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Preface

The main purpose of a ship owning company is profit. Whether a company will make a profit or a loss depends on its revenue and expenses. For shipping companies, freight rates are considered source of income, and operating costs are considered expenses.

Shipowners decide on the type of ship they will invest in; in practice, they decide on the market segment in which they are willing to operate. In addition, they seek for the highest freight rate in combination with the desired destination.

Cargo owners, based on the characteristics of their cargo, decide on the most favorable vessel, which will ship their cargo with the lowest possible freight rate.

This study aims at analyzing shipowners' decisions on vessel profitability by looking at the freight rates and operating costs for the year 2018 on tankers, through the Moore Maritime Index. In addition, it highlights the factors that affect revenues and operating costs via the fluctuations for tankers in general and Aframax ships in particular.

After all this analysis, I would like to thank my supervising professor Dr. Ioannis Lagoudis for encouraging me to study this interesting topic and the freedom he gave me in approaching the issue, as well as for his advice and guidance during the postgraduate program.

Completing this course, I feel the need to express my gratitude to those who stood by me during this time and supported my effort. Firstly, my parents, Michael and Georgia, and my brother Vaios for their multifaceted support. Also, I would like to thank my friend Eleftheria and my classmate and friend Elida, who stood by me in my concerns and difficulties in general during these years and for the elaboration of this dissertation.

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Abstract

The aim of this paper is to investigate yield management in the tanker sector with focus on the Aframax sector. This is achieved via using Time Charter Equivalent (TCE) and Operating Expenses (OPEX) provided by the Moore Maritime Index (MMI) database. The work focuses on data reported for the financial year 2018. Data analysis suggests that there are significant levels of uncertainty in the behavior of income and cost. This uncertainty is evident in the various values given by the index depending on the type of ship, its age, its flag, and other factors. The expenses included when calculating OPEX are the costs for the crew, stores, repair and maintenance, insurance, and admin, of which the crew costs have the lowest variability levels while repair and maintenance costs, in almost all cases, are regarded to have the highest variability levels.

1.Introduction

The tanker shipping market is by far the largest sector in the shipping industry in terms of trading volume and weight. Therefore, it is not surprising that the majority of investigations have been dedicated to analyzing tanker freight rates, strategic chartering decisions based on the reduction of risks and the increase of revenues, and strategic chartering choices based on the type of merchandise and the cost of their transportation.

As in any firm, the main goal of a shipping company is profitability heedless of the factors that will be used to achieve it as even in sectors such as the one of the developments of technology or science, the ultimate goal is to generate more revenue. For this reason, the aim of this paper is to have a financial analysis. The fact that most analyzes (with any goal) focus on the dry cargo sector led us to choose the analysis of the tanker sector as it is the largest sector in the world of shipping after the transport of dry cargo.

Analyzing a specific part of a market is different from analyzing the economic performance of one special shipping firm (with specific ships, reputation, characteristics, etc.) , which triggered our interest in this study.

This research aims to achieve its goal with the presentation of all the data of the Moore Maritime Index. In more detail, the study will present data of income, costs, etc. of many ships that have been given in Moore global without making known which ship has any respective data and irrespective of the firm's name.

Also, through all these, there can be a holistic approach to both the performance of the sector and the ship performance of the sector separately without taking into account specific data of companies (i.e. loans) that will complicate the analysis by comparing dissimilar things.

After this analysis, it is recognized that volatility in freight rate exists. Therefore, the need to analyze if the cost of the ship is affected in the same way emerged. Generally, it is noticed that freight rates and costs are those that will play a vital role in the financial performance of the firm regardless of the factors that affect freight rates and costs.

A shipping firm can have from one to many ships in order to be functional, either in the dry sector or tanker sector. However, this begs a lot of questions. We cannot compare dry and tanker sector because they are two different things with various characteristics. But the basic query is whether what happens in the dry sector also happens in the tanker sector. Also, we are wondering if something would change when there is only one category of ship in the firm’s possession.

Furthermore, we know that each vessel has its characteristics (i.e. age of ship). These characteristics affect the life and the course of the ship, but which are the factors that influence the yield management of a shipping company and how can these factors influence the financial performance of the firm and consequently freight rates and costs?

One of the characteristics that influence the vessel’s course is for sure the cargo that is transported. Obviously, each cargo gives us different income due to the fact that they are traded in different markets. So, we are wondering if something would change when ships do not transport crude oil but other products. Not only from the side of freight rates and OPEX but also for the firm’s profitability. Also, we want to know which vessels transport each cargo and if there are common ships per transported cargo .

Factors such as the cargo and age of the ship are obvious and predictable. However, is the market and every shipping company affected by unpredictable changes? And how was the market affected by the 2008 crisis (as an unpredictable change)?

All the above are deemed to be very important for the financial performance of each shipping company because by resolving these issues we will be able to help the shipping market grow by getting both shipowners and shippers to make the right choices for their own interest. In addition, the resolution of these problems provides the most important elements which help recognize a good or bad market and whether or not each company can be profitable.

However, in order to be able to make the research a little more specific and definite, we consider that it is important to focus on a more specific environment so that the research can be carried out and its results can be useful and usable today. Both from the side of the shipowners and from the side of the shippers.

Special emphasis is given to the companies of bulk shipping, because not only do they constitute the market with the greatest diversity and the most peculiarities but also because most of the Greek-owned companies are active in it (see Theotokas, 2019, pg. xxiv). So, in order to make a contrast we chose to analyze something different and we decided to concentrate on the tanker sector.

Global economic expansion is the main driving force in the world of shipping demand, and 2017 will be remembered as the year when the world economy and global shipping experienced a cyclical recovery from the historic lows of 2016, nearly a decade after the 2008-2009 global economic and financial crisis. Meanwhile, 2017 proved to be a challenging year for the tanker market, mainly because of the pressure faced by markets from continuous growth in supply capacity, particularly in the crude tanker sector that was matched by a relative deceleration in demand growth (UNCTAD, 2018). The crude oil tanker fleet grew by 5 per cent and the product tanker fleet grew by 4.2 per cent (Clarksons Research, 2018c). For all these reasons, the environment that we particularly choose to analyze is the 2018 period.

The basic purpose of this paper is to explore insights on the tanker vessel performance based on TCE (incomes) and OPEX (costs). In order to succeed in this goal, the analysis is fourfold: (1) the investigation of the 2018 period in the tanker sector, (2) the analytic investigation on the economic performance of ships of the same sector, (3)the research of some of the factors that influence both ships and the financial performance of them and (4) the investigation in the way that this influence exists and what happens both with incomes, costs, and risks of them.

The remainder of the paper is as follows. Section 2 presents a brief review of previous studies on tanker and dry shipping both for freight rates, costs, risks, and cargoes. Section 3 presents the methodology (i.e. Moore Maritime Index and Excel) and the data of analysis. Empirical results are presented in Chapter 4. Finally, conclusions are presented in Chapter 5.

In more detail, specific problems that need to be solved are mentioned in chapter 2 . Possible issues of analysis and some problems are also proposed. Chapter 3 refers to our research, to our problem and the data that is utilized is also presented there. Chapter 4 presents all the results of the analysis the data, comparisons, and answers to our problem. Finally, chapter 5 introduces possible following problems.

