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Ph.D Thesis

«Analysis of dry bulk freight markets using the Cobweb Theorem».

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Περίληψη

Η ναυλαγορά των χύδην ξηρών φορτίων είναι μία ευμετάβλητη αγορά, παρουσιάζοντας πολλές διακυμάνσεις βραχυπρόθεσμα και μακροπρόθεσμα. Η ναυλαγορά των χύδην ξηρών φορτίων παρακολουθείται από την πορεία του γενικού δείκτη ξηρού φορτίου (Baltic Dry Index), αλλά και των επιμέρους δεικτών των διαφόρων ναυλαγορών ξηρού φορτίου. Στην παρούσα διατριβή εξετάζονται οι περιπτώσεις όλων των κατηγοριών των πλοίων μεταφοράς χύδην ξηρών φορτίων, και πιο συγκεκριμένα Capesize, Panamax, Supramax, Handymax και Handysize. Εξετάζεται η πορεία της κάθε κατηγορίας στην ελεύθερη αγορά (spot market) και στην αγορά χρονοναυλοσυμφώνων, βραχυπρόθεσμα και μακροπρόθεσμα, χρησιμοποιώντας το θεώρημα του ιστού της αράχνης και τις βασικές παραδοχές του: τις προσδοκίες (expectations) και την χρονική υστέρηση (time lags). Η επιλογή των βέλτιστων χρονικών υστερήσεων γίνεται με βάση το κριτήριο Hannan – Quinn criterion και κατασκευάζεται ένα αυτοπαλινδρομικό μοντέλο (autoregressive model) για την στατιστική ανάλυση. Τα αποτελέσματα αναδεικνύουν μια ισχυρή συσχέτιση μεταξύ των χρονικών υστερήσεων και των ναύλων σε όλες τις ναυλαγορές χύδην ξηρού φορτίου και μια πρόβλεψη της πορείας των επιμέρους ναυλαγορών είναι εφικτή ακολουθώντας την μεθοδολογία της παρούσας διατριβής. Η διατριβή έχει και πρακτική εφαρμογή, καθώς οι πλοιοκτήτες και οι ναυλωτές μπορούν να βελτιστοποιήσουν τις αποφάσεις που λαμβάνουν σχετικά με τις ναυλώσεις πλοίων, έχοντας κατανοήσει την συμπεριφορά της αγοράς και προβλέποντας την πορεία της.

Abstract

It is widely accepted that the dry bulk market is highly volatile, with many fluctuations in the short- and long-term. The general aspect of the dry bulk market is monitored with the progress of the Baltic Dry Index (BDI), along with progress of the other dry bulk sections. Specifically, the markets of Capesize, Panamax, Supramax, Handymax and Handysize vessels are examined. This thesis investigates the behavior of the aforementioned markets focusing on expectations and time lags. Expectations play a critical role in the freight market both for the short-term and the long-term decision making. In particular, the relation between time lags and time-charter, trip and spot market rates as well as the average earnings of the dry bulk vessels of various ages are investigated. Time series analysis is used to reach conclusions. The Hannan – Quinn criterion has been selected to identify the important lags of the freight markets and Autoregressive (AR) model has been constructed to perform the statistical analysis. The findings indicate that there is a strong correlation between time lags and progress of the freight markets, forecasting indeed the behavior of the markets. At a practical level, better understanding of the behavior of the dry bulk freight markets market can improve the planning decision of ship-owners and charterers alike.

Keywords: Dry bulk freight markets; Expectations; Time lag; Volatility; Cobweb Theorem

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List of abbreviations

AR – Auto Regressive

ARIMA – Auto Regressive Integrated Moving Average

ARMA – Auto Regressive Moving Average

VAR – Vector Auto Regressive

BDI – Baltic Dry Index

BCI – Baltic Capesize Index

BPI – Baltic Panamax Index

BSI – Baltic Supramax Index

BHSI – Baltic Handysize Index

DWT – Deadweight

FFA – Forward Freight Agreement

EQ – Equation

GDP – Gross Domestic Product

SIN – Shipping Intelligence Network

1. Introduction

1.1 Overview of shipping industry, changes and challenges

The shipping industry is a very important industry, since the majority of the world trade happens with vessels. Specifically, almost 90% of commodities are transported with vessels. The shipping industry is affected by many factors. Specifically, the factors affecting demand and supply have a crucial impact on the shipping industry and on the decision making of its participants.

The shipping industry has suffered from abrupt demand changes, from new regulations imposed pushing for technological advances that have to be applied to vessels, and from geopolitics, among others.

Historically, one can observe that the freight markets follow the shipping cycles theory, leading to fluctuations. This affects directly the cash flow of the shipping companies, and their investment and scrapping policy. As a result, based on their decisions, the supply of the industry changes. However, the demand constantly changes and sometimes the market conditions rapidly alter towards unexpected and unforeseen results. Thus, the freight markets suffer from instability and negotiations happen with different behaviors and oscillations of equilibria.

The recent case of Covid – 19 period is another example of an external factor affecting the industry. The difficulty if this situation is twofold: First the lockdowns of world economies, a phenomenon that is met for the first time in the history, and second, its long duration, which again was dealt for the first time of modern shipping industry.

The impact of the coronavirus period was great on all markets. Others declined, while others flourished. The nature of the cargo played an important role. For example, the container and the dry bulk industries in general, suffered from losses, especially after a few months of pandemic duration. On the other hand, the tanker industry was highly increased, since the demand for tanker vessels grew bigger, due to the fact that tankers could be used as extra storing places. However, after the end of the pandemic and the markets opening, the container industry faced a great increase, resulting to skyrocketing rates in the freight market. Considering at the same time the increased cost to relocate an empty container, the total transportation cost of a container was significantly increased. Along with the geopolitical changes, this has led to the transformation of the total supply chain management.

In addition to this, the energy crisis and the war between Russia and Ukraine have enforced the need for new options regarding the worldwide trade routes of resources and commodities. The above statement strengthens the argument for the expected changes in the total supply chain.

New challenges have also been in place towards the “Green Shipping 2050” agenda, which started in 2020, with the implementation of new regulations such as ballast water management and low carbon and sulphur emissions, raising concerns over sustainability issues. The sustainable management of shipping companies is an ongoing process, which has significantly affected the shipping participants in the following pillars: financial management, strategic management, investment policy, technological advancements.

As an example, it is worth mentioning that the shipping companies had to decide whether they should invest in scrubber installation or not for the existing fleet. A crucial dilemma, which shifts the risk and cost escalation to the shipowners. Such an investment would be expensive, with expectations of returns due to the ability to consume a cheaper fuel, decreasing the voyage costs and increasing competitiveness of such vessels.

However, in some cases things may not turn out as planned. Due to pandemic and the lockdowns of economy worldwide, the expected difference of prices among various types of fuel was not materialised and prices remained similar. As a result, the strategic plan and the investment couldn’t pay off within the expected period. Many more examples can be mentioned.

As a highlight of the above, one can understand that the cost distribution has changed and due to new regulations and green policies followed, there is a trend for higher capital costs. Thus, the transportation cost may increase, but this affects the world seaborne commodity trade and the demand for shipping services. This leads to negotiations in the freight markets and to possibly new equilibria.

To conclude, after considering all the above, it is of the author’s belief that the analysis of the freight markets and the forecast of their progress is imperative for the viability of the shipping participants. In terms of academic perspective, there is a great interest to understand the behavior of the freight markets, since this is a traditional topic concerning the scholars. In this research, the dry bulk freight markets of various vessel sizes are analysed, in an effort to identify similarities and differences in their behavior and forecast their trend. This will contribute to the better understanding of markets’ fluctuations, even during periods with great changes and challenges as previously described.

1.2 Research questions

It is highlighted that in all markets, the shipping participants take decisions regarding their expectations for the progress of the market short- and long-term. The time lag is a very important factor for the shipping industry. Along with expectations, time lags play a critical role in the determination of the freight market equilibrium.

The research questions are the following:

- What is the behavior of each dry bulk sector?
- Is it possible to analyse the dry bulk freight markets considering the time lags and expectations?

1.3 Aims and objectives

This thesis aims to investigate the behavior of all dry bulk markets, under the unique conditions existing in each dry bulk market. Each sector has different conditions and peculiarities, from free markets and open competition to close markets and oligopoly.

The purpose of this thesis is to analyse the behavior of each dry bulk sector taking as key elements the time lags and the expectations and to critically discuss the markets' future progress. Furthermore, an effort is conducted to forecast the trend of the various freight markets.

Although it is not the purpose of this thesis, this will help practitioners to the formation of an optimum chartering strategy.

1.4 Methodology

In order to answer the research questions, focus is cast on each dry bulk sector investigating the impact of market expectations and time lags on freight rates. The volatility of the rates is very high, and the shipping industry is proved to be very risky. Thus, the shipping investors are willing to accept lower expected returns if there is a chance to earn high payoffs in the future (Theodosiou et al., 2020).

Attention is also given to the relation between time lags and earnings, time charter, trip and spot market rates of each vessel of various ages and sizes. Time series analysis is used to reach conclusions.

The Hannan – Quinn criterion has been selected to identify the important lags of each dry bulk freight market for the period 1977-2022 and an Autoregressive (AR) model has been constructed to perform the statistical analysis.

The findings indicate that there is a strong correlation between time lags and the capesize freight market, as far as it concerns efforts to forecast the behavior of the market. At a practical level, a better understanding of the behavior of each dry bulk sector could contribute in an improvement regarding ship-owners and charterers markets' forecasting.

In the literature and methodology section of this thesis, there is a presentation of different models, used to capture future fluctuations and behavior of the various dry bulk freight markets, mostly in the area of autoregressive models such as autoregressive moving average (ARMA), autoregressive integrated moving average (ARIMA), vector autoregressive (VAR). In the methodology followed, an autoregressive model (AR) has been selected, as it provided better results than ARMA and ARIMA models for the purposes of this research.

Compared with previously mentioned models, it is also highlighted that by using this method, one can accurately explain and foresee unexpected behaviors of this market, which is critical for the viability of the "market players".

The Hannan – Quinn criterion has been selected to identify the leading lags, affecting specific time series among the last 16 observations. Upon the identification of the lags significantly affecting time series, the optimum AR model is constructed for each case.

After running the model for every dry bulk sector of earnings, spot, time charter and timecharter trips with the available data of each case. The trade routes selected for analysis in this thesis are the most established routes for every dry bulk market.

The empirical analysis of the results follows. An analysis takes place on the results taken from running the AR model, along with the progress of demand and supply, and the expectations for the future market being captured from the FFA market, which is taken into account to conclude. The findings indicate that it is possible to explain the fluctuations of all dry bulk sectors and forecast future market behavior, to the benefit of the shipowner and the charterer alike.

1.5 Research contribution and motivation

The behavior of the freight market is what all shipping participants try to predict. Due to its importance, many scholars have used various methods to analyse the behavior and try forecast its progress, mainly in the dry bulk sector and in the tanker sector.

Shipping practitioners take decisions on a daily basis with short- and long-term scope. Various factors affecting their decisions and as a result the progress of the freight market. Within the years, the industry has faced high peaks and serious collapses.

In 2008, the freight markets reached their highest level historically, with a great collapse following. The trough period had a very long duration till 2017, with early signs of recovery. Many lessons were learnt from this period, preparing the culture, the mentality, and the way of thinking of the shipping participants for the random shocks followed, the two lockdowns and the energy crisis with the war between Russia and Ukraine.

All the above have urged the author to conduct a research of dry bulk freight market analysis. The author has used the main principles of the cobweb theorem to analyse the market behavior. The contribution of this thesis to the literature, is an alternative approach of market analysis, considering the time lags and expectations to analyse the dry bulk freight markets.

In this research, the most recent data is used, containing periods with abrupt demand changes and unpredictable random shocks, along with new regulations and technological upgrade towards green shipping, resulting to supply changes too.

1.6 Thesis structure

This thesis is structured as follows:

Section 1 is the Introduction. In this section the author puts the research into context, discussing the overview and key elements of the dry bulk industry. The research questions, the aims and objectives are also discussed in this section.

Section 2 is an overview of the dry bulk market structure. In this section, the various dry bulk vessel categories are presented, along with the main cargoes they transport. Data is provided for the supply of vessels, such as the development of each fleet, the existing number and deadweight (dwt) of fleet, the orderbook and the scrapings. Moreover, the progress of demand elements such as the seaborne trade of various cargoes is also discussed, as an important factor affecting demand.

Section 3 addresses the extant literature review. The main definitions used in the thesis are discussed in this section. Moreover, the main principles and theories regarding former analyses of freight markets are included. Finally, methods used to analyse and forecast the freight markets and price behavior of other markets are thoroughly analysed.

Section 4 covers the methodology and its theoretical framework. It also presents and explains the method and the model used. Also, data collection is included in this section.

Section 5 presents data analysis and discussion with descriptive statistics of the markets analysed. Analytically, the spot market, the trip rates, the time-charter rates and average earnings of ships of all freight markets are examined, tested and analysed to reach conclusions.

Section 6 is the conclusion, containing concluding remarks and recommendations for future research.

Finally, section 7 is the bibliography used to conduct this research.

2. Dry bulk market structure

2.1. Introduction

The dry bulk market consists of five (5) main submarkets:

- Capesize market
- Panamax market
- Supramax market
- Handymax market
- Handysize market

These submarkets include specific vessels to offer their services in the shipping trade. The smaller vessels are the Handysize vessels with size from 16.000 dwt to 38.000 dwt, conducting mostly regional and short trips. Then, Handymax vessels follow with size from 40.000 dwt to 52.000 dwt.

The Handymax vessels compete the Handysize vessels, though they transport larger parcels. Originally, the Supramax vessels were considered as a part of Handymax market. However, due to Supramax vessels importance to the trade and due to the fact that the demand shipments have formed a unique frequency in that parcel size, the Supramax market is now considered as a separate market of the dry bulk industry with vessels' size from 52.000dwt to 59.000dwt. The Supramax vessels frequently compete the next category, the Panamax vessels. They are capable to transport a satisfying quantity in longer distances (Stopford, 2009).

The Panamax vessels vary in size. They have a size from 60.000 dwt to 85.000 dwt, including the modern Ultramax vessels (61.000 dwt – 67.000 dwt) and the Kamsarmax vassels with size 82.000 dwt. The Panamax vessels transport cargoes worldwide in a balanced trip in terms of quantity and duration. They also conduct trips from East Coast to West Coast North America and vice versa, competing other land transportation means (Clarksons SIN, 2023).

The Kamsarmax vessels are designed in a special way, making them able to enter the Port of Kamsar, avoiding the port restrictions, and at the same time maximize the loading quantity of bauxite.

Finally, there is the Capesize market with vessels' size more than 100.000 dwt. Normally, a small Capesize vessel has a size about 127.500 dwt, a medium one has 150.000 dwt while the larger one used to have 170.000dwt, with the modern Capesize to reach even 180.000 dwt, in an effort to satisfy the increasing demand. These vessels transport mainly iron ore and coal under certain trade routes in a close market system. Each market has a different behavior, even in the same period. A raise of one freight market does not automatically imply the raise of the other freight markets. On the contrary, it is more common one freight market to raise, while another one drops. This might happen in terms of earnings and/or rates level. The shipowners and the charterers have to take decisions regarding the strategy they follow in the freight market. There are two (2) options: the timecharter and the voyage contracts. Charterers and shipowners establish their strategies and act accordingly in the freight market, with either long-term or short-term aspect (Stopford, 2009).

2.2 Market structure and decision making

In this chapter, a brief description of each market segment structure is presented. Specifically, details of each dry bulk market sector are discussed, aiming to better determine the behavior of each market.

Their analysis is very important, since the freight market heavily depends on the supply and demand theory, along with expectations and time lags. These are analysed, in order to better understand the structure, the progress and the decision making of each dry bulk market segment. The market structures are discussed in the below sub – charters.

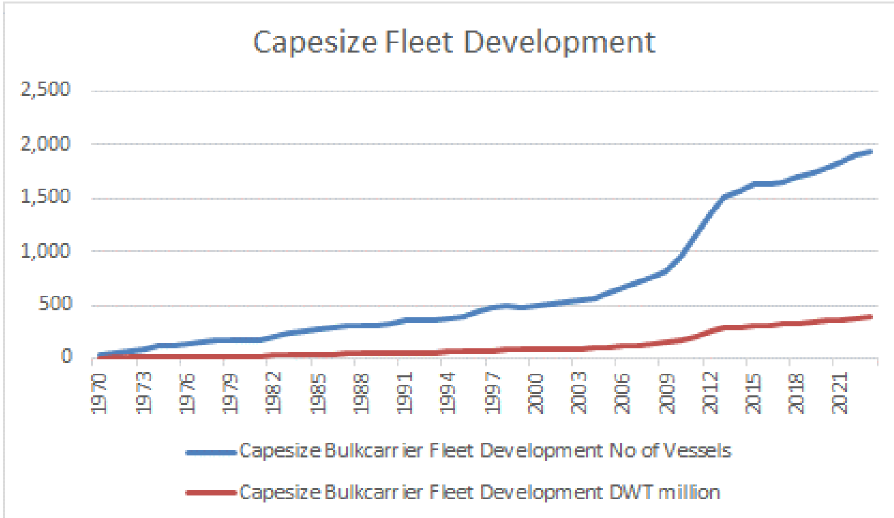
2.2.1 Capesize market structure

The Capesize market consists of the small, medium, and big Capesize vessels. The small Capesize vessel has a deadweight of 127.500 dwt, the medium 150.000 dwt and the big 170.000 dwt and 180.000 dwt. Recently, in an effort to satisfy the increasing demand for larger parcels, shipowners tend to invest in the larger vessels, others prefer the 170.000 dwt vessel and others the 180.000 dwt one. Some exceed the dwt capacity of 200.000 tn but they are not considered in this research (Clarksons SIN, 2023).

In order to analyse this market, it is important to examine the number of ships and the DWT capacity at the same time, because in this way one can identify any possible change in the total supply of shipping transportation services, since there might be a trend for larger shipments, so shipowners tend to invest in new bigger vessels, while scrapping older and smaller vessels.

According to Clarksons Shipping Intelligence Network database and as seen in the below graph, with data retrieved on 24th January 2023, the fleet growth of the capesize vessels is at the number of 1942 vessels with a dwt capacity of 383,76 million tns.

Figure 1 – Capesize Fleet Development



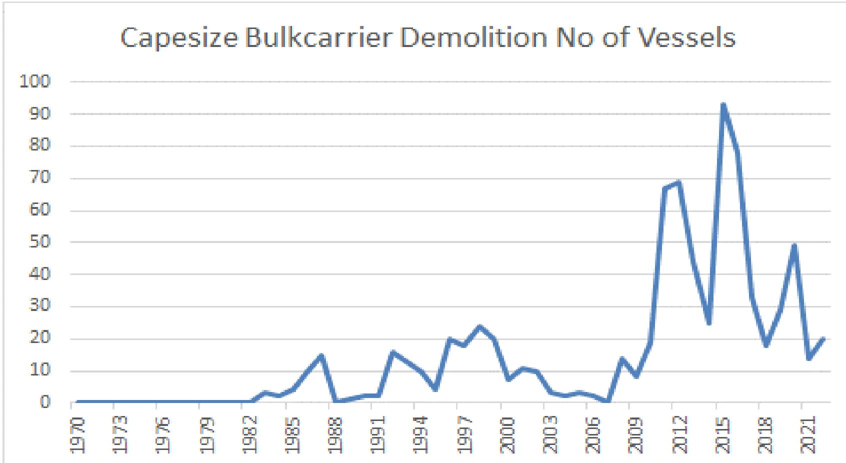
Clarksons Shipping Intelligence Network, 2023

In 2022, the scrapped capesize vessels were 20, and 3.386.610 tns in terms of dwt capacity. As seen in the below figures (2) and (3), shipowners have decided to intensively scrap vessels after 2009 and until 2012, where one can notice that there is a halt in scrapings both in terms of number of ships and in terms of DWT capacity.

In 2013 and 2014, the demolition market for capesize vessels remain active and at high levels, though at a lower rate than the previous years. In 2015 one can see the peak of the demolition market with 93 vessels and 15.438.232 dwt, while the year 2016 remained close with 78 vessels and 13.335.427 dwt. In the next years the scrap rate is reduced, till we reach the year 2019 with the first signs of the covid – 19 resulting in 29 vessels and 5.911.086 dwt to lead to scrap.

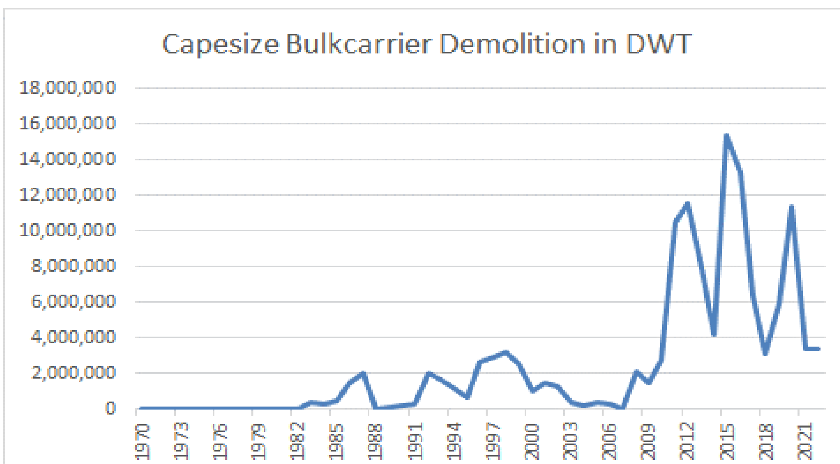
In 2020, with the global quarantines due to coronavirus, the shipowners decided it was time to scrap 49 vessels and 11.409.883 dwt in total. In the remaining years till today, the scrapping rate was decreased and remained close to the average of the demolition market for capesize vessels. It is highlighted that the average scrapped number is 15 capesize vessels per year and 2.504.784 dwt.

Figure 2 - Capesize Demolition No of Vessels



Source - Clarksons Shipping Intelligence Network, 2023

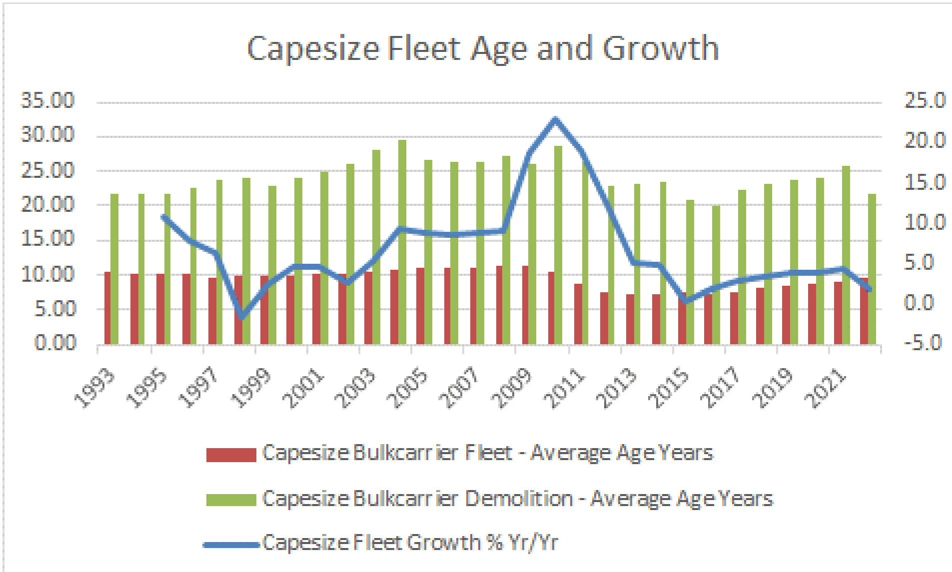
Figure 3 – Capesize Demolition in DWT Capacity



Source - Clarksons Shipping Intelligence Network, 2023

In the below combo figure (4), data retrieved from Clarksons SIN, 24th January 2023, the fleet growth in 2022 was 1,8 %, with the average fleet growth to be 6,9% considering the heavy delivery period 2004 – 2014. At the same time, the age of the fleet seems to be young, since the age of the fleet in 2022 was 9,5 years and the average was 9,52 years. This is due to the fact that many ships were scrapped from 2010 till 2020, with the peak year of 2015 with 93 vessels being scrapped. It is important to highlight that the average scrapping age of these vessels is 24,26 years.

Figure 4 – Capesize Fleet Average Age, Demolition Average Age, Fleet Growth

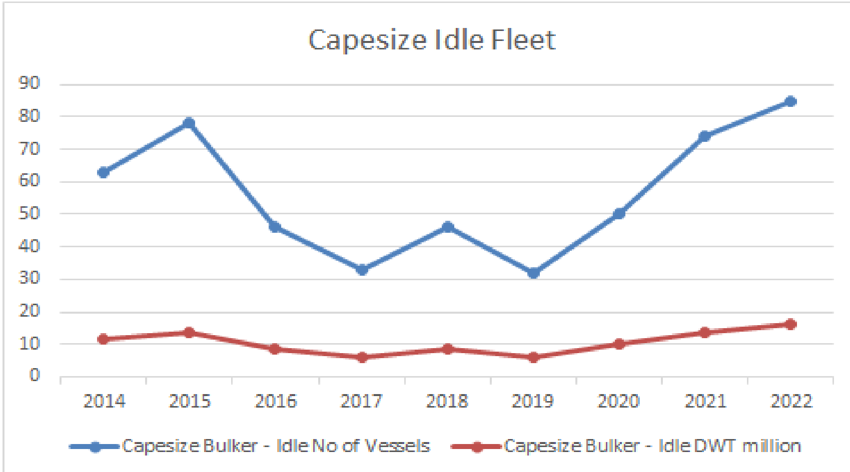


Clarksons Shipping Intelligence Network, 2023

The aforementioned heavy scrapping decade helped the freight market to recover from the deep recession of the dry bulk market after 2009 and remain at acceptable levels. However, considering the idle vessels, one can see that there is an increase in the last years. In 2021 there were 74 idle vessels with 13,86 million dwt capacity and 85 vessels with total 16,16 million dwt capacity remained idle in 2022, with the average (from 2014 – 2022) being 56 vessels and 10,51 million dwt (Clarcksons Shipping Intelligence Network, 2023).

As seen in the figure (5) below, the idle capesize vessels have increased in the last 3 years, depicting the strong suffering of the market during and after the Covid – 19 period.

Figure 5 – Capesize Idle Fleet



Clarksons Shipping Intelligence Network, 2023

These vessels mainly transport iron ore and coal under certain routes. Thus, the demand for shipping services of such large parcels, is heavily depended on the progress of the world seaborn trade of these cargoes.

As seen in the below figures (6) and (7), there is an impressive increase in the world iron ore seaborne trade. Specifically, the world seaborne trade of iron ore in 1990 was 355,8 million tonnes and 1864,40 billion tonne miles, reaching 398,8 million tonnes and 2.193,8 billion tonne miles in 1999. Within this decade, one can highlight the year 1997 as the peak, with 426,2 million tonnes and 2.303,6 billion tonne miles, as a result of 8.8% change from the previous year in terms of tonnes, and 9,7% change from the previous year in terms of tonne miles (Clarksons SIN, 2023).

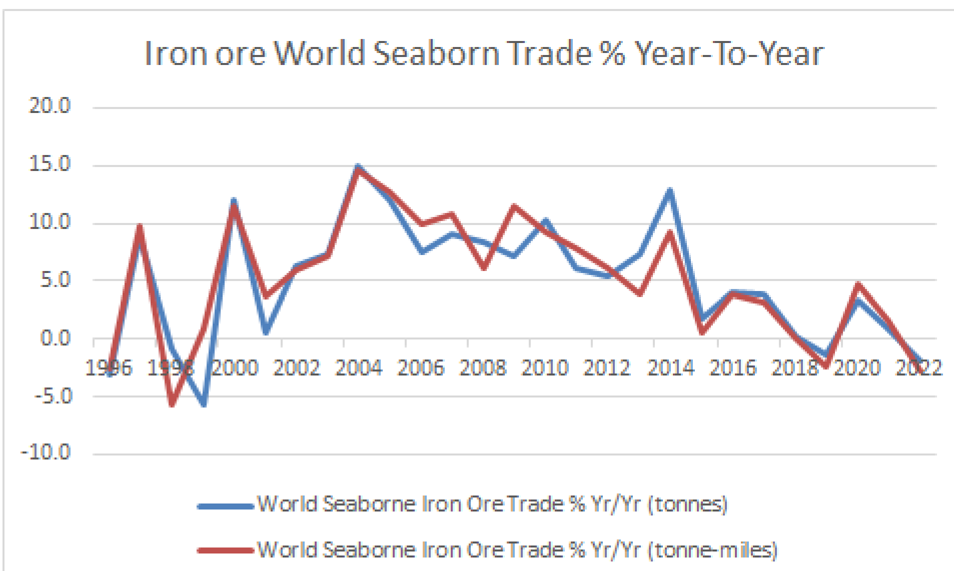
In the next decade 2000 – 2010, the increase in the world seaborne trade continuous, with a positive percentage change from one year to the next one, though with a different rate. In 2000, one can identify the sharp change of 12,1% in tonnes and 11,5% in tonne miles compared to 1999. The world seaborne trade reached the level of 446,8 million tonnes and 2.446 billion tonne miles, indicating the trend for the next years. In 2010, the world iron ore seaborne trade has been almost doubled compared to the year 2000, being 989,50 million tonnes and 5.864 billion tonne miles. The change, compared to 2009, was 10,3% of tonnes transported and 9,2% tonne miles. Within these years, one can observe sharp year to year positive changes. However, the peak was in 2004, with 15% year-to-year change in tonnes (Clarksons SIN, 2023).

This increase of the iron ore world seaborne trade continuous in the next years till today, with 2019 and 2022 being the exceptions, since a reduce is observed these years. The year 2014 is the peak of this period in terms of a year-to-year change both in terms of tonnes (12,8%) and in terms of tonne miles (9,2%). However, this is not the peak of transported million tonnes, neither of the billion tonne miles. The year 2021 is the peak of transported million tonnes of iron ore (1,516,8 million tonnes) and of iron ore billion tonne miles (8.494 billion tonne miles). This is reasonable, since the world economy and the markets have gone back to normality, after two years of quarantines and lockdowns (Clarksons SIN, 2023).

In 2019, due to coronavirus and worldwide lockdowns of economies, the world iron ore seaborne trade was 1.454,5 million tonnes (was 1.475,4 million tonnes in 2018) and 7.990,3 billion tonne miles (was 8.190,2 in 2018). The year-to-year change was -1,4% in tonnes and -2,4% in tonne miles. Finally, in 2022, there was a decrease in the iron ore world seaborne trade as mentioned above. Specifically, 1.487,6 million tonnes of iron ore were transported, with a negative year-to-year change (-1,9%). Moreover, the world seaborne trade in billion tonne miles was 8.261,1, with a negative year-to-year change (-2,7%) (Clarksons SIN, 2023).

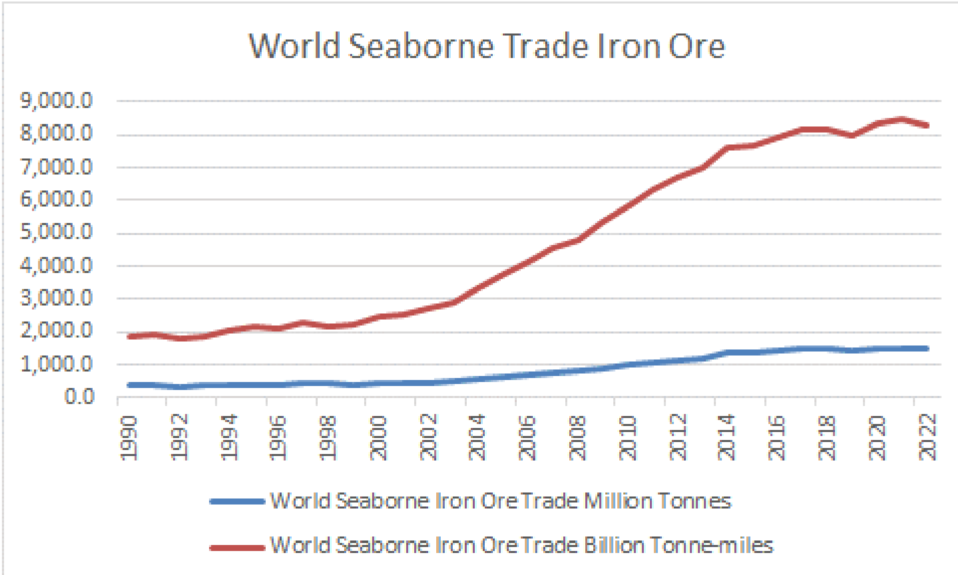
Considering the average indicators of iron ore world seaborne trade from 1990 till 2022, it is noticed that the average million tonnes is 835,2 and the average billion tonne miles is 4.707,3. With the available data from 1996 till 2022, the average year-to-year change of tonnes is 5,1%, while the average year-to-year change of billion tonne miles is 5,2% (Clarksons SIN, 2023).

Figure 6 – Iron Ore World Seaborne Trade % Year-To-Year



Clarksons Shipping Intelligence Network, 2023

Figure 7 – Iron Ore World Seaborne Trade

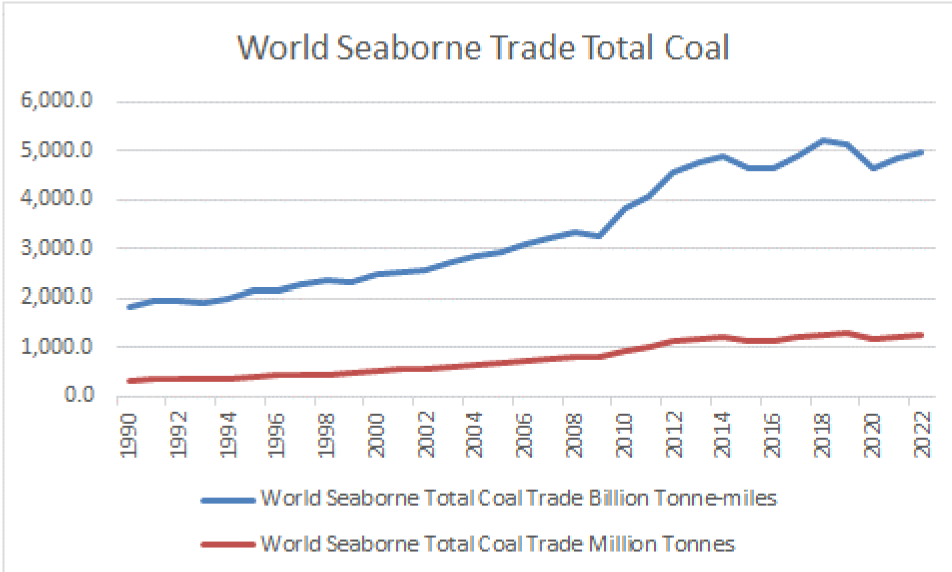


Clarksons Shipping Intelligence Network, 2023

Coal is the other important cargo affecting the capesize market significantly. The trade of this cargo affects the freight market of the capesize vessels, since it heavily affects the demand for shipping services of large vessels, offering economies of scale. Thus, it is important to examine the world seaborne trade of this cargo as well.

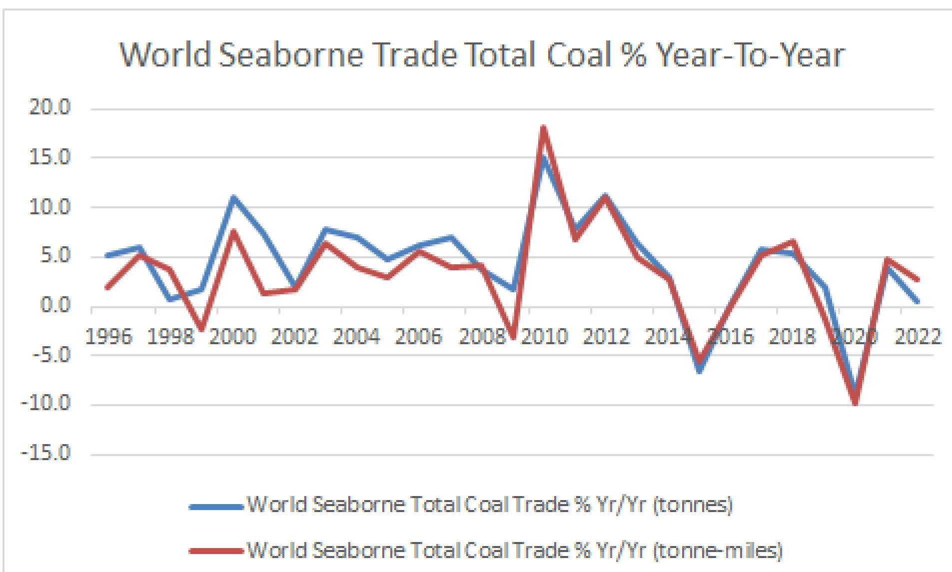
As we can see in the below figures (8) and (9), the trend of the world seaborne total coal trade is similar to the world seaborne iron ore trade. It follows a continuous increase from 1990 till today, with the years 2015 and 2020 being the exceptions in terms of million tonnes when a sharp drop happened at each year. In terms of billion tonne miles, we can observe a drop in the years 1999, 2009, 2015, 2019, and 2020.

Figure 8 – World Seaborne Trade Total Coal



Clarksons Shipping Intelligence Network, 2023

Figure 9 – World Seaborne Trade Total Coal % Year-To-Year



Clarksons Shipping Intelligence Network, 2023

Specifically, in 1990, the world seaborne total coal trade was 331,1 million tonnes and 1.811,9 billion tonne miles. With a continuous increase from one year to another, the world seaborne total coal trade was 458 million tonnes and 2.315 billion tonne miles in 1999. The trend is similar to the iron ore world seaborne trade. It is worth mentioning that in 2000, there is a big increase in the world seaborne total coal trade, being 508,9 million tonnes and 2.492,1 billion tonne miles. This is the biggest year-to-year change till 2009, with 11,1% year-to-year change in tonnes and 7,7% in tonne miles (Clarksons SIN, 2023).

In 2010, there is the peak of year-to-year changes of tonnes and tonne miles. The world seaborne total coal trade was 926,5 million tonnes and 3.826,8 billion tonne miles, with a year-to-year change of 15,2% in terms of tonnes and 18,2% in terms of tonne miles. The next years follow a steady increase with high rates with the notable year of 2012 with 11,9% year-to-year change in tonnes and 11,1% change in tonne miles. This is the year when the million tonnes exceed the 1.000 million tonnes, reaching the level of 1.111,7 million tonnes and establishing the billion tonne miles above the level of 4.000, closing the year with 4.540,6 billion tonne miles (Clarksons SIN, 2023).

The turnover point of this trend is the year 2015, when we can notice the sharp drop of the world seaborne total coal trade in tonnes and in tonne miles, a period when this freight market was suppressed. The numbers indicate a reason for this recession in the freight market. The world seaborne total coal trade was 1.137,7 in million tonnes with a negative year-to-year change (-6,5%) and 4.631,4 billion tonne miles with a negative year-to-year change (-5,5%).

The next year remained at similar levels, with a minor positive year-to-year change. Then, we can see an increase in 2017 and 2018, exceeding the 5.000 billion tonne miles at the end of the latter year.

However, in 2019 and 2020, the market is affected by the Covid – 19 pandemic and the lockdowns of economies worldwide, resulting to a sharp drop of 9% in tonnes and 9,8% of tonne miles as a negative year-to-year change. After the opening of economies and the end of lockdowns, there is an increase in the world seaborne total coal trade in an effort to reach the peak points.

At the end of the year 2022, the world seaborne total coal trade was 1.233,5 million tonnes with a relevant 0,5% year-to-year change, and 4.989,2 billion tonne miles with a relevant 2,7% year-to-year change, continuing the increase of 2021 (Clarksons SIN, 2023).

It is important to mention that the average of world seaborne total coal trade is 777,8 million tonnes and 3.362,5 billion tonne miles, with a year-to-year increase of 4,4% in terms of tonnes and 3,3% in terms of tonne miles (Clarksons SIN, 2023).

Normally, capesize vessels perform trips from South America (Brazil) to Far East (mostly China) and Europe, from North America to Far East and Europe, and from Australia to Far East and Europe, conducting mainly Transatlantic, Transpacific, and Far East – Continent trips.

A characteristic of this market is that it is a close market, with few shipowners and charterers. This derives from the fact that there are specific exporters i.e., the Brazilian exporter Vale, and specific importing countries, which can support the port services to such big vessels.

Furthermore, charterers who can afford these large parcels, and cargo nature characteristics requiring no further material treatment while storing, rather than big warehousing facilities, lead to the conclusion that few market players can engage this market. Thus, the market suffers from sharp fluctuations, mainly due to high demand volatility.

This market structure is similar to oligopoly, with similar characteristics of the tanker industry, where the tanker freight market is characterized by non-linearity, non-stationarity and seasonality (Koekebakker, Adland and Sødal 2007), which makes it difficult to understand the spot market function and, thus, to forecast future freight rates.

Few capesize vessels and high-volume cargoes exist in the market, with shipowners and charterers to take decisions and determine the equilibrium short- and long-term. The equilibrium is strongly affected, especially in the short-term by abrupt demand changes causing sharp fluctuations of the freight market.

Moreover, in the long run, the market is affected by the long-term decision making of charterers (offering long timecharter contracts) and the shipowners (investing in new ships). The expectations regarding the progress of the market are very important to determine long term strategies.

Considering the future demand and progress of the freight market, the shipowners tend to invest in new vessels or not. Likewise, the charterers follow the market signs and based on their expectations, they offer long timecharter contracts or not.

This market is also offered for hedging through the Forward Freight Agreements (FFA) and other shipping derivatives. However, the FFA market tends to represent the expectations of shipping participants, as presented in the literature review chapter.

Through this common practice, the shipping participants can hedge potential financial losses of spot or short-term necessary transportations of cargoes, due to market conditions, with future earnings when engaging the FFA market.

However, misjudgments can lead to devastating results, since shipping is considered as a capital-intensive industry. When it comes to large vessels, the initial cost required to invest, and the daily operating cost are much higher compared to smaller vessels.

As a concluding remark, after examining the behavior of the world seaborne iron ore and total coal trades, as a major contributing factor to the demand, and the behavior of capesize fleet development and investments, as representative supply factors, the author can reach to the conclusion that they follow a similar trend. When the demand tends to be higher, then the supply follows the same path. It is also observed that the volumes of parcels have grown, resulting to the construction of new larger vessels. As a result, the shipping capacity can satisfy the demand.

However, when abrupt negative changes happen to demand, the freight market suffers, especially when this is a prolonged drop, where shipowners need to lay up or scrap vessels and delay deliveries of new vessels. At the same time, they need to stop ordering new ships, so that the supply comes again to a balance with the demand.

2.2.2 Panamax market structure

The Panamax market includes the modern Ultramax vessels (61.000 dwt – 67.000 dwt) and the Kamsarmax vessels (special designed Panamax vessels with 82.000 dwt, able to call the Port of Kamsar and load bauxites).

In the below figures we can see an effort to depict the characteristics of the supply of this market. Thus, the panamax fleet development, the demolition panamax market, the average age of the existing fleet and the scrapping age of the fleet are discussed.

The available data start in 1970, with 94 panamax vessels and 6,95 million DWT. In the decade of 70s, there is a continuous increase both in terms of vessels and in million DWT, closing the year of 1979 with 317 vessels and 22,18 million DWT. At the same time, the demolition market is inactive, with only 2 vessels and 143.996 million DWT being scrapped in 1976, and 3 vessels with 207.414 million DWT sent to scrap in 1978 (Clarksons SIN, 2023).

In the next decade 1980 - 1989, the increase of the number of vessels and the capacity of the fleet continues. In 1989, there were 598 panamax vessels with 40,72 million DWT available for shipping services. It is almost the double, compared to one decade ago, indicating the trend of a growing market. The demolition market starts to be active, with the years 1985 and 1986 being the peak of this decade, as 19 and 31 vessels were scrapped, with 1.354.366 DWT and 2.348.070 DWT respectively at each year (Clarksons SIN, 2023).

The next decade, 1990 – 1999, we can identify the increase of the fleet growth. In 1990, the fleet exceeds the 600 vessels for the first time, actually it is 629 vessels at the end of 1990, with 42,82 million DWT. At the same time, the scraping of panamax vessels remain at a very low level, especially until 1995, the year when the fleet exceeds 700 vessels and 50 million DWT for the first time.

Despite the fact of increasing scrapping in the last 4 years of this decade (1996 – 1999), the fleet continuous to grow both in terms of number of vessels but in DWT capacity as well. Specifically, in 1998 the fleet exceeds the 60 million DWT (884 vessels) and 1999 the fleet exceeds the 900 vessels (906 vessels and 63,03 million DWT).

The demolition market becomes active, starting with 14 vessels and 965.816 DWT in 1996, continuing with 19 vessels and 1.332.928 DWT in 1997, reaching the peak in 1998 with 38 vessels and 2.703.311 DWT, ending the decade with 30 scrapped vessels and 2.163.270 DWT in 1999 (Clarksons SIN, 2023).

In the next years we can observe an impressive increase in the fleet growth. It is highlighted that in 2001 the fleet was consisted of 997 vessels and 70,01 million DWT, while at the same time 33 vessels and 2.218.454 DWT were sent to scrap. Despite the intensive scrapping of the next year (24 vessels with 1.580.510 DWT), the fleet grown bigger, consisting of 1.078 vessels and 76,33 million DWT.

The fleet growth continuous in a declining scrapping period, which is very reasonable due to the constantly increasing high level of the freight market. In 2008, having reached the peak of the dry bulk freight market, only 17 vessels with 1.118.430 DWT are scrapped. At the same time, new vessels are delivered (1.474 vessels with 107,93 million DWT exist in the market) and many more are expected to be delivered, due to the huge orders placed following the high levels of the freight market and the expectations of the shipowners for a continuous demand and freight market growth.

With the early signs of collapse of the freight market, and with a mix of feelings (realism and enthusiasm) and ambiguous expectations of shipping participants, in 2009, 32 vessels with 2.128.956 DWT were scrapped. However, heavy deliveries were still in place, so the fleet consists of 1548 vessels and 114,19 million DWT (Clarksons SIN, 2023).

In the following years, 2011 – 2017, under a clear recession period, in the trough stage of the shipping cycle, it is obvious that there is a clear effort in balancing again the supply with the demand, through massive demolitions.

With the historically (1970 – 2022) average scrap of 19 vessels and 1.345.588 DWT per year, we can see that the demolition market is very active within the period of 2011 – 2017, following the very low levels of the freight market. In 2011, 76 vessels and 5.233.601 DWT were scrapped, while the peak was the next year with 127 vessels and 8.710.769 DWT.

However, the heavy ordering of the previous years leads the market to a deeper recession since the fleet growth for these years was 12,2% and 12% respectively. Deliveries and scrapping at high levels continue for the next couple of years as well. The fleet growth rate is reduced though, since in 2015 it was only 1,5%, indicating the strategy followed by the majority of the shipowners to stop delivering new vessels and continue scrapping older vessels, to bring the freight market back to balance.

In 2016, the panamax fleet growth was 2.450 vessels and 195,21 million DWT of capacity. The year-to-year change was only 0,4%, and 118 vessels with 8.491.957 DWT were scrapped, while 202 vessels and 15,78 million DWT of capacity remained idle. At the same time, it is worth mentioning that the fleet age was significantly reduced to 8,34 years, while the demolition average age of panamax dry bulk carrier was also significantly reduced 21,10 years.

Only a few years ago, in 2011, the fleet age was 11,46 years and the demolition age was 29,30 years. This dramatic drop of the operational age of the fleet, was the result of the drastic measures taken by the shipowners, as the freight market was deeply suppressed, and shipowners were suffering great losses from the operation of the fleet in the freight market.

Early signs of recovery of the freight market were observed in 2017 and 2018. This is supported by the decrease of the idle number of vessels (117) and capacity (9,40 million DWT). Moreover, the operational age of the fleet is increased to 9,13 years. The fleet growth remained at low levels, 2,7% at each year.

Projections for the increase of the demand and of the freight market in the following years, resulted in an increase of the fleet growth 5,3% in 2019 (2.568 vessels with 201,36 million DWT) and 5,1% in 2020 (2.699 vessels and 217,60 million DWT).

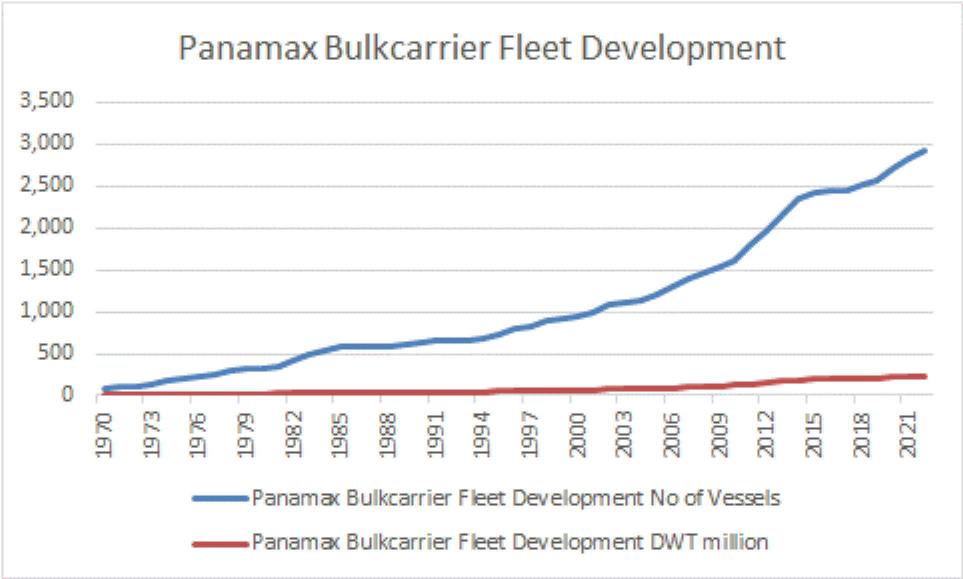
Scrap market remained at very low levels, only 6 vessels with 418.965 DWT were scrapped in 2019 and 14 vessels with 1.036.286 in 2020. The operational age of the fleet was increased to 9,73 and 10,11 years respectively. At the same time, the demolition age of the fleet was 30,06 and 28,14 years (Clarksons SIN, 2023).

However, these estimations were not fully materialised due to the Covid – 19 pandemic and the lockdowns of the economies worldwide. As a result, an increase of idle capacity was observed, with 133 vessels and 10,57 million DWT in 2019. During the prolonged pandemic period and the next wave in 2020, there were 160 vessels idle with 12,69 million DWT.

A low year-to-year fleet growth (3,5%) was also identified in 2021. The fleet numbered 2.831 vessels with 228,65 million DWT. The hope for the end of pandemic, lead the shipowners to wait (222 vessels with 18,12 million DWT remained idle) and not to scrap their vessels. As a result, only 9 vessels with 644.368 DWT were scrapped (Clarksons SIN, 2023).

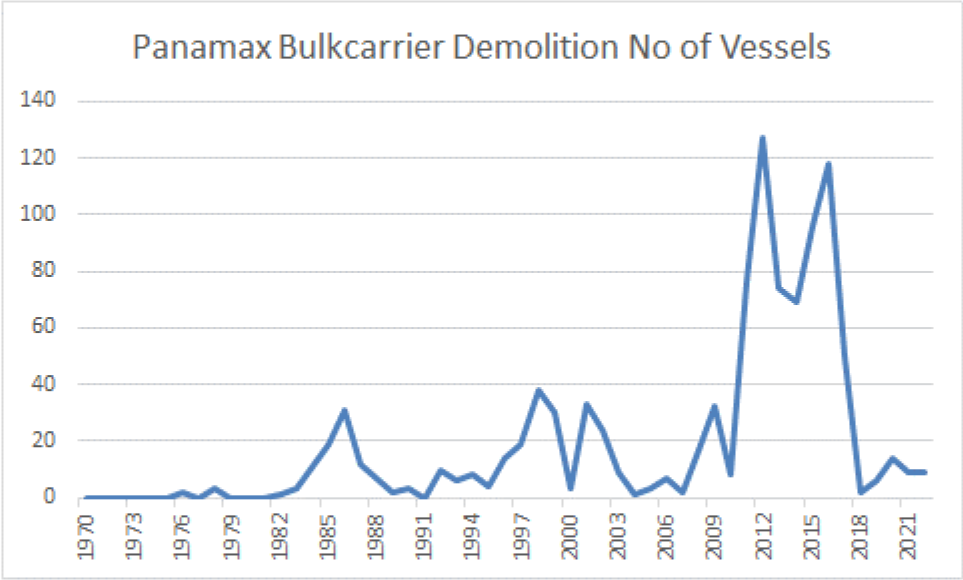
Finally, in 2022, the fleet growth was 2.925 vessels with 236.63 million DWT, as a year-to-year change of 3,9%. The operational age of the fleet was increased to 11,15 years and the demolition age of a panamax dry bulk vessel was 28,89 years. Only 9 vessels with 670.508 DWT were scrapped. Furthermore, there was a significant drop in the idle number 175 from 222 vessels) and capacity of the panamax dry bulk fleet (14,08 million DWT) (Clarksons SIN, 2023).

