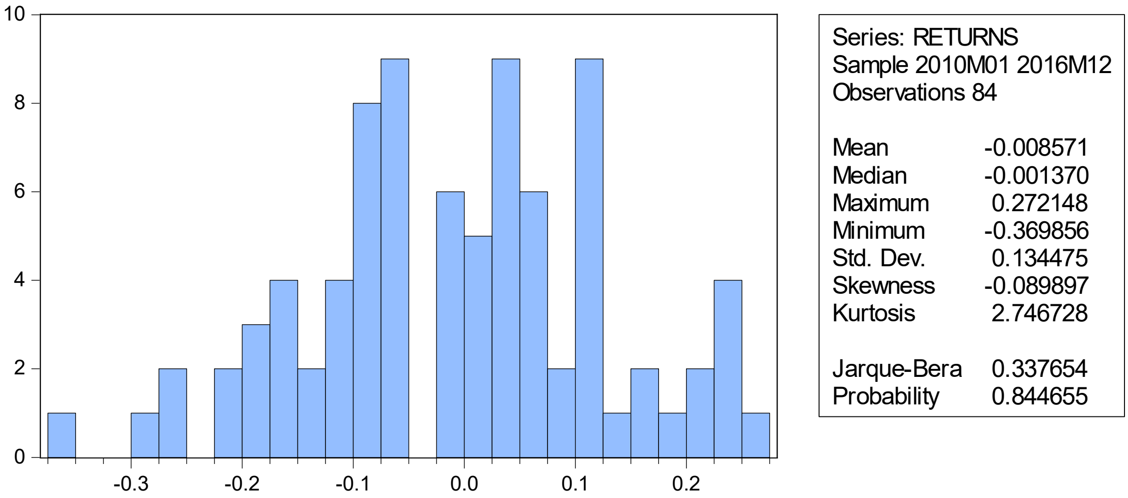


Figure 5-2 Handysize Descriptive Statistics

In figure 5.2, the descriptive statistics of Handysize returns are presented. The values present fluctuations from 27.2% to -36.9%. The standard deviation is 13.4%. The distribution is positively left skewed and it can be characterized as platykurtic.

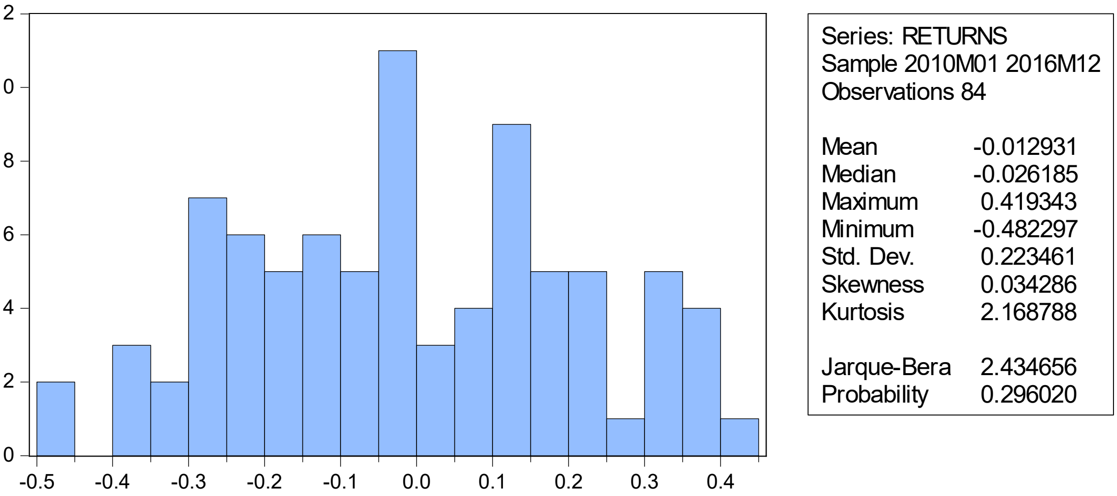


Figure 5-3 Panamax Descriptive Statistics

In figure 5.3, the descriptive statistics of Panamax returns are presented. The values fluctuate from 41.9% to -48.2%. The standard deviation is 22.3%. This distribution is negatively skewed and it can be characterized as platykurtic due to the fact that its value is smaller than 3.

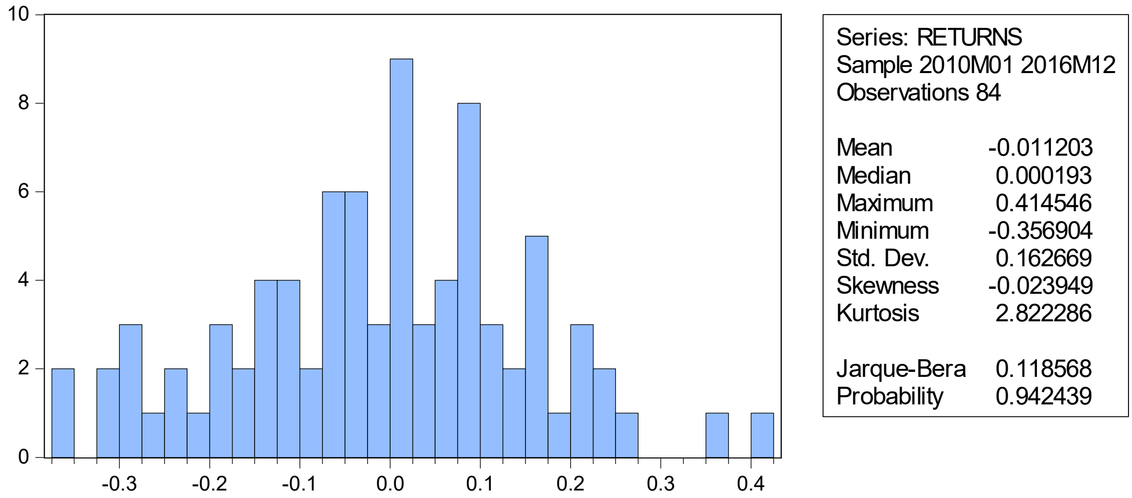


Figure 5-4 Supramax Descriptive Statistics

In figure 5.4, the descriptive statistics of Supramax returns are presented. The values fluctuate from 41.4% to 35.6%. The standard deviation is 16.2%. The distribution is positively skewed and it can be characterized as platykurtic.