2.Literature review

Many theories have been proposed to explain what happens in maritime which concern mainly the various types of chartering because apart from owning a vessel, chartering it is also essential so as to make it profitable. But what do we actually mean when we refer to chartering? How many types of charter are there?

For shipping companies, chartering constitutes the most important activity and is of primary importance due to the fact that it produces the main profits of shipping firms. Chartering, in other words, represents the sales of shipping companies and the product on sale is the leased vessel, namely the service provided by the maritime means of transport. The goal of every shipping company is a profitable chartering of a vessel or vessels for as long as possible.

The main types of chartering are Voyage Charter, Time Charter, Bareboat Charter, Consecutive Voyage, Contract of affreightment, and Time Charter Trip. The usual aspects are Voyage Charter and Time Charter, which will be analyzed later.

Although literature covers a wide variety of such theories, this review will focus on two major themes that emerge repeatedly throughout the reviewed literature, which are strategic chartering decisions based on the reduction of risks and on the increase of revenues and strategic chartering choice based on the type of merchandise and on the cost of their transportation.

Whichever charter option the company decides on will be the one that will bring its profits or losses. As far as risks and revenues are concerned, Berg-Andreassen (2011) states that as any other company, shipping companies make many decisions every day and on a continuous basis, with the ultimate goal of sustainability. Some decisions made by shipping companies are about whether they will carry bulk liquid cargo or bulk dry cargo or containers or a combination of the above. The author emphasizes that such decisions are based on profits, risks, traditions, and experience. It is also pointed out that in any such decision the main goal is to reduce the risk of the market and increase profits, as these two factors play a very important role in the selection of charter strategies in shipping markets.

Once the shipowner has chosen the type of ship they will have in their fleet, another crucial decision to be made is what kind of charter each of their ships will follow as well as whether it needs to leave the market. Thus, it is thought that the remaining problem is opting for charter strategies and their implementation, having as a basic assumption for such an analysis that the main goal of the shipowner is to maximize their wealth, namely their profits or the performance of their investment while carefully taking some risks .

For this reason, in order to solve the above problem, the author is guided by the risk-return model which has been used in the financial analysis of assets. To simplify the solution of this model, it is assumed that each route has a predetermined ship.

It is also preassumed that there are 10 specific routes and that the shipowner owns 10 ships (2 small, 5 Panamax, and 3 Capesize), which at the beginning of 1987 when the necessary data were obtained, are 5 years old. It is also assumed that ships perform continuous voyages and are out of lease for 15 days a year whether these are time-chartering or chartering per trip. Moreover, the return on investment (ROI) in the voyage market is measured as net income minus travel, running and administration costs, while for the time charter market the return on investment is the net income minus current expenses and administration costs.

All calculations were made on an annual charter basis after taking into consideration all the necessary data for the implementation of this model such as the performance of time charter or voyage charter, for each ship, the respective variations, the exposure index and so on. Berg-Andreassen (2011) came to certain conclusions about the profitable routes and the routes that must be avoided because they have low returns and high risks. Moreover, he concluded which of the lucrative routes is most advantageous to each ship. Finally, he reported that the shipowner can adjust the participation of the ships in each market so that it suits their preference for risk, expected performance, and market exposure. They may have many feasible options, but what they really choose depends on whether they are a risk lover, risk-averse, or risk-neutral.

A theoretical study (Timur and Cetin, 2012) determines the most frequently preferred charter types by Turkish general cargo and dry bulk shipowners and probes the factors which affect and determine the selection of charter types. More specifically, the study reveals that Turkish shipowners mostly prefer voyage charter. Another point revealed through the study is that shipowners reckon that factors such as the risk in the selected charter type, the reliability of the charterer, and the condition of the operated ship are relatively more important than anything else when deciding the charter types. Moreover, due to the fact that different methods of chartering exist, shipowners and cargo owners must decide on the most appropriate charter types.

As with every research, some limitations appear, creating the following restrictions. Turkish ship owning companies, members of the Turkish Chamber of shipping, which have general cargo and dry bulk cargo ships of and over 1500 Deadweight Tons (DWT) took part in the study which utilized a questionnaire, given to shipping companies, prepared by using the influencing factors determining the type of charter contract in order to determine the appropriate charter types. The factors that have been utilized and influence the choices of charter types were determined after communication with senior managers and shipbrokers who actively work in shipping companies.

As a result of this questionnaire, the researchers have had the unique opportunity to find the profile of the participants (age, education, experience, etc.), the profile of the companies (number of ships, types/size of the ships, etc.), and the charter type which is mostly preferred by participants - Turkish ship owning companies mainly opt for voyage charter contracts. Moreover, the author has had the chance to recognize the factors that affect the selection of the charter party type for example the risk in the selected charter type, the reliability of the charterer, etc.

Following the research findings, the investigator applied factor analysis on the answers in order to show the effect levels of these factors. Through this, it was concluded that 9 main criteria exist that affect the selection of chartering: market risk, qualifications and reliability of the charterer, the sufficiency of scientific market estimation, knowledge and experience of the shipowner, prejudgment, corporate structure and asset-related situation, technical sufficiency of the ships, and daily market changes.

Another study (Jing, Marlow, and Hui, 2008) mentions that the major component of the international shipping market is the dry bulk cargo shipping market. Generally, it is highlighted that this part of the market is characterized by high risk and volatility due to the uncertainty caused by factors such as the volume and standard of the world trade, the global economy, and government policies. In addition to this, it is thought that volatility of freight rates has brought risks and opportunities to the operators, so it has been decided to investigate it in the period from 1999 to 2005.

The main aim of this paper is to conduct a thorough investigation into the volatility characteristics and find the inherent discipline of freight rate indexes by using GARCH (Generalized Auto Regressive Conditional Heteroskedasticity) and EGARCH (Exponential Generalized Auto-Regressive Conditional Heteroskedasticity) models.

GARCH model is unable to capture the asymmetric effect of negative or positive returns on volatility, so Nelson (1991) introduced a modified GARCH model, the EGARCH model. He created this model to cover the gap and make the previous model appropriate.

This (EGARCH) model also overcomes the main drawbacks in GARCH, the non-negativity limits on the coefficients and the variables, and is used to ensure that the variance remains non-negative for all the periods with probability one.

In general, as far as data is concerned, it has been chosen to investigate the period from 1st March 1999 to 23rd December 2005, due to the fact that in this period dry bulk shipping market was at its best.

In the analysis, the dry bulk market is divided into three sub-markets by vessel size, since different vessel sizes are involved in different commodity trades and routes/regions of the world, and are distinct in terms of their risk-return characteristics. The investigation has data for Capesize, Panamax, handysize, and handymax vessels. As a result, it has been decided to utilize BCI, BPI, and JEHSI to analyze the fluctuations in the freight rates of the three sub-markets.

BCI and BPI are daily benchmark indexes published by the Baltic. The BCI shows the Capesize vessels market and is calculated from the weighted average weights on major routes, 7 voyage chartering routes, and 4-time chartering routes. The BPI shows the Panamax vessels market and is calculated from the weighted average weights on major routes, 3 voyage chartering routes, and 4-time chartering routes. JEHSI is compiled daily by Barrie Wooderson. The JEHSI reflects the handysize and handymax vessels market. The indicator for handysize and handymax vessels that are created by the Baltic is not appropriate because it has changed several times, so the author has decided to utilize JESHI for more reliable results.