Figure 10 - Panamax Bulkcarrier Fleet Development



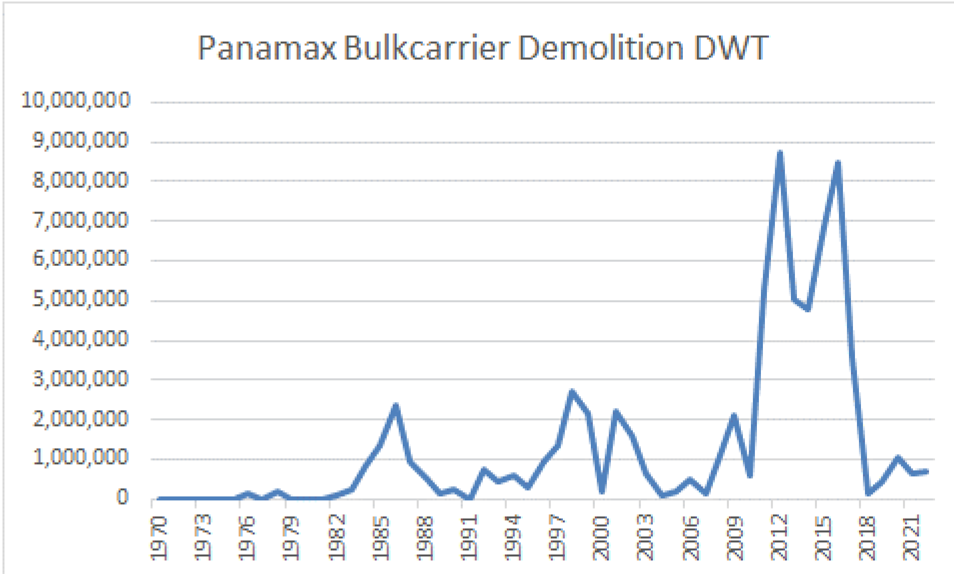
Clarksons Shipping Intelligence Network, 2023

Figure 11 – Panamax Bulkcarrier Demolition No of Vessels



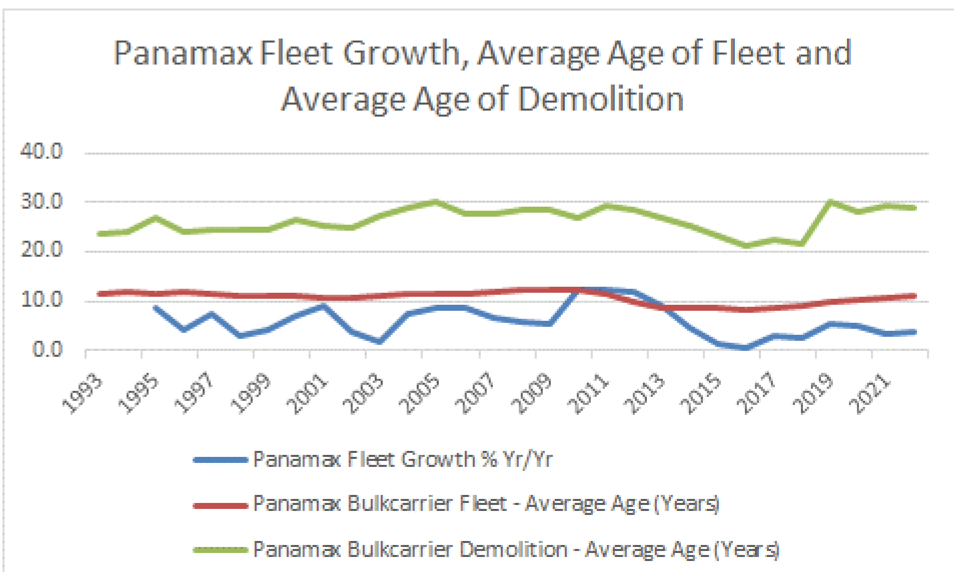
Clarksons Shipping Intelligence Network, 2023

Figure 12 – Panamax Bulkcarrier Demolition in DWT



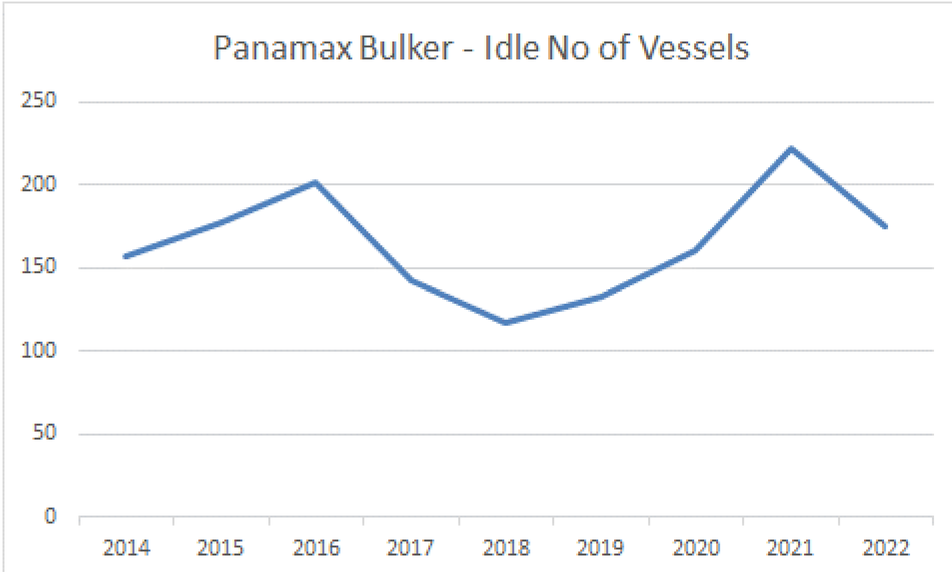
Clarksons Shipping Intelligence Network, 2023

Figure 13 – Panamax Fleet Growth, Average Age of Fleet and Average Age of Demolition



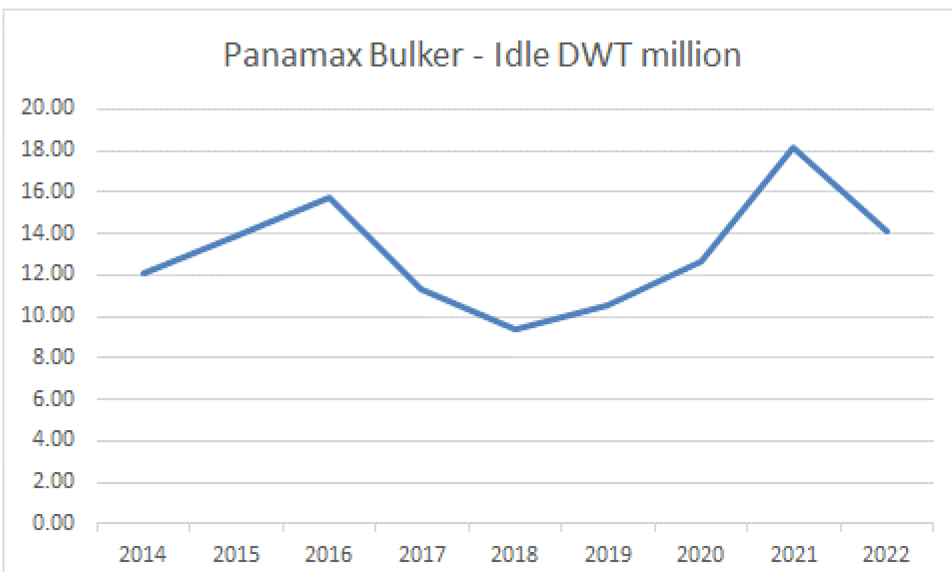
Clarksons Shipping Intelligence Network, 2023

Figure 14 - Panamax Bulkcarier - Idle No of Vessels



Clarksons Shipping Intelligence Network, 2023

Figure 15 – Panamax Bulkcarrier - Idle DWT million



Clarksons Shipping Intelligence Network, 2023

Panamax vessels transport the major and the minor dry bulk cargoes. Regarding the major dry bulk cargoes, they are the optimum choice for the transportation of grains worldwide, considering the parcel size and the distance factor. On the contrary, the iron ore is a different case, since the majority of the shipments happens with Capesize vessels for the reasons explained in the previous sub chapter.

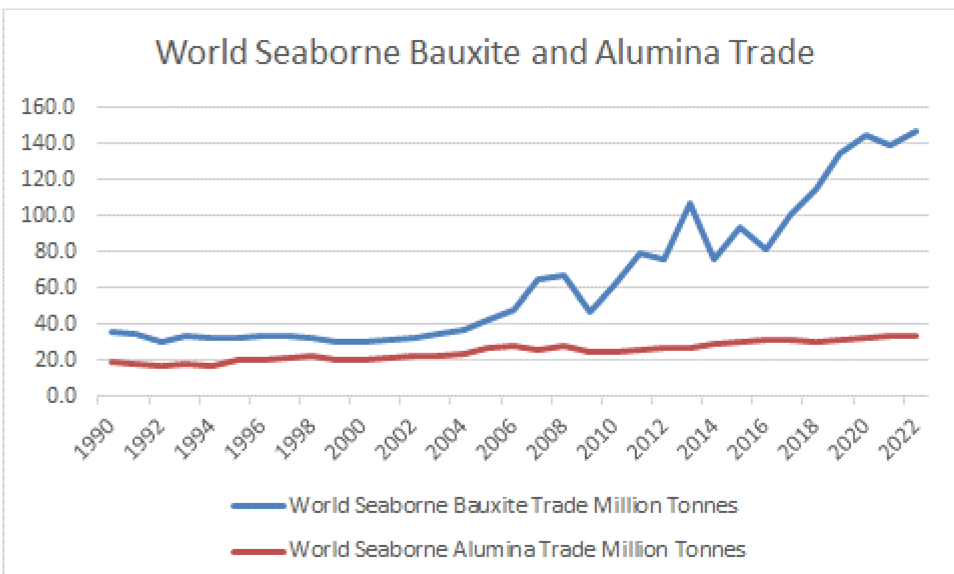
Nonetheless, Panamax vessels are the second most popular choice of charterers to transport iron ore and coal, among the dry bulk vessels. These vessels are the optimum option for the transportation of bauxite and alumina.

The special design of the kamsarmax vessels strengthens the argument, since the kamsarmax vessel is the largest vessel able to call the port of Kamsar in Guinea, a major exporting port of bauxites. Thus, below an analysis of the world seaborne trade of the grain family in total, including soyabeans, and bauxites and alumina will be presented, as a representative demand factor, affecting the relevant freight market.

The iron ore and the total coal world seaborne trades have been presented in the previous chapter, as these are the cargoes which solely affect the capesize market.

As seen in the below figure, the world seaborne bauxite and alumina trade in million tonnes is increased over the years.

Figure 16 – World Seaborne Bauxite and Alumina Trade



Clarksons Shipping Intelligence Network, 2023

The alumina world seaborne trade suffered from fluctuations in the 1990s. Starting from 19 million tonnes in 1990, there is a continuous decrease in the next 4 years. As a result, in 1994, the drop was 2 million tonnes compared to 1990, and the world seaborne alumina trade was 17 million tonnes.

However, there was a significant increase in 1995, closing the year with 19,7 million tonnes. This increase continued for the next years, swiftly exceeding the 20 million tonnes, and reaching the level of 22,5 million tonnes in 1998, as a peak of alumina world seaborne trade for this decade. The end of 1999 found the alumina world seaborne trade with a great drop, ending with 19,8 million tonnes (Clarksons SIN, 2023).

The world seaborne bauxite trade followed the same progress with the alumina world seaborne trade. In 1990, the world seaborne bauxite trade was 36 million tonnes. At the end of this decade, there was a drop of the bauxite world seaborne trade. Within the decade, many fluctuations occurred. In 1992, the bauxite world seaborne trade was 30,3 million tonnes. An increase followed in 1993 (33,2 million tonnes) with ups and downs for the next years. In 1999, the world seaborne trade was 30,6 million tonnes, which was 5,4 million tonnes less compared to the beginning of the decade (Clarksons SIN, 2023).

However, the trend was clear, and the signs of the market could not have been overlooked. The demand for shipping services was increased and the global trade was flourishing in the modern concept of globalization.

In 2000, the alumina world seaborne trade was 19,9 million tonnes and the bauxite world seaborne trade was 30,6 million tonnes. For the next years, a growth was monitored in both world seaborne trades. The bauxite world seaborne trade exceeded the 40 million tonnes in 2005 (42,2 million tonnes). This growth continued in the next years. As a result, the bauxite world seaborne trade was 64,9 million tonnes in 2007. The peak of world seaborne alumina trade was in 2006, with 27,7 million tonnes. A drop happened in 2007, with the world seaborne alumina trade still being at a high level (25,6 million tonnes) (Clarksons SIN, 2023).

The next year, 2008, was the peak of the dry bulk market. Thus, the world seaborne trade of alumina reached the 27,6 million tonnes (almost the same with the peak of 2006). At the same time, the world seaborne bauxite trade reached its peak with 66,7 million tonnes. This was the peak for both world seaborne trades. While 2009 was the year of the collapse of the dry bulk freight market, one can notice the significant drop of both bauxite and alumina world seaborne trades, with 46,6 and 24 million tonnes respectively (Clarksons SIN, 2023).

The following years, the forecast for the increasing demand was materialised. In 2010, the world seaborne alumina trade was 24 million tonnes and the world seaborne bauxite trade was 61 million tonnes. These levels were very close to the average world seaborne bauxite and alumina trades, 64,2 and 24,7 million tonnes. In 2013, the world seaborne bauxite and alumina trades were 107,2 and 26,8 million tonnes respectively. The next year was a year with a dramatic drop of the bauxite world seaborne trade (75,8 million tonnes).

However, it was not the same for the world seaborne alumina trade, since a significant increase happened, being 28,5 million tonnes at the end of the year. From 2015 and onwards, there was an increase for both world seaborne trades till 2018, when a decrease was noticed for the world seaborne alumina trade (29,6 million tonnes from 31,2 million tonnes).

In addition to the above, the world seaborne bauxite trade continued its growth (114,9 million tonnes). Even during the Covid – 19 period and the world lockdowns of economies, surprisingly, the growth of both world seaborne trades was increased. In 2022, the world seaborne bauxite trade was 147,1 million tonnes and the world seaborne alumina trade was 33,2 million tonnes, while the estimated trend is for an increase for the next two years (Clarksons SIN, 2023).

The grain family is a very important dry bulk cargo. Actually, it is one of the three major dry bulk cargoes. The panamax vessels are the first choice of charterers, who can afford the transportation of large parcels. Although a seasonality exists, it is of paramount importance to discuss the progress of this cargo. One key factor of the demand for such shipping services is the world seaborn grain trade. For the purpose of this research, the soybeans are included in the grain data. The data is available from 1990 to 2022 and is retrieved from Clarcksons Shipping Intelligence Network database (2023).

In 1990, the world seaborne grain trade was 195,5 million tonnes and 1.156,4 billion tonne miles. In the next years, there were some fluctuations with negative result. By the end of 1994, the drop was notable since the world seaborne grain trade was 177,5 million tonnes and 1.069,1 billion tonne miles. 1995 was a much better year for the demand of grains and 192,6 million tonnes were transported. In the same year, there were 1.250,2 billion tonne miles.

In 1996, we can notice an increase in the million tonnes of the world seaborne grain trade, reaching 198,1 million tonnes with a 2,9% year-to-year change. However, the opposite happened in the world seaborne grain trade in billion tonne miles, with a strange -2,9% year-to-year change and 1.213,5 billion tonne miles. The fluctuations continue for the next years too.

In 1997, the world seaborne grain trade was 210,7 million tonnes and 1.259,9 billion tonne miles, with a 6,4% and 3,8% year-to-year change respectively. However, the next year, 1998, was a year with a minor decrease in terms of million tonnes transported (208,8 with a -0,9% year-to-year change), and a major drop in terms of billion tonne miles (1.146,7 with a notable -9% year-to-year change).

The decade ended with its peak in 1999. The world seaborne grain trade was 223,3 million tonnes, which was a significant increase compared to last year (6,9%) and 1.278,2 billion tonne milles with a skyrocketing year-to-year change of 11,5% (Clarksons SIN, 2023).

The next decade, 2000 – 2009, was characterized by globalization and thriving economy. Thus, the demand for shipping services was increased and trade flourished. The world seaborne grain trade was positively affected. Only two years faced a drop in terms of million tonnes and only one year in terms of billion tonne miles.

In 2002, the world seaborne grain trade was 232 million tonnes and 1.293 billion tonne miles, following a year-to-year change of -0,8% and 9% respectively. In 2003, an increase was observed, resulting to 234,2 million tonnes and 1.401,9 billion tonne miles, with 1% and 8,4% year-to-year change respectively.

The fluctuations with many ups and downs continued for the next year, when a drop was noticed for the million tonnes of grain transportation (225,9 with -3,6% year-to-year change), but there was an increase for the billion tonne miles (1468,4 with 4,7% year-to-year change) (Clarksons SIN, 2023).

The next years till the end of the decade followed an increase in both terms (million tonnes of transportation and billion tonne miles) of the world seaborne grain trade, materializing the forecasts for an increased demand, pointing out the issue of oversupply in the years of the collapse and trough stages of the dry bulk freight market.

It is worth mentioning that the peak of the world seaborne grain trade in this decade, was in 2009, with 298,8 million tonnes (5,2% year-to-year change) and 1.909,5 billion tonne miles (5,1% year-to-year change) (Clarksons SIN, 2023).

Even though the collapse of the dry bulk freight market continued in the next year, with a prolonged recession period, the world seaborne grain trade continued its growth. In 2010, there were 319,4 million tonnes with a 6,9% year-to-year change. At the same time, there were 2.186,9 billion tonne miles with an impressive increase of 14,5% year-to-year change.

One can justify as reasonable the minor drop of 2011 with -0,5% million tonnes and -2,7% billion tonne miles compared to the previous year, since an impressive increase was observed, within the recession period of the dry bulk freight market (Clarksons SIN, 2023).

From 2012 till 2017, there was an increase in the world seaborne grain trade at every year. It is worth mentioning the increase of 2012 and 2014 in terms of million tonnes of transportation, as the level was 346,5 million tonnes in 2012 (with a 9% year-to-year change) and 409 million tonnes in 2014 (with a 12,6% year-to-year change).

In terms of billion tonne miles, it is highlighted the year 2013 with 2.575,5 billion tonne miles (12,5% year-to-year change) and 2015 with 3.033,5 billion tonne miles (10,1% year-to-year change). A minor drop occurred in 2018, as 473,8 million tonnes were transported (-0,2% year-to-year change) and 3.158,4 billion tonne miles (-3,5% year-to-year change) (Clarksons SIN, 2023).

The growth continued even during the pandemic period, with the boom of 2020, exceeding the 500 million tonnes. Specifically, the world seaborne grain trade was 517,8 million tonnes and 3.743,4 billion tonne miles, with 8,1% and 10,7% year-to-year change respectively.

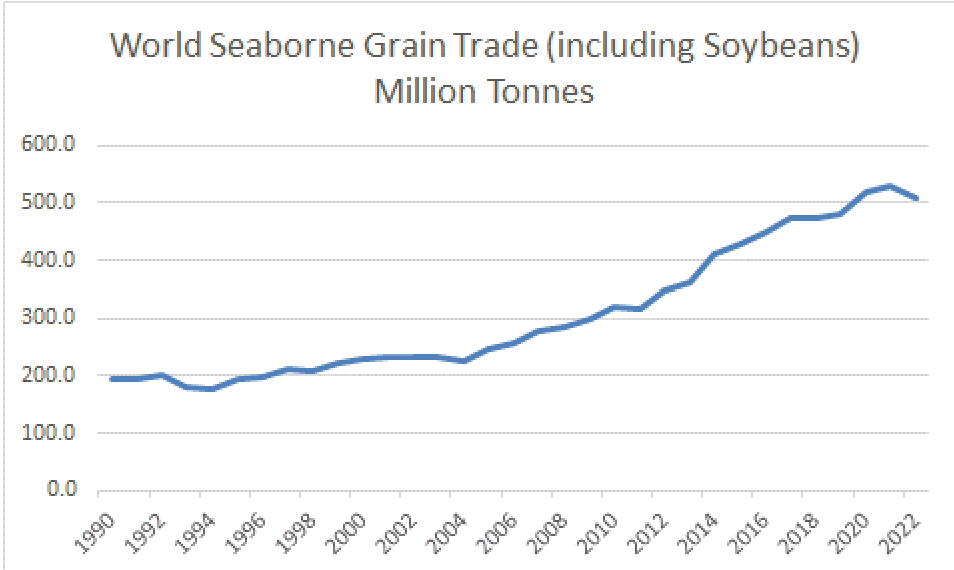
The increase continued in 2021. However, a drop was noted in 2022. The year ended with 528,3 million tonnes and 3.804 billion tonne miles. This was -3,4% and -2,9% year-to-year change (Clarksons SIN, 2023).

A possible explanation is the sudden war outburst between Russia and Ukraine. The latter was considered as an important exporting country of grains, with many shipments in various size parcels. Since the area was not compatible with the needs of the trade due to the high risk of vessels approaching the war zone, due to the damage of infrastructure and due to the fact of the reduce of harvesting quantities, it is logical to expect a significant drop of exports from this area.

Furthermore, those who were not directly affected by the war, but could not proceed with the trade through the ports of the area, needed some time for relocation. Time was also required for adjusting to the new reality. As a result, new trade routes with possible other transportation means might have resulted to the aforementioned decrease of the world seaborne grain trade.

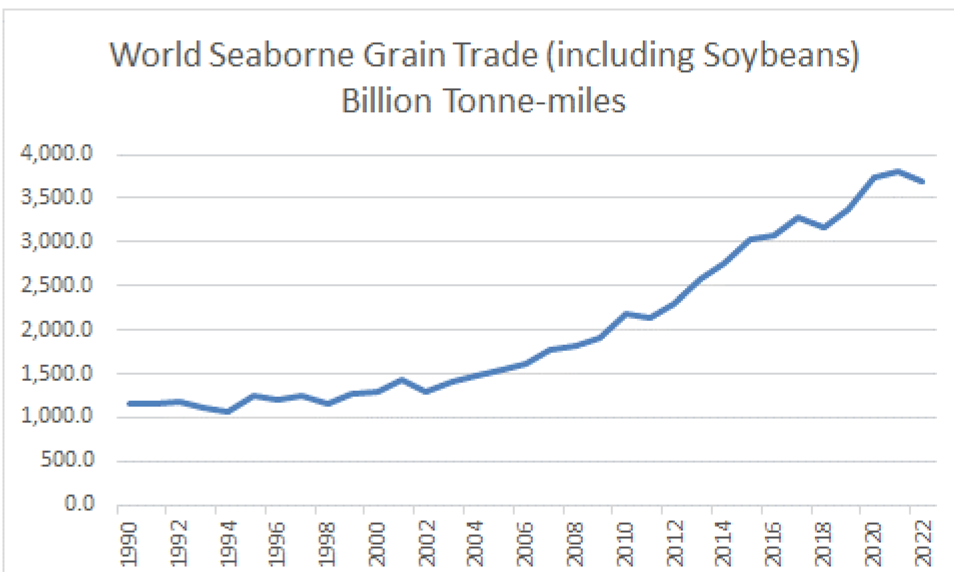
Finally, commodity price and sea trade costs have also changed, and this cost increase might have affected the world seaborne grain trade for this year. Finally, an estimation for increase in the next two years exists. It is expected to have a growth close to the average year-to-year change. The average world seaborne grain trade is 3,7% tonnes and 4,3 tonne miles (Clarksons SIN, 2023).

Figure 17 – World Seaborne Grain Trade Million Tonnes



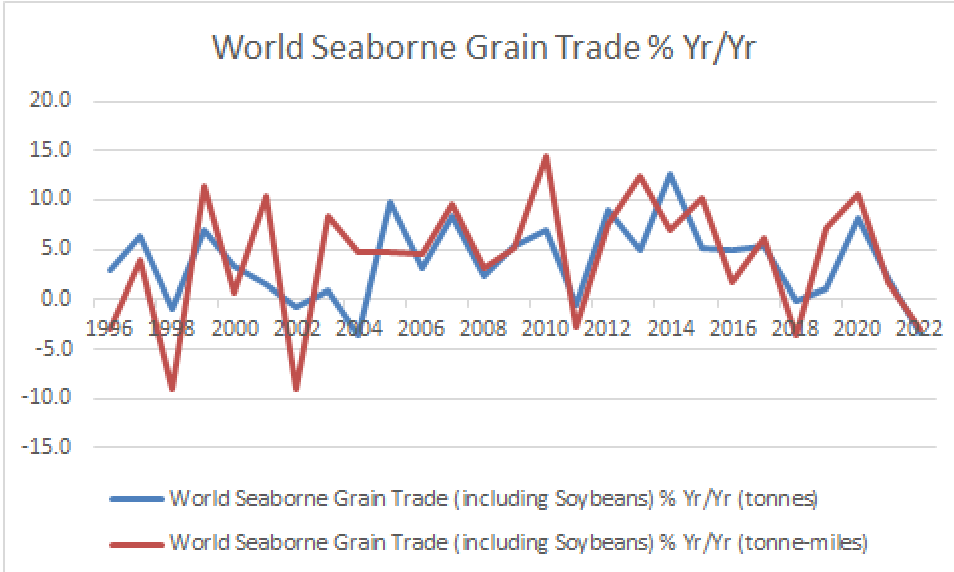
Clarksons Shipping Intelligence Network, 2023

Figure 18 – World Seaborne Grain Trade Billion Tonne Miles



Clarksons Shipping Intelligence Network, 2023

Figure 19 – World Seaborne Grain Trade % Yr/Yr



Clarksons Shipping Intelligence Network, 2023

The last of the five major dry bulk cargoes is the phosphates. Its volume per year is similar to alumina world seaborne trade. The average is 24,6 million tonnes per year. In 1990, the starting point of the available data, the world seaborne phosphate rock trade was 28,5 million tonnes. In this decade, this was the peak, since there was a trend for a lower phosphates demand.

As seen in the below figure (20), the lowest level was 20,4 million tonnes in 1993. From this year and onwards, there was an increase in the trade of phosphates. However, it never reached the peak of 1990. Till 1999, minor fluctuations with upturns mostly are observed, reaching the 25 million tonnes by the end of the decade. Still not that high compared to the starting point (Clarksons SIN, 2023).

The next decade started with a drop of 3,2% as a negative year-to-year change. In 2000, the world seaborne phosphate rock trade was 24,2 million tonnes. This decrease continued till 2003, while in 2004 the level was the same with 2000, with signs of increased demand.

Following the trend of the dry bulk market, in 2005 the world seaborne phosphate rock trade increased to 25,2 million tonnes. A drop occurred in the next year, 23,2 million tonnes, but during the boom of the dry bulk freight market there was a significant increase of the tonnes transported. In 2007 and in 2008, there was an increased trade, reaching 25,9 and 26,5 million tonnes of world seaborne phosphates trade respectively.

In 2009, the year of the collapse of the dry bulk freight market, we noticed a sharp drop of the world seaborne phosphates trade, only 15,3 million tonnes (Clarksons SIN, 2023).

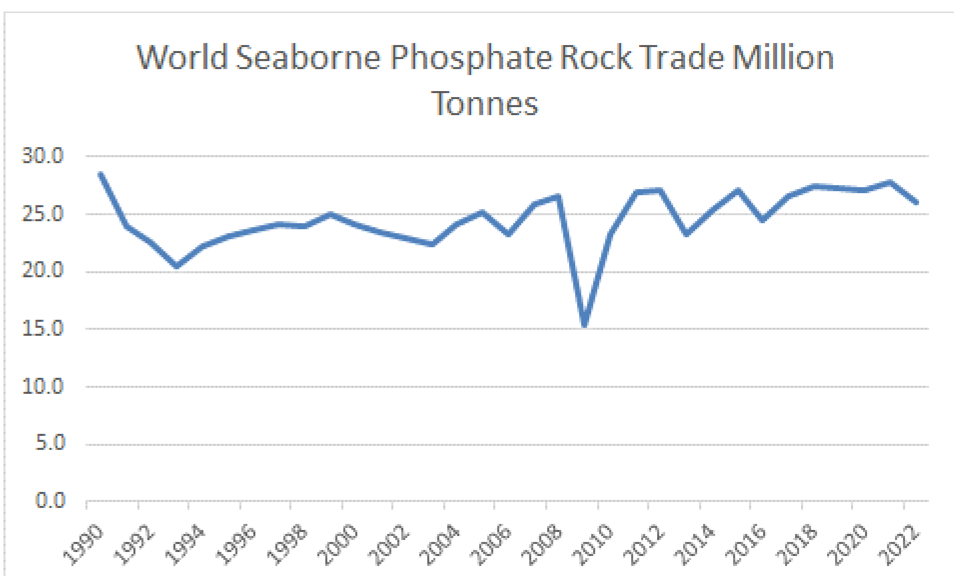
However, in the next years a significant increase of the world seaborne phosphates trade was identified, although the dry bulk freight market was in a deep recession period. Again, as argued before, the estimations for an increased demand can be observed for this cargo as well, pointing out that the crucial reason behind the deep recession was the oversupply of the dry bulk fleet.

In 2010, there was an impressive increase, almost a 53% year-to-year change, ending with 23,3 million tonnes. This increase continued for the next two years, with 27 million tonnes each year. Some fluctuations existed in the next years, with negative year-to-year changes in 2013 and in 2016.

In 2017, the world seaborne phosphates trade was 26,5 million tonnes. In the next years, its world seaborne trade was at similar levels in the range of 27 – 28 million tonnes. The Covid – 19 pandemic and the lockdowns of economies worldwide, did not affect the world seaborne phosphates trade.

In 2022, there was a minor drop, ending with 26 million tonnes. However, the forecasts for the next couple of years are promising, since it is expected an increase in the world seaborne phosphates trade, possibly slightly above 27 and up to 27,5 million tonnes per year, far beyond the average (Clarksons SIN, 2023).

Figure 20 – World Seaborne Phosphate Rock Trade Million Tonnes



Clarksons Shipping Intelligence Network, 2023

In the below combo figure (21), we can see the panamax fleet development from 2009 till 2022. Moreover, the progress of world seaborne trade of total coal and total grains is depicted.

Finally, the average earnings of Panamax and Supramax vessels built in 2010 are presented. Specifically, the earnings of simple and scrubber fitted vessels are distinguished, aiming at the discussion of their progress and pay off in the market.

A scrubber fitted vessel has a higher capital cost compared to a simple vessel. If a secondhand vessel is converted to a scrubber fitted vessel, then an extra cost has to be calculated. We also have to consider in such a case, the loss of transportation capacity of this vessel and the possibility of a change in speed and fuel consumption. However, the advantage of such a vessel is the ability to burn a lower cost fuel and her increased value, balancing the disadvantages mentioned before.

As one can see in the below figure the world seaborne trade of total coal and total grain has increased over the years with fluctuations, which were previously analyzed. At the same time the panamax bulk carrier fleet development has increased as well. At this point we can see that the earnings of panamax and supramax vessels which were constructed in 2010 have suffered great losses from 2010 until 2016.

One can also notice that the average supramax earnings are higher than the average panamax earnings for the same period of time, while in 2015 and 2016 we can see that they are almost equal resulting to the fact that panamax vessels were more efficient. This drop of the freight market is a result of the oversupply and the over expectations of the previous years for the progress of the demand, which was materialized though, but the earnings were not higher as believed from the shipowners.

From 2016 and onwards, we can see the recovery of the freight market mainly due to the fleet development remained almost the same, as a supply factor and due to the increase of the world seaborne trade at the same time.

In 2018 and 2019 the world seaborne total coal trade reached its peak with the world seaborne total grain trade to remain at high levels at the same time. Since the fleet development remained almost the same the freight market recovered. With the demand drop in 2019 – 2020 as an effect of the covid – 19 pandemic, and the marginal increase of the supply (the fleet was increased in million dwt) at the same time, the freight market faced a drop.

In 2021 we can see the peak of the average earnings of supramax and panamax vessels following the increase noticed in the last months of the previous year. This peak is the result of the increased demand and the almost same supply of fleet, following the expectations of returning back to normality after the lockdowns of economies of the previous years.

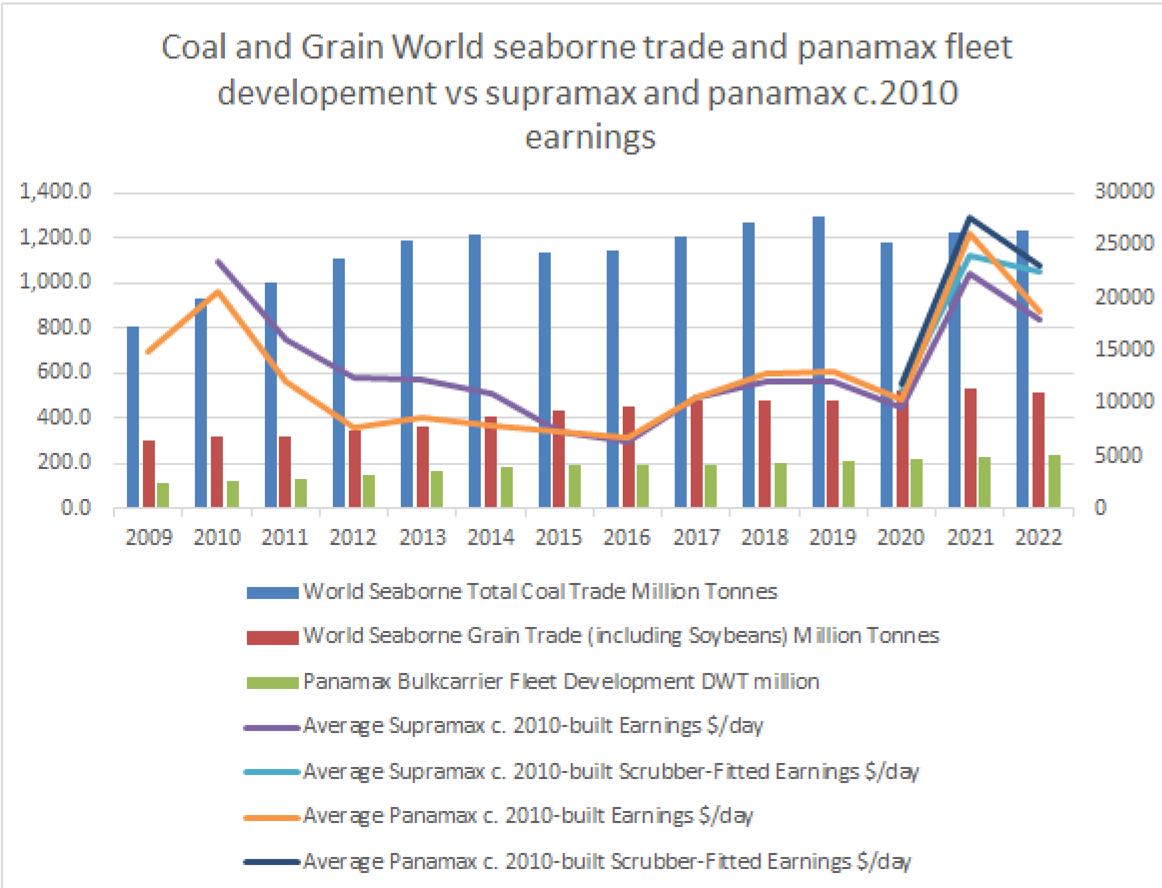
However, the demand remained almost the same in 2022 and with the increase of the supply at the same time we can see the freight market to decline in 2022. Based on the data collected from Clarksons SIN database (2023), an important identification made, is the fact that the scrubber fitted vessels have received much higher rates in the freight market compared to a simple vessel in 2022.

his was not the case for the previous two years (2020 and 2021) based on the available data. In 2020 and 2021, the scrubber panamax and supramax vessels received marginally higher rates in the freight market, only within the range of 1.500 – 2.000 $/day, making the shipowners having second thoughts about their investment.

As Tamvakis and Thanopoulou concluded in their research in 2000, there is no indication that the quality is paid more compared to other vessels, which is in accordance with this case. However, in 2022, the scheme is totally different, with the shipowners receiving much higher rates within the range of an average 4.000 – 4.500 $/day. It remains to be seen whether this continues in the future, resulting to quality paying off or this was just a sporadic change in the freight market due to other factors.

Finally, it is important to mention that although in the starting point of available data the supramax vessels produce higher earnings, we can now notice that the panamax vessels have overwhelmed the supramax earnings, indicating the trend for a larger competitive vessel for the same purpose.

Figure 21 – Coal and Grain World Seaborne trade, and Panamax Fleet development vs Panamax and Supramax vessels c. 2010 Earnings $/Day



Source – Elaborated by the author based on data from Clarksons SIN, 2023

Panamax vessels perform Transatlantic and Transpacific trades, along with trips from Europe to Far East and vice versa. They also offer a balanced choice in transportation, considering the transported quantity and the distance effect. They are operated worldwide, in an open competitive shipping market, and they are able to call most of the ports in key areas. They are able to transport every kind of dry bulk cargo.

Furthermore, they are able to transport unitized cargoes as well, such as pallets and containers, even project cargoes and machineries, although not being the first choice. Thus, they offer flexibility in the types and parcel size of cargoes, and they strongly compete other transportation means, such as rails and trucks, with the example of USA West- and East Coast trade being well known (Stopford, 2009).

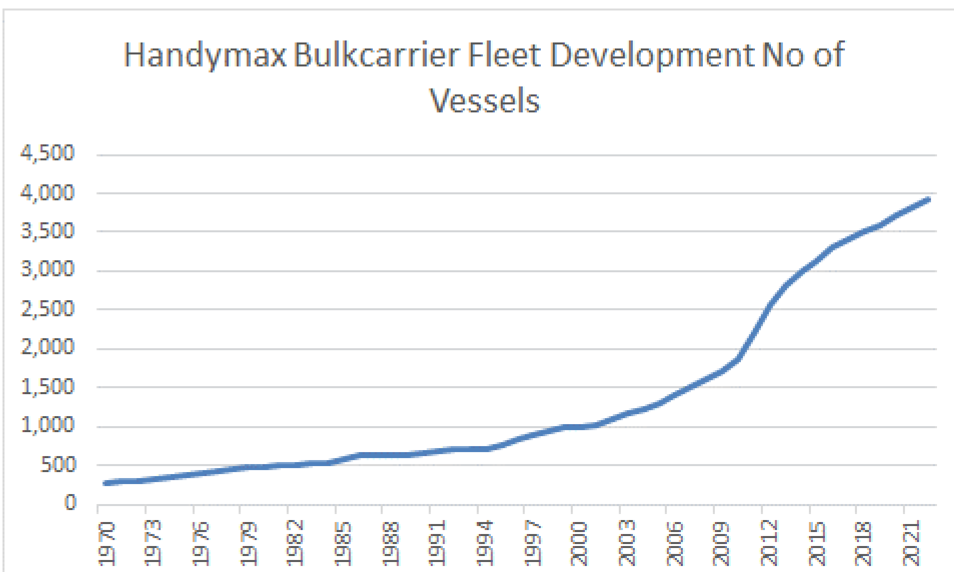
2.2.3 Handymax market structure

The handymax market is normally the market where vessels within the range of 40.000 – 59.000 dwt perform trade. For the purpose of this research, and as a result of data retrieval limitation, this market includes the supramax vessels. These are vessels of size 52.000 – 59.000 dwt and they directly compete the panamax vessels and other transportation means.

In the below figures, the handymax fleet development in terms of number of vessels and deadweight, the demolition of vessels in number of vessels and deadweight, the year-to-year percentage, the average age of fleet and demolitions are presented. A discussion follows, based on the historical data available, to determine the market structure in terms of supply.

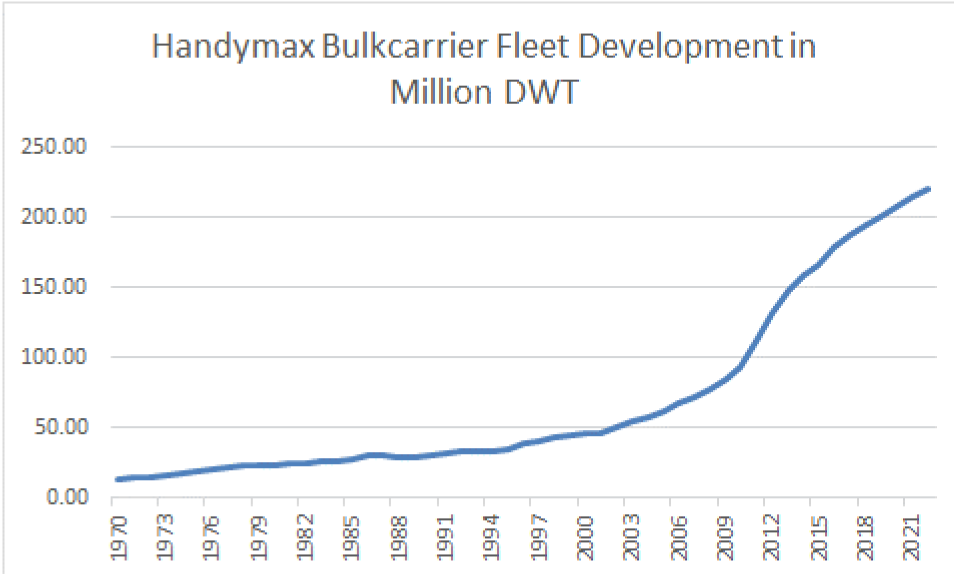
The average fleet development is 1.345 vessels and 68,76 million dwt. The average of the fleet is 10,27 years. The average demolition of the fleet is 21 vessels and 970.403 dwt per year, while the average demolition age of a handymax vessel is 27,37 years. We can notice that the fleet age is relatively low. On the contrary, the demolition age of these vessels is very high, which indicates the maximization of the operational years of the vessels. The average year-to-year fleet growth change is 7% (Clarksons SIN, 2023).

Figure 22 – Handymax Bulkcarrier Fleet Development No Vessels



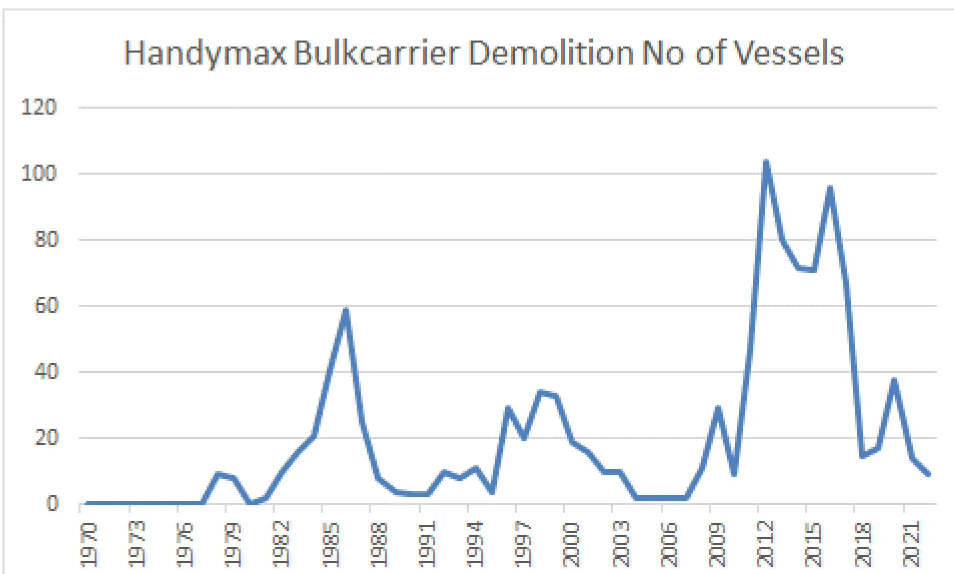
Clarksons Shipping Intelligence Network, 2023

Figure 23 – Handymax Bulkcarrier Average Age Fleet Development in Million DWT



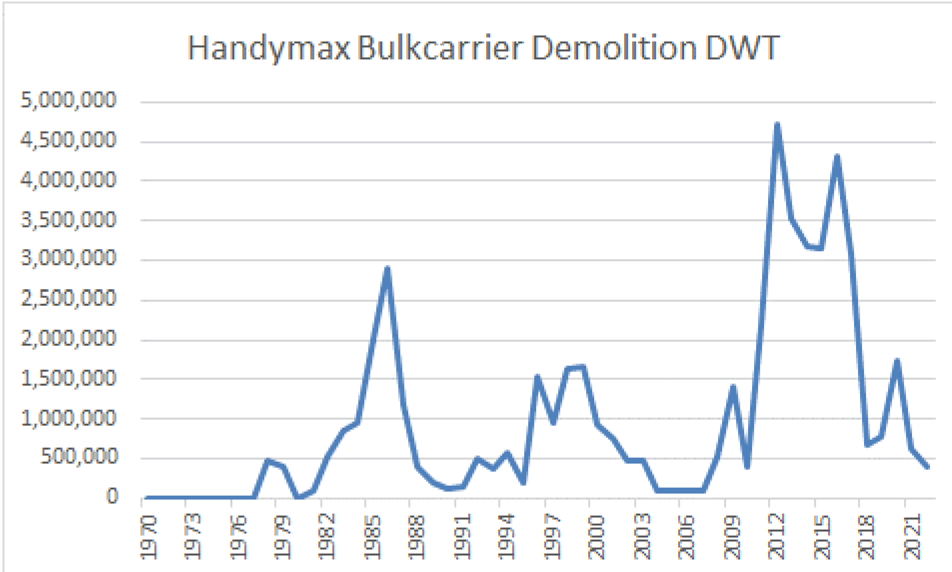
Clarksons Shipping Intelligence Network, 2023

Figure 24 – Handymax Bulkcarrier Demolition No Vessels



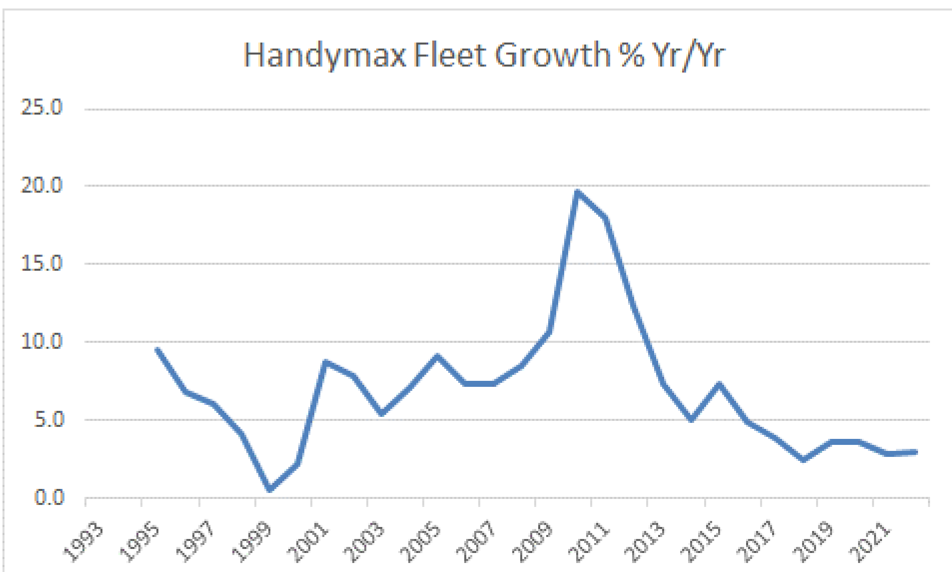
Clarksons Shipping Intelligence Network, 2023

Figure 25 – Handymax Bulkcarrier Demolition DWT



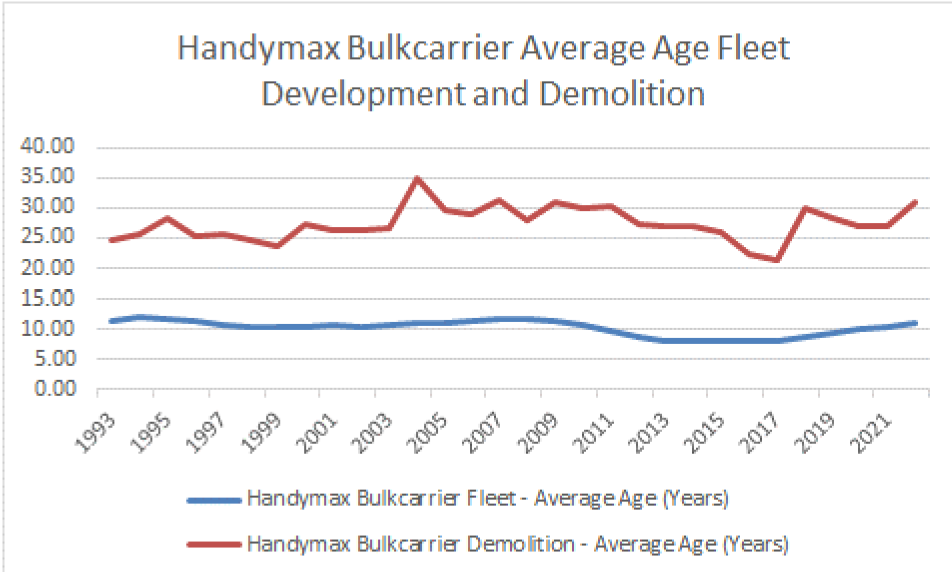
Clarksons Shipping Intelligence Network, 2023

Figure 26 – Handymax Bulkcarrier Fleet Growth % Year-To-Year Change



Clarksons Shipping Intelligence Network, 2023

Figure 27 – Handymax Bulkcarrier Average Age Fleet Development and Demolition



Clarksons Shipping Intelligence Network, 2023

As previously depicted, there are many fluctuations, but generally the trend was for more vessels and few demolitions, to satisfy the need for the shipping services.

Specifically, in 1970, the fleet consisted of 272 vessels and 13,38 million dwt. In 1978, there were 467 vessels and 22,91 million dwt, despite the 9 vessels and 476.301 dwt that were scrapped. In the next year, the fleet had grown bigger, having 487 vessels and 23,76 million dwt, although 8 vessels and 405.909 dwt were scrapped (Clarksons SIN, 2023).

In 1982, the fleet development exceeded the 500 vessels (actually it was 505 vessels) and 24,58 million dwt. At the same time, the demolition market began active, since 10 vessels and 528.942 dwt were scrapped. This increase of the fleet development continued in the next years.

Moreover, the demolition market was very active year by year, until 1986, when the fleet development was 644 vessels and 30,22 million dwt. At the same year, the demolition market reaches its peak till that period. The vessels scrapped were 59, with 2.900.987 dwt. A drop in the fleet development was noticed in the next years, 640 vessels and 29,75 million dwt in 1987, 633 vessels and 29,34 million dwt in 1988. Regarding the demolition market, in 1987, many vessels were scrapped (25 vessels and 1.184.904 dwt) (Clarksons SIN, 2023).

From 1989 till 1995, we can identify the increase of the fleet. The fleet development was 762 vessels and 34,91 million dwt, in 1995. Few vessels were scrapped per year, with the highlights of 1992 and 1994. These two years 10 vessels with 498.274 dwt and 11 vessels with 573.696 were scrapped respectively. This led the fleet to a higher average age (11,90 years) and demolition age (25,46 years). In 1995, the fleet development was 762 vessels and 34,91 million dwt with a 9,6% year-to-year change, since only 4 vessels and 200.387 dwt were scrapped.

Towards the end of the decade and following a yearly growth, the fleet development was significantly increased (991 vessels and 45,16 million dwt with a 0,6% year-to-year change in 1999). The demolition market was very active in the last years of the decade. In 1998 and 1999, 34 vessels with 1.640.417 dwt and 33 vessels with 1.660.743 were scrapped respectively (Clarksons SIN, 2023).

In the next decade, there was a notable increase of the fleet development. The average year-to-year change during these years was 7,5%. From 998 vessels and 45,41 million dwt in 2000, the fleet development was 1.722 vessels and 84,02 million dwt in 2009. Some vessels were scrapped in 2000 (19 vessels and 936.872 dwt), and few in 2001 (16 vessels and 743.124 dwt). Even fewer were scrapped in the next years, as the dry bulk freight market was in the recovery period with high earnings.

In 2008, which was the peak of the dry bulk freight market, the fleet development was 1.605 vessels and 77,46 million dwt, while 11 vessels and 513.707 dwt were scrapped. Closing the decade, in 2009, the year of the great collapse of the dry bulk freight market, the fleet development was 1.722 vessels and 84,02 million dwt with average fleet age 11,46 years. However, the demolition market was reactivated with 29 vessels and 1.399.477 dwt under scrap. The average age of a scrapped handymax vessel was increased to 30,90 years (Clarksons SIN, 2023).

The estimations for the progress of the dry bulk demand for an immediate recovery after the collapse of 2009, led the shipowners to wait for the progress of the dry bulk freight market in the next years. Thus, only 9 vessels and 398.418 dwt were scrapped. Since the dry bulk freight market did not recover immediately and still remained in the recession stage for the next years, the demolition market was very active at very high levels.

In 2011, 47 vessels and 2.195.844 dwt were scrapped, but this was the beginning of what was about to follow. In 2012, we can notice the peak of the demolition market with 104 vessels and 4.705.530 dwt, slowly dropping the average demolition age to 27,21 years and the fleet development age to 8,71 years. In the same year, the fleet development was 2.551 vessels and 131,46 million dwt with 12,3% year-to-year change.

Since the recession continued, the shipowners were scrapping vessels and capacity. However, the heavy ordering of the previous years led to the increase of fleet in terms of number of vessels and dwt capacity (Clarksons SIN, 2023).

Thus, in 2013, the fleet development was 2.820 vessels and 147,64 million dwt, but 80 vessels and 3.529.732 dwt were scrapped, lowering the fleet development age to 8,15 years, and the demolition age of a handymax vessel to 26,87 years.

The heavy ordering resulted to heavy deliveries of new vessels in this period. In 2016, the fleet development was 3.303 vessels and 178,71 million dwt, but the demolition market reached similar levels to the previous peak, with 96 vessels and 4.311.121 dwt under scrap, lowering even further the age of the fleet to 8,03 years and the demolition age to 22,39 years.

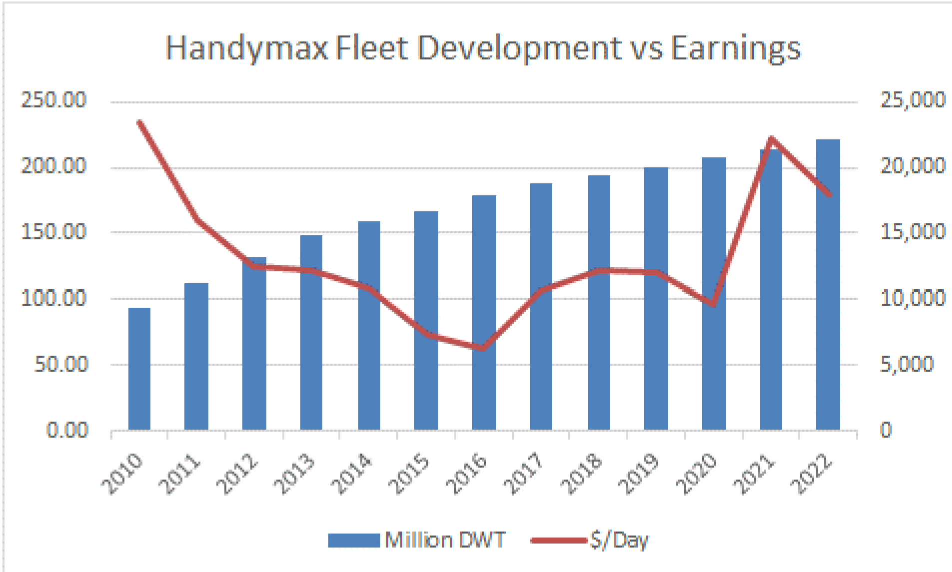
In the next years, including the pandemic period, the fleet development continued, along with scrapping of handymax vessels. In 2020, although the fleet development was 3.712 vessels and 207 million dwt with a 3,6% year-to-year change, 38 vessels and 1.735.153 dwt capacity were scrapped.

It is worth mentioning that in this year, the average age of the fleet was increased to 9,92 years and the demolition age of a vessel was increased to 27 years. This is explained by the recovery of the freight market in the previous years and after 2016 – 2017, as a result of a heavy scrapping and little ordering period of the previous years (Clarksons SIN, 2023).

In 2022, the fleet development was 3.922 vessels and 220,74 million dwt. The year-to-year change was 3%. Very few vessels were scrapped. Only 9 vessels and 407.474 dwt capacity were scrapped. The average fleet age was 11,10 years, while the demolition age was significantly increased to 31,05 years. The forecasts for the supply of the next couple of years are encouraging for a minor increase, which will lead to the fleet development above 4.000 vessels (Clarksons SIN, 2023).

Finally, as we can see in the below figure (), the fleet growth has a negative effect on the earnings of the shipowners, when the demand is not increased. From 2010 and onwards, we can see that the fleet had a rapid development, with the earnings to decline. In 2016 and onwards, a positive impact on the demand growth to the earnings of the shipowners has been noticed.

Figure 28 – Handymax Fleet Development and Earnings



Source – Elaborated by the author based on data from Clarksons SIN, 2023

It is also important to analyse the demand for shipping services of the vessels in this category. Apart from the cargoes that have been already analysed, the steel products and the scrap world seaborne trades also affect the demand of this market. Below, an analysis follows with relevant figures.

In 1990, the world seaborne scrap trade was 35,8 million tonnes. In this decade, there is a continuous increase till 1997, when the world seaborne scrap trade was 52 million tonnes. A minor drop occurred in the next year to 51 million tonnes, but an immediate recovery was noticed in 1999, reaching 53,8 million tonnes (Clarksons SIN, 2023).

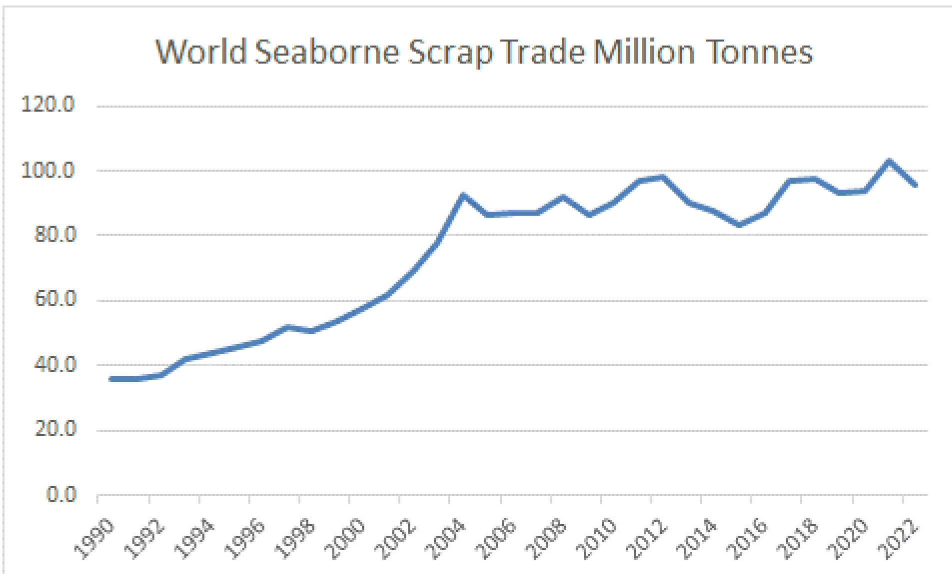
In the next decade, the general trend was for increased demand. In 2004, the world seaborne scrap trade reached its peak with 92,6 million tonnes. Although the trade levels were slightly lower in the next years, it still remained at high levels with smooth fluctuations, from 86,4 to 87 million tonnes. The year 2008 is the exception, when the world seaborne scrap trade was 92 million tonnes. In the collapse of the dry bulk freight market in 2009, a minor drop occurred, and the world seaborne scrap trade was 86,7 million tonnes (Clarksons SIN, 2023).