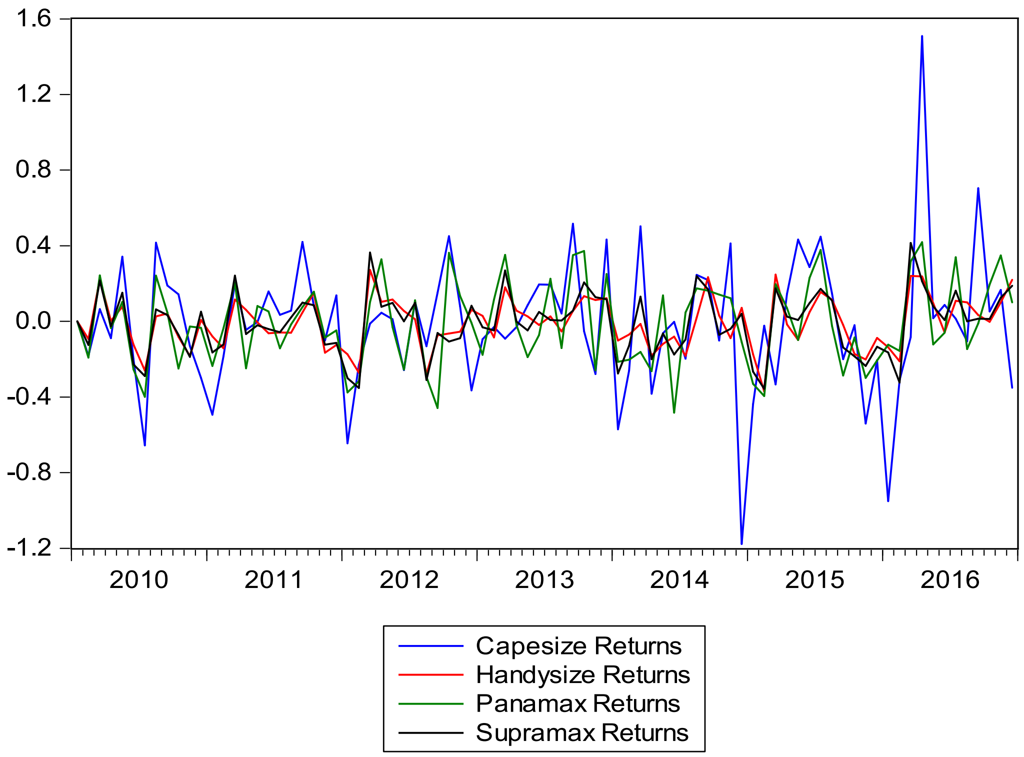


Figure 5-5 The progress of spot freight rates for different size dry bulk carriers

Table 5-1 Summary statistics of logarithmic dry bulk freight rates, sample: 2010:1-2016:12

	CAPESIZE RETURNS	*HANDYSIZE RETURNS*	*PANAMAX RETURNS*	*SUPRAMAX RETURNS*
Mean	-0.011653	-0.008571	-0.012931	-0.011203
Median	-0.002922	-0.001370	-0.026185	0.000193
Maximum	1.509296	0.272148	0.419343	0.414546
Minimum	-1.176800	-0.369856	-0.482297	-0.356904
Std. Dev.	0.359690	0.134475	0.223461	0.162669
Skewness	0.307444	-0.089897	0.034286	-0.023949
Kurtosis	6.836713	2.746728	2.168788	2.822286
Jarque-Bera	52.84460	0.337654	2.434656	0.118568
Probability	0.000000	0.844655	0.296020	0.942439
Sum	-0.978818	-0.719954	-1.086211	-0.941026
Sum Sq. Dev.	10.73830	1.500936	4.144590	2.196277
Observations	84	84	84	84

In table 5.1, a summary of descriptive statistics of logarithmic dry bulk freight rates is presented. Firstly, we can mention that the greatest fluctuations are observed in Baltic Capesize Index. Furthermore, we can observe that the mean values of spot rates are higher for smaller vessels than for larger vessels. For instance, the mean value of Panamax sub-market is -0.012 while the mean value of Handysize sub-market is -0.011. This can be explained by the fact that the value of spot rates in the dry bulk market is estimated by the method of a dollar per ton. Consequently, larger vessels succeed higher economies of scale through the transportation of commodities, resulting to the decrease in the value of spot rates, proving that these vessels provide smaller mean value.

Moreover, with Jarque-Bera results, we can conclude that all the series are heteroscedastic, auto correlated and non-normal at all significance levels, rejecting the null hypothesis. Finally, the negative coefficient of Skewness for Handysize vessels and Supramax vessels indicates flat and left skewed distributions, while the coefficient of Skewness for Capesize sub-market indicates a leptokurtic distribution.

5.2. Capesize Results

The figure 5.6 displays the performance of the Baltic Capesize Index (BCI) which consists of four time charter routes from January 1st 2010 until December 31st 2016 while the figure 5.7 shows the logarithmic returns for the Baltic Capesize Index (BCI).