Using the data and applying the models the author came to the conclusion that Handy vessels are more efficient than other ships. This is reasonable because Handy vessels have the opportunity to change their routes or cargo more easily to make a profit or suffer less loss according to the unpredictable market conditions. Moreover, Capesize and Panamax vessels are less flexible than handysize vessels. They are restricted by their waterline, routes, and cargoes so they cannot respond to changes in the bulk shipping market. Every vessel is different in terms of size, the merchandise that they transport, etc. but what does this actually mean? Does it mean that making more use of smaller ships is more advantageous ? Also, the results show that the freight rates volatility of handysize vessels reacting to the market's shocks are more intense in the other types of ships.

Another article related to risk and return in the strategic chartering decision (Kavussanos,1996) mentions that a lot of companies can collapse overnight as a consequence of wrong calculations of the risks included. Furthermore, he deems it more important to be able to calculate risks, and generally to minimize them through some diversified portfolio assets.

The purpose of this paper is to liberalize the ARCH (Autoregressive Conditional Heteroscedasticity) model and to examine volatility in the spot and time charter markets of dry-bulk vessels. In general, this research tries to address the following two questions:

1. Is volatility higher in the spot or the time charter market? And
2. Is the spot freight market riskier for a smaller size or larger size vessels?

The author uses ARCH and GARCH (Generalized ARCH) models in order to answer these questions. Also, in order to apply these models, monthly data from January 1973 to December 1992 have been collected for aggregated time charter and spot freight rate of dry-bulk, as well as disaggregated freight rates for Handysize (30,000 dwt), Panamax (60,000 dwt), and Capesize (120,000 dwt) vessels in dry-bulk. As a consequence of this investigation and the application of the models, the following results have been concluded.

Firstly, risks in dry-bulk markets are not constant over time. Time-varying risks are a combination of industry-market risk and the characteristics of every vessel for example size etc.

After periods of large external shocks to the industry, (i.e. the 1973-74 and 1980-81 oil crises), volatility has a high duration. As a consequence, there is a high risk.

After the evaluation of discrepancies between various vessels, the author concludes that risk premiums are higher in larger ships. Also, it is pointed out that smaller ships (Handysize) cover the trade market more than larger ones, with fewer limitations of ports because of size. So, this market, which is covered by small vessels, does not face many fluctuations and risks.

Finally, if the shipowner is risk-averse (in the dry bulk sector), then they prefer to invest on smaller vessels in order to confront a risk/return minimization problem.

All this comprehensive research gives us meticulous data for freight rates of the dry bulk sector and chiefly in the main vessel types of this market. However, it would be useful to investigate whether there would be similar results in the tanker sector (and in the ships that this market has).

On the other hand, some studies refer to strategic chartering decisions via cargo and the cost of it. Zheng, in his research (2013) points out that more than 90% of the volume of international trade is carried out by sea (IMO 2009). Moreover, he thinks that there is increased volatility in the freight market and that managing the risk of this market is an important issue for shipping companies as well as for companies that want to transport raw materials or even perfected products. As far as refineries are concerned, the author describes that crude oil transportation costs play a vital role in their profitability and that the right moment for the charter decision is important for oil refineries that rely on ocean freight shipping services to transport crude oil.

Therefore, the problem that arises in this article is the choice of the right time and the right freight for a refinery that needs to transport its merchandise via sea but does not have the fleet in its supply chain to achieve the minimization of transport costs. Also, what should be taken into account is the spot freight rate dynamics and the availability of tankers from the spot market. In general, the decision process can be confronted as an optimal stopping problem, in which the spot freight rate is modeled by a stochastic process (geometric Brownian motion) and the arrival of tanker offers follows a Poisson process. For straightforwardness, it is assumed in this paper that the freight rate process and ship arrival process are independent. This hypothesis is reasonable for a short time horizon because the supply and demand of the shipping market usually need more time to respond to the freight rate change.

In the case of Zheng (2013), the company imports a large portion of crude oil from the Middle East, which is transported to the company's port terminals by VLCC vessels chartered from the spot market. The arrival frequency of the VLCC tankers at the port is about 6-10 vessels per month. The company has two months to make a decision. If a firm decides within this time frame, it will pay the agreed freight rate. On the other hand, if a business fails to do so, then it will pay a penalty cost. Due to the fact that the offer arrival rate and penalty cost are not available, they consider a scenario analysis with specific prices.

After analyzing the scenarios, the author mentions that an optimal charter option can achieve cost reduction. Also, they believe that a charter option is more efficient when it has a large offer arrival rate because there are more tankers available in the market.

In a theoretical study, Goulielmos and Psifia (2007) address the question of whether the time series for the trip and time charter, between 1968-2003 and 1971-2003, are identically and independently distributed and if these have nonlinear dependence. For this study, they use BDS (Brock, Dechert, and Scheinkman) test. As a result of this investigation, the indicators were not random and identically and independently distributed. In general, it is concluded that nonlinear dependence exists indeed between them.

In addition to this, a notable part of this research is the fact that the trip charter rate has many changes and fluctuations compared with the time charter rate. Also, in the period that they have chosen to analyze, they noticed that the 1974 oil crisis shock was reflected and it is interesting to note that risk and volatility were different in relation to trip charter and time charter. Likewise, they report that ship owners lead an easier business life with time charters than with trip charters. Obviously, this reference is theoretically accepted but they prove it with their investigation and with the results of the test that they carried out.

Another paper analyzes seasonality in dry bulk freight rates and generally measures and compares freight rates of different vessel sizes- the types of vessels that are included in the investigation are Capesize, Panamax, and Handysize. This research takes into account firstly market conditions (peaks and troughs) and secondly the duration of the contracts that are analyzed for spot, 1-year, and 3-year charters. Both spot and time-charter rates are based on the average of daily fixtures over the month and cover the period from January 1980 to December 1996. The authors (M. Kavussanos, Amir H. Alizadeh-M, 2000) refer that tramp shipping freight markets are characterized by the interaction of supply and demand for freight services.

As is broadly known and has been mentioned in another article, the dry bulk shipping sector consists of a variety of vessels of different sizes, goals, characteristics, etc. The writer investigates freight rates of Handysize, Panamax, and Capesize vessels, so they report the characteristics of each one, which are well known from other bibliographies.

Handysize vessels (around 30,000dwt) transport mainly grain merchandise from North and South America and Australia to Europe and Asia, and minor dry bulk commodities (such as bauxite, fertilizers, etc.) around the world. These vessels have a small size, shallow draught, and are flexible in the trading routes and ports that they can attend.

Panamax vessels (around 65,000dwt) transport coal, grain, and sometimes iron ore from North America and Australia to Japan and West Europe. These vessels have a deeper draught but actually, these can transport fewer commodities than Handysize vessels.

Capesize vessels (around 120,000dwt) transport iron ore from South America and Australia to Japan, West Europe, and North America and sometimes transport coal from Australia and North America to Japan and West Europe. These vessels have limitations in the trading routes and ports that can serve them due to the very deep draught and a restricted quantity of commodities that they can transport.