The forecasts for a higher demand in the following years were materialised since the world seaborne scrap trade was increased. In 2010, the world seaborne scrap trade was 90,3 million tonnes. In 2012, the increase was significant since it reached 97,9 million tonnes.

In the next years, a drop was observed till 2015, the lowest point of the decade, when 83,2 million tonnes were transported. Thereafter, an increased trend was observed on annual basis, till the beginning of the pandemic, when a minor decline was noticed, but the trade was still at a high level. Finally, the peak was in 2021 with 102,9 million tonnes.

In 2022, a drop was seen in the world seaborne scrap trade with 95,8 million tonnes at the end of the year. A drop is also estimated for the next year (93,3 million tonnes), but a good increase is estimated for 2024 to 95,2 million tonnes (Clarksons SIN, 2023).

Figure 29 – World Seaborne Scrap Trade



Clarksons Shipping Intelligence Network, 2023

The world seaborne trade of steel products is another important part of the demand. As seen in the below figure, the trade has been increased over the years. In 1990 the world seaborne steel products trade was recorded as 168 million tonnes, way below its yearly average of 303.10 million tonnes. In a continuous increased demand, we can observe that in 1996 the world seaborne steel products trade was 200 million tonnes. At the end of this decade, the trade was 228,8 million tonnes (Clarksons SIN, 2023).

This demand growth continued in 2000 as well, reaching the level of 250,6 million tonnes. However, in the next year, a minor drop was occurred, and as a result 247,8 million tonnes were transported. In a booming economy, a sharp increase was observed in the next years.

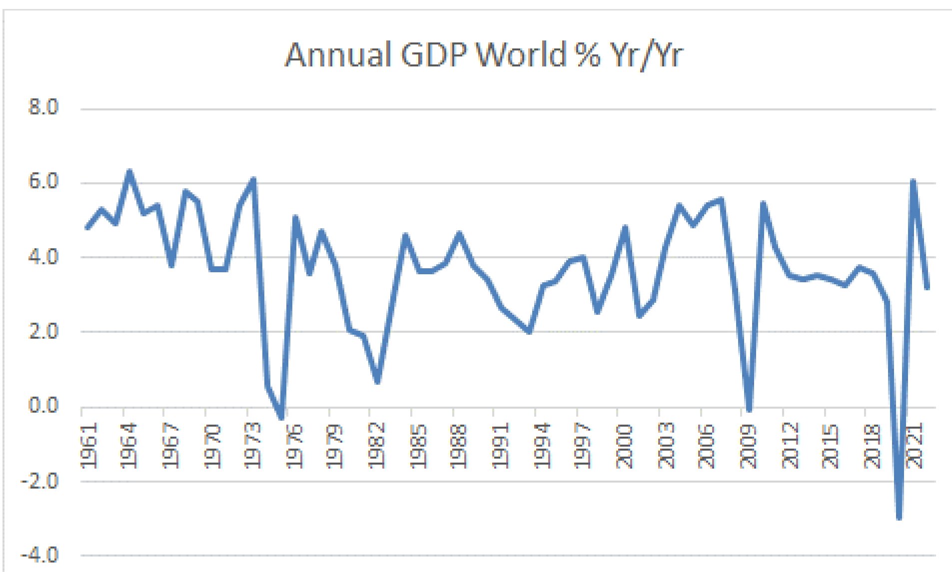
A notable increase was monitored in 2002 (271,2 million tonnes with about 9,5% year-to-year change) and onwards. Very swiftly and in 2004, the world seaborne steel products trade way exceeded the 300 million tonnes. The growth continued till 2007, in a flourishing dry bulk freight market, reaching the peak with 389,6 million tonnes. In 2008, when the peak of the dry bulk freight markets noticed, the world seaborne steel products trade remained still high and similar with the previous year, with 386,3 million tonnes (Clarksons SIN, 2023).

However, in the collapse of the freight market of 2009, the world seaborne steel products trade collapsed too, falling to 291,6 million tonnes, slightly higher than the one in 2003. In the recession period of the dry bulk freight market and till 2013, the level of the world seaborne steel products trade remained high, with minor fluctuations in the range of 355,8 and 360,9 million tonnes.

A significant increase followed the next two years, with 416 million tonnes in 2015. Thereafter, a declining trend existed, leading the world seaborne steel products trade to a low level in 2018 with 391,7 million tonnes. With the pandemic outburst worldwide, the trade suffered, and in 2020 only 347,5 million tonnes were transported. This is reasonable since the industrial areas were under long term lockdowns and the need for the steel products became much lower than in the ordinary economy.

As seen in the below figure (), we cannot omit the fact that the world Gross Domestic Product (GDP) was reduced by 3% this year, as a negative year-to-year change, which was the highest drop recorded from 1961 (Clarksons SIN, 2023).

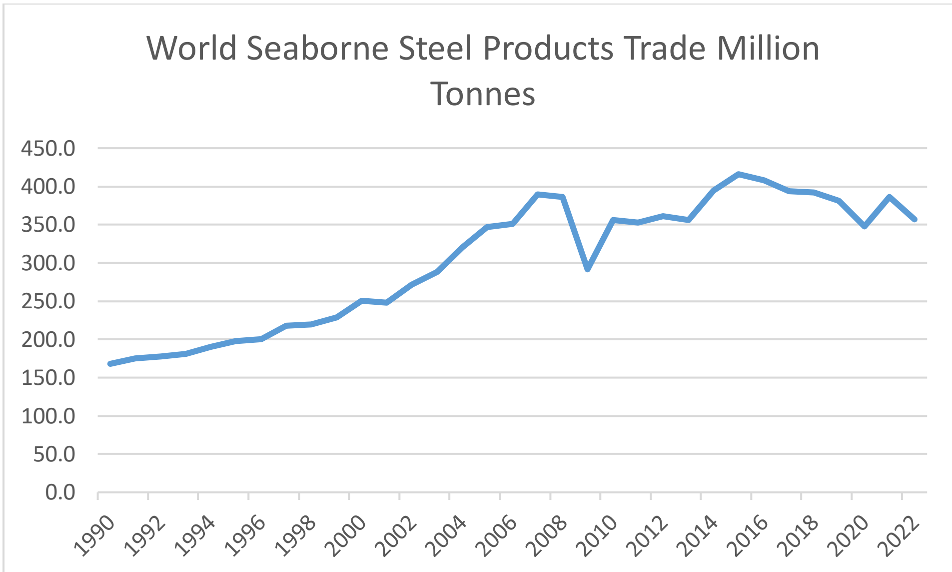
Figure 30 - Annual GDP World % Yr/Yr



Clarksons Shipping Intelligence Network, 2023

In 2021, there were signs of recovery since 385,8 million tonnes were transported, but a significant drop followed in 2022, closing with 356,9 million tonnes. The forecast for the demand of the world seaborne steel products trade indicate a drop in 2023 (348,1 million tonnes) but a recovery in 2024, reaching 361,4 million tonnes (Clarksons SIN, 2023).

Figure 31 – World Seaborne Steel Products Trade



Clarksons Shipping Intelligence Network, 2023

Handymax and supramax vessels are traded worldwide, mainly in the Atlantic (transatlantic trade), Pacific (transpacific trade), Far East (handymax vessels are famous in Indonesia, India and China), Continent – Far East, East Mediterranean and Black Sea areas. The transported cargoes with these vessels are dry bulk, mainly coal, petcoke, scrap and grains.

They also transport the minor dry bulk cargoes, while sometimes compete with panamax vessels for the major dry bulk cargoes, with focus on grains after the harvesting period. However, unitized, and special cargoes can also be transported upon demand. The market is open structured and highly competitive with a variety of shipowners and charterers to participate.

These vessels offer economies of scale for medium parcels, either in the spot market or in the timecharter market. They can also be very good options for transpacific, transatlantic trade and good competitors of other transportation means such as rails and truck, or useful part of the logistics chain.

As a closing remark of this market, it is noticed that the demand for key cargoes affects the freight market. As a result of the progress of the freight market and the estimations of the demand progress, the shipowners decide about their investments, affecting at the end the supply. This leads to the alternation of the equilibrium of the freight market, with re-evaluation of the fleet development (supply) compared to demand for its services (world seaborne trade). The freight market will be analysed in the data analysis section.

2.2.4 Handysize market structure

The handysize vessels are small dry bulk vessels from 16.000 dwt – 38.000 dwt. These vessels are very flexible, and they transport all dry bulk cargoes worldwide. They can also call almost all ports, due to their size. This type of vessel has developed in the years in a reliable and efficient transportation mean in the dry bulk industry. It is important to analyse the fleet development and the demolition market as supply factors.

As seen in the below figures, the fleet was 1.675 vessels and 36,79 million dwt in 1970. As the years went by and the trade developed, more vessels and capacity were required. By the end of this decade, the fleet was almost the double, both in terms of numbers of vessels (3.129) and of dwt capacity (75,4 million dwt). In this period, few vessels and capacity were scrapped, apart from the end of the decade, when 53 vessels and 1.115.594 dwt were scrapped in 1977 and 70 vessels with 1.529.395 dwt were scrapped in 1978. A good number of vessels (47) and capacity (875.582) were scrapped in 1979 (Clarksons SIN, 2023).

In the next decade, we can identify two stages. The first stage from 1980 till 1985, when the fleet development had a steady increasing reaching 3.483 vessels and 88,70 million dwt. At the same period, one can identify that the shipowners were massively scrapping vessels, with the highlight of the years 1984 and 1985, when 158 vessels with 3.197.153 dwt and 235 vessels with 5.608.115 dwt were scrapped respectively. The year 1985 is the peak of the demolition market (Clarksons SIN, 2023).

The second stage is the years from 1986 till 1989. In this period, the heavy scrapping continued. In 1986, 220 vessels with 5.572.562 dwt were scrapped. This level was close to the peak recorded in the previous year. In 1989, the fleet consisted of 3.163 vessels and 82,43 million dwt, while 28 vessels were scrapped with 632.885 dwt capacity (Clarksons SIN, 2023).

The shipowners continued to scrap vessels and along with limited deliveries of new vessels, the fleet was decreased in terms of supply. This drop ended in 1996, the year when a positive year-to-year change was observed in the fleet development. This year, the fleet development was 3.112 vessels and 82,05 million dwt, slightly higher above the average of 3.092 vessels and 79.86 million dwt.

However, the demolition market was very active too. Shipowners scrapped 75 vessels and 1.992.327 dwt. At the same time, the average age of the fleet was 16,78 years and the average demolition age of handysize was dropped to 25,94 years (from 29,30 of the previous year) (Clarksons SIN, 2023).

From 1997 till 2004, the fleet development was significantly decreased in a very active demolition market at high levels. Specifically, in 2003, the fleet development was 2.744 vessels and 72,35 million dwt with -3,4% year-to-year change. In this period of time, the average demolition per year was 116 vessels and 3.003.159 dwt capacity.

The highlight was the year 1998 with the notable scrapping of 168 vessels and 4.509.225 dwt. At the same time, the average fleet development was 17,04 years, while the average scrap age was 25,36 years. In 2004, the fleet development was 2.712 vessels and 71,58 million dwt. The demolition market was at high level, as 79 vessels and 2.095.206 were scrapped in 2003, while 28 vessels and 702.653 were scrapped in 2004 (Clarksons SIN, 2023). This fleet development decrease, and the heavy scrapping, came in the period of the recovery of the dry bulk freight market. Probably, this was because of the young age of the fleet.

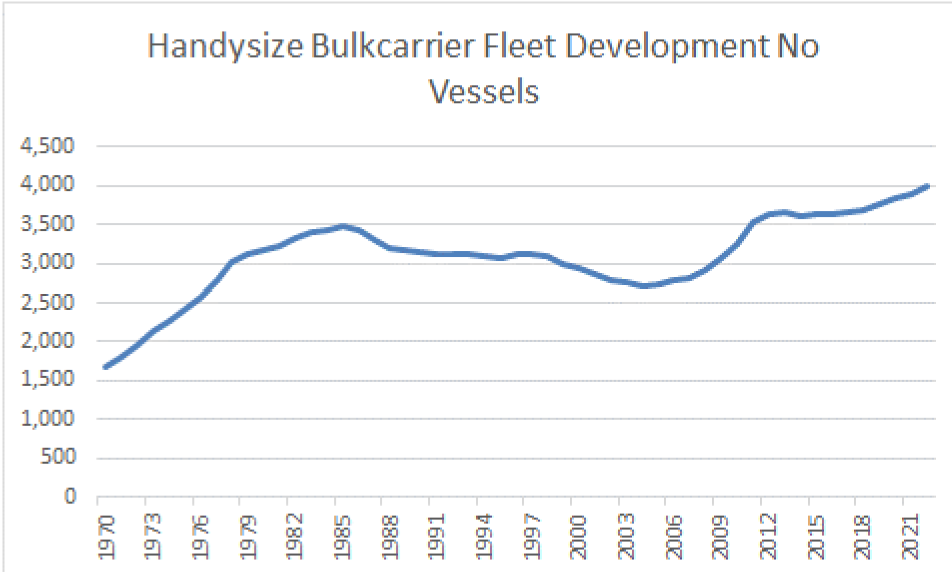
From 2005 till 2013, the fleet development was continuously increased every year, both in number of vessels and dwt capacity. The demolition market was still at high levels and many vessels were scrapped. Specifically, in 2013, the fleet development was 3.647 vessels and 95,93 million dwt, while 233 vessels and 6.695.660 dwt were scrapped.

However, the peak of the demolition market was 2012, when 290 vessels and 8.299.586 dwt were scrapped. The average scrap number of the vessel was 132 and 3.596.652 dwt. The heavy scrapping continued in the next years, along with the increase of the fleet development. As a result, in 2016, the average age of the fleet was 9,82 years, which is the lowest historically.

In the next years, the fleet development increase continued. In 2022, there were 3.991 vessels and 111,69 million dwt. The low scrapping (10 vessels and 232.788 dwt) of this year resulted in the increase of the age of the fleet (12,63 years) and of the demolition age of a handysize vessel (29,53 years). Based on the available data, the historical average is 80 vessels and 2.012.249 dwt, with 29,50 years as an average demolition age.

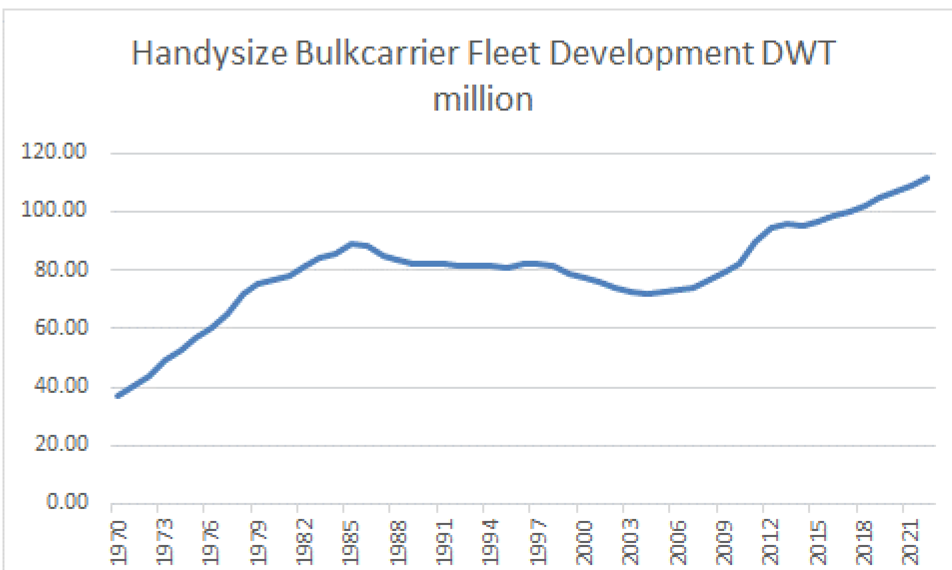
Finally, the age of the fleet is 15,04 years, which is relatively low compared to the demolition average age of a handysize vessel. The estimation for the next year, 2023, is for an increased fleet development (115,10 million tonnes), though for the next years 2024 and 2025 the forecasts indicate a decrease of the fleet development to 114,82 and to 112,88 million tonnes respectively (Clarksons SIN, 2023).

Figure 32 – Handysize Bulkcarrier Fleet Development No Vessels



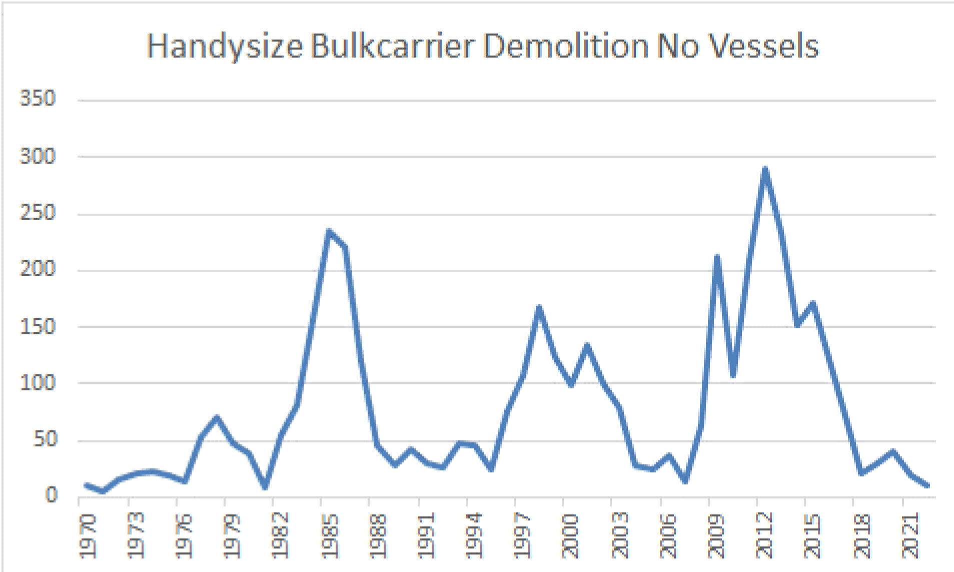
Clarksons Shipping Intelligence Network, 2023

Figure 33 – Handysize Bulkcarrier Fleet Development DWT million



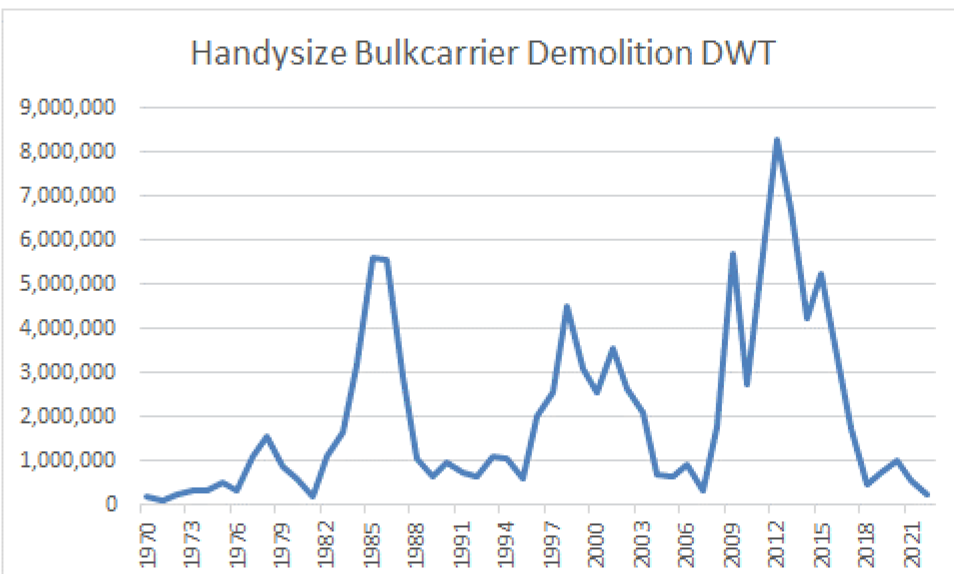
Clarksons Shipping Intelligence Network, 2023

Figure 34 – Handysize Bulkcarrier Demolition No Vessels



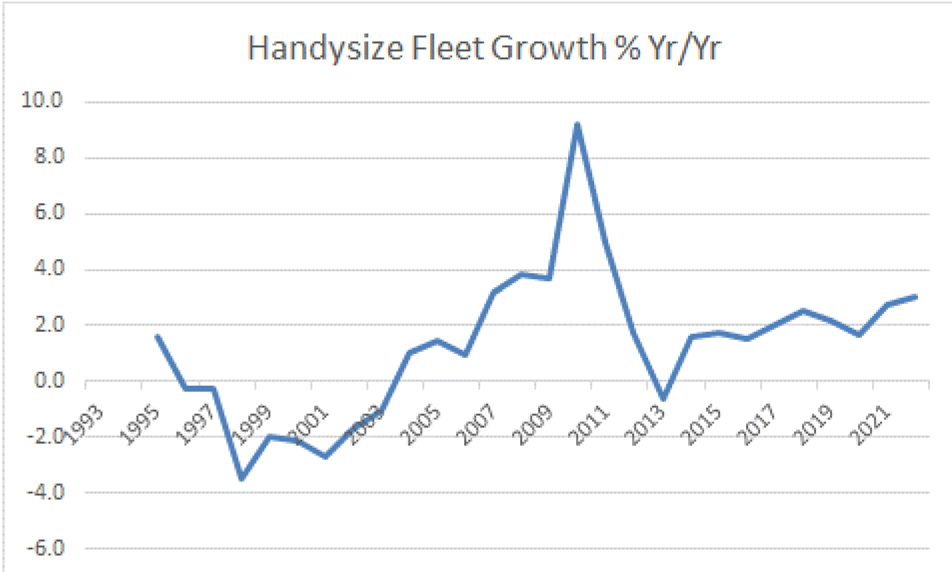
Clarksons Shipping Intelligence Network, 2023

Figure 35 – Handysize Bulkcarrier Demolition DWT



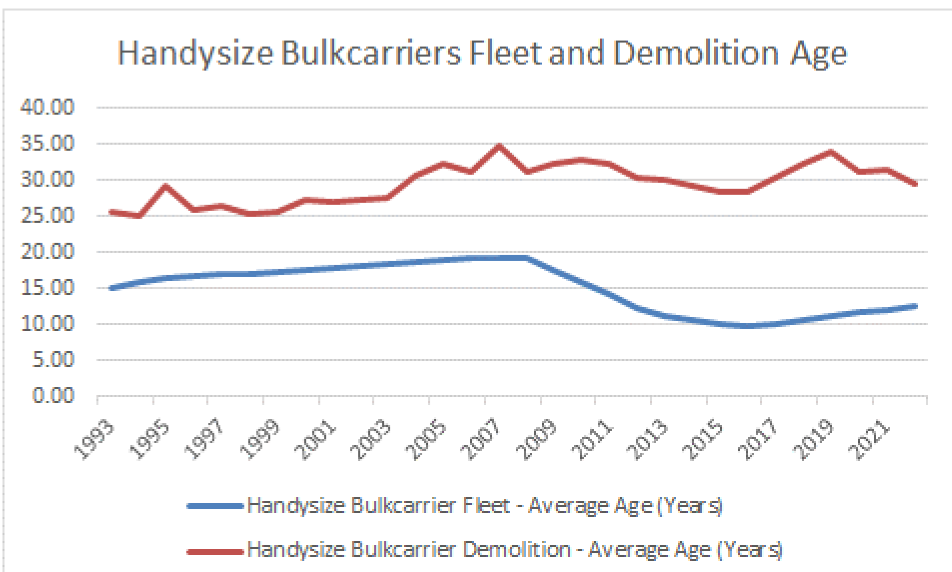
Clarksons Shipping Intelligence Network, 2023

Figure 36 – Handysize Fleet Growth % Yr/Yr



Clarksons Shipping Intelligence Network, 2023

Figure 37 – Handysize Bulkcarriers Fleet and Demolition Age



Clarksons Shipping Intelligence Network, 2023

Regarding the demand for the handysize shipping services, the world seaborne trade of grains (which was analysed in a previous section), cement, sulphur, sugar, and minor bulk commodities in general will be discussed, in an effort to depict and analyse the demand progress, as an important factor of the equilibrium of the freight market.

Cement is a dry bulk cargo, transported in smaller quantities compared to other materials. The handysize vessels are the most favorite vessel for cement, because they offer the optimum size of vessel for economies of scale, and they meet the requirements for calling many ports.

The world seaborne cement trade followed the trend of the majority of the dry bulk cargoes within the years. As seen in the below figure, its trade has been significantly increased, if we consider the starting point of the available data back in 1990, with 53 million tonnes. A minor drop was recorded in the next year (-3 million tonnes), but the recovery was instant. This steady recovery continued till the end of the decade, ending with 80,6 million tonnes in 1999 (Clarksons SIN, 2023).

In the next decade, we can observe the upcoming trend of the transportation need for cement. This is explained by the upgrading of infrastructures and the need for materials used in constructions.

In 2001, the world seaborne cement trade was 87,1 million tonnes, which was the highest level recorded till then. However, a drop occurred in the next year, leading the cement trade by sea to 82,6 million tonnes. Thereafter, a swift and constant recovery took place with a positive year-to-year change till 2007, when the world seaborne cement trade reached its peak with 127,6 million tonnes.

From 2008 till 2011, there was a drop in the cement world seaborne trade. This happened during the collapse and the trough cycle stages of the dry bulk freight market. In 2011, the world seaborne cement trade was 97,2 million tonnes, similar to the one back to 2004, and very similar to the average 98,9 million tonnes from 1990 till 2022 (Clarksons SIN, 2023).

Although the demand fluctuations of dry bulk cargoes were not sharp, there were ups and downs, within an increasing trend over the next year. However, the slow demand recovery was overcome by the increased supply of fleet as previously discussed by analysing the fleet development, resulting to a prolonged recession of the freight market.

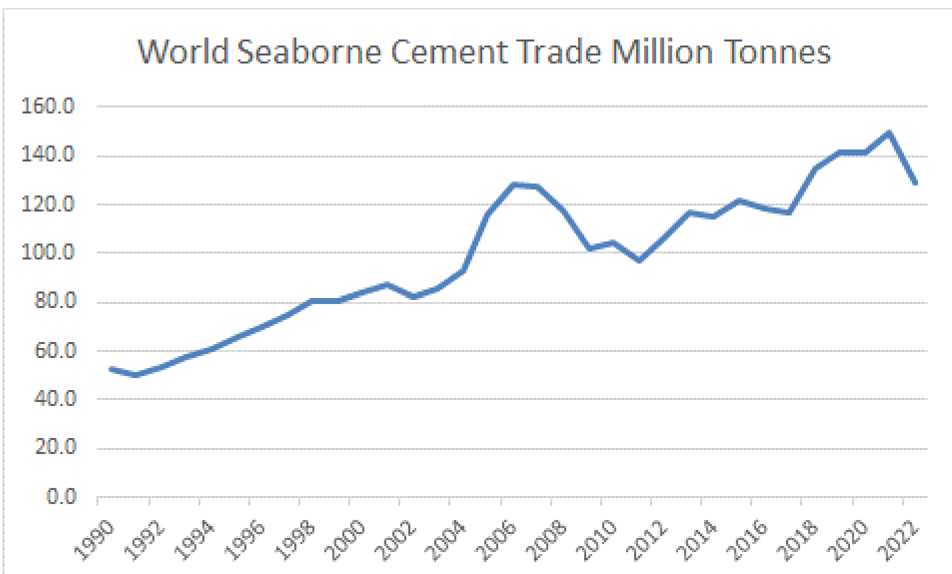
Specifically, the world seaborne cement trade was 117,1 million tonnes in 2017, almost the same level of this trade 10 years ago in 2008. This minor increase over the years was not enough for the freight market to recover. However, in 2018 we can see an increase, reaching 134,4 million tonnes of world seaborne cement trade. Even in the years of pandemic and lockdowns, the demand for cement was higher than the previous years.

In 2021, the cement trade was 149,9 million tonnes. In 2022, the world seaborne cement trade was 129,1 million tonnes, with a significant negative year-to-year change. However, it was still higher than the average 113,8 million tonnes of the last 22 years from 2000 - 2022 (Clarksons SIN, 2023).

We also need to consider that 2022, was the year with many abrupt demand changes, due to the energy crisis and geopolitical changes. The outburst of war between Russia and Ukraine affected the demand significantly, and specifically the smaller vessel sizes, which are traded in shorter distances and in areas such as East Mediterranean and Black Sea.

The estimations for the next two years are ambiguous. For 2023, a deeper drop is expected (125,5 million tonnes), while for 2024 a forecast of 129,2 million tonnes is made from Clarksons SIN (2023).

Figure 38 – World Seaborne Cement Trade Million Tonnes



Clarksons Shipping Intelligence Network, 2023

Sulphur is another cargo which is transported with handysize vessels, and its world seaborne trade is important for the demand of this market. As seen in the below figure (39), the world seaborne sulphur trade has followed a similar trend with the other dry bulk cargoes. The available data is from 1990, which is used as reference year. At this year, the world seaborne suplhur trade was 17,7 million tonnes.

Like the progress of the majority dry bulk cargoes discussed so far, there was a drop in the next years and their trade was at lower levels, till the close end of the decade. In 1997, the world seaborne sulphur trade was 17,8 million tonnes, almost the same with the reference year. From that year and onwards, the demand for cement shipping transportation was increased, exceeding the 20 million tonnes in 1999. Entering the next decade, the cement trade by sea was steadily at higher levels. In 2000, the world seaborne cement trade was 20,9 million tonnes.

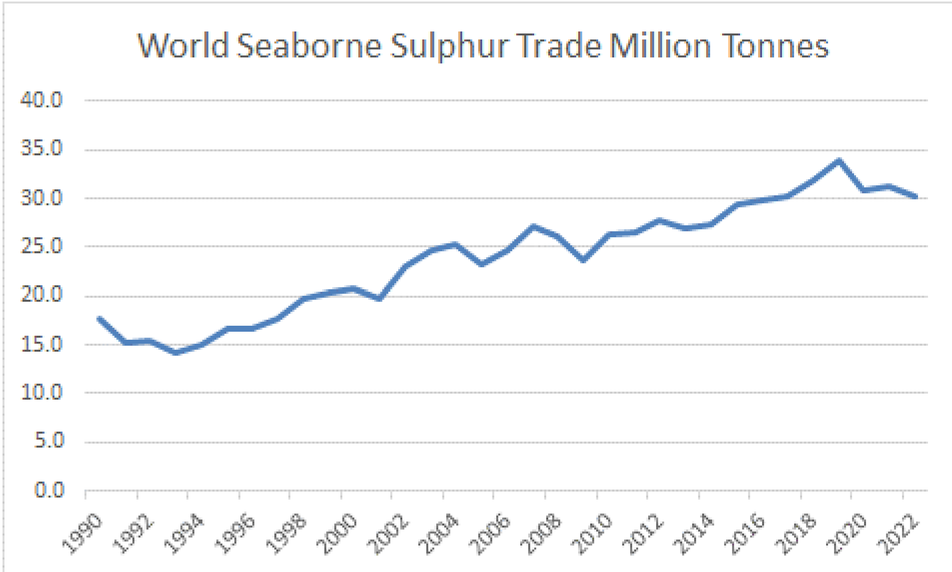
With small fluctuations over the next years and a general increasing trend, it reached the peak of the decade with 27,2 million tonnes. A drop was noticed in 2008 (26 million tonnes were transported) and a collapse happened in 2009, when 23,7 million tonnes were transported, following the sudden collapse of the demand in the dry bulk sector and along with the oversupply due to extensive deliveries of new vessels and low scrapping, resulted to the collapse of the dry bulk freight market Clarksons SIN (2023).

Although the demand for this cargo followed the same upcoming trend with the rest dry bulk cargoes in the next years, materializing the prospects of the shipping participants (reaching the level of 27,7 million tonnes in 2012), the freight market remained at lower levels. A complete analysis for the freight market follows in the data analysis section.

According to Clarksons SIN (2023), in 2015, the world seaborne trade was 29,5 million tonnes, with a continuous year-to-year growth till 2019, when it was 34 million tonnes, although the first wave of covid – 19 was in place. Due to the next pandemic waves, the demand dropped, though not at very low levels and always above 30 million tonnes.

Specifically, in 2022, the world seaborne sulphur trade was 30,2 million tonnes, way above the historical average of 23,9 million tonnes and the average of the period 2000 – 2022 of 27 million tonnes. The estimations for the next two years are not very promising, with the trade to be exactly the same for 2023 and for a minor increase in 2024 reaching about 31 million tonnes (Clarksons SIN, 2023).

Figure 39 – World Seaborne Sulphur Trade Million Tonnes



Clarksons Shipping Intelligence Network, 2023

The sugar world seaborne trade is another indicator which should be consider as an important demand factor. Sugar is normally transported in smaller quantities and few traders exist in the market. In the below figure, we can notice the progress for the world seaborne sugar trade.

According to Clarksons SIN (2023), in 1990, the first year of available data like the previous cargoes, the world seaborne sugar trade was 28,5 million tonnes. Minor ups and downs followed in the next years, reaching the level of 34,1 million tonnes in 1995. Like the cargoes already discussed in previous sections, the remaining years of this decade were characterized by an increasing trend and in 1999 the world seaborne sugar trade was 40,1 million tonnes. In 2000, the demand for bulk sugar shipping transportation was 36,5 million tonnes, recording a significant drop compared to the previous year (Clarksons SIN, 2023).

However, in 2001, a notable increase was recorded with the transportation of 41,2 million tonnes. A year-to-year increase followed till 2006, when 49,6 million tonnes were transported with dry bulk vessels. A steady but very minor decrease occurred in the next years till 2009, when the level of world seaborne sugar trade was 48 million tonnes (Clarksons SIN, 2023).

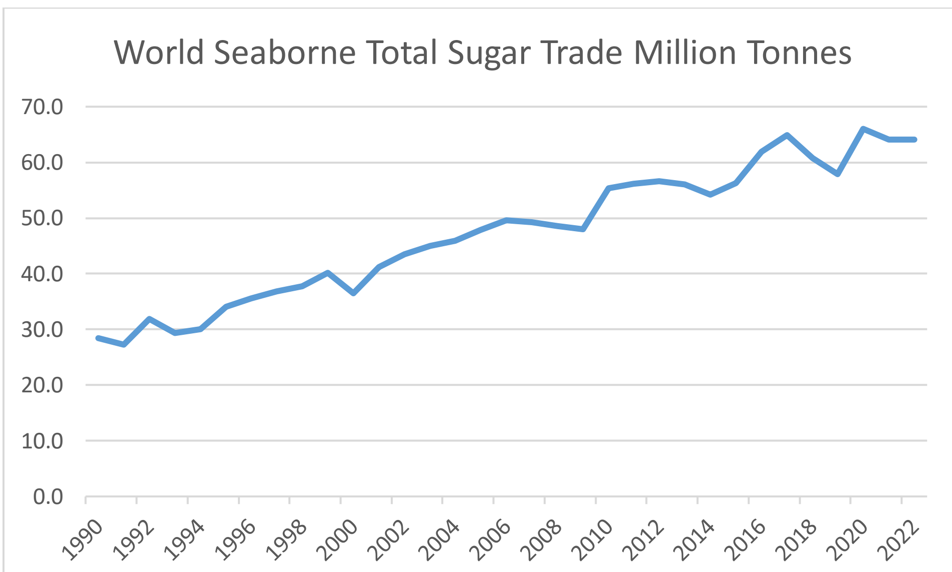
We can notice that the demand for shipping services for sugar was not affected very much, despite the collapse of the dry bulk freight market. This is mainly due to the fact that sugar is an important resource, with many derived products, used in many forms in the daily diet of people around the world. It is also characterized by a seasonality in terms of intensive trade.

Furthermore, in 2010 and onwards, the world seaborne sugar trade flourishes. In 2010, it was 55,3 million tonnes with similar levels for the next years. In 2017, it was 64,9 million tonnes, having marginally exceeded the 60 million tonnes the previous year.

A drop was noticed in 2018, but the world seaborne sugar trade seemed to have been affected by the covid pandemic in 2019, since it fell to 57,9 million tonnes, still way above the historical average of 47,3 million tonnes and the average of 53,5 million tonnes since 2000.

An increase occurred in 2020 reaching its historical peak during the pandemic waves (66 million tonnes were transported), but a drop followed in the next year. As a result, in 2022, the world seaborne sugar trade was 64,1 million tonnes, which is still very high. The projections for the next years look promising, with 65,7 and 66,4 million tonnes in 2023 and 2024 respectively (Clarksons SIN, 2023).

Figure 40 – World Seaborne Sugar Trade Million Tonnes



Clarksons Shipping Intelligence Network, 2023

Finally, a representative indicator for the demand progress is the world seaborne minor bulk trade. A discussion follows to identify its progress over the years, depicting the demand levels and changes. This category is very important for the handysize, the handymax and occasionally the panamax vessels because it contains crucial information for the demand for shipping services for such types and vessel sizes.

As stated before, the handysize fleet often competes with the handymax fleet and in rare cases with the panamax vessels for the same types of cargoes. Parcel volumes vary from time to time and many times the alternative of the smaller or of the larger vessel might seem more beneficial for the charterer.

According to Clarksons SIN (2023), the first year of available data is 1990 with 814,2 million tonnes. A drop was recorded in the next year as an exception of a constant positive year-to-year change within this decade.

In 1995, the world seaborne minor dry bulk trade way exceeded the 900 million tonnes, actually it was 945,10 million tonnes, and in 1997 it exceeded the 1.000 million tonnes (it was 1.033,2 million tonnes). In 1999, the world seaborne minor dry bulk trade was 1.120,7 million tonnes with a positive 5,4 % year-to-year change, and 5.233,7 billion tonne miles in terms of tonne miles. In the starting of millennium, the level of trade was increased by 6% of a year-to-year change for both tonnes and tonne miles (Clarksons SIN, 2023).

The world seaborne minor bulk trade continued its steady growth in the next decade as well. In 2000, there was a notable 6% year-to-year change both in tonnes and in tonne miles, while in 2004 a 9,4% year-to-year change was recorded in tonnes and 7,3% in tonne miles. In a rapidly developing world economy, the shipping transportation services were necessary to satisfy the high needs of demand.

At the same time the dry bulk freight market was under recovery with very high spikes, keeping the freight rates at very high levels. In 2006, the world seaborne minor bulk trade was 1.591 million tonnes and 7.591,7 billion tonne miles, with a 3,9% and 10% year-to-year change respectively.

The rapid growth of the seagoing trade of minor bulk commodities continued in 2007, with 1.725,2 million tonnes and 8,4% year-to-year change, and with 8.326,7 billion tonne miles and 9,7% year-to-year change. However, in 2008 a drop was noticed and in 2009 the collapse took place, with the significant drop of tonnes and tonne miles, -13,2% and -10,7% compared to the previous year (Clarksons SIN, 2023).

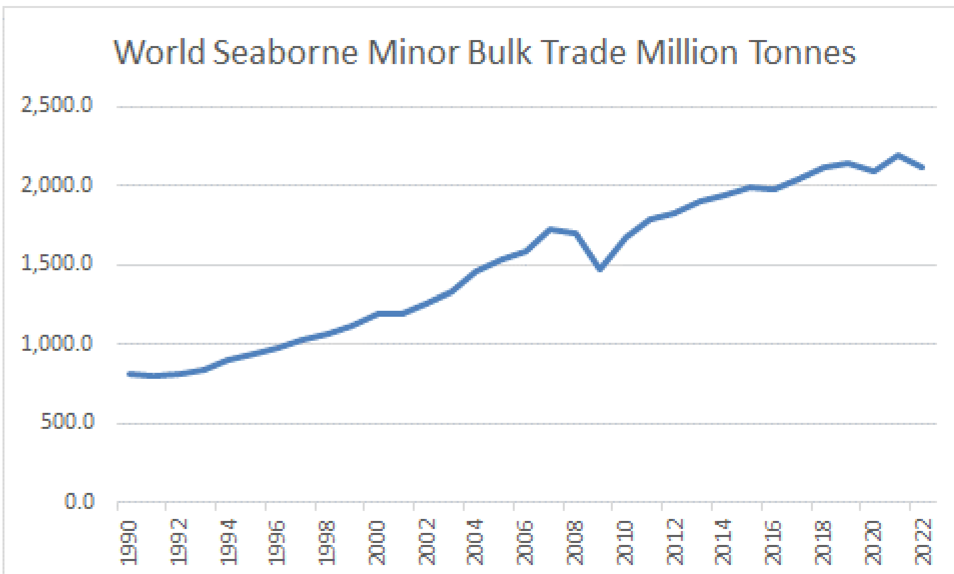
The world seaborne minor bulk trade followed an increasing trend for the next years, indicating again that the main reason behind the collapse of the freight market and the deep prolonged recession period of the next years was the oversupply of the dry bulk fleet.

In 2010, the world seaborne minor bulk trade was 1.668,9 million tonnes and 7.996,2 billion tonne miles, with an instant recovery and an impressive 13,6% and 10,7% year-to-year change respectively. This increase continued in the next years and in 2017 it exceeded the 2.000 million tonnes and the 10.000 billion tonne miles.

Actually, it was 2.043 million tonnes and 10.531,9 billion tonne miles, with the highlighted 6,3% year-to-year change of tonne miles. During the pandemic and the worldwide lockdowns, the growth of the world seaborne minor bulk trade continued.

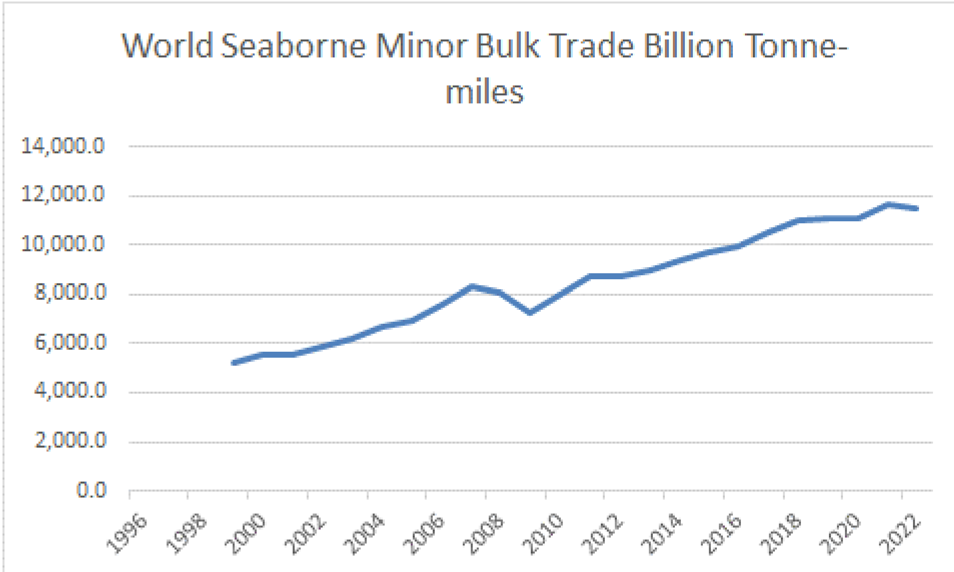
A minor drop was recorded in 2020, but its peak historically, happened in 2021, with 2.192,1 million tonnes and 11.663 billion tonne miles. This is explained by the partial opening of lockdowns and signs of returning to normality. Though the peak happened in 2021, a drop occurred in 2022 with normal fluctuations, but still remained at a higher level than 2020. The forecasts for 2023 indicate a similar level of world seaborne minor bulk trade with 2022, and a minor increase for 2024 (Clarksons SIN, 2023).

Figure 41 – World Seaborne Minor Bulk Trade Million Tonnes



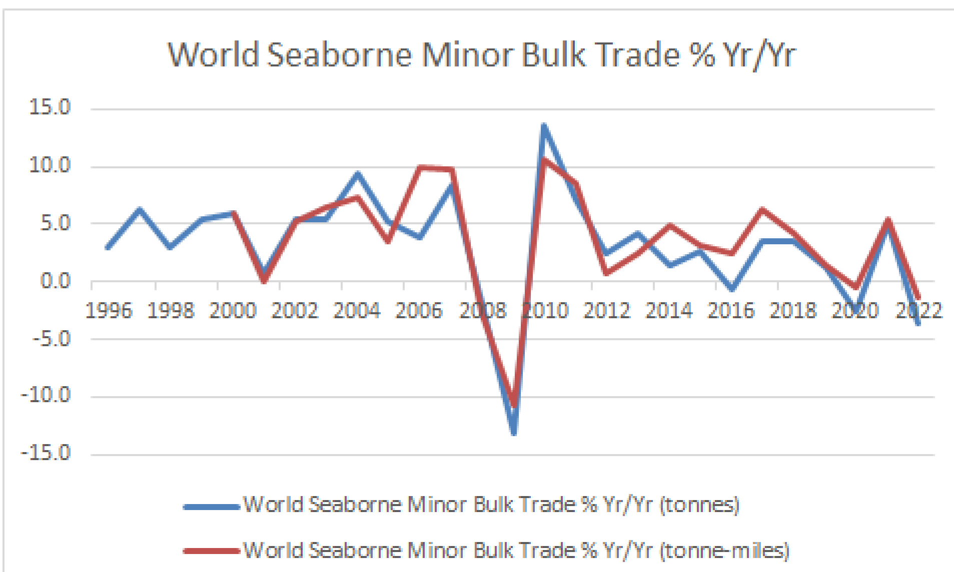
Clarksons Shipping Intelligence Network, 2023

Figure 42 – World Seaborne Minor Bulk Trade Billion Tonne Miles



Clarksons Shipping Intelligence Network, 2023

Figure 43 – World Seaborne Minor Bulk Trade Year-To-Year Change



Clarksons Shipping Intelligence Network, 2023

To conclude, it is important to monitor the progress of the supply and the demand of the dry bulk fleet and commodities, since it affects the level of the equilibrium in the freight market. Almost all dry bulk cargoes presented in the section follow a similar trend. There was a minor drop in the early first years of 90s and a recover in the next years. The world seaborne dry bulk trade was increased over the years, following the globalization and the developing of economies.

It is also very important to highlight the year 2009, when the collapse of the demand was recorded. However, the fleet growth continued since a heavy ordering of new vessels was in place the previous years. The demand varied in fluctuations for each cargo, affecting the freight market of specific vessels in a different way. As a result of the oversupply and continuous deliveries of new vessels and the low scrapping policy, and the different progress of the demand but generally in low levels, the dry bulk freight market collapsed in 2009 and a deep recession followed in the next years.

Apart from demand and supply progress, the expectations and time lags play an important role in the formation of the equilibrium in the freight market. In the next chapters, these will be developed.

2.3. Summary

In this chapter the dry bulk market structure is presented. A critical discussion is made regarding the progress of the relevant markets, based on available data regarding supply and demand factors. These markets have faced many different changes regarding their progress. One can notice that the decisions regarding the development of the fleet in number and in dwt are not the same for each market in the same period of time. This results from the fact that the demand does not behave in the same way for each market, during the same period of time.

Thus, the expectations for the progress of each market vary, resulting to the different decision making. Furthermore, the markets have different characteristics. For example, the capesize market is a close market, while the handysize market is an open and highly competitive market. The characteristics of each market structure also affect the decision making and the progress of each market.

In the next section, the literature review is discussed, starting with the key elements of the dry bulk industry, continuing with the efforts of scholars to forecast the freight markets and indices.

3. Literature review

3.1. Introduction and main concepts of maritime economics

The dry bulk market is one of the most important shipping segments. The progress of the freight market is heavily relied on the demand and supply factors. These factors are also affected by the decision making of the shipping participants, who take decisions based on freight rate fluctuations, bunker prices, exchange rates, inflation, vessel value and their expectations in return among others (Kavussanos 2010), with a time lag though.

Demand is affected by the world economy including multiplier and accelerator, the mass psychology, the stock building, the time lags, the seaborne commodity trade, the average haul and tonne miles, the impact of random shocks, the transport cost and the long run demand function (Stopford, 2009). The key determinants of demand for sea transport are the distance factor, the volume and quantity of cargoes to be transported (Grammenos, 2010).

These determinants are also linked with the freight rates and asset values. The stockbuilding affects the demand as during recessions the manufacturers tend to run down stocks, intensifying the already low demand for sea transportation. On the other hand, during the recovery and the peak of the market, the manufacturers tend to intensify the production and increase their stocks (Stopford, 2009). Shipping stocks can be considered as alternative asset class, since relevant information can be used in the decision-making process. A change in the stock and the trade of one commodity affects the trade and the stock of others (Pouliasis et al, 2018). Commodity prices affect the freight market and the volume of sea trade. As a result, their prices are monitored to gain insight into the demand of the dry bulk market. Furthermore, commodity prices and BDI have a correlation, since commodity prices influence BDI at a stronger level when the market is normal, compared to bullish and bearish markets (Bandyopadhyay and Rajib, 2018).

The seaborne trade is another important demand factor, affecting the market in the short- and long run. In the short term, seasonality and volatility affect the spot market. In the long term, the commodity trading is affected by the characteristics of the industries producing and consuming the commodities. Depending on the prices of domestic and imported substantial products, changes happen in the demand (Stopford, 2009). According to Michail (2020), changes in commodity prices are correlated with the world GDP and the long run freight rates.

The average haul and ton miles also affect the demand for shipping services. The distance effect is highlighted as the tonnes of imports and exports change within the years (McConville, 1999). Following the geopolitics and new trade routes, the ton miles have been differentiated in the last years, compared to the traditional routes. For instance, the war between Ukraine and Russia, has significantly affected the trade of grains and ores/minerals, resulting to the change of the equilibrium in the freight market, as grain exports from South America tend to grow, with destination Europe. Due to the longer trips and the increased voyage cost, the freight rates will be increased, resulting to higher transportation cost, which may affect the demand in return. Apart from wars, more random shocks happen and affect the demand. For example, the coronavirus has negatively affected the worldwide economy and the demand for sea transportation, with a significant drop due to lockdowns.

The time lags affect the shipping industry heavily. Shipping participants take decisions based on the level of the freight market. They also decide for their future strategy and investments based on current level of freight market. Their today's decisions affect the future progress of the industry (Stopford, 2009). As a result, when the freight market is at high levels, shipowners place orders for new ships, which will be delivered in about two years. Upon delivery of the new vessel, there is a disruption of the supply, affecting the equilibrium of the market, noticing the time lag between the time of placing the new order and the time of the delivery of the vessel (Karakitsos E. and Varnavides L., 2014).

When an abrupt change in the demand occurs, the market balances with a time-lag and changes in supply take some time to realise (Stopford, 2009). The supply is affected by the shipowners and investors, the merchant fleet, the fleet productivity, the shipbuilding production, the scrapping and loses, and the freight revenue (Stopford, 2009).

The expectations for the future income also affect the supply of vessels. Thus, when the shipowners operate their vessels in a bull market or they expect a bull market, they tend to place orders for new vessels (Karakitsos E. and Varnavides L., 2014). They are also more willing to buy second hand vessels for higher prices than usually, with the expectation of high returns through the daily operation of the vessel in a high freight market. On the contrary, when the shipowners expect a bear market, they avoid placing orders for new vessels and tend to sell or scrap vessels of their existing fleet. At this level, they are eager to accept lower prices for their vessels. As a result, the value of second hand vessels and new buildings, also depends on the expectations regarding the progress of the freight market in the short- and long-term (Grammenos, 2010). The FFA market, which is highlighted as the indicator for the expectations regarding the progress of the freight market, in a combination with the timecharter rates can be also used to forecast the spot freight rates (Zhang et al, 2014).

In the shipping industry, the supply technically changes as an immediate or long term effect. For example, the fleet productivity improvement results in the short-term increase of the supply, adjusting to the new market situation. In such a case, the vessels perform trips faster as they are operated with high speed, increasing the supply immediately. On the other hand, the heavy scrapping in a bear market will lead to a declining supply. In the long-term, the supply increases with the deliveries of new vessels, which take about two to three years, creating a time lag which is a critical factor (McConville, 1999).

When demand changes, shipowners increase or decrease the supply of fleet capacity, depending on expectations for the future level of the freight market (Stopford, 2009). Any change in the supply and/or demand functions causes changes to the world fleet capacity and/or to the world seaborne trade, nudging fluctuations to the freight market.

This effect is known as the cobweb effect, as these oscillations will either lead to a new stable or unstable equilibrium (McConville, 1999).

Four shipping markets exist. The freight market, the second hand or ship sale and purchase market, the newbuilding market and the demolition or scrap market. The freight market is the driving force to the other markets, so the expectations for the progress of this market has a significant impact on the other markets (McConville, 1999). All four markets are interrelated and one affects the other(s) (Xu et al, 2021).

When the freight market is at a high level, the shipowners place new orders and they are eager to buy second hand ships for high prices. At the same time, they are not willing to scrap vessels. On the contrary, when the freight market is at a low level, the shipowners are willing to sell their vessels for distress prices or scrap the older, in an effort to avoid the operation of the vessel in a bear market, leading to losses especially for older vessels. Finally, they are not keen on placing new orders, since they feel pessimistic and investment cost is considered high, with difficulties in getting finances (Stopford, 2009). According to Adland et al (2018), the energy efficiency of a vessel is another factor affecting the value of the second hand ships. Moreover, as Tsolakis et al (2003) found in their research, the capital cost is very important factor for the dry bulk industry. They also concluded that the fluctuation of the value is different at each segment. It is highlighted that during the collapse and recession period of 2008 – 2013, the BDI was found to have a strong lead lag relationship with the China containerized freight index, reflecting the economic trend earlier than noticed in the container sector (Hsiao et al, 2013).

According to Haralambides et al (2005), the timecharter rates (which secure a stable cash flow to the shipowner for a long period compared to the spot freight rates) and the newbuilding prices (which are increased when a high market is expected in the future and decreased when a low level of the freight market is anticipated) affect at a great level the prices for the second hand vessels. Further findings of this research indicate that the orderbook has a negative effect on the second hand prices in the long run and especially for Panamax vessels. They also concluded that the newbuilding prices are affected by the construction cost (which is also dependant on the raw materials and transportation cost), by the timecharter rates and by asset pricing and speculation. According to Marcus et al (1991), the proper strategy of investing in shipping, is to buy when the prices are low and sell the vessels when their prices are very high. This is described as buy-low and sell-high strategy.

As mentioned before, the operation of the vessels happens during changes of market conditions. Four different stages have been noticed, regarding the levels of the freight market: Trough, Recovery, Peak/Plateau, Collapse. Within these stages of the short shipping cycle, the shipowners operate their vessels, while the rest of the shipping participants take decisions. Goulielmos (2010) examined the historical data and identified short shipping cycles with duration from ten (10) to twenty (20) years.

Certain characteristics exist within the various stages of the shipping cycles. As per Stopford (2009), during the trough stage of the shipping cycle, there is a surplus of supply in the market, leading to low freight rates, much lower than the operating cost of the old vessels. As a result, these old vessels will move to lay up or even to the scrap market. Furthermore, the stagnation of the cash flow and the pessimistic feeling for the progress of the market, lead to shipowners being willing to sell their vessels for distress prices to inject their cash flow, while they are not willing to invest in new vessels. Hence, the scrap market will be active. On the contrary, the newbuilding market will remain with shallow orders. Due to the fact that the shipowners are not very willing to invest, the prices of the second hand vessels fall to scrap value. According to Pruyn et al (2011), there are some factors affecting the value of second hand vessels such as age, DWT and others, including the earnings from the operation of the vessels in the freight market. Moreover, with emphasis in the dry bulk sector, the buy and hold strategy can improve the results and performance of shipping companies, according to the findings of Adland and Koekebakker (2004).