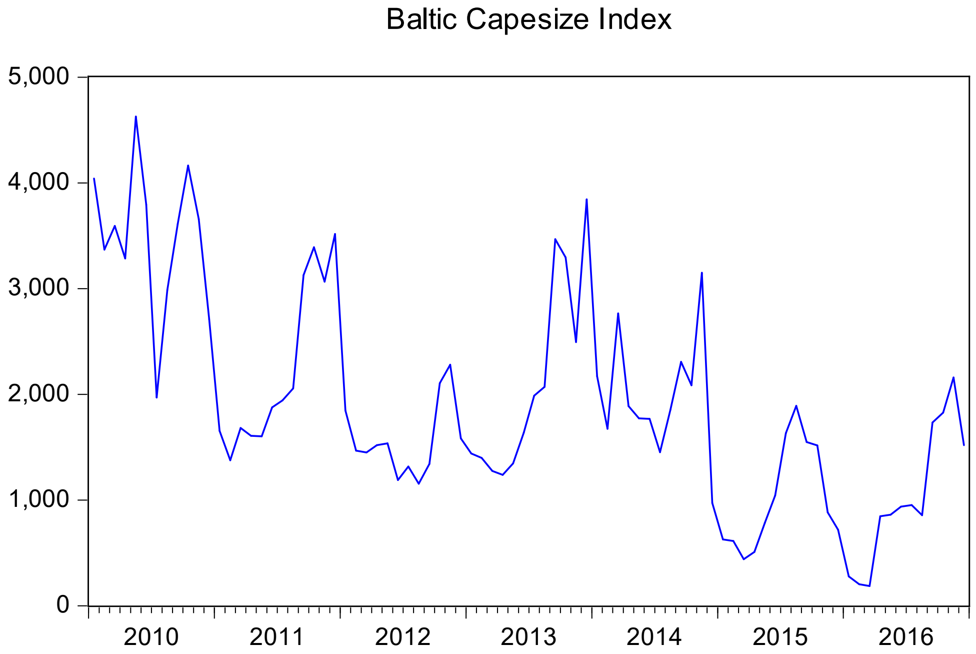


Figure 5-6 Baltic Capesize Index 01/01/2010-31/12/2016

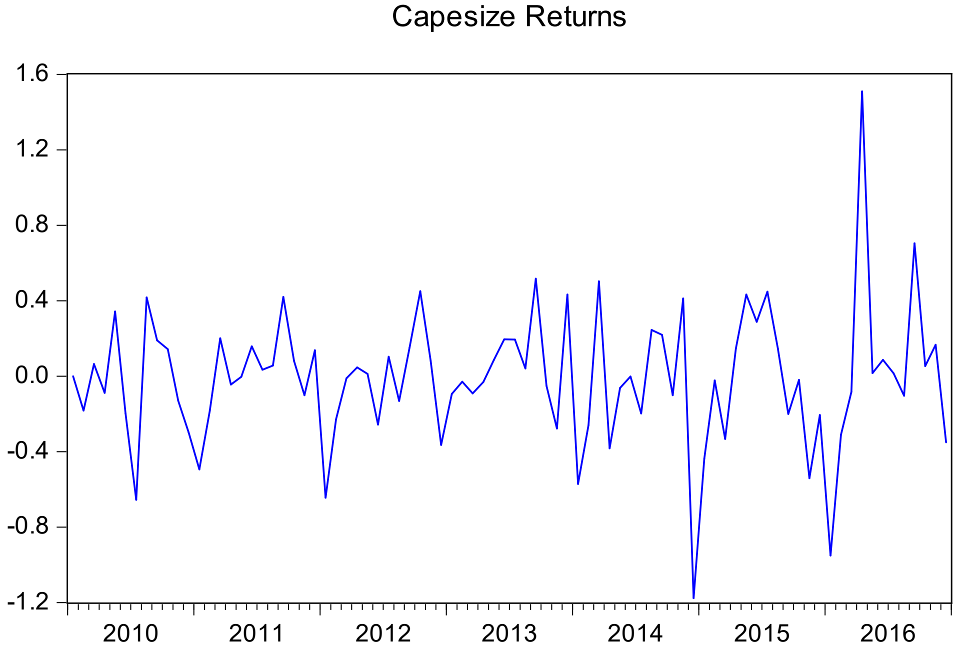


Figure 5-7 Capesize Returns 01/01/2010-31/12/2016

Applying the HEGY test with a trend, an intercept and seasonal dummies, we check for the existence of seasonal unit roots at the frequencies other than zero and one and we reject the null hypothesis (F=4.91) at the 5% level of significance, proving that the existence of stochastic seasonality at all seasonal frequencies is rejected for the Capesize market for the period 2010-2016.

5.3. Handysize Results

The figure 5.8 displays the performance of the Baltic Handysize Index (BHI) which consists of six time charter routes from January 1st 2010 until December 31st 2016 while the figure 5.9 shows the logarithmic returns for the Baltic Handysize Index (BHI).

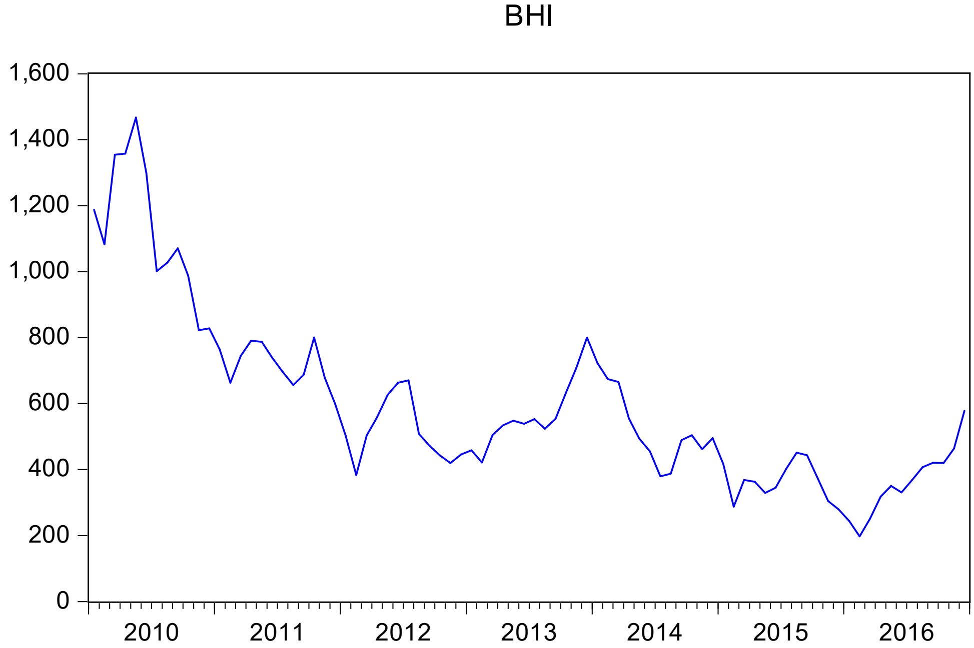


Figure 5-8 Baltic Handysize Index 01/01/2010-31/12/2016

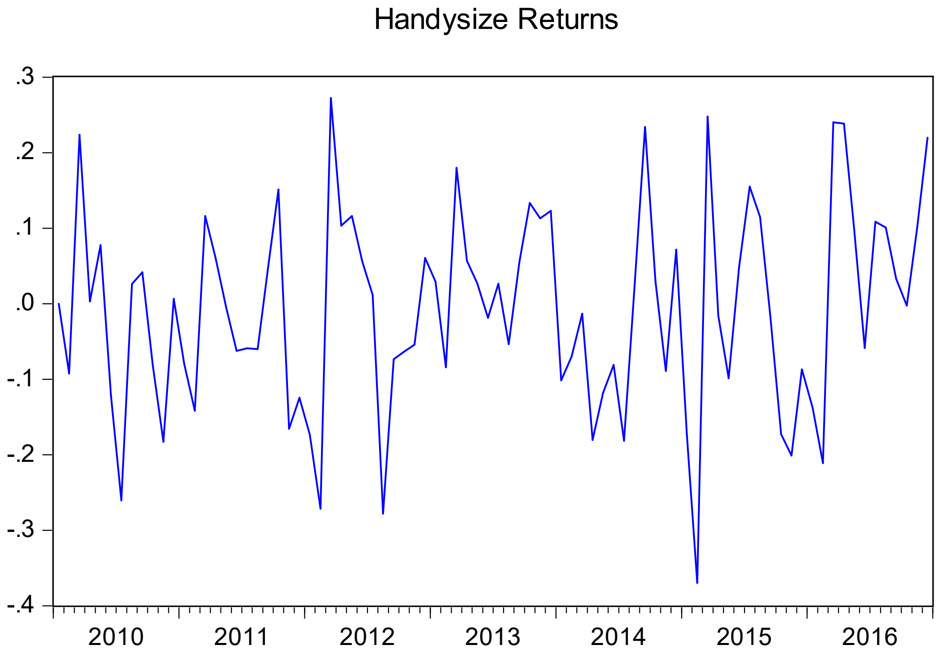


Figure 5-9 Handysize Returns 01/01/2010-31/12/2016

Applying the HEGY test, with a trend, an intercept and seasonal dummies, we reject the null hypothesis (F=5.1) at all seasonal frequencies, showing that the data series for Handysize market follows a deterministic seasonal pattern for the period 2010-2016.

5.4. Panamax Results

The figure 5.10 displays the performance of the Baltic Panamax Index (BPI) which consists of four time charter routes from January 1st 2010 until December 31st 2016 while the figure 5.11 shows the logarithmic returns for the Baltic Panamax Index (BPI)