Observing the monthly spot freight rate series, for the previous three different sizes of dry bulk, the author notices that in the long run freight rates move in the same direction but in the short run movement of freight rates are quite different. These discrepancies come from some distinct factors such as trade-in commodities which each type of vessel is engaged in.

Moreover, noticing one year and three years' time-charter rates respectively, it is noted that time-charter rates seem to show less short-run fluctuations compared to spot rates. It is mentioned that this is expected since long-term charter contracts are used for transportation of industrial commodities with regular trading patterns over the year such as iron ore and minerals, in contrast to voyage charter contracts, which are used for transportation of commodities with irregular and cyclical patterns such as grain (see Stopford, 1997, p 122). Furthermore, it is referred that the longer the duration of the contract, the smoother the rates.

In general, it is pointed out (from January 1980 to December 1996) that the mean values of spot rates for smaller vessels are higher than larger ones. It is highlighted that in contrast to spot rates, time-charter rates are higher for larger vessels compared to smaller size vessels. In addition to this, it is brought to our attention that the cost of transportation in time charter is again lower for larger vessels than for smaller ones, when these rates are converted into their spot equivalent in order to be comparable. Also, the author emphasizes the fact that these freight rates have different comparable units and different costs, for instance time charter rates do not include voyage costs such as spot market. Basically, it is concluded that heedless of the type of freight rate, the larger the vessel ,the higher the volatility that exists. This is expected due to the flexibility of smaller vessels.

The results of the investigation on freight rates whether they are spot market or time-charter show seasonality and these are influenced by the products that are transported. All the findings of the investigation show increase in freight rates in April and March either for spot or time chartering. Moreover, beyond these increases, there are decreases in freight rates during June and July in all three sizes of vessels. This decline is caused by the start of the summer holidays. There is a higher reduction in the time charter market than the spot market. But a decrease remains a decrease.

In the spot market, during these months all these increases could be reflected in the demand from Japanese importers for all merchandises due to the end of the fiscal (tax) year in Japan at the end of March. Also, the harvest season from February to March in Australia and Argentina increases the demand for Handysize and Panamax vessels during March and April because there is a shortage of storage facilities for the commodities that are harvested.

In contrast to the spot market, the rise in time-charter rates for Handysize vessels during spring is higher than the increase in Panamax and Capesize. This happens due to the fact that charterers, who need to fix the contracts, choose smaller vessels in order to avoid possible restrictions such as limits on loading or discharging ports.

Based on all the above results, Shipowners -and Charterers- have the unique opportunity to choose their strategy in order to maximize their revenues and minimize their transportation costs. For instance, the best time for a charterer to fix a dry bulk vessel for one year is June and July, etc. Moreover, the author claims that the degree of seasonal fluctuation of shipping freight rates varies across vessel size and duration of the contract.

The study of Alizadeh, Wayne, and Talley (2011) refer to the fact that the tanker shipping market is by far the largest sector of the world shipping industry in terms of trading volume and weight.

In general, they report that tanker freight rates are changing significantly in the short run. Moreover, they recognize that a lot of determinants that influence tanker freight rates exist. Some of these determinants are the vessel size, age, etc., route characteristics of ship, terms and conditions of the charter contract such as loading date in relation to contract date, cargo size in relation to vessel capacity, etc.

In particular, the researcher wants to analyze how each factor individually affect tanker freight rates if any discrepancies exist in tanker freight rates across different routes.

As referred in the previous article regarding the dry bulk sector, the researcher also reaches the conclusion that the tanker freight market is characterized by the interaction of supply (available tonnage for trading, etc.) and demand (oil, oil products, etc.) for tanker shipping services.

The tanker fleet is divided into five size classes: Very Large Crude Carriers (VLCC)(more than 160,000dwt), Suezmax (130,000 -160,000dwt), Aframax (70,000-120,000 dwt), Panamax (50,000-70,000 dwt) and Handysize (20,000-45,000 dwt). VLCC and Suezmax transport only crude oil. Aframax vessels transport crude oil but sometimes are hired for the transportation of oil products. Panamax and Handysize vessels transport clean and dirty oil products and sometimes are hired for short-haul crude oil transportations.

This investigation takes into consideration data for VLCC, Suezmax, and Aframax vessels due to the fact that they are involved in the transportation of one merchandise (crude oil) and they have a limited number of trading routes. The data concern the period from January 2006 to March 2009.

After calculations, the investigators observed that tanker freight rates are higher for smaller tankers than larger ones. This is predictable since vessels exhibit economies of ship size at sea. Moreover, it is understood that the average age of the VLCC fleet is higher than other types of vessels but the maximum ages of Suezmax and

Aframax are bigger than the maximum age of VLCC tankers. It is noted that the average utilization rate is higher for VLCC than for other ships.

In general, this research gives us significant data for each ship and their freight rates and shows us an overview of the tanker sector. The researcher shows numerical data about how each determinant influences the tanker freight rates. Furthermore, it is mentioned that freight rates for larger tankers are expected to be more sensitive to market uncertainty and changes in the market in comparison to smaller tankers.

All these findings are very useful for shipowners and charterers to make their decisions and generally to negotiate freight rates and make contracts. If shipowners are aware of all this data, then they can utilize it in their investments, operations, etc.

This paper tries to answer whether something would change if there was only one category of a ship in the firm's possession and if influence from the various differences of the ages of the ships existed. In addition, this research wants to respond to whether what happens in the dry sector also happens in the tanker sector.

After all these cases, it is recognized that freight rates are volatile but, in this research, the aim is to analyze if the cost of the ship is affected in the same way. As a result of this analysis, the goal is to learn whether these changes have an impact on the financial performance of the company and if something is altering in the profitable market.

Given that financial performance is a very important part for any business not just for that of shipping companies we want to research if something would change when ships do not transport crude oil but other products in the tanker sector. Not only for freight rates but also for their OPEX.

In a previous research, it was noticed that a period with an oil crisis shock is reflected in the freight rates. So, it is recognized that every important event (in any period) influences the movement of freight rates. For this reason, the aim is to analyze if the same thing happens in the move of OPEX and how the 2008 crisis affected the freight rates and OPEX.

Finally, what has not been studied in-depth and needs to be studied further is whether all these useful findings can result in a profitable choice and if this option is affected by other factors.

3.Methodology

In order to analyze all the previous gaps in this incredible sector of tankers with such useful commodities to be transported, we will utilize all the data of the Moore Maritime Index with the help of excel so as to reach certain conclusions.

Moore Maritime Index (MMI) is a statistical and analytics tool on shipping operating costs and revenues of more than 1,500 vessels, 629 of which were tankers. This index is created by Moore Global. Data for this index are extracted from the financial statements of ship-owning companies audited by Moore Global member firms.

More precisely, Moore Maritime Index gives information mainly about Dry Bulk and tankers and then about containers, gas carriers, etc. Regardless of the type of vessel, this tool analyzes data about income and operational expenses more extensively. Apart from these data, MMI gives a unique opportunity to use some filters in order to recognize how income and expenses are influenced by various parameters and to come to some conclusions.