Continuing with the remaining stages of the shipping cycles, the recovery stage is what follows after the trough stage. During the recovery stage, the main characteristic is that the supply and demand move towards balance, with a noticeable improvement of the freight market. Shipowners start believing for a brighter future of the freight market as the freight rates improve and move above the operating costs, resulting to the reduce of the number of the laid up vessels, since shipowners bring them back to the market. Moreover, shipowners are more optimistic and as liquidity of cash flow improves, they become more willing to invest in second hand and newbuildings (Grammenos, 2010).

During the peak stage, the demand way exceeds the supply, resulting to a bull market, since there is strong competition among charterers. The freight rates are way above the operating cost of the vessels, from three to ten times, so the liquidity of the shipping companies improves and shipowners are eager to invest in vessels, because of the high profitability they produce. Thus, the value of the second hand vessels is very high and some shipowners decide to cash out some vessels. According to Dikos G. and Marcus H. (2003), the newbuildings price and the level of the freight market affect the value of the second hand vessels. Alizadeh and Nomikos (2007) also found that price is cointegrate and this relationship is an investment indicator. Excitement in the market exists and financial support from banks and other funds can be found to invest in new vessels, while the scrap market remains inactive since even the very old vessels are tradable in the freight market (Stopford, 2009).

As demand is satisfied and supply increases due to the heavy ordering of the peak stage, the supply overcomes demand and a new equilibrium is formed, though at lower levels. Signs of the market indicate a rapid drop of the freight market, resulting to a bear market. This is the collapse stage of the cycle. When this stage is over, a new cycle begins. In the beginning of the collapse stage, the liquidity is still high from the earnings of the previous period. Moreover, the freight rates are still higher than the operating costs. However, as demand and supply tighten and supply overcomes the demand, the sharp fall of the freight market cannot be avoided in the near future. The drop of the freight market is rapid, which can lead to new equilibrium with very low freight rates within few weeks. In that short period of time, the shipowners do not have the time to adjust, therefore a need for a prior forecasting of the freight market and its trend is required, so that enough time exists to prepare for the coming market circumstances. At the end of this stage, the shipowners are not very willing to sell their vessels at discounted prices, since feelings are mixed and cannot believe the peak is over (Stopford, 2009).

The cyclical behavior of the shipping industry has been also examined and identified by Chiste C. and Vuuren G. (2013), verifying the findings and theories previously described.

In the next section of this thesis, an overview and key elements of dry bulk industry are discussed.

3.2 Overview and key elements of dry bulk industry

Taking into account that over 80% of the volume of international trade in goods is carried by sea, an increase in freight rates can affect global supply chains with adverse consequences for many economies. Limão and Venables (2001), investigating the dependence of transport costs on geography and infrastructure, found that a 10% increase in transport costs reduces trade volume by 20%. Both freight rates and seaborne volume trade have a significant effect on the fleet size too. Same is in the tanker industry, as both freight rates and secondhand ship prices volatilities increase as the vessel size increases; consequently, the risk also rises (Kavussanos 2010).

The seaborne trade is also affected by the dry bulk commodity prices. A possible change in the commodity prices might influence imports and exports, and finally, the volume of the seaborne trade (Tsioumas and Papadimitriou, 2018). Angelopoulos *et al.* (2020) examined the economic relationship between 65 major commodities, freight rates and financial variables (including derivatives) using a novel dynamic factor model. They investigated these relationships on a daily, weekly and monthly basis. Their findings indicate a strong economic relationship between commodities and freight markets. Furthermore, Michail and Melas (2020), using a Bayesian vector autoregressive approach (BVAR), quantified the relationship between seaborne trade and shipping freight rates; they concluded that the seaborne trade strongly impacts the BDI regarding the dry bulk market.

Shipowners tend to increase the fleet size when cargoes are available, and the return of such an investment depends on trade volume. If the fleet size has not been increased while trade grows, sea transport will be overburdened due to a shipping shortage. On the other hand, if the fleet size has been increasing, but the trade does not grow, expensive and inefficient ships will move to lay-up and then some of them to scrapping (Fan et al, 2018).

In the beginning, most shipowners try the hot lay–up to be ready for a swift market recovery. In this case, they enter the market again to profit from the recovery of the market. However, the most possible is the market not to instantly recover, and as a result, these inefficient vessels will move to cold lay-up. As a result, these vessels will remain out of the market for a long period, till their shipowners decide whether to enter the market again or sell these vessels, either in the ship sale and purchase market or in the demolition market. Some of them will eventually be scrapped (due to their inefficiency), or a few will be sold in the second-hand market (this is the case of vessels with management deficiencies leading them to be non-profit). When these vessels are scrapped, the supply is reduced (Stopford, 2009). Therefore, shipping companies adjust their fleet size when optimistic about shipping services' cargo volume (Lun and Quaddus, 2009).

The freight market's short-term fluctuations do not imply anything about the expected returns to owning or operating the ship. However, it is noticed that after a sudden increase in the demand for shipping services, freight market prices increase, and shipowners tend to invest in new ships. Shipowners must completely comply with all international regulations and sometimes with additional national regulations. Thus, the new vessels are set with technology to meet the International Maritime Organisation's "green" shipping policy standards.

The general progress of the market is depicted in the progress of the Baltic Dry Index (BDI). The BDI is affected by the relevant indices of the other dry bulk sectors, and specifically by the Baltic Capesize Index (BCI) and Baltic Panamax Index (BPI).

The Capesize shipping market is a key barometer of commodities international trade, due to the large commodities they transport. Therefore, the BCI has a great impact on the BDI. The economic perspective of these industries affects the micro and macro-global changes. The structure of the shipping dry companies varies and depends on the environment they operate their ships.

Capesize vessels, although varying in size they normally have dead weight tonnage (dwt) more than 100.000 tones. In particular, a small capesize vessel has 127.500 dwt, a big one has 170.000dwt, while a modern capesize ship revolves around 180.000 dwt. These vessels transport mostly dry bulk cargoes, mainly iron ore and coal, in a close market, under specific routes and in high volumes with freight rates suffering sky-high fluctuations both in the short and in the long term (Stopford, 2009).

The BPI contributes at a very high weighting, which was increased from 25% to 30% in January 2018, pinpointing the critical role that the Panamax shipping market plays in international trade since it is a balanced choice between the nature and the parcel size of the cargoes, and the distance covered. The economic perspective of this industry is affected by the micro- and macro-global changes, specifically by the changes in volume and frequency of dry bulk commodities. For example, the first wave of the Covid-19 pandemic led the world economy to lockdown with a bull expected market.

However, companies with Panamax ships managed to react and recover due to the Panamax market structure's nature. Dry companies operating in this market do so in a flexible economic environment with various cargoes available under open competition. As a result, the companies need to adapt to new changes such as regulations (emissions control) and market fluctuations. The short- or long-term decisions are taken in adjusting ships' speed, buying second-hand ships, building new ships equipped with new technology, and scrapping older ships.

The structure of the Panamax industry is different from others. Panamax vessels offer a balance between the volume and the cost required to transport cargo (Stopford, 2009). The sharp changes of the demand due to parcel distribution and other market restrictions, such as port congestion and restrictions, make the Panamax vessels very competitive relatively to bigger vessels (Capesize vessels) and smaller vessels (Supramax and Handysize vessels).

The Panamax fleet consists of a vast fleet to address the demand needs. Although varying in size, Panamax vessels typically have deadweight tonnage (dwt) from 60,000 to 82,000 tonnes (Clarksons Shipping Intelligence Network, 2023). These vessels transport mostly dry bulk cargoes worldwide, with flexibility in nature and quantity of cargoes, since they transport both the major and the minor dry bulks cargoes, such as coal, wheat, sugar etc.

According to Tsioumas and Papadimitriou (2018), the wheat price leads the BPI, pointing out the importance of this commodity for the Panamax freight markets. Michail and Melas (2021) applied a Vector Error Correction Model to the dry bulk shipping market to quantify the relationship between agricultural commodities and dry bulk freight rates. They concluded that commodity prices strongly impact the freight rates on the various vessels' types and sizes.

The demand forecast is overturned for 2020 due to Covid-19. However, as expected, the year 2021 turned positively, after a decline for three years in a row 2017 – 2020, as seen in Figure 44. Regarding the world seaborne dry bulk trade predictions for 2022, initially the predictions were for a more positive year than the previous one, as the expected percentage rate was higher (Clarksons SIN, 2023).

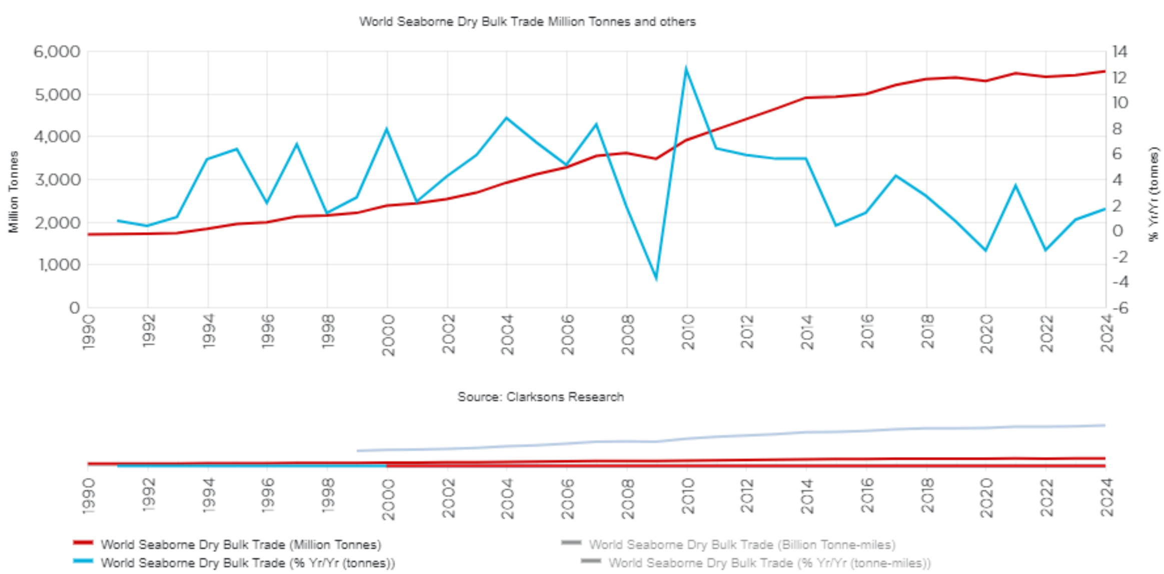
However, mainly due to the war between Ukraine and Russia, the year will turn slightly negatively compared to last year. One can notice that the percentage of world seaborne trade as a share of total trade is decreased in the main categories (iron ore, coal, grains, minor bulk cargoes), which affect the dry bulk world seaborne trade growth.

The transported volumes make Panamax vessels the ideal choices for balancing the economies of scale theory with the demand and seaborne trade, with freight rates suffering sky-high fluctuations both in the short and long term. Thus, the difference between demand and supply plays a critical role in the progress of the freight markets.

According to Michail and Melas (2020), the dry bulk freight rates are directly affected by exogenous factors, such as a pandemic. In order to demonstrate this relationship, Michail and Melas used a vector autoregressive (VAR) model and a generalised autoregressive conditional heteroskedasticity (GARCH) model, which verified this hypothesis.

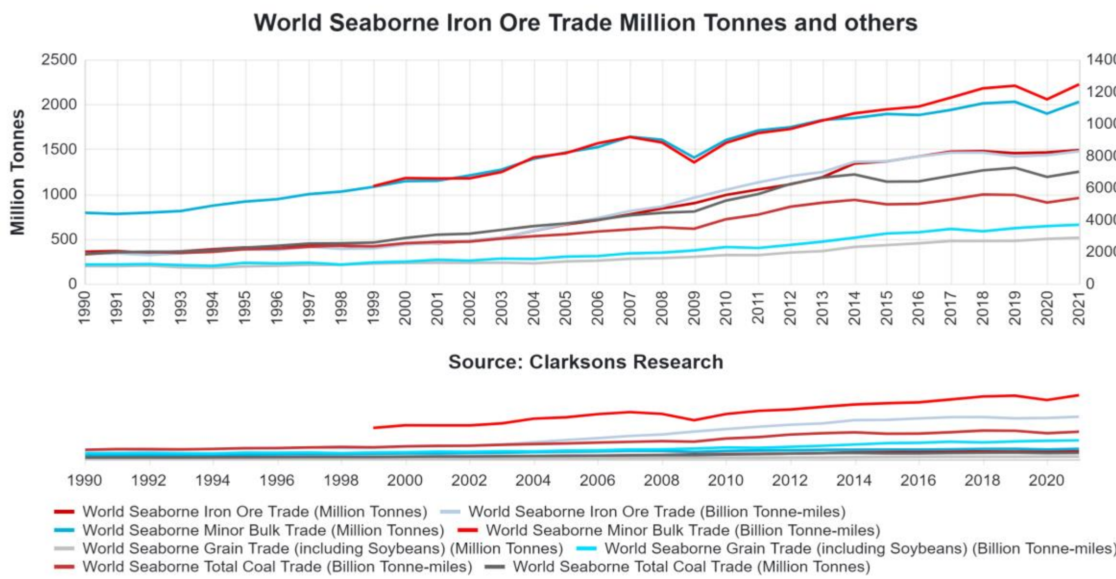
Along with expectations, they form the market conditions (Stopford, 2009). Thus, market expectations and time lags play a critical role in determining the freight market equilibrium (Stopford, 2009).

Figure 44 – World seaborne dry bulk trade growth



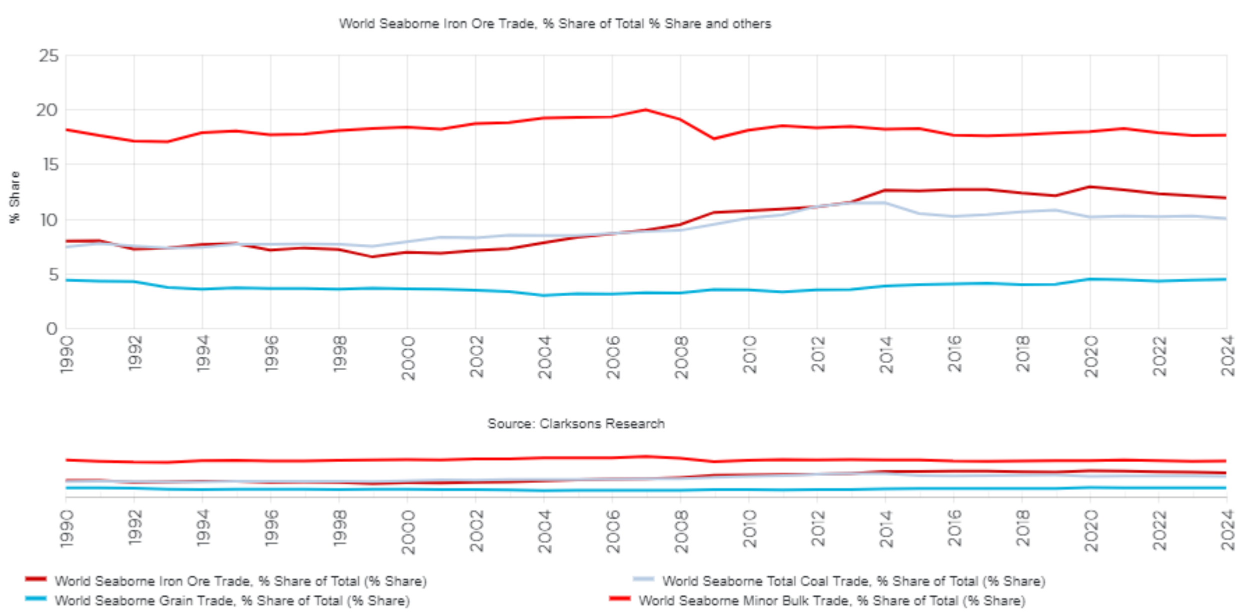
Source – Clarksons Research Intelligence Network (November 2022)

Figure 45 – World seaborne dry bulk trade growth



Source – Clarksons Research Intelligence Network (December 2020)

Figure 46 – World seaborne dry bulk trade as % share of total



Source – Clarksons Research Intelligence Network (November 2022)

After the heavy scrapping period 2012 – 2017, the Panamax fleet's average age fell to 8,5 years. In the latest years, the demolition market remained active at shallow levels, and today the fleet has an average age of 10 years (Clarksons, 2020).

However, this age does not imply anything for the ships and the shipping companies' sustainability. It is considered a good age for a dry bulk vessel, considering the life span of a ship is 20 – 25 years, depending on the freight market and the shipping cycle (Stopford, 2009). One of the main supply factors is the order book containing the deliveries of new ships.

The order book percentage of the fleet is 9.02% on average for the first semester of 2020, while the historical average from 1996 is 23.35% (Clarksons, 2020). The deliveries expected for 2020 indicate an increase in the number of ships (by 93) and deadweight capacity (by 7.676.623 tons) (Clarksons, 2020).

Heavy investment during booms depresses future earnings and the capital's price, leading prices to overshoot their rational-expectations levels (Greenwood and Hanson, 2013). As a result, a lead-lag relationship between time-charter and spot freight rates exists in the dry bulk vessels.

Another critical supply factor is port congestion. Port congestion is critical because ships will be queuing at ports, which technically reduces the active fleet. Thus, it is essential to consider the percentage of Panamax port congestion to check ships' employability and available ships for cargoes. It is noticed that only 3.64 % of the fleet suffered from port congestion for 2020, including those at major port anchorages, with the total average for the last decade being 3.84%.

This implies that most of the fleet is under operation, transporting cargoes worldwide. The increase of both supply and demand cannot imply anything about the market's progress. It remains to be seen if the demand overcomes supply leading to a bull Panamax freight market or the supply overcomes the demand resulting in a bear market.

It is also essential to examine the market's expectations and the expectations regarding the progress against the pandemic and a possible third wave of coronavirus as a random shock to the economy. With the supply becoming lower and demand expected to be positive in 2021 and at similar levels in 2022, as seen in Figure 44, the profitability of the Panamax vessels managed to recover the instant collapse of 2020 due to lockdowns and to remain at acceptable levels during the covid period, though improving when returning to "normality".

However, the dry bulk sector is also consisted of the Supramax market with the Baltic Supramax Index (BSI) and of the Handysize market with the Baltic Handysize Index (BHSI). The smaller vessels (Handysize and Handymax from 16.000 dwt to 48.000 dwt), are operated in even more competitive and open markets, performing trips with all dry bulk cargoes mainly in short distance and duration. The smaller the vessels, the more open and competitive the market is. The smaller the vessel, the shorter the duration of the trip.

These vessels transport various cargoes, in various but smaller quantities, contributing at a very high level in the regional trade and improvement of local economies. The demand growth was initially expected higher for 2022, as seen in Figure 45, but it will eventually end up negatively, though at similar levels with 2021 (Figure 1). As seen in Figure 46, the percentage of the world seaborne trade for minor bulk cargoes, for grains and for coal, is predicted to be lower for 2022 compared to 2021.

Random shocks of economy continue to exist, since the beginning of covid 19 pandemic with two lockdowns and with the war between Russia and Ukraine in 2022, disrupting the normality of the trade flow. As a result of this war, the shipments had to follow alternative routes and ways for their transportation.

Even the reduction or the total stop of the trade of such cargoes in this area, affected the total world seaborne trade, since Ukraine is considered as a major grain and ores exporter. This limited to non-existent trade in Black Sea and nearby area, affected the Handysize, the Handymax and the Supramax markets, as the main sizes of ships trading in the area.

The expectations also play an important role in the shipping industry. The concept of expectations is one the two main cobweb principles. The second cobweb principle is the time lag effect. In the shipping industry, the expectations can be expressed as the FFA progress, as scholars have indicated through their research. The time lag effect is measured in the model used for this research, as important lags are incorporated and the result is produced.

3.3 Various models and efforts to forecast freight markets

The shipping industry consists of many different markets and sectors. Many participants are involved in one or more different sectors of the industry at the same time. These markets differ in terms of type and size of vessels. In all these markets, the progress of the freight market is the common issue that the participants have to deal with.

The level of the freight market is indicative for the level of the earnings of the shipowners. When the freight market is at very high levels, the shipowners try to leverage that advantage and in return, they invest in new vessels. At this point, the transportation cost is very high too, and the charters have to either postpone the shipment waiting for a lower cost in the future or proceed with the transportation via sea (provided that there is no alternative transportation mean), seeking ways to hedge their losses in the derivatives market.

On the other hand, when the market is at a low level, the shipowners try to reduce the supply in order to bring the freight market back to balance and at higher levels, while the charters take advantage of this low transportation cost. As a result, this affects the profitability of the shipping participants, and this makes the forecasting of the freight market a very important matter of the industry.

Borger and Nonneman (1981) tried to estimate the sea transportation cost for the dry bulk vessels. They created cost functions and performed regression and correlation analysis among freight rates, various sizes of bulk carriers and the major three dry bulk cargoes. They proved that the supply and demand law apply to the dry bulk industry and that elasticities of supply can be estimated, being more inelastic in a tighter market.

According to Veenstra and Franses (1997), although the freight rates timeseries are likely to be non – stationary, in the long term there is existence of stable relationship between the series. Moreover, in pairs of two, their linear combination can be stationary. They developed a VAR model, and they collected data from the dry bulk industry. The stochastic trend of the model provided better results compared to a reliable timeseries forecast with their model, since it seems that the freight rate series have a stochastic nature.

At the same time, Kavussanos (1997) engaged with the dynamics of time-varying volatilities in different size secondhand dry bulk vessel prices. He ran an ARCH model with monthly data, in order to compare the volatility estimates between vessels of different size, using the AIC criterion. He pointed out the necessity of one lag of the dependent variables used. He concluded that prices of small vessels are less volatile than the larger ones and that the volatilities in the panamax market are mostly affected by old news, while the handysize and capesize markets are affected at a greater level from new shocks.

Kalouptsidi (2014) examined the importance of fluctuations in the shipping industry. She incorporated the importance of the lags in construction of new vessels in her dynamic model. She concluded that moving from time-varying to constant to no time to build can reduce the prices, while it increased the level and volatility of an investment.

Further research on volatility forecasting, was conducting by Gavriilidis *et al* (2018). They examined the oil price shock as an exogenous factor in a GARCH-X model to forecast the volatility of the spot and of the 1-year timecharter contracts in the tanker freight market. Through their method, the found better results compared with other methods, as including aggregate oil demand and oil-specific (precautionary) demand shocks improved the accuracy of the volatility forecasts significantly.

Additionally, Lim *et al* (2019) emerged the importance of volatilities in the freight market. Specifically, they used macroeconomic factors affecting the supply and the demand, and they examined their impact on the term structure of the freight options implied volatilities. They found that the level of the implied volatilities is affected by the level of the spot freight rate, the slope of the forward curve and by the demand and supply factors. The demand factors seemed to have a greater impact on the implied volatilities than the supply factors. The resulted that the forward curve is non-monotonic and has the V – shape. They also reached to the conclusion that when an economic growth is expected with a higher freight market, then the implied volatilities are reduced. However, when there is uncertainty regarding the progress of the economy and the freight market and when excess of shipping capacity exists, then the implied volatilities tend to increase. Their results were verified after conducting several tests.

Kavoussanos and Visvikis (2003) tried to investigate the market interactions in returns and volatilities between spot and forward shipping freight markets. Their contribution was important, since they applied the lead-lag relationship in returns and volatilities between spot and future markets (with emphasis on FFA) in an industry of a non-storable commodity, but a service provider. They applied a VECM-GARCH model with empirical data of traditional panamax voyage routes (1 and 2) and timecharter routes (1A and 2A). They concluded that the findings of the model using the bi-directional lead-lag relationship in the means are in relevance with the results in most future markets.

In another research regarding the possibility of hedging concept in the shipping industry, Alizadeh *et al* (2006) investigated the effectiveness of hedging against bunker price fluctuations using petroleum futures contracts. They also compared the performance of a number of proposed contracts with the performance of future contracts in other markets. Based on the literature, the commodity and financial futures contracts have a great performance as hedging mechanisms, with R-squared to range from 80% to 99%. For the purpose of their research, they compiled weekly data and ran VAR with 3 lags and VECM with 2 lags of first differences of the dependent variables plus the error-correction term, and VECM-GARCH models. They concluded that forecasting the bunker industry with a cross market hedging is limited. This is due to the fact that oil prices vary from one area to another, which is logical since the price is the equilibrium of the demand and supply locally and not the average worldwide. Furthermore, the commodities they used in their research were not the same and they have different fluctuations, leading to poor hedging forecasting.

Kasimati and Veraros (2018) proved that FFAs can predict market directions and many scholars have tried to analyse the FFA market to indicate the future progress of the actual freight market. In 2018, Taib and Mohtar employed an applied econometric study concerning forecasting the spot freight rates based on Forward Freight Agreement and timecharter contracts.

Another forecasting effort, for the FFA price this time, was conducted from Koekbakker *et al* (2007). They made the assumption of lognormal spot and forward prices and resulted that when the spot freight rates are lognormal, then the FFA price is lognormal too, but before the period of the settlement. As long as this settlement is in place, the previous statement is not accurate.

Also, they didn’t consider the seasonal volatility, which is an important factor affecting the spot freight rates.

On the contrary, Kavussanos and Alizadeh (2002) had examined the possibility of the existence of seasonality and its nature, if existed, in the tanker freight market. A seasonality pattern has been noticed with increased freight rates during the period November – December and decreased ones in the period January – April. However, the seasonality varies and depends on the market conditions and the size of the vessel.

Moreover, they compared different market conditions and found that when the market was recovering, the seasonal rate movements were more pronounced, while smaller changes were observed when the market was falling. In order to achieve this comparison, a Markov Regime Switching Ž. Seasonal regression (MRSS) model was constructed and applied to.

Cockburn and Frank (1992) and Bae et al (2013), have also reached the conclusion that the tanker freight rates are characterised by episodes of high seasonal and non-seasonal volatility. Further to these, Yin and Shi (2018) have considered the seasonality issue in the container industry. They used the HEGY and the Monte Carlo methods to analyse the China Containerized Freight Index (CCFI) and the spotted seasonality fluctuation patterns within one year period, indicating the importance of considering the seasonality effect on the various freight markets.

Expectations play a significant role in every industry. Specifically, in the shipping industry, the determination of the rate level is based on the current difference between supply and demand, on the time lag effect and on the expectations for the freight market’s progress in the short- and long term.

In shipping, the expectations can be explained by analysing the forward freight agreement (FFA) market since the forward prices of non-storable commodities are the forecasts of future spot prices, according to Batchelor *et al.* 2007. Specifically, they tested ARIMA, VAR and VECM models to forecast the spot and the forward prices in the route definitions of BPI. They reached to the conclusion that the VAR model has more accurate prediction than the ARIMA model, considering the RMSE, though the VECM model can offer the best estimations. They have also found that spot and forward rates are cointegrated when liquidity existed in the forward market and convergence of spot to forward rates. Moreover, the forward rates tend to stronger adjust than the spot rates, in an effort to close their gap.

Alizadeh (2012) conducted research on the relationship between the trading volume and the forward freight market. He found that the changes of the FFA prices affect the trading volume in a positive way. A positive relation between trading volume and volatility was also found. However, increases in price volatility led to lower future trading activities in the FFA market. He used asymmetric conditional heteroscedasticity models and applied them to supramax, panamax and capesize markets. He concluded that a momentum effect can drive the FFA market and trading activities to more transactions when the price increased. Furthermore, he proved the positive contemporaneous relationship between volatility and the FFA trading activity, and that the prices and trading volume changes depend on the information received. At the same time, the FFA market is based on the information received, connecting the information and its impact on price and trading volume changes and FFA market. Moreover, the FFA trading volume declines when the market volatility increases, resulting to higher hedging cost. Finally, he found that the dry bulk FFA trade was mainly driven by speculative concept rather than hedging objectives.

Kavoussanos *et al* (2003) investigated the impact of FFA on the spot freight market volatility of panamax Atlantic and Pacific trading routes, using a GARCH model. Their findings were in relevance with the most future markets and the onset of FFA trading had a stabilizing impact on spot price volatility in all cases examined. Moreover, its impact on the asymmetry of volatility in the Pacific routes was verified. Furthermore, its positive effect on the quality and speed of the flow of information as determined in Atlantic routes and in Pacific route 2, but not for Pacific route 2A. They also found that when considering other variables, their effect on the spot volatility indicates a reduction of routes 1 and 2.

Many efforts have been made to forecast the actual freight rates, since it is of paramount importance for the shipping participants. The freight rates progress has a great impact on the decision making and risk management.

Dikos *et al* (2007) tried to model the structural relationship between tanker freight rates and exogenous factors. They applied a hybrid model combining statistical analysis and economics insight, with data from 1980 till 2002. They considered the exogenous factors of lay-up, productivity of vessels and demand fluctuations. Their findings indicate that the model has a very good predictability and can be used for decision making in investments and risk management, highly competitive sectors with the time lag effect as characteristic.

Goulielmos and Psifia (2009) used nonlinear methods to forecast the weekly freight rates for the one-year timecharter of a Panamax vessel, retrieving data of 996 weeks for the period 1989 - 2008. Although Goulielmos and Psifia demonstrated that freight rates volatility can be chaotic, there is a good possibility of a nonlinear forecast without considering expectations and time lags, depending on the forecast length period. However, according to their findings, the GARCH model overwhelmed their forecasting results.

Duru and Yoshida (2009) used the judgmental method to investigate the possibility to forecast the BDI. This method implements the judgmental aspects of the system purely. They compared it with other available statistical methods, with the conclusion of expert predictions to outperform traditional time series methods. Specifically, the participants were selected from the shipping industry with experience in freight negotiation, as most of them came from the ship brokering field. Expert-opinion and Delphi strategies were applied and achieved higher predictability than quantitative forecasting, due to the fact that the latter method cannot predict the random shocks.

Lun and Quaddus (2009) constructed an empirical model in order to explain the impact of the four shipping markets one on another. They conducted various tests to analyse the relationships among key variables of the bulk market. Their results showed that the seaborne trade and the freight rates significantly affect the size of the fleet. The freight rates also affect the prices of new and secondhand vessels, along with the scrap prices. In the case of fleet size as dependent variable and seaborne trade as independent variable, the R – squared is 96,8%, proving their strong correlation.

Ten years after this research, Bai and Lam (2019) conducted an integrated analysis of the interrelations between fleet size, demand expressed in tonne miles, freight rates, new and secondhand vessels prices in the very large gas carrier (VLGC) market. They identified a very high demand volatility and its significant impact on the freight market, affecting indirectly the decision making regarding the fleet size. According to their findings, the freight rates were the most important variable affecting the prices of secondhand vessels.

Tavasszy *et al* (2011) developed a strategic network choice model for global container flows considering specification, estimation, and application. Their concept was inspired by the declining expectations of the container market for the 21st century, due to climate and energy policy changes. The model included import, export and transhipment flows of containers, as well as hinterland flows. Six scenarios were applied including new routes, rail connection between China and Europe, increase in inland transportation cost, reduction of transhipment cost (Antwerp is used as a case study), an overall increase of transhipment costs and slow steaming. The model predicts the yearly container flow satisfactorily, and can be applied to evaluate the impacts of future changes.

Merikas *et al* (2013) applied copula models to reconstructing joint return distribution of timecharters in the dry bulk market. Their hypothesis was tested successfully. They also observed strong increase of correlation in crisis. Their findings suggest that the dry bulk timecharter rates returns (retrieved on a weekly basis) show a symmetric distribution.

Mishra *et al* (2014) applied freight transportation modeling techniques to evaluate the impact of three different market participants (shippers, planners and decision makers) in a multimodal transportation network, combining three geographical scales (national, state and local). They used performance measures to evaluate the impact of the three objectives to the transportation system. According to their findings, it is possible to compare the performance measures in different scenarios, assisting in the proper decision making.

Ko (2011) suggested the establishment of an alternative index for the dry bulk freight market, in order to overcome the limitation of the generic assumption to follow the BDI as an indication of the progress of the dry bulk market, since it is not representative for all dry bulk sectors. He used a stochastic trend model and he found that there is a strong correlation between the new index and the BDI. Furthermore, he found that when there was a divergence among the market sectors, the new index was more similar with the smaller vessels and not the capesize market. This was explained by the possibility of the smaller vessels to capture the dynamic properties of common stohchastic trend faster than the larger vessels. Finally, he found that following his decomposition method, one can identify whether the freight market is far from the long equilibrium or near. In case the freight market was far from the equilibrium, he expected oscillations upwards or downwards for the equilibrium.

Another forecasting effort of a shipping index was conducted by Shuangrui *et al* (2012). With their research, they tried to forecast the Baltic Dirty Tanker Index by applying a WNN model. They examined nonlinear and non-stationary features of BDTI and compared their model with an ARIMA timeseries model. The advantage of their method is that they considered many different variables such as external factors of oil demand (six different indices are incorporated to form this variable), supply price, world economy and fleet capacity. However, they do not consider time lags and expectations in their model, which are key characteristics/determinants of the shipping industry. Compared to the ARIMA model, there were no significant differences in the short-term prediction, as both models performed high. According to their findings, in the long term the WNN model suggested better forecasts compared to the ARIMA one, due to its nonlinear ability. Although the trend of the index was captured, the long-term predictability of the WNN model was not the one expected.

Later in 2014, an improved support vector machine (SVM) model has been used to forecast the trend of the BDI in the short term with satisfactory results (Qianqian *et al.*, 2014). Specifically, they used wavelet analysis and incorporated a kernel function to deal with the nonlinear problem, in an effort to convert it to linear through a high dimensional space. They compiled data from 2005 to 2012 on a monthly basis. They compared their model with ARMA, VAR and NN models, concluding that using the root mean square error as forcasting method results to their model producing better forecasting results, although the ARIMA and VAR models captured the trend even in the volatile period 2007 – 2009. However, the SVM model had a more accurate prediction at the turning points of the market, which is a great advantage.

This modern approach of ANN models was also followed from Ruiz – Aguilar *et al* (2014), suggesting the using of a hybrid model based on seasonal autoregressive integrated moving average (SARIMA) and ANN to inspect the timeseries forecasting. With this method, the seasonality is captured and then the ANN model is applied to predict the non – linear patterns. Their model proved to be reliable and outperformed other single models.

Eslami et al. (2017) developed a rates prediction model that was based on ANN and adaptive genetic algorithm (AGA). Lyridis et al. (2017) introduced Foresim, a simulation technique that models shipping markets. Huang et al. (2014) proposed a combination of projection pursuit regression and geniting programming algorithms. Mo et al. (2018) developed a hybrid model that applied vector regression genetic programing indicating that the performance of the hybrid model was better than the other evaluated models.

Further research, considering other factors such as machine learning (ML) methods, have been conducted, and various models have been used. For example, Hassan et al. (2020) proposed a new approach based on machine learning to forecast freight demand and Barua et al. (2020) stated that ML is a powerful tool for better prediction in international freight transportation management. Overall, various studies have been implemented in order to determine the most efficient model for forecasting tanker freight rates. These methods can also be applied to the dry bulk sector, since markets have some common characteristics and sufficient data exist.

Duru and Yoshida (2009) investigated the establishment of a long-term freight index for the dry bulk cargoes and examined its particulars among the cyclic fluctuations. They also modelled the long-term freight rates and seaborne trade. They reached the conclusion that the life expectancy is an important factor for both seaborne trade and freight rates of dry cargoes. There are time lags among freight rates, seaborne trade, and life expectancy, which are defined in years. Finally, they closely estimated the price elasticity of seaborne trade with similar results of the extant literature.

Goulas and Skiadopoulos (2012) examined the efficiency of the International Maritime Exchange (IMAREX). They approached the research topic with a statistical and an economic setting. Their findings indicate that the daily evolution of IMAREX freight future prices can be predicted. Having also considered the transaction costs, they found that future trading strategies can be made, based on their method, minimizing the risks. However, the predictability deteriorated when they considered weekly horizons. They concluded that IMAREX is not efficient due to lack of information on the short evaluation period.

Alexandridis *et al.* (2016) investigated the interactions between freight rates and the freight futures in the dry bulk industry, by applying VECM- and VAR-BEKK GARCH models. A strong interaction between timecharter rates, freight futures, and options prices were found in the capesize, panamax and supramax markets. The results also indicate that future freight markets inform the freight rate market, though freight options lag behind futures and physical freight rates. They also concluded that the use of a model considering three variables at the same time, captures the dynamics of the markets in a better way.

Moscoso – Lopez *er al* (2016) conducted research regarding the short-term forecasting of intermodal freight using ANN and SVM models on the case study of the port pf Algeciras Bay. Specifically, they retrieved historical data from RO-RO freight transport, aiming to forecast the intermodal freight, as it has a great impact on the port management and in the planning of the fundamental port activities. In their model, the time lag effect is considered, but not the expectations. They concluded that the forecasting of the daily weight of the freight was achievable, but acceptable for the next seven days ahead. They also found that the SVR model offered better predictions compared to the ANN model. In addition to this research, Zhang *et al* (2019) compared various econometric models with ANN models to predict the BDI. They found that the econometric models using timeseries analysis have a stronger prediction when considering daily data. However, when considering weekly and monthly data, the ANN models have a better forecasting ability, since the produce fewer errors. They pointed out that during the crisis of 2008 – 2009, the GARCH model can have safer results for one step ahead (next observation) but the ANN model can offer better forecast for seven steps ahead.

Adland and Alizadeh (2018) explained the price differences between physical and derivatives freight contracts. By applying an ARMA-X model with X being the linear form, they proved that the TC and the FFA prices are co-integrated and the price difference between them can be estimated. They also applied the model to individual fixtures in the TC market they resulted that the variables of specific vessel and contract can determine the outcome at micro level. This premium is explained by the fact that the risk for such a contract is physical and secondly, only the physical contract can provide access to transportation. Their findings indicate that since this difference can be estimated, then the arbitrage opportunities can be eliminated. Finally, their model can adjust physical TC rates and FFA prices for different periods, for different vessels according to their specification, and for various contracts with different clauses. As a result, a better comparison among the hedging cost and the alternatives can be made.

Ko and Chang (2022) applied a VAR model combining the asymmetric hypothesis between spot market and FFA prices, and the Shock Diversity hypothesis. They gathered weekly spot, TC and FFA data. Their model consists of two structural VAR models. They proved that the rates have different but dynamic responses to permanent shocks. They also resulted in the better forecast by using a VAR model with three variables than two. Specifically, by considering TC – spot – FFA rates in the same VAR model, they concluded that one can have more accurate forecasting rather than selecting a VAR model with TC – Spot rates and another VAR model with FFA – Spot rates.

3.4 Summary

Many scholars have conducted research on the shipping industry, due to its contribution and importance to trade, since about 90% of the commodities is transported with vessels. As discussed in the previous chapters, many efforts were made in order to investigate the progress of the shipping market. Various ideas and models were tested.

Through the extant literature, it is proved that the cobweb effect can be valid for the shipping sector too. The shipping market is an environment where the supply and demand law functions. However, other factors affect the outcome of the freight market. Heterogeneous external factors are in place.

Moreover, time lags and expectations have a great impact on the formation of the equilibrium point. Taking into consideration that the human behavior, expectations, and decision making vary from one individual to another, one can understand that the forecasting is a very complex procedure. Furthermore, considering the time lag effect on the shipping industry, many fluctuations in a complex and volatile environment with cyclical behavior are observed.

In the extant literature, it is also proved that the indication of the expectations of the shipping participants, can be expressed through the FFA market. Many different forecasting methods and models have been used to predict the freight rates, the hire rates, and the main indices (i.e. BDI, BIFFEX etc) of the shipping freight market. Models like ARMA, ARIMA, VAR, VECHM, GARCH etc have been tested in different markets (mostly tanker timecharter, dry bulk timecharter), considering different parameters and variables.

The shipping industry is a highly regulatory industry, governed by many and strict laws and regulations to follow. Since the last years the decarbonization path is followed, with the green shipping as a master plan in progress, many changes have occurred and attributed the industry. The decarbonization have led the shipowners to invest in scrubbers or not, the ballast water management system, the ISM code under a sustainable shipping management etc affect the operation of the vessels, as well as the investment and scrapping strategy. As a result, the freight market's equilibrium is affected, with oscillations to happen in a market, which is already difficult to be predicted.

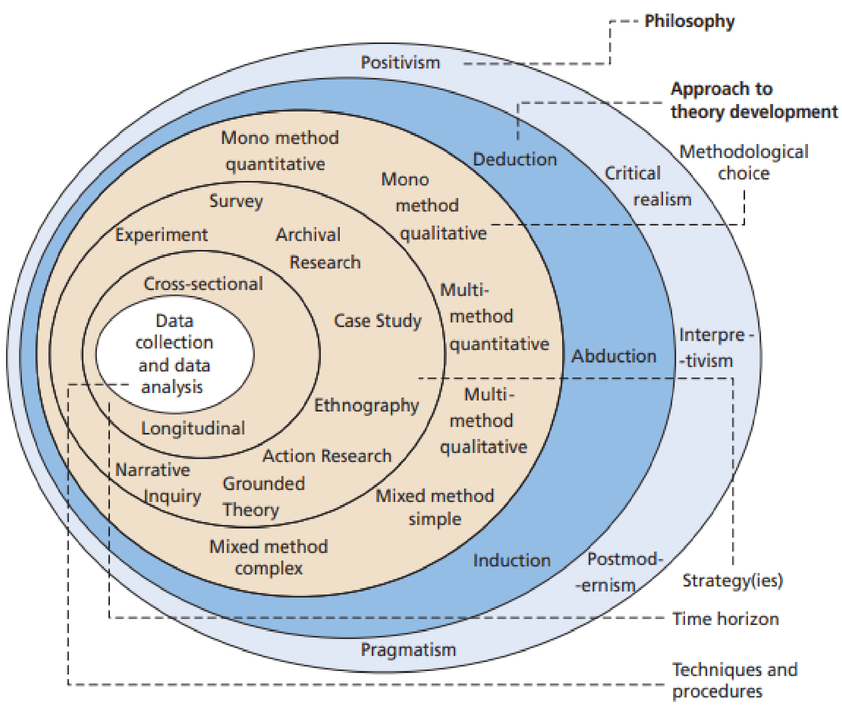
The contribution of this research to the current literature is the use of an alternative AR model considering the time lag effect, in an effort to investigate the behavior of the dry bulk industry. Specifically, the dry bulk sectors of capesize, panamax, handymax and handysize vessels are examined. The timecharter contracts, the timecharter trips and the spot market of selected routes are tested with the model used in this research. Finally, an effort to forecast the trend of the market is made, in order to analyse the dry bulk sector. The empirical use of the FFA market will help to verify the results of this research, before conducting the relevant back test analysis. The methodology and data analysis sections follow.

4. Methodology and Data collection

This section outlines an overview of the methodology used by the author to fill the purpose of this project (Crotty 1998).

In order for research to be taken seriously and considered credible, the author should inevitably justify the reason towards the philosophical approach selection in relation to the chosen research method. Research philosophies assist to sketch a coherent research project and aims to pave the way for knowledge development in a particular field, declare the methods deployed and the way followed to interpret findings (Saunders *et al.* 2020).

Figure 47 - Research Onion



Source: Saunders et al. (2020)

4.1 Research Philosophy

Research philosophy delineates the way of carrying out research and is defined by the type of knowledge being investigated in the research project. It constitutes the baseline for the appropriate research approach selection which is adopted in the above figure (see Figure 47).

The purpose of the research can be classified into exploratory, explanatory, descriptive, qualitative and quantitative analysis. This is descriptive research with quantitative analysis, as it seeks to portray the profile of events, situations (Saunders et al, 2020) with the purpose to describe the characteristics of separate market segments, to determine the manner these certain segments act under a certain situation and make predictions.

Pragmatism is deployed as the philosophical position of this research. The concept of pragmatism strives to reconcile accurate and rigorous knowledge, facts and values by examining concepts, theories, ideas and research findings in a structured form and in terms of their empirical consequences in specific contexts. With pragmatism, research initiates with a problem and intends to furnish practical outcomes that motivate unexplored future practice (Saunders 2020).

A pragmatist is more interested in practical outcomes rather than abstract distinction and recognizes that there are several ways of undertaking research. Interpreting the world involves multiple realities and cannot be contained at a unique point of view. Thus, pragmatism can be perfectly exercised with multiple types of methods and knowledge, as different methods may be proved as highly appropriate within one study, without excluding the possibility of using only one method enabling reliable, well-founded, and credible data to be gathered that support the research (Kelemen and Rumens 2008).

4.2 Research Approach

There are three distinct approaches to theory development, namely inductive, deductive and abductive approaches. With deduction, the reasoning starts with a theory and/or hypothesis and aims to test the hypothesis. In deduction, one proceeds from a set of general premises to more specific conclusions (Ketokivi and Mantere, 2010) and the investigator tends to be quantitative-oriented.

Opposite to that direction, inductive reasoning starts with the data collection and the data analysis will result in the generation of a new theory. Induction is a data-driven approach; the researcher attempts to infer conclusions from the employed data and tends to conduct qualitative research. Despite their diametrically opposed nature, the combination of deductive and inductive elements, may work favorably within the same research.

Such an approach is referred to as ''abduction'', which forms an intangible bridge combining both deductive and inductive reasoning. With abduction the research starts with data collection in pursuit to generate a theory (induction) followed by the exploration and testing of the theory (deductive logic). There is no single, 'best' way approach; all are valuable and no one can overshadow the other. Each one serves different things, yields different data and its functionality and appropriateness depends heavily on the feasibility of the research.

Through the existing and established literature relevant to the field of study, the deductive reasoning approach is followed to reach a conclusion. Given the generalized ideas and a perceived gap extracted through literature, the utilization of specific examples through a multiple case study facilitated to test the theory, reach an accepted conclusion and address the objective.

4.3 Cobweb theorem

The cobweb theorem was initially introduced by Kaldor (1934) and Ezekiel (1938) and it was used by many scholars over the years. Its main purpose was to explain the affection of expectations and time lags over the actual outcome. It was originally devised to explain the relationship between agricultural prices for various goods.

According to Hicks (1953), the future supply of a commodity depends on its price expectations and not so much on the current price. These expectations, whether right or wrong, mainly affect the outcome and not the current price (McConville, 1999).

Based on the cobweb theorem, when a demand change occurs, the supply does not change simultaneously to a new equilibrium. This happens because the supply can be partially adapted to the new market situations, and it takes longer to completely adopt. Thus, a new equilibrium is established, waiting for the supply to adjust. In the case of the agricultural products, this could be a season, but in any case, a time lag exists. The supply of this product for the next period depends on the price expectations of its future price (McConville, 1999).

In the shipping industry, we have seen from the previous sections, that the fleet development (supply) depends on the forecasts for the demand progress. In case the shipowners estimate a high future demand, they expect from the charterers to pay a higher freight or hire rate.

After having seen a part of the expectations materializing and the new equilibrium to be more favorable to them, they tend to place orders for new vessels. Their deliveries will be in two or three years, affecting then the supply and the freight market. This is a typical example of long-term time lag effect on the shipping industry.

Moreover, the partial instant adapt of supply in the new situations, can also be achieved with the lay up or slow/full speed steaming strategy followed by the shipowners, as an instant reaction the abrupt demand changes. In the case of the collapse of the demand such as in 2009, many shipowners laid up ships and others who were still operating the vessels in the spot market decided the slow steaming approach, in an effort to minimize the cost of fuel consumption, since delays were expected in finding another available shipment immediately (Stopford, 2009).

According to McConville (1999), "*a change in demand or supply will lead to a succession of reactions in quantity demanded and supplied, thus creating a cyclical or oscillating movement in freight rates and tonnages, known as the cobweb effect*".

The oscillations can be of three types, presented below:

1. Dampening or stable oscillations, which lead to a new relatively stable equilibrium.
2. A dynamic explosive or anti-dampening oscillation causing increasing distance from an equilibrium, resulting to a change in supply or demand.
3. The uniform oscillation, resulting to cyclical or repeated oscillation with no new equilibrium.

The below figure (48) explains in detail the cobweb theorem and the form of oscillations when a change in supply occurs. As seen below in figure (), the D curve represents the demand, while the S curve stands for the supply. The original equilibrium is the E point, where the freight rate is F^0 and the quantity tonnage is Q^0.

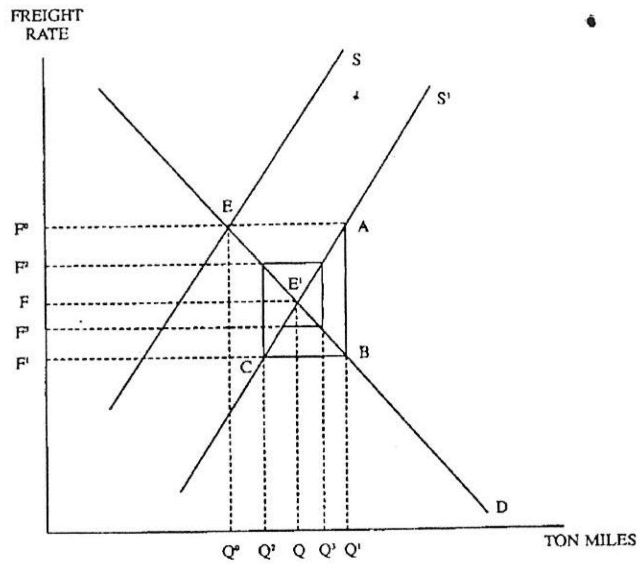
When the supply increases, the supply curve moves to the right. The new curve is the S^1. At this point, with the freight rate F^0, we can see that the shipowners are more willing to transport cargoes (point A) at Q^1. At the same time, the quantity available from the charters as demand, is much lower at point B. At this point, the charterers are willing to pay the freight rate of F^1 level.

However, at this point the shipowners are willing to offer less supply, which is depicted at point C, with Q^2. This is a repeating process till we reach the new established equilibrium point E^1, with F for freight rate and Q for quantity under balance, as depicted below (McConville, 1999).

Based on the above, when the demand is higher than the supply, then the freight rates are increasing. When this happens and depending on the expectations for the progress of the freight market, in the case of even higher future freights and hire rates, the shipowners will invest in new vessels and the supply will be increased.

If the demand is lower than the supply, then there is a drop in the freight market. Depending on the difference between supply and demand, and on how fast the fleet tonnage will adjust to the new market conditions of a low demand, the shipowners will decide to minimize their investments for new vessels and will lay up or scrap vessels, according to their expectations for the future.

Figure 48 – Damping Stable Oscillations



McConville, 1999

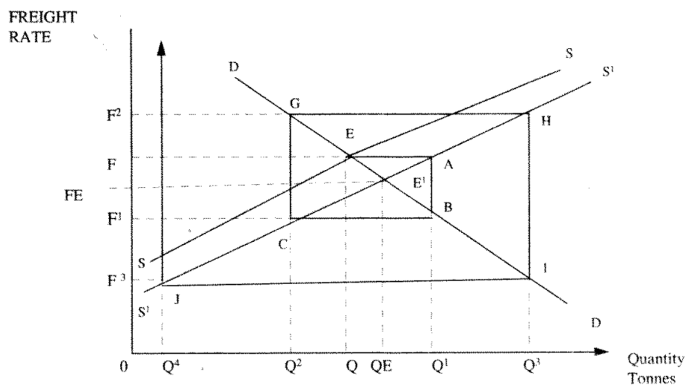
But what happens when the equilibrium is not stable? Different cases exist.

In the following case, as seen in figure (49), D represents the demand curve and S the supply curve, with E the equilibrium point, under F for freight rate and Q for fleet tonnage. When the supply curve moves to the right, there is the new supply curve with S^1. Therefore, for the freight rate F, the shipowners are willing to offer more capacity, which is Q^1 at point A (McConville, 1999).

However, charterers are willing to reduce the freight rate paid for shipping services, since more options are available in the market. Thus, they offer freight rate at level F^1. This leads the shipowners to offer less quantity, Q^2 at point C, by scrapping or laying up vessels. This limited quantity will result in a boom of the freight market, increasing the freight rate to the F^2 level, which is the G point in the below figure. For such a high freight rate level, the shipowners are willing to offer Q^3 capacity, point H (McConville, 1999).

As a result, they will try to increase the fleet by bringing the laid-up vessels back to the market and/or investing in new vessels, so that they will increase their earnings. However, at this point, a surplus of shipping capacity can be observed and as a result, the charterers will only offer limited cargo quantity for a freight level F^3, which is point I in the below figure. On the other hand, the shipowners are willing to only offer limited capacity for shipping transportation Q^4 at the point J. This continues and the result is to record sharp fluctuations with high and low spikes in the market, until the elasticity of either curve is modified. In this case, the movement is not towards the stable equilibrium E^1, but around it (McConville, 1999).

Figure 49 - Cobweb Theory Explosive Unstable Equilibrium



McConville, 1999

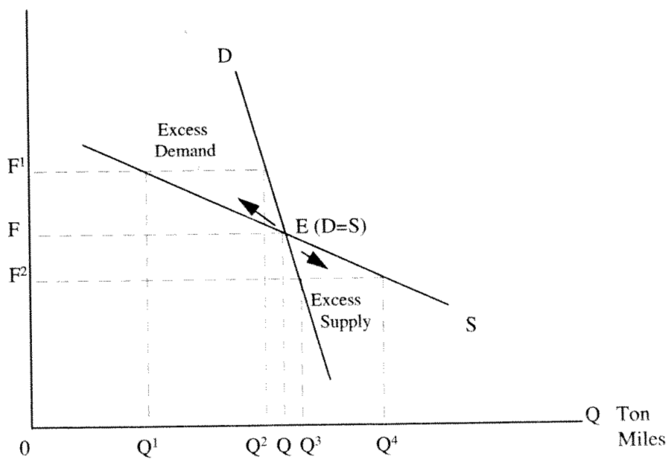
When the elasticities of demand and supply are the same, then the oscillations are uniform, and they occur at points with equal distance from the initial equilibrium. However, in the most cases the equilibrium is not stable. Thus, the level of the freight rate and whether it will be near to or far from the equilibrium, depends on the elasticity of the curves. A time period is required to adjust to the new market conditions after changes in demand or supply. The duration and the period may vary, but they are important, especially in the case of inelastic supply and substantial commodities (McConville, 1999).

The cobweb theorem contains two main adjustment processes. The first is the adjustments of the fleet based on the previously freight rate and the second is the adjustment of the freight rate to the new supply conditions. This conversion from static to dynamic analysis is complicated, as it has to do with the behavior and the expectations of the shipping participants. With the cobweb theorem, there is an effort to explain the fluctuations and movements of the freight rates around the equilibrium. This strictly considers a stable market equilibrium, and this happens as long as the demand curve cuts the supply curve from above. In this case, the excess demand drives the freight rates up and the excess supply will drive the freight rates down. The equilibrium becomes unstable when the demand curve cuts the supply curve from below, since the excess supply is below the equilibrium and the excess demand above (McConville, 1999).

This case is depicted in the following figure (50). The main characteristic of this case is that if a movement away from the equilibrium happens, the mechanism to restore the equilibrium is not in place, like the previous case with the stable equilibrium. In this case, if a positive change happens in the freight market and the freight rates become higher to F^1 level, then the demand for the available shipping capacity is Q^2, which is in the excess of the available fleet (Q^1), creating excess demand. Practically, this means that the charterers try to outbid themselves for the available vessels, leading the freight market to an even higher level, far from the equilibrium (McConville, 1999).

On the other hand, if the freight rate drops to level F^2, demand for shipping services will be at Q^3, while the supply of the fleet will be at Q^4, forming an excess supply. In the case that charterers try to take advantage of some of the excess supply, the shipowners will be eager to offer more supply to cover this extra demand, leading the freight rates to further decline and moving the market even farer from the equilibrium point (McConville, 1999).