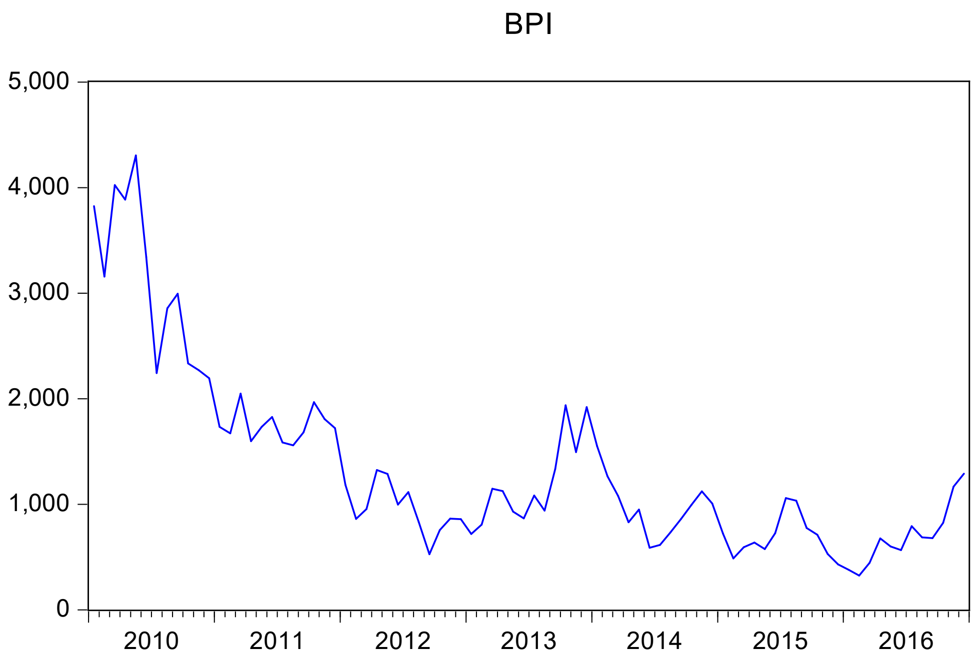


Figure 5-10 Baltic Panamax Index 01/01/2010-31/12/2016

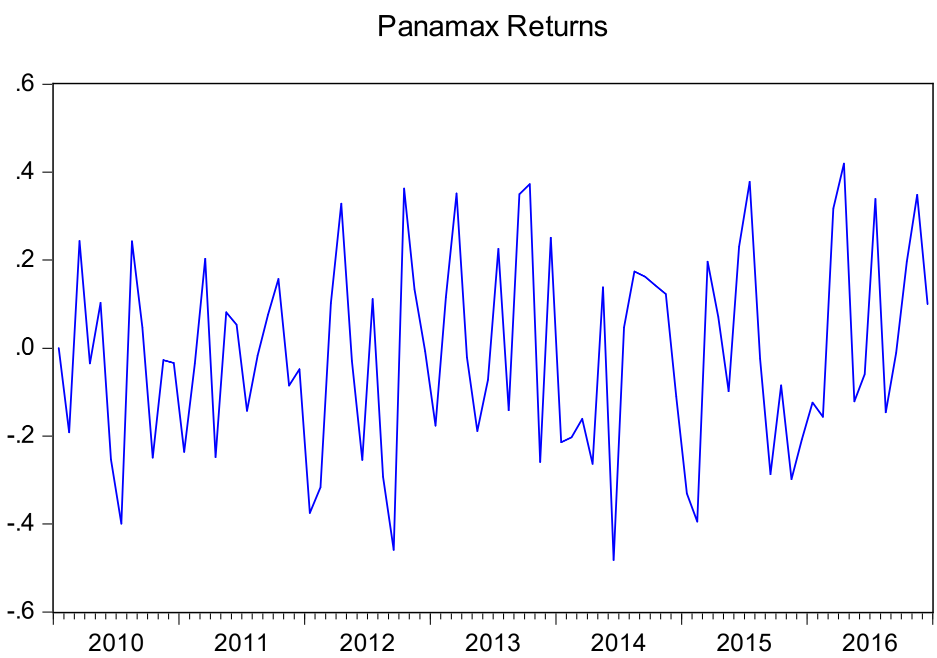


Figure 5-11 Panamax Returns 01/01/2010-31/12/2016

The results of HEGY test with a trend, an intercept and seasonal dummies show that the null hypothesis is rejected (F=5.27) for all seasonal frequencies concluding that the Panamax sub-index market consists of deterministic seasonal pattern for the period 2010-2016.

5.5. Supramax Results

The figure 5.12 displays the performance of the Baltic Supramax Index (BSI) which consists of six time charter routes from January 1st 2010 until December 31st 2016 while the figure 5.13 shows the logarithmic returns for the Baltic Supramax Index (BS)I

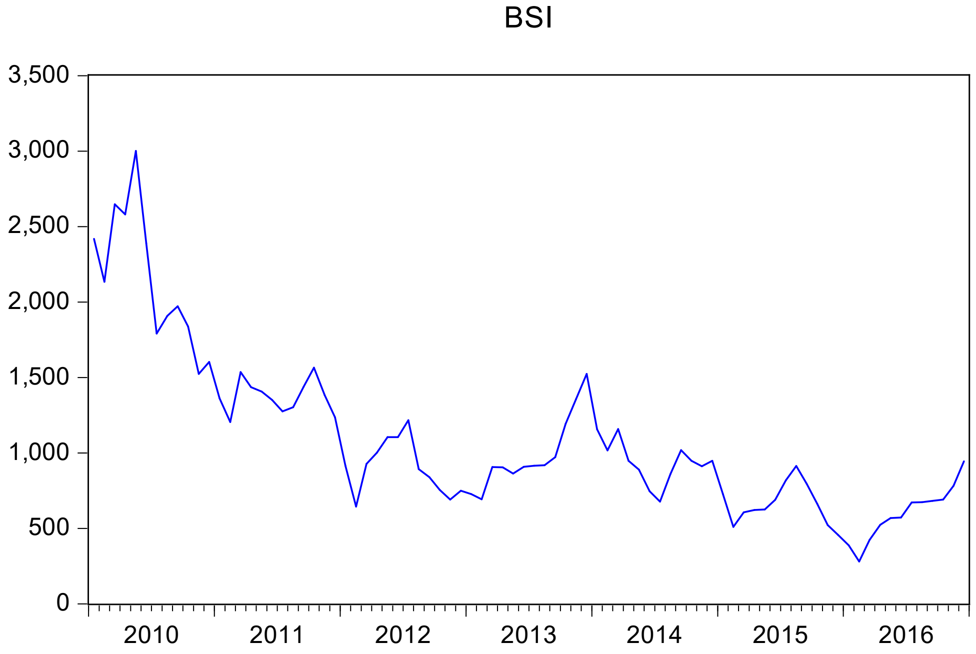


Figure 5-12 Baltic Supramax Index 01/01/2010-31/12/2016

Supramax Returns

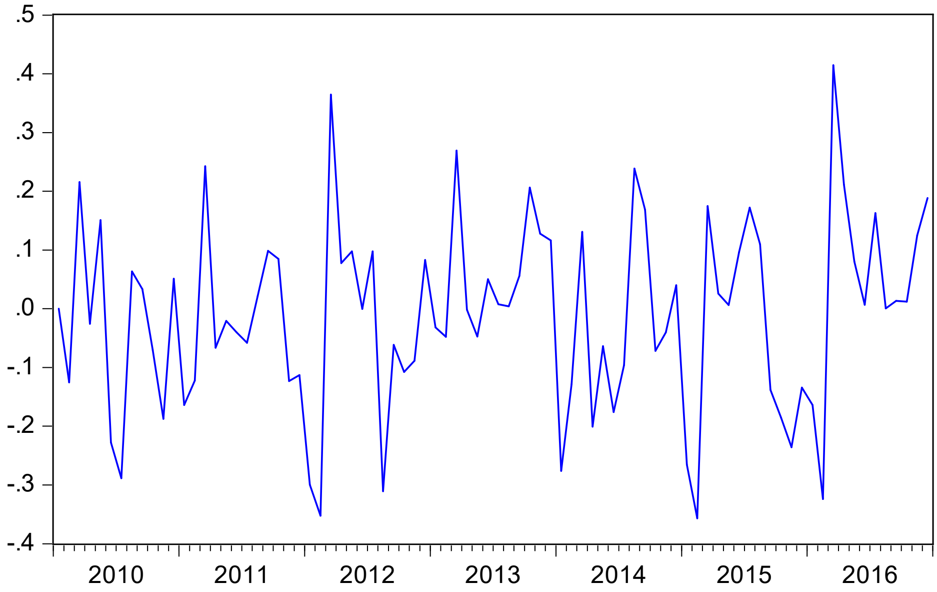


Figure 5-13 Supramax Returns 01/01/2010-31/12/2016

The results of the HEGY test with a trend, an intercept and seasonal dummies indicate that there is no unit seasonal root rejecting the null hypothesis (F=5.79) for all frequencies, letting us to conclude that Supramax sub-index follows a deterministic seasonal pattern for the period 2010-2016.