However, before starting the analysis, it is very important to mention some information that are widely known in the shipping industry. Regarding the tanker sector, tanker ships are responsible to transport bulk liquid cargoes, such as crude oil, oil products, chemicals, LPG, and LNG.

Crude oil tankers are dedicated to transporting crude oil from offshore oil plants (oil platforms) or oil fields to refineries. Ships in this category belong to the real "giants of the sea" and the world's largest ships could be found among the fleet of crude oil tankers. Product tankers are designed for transporting refined products from the refineries such as gasoline, diesel oil, and aviation fuel. Chemical tankers are designed to transport different kinds of chemicals but are also able to transport the same products as the Product tankers. A chemical tanker is in most cases more advanced than the Product tanker when it comes to the cargo handling system as it has to avoid mixing the products it is transporting. LNG and LPG are designed to transport liquified gas. Apart from what has been described above, there are also a number of specialized tankers like wine tankers, Sulphur tankers, etc.

Oil tankers form by far the largest fleet of specialized bulk vessels, with over 6000 vessels, accounting for 37% of the merchant fleet measured in tonnes deadweight (See Stopford, 2009, pg.596). The size of individual tankers ranges from below 1,000 dwt to over 400,000 dwt. This fleet can usefully be subdivided into seven segments: small tankers (under 20,000 dwt), Handy (20,000-49,999 dwt), Panamax (50,000-79,999 dwt), Aframax (80,000-119,999 dwt), Suezmax (120,000-179,999 dwt), VLCC (180,000-319,999 dwt) and ULCC (up to 550,000 dwt). Each of these segments operates as a separate market and from a ship design viewpoint, each has its own specific requirements (Moore Maritime Index, 2020)

With the Moore Maritime Index, conclusions are presented about the incomes (TCE - time charter equivalent) and the operating (OPEX) costs of all the vessels in their management for which there is data.

The revenues, namely TCE, as stated in the Moore maritime Index glossary (2020), is the annual operating income less the direct voyage cost divided by the total voyage duration, where: a) operating income equals annual hire/freight/pool income plus any ballast bonus if any; b) direct voyage cost is the cost of bunkers consumed plus any other relevant expenses, including commissions, port expenses, canal dues, etc. and c) total voyage\ duration is the ballast time plus days on hire/freight/pool.

Moreover, operating (OPEX) costs include costs of the crew, stores, repair and maintenance (R&M), insurance, and admin. As for crew costs, all expenses for wages of the crew such as wages/overtime/bonuses etc. are added, as well as provisions and others such as crew agency fee, training, social contribution, etc. As far as the category stores are concerned, medicine, freshwater, lubricating oil, etc. are also incorporated. Namely, lubricants are oils for the main and auxiliary engines as well as for steering gears, compressors, shaft bearings, greases, and other equipment and on-board systems. (Moore Maritime Index , 2020)

As referred in the Moore Maritime Index glossary (2020), the R&M category include repairs and maintenance for deck machinery, electrical equipment, propulsion and rudder systems, auxiliary machinery, diesel engine, etc. and spares. As spares, we mean main and auxiliary engine ones, charts and nautical deck machinery, freight and forwarding other spares.

Moreover, insurance costs comprise of hull and machinery, P&I insurance and other insurance. Finally, annual registration fees such as annual tonnage tax, an inspection of the registry, etc., sundry expenses such as agency fee, communication etc. and management fees are all part of the category of admin costs. (Moore Maritime Index, 2020)

Via this platform, all these data are not to be introduced more extensively but actually, with the help of some mathematical functions, the number of observations (vessels) is firstly presented to us along with the average bound, the lower and higher bound for each element, namely TCE, OPEX or even OPEX/TCE index. So, an opportunity arises to form a general opinion without knowing whose ship the respective data are. It also shows the mean, variation, and covariance of these data in order to perceive not only possible deviations but also risks. Finally, the average age of vessels is annotated at the final observations of each category, namely TCE, OPEX, and OPEX/TCE index.

The OPEX per TCE index shows how many times the operating expenses of the vessel are covered by the earned time charter equivalent. In other words, this index is defined as the amount or percentage of income that corresponds to the operating costs of ships. This indicator is one of the most important and useful ones because it is the only indicator that combines revenue and expenses. Also, it can assist to recognize the economic performance and the risk that may exist.

All this information refers to the year 2018 when the index was created and all the numerical data are expressed in USD so that they are comparable and the exchange rates are not involved in order not to complicate this investigation.

After all these, it is perceived that all the data are useful but are not comparable in order to reach some conclusions. Also, when filters of MMI are utilized then it gives a variety of results. For these two reasons, both investigation without filters and investigation with filters will be held and results will be drawn with the help of Excel in order not to change the numbers, and in order to create tables and figures, through which, the results will be comparable and so, the conclusions will be feasible.

The filters of the Moore Maritime Index are the fiscal year to be analyzed, the ship’s flag, the type of vessels, the year the ship was built, the transportation cargo, and the shipyard of the vessel. The fiscal year is the one-year period used for accounting purposes to prepare financial statements as mentioned in the Moore Maritime Index glossary (2020).

The first part of the analysis will concentrate on general results of the tanker sector, then it will continue per type of vessel (as a first filter). As a second filter, the category of transported cargo will be utilized and then a combination of these two filters will be applied. In this way, the first basic results will be created.

Next, the research will focus on Aframax vessels. Having this in mind and using the ship's flag filter some results regarding flag preference will be extracted.

The performance of the shipyard can be measured using the filter for the shipyard and considering the ship Aframax as data. Using the filter of build’s year on Aframax vessels -heedless of transported cargo- the research can get very important evidence about the revenues and operating costs of Aframax ships per five-years of their manufacture.

Finally, the application of filters of the transported cargo, the type of ship, and per five-years of their manufacture simultaneously can give extraordinary conclusions both per type of vessel and in the tanker sector.

The Moore Maritime Index was selected in this analysis due to the fact that it is an innovative index with a lot of data regardless of the name or reputation of one specific firm. Moreover, there is data irrespective of the type of charter. The tanker sector was chosen because it is a huge sector that has not been analyzed as much as other sectors.

4.Results

Through this approach, very important information is derived both for the MMI index and for the shipping market, especially for the tanker sector as this is the focus of the investigation.

First and foremost, from the point of view of the indicator (MMI) and its filters, it is understood that the data concerning the ship and its operation play a vital role both for its operation (the customers who choose them in order to operate) and for the profitability or not of the shipping company itself.

Unfortunately, although it is logical, either through the MMI which simply shows some data or through the choice to analyze specific data of a particular company, it would not be easy to determine the imponderables. The imponderables in shipping are considered to be the variable costs (bunkers-costs from canals, etc.) that exist and do not give the opportunity to accurately calculate the company's revenues as well as the external factors that exist in the market (crisis, fluctuation of bunkers, war, etc.).

However, revenues may not be able to be accurately calculated in order to compare them but there is a coefficient of variability that comes out of the data given by the index. This coefficient of volatility represents the underline risk in each category and position. It is only a number and because of this it is useful and mainly comparable with other coefficients of volatility.