Figure 50 - Cobweb Theory Unstable Equilibrium I

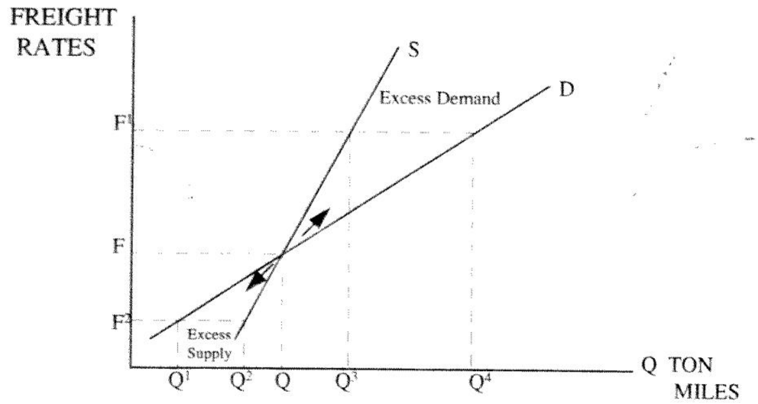


McConville, 1999

In the next figure (51), another case of unstable equilibrium is presented, where demand and supply curves have positive slopes. As one can notice that a movement away from the equilibrium will create instability, like in the previous case. Specifically, when the freight rate increases to F^1, the supply is at Q^3 level. The demand is at Q^4, creating excess demand. In this case, the charterers will try to fix the available vessels and will tend to increase the freight rate offered, in an effort to secure their interests of trade. This will result to negotiations far from the equilibrium point, in a bull freight market, like the case of 2008 leading the dry bulk freight market to historical peaks.

In the case of a freight rate drop to level F^2, there is excessive supply. The demand will be at point Q^1 and the supply at point Q^2. As a result, the shipowners will compete each other by offering lower freight rates, in an effort to secure the employment of their vessels. This happens in the period of a deep recession, and it was observed in the shipping cycle after the collapse of 2009 (McConville, 1999).

Figure 51- Cobweb Theory Unstable Equilibrium II



McConville, 1999

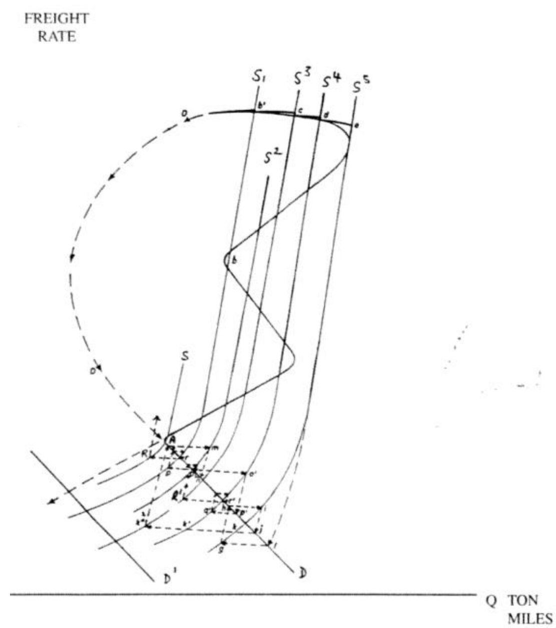
In the below figure (52), we can see the spins of the equilibrium in the various points of the supply and demand curves. At the lower point of the supply curve, which is the elastic part, the cobweb theorem functions in the short term (spot market for the shipping industry), where the freight rate fluctuates around the equilibrium. In the inelastic part of the supply curve, there are rapid spirals with dynamic fluctuations, mainly due to the expectations of the demand curve. As a result of a period with increased demand and level of freight rate, the supply of the fleet increases to S^5. Following this supply adjustment, the freight rate will drop to point F, as a result of an oversupply. This will lead to further supply adjustments and the shipowners will have to remove the inefficient vessels from the market (lay up or scrap), moving the supply curve to S^1 (McConville, 1999).

In the upper part of the below figure (52), the demand curve moves from D^1 to D. This creates very high expectations for the shipping participants. As a result, the charterers will try to swiftly fix the vessels for long term. The spot market becomes more excited and ambitious. Supposing that the starting effect point is q, the freight rate will move up to b or b^1. In this case, the shipowners might technically alter the supply in the short term with the slow/full speed steaming policy. This moves the supply to the right (S^3) at point c. It can also move to S^4 at point d (McConville, 1999).

Another option comes to the charterers side. The charterers might decide to withdraw from the market and postpone the shipments or find alternatives, due to the high transportation cost. As a result, the demand becomes lower and moves downwards to equilibrium q (McConville, 1999).

This figure deals with the spot freight rates in the short, medium and long run. The freight rates in the short- and in the long run are affected by expectations and cost. The charterers have the option of the spot market or the time charter period. Based on the expectations and market equilibrium, the advantage changes from shipowners to charterers and vice versa.

Figure 52 - Dynamic and cobweb adjustment



McConville, 1999

4.4. Application of Cobweb Theorem and Expectations

The expectations can be of 3 categories. First the naive or static expectations, then the adaptive expectations and finally the rational expectations.

According to Ferguson, in the static or naive expectations the producers take decisions regarding the supply of the product based on the price of the previous season. These expectations have the form of $P^e_t = P_{t-1}$ and they do not consider any random shocks.

In the adaptive expectations, the producers attached based on the last price of the product, but they also consider other factors in the meantime. They also adopt their decisions based on the development of the of the market. They have the form of $P^e_t = P^e_{t-1} + \lambda(P_{t-1} - P^e_{t-1})$. In the case where $|1-\lambda(1-\alpha)|<1$, then both prices and expectations converge to stationary stochastic processes. The rate of the time lag is equal with $1-\lambda$.

In the rational expectations, although the producers might occasionally have the wrong expectations and take wrong decisions, it is assumed that on average they have the correct expectations, and they take the correct decisions over the time. The form of the rational expectations is $P^e_t = E_{t-1} P_t$, where for the cobweb E_{t-1} denotes the mathematic expectations of P_t with observations noticed in time t-1.

The cobweb model has been used in many different markets. Indicative examples follow. It is the authors belief that the cobweb phenomenon is observed to the shipping industry and its main principles can be applied to analyse the markets' behavior.

In the classic cobweb model of Ezekiel, the producers follow the static expectations. This was proved by Baak (1999) and Chavas (2000), revealing the simple strategies followed from the producers to forecast the future price of the product. This has also been verified in many laboratory experiments from Hommes et al (2007) and Sonnemoms et al (2004). However, because of the assumption of the linear supply and demand the extent of the classic cobweb linear model in the long term is deteriorated around the equilibrium of the market.

Scholars like Chiarella (1988), Day (1994), Hommes (1994, 1998), by investigating nonlinear supply and demand markets, have proved in an analytical way, the possibility of chaotic price dynamic for the producers when they have adaptive expectation schemes. The traditional code word models describe the dynamic price adjustment process on a competitive market for a single non storable commodity with a supply response lag. in the case of two markets X, Z the producers decide to enter to the most profitable market at that moment.

The more profitable the market the more producers engage. As a result, the supply increases, and the future price declines. In the shipping industry, when the freight market is very high, the ship owners invest in new vessels, increasing the supply. This increase leads to freight rate fluctuations. When the demand is lower than the supply, the freight market will decline.

According to Dieci and Westerhoff (2010), analytical and numerical investigations of four-dimensional nonlinear models indicate that, when we deal with markets where the cobweb theorem can be applied, may contribute to the cyclical price motion like in many commodity markets. This is applied to markets with time lags in supply, and specifically at the time when the products are ready to be sold. Their model incorporates the reaction of the supply in the market, ignoring the demand side effects. They also consider the expectations to be naive. They also assume that the available two markets at this specific period of time are profitable. Their outcome was that when the profit is increased, the supply is increased too. As a result, the price declines and the future profits are reduced. At the end, this will lead to the decrease of supply. Their second outcome was that the company supply curve increases in a linear way, while the market supply curve hey is nonlinear. The supply progress is based on the profitability of the product of the previous period.

In the shipping industry, the above conclusions are verified. The fleet development has been already discussed in the previous chapter. It has been noticed that when the demand is very high, which indicates a profitable period, the shipowners tend to increase the supply. At some point, the oversupply leads to the decline of the freight market, especially when the demand is reduced leading to the collapse, like the dry bulk freight market of 2009.

Finally, the shipowners tend to consider the previous level of the freight rate and based on the expectations for the progress of the market decide regarding the chartering of their vessels. The behavior of the shipping participants is very important. According to Ishizaka *et al* (2018), the average risk attitude of the shipping participants tends to be more risk-averse after 2010, possibly due to the collapse of the dry bulk freight market in 2009 and the long recession period which followed till 2016.

Westerhoff and Wieland (2010) analysed commodity markets with cobweb behavioral considering the behavior of speculators. They showed that various interactions among consumers, producers and speculators out of the market may produce price dynamics similar to a cyclical behavior of the commodity market, drived either by optimistic or pessimistic prices.

They also found that the speculators have an impact on the prices sometimes positive and other times negative, regarding the progress and the stability of the market. this is very difficult to be applied to the shipping industry because it is assumed that producers and speculators act at the same time. Moreover, the producers update their decisions regarding the supply per week or per month while the speculators trade on a daily basis. Finally, this is only for the spot market. The above has been observed in the shipping industry too.

As previously said, the initial purpose of the cobweb theorem was to explain the price of agricultural products and their future supply. According to the theorem in order to bring the market back to equilibrium a change in the supply should happen as a reaction to the demand changes. However, this does not happen simultaneously enter time log is required.

M. Rahji and M. Adewumi (2008) used the cobweb theorem to predict the rice price in order to adjust its supply. Their conclusion was that they could explain the price fluctuations of rice by using the cobweb theorem, since the producers rely their judgment for the future supply on the current prices. The higher the price the more the supply is. This is similar to the main concept of the shipping companies in terms of investments in ship building.

Choudhary and Orszag (2008) showed that the Lucas model (1972) for the rational expectations considers a market, where the local information is distinguished from the total market information worldwide. They also concluded that prices and quantities suffer from a time lag, which affects the equilibrium of the market, since they are dependent on their behavior of the previous period. Another important contribution to the cobweb literature was that positive local interactions increase the stability margin.

Bray and Savin (1986), Evans and Honkapohja (1999), Guesnerie(1992), Evans and Guesnerie (1993), and Townsend (1978) made efforts to examine the stability of the equilibrium of rational expectations, under the concept of various expectation formation schemes. They proved that the time lag of information had a great impact on the price fluctuations. This also happens in the shipping industry, with the example of placing new orders and the deliveries to affect the freight market after two or three years.

Dufrense and Vazquez – Abad (2013) investigated the impact of a time lag production on the uncertainty and instability of the prices, by using the cobweb theorem. They concluded that the demand and supply law functions. They also found that by increasing the production lag, this may lead to instability or may not, but this may lead to cycles of constant amplitude.

Furthermore, Arango and Moxnes (2012) investigated the behavior of the market applying cobweb models. They didn't find any cyclicality in the simple supply lag with five participants. They added investment lags and capacity of crops and cyclicality was found. As the complexity was increased, the prices became autocorrelated with cyclical tendencies. It was observed that the participants put little interest on the quantity of the crop when they decide for an investment. In this case the adaptive expectations are not enough to eliminate the fluctuations.

The cyclicality also increases when the lag and the capacity grow bigger. The suppliers also cause random shocks. When the crops are increased, the investments are based on the evidence and their expectations about the future price rather than on the expected quantity, and as a result they change to the expected ones.

According to Matsumoto and Szidarovszky (2015), the delay effect on price fluctuations was significant. They applied cobweb models with lags in one and two markets. They concluded that when the lags were increased, stability was lost, and oscillations were monitored in a cyclical way, as expected.

Greenwood and Hanson (2013) investigated the wave in ship prices and investments. They applied the cobweb model in an effort to reveal the possibility and the extent of predicting the investment returns based on price and investment dynamics. They considered the rational expectations, and they gathered data from Clarkson database regarding the earnings, the secondhand prices and the investment in the dry bulk industry. They proved that the fluctuations of the freight market cannot guarantee earnings from the daily operation of the vessels. However, when the demand suddenly increases, then the freight rates increase too. As a result, the shipowners massively invest during the boom of the freight market, and this results in lower earnings in the future. They have also concluded that by using cobweb dynamics, rational expectations and competition neglect theory, future returns of investments can be estimated.

The phenomenon of massive investments in the recovery and peak stages of an economy, was also analysed by Barberis *et al* (1998), Rabin (2002), Barberis & Shleifer (2003). According to Barberis *et al* (1998), it is possible to understand the underreaction or the overreaction formed by market participants, as their behavior against bad or good news. Their model is based on psychological evidence and produces a underreaction and overreaction under wide range of parameters. This was applied to the financial sector and specifically in stock prices. They concluded that the weighting of evidence is important, order the participants of the market to form expectations. When an overreaction is achieved, then massive investments were in place.

In the shipping industry, as seen previously through the analysis of the fleet development and world seaborne trade progress, many shipowners invest when the freight market is high, producing high earnings, as a result of an overreaction. A company or an individual might fall into the above mistake for the following reasons.

Firstly, there is the strong possibility to overestimate the strength of the exogenous factors which affect the demand for shipping services, as proved by Greenwood & Hanson (2013), Tvesky & Kahneman (1974), and Robin (2002). Secondly, they might overestimate the future earnings due to high expectations produced, again as an outcome of an overreaction, since they are not in a position to estimate the long-term behavior of supply, and especially in cases of random and sharp demand fluctuations (Greenwood & Hanson, 2013). This is also known as competition neglect theory developed by Metaxas (1971), Cufley (1972) and reapplied by Stopford (2009).

According to Kahneman (2011), the competition neglect theory becomes even more applicable in markets where the decisions taken affect the market in the long-term as a time lag, which is also a characteristic of the shipping industry.

To sum up, the cobweb concept has been used in many different markets. Its main purpose is to predict the future price of a market. The theorem is based on the time lag and expectations concepts. The shipping industry is an industry with the two above concepts as main characteristics. It is also governed by the supply and demand force. As a result, there are many oscillations and fluctuations around the equilibrium with the trend to return to the equilibrium or to move far away from the equilibrium. In the following section, various models and efforts from scholars to predict the progress of the shipping industry will be discussed.

4.5 Model

The author starts by investigating the relationship between time lags and timecharter, trip and spot rates, as well as the average earnings of dry bulk vessels of various ages and sizes. To achieve this, the Hannan – Quinn criterion as per Equation (Eq.) 1 is selected.

$$AIC^*(m) = \ln \ 〚\sigma\text{^\_}m\text{^}2\ 〛 + N\text{^}(-1)\ 2m\ lnlnN \qquad \text{(Eq. 1)}$$

Where:

- AIC* is the Hannan – Quinn criterion
- m is the chosen lag,
- N is the sample size and
- $〚\hat{\sigma}\_m\text{^}2〛$ _^ is the log maximum likelihood estimate of error variance from the model.

The Hannan – Quinn criterion is the modified Akaike's criterion (AIC), which identifies the number of lags used in an autoregressive model. The purpose of this criterion is to indicate the statistically critical lags affecting time series. Moreover, the methodology is selected as the criterion for lead-lag selections, since it is asymptotically very well behaved.

Another advantage of AIC* over AIC criterion, is that the ln(ln(N)) ensures a strong consistency. To achieve this, the first step is to run the time series, and then to choose the statistically critical lags among the last 16 observations, i.e. the last 16 lags. The lags that improve the model are determined as those that reduce the result of the AIC*. Once the lags that significantly affect time series, are identified, the AR model is constructed and the optimum lags for each examined case are selected. It is also highlighted that in all cases, the AIC* is very close with the AIC criterion.

In the literature review, different models used to capture future fluctuations and behavior of freight markets are analysed, mainly using AR models. Examples are the autoregressive moving average (ARMA), ARIMA, and VAR. To conduct this research the author has selected an AR model since it provides better results than the ARMA and ARIMA models. The integrated moving average is not statistically significant, and the backtest analysis of these models provided worse results than the AR model. As a result, the AR model is the one selected as appropriate for this thesis. Compared with previously mentioned models, it is also worth highlighting that by using this method, one can accurately explain and foresee unexpected behaviors of this market, which is critical for the viability of the "market players".

For performing the statistical analysis, an autoregressive model is created as shown in Eq. (2).

$$Yt = bo + b1Yt - 1 + b2Yt - 2 \ldots + bnYt - n + Dummy\ Outliers + Ut \qquad \text{(Eq. 2)}$$

Where:

- Yt is the outcome variable at some point,
- $Yt - 1$ is the previous observation (latest lag),

- $Yt - 2$ is two observations back (lags) from the outcome variable and so on.
- Dummy Outliers are constructed in the case where some spikes (very high peaks and lows) are considered separately and
- Ut is the white noise.

The model is performed for all dry bulk markets of the spot, timecharter and timecharter trips. The trade routes selected for analysis in this thesis are the most established routes for these markets. This methodology is applied in different cases, and it allows us to reach conclusions for the analysis of the markets' behavior.

Last but not least, a static forecast is conducted to predict the next rate level and a dynamic forecast for the next six-month period. A static forecast, predicting the following week's rates, is safer than predicting the rates for a longer period, i.e. six months like this case. However, it is essential to identify the trend for the progress of the market.

Thus, a dynamic forecast is performed to identify the behavior of the market long term. It is suggested to constantly update the data and perform static forecasts for a safer everyday business approach. It is also important to consider the demand and supply growth and the trend of the FFA market to complete the analysis of this research.

The methodology has been applied in all cases of the dry bulk markets. The Huber – White method and then the Newey – West (HAC) have been applied to deal with autocorrelation and heteroskedasticity. For all the time series that autoregressive models describe the absolute value of the coefficients on the lag variable is less than one. That means that the processes are not explosive because there is equilibrium in terms of an unconditional mean. Furthermore, and as required, the autoregressive coefficient (1) is below 1 and the Durbin Watson test result is below 2 in all cases that the model was tested, so the model's stationarity has been achieved.

The empirical analysis of the results follows. In order to complete the analysis, the progress of supply and demand is considered along with the FFA market since it is in line with expectations, and finally the results of the model can be retrieved.

4.6. Data Collection

Weekly data has been retrieved from the Clarkson database (Shipping Intelligence Network) from 1977 until February 2023. The data reflects 1) the equilibrium level for the freight rates and time-charter equivalent of the spot market and 2) the hiring level of the timecharter market. The spot market freight rates and the timecharter contracts of various short-and long-term duration are analysed. The timecharter contracts examined are of six months, one year and three years duration.

The E-views 9 software has been used to run the time series with lags, and finally, select the optimum lags for each case and then analyse the time series.

4.7. Summary

In this research, the cobweb theorem principles have been applied to investigate its use to the dry bulk shipping market. It is of the author's perception that the dry bulk market is a volatile market and the expectations about the progress of the freight market, affect the supply of the fleet in a positive or negative way.

As a result, shipowners increase or reduce the supply, while at the same time demand fluctuates causing disruptions in the market. All possible cases with oscillations that may happen, have been previously explained at a theoretical level.

A strong connection of the above principles of the cobweb theorem with the current methodology approach exists. The time lags of freight and hire rates have been taken into consideration, as indicated by the Cobweb theorem principles. The result indicates a possible forecast for the future progress of the freight market, considering the lagged equilibria of the dataset tested.

The oscillations of the freight market are very similar to the oscillations presented in the precious chapter. In the various stages of the shipping cycle, all these oscillations have happened in the dry bulk industry.

There are periods when fluctuations are not sharp, and the market gets back to balance, while there are other periods when the oscillations are extreme and the market is out of balance, resulting to negotiations away from the equilibrium. In this case, a longer period is required, so that the market starts to behave again normally. This is in extreme cases such as the peak of 2008 and the historically lowest levels of 2015-2016. Nonetheless, having considered all the above, lags and expectations may indicate the future trend of the market. In this research, they are considered for analysis in the dry bulk freight markets.

In the next chapters, the impact of the main cobweb theorem principles on the dry bulk industry has been investigated, concluding that the cobweb theorem principles have an important impact on the progress of the freight market, and it is important to be considered when a market analysis takes place.

5. Data Analysis

5.1 Capesize market

In this chapter, the capesize freight market is analysed. The spot market with indicative voyages which characterise the capesize industry are discussed. Timecharter trips and the short- and longterm timecharter contracts are also considered for analysis.

5.1.1. Spot Market

The capesize vessels transport mainly iron ore and coal. Thus, specific routes and various cargo quantities from these two cargo families have been selected for analysis. The selection is based on their importance and on the contribution of these trade flows to the BCI.

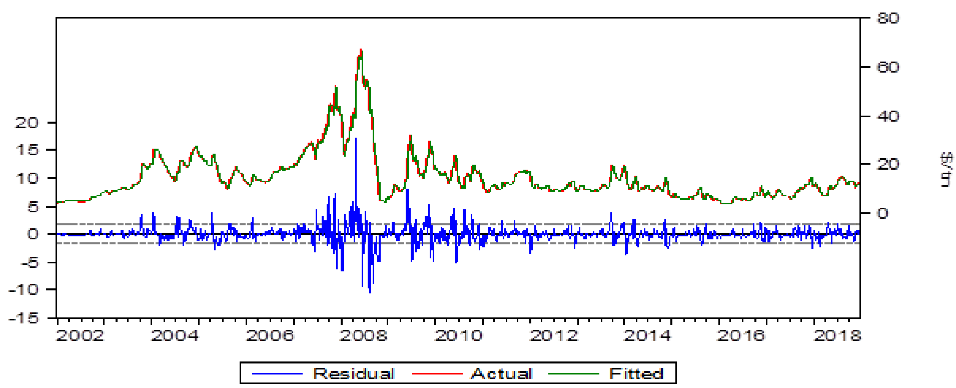
5.1.1.1. Baltimore – Rotterdam 133.000tn of coal

The data for this specific trade route is on a weekly basis from 4/1/2002 until 21/12/2018. The latest lag is considered as the most important one, affecting the decisions of the participants regarding the freight rate level, according to the Hannan – Quinn criterion and other statistical parameters. This is in line with the findings of the extant literature and the practical way of the shipping participants. Specifically, for the sport market, the practical aspect is to check the latest information about the level of the freight rate of the suggested trade route and cargo. The construction of a dummy variable is not necessary, since the incorporation of a dummy variable to the model weakens the results. Therefore, the equation for this route is:

$$Yt = bo + b1Yt - 1 + Ut \qquad (3)$$

As seen in Figure 53, the fitted numbers of the model follow the fluctuations of the actual data in the various stages of the shipping cycle.

Figure 53 – Baltimore – Rotterdam Coal



Source: Elaboration by the author

Table 1 – Baltimore – Rotterdam Coal

R-squared	0,972438
Adjusted R-squared	0,972406
Static Forecast (Freight rate on 28/12/2018)	\$11,80 /tn
Actual freight rate on 28/12/2018	\$11,75 /tn

Source: Elaboration by the author

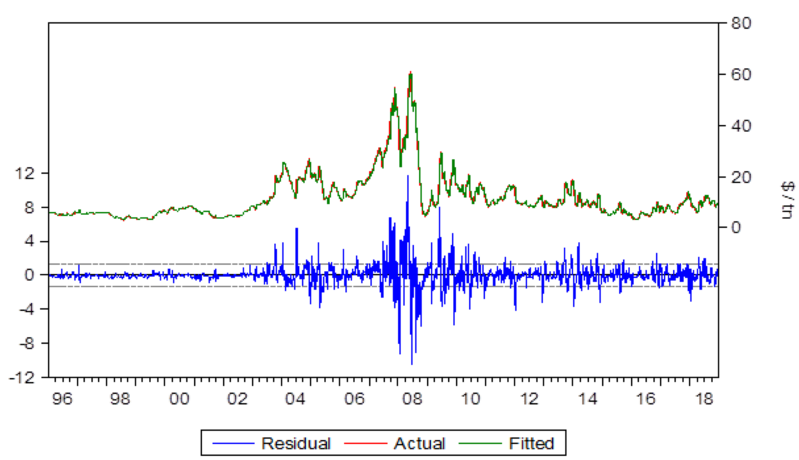
As seen in the above table, the predicted rate in the static forecast is very close to the actual freight rate. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will stay close to the equilibrium with very tight fluctuations to a slightly higher level.

5.1.1.2 Bolivar– Rotterdam 166.000tn of coal

Compared to the previous route, the volume of the transported cargo is larger under this route. The exporting port is different, while the destination is the same. The capesize vessel used to perform this voyage, is a larger vessel able to transport larger quantities. The data used for this specific trade route is on weekly basis from 2/2/1996 until 21/12/2018. The suggested methodology is applied and the author found that the optimum lag for this case to be the latest lag, as in the previous route. Thus, the equation for this route is the same with the previous route, eq. (3).

As seen in Figure 54, the fitted numbers of the model follow the fluctuations of the actual data in the various stages of the shipping cycle.

Figure 54 – Bolivar – Rotterdam Coal 166.000tn



Source: Elaboration by the author

A static forecast is performed and as seen in table 2, the freight rate is accurately predicted. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will stay close to the equilibrium with very tight fluctuations to a slightly higher level.

Table 2 – Bolivar – Rotterdam Coal 166.000tn

R-squared	0,977928
Adjusted R-squared	0,977910
Static Forecast (Freight rate on 28/12/2018)	$9,28 /tn
Actual freight rate on 28/12/2018	$9,25 /tn

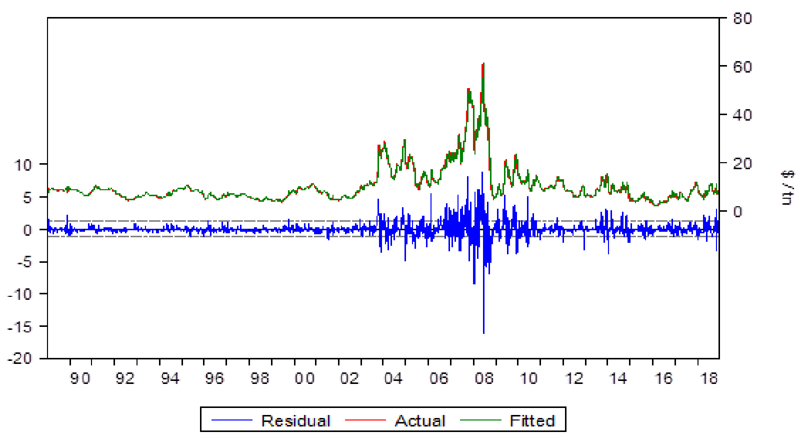
Source: Elaboration by the author

5.1.1.3 Richards Bay – Rotterdam 168.000tn of coal

The geographical area of the loading and discharging port affects the freight rate level. Additionally, the transported cargo in terms of nature and quantity also affects the determination of the equilibrium of the freight market. As in the previous routes, the latest lag is the most important lag, the one that affects the decision of the shipping participants. The data used for this specific trade route is on weekly basis from 3/2/1989 until 21/12/2018. Thus, the equation (3) is applied to this route.

As seen in Figure 55, the fitted numbers of the model follow the fluctuations of the actual data in the various stages of the shipping cycle.

Figure 55 – Richards Bay – Rotterdam Coal



Source: Elaboration by the author

Table 3 – Richards Bay – Rotterdam Coal

R-squared	0,975337

Adjusted R-squared	0,975322
Static Forecast (Freight rate on 28/12/2018)	$8,77 /tn
Actual freight rate on 28/12/2018	$8,50 /tn

Source: Elaboration by the author

A static forecast is conducted with excellent results as seen in table 3. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will stay close to the equilibrium with very tight fluctuations to a slightly higher level.

5.1.1.4 Tubarao – Qingdao 176.000tn of iron ore

This trade route has the characteristic of a long distance and competition of iron ore quality. Brazilian iron ore is considered of high quality and as a result imports to industrial areas, such as China, are of large volumes. However, the cost is important and sometimes other solutions are preferred. The sample used for this route is from 2/2/1996 until 21/12/2018. Only the latest lag seems to be important, like in the previous routes examined. Probably due to the long distance covered and the change of the demand until the delivery of the cargo, the participants are affected by these lags. Thus, the equation (3) is used again.

The fitted numbers of the model follow the fluctuations of the actual data in the various stages of the shipping cycle.

A static forecast is performed to identify the level of the next week's freight rate. As seen in table 4, again, the forecasted rate is very close to the actual freight rate, which is very encouraging. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will stay close to the equilibrium with a slight trend of increased freight rates.

Table 4 - Tubarao – Qingdao iron ore

R-squared	0,981800
Adjusted R-squared	0,981785
Static Forecast (Freight rate on 28/12/2018)	$16,54 /tn
Actual freight rate on 28/12/2018	$16 /tn

Source: Elaboration by the author

5.1.1.5 Tubarao – Rotterdam 176.000tn of iron ore

This route is the main route of importing iron ore to Europe from Brazil. The sample used is on a weekly basis from 3/2/1989 until 21/12/2018. The latest lag is the most important lag for this route. Thus, the equation for this voyage is the equation (3).

Table 5 - Tubarao – Rotterdam iron ore

R-squared	0,979925
Adjusted R-squared	0,979912
Static Forecast (Freight rate on 28/12/2018)	$8,76 /tn
Actual freight rate on 28/12/2018	$8,5 /tn

Source: Elaboration by the author

A static forecast is performed as seen in table 5. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will be relative to the equilibrium.

5.1.1.6 West Australia – Qingdao 176.000tn of iron ore

It is noticed that China apart from Brazil, imports iron ore from Australia, too. The Australian iron ore competes the Brazilian iron ore. The Australian competitive advantage of the shorter distance is covered by the quality of the Brazilian iron ore.

Due to the fact that iron ore can be stored, many factors affect the decision of the imports made. However, the high frequency and the short trips from Australia to Qingdao, compared to the one from Tubarao, pinpoints that the charterers and ship-owners do not rely just to the latest lag.

Therefore, the important lags of this route are the first, the third and the fourth. However, the first lag is the most important with the fourth one trailing. The charterers and the owners seem to monitor the previous equilibrium prices and they are affected by them for their future decisions.

Although the significance of the third lag does not seem to be very important, it is selected for the model, since the model provides better results with this lag incorporated. Thus, the equation for this route is:

$$Yt = bo + b1Yt - 1 + b2Yt - 3 + b3Yt - 4 + Ut \qquad (4)$$

The fitted numbers of the model follow the fluctuations of the actual data in the various stages of the shipping cycle. The static forecast is again very close to the actual rate of the market. A dynamic forecast is also conducted for the future freight rates until 28/06/2019, with the purpose to examine the trend of the market for this specific route. According to this, the future freight rate will be negotiated close to the equilibrium.

Table 6 – West Australia – Qingdao iron ore

R-squared	0,960410
Adjusted R-squared	0,960275
Static Forecast (Freight rate on 28/12/2018)	$7,32 /tn
Actual freight rate on 28/12/2018	$6,75 /tn
Dynamic Forecast	$7,3 /tn - $8,5 /tn

Source: Elaboration by the author

5.1.2. Trip rates

Another way of chartering a vessel in the spot market is to charter a vessel for one voyage under the terms of a time charter contract. Moreover, in order to compare the freights offered, it is important to convert the terms of the voyage to the terms of the time charter, which is the timecharter equivalent (TCE). This is also examined in the present research as following.

5.1.2.1 Transatlantic trade

The capesize vessels of two different sizes have been examined in the sample data set, those of 172.000 DWT and those of 180.000 DWT. The data is retrieved on a weekly basis, from 28/8/2009 until 21/12/2018 for the capesize of 172.000 dwt and from 22/8/2014 until 21/12/2018 for the capesize of 180.000 dwt. In both vessel sizes, the dummy variable is statistically significant and is incorporated to the model. The important lags vary in both cases. The equations for both vessels are formed as following:

$$Yt = bo + b1Yt - 1 + b2Yt - 5 + Dummy + Ut \quad (5)$$

$$Yt = bo + b1Yt - 1 + b2Yt - 3 + b3Yt - 7 + Dummy + Ut \quad (6)$$

The equation (5) refers to the capesize of 172.000 dwt and the equation (6) refers to the capesize of 180.000 dwt. It is observed that in both cases "older" lags affect the determination of the freight rate. This can be explained by the fact of the commodities trading and the possibility of seasonality. The reposition of the vessels and the backhaul cargoes may also affect the freight market.

The lower R-squared and Adjusted R-square results, compared to the previous cases examined, are explained by the smaller sample data set. The AR models require a high number of observations to produce better results. Relevant static and dynamic forecasts are performed as shown in table 7.
There is a strong possibility for the big capesize vessels to face a suppress in the freight market. Regarding the smaller capesize vessels, market is expected to bear.

The FFA market reflects the expectations of the shipping participants for the progress of the freight market. In this case, the FFA market indicates a decrease in the freight rates of the capesize vessels. This is in line with the literature, taking the expectations and the lags as important factors for the determination of the hire and freight rate level.

Table 7 – Transatlantic trade

Vessel's size (DWT)	172.000tn	180.000tn
R-squared	0,907135	0,820819
Adjusted R-squared	0,906560	0,817591
Static Forecast (Freight rate on 28/12/2018)	$17.317 /day	$17.034/day
Actual freight rate on 28/12/2018	$16.000 /day	$17.000 /day
Dynamic Forecast	$16.723 - $15.344 /day	$12.770 /day

Source: Elaboration by the author

5.1.2.2. Transpacific trade

Similarly to the transatlantic trade, two different sizes of capesize vessels have been examined in the sample data set, those of 172.000 DWT and those of 180.000 DWT. The data is retrieved on a weekly basis, from 11/9/2009 until 21/12/2018 for the capesize of 172.000 dwt and from 5/9/2014 until 21/12/2018 for the capesize of 180.000 dwt. By applying the same methodology as above, it is found that different lags are important in each case. On the contrary to the Transatlantic trade, the dummy variable is not statistically significant and is not incorporated to the model.

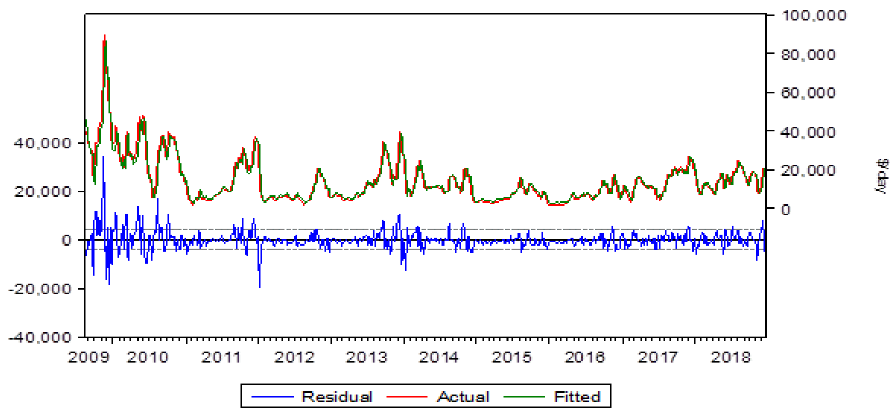
The equations for both vessels are formed as following:

$$Yt = bo + b1Yt - 1 + b2Yt - 5 + Ut \quad (7)$$

$$Yt = bo + b1Yt - 1 + b2Yt - 3 + b3Yt - 7 + b4Yt - 8 + Ut \, (8)$$

The equation (7) refers to the capesize of 172.000 dwt and the equation (8) refers to the capesize of 180.000 dwt. It is observed that in both cases "older" lags affect the determination of the freight rate. This can be explained by the fact of the commodities trading and the possibility of seasonality. The reposition of the vessels and the backhaul cargoes may also affect the freight market.

Figure 56 – Transpacific trade 172.000 dwt



Source: Elaboration by the author

Table 8 – Transpacific trade

Vessel's size (DWT)	172.000tn	180.000tn
R-squared	0,882481	0,827002
Adjusted R-squared	0,881996	0,823871
Static Forecast (Freight rate on 28/12/2018)	$12.964 /day	$13.744 /day
Actual freight rate on 28/12/2018	$12.500 /day	$12.500 /day
Dynamic Forecast	$13.968 - $13.031 /day	$11.396 - $10.916 /day

Source: Elaboration by the author

As presented in table 8, the forecasted results indicate a bear market, especially for the bigger capesize vessels.

5.1.3. Timecharter rates

The time charter rates are negotiated in the short and in the long term. Under a timecharter contract, the charterer becomes responsible for the commercial management of the vessel and pays to the owner a daily hire for the chartered period. In this research, the period of six months, the time charter of one year and the time charter of three years for the capesize vessels of 170.000 dwt and 180.000 dwt are examined.

5.1.3.1 Six – months timecharter

The timecharter contracts offer a different option regarding the strategic decision. The capesize vessels of two different sizes have been examined in the sample data set, those of 170.000 DWT and those of 180.000 DWT. The data is retrieved on a weekly basis, from 8/2/2002 until 21/12/2018 for the capesize of 170.000 dwt and from 18/7/2014 until 21/12/2018 for the capesize of 180.000 dwt.

The selected lags for the 170.000 dwt capesize is the first one, while for the 180.000 dwt capesize the selected lags are the first and the fifth lags. Thus, the equations (3) and (7) for the smaller and the bigger capesize vessels respectively, are applied. The older lags seem to be more important for the smaller capesize, while the bigger capesize is affected by the latest news of the market.

It is noticed that different lags are considered for the different sizes of the vessels. Regarding the bigger capesize vessel, the participants of the industry take into consideration the first and the fifth lag, which is in this case the latest information they have and the rate level of the closing of previous month.

Although statistically the latter lag does not seem important, if it is removed from the model, the results worsen.

The static and dynamic forecasts indicate that the smaller capesize vessel is expected to recover. On the contrary, the big capesize vessels are expected to suffer suppressions in a bear market, as presented in table 9 below.

Table 9 - Six – months timecharter

Vessel's size (DWT)	170.000tn	180.000tn
R-squared	0,983787	0,939481
Adjusted R-squared	0,983769	0,938945
Static Forecast (Freight rate on 28/12/2018)	$17.684 /day	$18.392 /day
Actual freight rate on 28/12/2018	$17.500 /day	$18.500 /day
Dynamic Forecast	$18.097 - $24.714/day	$18.345 - $15.513 /day

Source: Elaboration by the author

5.1.3.2 One-year timecharter

The one-year contract is a safer option for the ship-owner, since the ship owner will not have to deal with the chartering issue of the vessel for a period of time. In this case, the fluctuations of the market do not affect the revenue of the ship-owner. Thus, the risk of the price volatility is a burden that the charter has to carry out.

This is the reason why normally, the longer timecharter contracts offer lower hire rates, as the duration of the contract is increased. Both sizes of the examined market are affected by the latest lag only. Thus, the future equilibrium is determined based on the previous lag. The equation (3) is applied.

In the table below, the results of the static and dynamic forecasts are presented. Specifically for the bigger capesize vessels, a bear market is expected.

Table 10 - One – year timecharter

Vessel's size (DWT)	170.000tn	180.000tn
R-squared	0,985417	0,959553
Adjusted R-squared	0,985400	0,959378
Static Forecast (Freight rate on 28/12/2018)	$16.646 /day	$17.378 /day
Actual freight rate on 28/12/2018	$16.500 /day	$17.500 /day
Dynamic Forecast	$16.302 - $20000 /day	$17.395 - $15.151/day

Source: Elaboration by the author

5.1.3.3 Three years timecharter

The three-year contract is a longer contract, is either given to the ship-owner when the expectations for the freight market are extremely high and as a result due to the expectations the ship-owner increases his revenue, or when the charterer has cargoes available for transportation on a regular basis and she/he is not willing to undertake the risk of the volatile spot market.

The capesize of 170.000 dwt is affected by the older lags and equation (8) is applied. On the contrary, the 180.000 dwt capesize is affected by the latest lag only and equation (3) is applied. According to the forecasts of this research, the signs of the small capesize market are encouraging. On the contrary, the bigger capesize vessels are expected to face difficulties in a sharply declining market.

Table 11 - Three – years timecharter

Vessel's size (DWT)	170.000tn	180.000tn
R-squared	0,987688	0,974925
Adjusted R-squared	0,987617	0,974816
Static Forecast (Freight rate on 28/12/2018)	$16.483 /day	$17370 /day
Actual freight rate on 28/12/2018	$16.500 /day	$17.500 /day
Dynamic Forecast	$16.483 - $21.380/day	$17.408 - $14.674/day

Source: Elaboration by the author

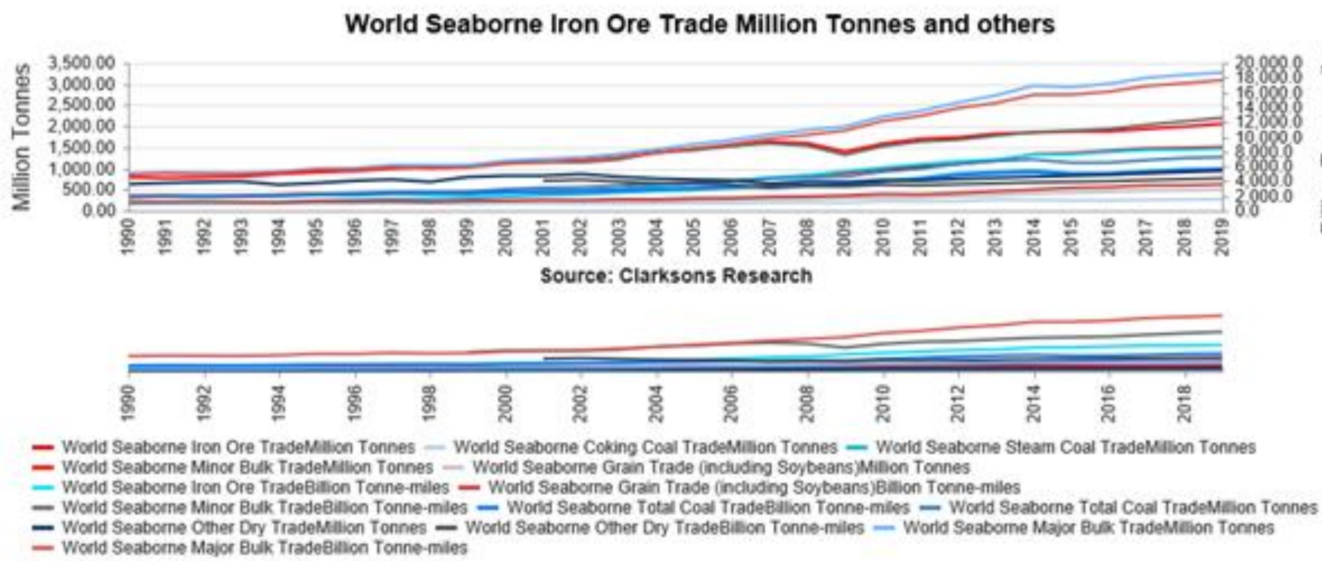
5.1.4. Demand, Supply and Expectations

The purpose of this investigation is to analyze the abnormal fluctuations of the capesize market. Therefore, it is necessary to take into consideration the demand, the supply and the expectations of this market. A main factor that affects demand is world seaborne trade.

As shown in Figure 57, the trend of the world seaborne trade for the dry bulk market has been increased especially during the last 20 years. Even in the sudden drop of the freight market in 2006 and in the collapse of 2008, the demand has in general remained at high levels. Actually, it was increasing over the years.

As presented in the current literature, the ship-owners have the tendency to invest when the freight market is high. This increases the supply over the years and based on the demand fluctuations, the market becomes unstable. In this case, the supply overcame the demand, resulting to the collapse of the freight market and the very long duration of the trough period, reaching historically low levels in 2016.

Figure 57 – World Seaborne Trade Dry Bulk



Source: Clarksons Research Intelligence Network

The supply of the capesize market has increased. According to the order book, many vessels have been delivered in 2018 (51 in number and 14.261.539 in terms of dwt) resulting to the increase of the fleet by 41 vessels in number and 8.670.000 in dwt.

The supply growth of the capesize market is +3.55% from 2017 to 2018. Furthermore, an increase of 3.82% is expected for 2019 and a further 3.28% increase in 2020, with the given numbers so far. Considering the massive deliveries and growth of the fleet from 2004 until 2014, and since some time is required before start scrapping the vessels (it is common to scrap the vessels after the age of 20), the supply is expected to rise.

Another characteristic coming from the order book is that the ship-owners try to take the advantage of the big vessels, due to economies of scale, and as a result they order big capesize vessels. However, deliveries of bigger vessels and the possibility of the demand change for shipments with smaller vessels, will suppress the rates of the bigger vessels to lower levels.

As stated in the relevant literature, the lags and the expectations play important role in the determination of the price. According to the findings of previous researches, the FFAs represent the expectations of participants of the market for its progress. The FFA reports indicate a drop in the capesize market for the near future. Normally, the bigger vessels are affected at a higher level, compared to the smaller vessels.

The findings of this research indicate that the participants of the industry should expect a decrease in the rate levels. Especially for the time charter contracts, the daily hire is expected to gradually decrease at low levels. This is due to the fact that the risk for the charterer is very high and since the expectations of the market indicate a decline of the capesize market, the charterers will offer lower hires. On the other hand, the ship-owners will obviously try to negotiate for higher rates. Depending on the timing, the area and all the relevant factors affecting demand and supply, the equilibrium will be preserved, thought at lower levels.

Taking all the above into account, along with the FFA reports which indicate a drop in the capesize market, the participants of the market can expect a drop in the freight market in the long term and especially for the bigger capesize vessels. In the short term and as shown in the previous sections, the market will still face some fluctuations and the negotiated prices will be close to the current levels.

5.1.5. Summary

In this research, the Hannan – Quinn criterion has been selected to identify the important lags of the capesize freight market for the period 1977-2018 and an Autoregressive (AR) model has been constructed to perform the statistical analysis.

The findings indicate that there is a strong correlation between time lags and capesize freight market, which enables a possible forecasting of the behavior of the market. The back tests for static and dynamic forecasts indicate the strong predictability of the model. In most cases, the latest lag was the only lag that affected the rate level. In some other cases, more lags were taken into account to determine the rate level and this is in line with the common practice of ship-owners and charterers. Especially in the spot market where the primal factor that they consider is the freight rate paid for the latest shipment of this trade route.

Moreover, the behavior of the coal and iron ore markets through the most important trade routes is examined, with various exporting and importing ports and cargo quantities shipped. As far as the iron ore market is concerned, main routes with the same quantities (176.000 tones) but different ports have been selected.

Based on this research, the author has concluded that the spot market will not suffer from sharp fluctuations, but the market will remain at a similar level for the next months.

Apart from the freight market, it is very important to examine timecharter contracts. Thus, the same methodology in the trip rates for the Transatlantic and Transpacific trades for capesize vessels of 172.000 dwt and 180.000 dwt has been applied. In the Transatlantic trade, it is noticed that different lags are important for the two different sizes of the vessel. The dummy variable is also important, since its use improves the results of the model in some cases. The forecast for this market indicates small fluctuations in the current level for a smaller capesize, while for a bigger one a drop is expected, reaching low levels, even $12.770 /day.

In the Transpacific trade, the important lags are very similar to the Transatlantic, while mall fluctuations are expected for the small capesize vessels. The estimation for the bigger capsize vessels indicates a bear market, where shipowners will struggle in the big competition.

Concerning period contracts, the author has examined the short and the long period contracts with duration six months, one year and three years for the capesize vessels of 170.000 dwt and 180.000 dwt. Specifically for the six month contracts, the author has considered the latest lag to be the most important for the capesize of 170.000dwt, while for the 180.000 dwt capesize the latest lag and the fifth lag have been identified as the most important lags. These sizes of the vessels follow opposite direction in the freight market, proving that even if they belong in the capesize type, the size of the vessel can differentiate the operation of the vessel in the market. The smaller capesize vessel is expected to be operated in a recovering market while the bigger capesize in a bear market.

Regarding the one-year timecharter contract, the latest lag is the most important for both sizes of the capesize market. The expectations for the markets are very different. The smaller capesize market is expected to continue recovering, while the bigger capesize market is expected to drop.

As far as the three-year contract is concerned, the big cape follows the latest lag, while the smaller cape is affected by the latest, the third, the fourth, the tenth and the eleventh lags. The small capesize is expected to be operated in a bull market, while a bear market for the bigger capesize vessels is expected.

In order to reach a safer conclusion, the demand and supply growth of the capesize market have been also considered as imperative factors affecting the progress of the freight market. According to the order book, the supply is expected to grow in the next years. A demand growth is also anticipated. However, the growth rate of supply and demand, along with scraps and losses, will determine the future progress of the market.

Considering the FFA market to reflect the expectations of the shipping participants, a drop in the market of the capesize vessels in the near future is expected, which is in line with the findings of this research. Specifically, the author expects the bigger capesize vessels to decline in the freight market and have a more stable freight market with small fluctuations and in some cases improvement for the smaller capesize vessels. It is also believed that based on the findings of this research, it seems that in the future the cargoes of this market will be transported in smaller quantities but more frequent, since the demand is expected to grow.

This will lead the freight market of the big capesize vessels (180.000 dwt) to face suppressed freight rates. This will also affect the decision making of the ship-owners of bigger vessels, leading to competition between smaller and bigger vessels for smaller quantities, undermining the main principle of the economies of scale theory and the purpose of the vessels being bigger.

The total supply of the capesize market is increased, due to deliveries of increasing orders regarding new buildings. The scrapings remain at a low level, resulting to the growth of the fleet within the years. According to the order book, as bigger and bigger capesize vessels enter the market, competing the older capesize vessels and in combination with a change of the demand for smaller capesize vessels, the market of the big capesize vessels may come to a decline.

At a practical level, this may lead to a better understanding of the behavior of the capesize market which would allow ship-owners and charterers to improve their planning decisions and investments. Further research may focus on the parameters considered in this tsesis. The FFAs, the demand and supply factors, such as the order book, and other factors that affect the determination of both the freight and hire rates could be possibly incorporated further to this approach.

5.2. Panamax market

Regarding the Panamax market, for the spot market, the timeseries of the following trade routes and cargoes are considered: Kamsar – San Ciprian with cargo 49.000tn of bauxite, Baltimore – Amsterdam – Rotterdam – Antwerp (ARA) with cargo 70.000tn of coal, Santos – Qingdao with cargo 60.000tn of grain and Tubarao – China with cargo 80.000tn of ores.

For the timecharter trip rates, the following trade routes and cargoes are considered for analysis: Transpacific round voyage (R/V), Transatlantic R/V and Continent – Far East for a Panamax vessel of 72.000dwt. Moreover, the research also looks into the timecharter rates, considering the duration of the hired period. The analysis of this case is for the period of six months, one year and three years for a typical Panamax vessel of 75.000dwt. Furthermore, the average earnings of the Panamax vessels being constructed in 2010 are analysed.

5.2.1 Spot market

The Panamax vessels transport a variety of cargoes worldwide. They transport the major and the minor dry bulk cargoes in large quantities. The flexibility to transport various cargoes in different parcels worldwide creates an unstable business environment under perfect competition. At the same time, charterers and ship owners can change the current and future market conditions following their strategies based on the rate levels and their expectations about the market's progress.

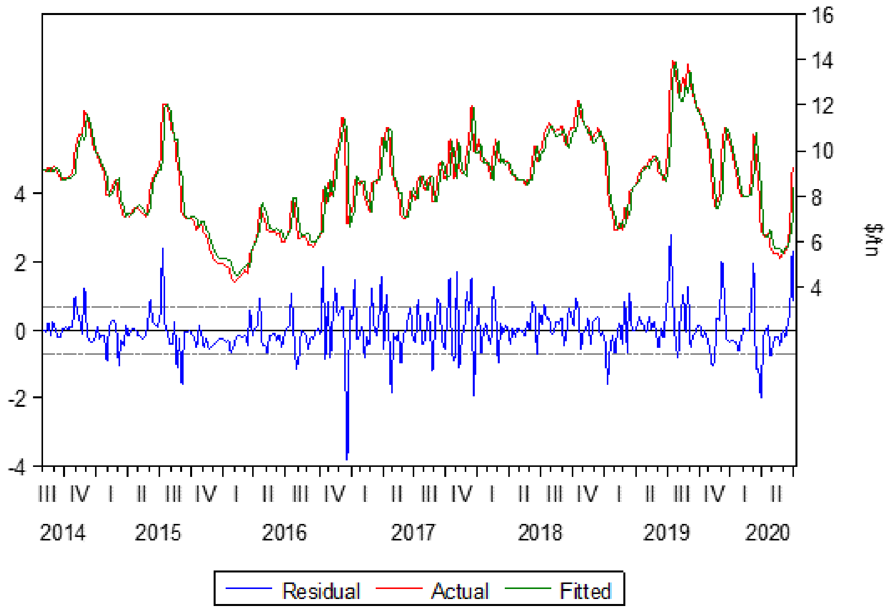
To analyse the market, the author has selected (i) four (4) trade routes of the spot market, which transported coal (Baltimore – ARA), ore (Tubarao – China), grains (Santos – Qingdao), bauxite cargoes (Kamsar - San Ciprian), (ii) three (3) timecharter period contracts with a duration of six – months, one year and three years, and (iii) three (3) timecharter trips: Transatlantic R/V, Transpacific R/V and Continent – Far East routes. The above routes are very typical routes for the Panamax industry, and their rates contribute to the calculation of the BPI.

5.2.1.1 Kamsar – San Ciprian 49.000 tn of Bauxite

Kamsar – San Ciprian is a typical trade route for bauxite. It contributes to the Panamax industry with high volumes during the year. The data used for this trade route is from 4/7/2014 to 3/7/2020. In this case, the optimum lags selected are lag(1) and lag(4). These two lags affect the model significantly, the reason why they are incorporated in the model. Eq. (3) is formed for this route.

$$Yt = bo + b1Yt - 1 + b2Yt - 4 + Ut \qquad \text{(Eq. 3)}$$

Figure 58 - Kamsar – San Ciprian Bauxite



Source: Elaboration by the author

Table 12 - Kamsar – San Ciprian Bauxite

R-squared	0,885040
Adjusted R-squared	0,884291
Static Forecast (Freight rate on 03/01/2020)	$ 10,29/tn
Static Forecast (Freight rate on 03/07/2020)	$ 9,43/tn
Actual freight rate on 03/01/2020 Actual freight rate on 03/07/2020	$10/tn $9,25/tn

Source: Elaboration by the author

The model predictability is satisfying, as seen in Table 12 and Figure 58. The forecasted rates are very close to the actual rates, and the market trend is captured. The model dynamic forecast indicates a market collapse in the last quarter of 2019 and 2020, which is also captured by the model static forecast. The model also captures the freight rate curve upturn at the end of June and the beginning of July. It is essential to mention that the Covid-19 period has affected all markets leading to high volatility and spikes in the freight markets.

5.2.1.2 Baltimore – Amsterdam, Rotterdam, Antwerp Area 70.000 ton of Coal

The Baltimore – Amsterdam, Rotterdam, Antwerp (ARA) Area is a traditional coal trade route. Data is collected for the period 6/01/1989 to 3/07/2020. Frequently, Panamax vessels transport coal, and this route contributes to the outcome of BPI. The most critical lags affecting this route are lag(1), lag(8) and lag(11). Although lag(11) is highly significant to the model, the other lags improve the model when incorporated. Therefore, Eq. (4) is presented.

$$Yt = bo + b1Yt - 1 + b2Yt - 8 + b3Yt - 11 + Ut \qquad \text{(Eq. 4)}$$

As we can see in Table (13) and Figure (59), the model's predictability is very satisfying. The model manages to capture the market fluctuations and accurately predict the level of the freight rates. The dynamic forecast suggests a bear market verified by the static forecast and the market's actual progress. The Covid-19 period affected this route too. The predicted rates are very close to the actual rates, following the market's suggested and current trend, with a bear market from February 2020 until the bottom rates of May 2020. The model predicts the low rates of May with accuracy, apart from the sudden drop from \$7,20/tn to \$4,85/tn in 8 May, although the model predicts that rate for the next week, 15th May 2020. This is probably due to the lag needed sometimes for models to adjust in sudden collapse or peak. The model also captures the instant recovery of the market (June – July 2020).