5.6. The results of seasonality

Table 5.2 summarizes the results of significant increase or decrease in monthly freight rate growth.

Table 5-2 Deterministic seasonality in dry bulk freight rate series from 01/01/2010 to 31/12/2016

(The corresponding t-values are presented in brackets)

		Spot Rates			
Month	**Coefficient**	**Capesize**	**Panamax**	**Handysize**	**Supramax**
Constant	β_0	-0.0117 (-0.36)	-0.0129 (-0.61)	-0.0086 (-0.75)	-0.0112 (-0.87)
January	β_1	-0.4445 (-4.08)	-0.1951 (-2.78)	-0.0824 (-2.18)	-0.1603 (-3.76)
February	β_2	-0.1626	-0.1560	-0.1688	-0.1969

		(-1.49)	(-2.23)	(-4.47)	(-4.61)
March	β_3	0.0470 (0.43)	0.1919 (2.74)	0.1895 (5.02)	0.2700 (6.33)
April	β_4	0.1766 (1.62)	0.0487 (0.69)	0.0465 (1.23)	0.1410 (0.33)
May	β_5	0.1289 (1.18)	-0.0037 (-0.05)	0.0219 (0.58)	0.0403 (0.94)
June	β_6	0.0501 (0.46)	-0.1069 (-1.53)	-0.0256 (-0.68)	-0.0304 (-0.71)
July	β_7	0.0029 (0.03)	0.0928 (1.32)	-0.0199 (-0.53)	0.0108 (0.25)
August	β_8	0.1074 (0.99)	-0.0164 (-0.23)	-0.010 (-0.27)	0.0294 (0.69)
September	β_9	0.2972 (2.73)	-0.0045 (-0.06)	0.0541 (1.43)	0.0356 (0.83)
October	β_{10}	0.0908 (0.83)	0.1410 (2.01)	-0.0077 (0.20)	-0.0076 (-0.18)
November	β_{11}	-0.0442 (-0.41)	0.0036 (0.05)	-0.0599 (-1.59)	-0.0491 (-1.15)
December	β_{12}	-0.2495 (-2.29)	0.0048 (0.07)	0.0470 (1.25)	0.0444 (1.04)

(Note B: For each sub-segment seasonality and its respective t-value see appendix 2)

As shown in the above Table, the spot rates for Capesize bulk carriers increase significantly by 17.6% and 12.8% for the months April and May respectively. The t-values for these months prove that there is a statistically significant increase in monthly freight rate growth. ($t_{April} = 1.62, t_{May} = 1.18$)

Furthermore, Panamax spot rates increase by 19.19% in March, while Supramax spot rates increase by 27% and Handysize spot rates by 18.9% for the same month, presenting a significant seasonal increase for these two major sub-markets. The t-values of these sub-segments indicate that there is a statistically significant increase at this particular month.

$March\text{: }(\text{Panamax}_{t-value} = 2.74, Supramax_{t-valu} = 6.33, Handysize_{t-val} = 5.02)$

Another result that draws our attention is the Panamax spot rates, which increase by approximately 14% in October and can be characterized as statistically significant since the t-value is 2.01. On the contrary, a decrease is observed for Handysize and Supramax spot rates during the autumn. Moreover, there is a decline in spot rates for all size of vessels during June and July. Specifically, during June, Panamax spot rates decrease by 10%, Handysize spot rates by 2.5% in June and 2% in July. The t-values indicate that there is a significant decrease in monthly freight rate growth. ($\text{Panamax}_{t-val} = -1.53 Handysize_{t-val} = -0.68, Capesize_{t-value} = 0.46$). Finally, Supramax spot rates fall by 3% for the same period. $Supramax_{t-val}$ =-0.71) However, this decline is more noticeable in larger vessels compared to smaller ones.

Lastly, there is a significant decrease in monthly freight rates for all types of vessels during January. Capesize spot rates decrease by 44%, Panamax spot rates by 19%, Handysize spot rates by 8% and Supramax spot rates by 16%. The t-value of each sub-segment for this particular month is an indication of this significant decrease at January. ($\text{Panamax}_{t-value} = -2.78, Supramax_{t-val} = -3.76, Handysize_{t-value} = -2.18, Capesize_{t-val} = -4.08$).

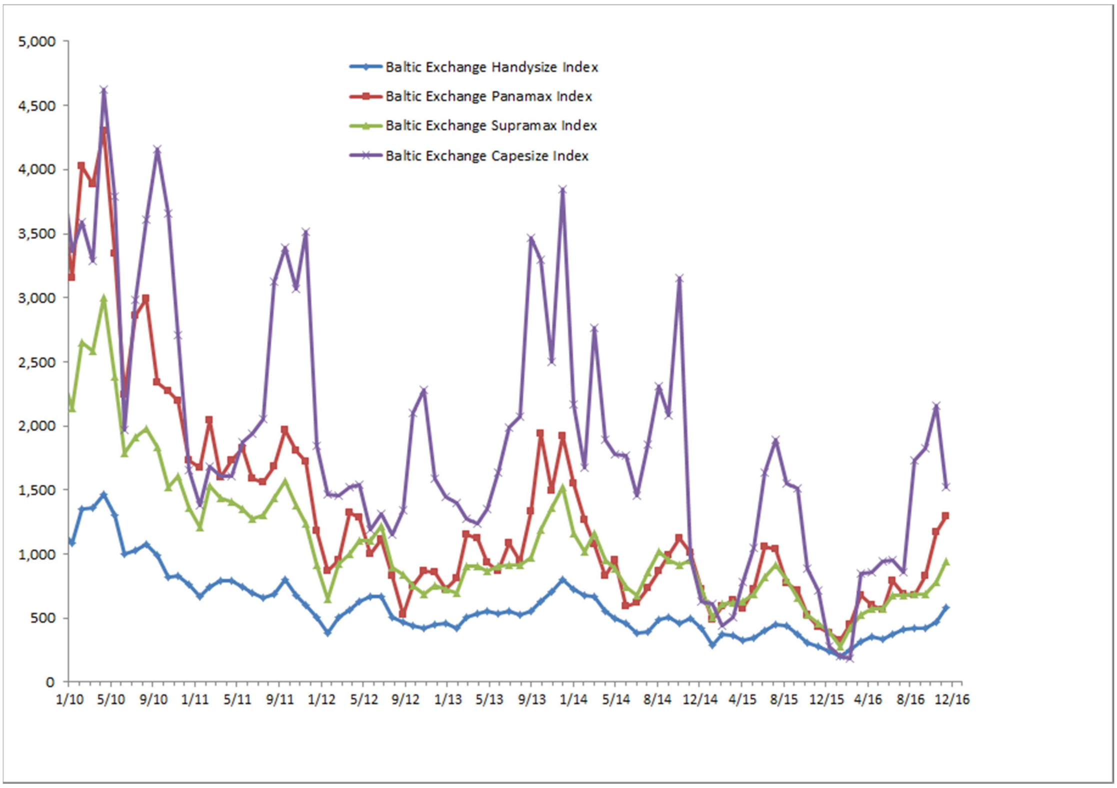


Figure 5-14 The BDI freight rate market for the sample period: 2010:1-2016:12

In this chapter, we presented the descriptive statistics analysing the differences in the mean values for each sub-sector and the characteristics of each distribution through the examination of coefficient of skewness and kyrtosis. In addition, the HEGY test was applied, rejecting the existence of stochastic seasonality in data series. Finally, we summarized the results of seasonality which showed remarkable fluctuations in the spot freight market.