So, in addition to comparing simple amounts per category of a ship, it can easily be distinguished whether there is risk in the market of cargo or per ship. Also, the risk of revenue (Freight rates) or the risk of costs (OPEX) per ship can be compared based on other characteristics.

MMI gives very important information to anyone who uses it. Shipowners can see the data from 2018 and realize how the market moved as their firm can also be compared-theoretically without this being done directly against a specific competitor. Cargo owners, on the other hand, can see where the revenues of each ship fluctuate, possibly also per cargo in order to see how the market moved and choose a subjectively correct category of the ship for the transport of their cargo in the future.

Returning to the investigation, all the data about tankers derived from Moore Maritime Index concern the year 2018. Within MMI there are some filters that give different results in the data. As a result, these data offer different information for this indicator to the public, whether this is the shipowners or cargo owners. In this research, specific filters of the index are utilized in such a way so as to cover some specific gaps, which were mentioned in the literature review, in the sector of tankers too.

Initially, the data of MMI, without placing any filters, are analyzed in order to recognize how the tankers sector is moving overall. Afterwards, the type of cargo that is transported is placed as the first filter to see which market is more important. Then, the data for each ship are analyzed separately by type of cargo to see per market how the ships are affected. One of the common ships of these two markets is the Aframax, for this reason, and because they are not so well known in relation to the Panamax (and the Panama Canal) this research is continued based on the Aframax to see how a specific ship is influenced by more specific factors. Then the Aframax and their data are analyzed based on their flag. After that, the Aframax are presented based on their country of built and finally they are analyzed based on the year of their construction (every five years).

Some of these factors such as the year and country of manufacture of the ship cannot be changed and affect inadvertently the data over time. Some other factors such as the ship's flag (which was chosen strategically with the aim not to make a direct profit but mainly to cover more ports) and the type of cargo (which may just happen because its transport was simply requested) may change and so again these affect data since supply and demand have changed.

4.1. Tankers

At first sight of the Moore Maritime Index, the following tables are recognized in a holistic approach without restrictions:

Table 1: Revenues and Operating costs in the tankers.

tankers	*without restrictions*		
KPIs(daily)	***TCE***	***OPEX***	***OPEX/TCE***
Observations	*408*	*629*	
Average	*$ 12.735*	*$ 7.035*	*0.55*
Lower bound	*$ 8.109*	*$ 6.095*	*0.75*
Higher bound	*$ 17.395*	*$ 8.291*	*0.48*
Median	*$ 11.872*	*$ 6.712*	*0.57*
stDEV	*$ 5.316*	*$ 1.371*	*0.26*
CV	*0.42*	*0.19*	*0.47*
Age(AVG)	*10.88*	*8.95*	

Source: Moore Maritime Index 2020

Based on Table 1, the first thing that can be recognized is the fact that MMI has data of 629 vessels for the year 2018 . From the observations that have OPEX, it is noticed that only 408 vessels give information about TCE. This means two things. Firstly, it means that 221 vessels have not been chartered or these 221 ships have not given information about their TCE at MMI.

Another conclusion from this table is that the average price of TCE is higher than the median for the same time period, which means that the area contains significantly higher freight rates even though in that particular time frame chartering rates were strong in the lower range. The same happens in OPEX.

Also, it can be observed that the average price of TCE is USD 12,735. This shows that the tanker market offers its ships approximately for this amount on a daily basis. As for OPEX, these vessels pay for their operating costs approximately USD 7,035 for each one on a daily basis.

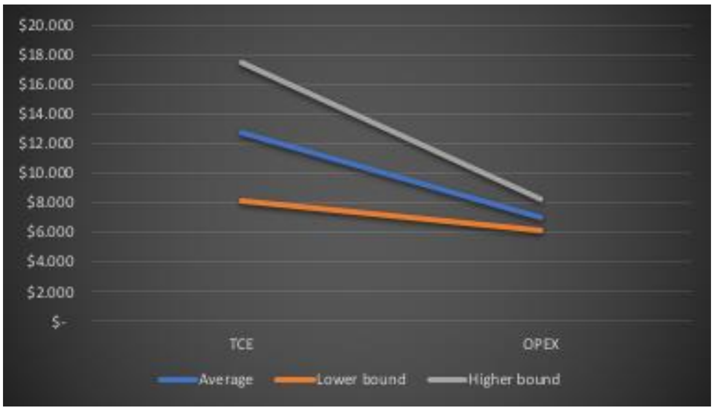
By observing this table, it can be concluded that the average age of TCE is 10.88 years and 8.95 years for OPEX respectively. So, it is understood that these vessels, which have not been chartered, are younger than 11-year-old whereas the average value of age falls as the observations increase.

In general, CV indicates the acceptable risk that the investor can take for each unit of return. So, since the CV is a number, it can be compared, either with TCE or with OPEX. Additionally, it is understood that the risk is greater for TCE but not prohibitive since the number is less than 0.5. The fact that the OPEX have a lower risk is also a bit obvious since the OPEX are paid whether the ship is chartered or not.

Moreover, in Table 1 it can be noticed that there is an OPEX to TCE ratio. The TCE to OPEX ratio shows how many times the earned time charter equivalent covers the operating expenses of the vessel. When the OPEX to TCE ratio lies at higher bound, then the number is lower (from lower bound or Average) and this is reasonable because higher liquidity is created since TCE has a higher value. By observing CV of OPEX/TCE index, it can be referred that at the tanker sector the value of 0.47 indicates that both OPEX and TCE can be modified but are not so easily controlled.

With the help of excel and Table 1 the following figure was created which gives us some further information:

Figure 1: Height of prices at lower, higher, average bound for TCE and OPEX respectively.



Source: Author

As a result of Figure 1, more conclusions can be obtained instantly in relation to Table 1. First of all, the fact that TCE is always above OPEX can be observed more easily (whether these are at the lower bound or higher bound or average.). So, a firm has the chance (at every level) to charter every vessel and to have a margin to pay for other costs. As a result, this firm will have profits. Through all these, it can be understood that the higher the freight rate, the higher the profits that will be created. Also, even at the lower bound, the freight rate gives a profit but less than at the higher bound which is logical.

Moreover, it can be seen that there is no symmetrical analogy (0.36 TCE- 0.18 OPEX & 0.57 TCE-0.15 OPEX). Since it is not known which freight rate corresponds to which ship and what OPEX.

Table 2: Analysis of Operating costs in the tankers.

OPEX	Crew	Stores	R&M	Insurance	Admin
Observations	628	629	625	628	629
Average	$ 4.068	$ 650	$ 923	$ 385	$ 1.021
Lower Bound	$ 3.587	$ 450	$ 578	$ 212	$ 740
Higher Bound	$ 4.743	$ 864	$ 1.277	$ 545	$ 1.162
Median	$ 3.932	$ 616	$ 844	$ 360	$ 955
stDEV	$ 671	$ 237	$ 422	$ 170	$ 430
CoV	0.16	0.37	0.46	0.44	0.42
Age(AVG)	8.93	8.95	8.94	8.95	8.95

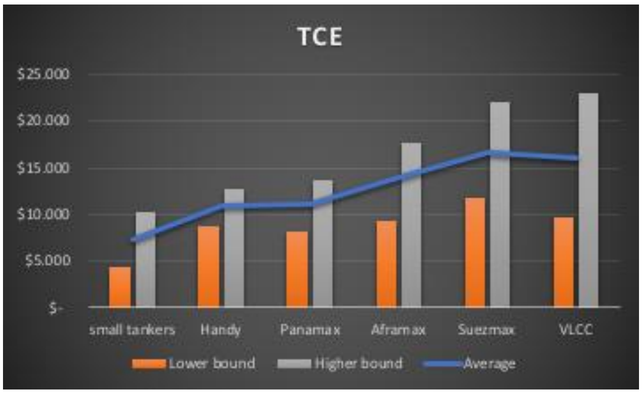
Source: Moore Maritime Index (2020).