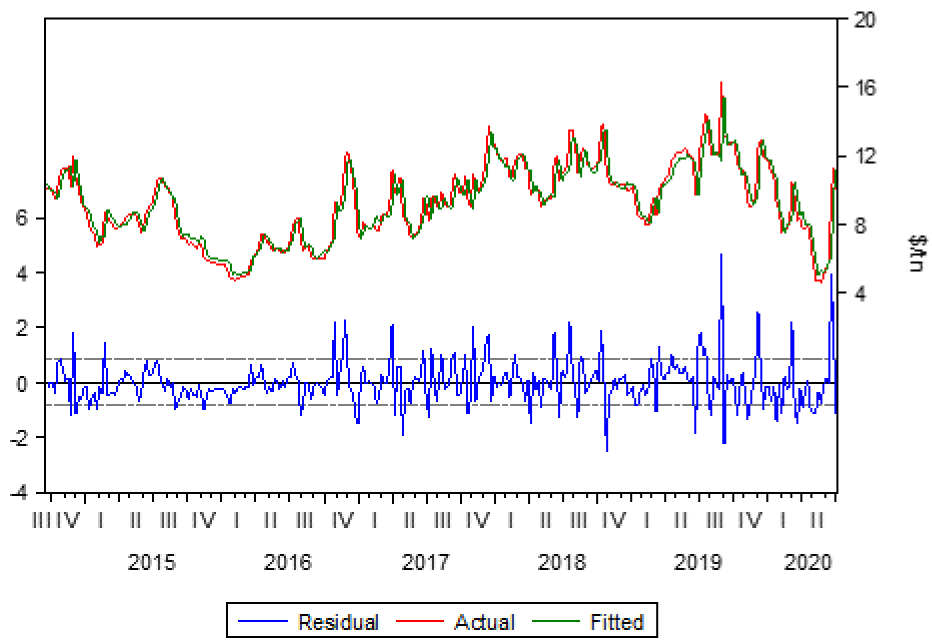
Table 13 - Baltimore – ARA Coal

R-squared	0,980414
Adjusted R-squared	0,980378
Static Forecast (Freight rate on 03/01/2020)	$ 11,94/tn
Static Forecast (Freight rate on 01/05/2020)	$7,04/tn
Static Forecast (Freight rate on 08/05/2020)	$7,28/tn
Static Forecast (Freight rate on 15/05/2020)	$4,90/tn
Static Forecast (Freight rate on 22/05/2020)	$4,81/tn
Static Forecast (Freight rate on 29/05/2020)	$4,68/tn
Static Forecast (Freight rate on 26/06/2020)	$ 10,40/tn

Static Forecast (Freight rate on 03/07/2020)	$ 11,15/tn
Actual freight rate on 03/01/2020	$11,85/tn
Actual freight rate on 01/05/2020	$7,20/tn
Actual freight rate on 08/05/2020	$4,85/tn
Actual freight rate on 15/05/2020	$4,85/tn
Actual freight rate on 22/05/2020	$4,70/tn
Actual freight rate on 29/05/2020	$5,70/tn
Actual freight rate on 26/06/2020	$11,20/tn
Actual freight rate on 03/07/2020	$9,80/tn

Source: Elaboration by the author

Figure 59 - Baltimore – ARA Coal



Source: Elaboration by the author

5.2.1.3 Santos – Qingdao 60,000tn of Grains (04/07/2014 – 10/07/2020)

Santos – Qingdao is a typical grain route for Panamax vessels. Although a Capesize vessel would be the charterers' first choice in such a long trip to take advantage of economies of scale, the Panamax vessels are usually the biggest vessels transporting grains due to the cargo nature. The grains cannot be harvested and stored for an extended period. As a result, grains have to be harvested and transported sooner to avoid spoiling the cargo, and Panamax vessels are preferred.

In such a case, lag(1) is the significant lag for the model. This adheres to the usual practice of considering the latest freight rate. Moreover, the distance factor is essential. Along with other factors affecting the freight market such as seasonality, bunker cost, storing and random shocks and others, the spot market fluctuates constantly. Therefore, Eq. (5) is formed for this route:

$$Yt = bo + b1Yt - 1 + Ut \qquad \text{(Eq. 5)}$$

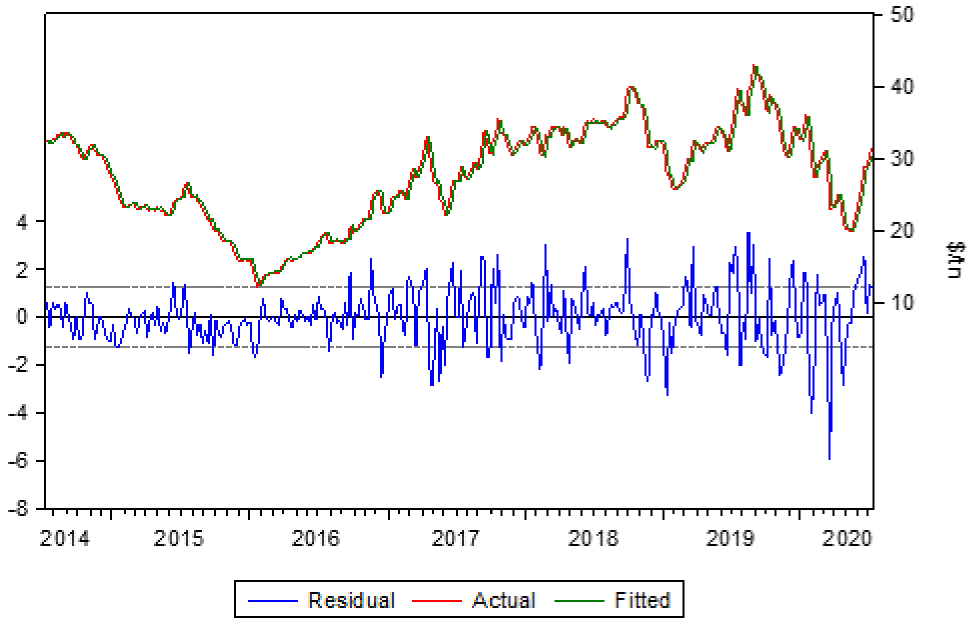
As seen below in Table (14) and Figure (60), the model's predictability is accurate. The backtest results indicate that the forecasted rates are similar to the actual rates. The market trend is captured by dynamic and static forecasts, indicating a bear market (February – May 2020) and a recovery afterwards, which is totally in line with the actual market behavior.

Table 14 - Santos – Qingdao Grains

R-squared	0,968770
Adjusted R-squared	0,968670
Static Forecast (Freight rate on 3/1/2020)	$ 33,13/tn
Static Forecast (Freight rate on 3/7/2020)	$30,30/tn
Actual freight rate on 3/1/2020 Actual freight rate on 3/7/2020	$32,5/tn $30,35/tn

Source: Elaboration by the author

Figure 60 - Santos – Qingdao Grains

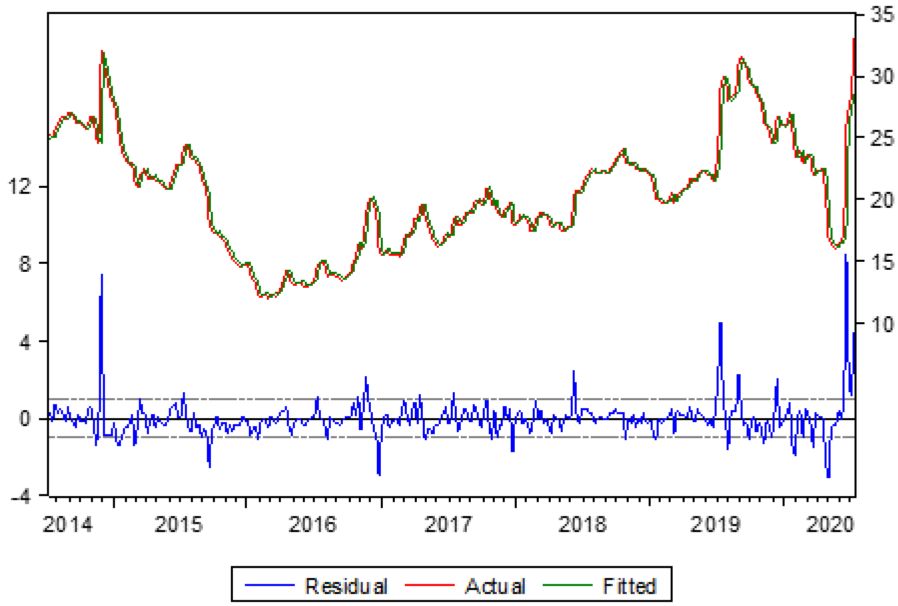


Source: Elaboration by the author

5.2.1.4 Tubarão – China 80.000 ton of Ores

Another typical trade route is Tubarão – China, with iron ore as cargo, a typical route for a Capesize vessel. In the meantime, the Panamax vessels compete with the Capesize vessels for some routes and cargoes, like this one, though they do not offer the same scale economies advantage. This is could happen because of the strategy the shipping participants follow, based on factors such as storing, commodity price, and expectations about the progress of the freight market. In such a case, a shipment with less cargo quantity might be more preferable for charterers. Moreover, timing, port restrictions, demand, among others, nominate the Panamax vessels, severe competitors, to Capesize vessels. In this case, lag(1) is the optimum one (for the same reasons presented in the previous route), which explains why Eq. 5 is used again. Data is collected for the period 4/7/2014 – 3/7/2020.

Figure 61 - Tubarão – China Ores



Source: Elaboration by the author

Table 15 - Tubarao – China Ores

R-squared	0,953041
Adjusted R-squared	0,952890
Static Forecast (Freight rate on 3/1/2020)	$ 25,94/tn
Static Forecast (Freight rate on 3/7/2020)	$27,43/tn
Actual freight rate on 3/1/2020 Actual freight rate on 3/7/2020	$26/tn $28,60/tn

Source: Elaboration by the author

As we can observe in Table (15) and Figure (61), the forecasted rates are similar to the actual rates. This is because the dynamic and static forecasts captured the fluctuations of the market in this period. Thus, apart from the trend and market behavior, the model proved significant predictability regarding the rates during the Covid-19 period since it managed to predict the market trends.

5.2.2 Trip rates

In this section the trip rates offered for a panamax vessel of 72.000 dwt is discussed. The trip rates offer an alternative way to charter a vessel in the spot market for the duration of a trip. In such cases, the charterer becomes responsible for the commercial management of the vessel only for the specific trip and under the specific clauses of the contract, while the shipowner still remains responsible for the technical management and seaworthiness of the vessel. Here, the trips in the trading routes of Continent – Far East, Transatlantic and Transpacific round voyages are analysed.

5.2.2.1 Continent – Far East 72.000 dwt

The Continent – Far East route refers to a trip from the continent (the United Kingdom, North of France, Germany, North of Europe) with destination Far East (China, Japan, Singapore, Indonesia mainly) under a timecharter contract. The lag(1) is the optimum lag for this route, and Eq. (5) is applied. Data is collected for the period 1/1/1993 – 3/7/2020. The model's dynamic and static forecasts responded successfully to the market fluctuations, capturing the rate curve's upturn and the collapse (April – mid-June 2020). The market displayed signs of increased rates for the period of July 2019 – November 2019.

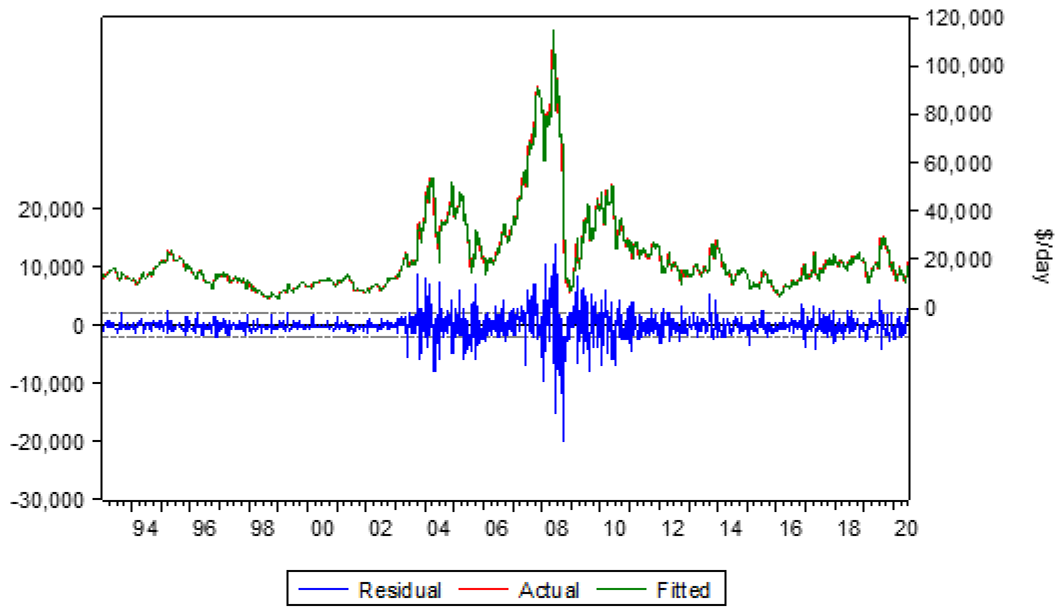
The expected drop in December 2019 – January 2020 was enhanced with the Covid – 19 pandemics in the Far East area. The lockdown of economies resulted in suppressing the rates until the end of February 2020. The market recovery took place in March 2020, mainly due to expectations of leaving behind the pandemic in the Far East and local economies re-opened. However, the European markets re–opening was postponed, and a longer period was required to overcome the pandemic. Finally, the rates recovered with the full re-opening of economies (end May – July 2020), as seen in Table (16) and Figure (62).

Table 16 - Continent – Far East 72.000dwt

R-squared	0,984365
Adjusted R-squared	0,984354
Static Forecast (Hire rate on 3/1/2020)	$16.935/day
Static Forecast (Hire rate on 3/7/2020)	$17.778/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$15.750/day $18.900/day

Source: Elaboration by the author

Figure 62 - Continent – Far East 72.000dwt



Source: Elaboration by the author

5.2.2.2 Transatlantic Round/Voyage 72.000dwt

Transatlantic Round/Voyage (R/V) is a crucial trade route for the Panamax industry as it contributes to the formation of the BPI level. Regarding this route, lag(1), lag(7) and lag(8) have been selected to form the model equation. Although lag(7) and lag(8) do not seem statistically significant, they improve the model results when taken into account. An explanation for this may be the presence of a market seasonality occurrence, mainly in the grain trades, which is critical to the transatlantic trade. Thus, Eq. (6) will be used for this route.

$$Yt = bo + b1Yt - 1 + b2Yt - 7 + b3Yt - 8 + Ut \qquad \text{(Eq. 6)}$$

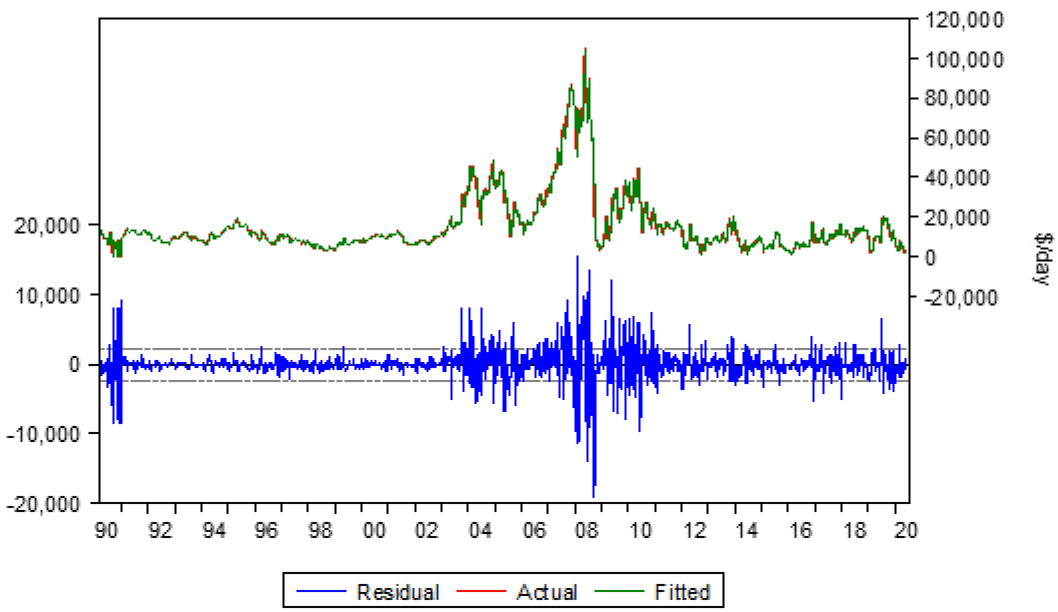
The data collection period is 5/1/1990 – 3/7/2020. As seen in Table 17 and Figure 63, the model produces satisfying results, with dynamic and static forecasts predicting the market trends. Again, the fluctuations vary in duration and level. Specifically for the Covid-19 period, the market tried to recover. However, it was suppressed by the lockdown of European and United States of America (USA) economies, leading to rock-bottom rate levels (below $2.000/day, mid-May 2020). Finally, with the re-opening of economies, the market recovered. The model captured these fluctuations and the market trend, shown in Table (17) and Figure (63).

Table 17 – Transatlantic R/V 72.000dwt

R-squared	0,977332
Adjusted R-squared	0,977289
Static Forecast (Hire rate on 3/1/2020)	$ 9.458/day
Static Forecast (Hire rate on 3/7/2020)	$12.042/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$9.000/day $13.000/day

Source: Elaboration by the author

Figure 63 – Transatlantic R/V 72.000 dwt



Source: Elaboration by the author

5.2.2.3 Transpacific Round/Voyage 72.000dwt

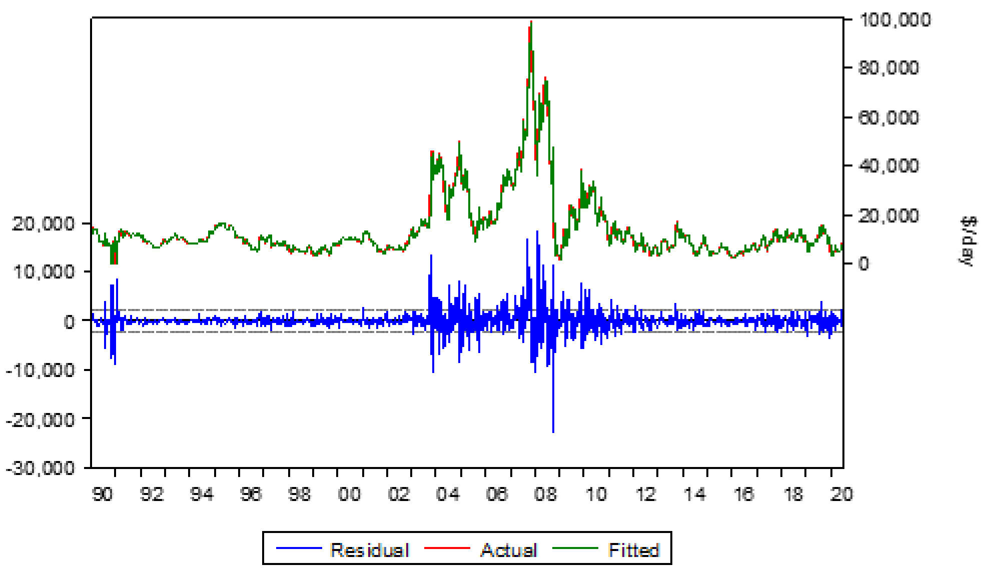
The Transpacific R/V refers to the routes via the Pacific. Data was collected for the period 5/1/1990 – 3/7/2020. The lag(1) is significant for this route, mainly due to the distance factor, and Eq. (5) is applied. The model has a positive predictability outcome since actual and forecasted rates are very close. The market faced difficulties during December 2019 – mid-February 2020, with signs of recovery onwards. The market had a stable condition with minor fluctuations around the equilibrium until May 2020. Afterwards, the market recovered, as seen in Table (18) and Figure (64).

Table 18 – Transpacific R/V 72.000 dwt

R-squared	0,976114
Adjusted R-squared	0, 976099
Static Forecast (Hire rate on 3/1/2020)	$5.109/day
Static Forecast (Hire rate on 3/7/2020)	$9.061/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$4.500/day $8.800/day

Source: Elaboration by the author

Figure 64 – Transpacific R/V 72.000dwt



Source: Elaboration by the author

This behavior is explained by the Covid – 19 situation. The early effect of coronavirus on the Asiatic economies led to the collapse of demand in Asia. Then, the European and USA economies faced the pandemic resulting in a lockdown. However, by the first signs of normality, the rates recovered, with June 2020 being promising. The model managed to capture the behavior of this market and forecast the rates with good results.

5.2.3 Timecharter rates

In this section the progress of the timecharter contracts in the panamax market is analysed. The timecharter contracts are an alternative way of chartering a vessel for a short or a long period. Under a timecharter, the charterer takes control of the commercial management of the vessel, while the shipowner remains responsible for the technical management and seaworthiness of the vessel. The cases of six months, one year and three-year timecharter contracts will be discussed for a panamax vessel of 75.000 dwt.

5.2.3.1 Six – months timecharter 75.000 dwt

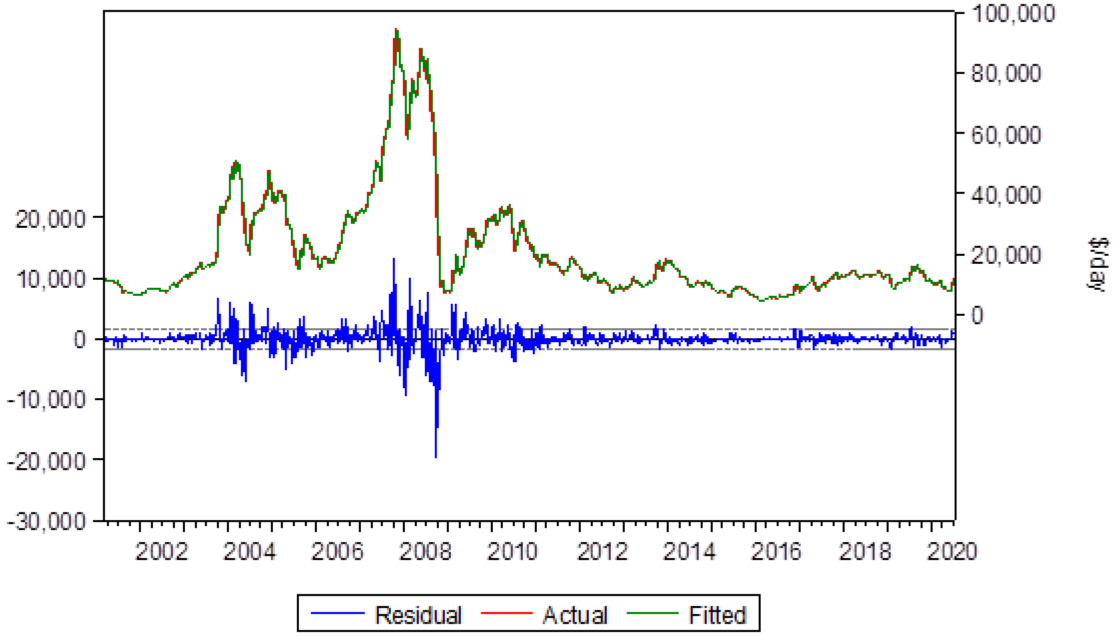
The timecharter contract for six months is a typical contract for a Panamax vessel. Table (19) and Figure (65) show the market progress. Eq. (5) is applied for this market since the latest rate is critical for decision making. In this case, lag(4) could be added to the model, with the inverted autoregressive roots being stationary too. However, the predictability is almost the same, and the models prove to be more stable when considering only lag(1). Thus, only lag(1) is selected. A bear market since mid-2019 continued the collapse in 2020, during the pandemic. However, the return to normality for global economies resulted in recovery during June 2020. As seen below, the model responded positively to this market's fluctuations, capturing the trend and fluctuations.

Table 19 – Six-months timecharter 75.000dwt

R-squared	0,989829
Adjusted R-squared	0, 989819
Static Forecast (Hire rate on 3/1/2020)	$10.677/day
Static Forecast (Hire rate on 3/7/2020)	$11.500/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$10.250/day $12.200/day

Source: Elaboration by the author

Figure 65 – Six-months timecharter 75.000 dwt



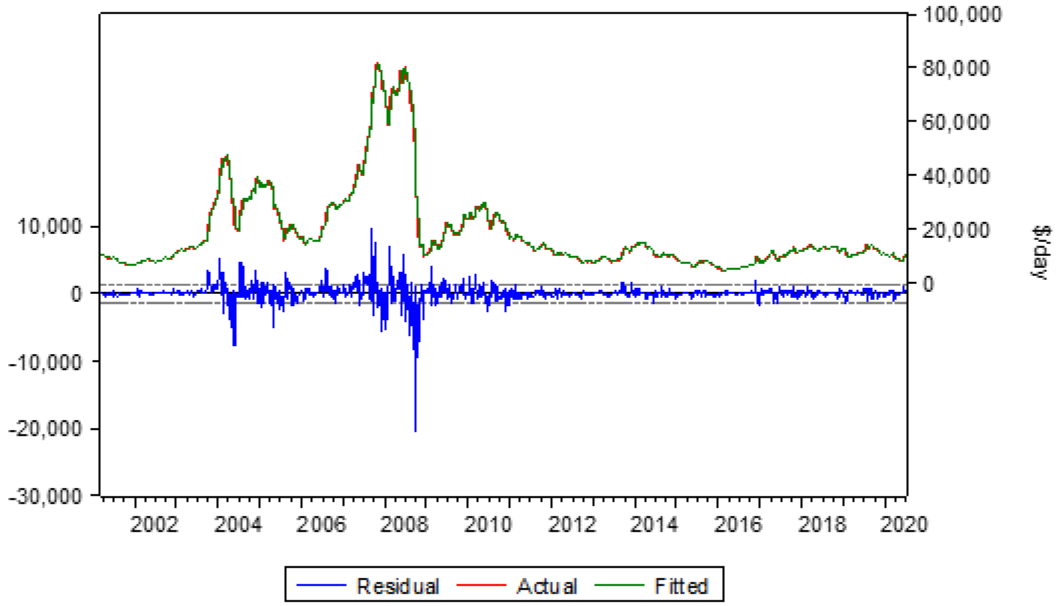
Source: Elaboration by the author

5.2.3.2 One–year timecharter 75.000 dwt

This is for a longer period contract. Regarding the equation formation for this route, the same applies as in the previous case; thus, Eq. (5) is applied. Data collection is for the period 2/3/2001 – 3/7/2020. The model has once more captured the trend and the fluctuations of the market.

Moreover, it has also predicted the rates at an acceptable level. The market for 2020 (up to the sample date) has suffered from small fluctuations (from $10.350/day to $8.500/day) until early June 2020, the recovery turn point, as seen in Table (20) Figure (66); this happens because expectations are high for future demand.

Figure 66 – One-year timecharter 75.000dwt



Source: Elaboration by the author

Table 20 – One-year timecharter 75.000dwt

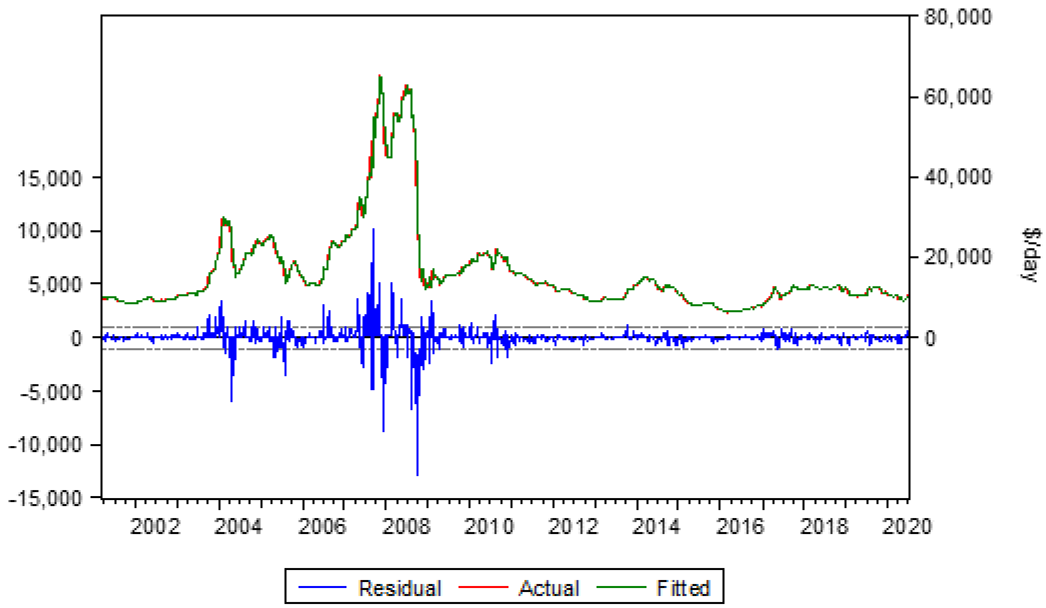
R-squared	0,992251
Adjusted R-squared	0, 992243
Static Forecast (Hire rate on 3/1/2020)	$10.782 /day
Static Forecast (Hire rate on 3/7/2020)	$10.783/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$10.375/day $11.250/day

Source: Elaboration by the author

5.2.3.3 Three – years timecharter 75.000 dwt

Three – years timecharter is for a long-term chartering strategy. This contract is for three years, and the market progress is presented in Table (21) and Figure (67). Eq. (5) is applied in this case too. The market for 2020 shows minor fluctuations, and contracts are signed at relatively stable rates, with a minor drop during the economic lockdown. However, this market is not affected significantly by very short-term issues of the world economy but by the generic future expectations and market trends in the long term. The model managed to capture the market's behavior and predict the trend with the rates at an acceptable level.

Figure 67 – Three-year timecharter 75.000 dwt



Source: Elaboration by the author

Table 21 – Three-years timecharter 75.000dwt

R-squared	0,990944
Adjusted R-squared	0, 990935
Static Forecast (Hire rate on 3/1/2020)	$10.775/day
Static Forecast (Hire rate on 3/7/2020)	$10.526/day
Actual hire rate on 3/1/2020 Actual hire rate on 3/7/2020	$10.500/day $10.750/day

Source: Elaboration by the author

5.2.3.4 Average earnings Panamax c. 2010 – built

An effort is also conducted to predict the earnings of the Panamax vessel with a 10-year age. Eq. (5) is used since the optimum lag is lag (1). The earnings category suggests that the voyage expenses have been removed from the freight/hire revenue, net of commission. The bear spot market does not always imply a drop in the earnings of the ships. This is mainly because the voyage costs are unstable and vary based on the trip's length and port calls.

Furthermore, the bunker cost, which varies from time to time, plays a critical role in determining voyage expenses and, finally, the ship owners' earnings. During the lockdown period, the bunker cost remained shallow, following the oversupply of oil and its price collapse. This could be an indicator for higher profitability, as according to BIMCO reports, the Panamax vessels managed even to double their earnings in some cases.

As per BIMCO report, dated 7 February 2020, the average earnings for the Panamax vessels were US$3.535 per day, with a further week on week increase to 28 February 2020 to be at the level of US$6.811 per day. After the end of the first week of March (6 March 2020), the average earnings of the Panamax market were $9.610 per day.

The model has managed to capture the market's overall behavior and predict the earnings level at an acceptable level. Nevertheless, it failed the back test dated 3/1/2020, having a significant difference in the actual and forecasted earnings. This is because the shipping industry has unexpected ups and downs, with high volatility for short or long periods.

This volatility can be positive or negative, especially in the last two weeks before the end of the year and two weeks after the new year, without always being predictable in terms of actual rates. This is due to sudden changes in demand for these dates since trading activity sometimes is proved to be reduced.

The important is that the model managed to adjust the next week's capture after considering the significant change of the market conditions. However, this difference is restored in the next week's earnings, as shown in Table (22) and Figure (68). As a result, in exceptional cases, a lead-lag is essential to shape the expected results.

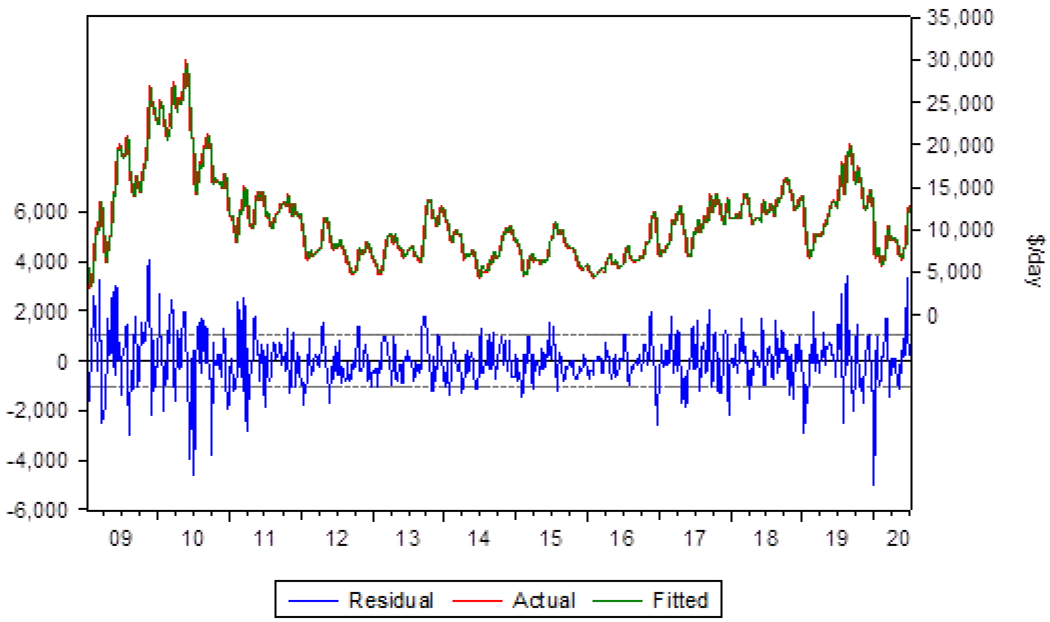
Table 22 – Average earnings c. 2010

R-squared	0,976114
Adjusted R-squared	0, 976099
Static Forecast (earnings on 3/1/2020)	$12.304/day
Static Forecast (earnings on 10/1/2020)	$7.376/day
Static Forecast (earnings on 3/7/2020)	$12.650/day
Actual earnings on 3/1/2020 Actual earnings on 10/1/2020	$7.276/day $6.728/day

Actual earnings on 3/7/2020	$12.854/day

Source: Elaboration by the author

Figure 68 – Average earnings c. 2010



Source: Elaboration by the author

5.2.4 Discussion

The FFAs and derivatives are used as hedging tools of physical trades. The FFA market, as pinpointed in the literature review section, is considered as the expectations' "mirror" for the progress of the market. The literature review indicates that there is a strong connection between the progress of the FFA market and the relevant freight markets (Kavussanos *et al.,* 2004). The shipping industry participants consider the changes in the FFA markets when it comes to decision making regarding the future, such as investments or chartering strategy.

Under this situation, the reaction of the states and global economies will affect the freight markets significantly. Nevertheless, the FFA market indicates an increase in the future rates of the Panamax industry for the next year, fulfilling shipping participants' expectations, possibly explaining the recovery in the one–year timecharter contracts. On the contrary, the stability of the more extended contracts' rates can be explained by the waiting stance of the shipping participants (mainly charterers) until the blur of the market is revealed in the short term, before getting long term strategical decisions.

Supply and demand factors affect the progress of actual freight rates. The demand constantly changes, resulting in sharp fluctuations within the year. According to predictions, a demand growth is anticipated. The Covid-19 has significantly affected the demand progress recently as the freight market is currently facing sharp fluctuations. On the other hand, the shipowners tend to change the speed operation of the vessels to balance the difference between supply and demand in the short term, thus increasing the fleet's efficiency.

This affects the progress of the freight market. The Panamax market's total supply has increased due to deliveries of increasing orders regarding new buildings. After six years (2012 – 2017) of heavy scrapping and few deliveries renewing the fleet, the scrapings remain at a low level, resulting in the reduction of the fleet the recent years. However, according to the order book, deliveries will increase the fleet in the short term. Thus, the supply of Panamax fleet will increase.

After testing the method in a relatively close market and intensive capital market like the Capesize market, the model is now tested in an open market with operation under strict daily competition. The Panamax market is an open market with flexibility regarding trade routes and cargoes transferred alike. The coronavirus has significantly affected the market progress and the consequent worldwide lockdown of economies as a random shock, so market expectations and forecasts' risks were not being accurate. The market has collapsed in the first semester of 2020, with signs of recovery afterwards. However, the profitability of Panamax vessels remained at a satisfactory level; in some cases, increased, despite a drop in the rates in most cases.

Regarding the spot market, it has been noticed that fixtures are made around the equilibrium of each analysed route within a six month period. However, in the coal, grains and bauxites routes, we have seen a small drop in the market with the closing of the first semester. The exception is the ore route, Tubarao – Qingdao, with the market having a positive outcome after the first semester. In the meantime, sharp fluctuations had happened during economies' lockdown, resulting in a drop of the freight rates in the spot market. The model predicted this situation with similar rates close to the actual ones, but in rare cases there was a lag either in the previous or in the following week. As a result, the model managed to capture the market trend in most cases at the right timing.

Apart from the spot market, it is imperative to examine timecharter contracts. Thus, the same methodology has been applied to the cases of Continent – Far East, Transatlantic R/V and Transpacific R/V trade trip rates for a typical Panamax vessel of 72.000 dwt. In all three cases, the market had a positive end at the beginning of July. That was also predicted by the methodology followed. Concerning period contracts, the short and the long period contracts have been examined, with duration six months, one year and three years for the Panamax vessels of 75.000 dwt. In all cases, lag(1) was the most important one. All markets had a similar trend, especially for the first semester of 2020, with different rates and drop percentages. However, the signs of recovery in June 2020 and the market's expectations indicate increased market rates; the only uncertainty is a possible next wave of coronavirus. Therefore, the predictions of the model are satisfying, capturing the behavior of the market.

To reach a safer conclusion, the demand and supply growth of the Panamax market have been also taken into consideration. However, the growth rate of supply and demand, along with scraps and losses, will determine the market's future progress. Considering the FFA market to reflect the shipping participants' expectations, a recovery is expected in the Panamax vessels' market shortly, in line with the findings of this research.

5.2.5. Summary

A better understanding of the Panamax market behavior could contribute towards more efficient decisions by shipowners and charterers at a practical level. The research suggests an alternative way to analyse the aforementioned market. In the current literature, different methods are used to forecast the progress of the Panamax markets. Most efforts were conducted in the time period market. Other efforts were focused on the connection between the FFA market and the progress of the freight market. Many different models were used with different combinations of variables. This research innovates using the lags and the empirical analysis of supply and demand changes to form the Panamax markets' behavior analysis.

The findings indicate that it is possible to explain the fluctuations of the Panamax markets and forecast future market behavior, to benefit the shipowner and the charterer alike. The findings indicate a strong connection between time lags and Panamax freight markets, which enables possible forecasting of the behavior of the market since the time lags affect the progress of the freight market significantly. The back tests for static and dynamic forecasts indicate the strong predictability of the model. In most cases, lag(1) was the only lag that affected the rate level, mainly in the timecharter contracts, either period or trip. In some other cases, mainly in the spot market, more lags were taken into account to determine the rate level, which is in line with the common practice of shipowners and charterers. This applies especially in short-term decision-making, where the prime factor is the freight rate paid for this trade route's latest shipment.

The author has also concluded that the freight markets collapsed during the pandemic and the worldwide economy lockdown, recovering when expected to return to normality or when the world economy had signs of being on track to normality. However, as reported by BIMCO reports from 17 January 2020 to 24 April 2020, the owners' earnings did not follow that collapse but managed to increase in some cases. This is partially explained by the multivariable function of shipowners' earnings, with bunker costs affecting the shipowner's profitability when operating the vessel. During this period, a collapse of the bunkers' prices significantly reduced voyage expenses at a higher rate than the drop of the freight market. As a result, the average earnings increased.

This research may lead to a better understanding of the Panamax market's practical behavior, allowing shipowners and charterers to improve their planning decisions and investments. Shipping participants may consider all these factors discussed in this thesis to reach conclusions. However, abrupt changes and volatility and the human factor must be considered before resulting in their decisions. Moreover, the trade of the dry bulk commodities will continue due to their necessity for the global economy. Thus, the trade will happen in some cases, even if the timing might not be profitable for some participants. In this case, hedging with FFAs is necessary.

Further research may focus on the parameters considered in this thesis. The FFAs, the demand and supply factors, such as the order book, and other factors affecting freight and hire rates' determination could be possibly incorporated further into the approach of this research.

5.3. Handymax market

5.3.1. Introduction

In this section, the freight market of the handymax vessels is analysed. As discussed in the literature review relevant section, these vessels vary in size and are competing the panamax and handysize vessels directly. Upon demand changes and shipment volumes, charterers may choose to charter a handymax vessel in the spot market (voyage by voyage), under a timecharter trip (voyage in a timecharter contract), and under a short or long timecharter period. The fluctuations in the industry exist and finally the average earnings of the sector will be analysed, under the scope of time lags.

5.3.2. Spot market

Regarding the spot market, four trade routes have been selected as a representative sample. These routes contain the transportation of different but important cargoes, trying to capture the different individual and cargo behavior within the same freight market.

The specific routes of Boston – Turkey with scrap cargo of 40.000 tn, US Gulf – Japan with grains of 49.000 tn, Bolivar – Chile and Richards Bay – Mundra with coal of 50.000tn for the two last routes, are examined.

5.3.2.1. Boston-Turkey Scrap 40.000 tn

Weekly data from Clarksons SIN database have been retrieved. The dataset starts on 8/8/2014 and ends on 24/2/2023.

The suggested methodology is applied to the route Boston – Turkey with scrap cargo of 40.000 tn. The eq (1) is used and the optimum lead lag selected is the lag1.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1 and the Durbin Watson test is between 0 – 2.

The author has noticed that when adding more lags in the model, the predictability remains high, but the model loses its stationarity. However, when considering one lag only, but a different lead lag i.e. lag(2) or lag(3) etc, the predictability of the model becomes weaker, with lower R-squared and adjusted R-squared (still above 0,80). Thus, the latest lead lag, the lag1, has been selected as optimum. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (3,81). As seen in the below table (23) and figure (69), the R-squared and the adjusted R-squared are also very high (0,966356 and 0,966356 respectively).

By performing a back test analysis, the author has reached to the conclusion that the static forecast is very accurate, predicting the freight rate to be 21,02 $/tn for the last three weeks, ending 24/2/23. In this period, the actual freight rate was 21 $/tn for the same period. It is also important to mention that the model has fully captured the trend of the market, even predicting the freight rates with high accuracy at the turn points of the market. For example, the model has captured the fluctuations of the up- and downward trend of the freight rates for the period 23/11/22 till 24/2/23.

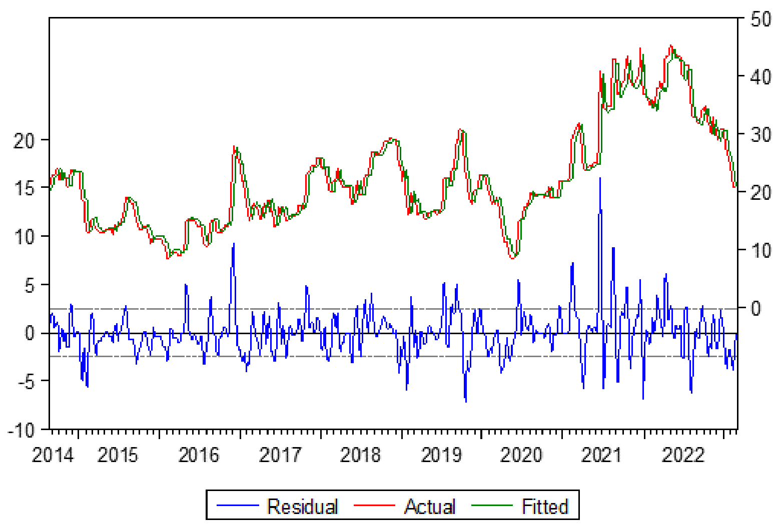
It is also concluded that the dynamic forecast provides weaker results compared to the static forecast. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

Table 23 - Boston-Turkey Scrap 40.000 tn

R-squared	0,966356
Adjusted R-squared	0,966356
Static Forecast (Freight rate on 24/2/23)	21,02 $/tn
Actual Freight rate on 24/2/23	21 $/ tn

Source – elaboration by the author

Figure 69 - Boston-Turkey Scrap 40.000 tn



Source – elaboration by the author

5.3.2.2. US Gulf – Japan Grains 49.000 tn

In this section the trade rout USGulf – Japan with grains of 49.000 tn is analysed. Weekly data from Clarksons SIN database have been retrieved to perform analysis. The dataset starts on 5/1/2007 and ends on 24/2/2023.

The suggested methodology is applied to this trade route. The eq (1) is used and the optimum lead lag selected is the lag1. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1.

Like in the previous trade route, it is noticed that when adding more lags in the model, the predictability remains high, but the model loses its stationarity. However, when considering one lag only, but a different lead lag i.e. lag(2) or lag(3) etc, the predictability of the model becomes weaker, with lower R-squared and adjusted R-squared (still above 0,90). When more lags are incorporated in the model, a safer prediction is noticed for the turning points of the freight market.

However, the model is not stationary and as a result it is rejected. Thus, the latest lead lag, the lag1, has been selected as optimum. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (4,55), although it is higher when "older" lags are considered. As seen in the below table (24) and figure (70), the R-squared and the adjusted R-squared are also very high (0.987618 and 0.987603 respectively). By performing a back test analysis, the author has reached to the conclusion that the static forecast is accurate, predicting the trend of the market, though in some cases and specifically at the turnpoints, the model needs time to adjust.

The predicted freight rate for the last three weeks of the dataset are close. The predicted freight rate was 51,01 $/tn for the last two weeks, ending 24/2/23, and 52,01 $/tn on 2/10/2022, having captured the drop from the previous week.

For the same period, the actual freight rate was 54 $/tn for the last week of the dataset and 51 $/tn for the previous two weeks. It is also concluded that the dynamic forecast provides weaker results compared to the static forecast. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

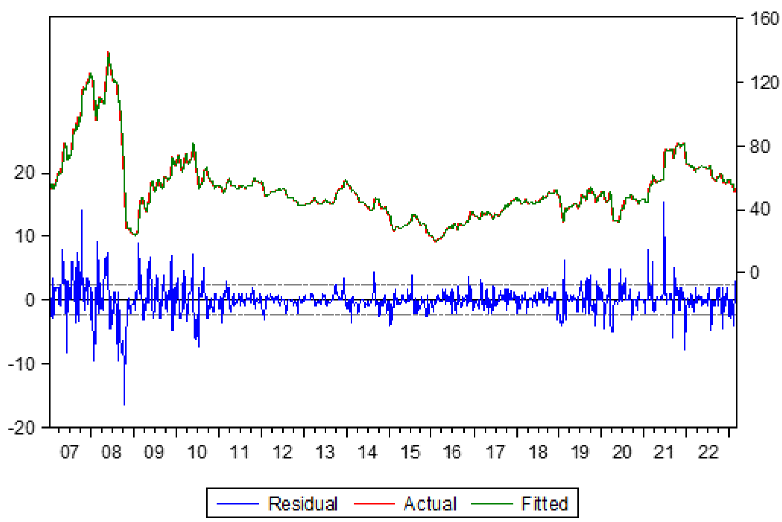
Table 24 - US Gulf – Japan Grains 49.000 tn

R-squared	0.987618

Adjusted R-squared	0.987603
Static Forecast (Freight rate on 10/2/2023)	51 $/tn
Static Forecast (Freight rate on 17/2/2023)	51 $/ tn
Static Forecast (Freight rate on 24/2/2023)	54 $/ tn
Actual Freight rate on 10/2/2023	52,01 $/ tn
Actual Freight rate on 17/2/2023	51,01 $/ tn
Actual Freight rate on 24/2/2023	51,01 $/ tn

Source – elaboration by the author

Figure 70 - US Gulf – Japan Grains 49.000 tn



Source – elaboration by the author

5.3.2.3 Bolivar – Chile Coal 50.000 tn

In this section the first route with cargo coal, of the two selected, is analysed. Weekly data from Clarksons SIN database have been collected. The dataset starts on 8/8/2014 and ends on 24/2/2023. The suggested methodology has been applied to this trade route. The eq (1) is used and the optimum lead lag selected is the lag1.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,978, within the acceptable range 0 – 1. Like in the previous trade route, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity.

It is worth mentioning that in this specific case, by considering the coexistence of lead lag(1) and lead lag(2) in the model, the predictability of the turn points is captured faster. However, the model is not stationary and as a result it is rejected. Thus, the latest lead lag, the lag1, has been selected. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (3,27), although it is higher when "older" lags are considered separately. As seen in the below table (25) and figure (71), the R-squared and the adjusted R-squared are also very high (0,960798 and 0,960710 respectively).

By performing a back test analysis, the author has reached to the conclusion that the static forecast is accurate for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the turn points, the model needs time to adjust.

The predicted freight rate for the last three weeks of the dataset are close. The freight rate prediction was for 18,55 $/tn for the last two weeks, ending 24/2/23, and 19,04 $/tn on 2/10/2022, having captured the drop from the previous week.

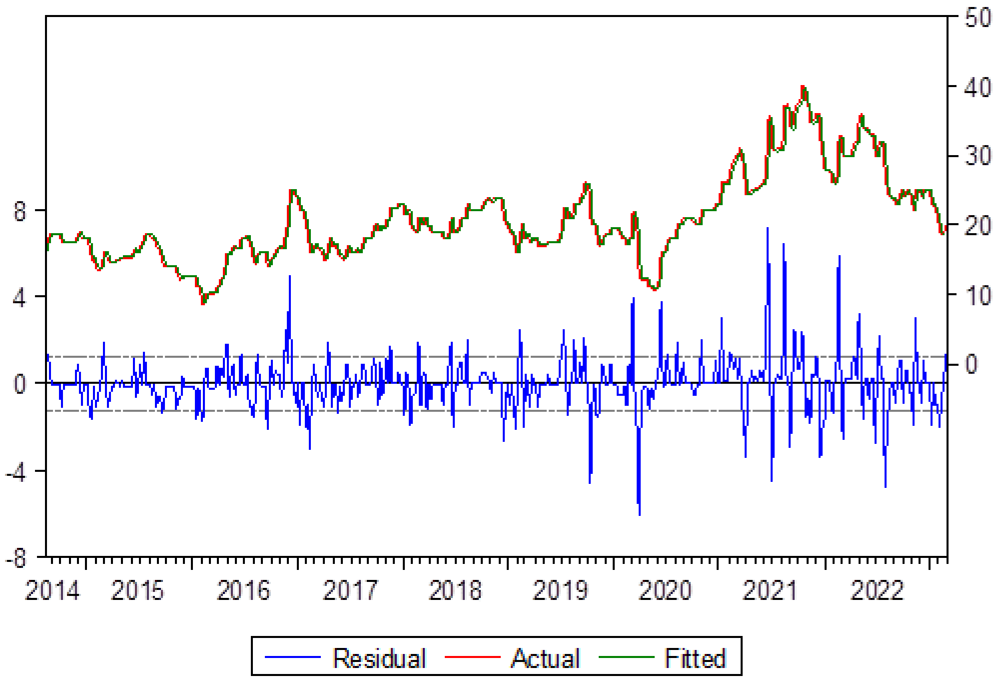
For the same period, the actual freight rate was 20 $/tn for the last week of the dataset and 18,50 $/tn for the previous two weeks. It is also concluded that the dynamic forecast provides weaker results compared to the static forecast. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

Table 25 - Bolivar – Chile Coal 50.000 tn

R-squared	0,960798
Adjusted R-squared	0,960710
Static Forecast (Freight rate on 10/2/2023)	19,04 $/tn
Static Forecast (Freight rate on 17/2/2023)	18,55 $/tn
Static Forecast (Freight rate on 24/2/2023)	18,55 $/ tn
Actual Freight rate on 10/2/2023	18,50 $/ tn
Actual Freight rate on 17/2/2023	18,50 $/ tn
Actual Freight rate on 24/2/2023	20 $/ tn

Source – elaboration by the author

Figure 71 - Bolivar – Chile Coal 50.000 tn



Source – elaboration by the author

5.3.2.4 Richards Bay – Mundra Coal 50.000 tn

In this section the second route with cargo coal, of the two selected, is analysed. Weekly data from Clarksons SIN database have been collected. The dataset starts on 8/8/2014 and ends on 24/2/2023. The suggested methodology has been applied to this trade route. The eq (1) is used and the optimum lead lag selected is the lag1.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. Like in the previous trade route, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity.

It is worth mentioning that in this specific case, by considering the coexistence of lead lag(1) and lead lag(2) in this model, the predictability of the turn points is captured faster. However, the model is not stationary and as a result it is rejected. Thus, the latest lead lag, the lag1, has been selected as optimum. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (3), although it is higher when "older" lags are considered separately. As seen in the below table (26) and figure (72), the R-squared and the adjusted R-squared are also very high (0,971105 and 0,971064 respectively).

By performing a back test analysis, the author has reached to the conclusion that the static forecast is accurate for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the turn points, the model needs time to adjust. The predicted freight rate for the last three weeks of the dataset are close.

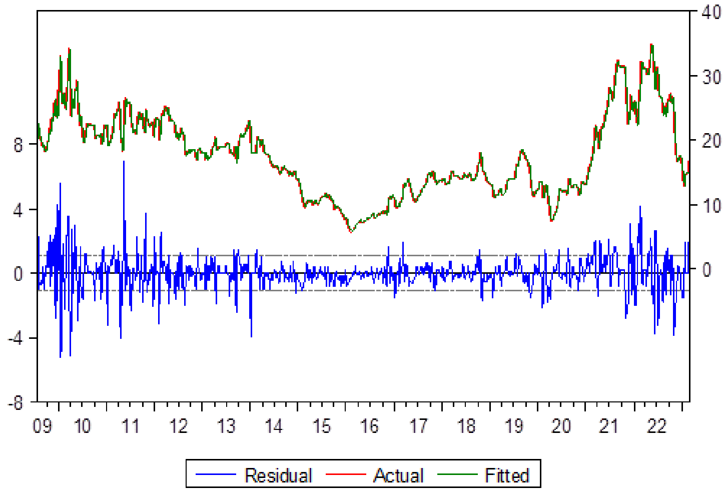
The freight rate prediction was for 14,78 $/tn for the last three weeks, ending 24/2/23 failing to capture the increase of the latest week. For the same period, the actual freight rate was 16,75 $/tn for the last week of the dataset and 14,75 $/tn for the previous two weeks. It is also concluded that the dynamic forecast provides weaker results compared to the static forecast. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

Table 26 - Richards Bay – Mundra Coal 50.000 tn

R-squared	0,971105
Adjusted R-squared	0,971064
Static Forecast (Freight rate on 10/2/2023)	14,78 $/tn
Static Forecast (Freight rate on 17/2/2023)	14,78 $/ tn
Static Forecast (Freight rate on 24/2/2023)	14,78 $/ tn
Actual Freight rate on 10/2/2023	14,75 $/ tn
Actual Freight rate on 17/2/2023	14,75 $/ tn
Actual Freight rate on 24/2/2023	16,75 $/ tn

Source – elaboration by the author

Figure 72 - Richards Bay – Mundra Coal 50.000 tn



Source – elaboration by the author

5.3.3. Timecharter trips

In addition to the previous section, the timecharter trips for various sizes are examined. Specifically, this research considers vessels of 45.000 dwt, 52.000 dwt and 58.000dwt as the average trip rates and some trips such as transatlantic, transpacific, Indonesia – China and ECSA – Skaw Passero, in an effort to analyse the behavior of this market under the scope of the time lags and expectations.

5.3.3.1 Average trip rates for handymax vessels of 45.000dwt, 52.000 dwt and 58.000dwt

Here, the behavior of the average trip rates of various handymax vessels is analysed. Specifically, the same methodology is applied to vessels of size 45.000 dwt, 52.000 dwt and 58.000 dwt.

Starting with the handymax of 45.000 dwt, weekly data from 5/1/1990 till 27/6/2014 from the Clarksons SIN database have been collected. As a limitation, it is pinpointed that the there is no data available further to this date, but in order to examine this case, the data is sufficient. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. Like in previous cases, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity.

It is worth mentioning that in this specific case, by considering the coexistence of lead lag(1) and lead lag(24) and lead lag(36) in the model, the predictability still remains high, probably indicating a cyclicality, and the model is more stable compared to more recent lags.

However, the model marginally does not meet stationary requirements and as a result it is rejected. Thus, the latest lead lag, the lag1, has been chosen for this case too. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (16,51), although it is higher when "older" lags are considered separately. As seen in the below table (27) and figure (73), the R-squared and the adjusted R-squared are also very high (0,992252 and 0,992246 respectively). By performing a back test analysis, the author has reached to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the sharp fluctuations, the model needs time to adjust.