The fluctuations in values of dry bulk freight rates may be useful for those who are able to recognize the seasonal pattern of the dry bulk market, exploiting the knowledge of systematic seasonality, in order to avoid a negative cash flow and to swift to other markets, where a better outcome is expected. In the following chapter, we will attempt to give the reasons for the existence of these fluctuations emerged by applying the model of seasonality. Furthermore, the limitations of this thesis will be discussed and further investigation that could be made on this issue.

Chapter 6: Discussion

6.1. Interpretation of the obtained results

Analysing the data with the model of seasonality, the following results for the different size of vessels were obtained:

Spot rates for Capesize bulk carriers increase significantly by 17.6% during April and 12.8% during May. Panamax spot rates increase by 19.19% in March. Moreover, there is a significant seasonal increase in Handysize spot rates in both March and April by 18.9% and 4.6%, while in Supramax spot rates an increase of 27% in April is observed.

On the contrary, in January, spot freight rates present a general decline for all types of vessels. Specifically, the biggest decrease is observed in Capesize spot rates, which fall by 44%. Panamax spot rates also decrease by 19%, Supramax spot rates decrease by 16% and Handysize spot rates decline by 8% for the same examined month. Furthermore, during the summer period, spot rates for all types of vessels show a decrease, which is lower than the decrease observed in the beginning of the year. Panamax spot rates decrease by 10% in June; Handysize spot rates decline by 2.5% in June and 2% in July and Supramax spot rates has dropped by 3% in July.

As shown, there is an increase in the percentage of dry bulk spot rates for all the type of vessels and this can be explained by the constantly increased demand for Japanese imports for all type of dry bulk commodities (grain, coal and iron ore). This increased demand emerged from the end of the fiscal year in Japan, which occurs in the end of March. Moreover, the harvest period in exporting countries such as Australia and Argentina takes place from February to March causing an increase in demand in Handysize and Panamax dry bulk carriers during March, April and May. The use of the vessels and the increased demand described above may be due to the fact that in these countries of production the shortage facilities are limited for all commodities. Another reason is the structure of these ports which unlike the other export ports are narrow and cause limitations which lead to the immediate export of the grain commodities. Hence, in order to achieve some flexibility, the transportation of the exported commodities is serviced by type of vessels of smaller size e.g. Handysize and Panamax. With these types of vessels, the restrictions caused by the maximum limitation of draught and depth are as much as possible abolished. Furthermore, the existence of larger inventories in the Northern Hemisphere shows a reduction in stock levels during March and April, due to the upcoming harvest season which requires adequate storage area, leading to the rise of demand in Handysize and Panamax vessels and consequently of the percentage of freight rates in this season. Though, Supramax and Capesize vessels are also affected by the increase in demand for smaller vessels, since the latter have caused a swift in the maritime market, trying to service the increased demand for transportation of grain. This situation has a positive impact in the bigger vessels because of the inconsistency between the increased demand and under-supply.

In addition, the observed increase in spot rates of Panamax carriers during October and November by 14% is worth mentioning. It can be explained by the fact that the Panamax vessels are sometimes involved in the transportation of coal and grain from US Gulf. Therefore the rise of Panamax spot freight rates can be justified by the US grain exports since the harvest period occurs between June and October proving the emergency of transportation in the following months. Furthermore, the necessity of coal storage for the upcoming winter may contribute to this rise. Moreover, the results reveal a generalized reduce in the percentage of spot freight rates during in June and July for all of the four types of vessels. In the bigger vessels this reduce becomes even more intensive while smaller vessels have the ability to swift to other routes and type of cargo easier than bigger vessels. Generally, the decline in the demand during the summer months coincides with the start of holiday season and the fall in demand for industrial output for industrialized countries (Beaulieu & Miron, 1991). Lastly, a significant decrease occurred for all types of vessels at the beginning of the year and especially in January. This fact can be explained by the delivery of new vessels which start being chartered and operating at the beginning of the upcoming year, causing over-supply in the dry bulk market.

By general admission, Capesize contracts refer to long term. As a consequence, the most part of cargo is occupied by this type of vessels reducing the remaining cargo for the rest market. Hence, in case that a shock to the spot freight market occurs, this shock is reflected more to Capesize rates than to smaller vessels. The results stand in accordance with other researches proving that freight rates for larger vessels are more volatile than smaller ones.

6.2. Conclusion

In this thesis, the existence and the kind of seasonality in dry bulk shipping sector were analysed. The selected sample concerns the period from January 2010 to December 2016 and contains the four fundamental sub-sectors of dry bulk market, namely Capesize, Panamax, Supramax and Handysize. The indicators that were used were based on the Baltic Dry Index.

Logarithmic returns of freight rates were used in order to explore the kind of seasonality that can be stochastic, deterministic and a combination of two. These returns seem to not have a seasonal unit root proving the rejection of stochastic seasonality. In addition, since we have proved the non-stationarity of time series, we concluded that in time series a regular seasonal pattern is shown, namely the deterministic seasonality.

Moreover, descriptive statistics were applied in order to define the characteristics of each sub-sector.

Our results justify the increase in spot freight rates during March, April and May, while there is a significant drop in the spot freight rates at the beginning of the year, especially in January, as well as in summer months namely June and July. As Panamax and Handysize spot rates are concerned, a significant rise is shown in the autumn months. The contrast between seasonal variations in freight rates for different size carriers provides an incentive for multi-vessel companies to diversify and extend their investments to vessels of different sizes (Kavussanos & Alizadeh, 2001). Moreover, the t-values reveal the statistically significance of these fluctuations.

The importance of results can be characterized as major, due to the fact that ship-owners can use information about seasonal fluctuations in spot freight market in order to make optimal decisions, such as sending the ship to dry-dock in seasons that freight rates are expected to fall (e.g. July and August in the dry bulk market) or to increase productivity during peak seasons (e.g. March, April and May) (Kavussanos & Alizadeh, 2001). In this example, we can detect whether the seasonality has a positive or negative impact on the Dry bulk Index and answer to the initial research question. The response received is that the impact of seasonality depends on what extent someone is able to recognize its behaviour. Taking into account the results presented in table 5.2, one can incorrectly conclude that there is randomness in the sign of seasonality. However, if someone investigates the existence of seasonality for each type of vessel, he will realize that there is a causality of this behaviour. For example, the rise of Panamax and Handysize spot freight rates in the autumn months indicates the ability of these types of vessels to service different stages of demand for dry bulk sea transportation. Therefore, better understanding of seasonality will allow the ship-owner and other involved parties to take advantage of the positive values of this pattern, through for example the use of shipping freight derivatives.