Table 2 shows in detail all the information about OPEX. Based on Table 2, the higher costs consist primarily of crew costs, then administration costs, repair and maintenance costs (R&M), stores and finally insurance ones. However, the biggest risk lies with R&M costs, which makes sense since crew costs are standard while at R&M, extra costs may arise that have not been calculated.

4.2. Type of tanker vessels

With a more detailed analysis of the above data (Tables 1 and 2) and the use some filters from the MMI, the following diagrams are created.

Figure 2: The freight rate (either at the lower bound or at the higher bound or at the average) per ship category



Source: Author

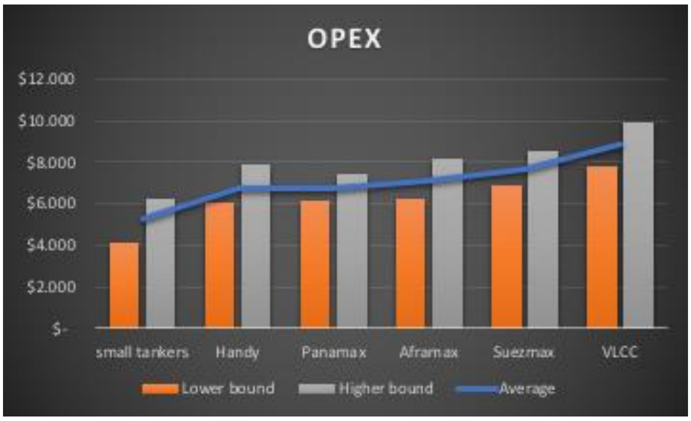
Firstly, it must be mentioned that in these diagrams the ULCC vessels have not been included, due to the fact that there is narrow data sample (8 ships) and the option to compare them with other ships is not available.

At first sight of Figure 2, it can be perceived that incomes at higher bound increase as the ship's DWT enhances too. Moreover, VLCC ships have the biggest price of TCE at a higher bound, which happens because they are the only ones that can transport a big quantity and justify this high price of TCE. The same relation between incomes and DWT occurs at the lower bound and that is why it is conceived that incomes for Panamax are a little smaller from handy-this happens due to the fact that Panamax ships cover more routes but handy vessels are more flexible due to their characteristics. Also, the same happens in the VLCC ships in relation to Suezmax and

Aframax vessels and this is because when VLCC ships are not fully loaded, they are not preferred to do the route for the OPEX that are paid.

On average in Figure 2, the same move with other bounds is noticed but also, it can be seen that the decrease of TCE starts in VLCC ships (compared with Suezmax). This obviously means that in this category of ship the space that is offered is bigger than the demand for cargo. So, the price is starting to decline because owners of cargo have another way to transport their merchandise and obviously, they do not need so much space for the quantity that they want to transport.

Figure 3: The Operating costs (either at the lower bound or at the higher bound or at the average) per ship category

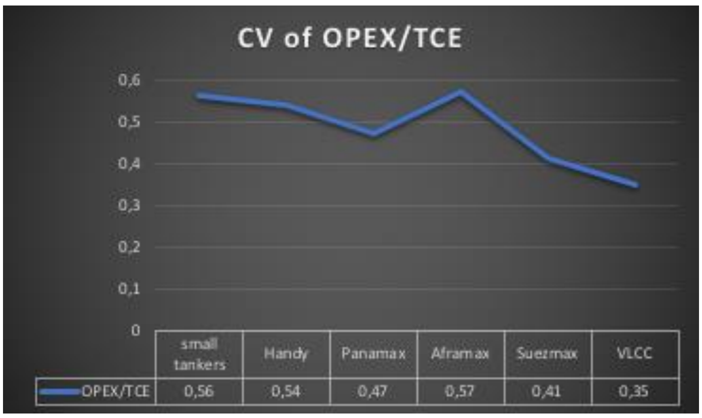


Source: Author

In general, Figure 3 follows the same upward trend as Figure 2 with TCE as long as the ship's DWT increases (in every bound). This time some fluctuations are observed at the higher bound. Actually, at higher bound from handy vessels to Panamax, it is conceived that operating expenses reduces.

However, when Figures 2 and 3 are observed independently, information can be obtained about which vessel is more profitable or which ship has less risk and variability. For this reason, it is deemed necessary to present the relation between TCE and OPEX and this comes to be true when we see the CV of OPEX per TCE. (Figure 4)

Figure 4: CV of OPEX/TCE in the type of tankers.



Source: Author

Unlike the previous figures, here it can be highlighted that as long as the DWT of ship increases then the OPEX per TCE index decreases. In Fig. 4, it is noticed that when the DWT of the ship increases then OPEX of each vessel are covered more easily than TCE. Characteristically, it can be distinguished that in small tankers 0.56 of the income per unit is OPEX and as for VLCC ships (bigger ships) the 35% of the incomes are the OPEX of a ship.

Furthermore, the largest ship after Panamax is Aframax, nonetheless, there is an increase (at the CV of OPEX/TCE) of 0.10 (while the ship's DWT is increasing). This may be due to the fact that Aframax vessels transport mainly crude oil and sometimes product oil, while Panamax ships transport mainly clean and dirty oil products and are sometimes hired for short-haul crude oil transportation.

4.3. Transported cargo

All things considered, the risk of each vessel is recognized and it becomes obvious that the cargo plays a role in the firm's profitability and influences the danger of each ship.

Table 3: TCE and OPEX depending on the cargo and independently of the ship's type.

tankers:	*Crude oil*		
KPIs(daily)	***TCE***	***OPEX***	***OPEX/TCE***
Observations	*230*	*328*	
Average	*$ 14.749*	*$ 7.523*	*0.51*
Lower bound	*$ 9.213*	*$ 6.393*	*0.69*
Higher bound	*$ 19.931*	*$ 8.780*	*0.44*
Median	*$ 14.268*	*$ 7.172*	*0.50*
stDEV	*$ 5.690*	*$ 1.481*	*0.26*
CV	*0,39*	*0,2*	*0.51*
Age(AVG)	*10,73*	*9,28*	

tankers:	*Product oil/Chemicals*		
KPIs(daily)	***TCE***	***OPEX***	***OPEX/TCE***
Observations	*178*	*301*	
Average	*$ 10.132*	*$ 6.502*	*0.64*
Lower bound	*$ 6.263*	*$ 5.833*	*0.93*
Higher bound	*$ 13.062*	*$ 7.326*	*0.56*
Median	*$ 10.593*	*$ 6.425*	*0.61*
stDEV	*$ 3.304*	*$ 997*	*0.30*
CV	*0,33*	*0,15*	*0.47*
Age(AVG)	*11,09*	*8,59*	

Source: Moore Maritime Index (2020).