The predicted hire rates for the last three weeks of the dataset are close. The hire rate prediction was 6.898 $/day, 6.525 $/day and 6.275 $/day for the last three weeks of the dataset, achieving to capture the downward trend of the market. For the same period, the actual hire rate was 6.500 $/day, 6.250 $/day and 6.250 $/day for the last three weeks respectively.

The model managed to capture the fluctuation of the market and to closely predict the level of the rate. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

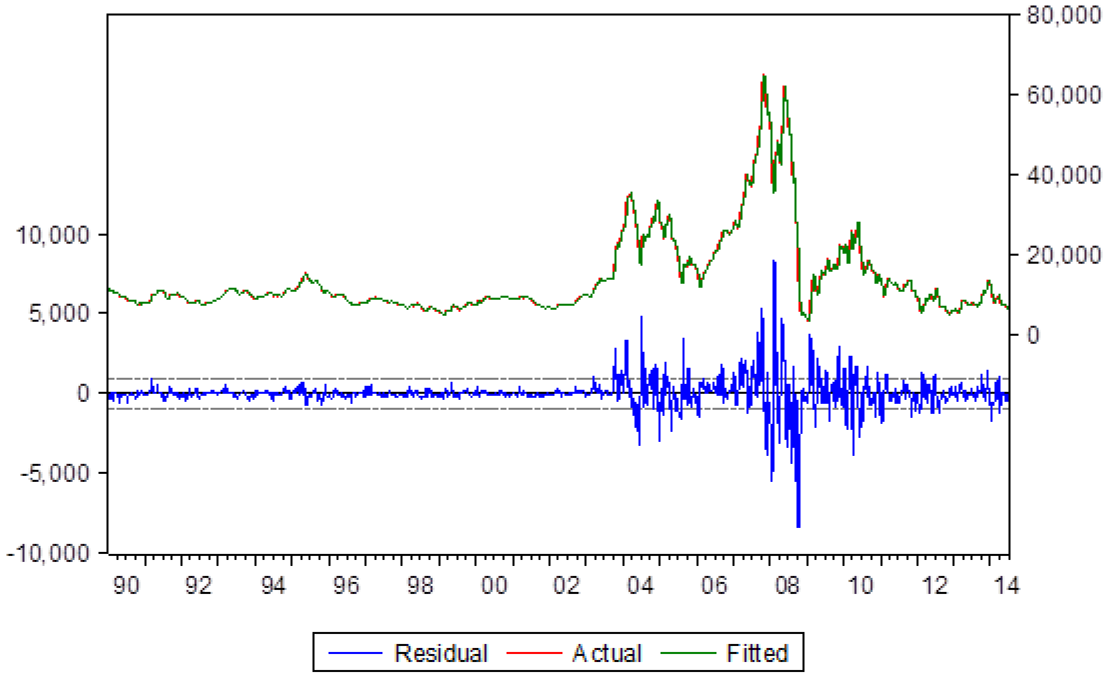
Table 27 – Average trip rates for handymax vessels of 45.000dwt

R-squared	0,992252
Adjusted R-squared	0,992246
Static Forecast (Hire rate on 13/6/2014)	6.898 $/day
Static Forecast (Hire rate on 20/6/2014)	6.525 $/day
Static Forecast (Hire rate on 27/6/2014)	6.275 $/day
Actual Hire rate on 13/6/2014	6.500 $/day

Actual Hire rate on 20/6/2014	6.250 $/day
Actual Hire rate on 27/6/2014	6.250 $/day

Source – elaboration by the author

Figure 73 – Average trip rates for handymax vessels of 45.000dwt



Source – elaboration by the author

The next case examined is the trip rates for the supramax vessels of 52.000 dwt. As in the previous cases, weekly data from 21/12/2001 till 31/3/2017 from the Clarksons SIN database has been retrieved to perform the analysis. As a limitation, it is pinpointed that the there is no data available further to this date, but in order to examine this case, the data is sufficient.

The model is tested and the eq(1) is applied in this case too, verifying again the strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1.

Like in previous cases, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity. As a result, the latest lead lag, the lag1, has been selected as optimum lead lag. This is also verified by practical perspective, since the participants of the industry consider the last fixture when negotiating.

In this case, the Hannan Quinn criterion is high (17,23), although it is higher when "older" lags are considered separately. As seen in the below table (28) and figure (74), the R-squared and the adjusted R-squared are also very high (0,991322 and 0,991311 respectively).

By performing a back test analysis, the author has reached to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the sharp fluctuations, the model needs time to adjust.

The predicted hire rates for the last three weeks of the dataset are close. The hire rate prediction was 8.612 $/day, 8.612 $/day and 9.047 $/day for the last three weeks of the dataset, achieving to capture the downward trend of the market. For the same period, the actual hire rate was 8.562 $/day, 9.000 $/day and 9.250 $/day for the last three weeks respectively.

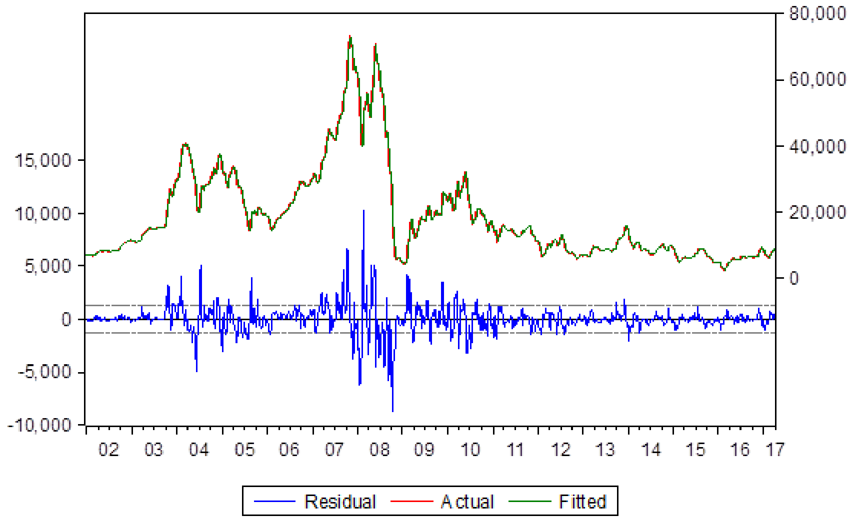
As seen in the below table (28) and figure (74), the model managed to capture the fluctuation of the market and to closely predict the level of the rate. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 28 – Average trip rates for supramax vessels of 52.000dwt

R-squared	0,991322
Adjusted R-squared	0,991311
Static Forecast (Hire rate on 17/3/2017)	8.612$/day
Static Forecast (Hire rate on 24/3/2017)	8.612 $/day
Static Forecast (Hire rate on 31/3/2017)	9.047 $/day
Actual Hire rate on 17/3/2017	8.562 $/day
Actual Hire rate on 24/3/2017	9.000 $/day
Actual Hire rate on 31/3/2017	9.250 $/day

Source – elaboration by the author

Figure 74 – Average trip rates for supramax vessels of 52.000dwt



Source – elaboration by the author

The last case this research examined regarding the average trip rates, is the supramax vessels with 58.000 dwt. These vessels can compete the ultramax vessels and the small panamax vessels, especially when the demand is low, and the volume of parcels may be reduced.

Data from Clarksons SIN database for the period 4/7/2014 – 24/2/2023 has been collected and the current methodology has been applied. The model has been tested and the eq(1) is applied in this case too, verifying again the strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,97, within the acceptable range 0 – 1.

The author has selected the latest lead lag, the lag1, as optimum lead lag, since adding more lags the model loses its stationarity. From practical perspective, the participants of the industry consider the last fixture as the most important when negotiating. In this case, the Hannan Quinn criterion is high (17,17). As seen in the below table (29) and figure (75), the R-squared and the adjusted R-squared are also very high (0,974116 and 0,974059 respectively).

By performing a back test analysis, the author reaches to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the sharp fluctuations, the model needs time to adjust. In the last observation, it is noticed that the model failed to accurately predict the level of the rate and the trend as well.

This is explained by the fact that a sharp fluctuation occurred, probably with exogenous factor affecting the decision making of the shipping participants. The predicted hire rates for the last three weeks of the dataset are close. The hire rate prediction was 7.474 $/day, 6.945 $/day and 8.498 $/day for the last three weeks of the dataset, achieving to capture the downward trend of the market.

For the same period, the actual hire rate was 6.850 $/day, 8.425 $/day and 12.000 $/day for the last three weeks respectively. As seen in the below table and figure, the model failed to capture the fluctuation of the market and the level of the rate for the last week of the dataset.

However, a good prediction of the trend is made overall, since the trend was captured for the previous weeks. It has been noticed that in this case, probably due to abrupt demand and expectations changes, instant and sharp fluctuations may exist, resulting to affecting the instant prediction of the model.

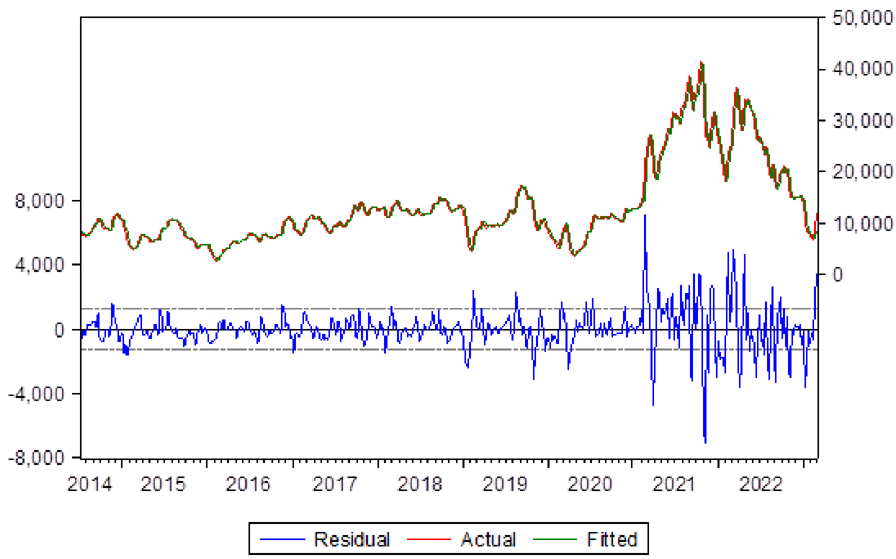
Considering more lags in the model would possibly improve this, since a cyclicality is observed, but the model wouldn't be stationary in such a case. The FFA empirical evaluation may attribute in a better understanding of the instant trend. From the available data, in general, the model is in line with the FFA prediction regarding the supramax market progress, an upward trend for February 2023. A static forecast with constant update of the weekly data is more suitable for this case, compared to dynamic forecast.

Table 29 – Average trip rates for supramax vessels of 58.000dwt

R-squared	0,974116
Adjusted R-squared	0,974059
Static Forecast (Hire rate on 10/2/2023)	7.474 $/day
Static Forecast (Hire rate on 17/2/2023)	6.945 $/day
Static Forecast (Hire rate on 24/2/2023)	8.498 $/day
Actual Hire rate on 10/2/2023	6.850 $/day
Actual Hire rate on 17/2/2023	8.425 $/day
Actual Hire rate on 24/2/2023	12.000 $/day

Source – elaboration by the author

Figure 75 – Average trip rates for supramax vessels of 58.000dwt



Source – elaboration by the author

5.3.3.2 Transatlantic rates for vessels of 45.000dwt and 52.000 dwt

In this section the transatlantic freight rates for handymax vessels of 45.000 dwt and supramax vessels of 52.000 dwt are analysed.

Starting with handymax vessels, the fluctuations of this market for transatlantic trade of handymax vessels 45.000 dwt are examined. Data for the period 19/4/1991 – 27/6/2014 has been compiled in order to test this model.

The suggested methodology has been applied and the author resulted that the eq(1) is the one should be chosen. The latest lead lag(1) is the optimum lag for this case. The coefficient of lag(1) is 0,98, within the acceptable range 0 – 1. The model is stationary.

The latest lag(1) is the most important lag, having a great impact on the fluctuations of the market. From practical perspective the previous is verified, since the participants of the industry consider the last fixture as the most important when negotiating. In this case, the Hannan Quinn criterion is high (17,23).

When adding more lags in the model, the inverted roots remain within the margin 0 -1, indicating a stationarity, but the coefficient of AR(1) becomes high, exceeding the acceptable margin, concluding that the model might not be stationary. As seen in the below table (30) and figure (76), the R-squared and the adjusted R-squared are also very high (0,988073 and 0,988063 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the sharp fluctuations, the model needs time to adjust. In the last observation, it is noticed that the model failed to accurately predict the level of the rate and the trend as well.

This is explained by the fact that a sharp fluctuation occurred, probably with exogenous factor affecting the decision making of the shipping participants. The model with more lags manages to capture the trend of the market at the turn points, but with lower predictability.

The predicted hire rates for the last four weeks of the dataset are close. The hire rate prediction was 4.805 $/day, 4.555 $/day and 3.809 $/day and 3.809 $/day for the last weeks of the dataset, achieving to capture the downward trend four weeks ago but failing to capture the last week trend of the market. For the same period, the actual hire rate was 4.500 $/day, 3.750 $/day, 3.750 $/day and 4.000 for the last four weeks respectively.

The model failed to capture the fluctuation of the market and the level of the rate for the last week of the dataset. However, a good prediction of the trend is made overall, since the trend was captured for the previous weeks. It has been noticed that in this case, probably due to abrupt demand and expectations changes, instant and sharp fluctuations may exist, resulting to affecting the instant prediction of the model.

Considering more lags in the model would possibly improve this, since a cyclicality is observed, but the model wouldn't be stationary in such a case. The FFA empirical evaluation may attribute in a better understanding of the instant trend. A static forecast with constant update of the weekly data is more suitable for this case, compared to dynamic forecast.

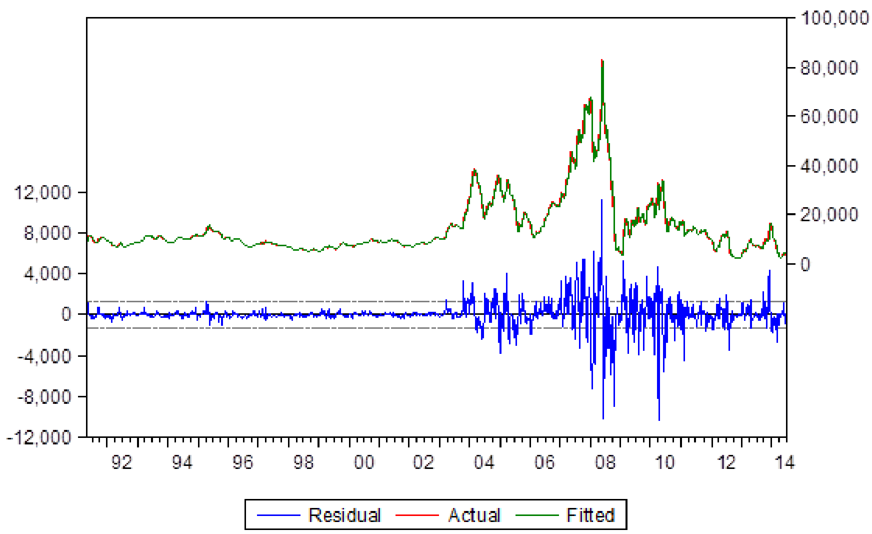
Table 30 – Transatlantic trade handymax 45.000 dwt

R-squared	0,988073
Adjusted R-squared	0,988063
Static Forecast (Hire rate on 20/6/2014)	4.805 $/day
Static Forecast (Hire rate on 13/6/2014)	4.555 $/day
Static Forecast (Hire rate on 20/6/2014)	3.809 $/day
Static Forecast (Hire rate on 27/6/2014)	3.809 $/day
Actual Hire rate on 20/6/2014	4.500 $/day
Actual Hire rate on 13/6/2014	3.750 $/day

Actual Hire rate on 20/6/2014	3.750 $/day
Actual Hire rate on 27/6/2014	4.000 $/day

Source – elaboration by the author

Figure 76 – Transatlantic trade handymax 45.000 dwt



Source – elaboration by the author

The next case examined is the transatlantic rates for supramax vessels of 52.000 dwt. It is very interesting to check the application of the methodology to these vessels as well, since they are larger vessels transferring same cargoes with panamax vessels and smaller handymax of 45.000 dwt, and as a result they are direct competitors.

Again, the data has been retrieved from Clarkson SIN database data for the period 21/12/2001 – 31/3/2017 in order to test the model. The suggested methodology has been conducted and resulted that the eq(1) is the one should be chosen. The latest lead lag(1) is the optimum lag for this case. The coefficient of lag(1) is 0,99, within the acceptable range 0 – 1.

The model is stationary. The latest lag(1) is the most important lag, having a great impact on the fluctuations of the market. From practical perspective the previous is verified, since the participants of the industry consider the last fixture as the most important when negotiating. In this case, the Hannan Quinn criterion is high (17,93).

When adding more lags in the model, the inverted roots remain within the margin 0 -1, indicating a stationarity, but the coefficient of AR(1) becomes higher than 1, exceeding the acceptable margin, concluding that the model might not be stationary. As seen in the below table (31) and figure (77), the R-squared and the adjusted R-squared are also very high (0,986489 and 0,986472 respectively). By performing a back test analysis, the author has reached to the conclusion that the static forecast meets in general the purpose of this research, predicting the trend of the market, though in some cases and specifically at the sharp fluctuations, the model needs time to adjust.

In the last observation, as seen in the below table, the model failed to accurately predict the trend in a great volatile environment but manages to capture an acceptable margin around the equilibrium. This is in line with the theory analysed in the literature review section when great volatilities exist in the market.

The model with more lags manages to capture the trend of the market at the turn points, but with lower predictability of the level and an ambiguous stationarity, due to coefficient of AR(1) exceeding the margin 0 - 1.

The predicted hire rates for the last four weeks of the dataset are close. The hire rate prediction was 7.582 $/day, 8.078 $/day, 7.830 $/day and 8.327 $/day for the last weeks of the dataset. For the same period, the actual hire rate was 8.000 $/day, 7.750 $/day, 8.250 $/day and 7.500 for the last four weeks respectively.

The model failed to capture the fluctuation of the market, but the level of fluctuations is within the spin of rate changes. A good prediction of the rate level is observed. Considering more lags in the model would possibly improve this trend prediction, since a cyclicality is observed, but the model might not have been stationary in such a case.

The FFA indicate an increase for the February 2023 but a drop in the next months. A static forecast with constant update of the weekly data is more suitable for this case.

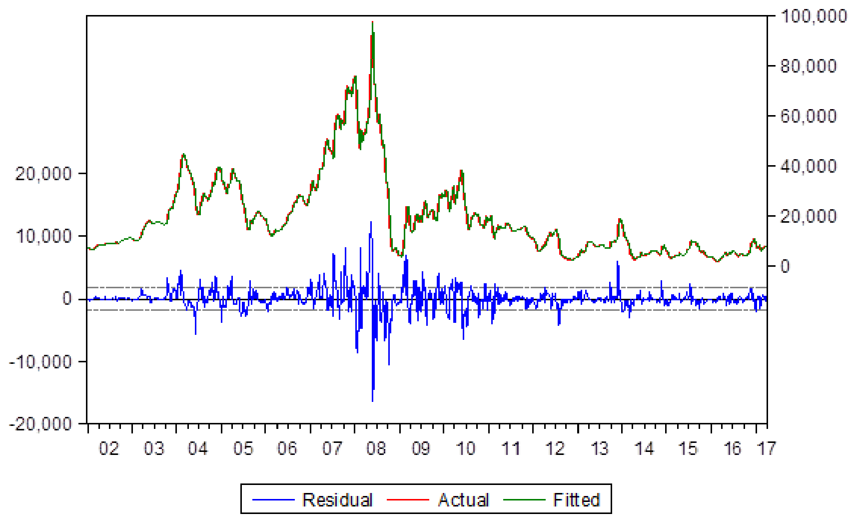
Table 31 – Transatlantic rates supramax vessel 52.000 dwt

R-squared	0,986489
Adjusted R-squared	0,986472
Static Forecast (Hire rate on)	7.582 $/day
Static Forecast (Hire rate on)	8.078 $/day
Static Forecast (Hire rate on)	7.830 $/day

Static Forecast (Hire rate on)	8.327$/day
Actual Hire rate on	8.000 $/day
Actual Hire rate on	7.750 $/day
Actual Hire rate on	8.250 $/day
Actual Hire rate on	7.500 $/day

Source – elaboration by the author

Figure 77 – Transatlantic rates supramax vessel 52.000 dwt



Source – elaboration by the author

5.3.3.3 Transpacific rates for vessels of 45.000dwt and 52.000 dwt

In this chapter the transpacific rates for handysize vessels with size 45.000 dwt and supramax vessels with size 52.000 dwt are considered for analysis.

Starting with the handymax of 45.000 dwt, weekly data has been collected for the period 4/12/1991 – 6/27/2014 from the Clarksons SIN database. As a limitation, it is pinpointed that the there is no data available further to this date, but in order to examine this case, the data is sufficient. The model has been performed using the eq(1) in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. Like in previous cases, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity. It is worth mentioning that in this specific case the statistically important lags are lag(1) and lag(2), but in this case the coefficient of lag(1) exceeds the acceptable margin for stationarity, although in total the inverted roots meet that requirement.

Thus, the latest lead lag, the lag1, has been selected. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating. In this case, the Hannan Quinn criterion is high (17), although it is higher when "older" lags are considered separately.

As seen in the below table (32) and figure (78), the R-squared and the adjusted R-squared are also very high (0,985585 and 0,985573 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market and the level of the hire rates. Specifically, the predicted hire rates for the last weeks of the dataset are close.

The hire rate prediction was 7.538 $/day, 7.041 $/day, 6.794 $/day and 6.545 $/day for the last four weeks of the dataset, achieving to capture the downward trend of the market. For the same period, the actual hire rate was 7.000 $/day, 6.750 $/day, 6.500$/day and 6.500$/day for the last four weeks respectively.

The model managed to capture the fluctuation of the market and to closely predict the level of the rate. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

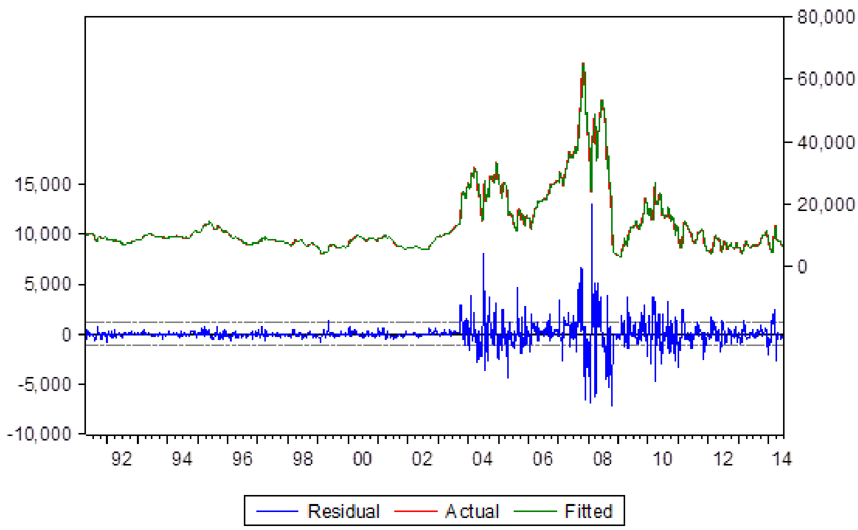
Table 32 – Transpacific rates handymax 45.000 dwt

R-squared	0,985585
Adjusted R-squared	0,985573
Static Forecast (Hire rate on 6/6/2014)	7.538 $/day
Static Forecast (Hire rate on 13/6/2014)	7.041 $/day
Static Forecast (Hire rate on 20/6/2014)	6.794 $/day
Static Forecast (Hire rate on 27/6/2014)	6.545 $/day

Actual Hire rate on 6/6/2014	7.000 $/day
Actual Hire rate on 13/6/2014	6.750 $/day
Actual Hire rate on 20/6/2014	6.500$/day
Actual Hire rate on 27/6/2014	6.500$/day

Source – elaboration by the author

Figure 78 - Transpacific rates handymax 45.000 dwt



Source – elaboration by the author

The next case examined is the rates of transpacific trade for supramax vessels of 52.000 dwt. Data is collected from Clarkson SIN database (2023) for the period 21/12/2001 – 31/3/2017. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high.

As seen in the below table (33) and figure (79), the R-squared and the adjusted R-squared are also very high (0,985033 and 0,985014 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level for the purpose of this research, predicting the trend of the market and the level of the hire rates. Specifically, the predicted hire rates for the last weeks of the dataset are close. The prediction was for 8.321 $/day and 8.569 $/day, achieving to capture the rising trend of the market. For the same period, the actual hire rate was 8.500 $/day and 8.750$/day.

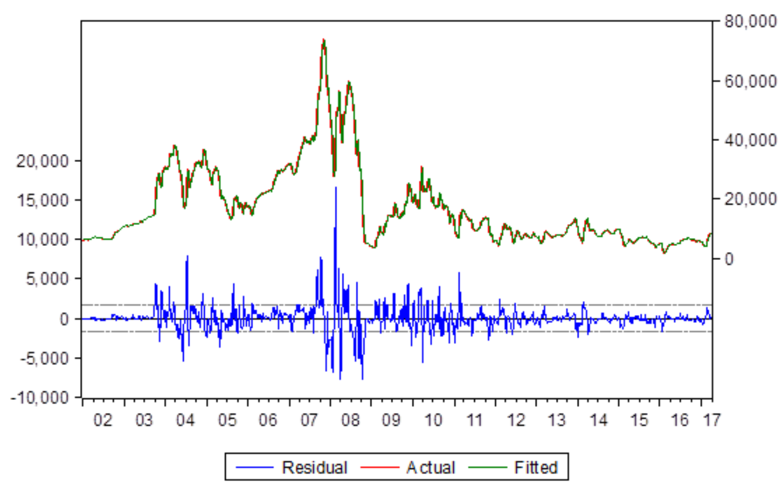
The model managed to capture the fluctuation of the market and to closely predict the level of the rate. This forecast is also in line with the FFA trend, indicating an increase for the supramax vessels in February 2023. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 33 – Transpacific rates supramax 52.000 dwt

R-squared	0,985033
Adjusted R-squared	0,985014
Static Forecast (Hire rate on 24/3/2017)	8.321 $/day
Static Forecast (Hire rate on 31/3/2017)	8.569 $/day
Actual Hire rate on 24/3/2017	8.500 $/day
Actual Hire rate on 31/3/2017	8.750 $/day

Source – elaboration by the author

Figure 79 – Transpacific rates supramax 52.000 dwt



Source – elaboration by the author

5.3.3.4 ECSA – Skaw/Passero rates for supramax vessels of 58.000 dwt

In this chapter the author considers the case of a supramax vessel with 58.000dwt performing trade for the route ECSA – Skaw/Passero. Data is collected from Clarkson SIN database (2023) for the period 7/4/2014 – 24/2/2023. In order to test the model, the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (17,11).

As seen in the below table (34) and figure (80), the R-squared and the adjusted R-squared are also very high (0,974721 and 0,974665 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the trend and the level of the hire rate are captured.

Specifically, the predicted hire rates for the last weeks of the dataset were 6.718 $/day and 6.768 $/day, achieving to capture the rising trend of the market, since for the same period, the actual hire rate was 6.700 $/day and 8.000$/day. As seen in the below table, the model managed to capture the fluctuation of the market and to closely predict the level of the rate.

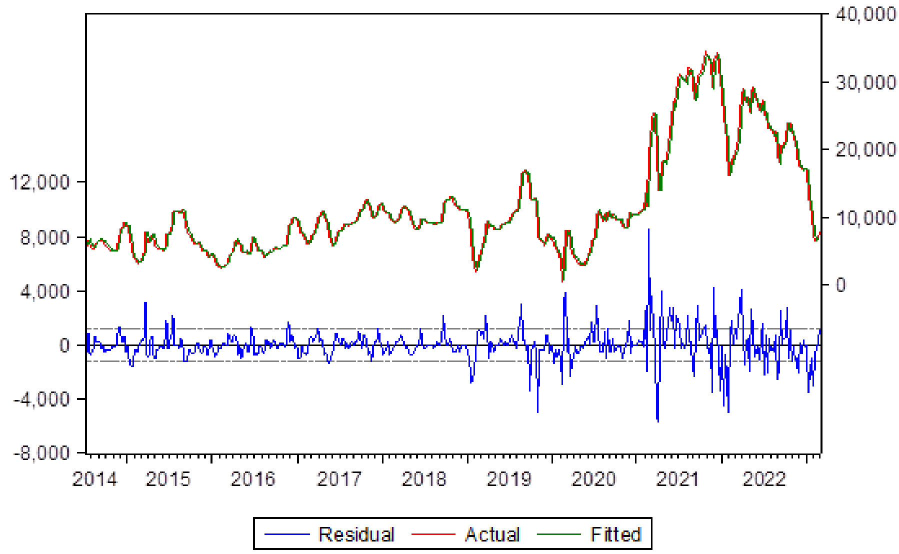
This forecast is also in line with the FFA trend, indicating an increase for the supramax vessels in February 2023. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 34 - ECSA – Skaw/Passero rates for supramax vessels of 58.000 dwt

R-squared	0,974721
Adjusted R-squared	0,974665
Static Forecast (Hire rate on 17/2/2023)	6.718 $/day
Static Forecast (Hire rate on 24/2/2023)	6.768 day
Actual Hire rate on 17/2/2023	6.700 $/day
Actual Hire rate on 24/2/2023	8.000 $/day

Source – elaboration by the author

Figure 80 - ECSA – Skaw/Passero rates for supramax vessels of 58.000 dwt



Source – elaboration by the author

5.3.3.5 Indonesia – China rates for supramax vessels of 58.000 dwt

In this section the freight market of the route Indonesia – China for a supramax vessel of 58.000 dwt is investigated. This is a trade route for a short distance, and it is very interesting to examine the behavior of the freight market in this territory. Data from Clarkson SIN database (2023) has been compiled for the period 7/4/2014 – 24/2/2023.

Having tested the model, the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,97, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (18,03).

As seen in the below table (35) and figure (81), the R-squared and the adjusted R-squared are also very high (0,951050 and 0,950941 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the trend and the level of the hire rate are captured.

Specifically, the predicted hire rates for the last weeks of the dataset were 8.121 $/day and 9.096 $/day, achieving to capture the rising trend of the market, since for the same period, the actual hire rate was 9.000 $/day and 15.000$/day.

The model managed to capture the fluctuation of the market, but the predicted last rate is not very close. This is a case where sharp oscillations happen, and the equilibrium is explosive unstable. Moreover, from statistical perspective, this change could have been incorporated as a dummy variable, as this observation is out of the margin when checking the relevant correlogram. However, not many changes like this are observed and the result does not differ.

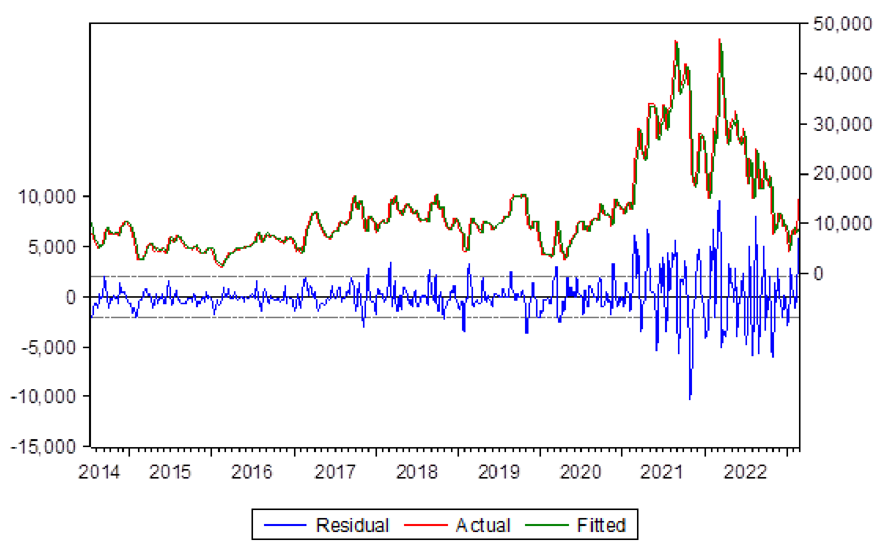
The forecast of this research is also in line with the FFA trend, indicating an increase for the supramax vessels in February 2023. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 35 – Indonesia – China rates for supramax vessels of 58.000 dwt

R-squared	0,951050
Adjusted R-squared	0,950941
Static Forecast (Hire rate on 17/2/2023)	8.121 $/day
Static Forecast (Hire rate on 24/2/2023)	9.096 $/day
Actual Hire rate on 17/2/2023	9.000 $/day
Actual Hire rate on 24/2/2023	15.000 $/day

Source – elaboration by the author

Figure 81 – Indonesia – China rates for supramax vessels of 58.000 dwt



Source – elaboration by the author

5.3.4. Timecharter contracts

In this chapter the behavior of the short- and long-term period timecharter contracts for handymax 45.000dwt and supramax 52.000 and 58.000 dwt vessels are examined.

5.3.4.1 Timecharter contracts with duration 6months

In this section the behavior of the short period (6 months) timecharter contracts for handymax 45.000dwt and supramax 52.000 and 58.000 dwt vessels are considered. Data from Clarkson SIN database (2023) has been compiled for the period 6/1/1989 – 27/6/2014. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,61).

As seen in the below table (36) and figure (82), the R-squared and the adjusted R-squared are also very high (0,992031 and 0,992025 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the downward trend (when checking previous weeks) and the level of the hire rate are captured.

Specifically, the predicted hire rates for the last weeks of the dataset were 9.269 $/day and 8.771 $/day, achieving to capture the rising trend of the market, since for the same period, the actual hire rate was 8.750 $/day and 8.750 $/day.

The model managed to adjust and capture the fluctuation of the market, especially when considering the previous weeks in a declining market. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

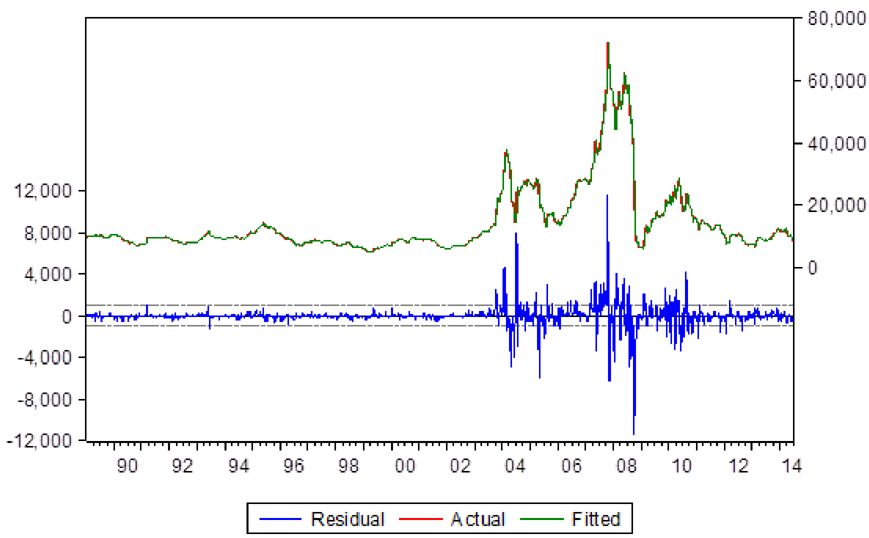
Table 36 – Timecharter 6 months handymax 45.000dwt

R-squared	0,992031
Adjusted R-squared	0,992025
Static Forecast (Hire rate on 20/6/2014)	9.269 $/day

Static Forecast (Hire rate on 27/6/2014)	8.771 $/day
Actual Hire rate on 20/6/2014	8.750 $/day
Actual Hire rate on 27/6/2014	8.750 $/day

Source – elaboration by the author

Figure 82 – Timecharter 6 months handymax 45.000dwt



Source – elaboration by the author

Continuing with the analysis of a larger supramax (52.000 dwt) vessel in the short timecharter period, weekly data from Clarksons SIN database has been gathered for the period 4/1/2002 – 31/3/2017. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1, with the case of the inverter roots and more lags in the model to apply here too. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (17,26). As seen in the below table (37) and figure (83), the R-squared and the adjusted R-squared are also very high (0,991751 and 0,991741 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the trend and the level of the hire rate are captured. Specifically, the predicted hire rates for the last weeks of the dataset were

10.297 $/day and 10.795 $/day, achieving to capture the rising trend of the market (following the previous weeks too) and being close with the level of actual rates, since for the same period, the actual hire rate was 10.750 $/day for the last two weeks.

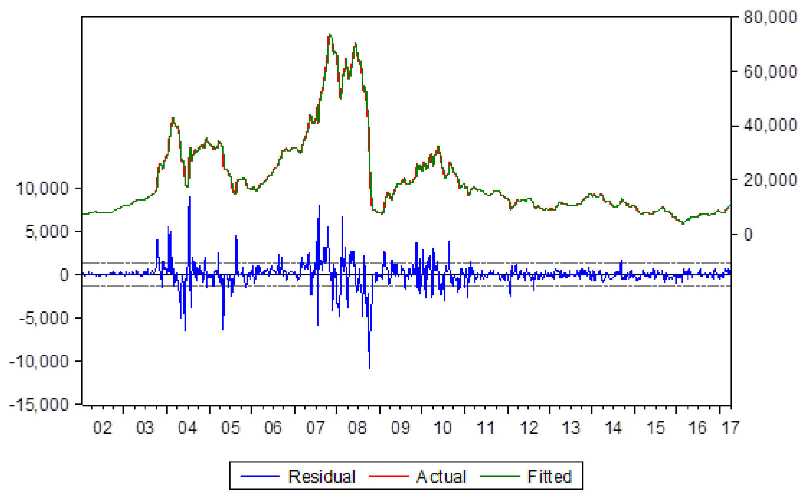
The model managed to capture the range of oscillations around the equilibrium. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 37 – Timecharter 6 months supramax 52.000 dwt

R-squared	0,991751
Adjusted R-squared	0,991741
Static Forecast (Hire rate on 24/3/2017)	10.297 $/day
Static Forecast (Hire rate on 31/3/2017)	10.795 $/day
Actual Hire rate on 24/3/2017	10.750 $/day
Actual Hire rate on 31/3/2017	10.750 $/day

Source – elaboration by the author

Figure 83 – Timecharter 6 months supramax 52.000 dwt



Source – elaboration by the author

Continuing with the analysis of the supramax vessels of 58.000 dwt, for a timecharter contract with duration 6 months, the author gathered weekly data from Clarksons SIN database for the period 7/4/2014 – 24/2/2023.

As in the previous cases, the model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1, with the case of the inverter roots and more lags in the model to apply here too.

From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,75). The R-squared and the adjusted R-squared are also very high (0,982254 and 0,982214 respectively).

By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the trend and the level of the hire rate are captured. Specifically, the predicted hire rates for the last weeks of the dataset were 12.029 $/day and 12.525 $/day, achieving to capture the rising trend of the market.

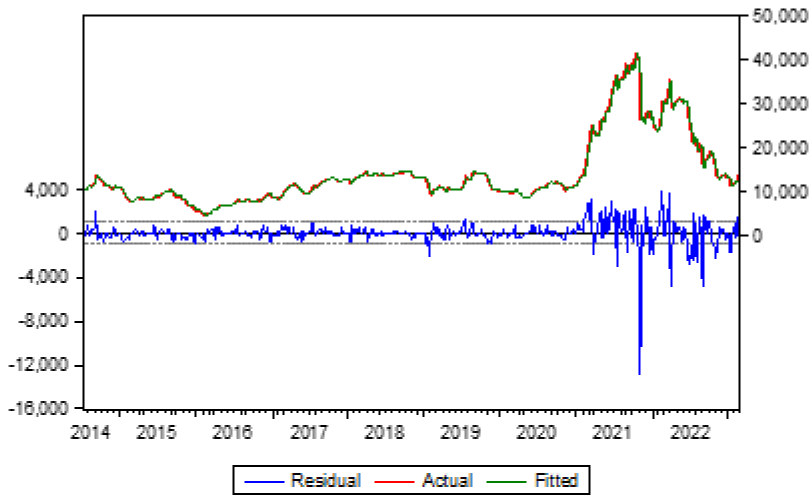
The actual hire rate was 12.500 $/day and 15.125 $/day for the last two weeks. As seen in the below table (38) and figure (84), the model managed to capture the rising trend of the market. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 38 – Timecharter 6 months supramax 58.000 dwt

R-squared	0,982254
Adjusted R-squared	0,982214
Static Forecast (Hire rate on 17/2/2023)	12.029 $/day
Static Forecast (Hire rate on 24/2/2023)	12.525 $/day
Actual Hire rate on 17/2/2023	12.500 $/day
Actual Hire rate on 24/2/2023	15.125 $/day

Source – elaboration by the author

Figure 84 – Timecharter 6 months supramax 58.000 dwt



Source – elaboration by the author

5.3.4.2 Timecharter contracts with duration 1yr

In this section, the timecharter contracts with duration 1 year for vessels of 45.000 dwt, 52.000 dwt and 58.000 dwt are analysed.

Firstly, the case of small vessels with 45.000 dwt is examined, compiling data from Clarkson SIN database (2023) for the period 6/1/1989 – 27/6/2014. The model is tested and it is noticed that the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (16,14). As seen in the below table (39) and figure (85), the R-squared and the adjusted R-squared are also very high (0,993821 and 0,993817 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the downward trend (when checking previous weeks) and the level of the hire rate are captured.

Specifically, the predicted hire rates for the last weeks of the dataset were 10.009 $/day and 9.262 $/day, achieving to capture the downward trend of the market, since for the same period, the actual hire rate was 9.250 $/day and 8.500 $/day.

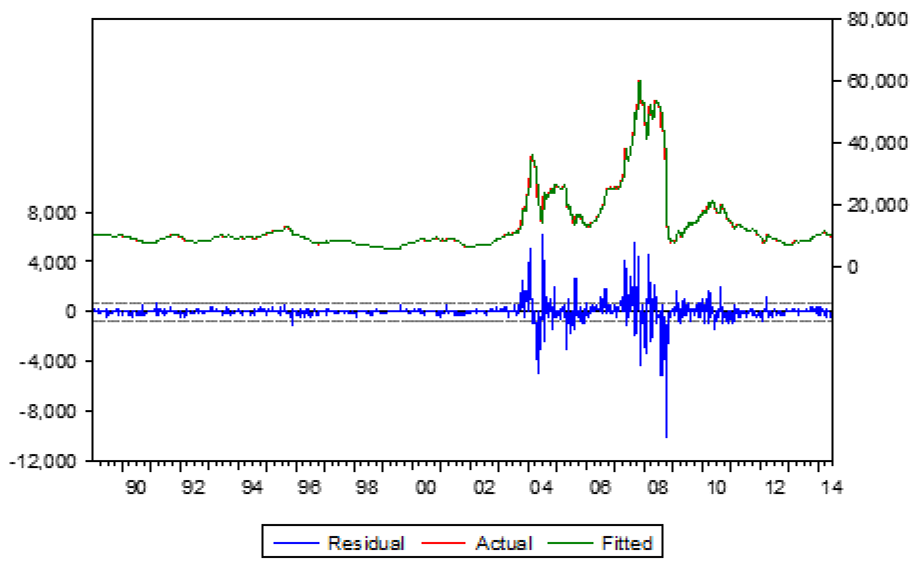
As indicated below, the model managed to adjust and capture the fluctuation of the market, especially when considering the previous weeks in a declining market. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 39 – Timecharter 1-year handymax 45.000dwt

R-squared	0,993821
Adjusted R-squared	0,993817
Static Forecast (Hire rate on 20/6/2014)	10.009 $/day
Static Forecast (Hire rate on 27/6/2014)	9.262 $/day
Actual Hire rate on 20/6/2014	9.250 $/day
Actual Hire rate on 27/6/2014	8.500 $/day

Source – elaboration by the author

Figure 85 – Timecharter 1-year handymax 45.000dwt



Source – elaboration by the author

Continuing with 1-year timecharter contracts of larger vessels, supramax size of 52.000 dwt, the author collected data from Clarkson SIN database (2023) for the period 4/1/2002 – 30/4/2017.

The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (16,91). As seen in the below table (40) and figure (86), the R-squared and the adjusted R-squared are also very high (0,993453 and 0,993445 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level in terms of level, though the trend is captured with a lag.

Specifically, the predicted hire rates for the last weeks of the dataset were 9.534 $/day, 9.285 $/day and 9.783 $/day, while for the same period, the actual hire rate was 9.250 $/day and 9.750 $/day. As seen below, the model managed to capture the oscillations around the equilibrium.

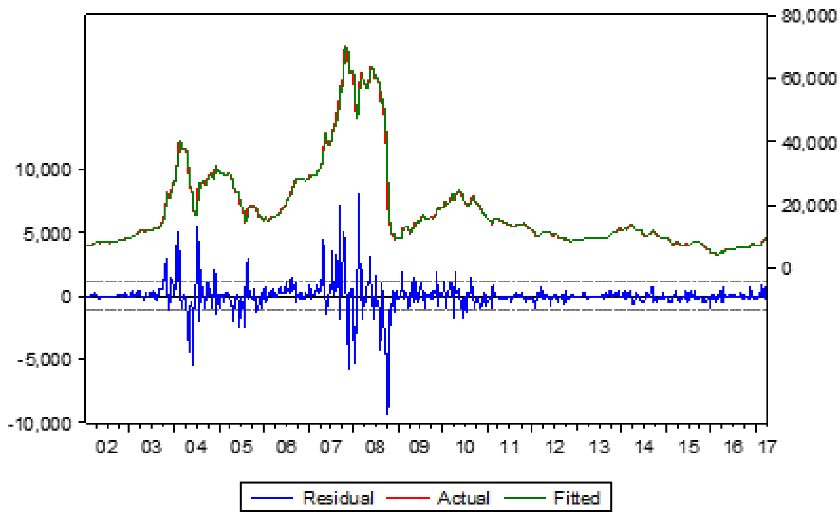
The trend is captured with a lag in this case. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 40 – Timecharter 1-year supramax 52.000dwt

R-squared	0,993453
Adjusted R-squared	0,993445
Static Forecast (Hire rate on 17/3/2017)	9.534 $/day
Static Forecast (Hire rate on 24/3/2017)	9.285 $/day
Static Forecast (Hire rate on 31/3/2017)	9.783 $/day
Actual Hire rate on 17/3/2017	9.250 $/day
Actual Hire rate on 24/3/2017	9.750 $/day

Source – elaboration by the author

Figure 86 – Timecharter 1-year supramax 52.000dwt



Source – elaboration by the author

Regarding the supramax vessels with 58.000 dwt, data from Clarkson SIN database (2023) has been retrieved for the period 4/7/2014 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (15,93).

As seen in the below table (41) and figure (87), the R-squared and the adjusted R-squared are also very high (0,985108 and 0,985071 respectively). By performing a back test analysis, the author believes that the static forecast is at a very good level in terms of level, while the trend of a rising market is also captured.

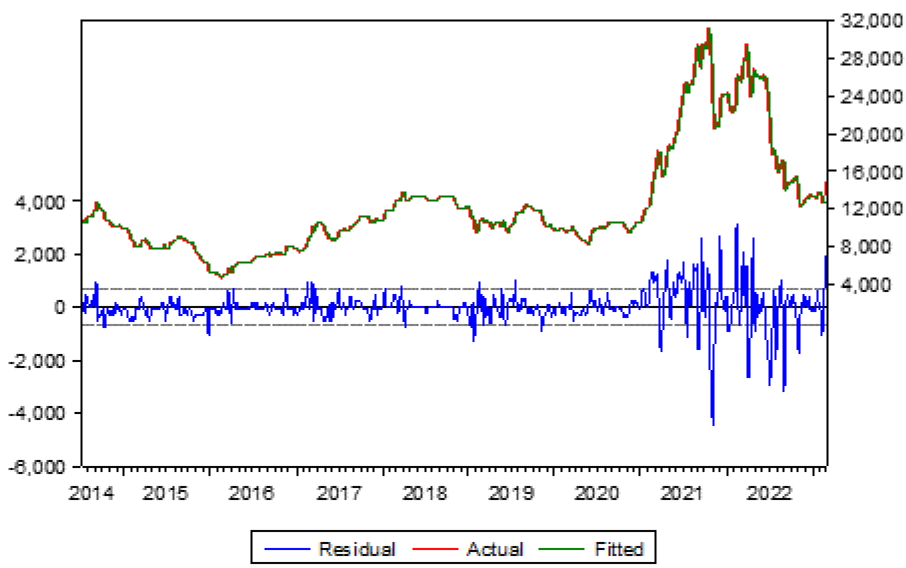
Specifically, the predicted hire rates for the last weeks of the dataset were 12.570 $/day and 12.943 $/day, while for the same period, the actual hire rate was 12.937,50 $/day and 14.937,50 $/day. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 41 – Timecharter 1-year supramax 58.000dwt

R-squared	0,985108
Adjusted R-squared	0,985071
Static Forecast (Hire rate on 17/2/2023)	12.570 $/day
Static Forecast (Hire rate on 24/2/2023)	12.943 $/day
Actual Hire rate on 17/2/2023	12.937,50 $/day
Actual Hire rate on 24/2/2023	14.937,50 $/day

Source – elaboration by the author

Figure 87 – Timecharter 1-year supramax 58.000dwt



Source – elaboration by the author

To summarise, the methodology of this research has been applied to 1 year period contracts to the handymax and supramax vessels. Once the analysis has been performed, the lagged rates can lead to forecasts, as in all cases the trend of the freight market is captured.

In the next session, the handymax and supramax vessels under a longer period, a timecharter contract of 3 years are considered for analysis.

5.3.4.3. Timecharter contracts with duration 3yrs

In this section analyses for the timecharter contracts with duration 3 years, offered to handymax vessels of 45.000dwt and to supramax vessels of 52.000 dwt and 58.000 dwt are performed.

Starting with the handymax vessesl of 45.000 dwt, data has been compiled from Clarkson SIN database (2023) for the period 6/1/1989 – 27/6/2014. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (15,04).

As seen in the below table (42) and figure (88), the R-squared and the adjusted R-squared are also very high (0,994450 and 0,994446 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level, since both the prediction of the downward trend (when checking previous weeks) and the level of the hire rate are captured.

Specifically, the predicted hire rates for the last weeks of the dataset were 10.254 $/day and 10.009 $/day, achieving to capture the downward trend of the market, since for the same period, the actual hire rate was 10.000 $/day and 9.500 $/day.

The model managed to adjust and capture the fluctuation of the market, especially when considering the previous weeks in a declining market. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

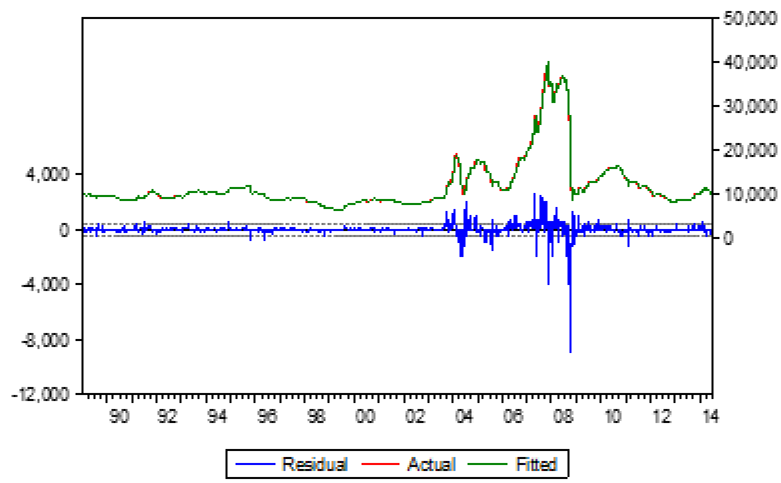
Table 42 – Timecharter 3-years handymax 45.000dwt

R-squared	0,994450
Adjusted R-squared	0,994446
Static Forecast (Hire rate on 20/6/2014)	10.254 $/day
Static Forecast (Hire rate on 27/6/2014)	10.005 $/day

Actual Hire rate on 20/6/2014	10.000 $/day
Actual Hire rate on 27/6/2014	9.500 $/day

Source – elaboration by the author

Figure 88 – Timecharter 3-years handymax 45.000dwt



Source – elaboration by the author

Next, supramax vessels with size 52.000 dwt are analysed within the timecharter market of 3 years contracts. For this purpose, data from Clarkson SIN database (2023) has been collected for the period 4/1/2002 – 31/3/2017.

Having tested the model, it is indicated that eq(1) should be applied in this case too, verifying that there is a strong impact of the last fixture on the next available trip rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (16,01). As seen in the below table (43) and figure (89), the R-squared and the adjusted R-squared are also very high (0,993456 and 0,993447 respectively).

By performing a back test analysis, it is of the author's belief that in order to reach to a better conclusion, a static forecast should be performed, since it is at a very good level, though the trend is captured with a lag.

Specifically, the predicted hire rates for the last weeks of the dataset were 10.020 $/day, 10.020 $/day and 10.269 $/day for the last three weeks, while for the same period, the actual hire rate was 10.000 $/day, 10.250 $/day and 10.250 $/day. As seen in the below table, the model managed to capture the oscillations around the equilibrium.

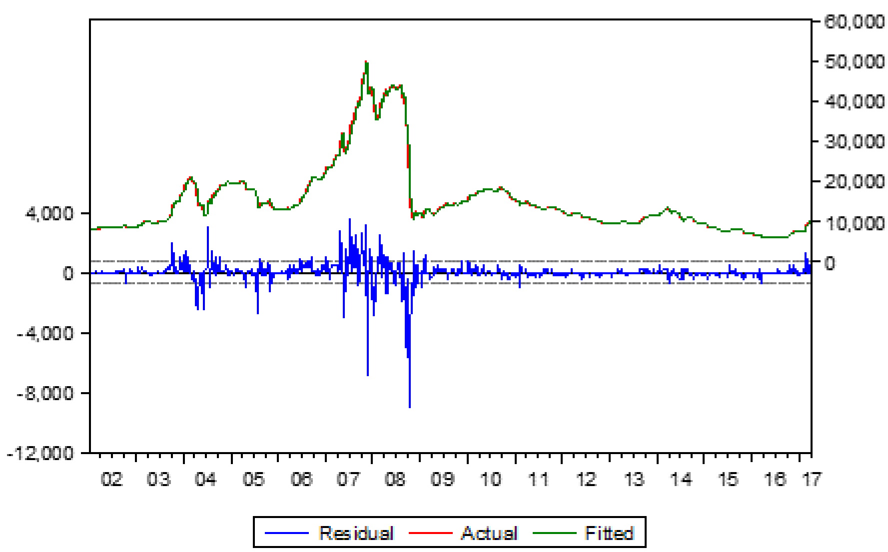
The trend is captured with a lag in this case, which is very important since the shipping participants can identify the oscillations of the freight market around the equilibrium and negotiate appropriately. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 43 – Timecharter 3-years supramax 52.000dwt

R-squared	0,993456
Adjusted R-squared	0,993447
Static Forecast (Hire rate on 17/3/2017)	10.020 $/day
Static Forecast (Hire rate on 24/3/2017)	10.020 $/day
Static Forecast (Hire rate on 31/3/2017)	10.269 $/day
Actual Hire rate on 17/3/2017	10.000 $/day
Actual Hire rate on 24/3/2017	10.250 $/day
Actual Hire rate on 31/3/2017	10.250 $/day

Source – elaboration by the author

Figure 89 – Timecharter 3-years supramax 52.000dwt



Source – elaboration by the author

Finally, the supramax vessels with 58.000 dwt are examined. Data have been collected from Clarkson SIN database (2023) for the period 4/7/2014 – 24/2/2023. The model has been tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (14,45). As seen in the below table (44) and figure (90), the R-squared and the adjusted R-squared are also very high (0,987922 and 0,987895 respectively).