6.3. Limitations and Further Investigation

In this thesis, the observed seasonality of monthly spot freight rates was presented concluding to significant results in the variety of seasonality in the dry bulk market. However, this thesis was focused only on the spot contract market, without examining the degree of seasonality when the duration of contract changes. A more detailed research would include all types of contracts, in order to form a consolidated overview of seasonality in the whole dry bulk market. Moreover, the examination of the four fundamental vessels' size covered a comprehensive range that allows the prediction of future freight rates through the model of seasonality.

References

Beaulieu, J. and Miron, J. (1992). A Cross Country Comparison of Seasonal Cycles and Business Cycles. *The Economic Journal*, 102(413), p.772.

Berg-Andreassen, J. (1997). The relationship between period and spot rates in international maritime markets. *Maritime Policy & Management*, 24(4), pp.335-350.

Canova, F. and Hansen, B. (1995). Are Seasonal Patterns Constant Over Time? A Test for Seasonal Stability. *Journal of Business & Economic Statistics*, 13(3), pp.237-252.

Chatman, T., Leptos-Bourgi, S. & Vanhoogenhuizen, J.-W., 2013. Review of Maritime Transport, New York, Geneva:UNCTAD.

Culp, L. C., 2010. OTC-Cleared Derivatives: Benefits, Costs, and Implications of 'Dodd-Frank Wall Street Reform and Consumer Protection Act'. *Journal of Applied Finance*, Issue 2, pp.1-27

Demeroukas, P. (Panagiotis). 'The volatility in the Dry Bulk Panamax Segment'.Maritime Economics and Logistics, 2014.http://hdl.handle.net/2105/33034.

Dickey, D. (1993). Seasonal unit roots in aggregate U.S. data. *Journal of Econometrics*, 55(1-2), pp.329-331.

Dijk D. Van, Haralambides, H. and Veenstra, A. W., undated, Modelling of
Evans, J. (1994). An analysis of efficiency of the bulk shipping markets. *Maritime Policy & Management*, 21(4), pp.311-329.

Fang, I., Cheng, F., Incecik, A., & Carnie, P. (2013). *Global Marine Trends 2030.* London: Lloyd's Register Group Limited.

Goulielmos, A. and Psifia, M. (2006). Shipping finance: time to follow a new track?. *Maritime Policy & Management*, 33(3), pp.301-320.

Hellenicshippingnews.com. (2017). *Dry Bulk: Seasonality comes into play, as ship owners rely more on grain trades to offset losses elsewhere | Hellenic Shipping News Worldwide*. [online] Available at: http://www.hellenicshippingnews.com/dry-bulk-seasonality-comes-into-play-as-ship-owners-rely-more-on-grain-trades-to-offset-losses-elsewhere/ [Accessed 19 Aug. 2017].

Herve, A., 2010. Coefficient of Variation. Dallas: Encyclopedia of Research Design.

Kavussanos, M. and Alizadeh, M- A., (2002), The expectations hypothesis of the term structure and risk premiums in dry bulk shipping freight markets. *Journal of Transport Economics & Policy*, 36, 267–304.

Kavussanos, M. and Alizadeh-M, A. (2001). Seasonality patterns in dry bulk shipping spot and time charter freight rates. *Transportation Research Part E: Logistics and Transportation Review*, 37(6), pp.443-467.

Kavussanos, M. and Alizadeh-M, A. (2002). Seasonality patterns in tanker spot freight rate markets. *Economic Modelling*, 19(5), pp.747-782.

Kavussanos, M. and Marcoulis, S. (1997). Risk and return of U.S. water transportation stocks over time and over bull and bear market conditions. *Maritime Policy & Management*, 24(2), pp.145-158.

Kavussanos, M. and Visvikis, I. (2006) The international handbook of shipping finance.

Kavussanos, M., Visvikis, M., 2006. Shipping freight derivatives: a survey of recent evidence. *Maritime Policy & Management*,33(3),pp.233-255

Kounis, N. (2014). 2015 Economic outlook. *Marine Money Greek Ship Finance Forum* (pp. 1–22). Athens: Marine Money

Kunst, R. and Franses, P. (2011). Testing for Seasonal Unit Roots in Monthly Panels of Time Series*. *Oxford Bulletin of Economics and Statistics*, 73(4), pp.469-488.

Lafranca, J.,2014. Forward Freight Agreement .Rotterdam:s.n.

Li, J. and Parsons, M. (1997). Forecasting tanker freight rate using neural networks. *Maritime Policy & Management*, 24(1), pp.9-30.

Mandelbrot, B. and Hudson, R., 2004, The (Mis) behavior of Markets: A Fractal View of Risk, Ruin and Reward (New York: Basic Books).

Ocean Charter Rates; an investigation into no-linearity and parameters variation, revised

Osborn, D. (1990). A survey of seasonality in UK macroeconomic variables. *International Journal of Forecasting*, 6(3), pp.327-336.

Pons, G. (2006). Testing Monthly Seasonal Unit Roots With Monthly and Quarterly Information. *Journal of Time Series Analysis*, 27(2), pp.191-209.

Rothbarth, E. and Koopmans, T. (1939). Tanker Freight Rates and Tankship Building. *The Economic Journal*, 49(196), p.760.

Salkind, N. J. & Rasmussen, K., 2007. Standard Deviation. In:. K. Rasmussen & N. J. Salkind , eds. *Encyclopedia of Measurement and Statistics.* Thousand Oaks: Sage Publications, Inc, pp. 941-942.

Scarsi, R. (2007). The bulk shipping business: market cycles and ship owners' biases. *Maritime Policy & Management*, 34(6), pp.577-590.

Stopford, 1997. Maritime Economics. 2nd ed. London: Routledge.

Stopford, M. (2009). *Maritime economics*. London: Routledge.

Tasseven, O. (2009). Seasonal co-integration: An extention of the Johansen and Schaumburg approach with an exclusion test. *Panoeconomicus*, 56(1), pp.39-53.

Tinbergen, J., 1934, 1959, Tonnage and Freight, Selected papers (Amsterdam: North-Holland)

Torp, H. (2014). Shipping and China—Impact on global freight dynamics. *12th Coaltrans China* (pp. 1–15). Shanghai: Euromoney Institutional Investor PLC.

Veenstra, A. W., 1999, *Quantitative Analysis of Shipping Markets* (Delft: Delft University Press).
Version.

Wergeland, T. (1981). NORBULK - a simulation model of bulk market freight rates. Bergen.