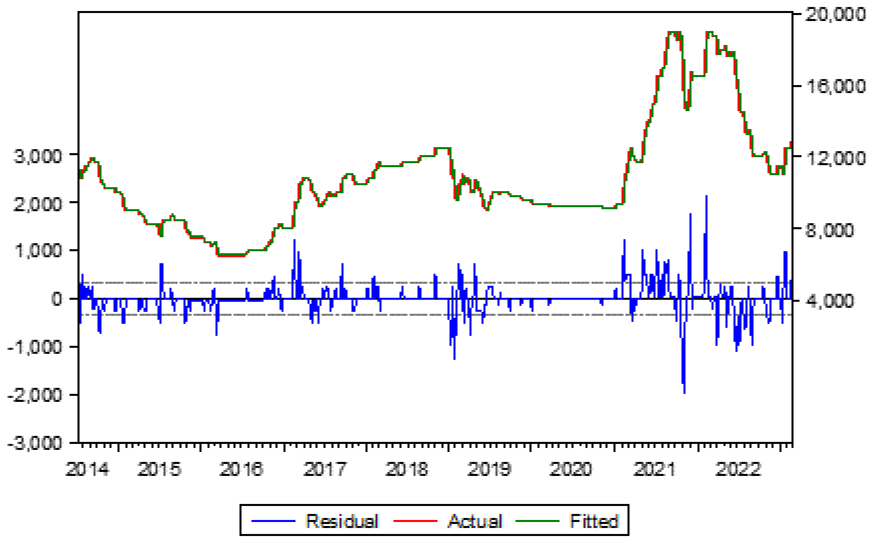
By performing a back test analysis, the author reached to the conclusion that the static forecast is at a very good level in terms of level, while the trend of a rising market is also captured. Specifically, the predicted hire rates were 11.500 $/day for 27/1/2023 and 12.495 $/day on 24/2/2023, while for the same dates, the actual hire rate was 12.500 $/day and 13.000 $/day. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 44 – Timecharter 3-years supramax 58.000dwt

R-squared	0,987922
Adjusted R-squared	0,987895
Static Forecast (Hire rate on 27/1/2023)	11.500 $/day
Static Forecast (Hire rate on 24/2/2023)	12.495 $/day
Actual Hire rate on 27/1/2023	12.500 $/day
Actual Hire rate on 24/2/2023	13.000 $/day

Source – elaboration by the author

Figure 90 – Timecharter 3-years supramax 58.000dwt



Source – elaboration by the author

As seen in previous cases, in this case the analysis of the relevant freight market is possible by considering the lags and reaching to conclusions regarding its progress. The various sizes of handymax and supramax vessels have been considered for the long-term chartering of a vessel. Although fluctuations are not very sharp, oscillations are identified around the equilibrium, resulting to possible prediction of the freight market.

In the next chapter, the average earnings of supramax vessels are analysed, since a possible investment heavily depends on returns and profitability.

5.3.5 Average Earnings

In this section, the average earnings of the supramax vessels (scrubber fitted or not) constructed in 2010 are discussed. It is very important to discuss the behavior of the earnings of scrubber fitted and non-scrubber fitted supramax vessels to analyse the future investment. It is expected that higher earnings are received from scrubber fitted vessels. It is also expected a similar behavior regarding the trend of both average earnings.

Regarding the non-scrubber fitted vessels, weekly data from 17/7/2009 till 24/2/2023 have been retrieved for the simple supramax vessels and from 3/1/2020 till 24/2/2023 for the scrubber fitted supramax vessels.

Data has been collected from the Clarksons SIN database. As a limitation, it is pointed out that the model requires many observations, as all econometric models, and its forecast might be affected by the limited available data for the scrubber fitted vessels. The suggested methodology is applied to this dataset of average earnings of supramax constructed in 2010. The eq (1) is used and the optimum lead lag selected is the lag1.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. Like in the previous trade route, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity.

It is worth mentioning that in this specific case, by considering the coexistence of lead lag(1) and lead lag(2) in this model, the predictability of the turn points is captured faster. However, the model is not stationary and as a result it is rejected. Thus, the latest lead lag, the lag1, has been selected. This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating.

In this case, the Hannan Quinn criterion is high (16,81), although it is higher when "older" lags are considered separately. As seen in the below table (45) and figure (91), the R-squared and the adjusted R-squared are also very high (0,966804 and 0,966758 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is accurate for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the turn points, the model needs time to adjust, such as the sharp increase of the last week.

The predicted hire rates for the last three weeks of the dataset are close. The hire rate prediction was for 8.619 $/day, 8.757 $/day and 8.865 $/day for the last three weeks, ending 24/2/23 failing to capture the increase of the latest week. For the same period, the actual hire rate was 8.682 $/day, 8.792 $/day and 12.354 $/day for the last three weeks respectively.

As identified, the model did not capture the sharp change at the turn point, although the predictions are very close. Nonetheless, the model has managed to capture the upward trend of the market. In this case, the dynamic forecast has predicted the latest hire rate of the dataset as 12.390 $/day, although the forecast was not very accurate for the previous weeks. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

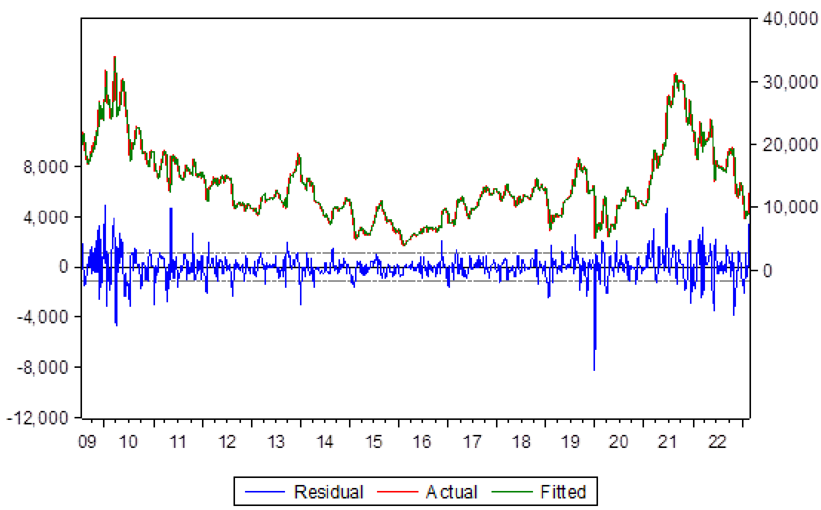
Table 45 – Average Earnings Supramax c. 2010

R-squared	0,966804
Adjusted R-squared	0,966758
Static Forecast (Hire rate on 10/2/2023)	8.619 $/day

Static Forecast (Hire rate on 17/2/2023)	8.757 $/day
Static Forecast (Hire rate on 24/2/2023)	8.865 $/day
Actual Hire rate on 10/2/2023	8.682 $/day
Actual Hire rate on 17/2/2023	8.792 $/day
Actual Hire rate on 24/2/2023	12.354 $/day

Source – elaboration by the author

Figure 91 – Average Earnings Supramax c. 2010



Source – elaboration by the author

The suggested methodology of this research is applied to the dataset of average earnings of supramax constructed in 2010 fitted with scrubbers. The eq (1) is used and the optimum lead lag selected is the lag1.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. Like in the previous trade route, it has been noticed that when adding more lags in the model, the predictability is reduced, since R-squared decreases, though still remains high, but the model loses its stationarity.

By considering the coexistence of lead lag(1) and lead lag(2) in this model, the predictability of the turn points is captured faster. However, the model loses it stationarity due to coefficient of AR(1)>1, although the inverted roots are within the acceptable range 0 – 1, and as a result it is rejected. Thus, the latest lead lag, the lag1, has been selected as an optimum lag.

This is also verified by practical perspective, since the participants of the industry tend to seek advice from the last fixture done when negotiating. In this case, the Hannan Quinn criterion is high (16,81), although it is higher when “older” lags are considered separately.

As seen in the below table (46) and figure (92), the R-squared and the adjusted R-squared are also very high (0,969398 and 0,969209 respectively). By performing a back test analysis, the author reached to the conclusion that the static forecast is accurate for the purpose of this research, predicting the trend of the market, though in some cases and specifically at the turn points, the model needs time to adjust, such as the sharp increase of the last week.

The model has identified the range within the equilibrium oscillates. The predicted hire rates for the last three weeks of the dataset are close. The hire rate prediction was for 13.904$/day, 13.597 $/day and 13.183 $/day for the last three weeks, ending 24/2/23 failing to capture the increase of the latest week.

For the same period, the actual hire rate was 13.484 $/day, 13.062 $/day and 15.735 $/day for the last three weeks respectively. As seen in the below table, the model did not capture the sharp change at the turn point of the latest observation, although the predictions are very close for the previous weeks.

The latest change is also out of the margins of the normal changes. It could have been omitted in the prediction or considered as dummy, but there are not any other fluctuations out of the margin, when the correlogram is checked, so no dummy can be incorporated in the model. Finally, it has been also noticed that the earnings of these two vessels are of similar behavior and the scrubber fitted vessels produce higher earnings, with the last year to offer an increased difference.

It is also concluded that the dynamic forecast provides weaker results compared to the static forecast. Thus, a static forecast with constant update of the weekly data, will help to reach safer conclusions.

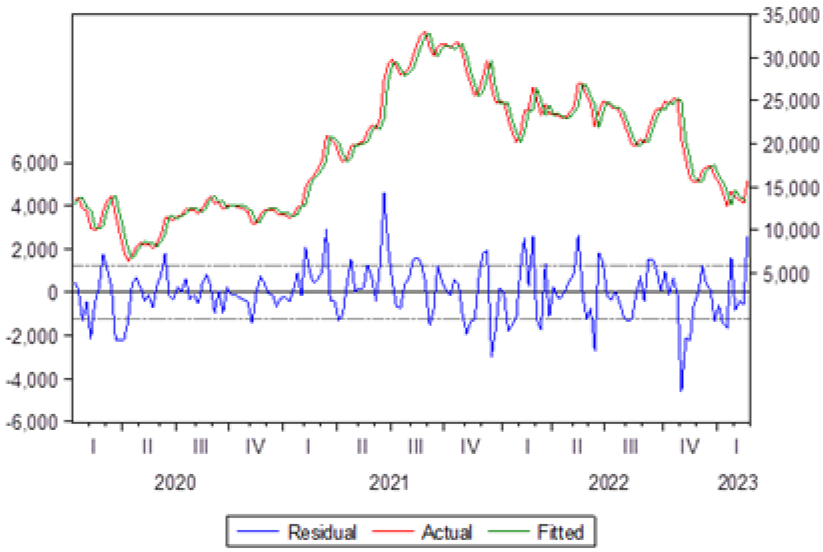
Table 46 - Average Earnings Supramax c. 2010 Scrubber Fitted

R-squared	0,969398
Adjusted R-squared	0,969209
Static Forecast (Hire rate on 10/2/2023)	13.904 $/day
Static Forecast (Hire rate on 17/2/2023)	13.597 $/day
Static Forecast (Hire rate on 24/2/2023)	13.183 $/day

Actual Hire rate on 10/2/2023	13.484 $/day
Actual Hire rate on 17/2/2023	13.062 $/day
Actual Hire rate on 24/2/2023	15.735 $/day

Source – elaboration by the author

Figure 92 - Average Earnings Supramax c. 2010 Scrubber Fitted



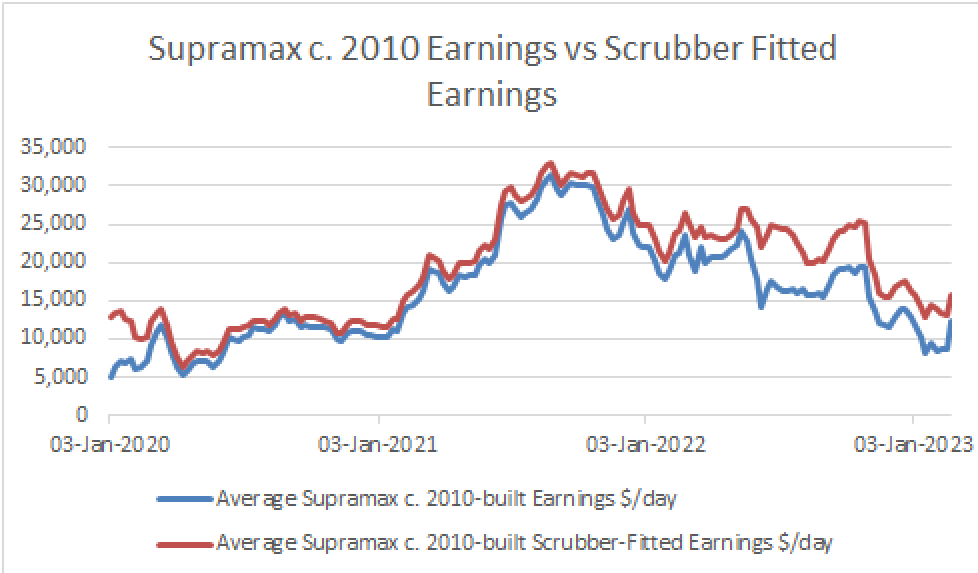
Source – elaboration by the author

As seen in the bellow figure (93), the earnings of the scrubber fitted vessels are constantly higher, answer the question of Kalouptsidi (2014) in the literature review section if quality pays. However, the crucial question that the author states is whether the quality out-pays the initial investment in terms of returns.

It has been observed that in this short-term period of the available data, that the earnings of both categories follow the same progress, so a positive and very high correlation is achieved, as expected. In the last year, one can claim that the difference is greater, favouring the scrubber fitted vessels. This is also supported by the fact that the freight rates are much higher for these vessels compared with the previous periods.

The progress of this trend and whether this continues, will play a critical role in the investments of the coming years, since a culture towards "Green Shipping 2050" is grown. This agenda might have a domino effect in all shipping markets. If expectations become different, the investment policy will change and as a result this will have a long-term impact on the supply, resulting to the macroeconomic change of the freight market.

Figure 93 – Supramax c. 2010 Earnings vs Scrubber Fitted Earnings



Source – elaboration by the author

The findings verify the initial expectations for the average earnings of these vessels. The scrubber fitted vessels tend to have higher returns, since they tend to receive higher rates. Moreover, they also have a similar trend and oscillations with the non-scrubber fitted vessels, though at a different level.

It can be observed that in early 2022 and onwards till today, the earnings of the scrubber fitted vessels are of much higher difference than in 2020 and 2021, compared to non-scrubber fitted vessels. This should be considered before a possible investment takes place, since the environmental regulations and emissions will have a major effect in the shipping industry, complicating the freight market too. The alternative fuels and the bunker cost should be highly considered, since it is a main voyage cost.

5.3.6. Summary

It is observed that in the case where the equilibrium remains almost the same for a short period of time and a sudden change occurs, the model needs time to adjust and capture similar changes. This is explained by the fact that the latest lead lag is considered for the majority of the cases and when there are not fluctuations, the model cannot identify the sudden changes. Moreover, these changes might happen due to unforeseen events or to a sudden behavioral change of the participants of the markets. However, it is encouraging the fact that the model captures the trend of the market or the range of freight/hire rate oscillations, and is able to provide a safe forecast for the level of the freight market.

5.4 Handysize market

In this chapter, the following cases are considered for analysis: timecharter trips and timecharter contracts of various handysize vessels, from 28.000 dwt to 38.000, under a different duration, from one trip (timecharter trip) to 3 years contract. The average earnings of handysize vessels are also considered.

5.4.1. Timecharter trip rates

In this chapter the timecharter trip rates of handysize vessels are examines. The Transpacific timecharter trips of a handysize vessel of 28.000 dwt and Transpacific timecharter trips of a larger hadysize vessel with 38.000 dwt are examined. Moreover, the average timecharter trip earnings of handysize vessels with 28.000 dwt and 38.000 dwt are also considered for analysis.

5.4.1.1. Transpacific trip rates handysize 28.000 dwt

In this section, the transpacific trip rates of handysize vessels with 28.000 dwt are discussed. Data from Clarkson SIN database (2023) have been retrieved for the period 15/10/2010 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,43).

As seen in the below table (47) and figure (94), the R-squared and the adjusted R-squared are also very high (0,972265 and 0,972222 respectively). By performing a back test analysis, the author reached to the conclusion that the managed to capture the trend of a rising market.

Specifically, the predicted hire rates were 4.056 $/day for 27/1/2023 and 5.041 $/day on 24/2/2023, while for the same dates, the actual hire rate was 5.000 $/day and 7.000 $/day. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

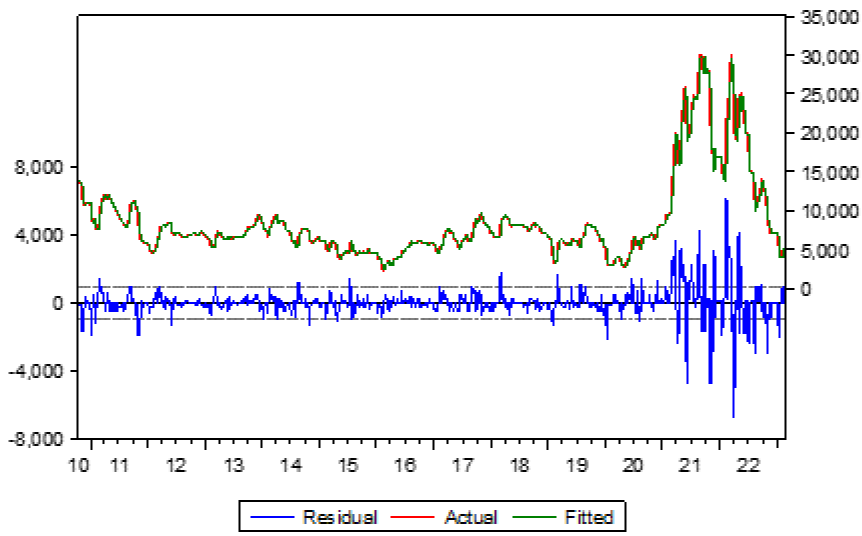
Table 47 – Transpacific trip rates handysize 28.000dwt

R-squared	0,972265

Adjusted R-squared	0,972222
Static Forecast (Hire rate on 27/1/2023)	4.056 $/day
Static Forecast (Hire rate on 24/2/2023)	5.041 $/day
Actual Hire rate on 27/1/2023	5.000 $/day
Actual Hire rate on 24/2/2023	7.000 $/day

Source – elaboration by the author

Figure 94 – Transpacific trip rates handysize 28.000dwt



Source – elaboration by the author

5.4.1.2. Transpacific trip rates handysize 38.000 dwt

In this section, the transpacific trip rates of handysize vessels with 38.000 dwt are discussed. Data from Clarkson SIN database (2023) has been retrieved for the period 4/7/2014 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,98, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (17,05).

As seen in the below table (48) and figure (95), the R-squared and the adjusted R-squared are also very high (0,976963 and 0,976911 respectively). By performing a back test analysis, the author reached to the conclusion that the managed to capture the trend of a rising market.

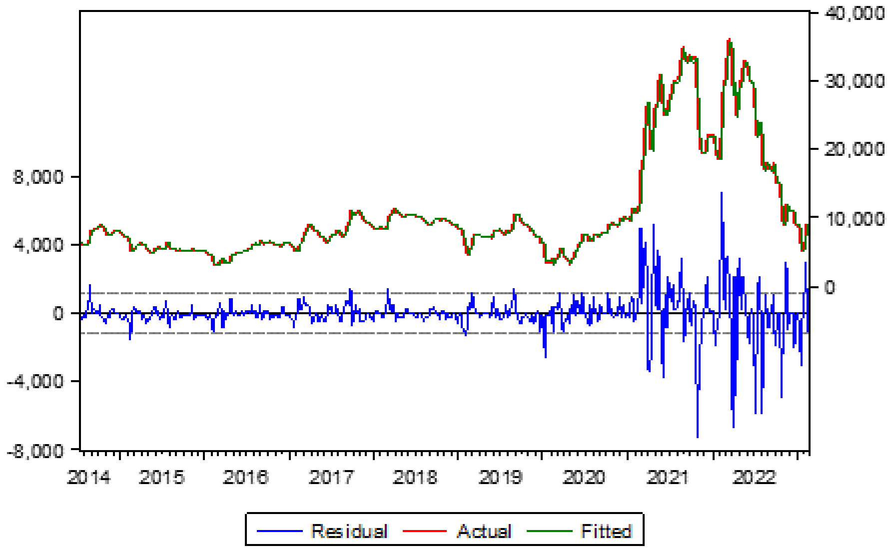
Moreover, the rate level prediction is at a very good level, being very close to the actual rates. Specifically, the predicted hire rates were 5.071 $/day for 27/1/2023 and 8.036 $/day for 24/2/2023, while for the same dates, the actual hire rate was 5.000 $/day and 8.000 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 48 – Transpacific trip rates handysize 38.000dwt

R-squared	0,976963
Adjusted R-squared	0,976911
Static Forecast (Hire rate on 27/1/2023)	5.071 $/day
Static Forecast (Hire rate on 24/2/2023)	8.036 $/day
Actual Hire rate on 27/1/2023	5.000 $/day
Actual Hire rate on 24/2/2023	8.000 $/day

Source – elaboration by the author

Figure 95 – Transpacific trip rates handysize 38.000dwt



Source – elaboration by the author

It is observed that in both previous cases, even the size varies, the transpacific trip rates can be predicted by using the time lags of the timeseries.

5.4.1.3. Average Timecharter trip rates handysize 28.000 dwt

In this section, the average trip rates of handysize vessels with 28.000 dwt are discussed. Data from Clarkson SIN database (2023) has been compiled for the period 15/10/2010 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1.

From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,16). As seen in the below table (49) and figure (96), the R-squared and the adjusted R-squared are also very high (0,981559 and 0,981530 respectively).

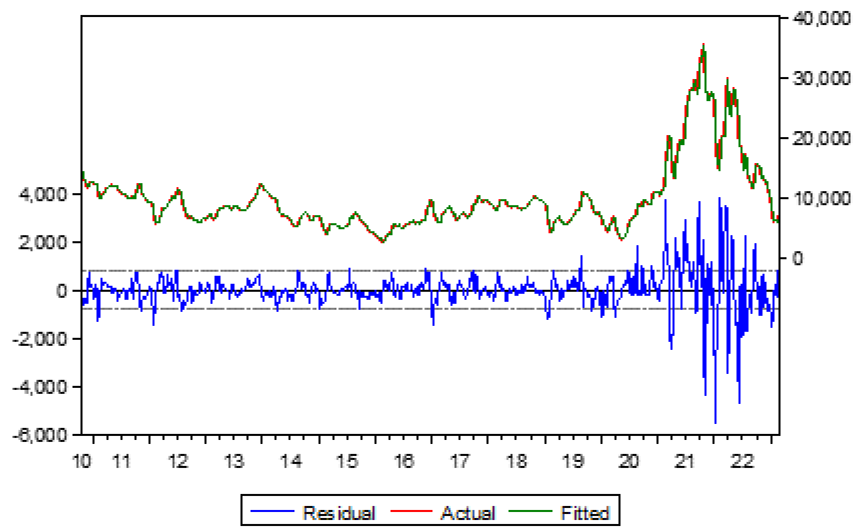
The back test analysis concluded that the model managed to capture the trend of a rising market. Furthermore, the level of prediction is at a good level, being close to the actual rates. Specifically, the predicted hire rates were 6.025 $/day and 6.272 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rate was 6.250 $/day and 7.333 $/day. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 49 – Average trip rates handysize 28.000dwt

R-squared	0,981559
Adjusted R-squared	0,981530
Static Forecast (Hire rate on 17/2/2023)	6.025 $/day
Static Forecast (Hire rate on 24/2/2023)	6.272 $/day
Actual Hire rate on 17/2/2023	6.250 $/day
Actual Hire rate on 24/2/2023	7.333 $/day

Source – elaboration by the author

Figure 96 – Average trip rates handysize 28.000dwt



Source – elaboration by the author

In the next section, the average trip rates of larger handysize vessels (38.000 dwt) are examined.

5.4.1.4. Average Timecharter trip rates handysize 38.000 dwt

In this section, the average trip rates of handysize vessels with 38.000 dwt are discussed. Data from Clarkson SIN database (2023) has been retrieved for the period 4/7/2014 – 24/2/2023. The model has been tested and, like in previous cases, the eq(1) should be applied, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,55).

As seen in the below table (50) and figure (97), the R-squared and the adjusted R-squared are also very high (0,984402 and 0,984367 respectively). The results of the back test analysis indicated that the model managed to capture the trend of a rising market. Furthermore, the level of prediction is at a very good level, being very close to the actual rates.

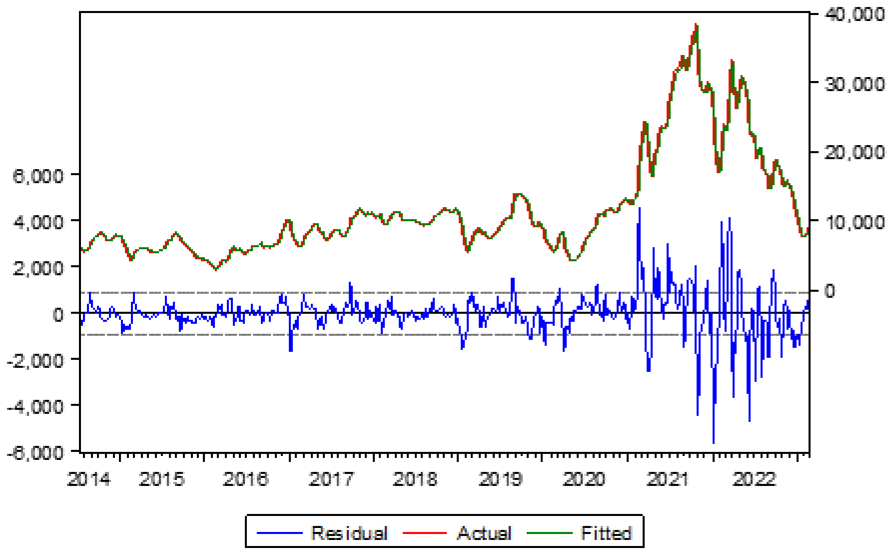
Specifically, the predicted hire rates were 8.285 $/day and 8.533 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 8.250 $/day and 8.500 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 50 – Average trip rates handysize 38.000dwt

R-squared	0,984402
Adjusted R-squared	0,984367
Static Forecast (Hire rate on 17/2/2023)	8.285 $/day
Static Forecast (Hire rate on 24/2/2023)	8.533 $/day
Actual Hire rate on 17/2/2023	8.250 $/day
Actual Hire rate on 24/2/2023	8.500 $/day

Source – elaboration by the author

Figure 97 – Average trip rates handysize 38.000dwt



Source – elaboration by the author

To summarise, the average timecharter trip rates of handysize vessels (sizes 28.000 dwt and 38.000 dwt) can be predicted followed the suggested methodology, as the latest lag seems to be the most important for the future fixtures. This is in line with the practical perception of the industry.

In the next section, the timecharter contracts of handysize vessels (32.000 dwt and 38.000 dwt) for short and long duration are analysed.

5.4.2. Timecharter Contracts

In this chapter, the timecharter contracts of 6 months, 1 year and 3 years duration are examined for the handysize vessels of 32.000 dwt and 38.000 dwt.

5.4.2.1. Timecharter contracts 6 months handysize 32.000 dwt

In this section, the timecharter contracts with duration 6 months for the handysize vessels with 32.000 dwt are discussed. Data from Clarkson SIN database (2023) has been retrieved for the period 6/1/1989 – 24/2/2023.

The model has been tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (15,84).

As seen in the below table (51) and figure (98), the R-squared and the adjusted R-squared are also very high (0,992111 and 0,992107 respectively). By performing a back test analysis, the author reached to the conclusion that the model managed to capture the trend of a rising market.

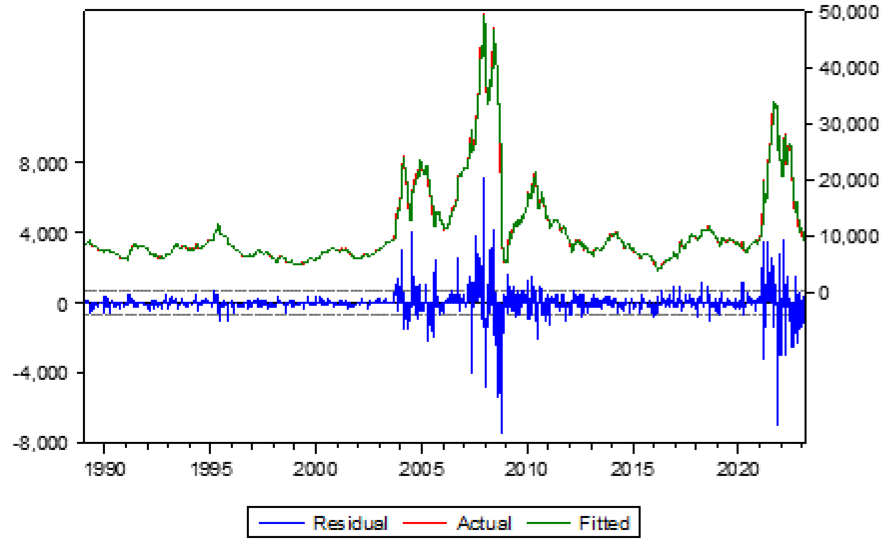
Furthermore, the level of prediction is at a good level, though a difference of around 2.000 $/day exists. However, answering to the research questions, the trend is captured using the lagged rates of the timeseries. Specifically, the predicted hire rates were 9.695 $/day and 9.882 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 9.875 $/day and 11.625 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 51 – Timecharter 6 months rates handysize 32.000dwt

R-squared	0,992111
Adjusted R-squared	0,992107
Static Forecast (Hire rate on 17/2/2023)	9.695 $/day
Static Forecast (Hire rate on 24/2/2023)	9.882 $/day
Actual Hire rate on 17/2/2023	9.875 $/day
Actual Hire rate on 24/2/2023	11.625 $/day

Source – elaboration by the author

Figure 98 – Timecharter 6 months rates handysize 32.000dwt



Source – elaboration by the author

In the next chapter, the same period contract is tested for larger vessels, to check if the method selected can be applied with success.

5.4.2.2. Timecharter contracts 6 months handysize 38.000 dwt

In this section, the timecharter contracts with duration 6 months for handysize vessels with 38.000 dwt are discussed. Data from Clarkson SIN database (2023) has been collected for the period 4/7/2014 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate.

The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (16,39).

As seen in the below table (52) and figure (99), the R-squared and the adjusted R-squared are also very high (0,987641 and 0,987613 respectively). By performing a back test analysis, the author reached to the conclusion that the model managed to capture the trend of a rising market. Furthermore, the level of prediction is at a good level, being close to the actual rates.

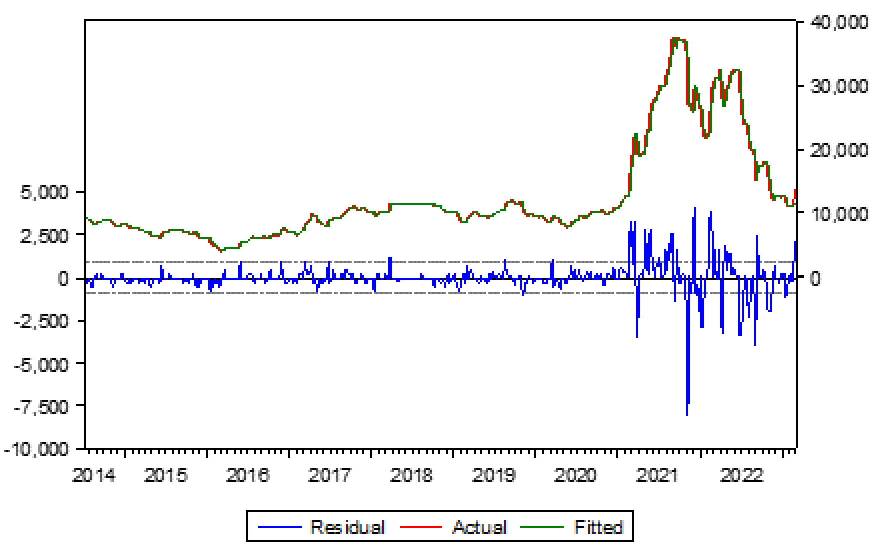
Although a difference of 2.000 $/day exists, the trend of the market is captured and the level of the market is better predicted when the oscillations are more normal and not that abrupt. Specifically, the predicted hire rates were 11.018 $/day and 11.516 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 11.500 $/day and 13.750 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 52 – Timecharter 6 months rates handysize 38.000dwt

R-squared	0,987641
Adjusted R-squared	0,987613
Static Forecast (Hire rate on 17/2/2023)	11.018 $/day
Static Forecast (Hire rate on 24/2/2023)	11.516 $/day
Actual Hire rate on 17/2/2023	11.500 $/day
Actual Hire rate on 24/2/2023	13.750 $/day

Source – elaboration by the author

Figure 99 – Timecharter 6 months rates handysize 38.000dwt



Source – elaboration by the author

After analysing the short-term contracts for the handysize vessels of 32.000 dwt and 38.000 dwt, it is observed that the trend of the market can be predicted by considering the time lags. The oscillations of the freight markets are captured and the trend of the market is predicted.

In the next sections, analyses are performed for the same sizes of handysize vessels but with longer duration.

5.4.2.3. Timecharter contracts 1 year handysize 32.000 dwt

In this section, the timecharter contracts with duration 1-year for the handysize vessels with 32.000 dwt are discussed. Data from Clarkson SIN database (2023) has been retrieved for the period 6/1/1989 – 24/2/2023.

The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

The Hannan Quinn criterion is high (15,27) in this case too. As seen in the below table (53) and figure (100), the R-squared and the adjusted R-squared are also very high (0,994070 and 0,994067 respectively).

The back test analysis indicates that following this method can lead to conclusions. In this case, the model managed to capture the trend of a rising market. Furthermore, the level of prediction is at a very good level, being very close to the actual rates.

Specifically, the predicted hire rates were 9.754 $/day and 10.128 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 10.125 $/day and 11.000 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

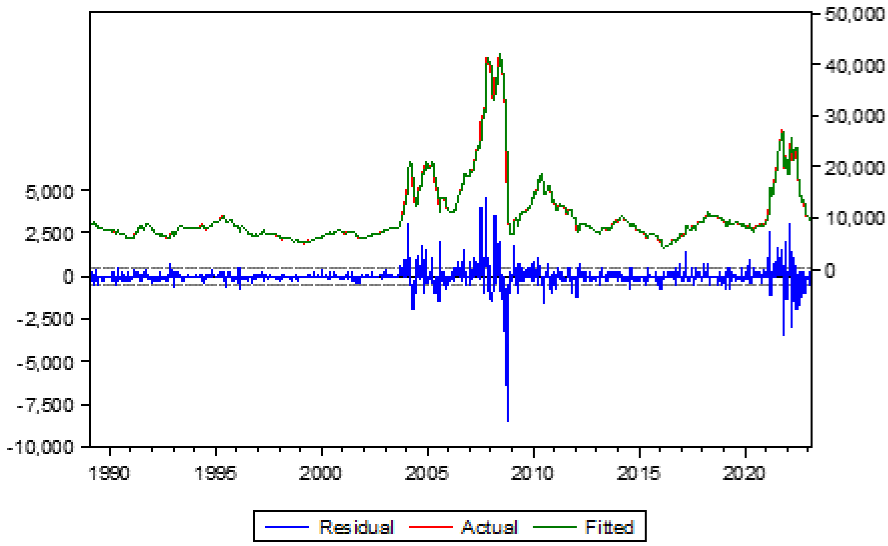
Table 53 – Timecharter 1-year rates handysize 32.000dwt

R-squared	0,994070
Adjusted R-squared	0,994067
Static Forecast (Hire rate on 17/2/2023)	9.754 $/day
Static Forecast (Hire rate on 24/2/2023)	10.128 $/day

Actual Hire rate on 17/2/2023	10.125 $/day
Actual Hire rate on 24/2/2023	11.000 $/day

Source – elaboration by the author

Figure 100 – Timecharter 1-year rates handysize 32.000dwt



Source – elaboration by the author

5.4.2.4. Timecharter contracts 1 year handysize 38.000 dwt

In this section, the timecharter contracts with duration 1-year for handysize vessels with 38.000 dwt are discussed. Data from Clarkson SIN database (2023) has been compiled for the period 4/7/2014 – 24/2/2023. The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1.

From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market. In this case, the Hannan Quinn criterion is high (15,52).

As seen in the below table (54) and figure (101), the R-squared and the adjusted R-squared are also very high (0,991033 and 0,991013 respectively). By performing a back test analysis, the author reached to the conclusion that the model managed to capture the trend of a rising market.

Furthermore, the level of prediction is at a good level, being close to the actual rates. Specifically, the predicted hire rates were 12.754 $/day and 13.252 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 13.250 $/day and 13.812 $/day respectively.

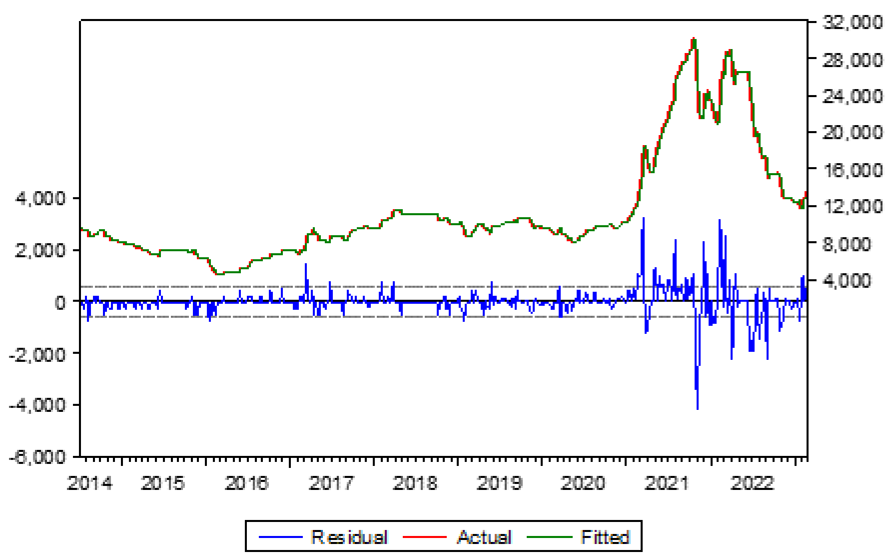
A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 54 – Timecharter 1-year rates handysize 38.000dwt

R-squared	0,991033
Adjusted R-squared	0,991013
Static Forecast (Hire rate on 17/2/2023)	12.754 $/day
Static Forecast (Hire rate on 24/2/2023)	13.252 $/day
Actual Hire rate on 17/2/2023	13.250 $/day
Actual Hire rate on 24/2/2023	13.812 $/day

Source – elaboration by the author

Figure 101 – Timecharter 1-year rates handysize 38.000dwt



Source – elaboration by the author

In the case of a longer duration contract, both sizes of examined handysize vessels freight market can be analysed, by considering the lagged hire rates to predict the trend of the market.

In the next chapters, analyses are performed for the long-term contracts of same vessels' size, with duration 3 years.

5.4.2.5. Timecharter contracts 3 years handysize 32.000 dwt

In this section the long-term timecharter contract (duration 3-years) for a handysize vessel of 32.000 dwt is analysed. Data from Clarkson SIN database (2023) has been gathered for the period 6/1/1989 – 24/2/2023.

The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1.

From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (14,45). As seen in the below table (55) and figure (102), the R-squared and the adjusted R-squared are also very high (0,993127 and 0,993123 respectively). By performing a back test analysis, the author reached to the conclusion that the model managed to capture the trend of the freight market, which was stable for a few weeks and finally the upward trend was captured in the last observation of the sample.

Furthermore, the level of prediction is at a very good level, being close to the actual rates. Specifically, the predicted hire rates were 9.000 $/day on 27/1/2023 and 9.500 $/day on 24/2/2023, while for the same dates, the actual hire rates were 9.500 $/day and 10.250 $/day respectively. A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

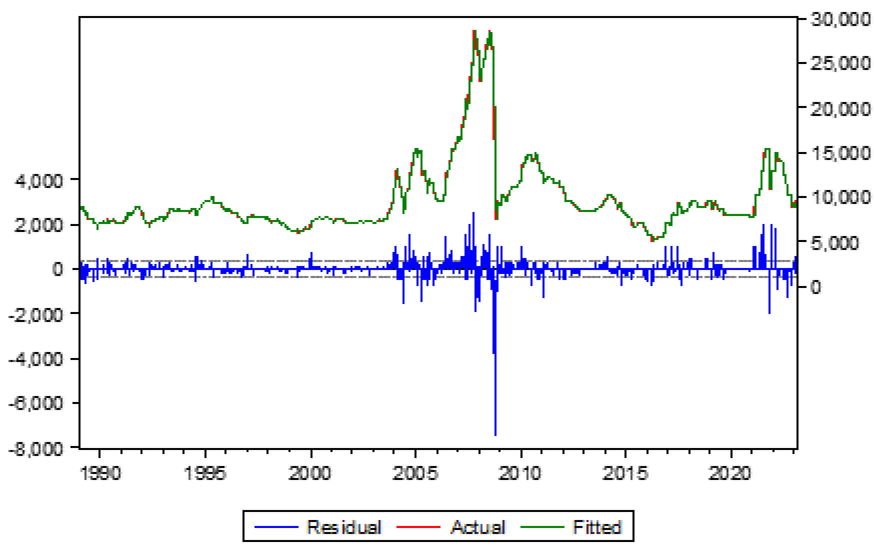
Table 55 – Timecharter 3-years rates handysize 32.000dwt

R-squared	0,993127
Adjusted R-squared	0,993123
Static Forecast (Hire rate on 27/1/2023)	9.000 $/day

Static Forecast (Hire rate on 24/2/2023)	9.500 $/day
Actual Hire rate on 27/1/2023	9.500 $/day
Actual Hire rate on 24/2/2023	10.250 $/day

Source – elaboration by the author

Figure 102 – Timecharter 3-years rates handysize 32.000dwt



Source – elaboration by the author

As seen in this case, the model was able to capture the fluctuations of the market for a long-term contract. In the next chapter, the period of 3-years for a handysize of 38.000 dwt is examined.

5.4.2.6. Timecharter contracts 3 years handysize 38.000 dwt

In this section, the timecharter contracts with duration 3-years for handysize vessels with 38.000 dwt are discussed. Data from Clarkson SIN database (2023) has been collected for the period 4/7/2014 – 24/2/2023.

The model is tested and the eq(1) is applied in this case too, verifying that there is a strong impact of the last fixture on the next available rate. The stationarity of the model is achieved, since the coefficient of AR (1) is 0,99, within the acceptable range 0 – 1. From practical perspective, the participants of the industry tend to get decisions based on the last fixtures and expectations of the market.

In this case, the Hannan Quinn criterion is high (14,45). As seen in the below table (56) and figure (103), the R-squared and the adjusted R-squared are also very high (0,988759 and 0,988734 respectively). By performing a back test analysis, the author reached to the conclusion that the model managed to capture the trend of a rising market.

Furthermore, the level of prediction is at a good level, being close to the actual rates. Specifically, the predicted hire rates were 11.500 $/day and 11.998 $/day for the last two weeks of the dataset, while for the same dates, the actual hire rates were 12.000 $/day and 12.750 $/day respectively, indicating a good overview for future negotiations.

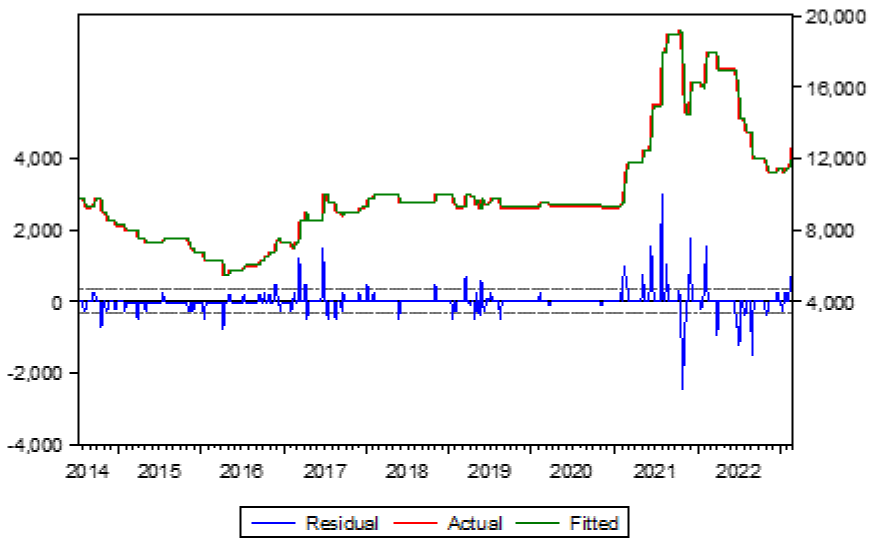
A static forecast with constant update of the weekly data is more suitable for this case and in order to reach safer conclusions.

Table 56 – Timecharter 3-years rates handysize 38.000dwt

R-squared	0,988759
Adjusted R-squared	0,988734
Static Forecast (Hire rate on 17/2/2023)	11.500 $/day
Static Forecast (Hire rate on 24/2/2023)	11.998 $/day
Actual Hire rate on 17/2/2023	12.000 $/day
Actual Hire rate on 24/2/2023	12.750 $/day

Source – elaboration by the author

Figure 103 – Timecharter 3-years rates handysize 38.000dwt



Source – elaboration by the author

In this section the long-term timecharter contracts are analysed. The model captured again the trend of the market, while the predicted rates were close to the actual rates.

5.5. Summary

The handysize market is a more competitive market, since it is a more open market compared to panamax and capesize freight markets. Smaller and more flexible vessels are operated. The method selected is applied in smaller and larger handysize vessels for timecharter trips and timecharter contracts (short- and long-term). Their average earnings have been also analysed.

It is of the author's conclusion that the market trend can be captured, by considering the lagged rates of the freight market. In all cases there was a very good prediction in terms of trend and a good prediction in terms of rate. It is also pointed that in most cases the market trend is positive, leading to a rising market, in the aftermath of Covid-19 era.

In all cases the latest lag is extremely important and can be considered as a key indicator before fixing the vessel. This is aligned with the practical perspective of the industry, where the shipping participants consider the latest fixture of the case as important indicator, along with the demand and supply factors.

6. Conclusion

6.1. Conclusive remarks

In this research the fluctuations of the dry bulk freight market of different vessel sizes are examined. The cases investigated are the average earnings, the spot market and the timecharter contracts for the short- and long – term. The findings indicate a strong connection between time lags and capesize, panamax (including kamsarmax), handymax (including supramax) and handysize freight markets, which enables possible forecasting of the behavior of the market since the time lags affect the progress of the freight market significantly.

The back tests for static and dynamic forecasts indicate the strong predictability of the model. In most cases, the latest lag was the only lag that affected the rate level, mainly in the timecharter contracts either period or trip. In some other cases, mainly in the spot market, more lags were taken into account to determine the rate level, and this is in line with the common practice of shipowners and charterers. This applies especially in short-term decision-making, where the prime factor is the freight rate paid for this trade route's latest shipment.

Moreover, the progress of the demand has been thoroughly discussed, by examining the world seaborne trade of various cargoes, such as iron ore, coal, grain, alumina and bauxite, scrap etc, which are affecting the relevant freight markets. The transportation of these cargoes under traditional routes was analysed, since they affect the progress of the freight market.

For the capesize market based on this research, the author has concluded that the spot market will not suffer from sharp fluctuations, but the market will remain at a similar level for the next months, for the period studied.

Apart from the freight market, it is very important to examine timecharter contracts. Thus, the same methodology has been applied to the trip rates for the Transatlantic and Transpacific trades for capesize vessels of 172.000 dwt and 180.000 dwt. In the Transatlantic trade, it is noticed that different lags are important for the two different sizes of the vessel. The dummy variable is also important, since its use improves the results of the model in some cases. Based on this research, the forecast for this market indicates small fluctuations in the current level for a smaller capesize, while for a bigger one a drop is expected, reaching low levels, even $12.770 /day.

In the Transpacific trade, the important lags are very similar to the Transatlantic, while mall fluctuations are expected for the small capesize vessels. The estimation of this research for the bigger capsize vessels indicates a bear market, where shipowners will struggle in the big competition.

Concerning period contracts, this research considered the short and the long period contracts with duration six months, one year and three years for the capesize vessels of 170.000 dwt and 180.000 dwt. Specifically for the six-month contracts, the latest lag is considered to be the most important for the capesize of 170.000dwt, while for the 180.000 dwt capesize the latest lag and the fifth lag are considered as the most important lags. These sizes of the vessels follow opposite direction in the freight market, proving that even if they belong in the capesize type, the size of the vessel can differentiate the operation of the vessel in the market. The smaller capesize vessel is expected to be operated in a recovering market while the bigger capesize in a bear market.

Regarding the one-year timecharter contract, the latest lag is the most important for both sizes of the capesize market. The expectations for the markets are very different. The smaller capesize market is expected to continue recovering, while the bigger capesize market is expected to drop.

As far as the three-year contract is concerned, the big cape follows the latest lag, while the smaller cape is affected by the latest, the third, the fourth, the tenth and the eleventh lags. The small capesize is expected to be operated in a bull market, while a bear market for the bigger capesize vessels is expected.

In order to reach a safer conclusion, the demand and supply growth of the capesize market have been also considered as crucial factors of the progress of the freight markets. According to the order book, the supply is expected to grow in the next years. A demand growth is also anticipated. However, the growth rate of supply and demand, along with scraps and losses, will determine the future progress of the market.

Considering the FFA market to reflect the expectations of the shipping participants, a drop in the market of the capesize vessels in the near future is expected for the period of the forecast, which is in line with the findings of this research. Specifically, it is expected the bigger capesize vessels to decline in the freight market and have a more stable freight market with small fluctuations and in some cases improvement for the smaller capesize vessels. It is also believed that based on the findings of this research, it seems that in the future the cargoes of this market will be transported in smaller quantities but more frequent, since the demand is expected to grow.

This will lead the freight market of the big capesize vessels (180.000 dwt) to face suppressed freight rates. This will also affect the decision making of the ship-owners of bigger vessels, leading to competition between smaller and bigger vessels for smaller quantities, undermining the main principle of the economies of scale theory and the purpose of the vessels being bigger. The total supply of the capesize market is increased, due to deliveries of increasing orders regarding new buildings. The scrapings remain at a low level, resulting to the growth of the fleet within the years. According to the order book, as bigger and bigger capesize vessels enter the market, competing the older capesize vessels and in combination with a change of the demand for smaller capesize vessels, the market of the big capesize vessels may come to a decline.

Regarding the Panamax markets, the author concluded that the freight markets suffered a collapse during the pandemic period and the worldwide economy lockdown, recovering when returning to normality. On the contrary, the owners' earnings did not follow that collapse but managed to increase in some cases. This is partially explained from the multivariable function of shipowners' earnings, with bunker cost affecting at a very high rate the profitability of the shipowner when operating the vessel.

Apart from the spot market, it is very important to examine timecharter contracts. Thus, the same methodology is applied to the trip rates for the Transatlantic and Transpacific trades for a typical Panamax vessel of 72.000 dwt.

Concerning period contracts, many cases have been examined for the short and the long period contracts with duration six months, one year and three years for the Panamax vessels of 75.000 dwt. In all cases, the latest lag was the most important one. All markets had a similar trend, especially for the first semester of 2020, with different rates and drop percentage. The signs of recovery in June 2020 and the market's expectations indicate a good end of the year, with the only uncertainty to be a possible next wave of coronavirus. The predictions of the model are satisfying, capturing the behavior of the market.

To reach a safer conclusion, the demand and supply growth of the Panamax market have been also considered. According to the order book, the supply is expected to grow. A demand growth is also anticipated. However, the growth rate of supply and demand, along with scraps and losses, will determine the market's future progress. Considering the FFA market to reflect the shipping participants' expectations, a recovery is expected in the Panamax vessels' market shortly, which is in line with the findings of this research.

The Panamax market's total supply is increased due to deliveries of increasing orders regarding new buildings. After six years (2012 – 2017) of heavy scrapping and few deliveries renewing the fleet, the scrapings remain at a low level, resulting in the reduction of the fleet the recent years. According to the order book, deliveries will increase the fleet soon. The market remains uncertain regarding the short term Covid – 19 situations, though recovery is expected from June 2020 and onwards.

For the handymax and handysize vessels, the spot market and the timecharter contracts, short- and long-term have been examined. Various sizes have been also considered, from small vessels of 28.000 dwt to 58.000 dwt.

The author reached to the conclusion that the latest lag affects the decision making of the market participants in all cases, spot and period market. In some cases where abrupt changes happened and a great volatility existed from one week to another, the model faced difficulties in capturing these sharp fluctuations. However, the model was able to identify the range of the oscillations occurring to the equilibrium. The sharp fluctuations could exist due to the fact that these markets are very open and competitive, since this trade is performed worldwide. In some cases, the prediction was extremely accurate, only a few $/day or $/tn difference, while in other cases a bigger difference was noticed (2.000 $/day). In almost all cases, the future trend of the market was captured, along with the oscillations around the equilibrium. In rare cases, the model was able to predict the fluctuations of the market with a lag. This happened when sharp and abrupt changes were observed from one week to another, in a constantly unstable freight market.

It is also important to mention that the freight market of eco-friendly vessels is different in terms of level, compared to the ordinary vessels. As seen in the section of average earnings of the supramax vessels, the eco vessels and the scrubber fitted vessels tend to receive a higher rate compared to other vessels. Depending on the market conditions, this might be a worth mentioning or a minor difference (in some rare cases the rate is almost at the same level). It is clear that moving on to the "Green Shipping Era", the investment in green vessels starts to pay off, since the difference in the rates they receive compared to an ordinary vessel is notably higher, with good expectations for the future freight market.

However, the behavior is the same. When the freight market falls or recovers, this happens for both green and ordinary vessels. The percentage though, might differ or might be the same. It is a recommendation for future research to monitor the levels of these freight markets.

The expectations can vary from one market to another. As discussed in the literature, the expectations may be expressed in the industry through the FFA market. The findings of this research are in line with the FFA projections in most of the times, indicating that the lagged rates may lead to projection of future rates and trend of the freight market.

The research questions of this thesis set in the introduction section, have been successfully answered. Following the suggested methodology, the findings indicate that the behavior of the various dry bulk markets can be captured. The results of this research are in line with the extant literature, since an alternative way to investigate the trend and behavior of the dry bulk market is successfully suggested.

Moreover, this thesis contributes at the academia by considering only the lagged rates of the freight markets. It is very important to mention that during this research many external factors have affected the progress of the industry, such as coronavirus, energy crisis etc. Even within an unstable environment, suffering many changes and many more to follow, especially due to the geopolitics and new regulations towards 'Green Shipping', the results of this research proved to be accurate and promising. As a result, this research may lead to a better understanding of the dry bulk freight markets' behavior at a practical level, which would allow shipowners and charterers to improve their planning decisions and investments.

6.2. Research limitations and future research

In order to conduct this research, the author used a variety of sources. Academic sources, such as published papers from trustworthy journals and books, have been used. Furthermore, the author had access to Clarksons SIN database to retrieve data, among other sources such as Lloyds database. Many reports were collected. A difficulty faced during this research, was the accessibility to FFAs and derivatives market. A direct application for subscription was rejected. As a result, the data collected for the FFA market were from published papers and limited free online sources for limited period of time.

Another limitation dealt with during this research, was the fact that some timeseries are not updated till today. However, for the purpose of this research and in order to test the model and reach results, sufficient data was retrieved and analysed.

The importance of markets analyses is extremely high from academic and practical perspective. The forecast of the progress of each market is imperative for all market participants. As analysed in the precious chapters, many scholars have conducted research with various approaches. Further research may focus on further parameters considered by this thesis.

The FFAs, the demand and supply factors, such as the order book, and other factors that affect both the freight and hire rates' determination could be possibly incorporated further to this approach. It might also be of further interest to evaluate the impact of the new environmental regulations to the freight markets. Finally, due to the energy crises, it is important in the future to consider the cost difference in bunkers, whether it is a green bunker (alternative fuels) or the traditional one. A recommendation for future research is to consider the different option of bunkers and relevant cost, in order to evaluate the relevant behavior of freight markets.

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