Zhang, Y. (2014). The development trend of Chinese iron ore and steel industry. *KMI's 33rd Annual International Seminar of World Shipping Market Outlook* (pp. 69–79). Seoul: Korea Maritime Institute

Appendices

Appendix 1- HEGY tests

Table A-1 Results of HEGY test for Capesize returns for the sample period 2010:1-2016:12

Seasonal Unit Root test for Capesize returns

Null	Simulated P-value*	Statistical
Non seasonal unit root (Zero frequency)	0.281886	-2.357879
Seasonal unit root (2 months per cycle)	0.008783	-3.504063
Seasonal unit root (4 months per cycle)	0.000000	11.40862
Seasonal unit root (2.4 months per cycle)	0.000177	12.77483
Seasonal unit root (12 months per cycle)	0.118005	4.165386
Seasonal unit root (3 months per cycle)	0.000000	10.11084
Seasonal unit root (6 months per cycle)	0.005441	7.542315

R-squared	0.714884	Mean dependent var	0.015940
Adjusted R-squared	0.569293	S.D. dependent var	0.474230
S.E. of regression	0.311229	Akaike info criterion	0.771350
Sum squared resid	4.552584	Schwarz criterion	1.561859
Log likelihood	-2.768612	Hannan-Quinn criter.	1.086054
F-statistic	4.910226	Durbin-Watson stat	2.082173
Prob(F-statistic)	0.000002		

Table A-2 Results of HEGY test for Panamax returns for the sample period 2010:1-2016:12

Seasonal Unit Root test for Panamax returns

Null	Simulated P-value*	Statistical
Non seasonal unit root (Zero frequency)	0.268467	-2.349447
Seasonal unit root (2 months per cycle)	0.035463	-2.725346
Seasonal unit root (4 months per cycle)	0.025272	6.095488
Seasonal unit root (2.4 months per cycle)	0.046014	5.292471
Seasonal unit root (12 months per cycle)	0.028659	5.677528
Seasonal unit root (3 months per cycle)	0.006153	7.620626
Seasonal unit root (6 months per cycle)	0.000549	9.134218

R-squared	0.729168	Mean dependent var	0.023006
Adjusted R-squared	0.590870	S.D. dependent var	0.304334
S.E. of regression	0.194662	Akaike info criterion	-0.167178
Sum squared resid	1.780985	Schwarz criterion	0.623331
Log likelihood	31.01841	Hannan-Quinn criter.	0.147526
F-statistic	5.272465	Durbin-Watson stat	2.044188
Prob(F-statistic)	0.000001		

Table A-3 Results of HEGY test for Supramax returns for the sample period 2010:1-2016:12

Seasonal Unit Root test for Supramax returns

Null	Simulated P-value*	Statistical
Non seasonal unit root (Zero frequency)	0.456874	-2.065111
Seasonal unit root (2 months per cycle)	0.124460	-2.325190
Seasonal unit root (4 months per cycle)	0.054884	4.963544
Seasonal unit root (2.4 months per cycle)	0.005441	7.905947
Seasonal unit root (12 months per cycle)	0.023593	6.045874
Seasonal unit root (3 months per cycle)	0.218393	3.327599
Seasonal unit root (6 months per cycle)	0.002138	9.216365

R-squared	0.747351	Mean dependent var	0.015799
Adjusted R-squared	0.618339	S.D. dependent var	0.178412
S.E. of regression	0.110221	Akaike info criterion	-1.304737
Sum squared resid	0.570985	Schwarz criterion	-0.514228
Log likelihood	71.97055	Hannan-Quinn criter.	-0.990033
F-statistic	5.792866	Durbin-Watson stat	1.989602
Prob(F-statistic)	0.000000		

Table A-4 Results of HEGY test for Handysize returns for the sample period 2010:1-2016:12

Seasonal Unit Root test for Handysize returns

Null	Simulated P-value*	Statistical
Non seasonal unit root (Zero frequency)	0.476957	-1.954668
Seasonal unit root (2 months per cycle)	0.048287	-2.805886
Seasonal unit root (4 months per cycle)	0.686240	1.261629
Seasonal unit root (2.4 months per cycle)	0.000549	8.403622
Seasonal unit root (12 months per cycle)	0.047780	5.306073
Seasonal unit root (3 months per cycle)	0.009111	6.769442
Seasonal unit root (6 months per cycle)	0.180179	3.519613

R-squared	0.755476	Mean dependent var	0.017389
Adjusted R-squared	0.607625	S.D. dependent var	0.157202
S.E. of regression	0.098471	Akaike info criterion	-1.513975
Sum squared resid	0.416952	Schwarz criterion	-0.646698
Log likelihood	79.98912	Hannan-Quinn criter.	-1.169482
F-statistic	5.109699	Durbin-Watson stat	2.079307
Prob(F-statistic)	0.000001		

Appendix 2- The results of seasonality

Table A-5 Capesize seasonal prices for the sample period 2010:1-2016:12

Parameter Variable	Estimate	Standard Error	t-value
Constant	-0.0117	0.03281	-0.36
Seasonal			
Jan	-0.4445	0.10882	-4.08
Feb	-0.1626	0.10882	-1.49
Mar	0.0470	0.10882	0.43
Apr	0.1766	0.10882	1.62
May	0.1289	0.10882	1.18
Jun	0.0501	0.10882	0.46
Jul	0.0029	0.10882	0.03
Aug	0.1074	0.10882	0.99
Sep	0.2972	0.10882	2.73
Oct	0.0908	0.10882	0.83
Nov	-0.0442	0.10882	-0.41
*Dec (derived)	-0.2495	0.10882	-2.29

Table A-6 Panamax seasonal prices for the sample period 2010:1-2016:12

Parameter Variable	Standard Estimate	Error	t-value
Constant	-0.0129	0.02113	-0.61
Seasonal			
Jan	-0.1951	0.07009	-2.78
Feb	-0.1560	0.07009	-2.23
Mar	0.1919	0.07009	2.74
Apr	0.0487	0.07009	0.69
May	-0.0037	0.07009	-0.05
Jun	-0.1069	0.07009	-1.53
Jul	0.0928	0.07009	1.32
Aug	-0.0164	0.07009	-0.23
Sep	-0.0045	0.07009	-0.06
Oct	0.1410	0.07009	2.01
Nov	0.0036	0.07009	0.05
*Dec (derived)	0.0048	0.07009	0.07

Table A-7 Supramax seasonal prices for the sample period 2010:1-2016:12

Parameter Variable	Standard Estimate	Error	t-value
Constant	-0.0112	0.01287	-0.87
Seasonal			
Jan	-0.1603	0.04268	-3.76
Feb	-0.1969	0.04268	-4.61
Mar	0.2700	0.04268	6.33
Apr	0.0141	0.04268	0.33
May	0.0403	0.04268	0.94
Jun	-0.0304	0.04268	-0.71
Jul	0.0108	0.04268	0.25
Aug	0.0294	0.04268	0.69
Sep	0.0356	0.04268	0.83
Oct	-0.0076	0.04268	-0.18
Nov	-0.0491	0.04268	-1.15
*Dec (derived)	0.0444	0.04268	1.04

Table A-8 Handysize seasonal prices for the sample period 2010:1-2016:12

Parameter Variable	Standard Estimate	Error	t-value
Constant	-0.0086	0.01138	-0.75
Seasonal			
Jan	-0.0824	0.03776	-2.18
Feb	-0.1688	0.03776	-4.47
Mar	0.1895	0.03776	5.02
Apr	0.0465	0.03776	1.23
May	0.0219	0.03776	0.58
Jun	-0.0256	0.03776	-0.68
Jul	-0.0199	0.03776	-0.53
Aug	-0.0100	0.03776	-0.27
Sep	0.0541	0.03776	1.43
Oct	0.0077	0.03776	0.20
Nov	-0.0599	0.03776	-1.59
*Dec (derived)	0.0470	0.03776	1.25