In relation to Table 3 and the total of these observations it can be seen that 52% (= 328/629) of the tankers carry crude oil while the remaining 48% (= 307/629) carry product oil. Moreover, from the total of 221 non-chartered ships, 98 of which carry crude oil, out of which 7 are Panamax and all the others are Aframax / Suezmax / VLCC/ ULCC and 123 carry product oil, which are small tankers/handy/ Panamax.

Furthermore, it is highlighted that the average of TCE is USD 14,749 (per ship and per day) for crude oil and USD 10,132 (per ship and per day) for product oil/ chemicals, which is logical since the price of crude oil is higher and for 2018 52% of the observations transported crude oil. This shows that the crude market is better and preferable.

Also, it is perceived that the average of TCE for crude oil is USD 4,617 higher than that for product oil while the average of OPEX for crude oil is USD 1,021 higher than that for product oil. So, it can be understood again that there is no symmetry or analogy, and the fact that income increases do not mean that OPEX increases by the same amount or percentage.

As for OPEX, ships which transport crude oil have USD 7,523 per ship and per day) as OPEX while those which transport product oil have USD 6,502, at the average bound. As for risk, it is highlighted that crude oil tankers have 0.51 at the CV of OPEX/TCE index while product oil tankers have 0.47. This shows that both of these two categories have the same volatility if it is taken take into consideration that the 0.04 discrepancy is insignificant and also there is a difference in the ships that are offered.

Table 4: Analysis of operating costs depending on the cargo and irrespective of the ship's type.

Crude oil					
OPEX	***Crew***	***Stores***	***R&M***	***Insurance***	***Admin***
Observations	*328*	*328*	*327*	*328*	*328*
Average	*$ 4.292*	*$ 724*	*$ 964*	*$ 462*	*$ 1.084*
Lower Bound	*$ 3.742*	*$ 501*	*$ 536*	*$ 303*	*$ 765*
Higher Bound	*$ 5.065*	*$ 956*	*$ 1.444*	*$ 593*	*$ 1.187*
Median	*$ 4.164*	*$ 683*	*$ 869*	*$ 431*	*$ 978*
stDEV	*$ 694*	*$ 247*	*$ 475*	*$ 166*	*$ 524*
CoV	*0,16*	*0,34*	*0,49*	*0,36*	*0,48*
Age(AVG)	*9,28*	*9,28*	*9,28*	*9,28*	*9,28*

Product oil/Chemicals					
OPEX	***Crew***	***Stores***	***R&M***	***Insurance***	***Admin***
Observations	*300*	*301*	*298*	*300*	*301*
Average	*$ 3.823*	*$ 569*	*$ 878*	*$ 301*	*$ 953*
Lower Bound	*$ 3.490*	*$ 389*	*$ 605*	*$ 192*	*$ 714*
Higher Bound	*$ 4.164*	*$ 756*	*$ 1.073*	*$ 412*	*$ 1.129*
Median	*$ 3.824*	*$ 546*	*$ 833*	*$ 275*	*$ 939*
stDEV	*$ 548*	*$ 197*	*$ 350*	*$ 132*	*$ 279*
CoV	*0,14*	*0,35*	*0,4*	*0,44*	*0,29*
Age(AVG)	*8,54*	*8,59*	*8,57*	*8,6*	*8,59*

Source: Moore Maritime Index (2020).

Analyzing further the average of operating costs for each type of merchandise, it can be distinguished in both cases that the largest part of OPEX is the crew and the smallest part is insurance. Also, in both cases it is understood that after the crew, the next biggest cost is the administration, then R&M, stores and finally insurance. The coefficient volatility (CoV) of OPEX does not have the same results in both cases. In the category of crude oil, it is observed that crew costs have the least risk, and then comes stores, insurance, administration and finally the R&M. While in the product oil category it is conceived that the cost of the crew has the lowest risk, then comes the admin cost, stores, R&M and finally insurance.

4.4 Per cargo and per vessel.

All things considered, by applying the parameters of cargo and type of ship at the same time, it can be identified which ship belongs to which cargo category.

Table 5: All type of ships that carry crude oil. TCE and in more detail OPEX costs of them.

CRUDE OIL

Panamax						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	28	28	28	28	28	21	28
Average	$ 3.970	$ 731	$ 934	$ 412	$ 1.264	$ 10.623	$ 7.310
Lower Bound	$ 3.485	$ 540	$ 492	$ 319	$ 764	$ 7.739	$ 6.343
Higher Bound	$ 4.593	$ 979	$ 1.411	$ 466	$ 2.154	$ 11.830	$ 9.377
Median	$ 3.993	$ 679	$ 899	$ 405	$ 884	$ 10.664	$ 7.136
stDEV	$ 589	$ 185	$ 464	$ 89	$ 695	$ 3.598	$ 1.427
CoV	0,15	0,25	0,5	0,22	0,55	0,34	0,2
Age(AVG)	12,39	12,39	12,39	12,39	12,39	12,57	12,39

Aframax						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	154	154	153	154	154	107	154
Average	$ 4.069	$ 660	$ 907	$ 388	$ 1.068	$ 14.260	$ 7.087
Lower Bound	$ 3.708	$ 484	$ 595	$ 292	$ 821	$ 9.699	$ 6.289
Higher Bound	$ 4.564	$ 871	$ 1.171	$ 500	$ 1.187	$ 18.048	$ 8.102
Median	$ 3.917	$ 604	$ 839	$ 355	$ 992	$ 14.231	$ 6.716
stDEV	$ 571	$ 229	$ 368	$ 109	$ 440	$ 4.243	$ 1.237
CoV	0,14	0,35	0,41	0,28	0,41	0,3	0,17
Age(AVG)	8,34	8,34	8,33	8,34	8,34	10,59	8,34

Suezmax						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	76	76	76	76	76	56	76
Average	$ 4.527	$ 777	$ 928	$ 473	$ 951	$ 16.713	$ 7.656
Lower Bound	$ 3.921	$ 561	$ 414	$ 401	$ 652	$ 11.868	$ 6.885
Higher Bound	$ 5.129	$ 1.000	$ 1.588	$ 565	$ 1.150	$ 22.129	$ 8.563
Median	$ 4.486	$ 730	$ 836	$ 453	$ 980	$ 15.682	$ 7.355
stDEV	$ 505	$ 258	$ 567	$ 85	$ 249	$ 5.350	$ 1.009
CoV	0,11	0,33	0,61	0,18	0,26	0,32	0,13
Age(AVG)	9,74	9,74	9,74	9,74	9,74	9,91	9,74

VLCC						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	51	51	51	51	51	31	51
Average	$ 4.907	$ 880	$ 1.189	$ 694	$ 1.208	$ 16.005	$ 8.878
Lower Bound	$ 4.403	$ 644	$ 698	$ 534	$ 876	$ 9.624	$ 7.834
Higher Bound	$ 5.395	$ 1.097	$ 1.774	$ 893	$ 1.164	$ 22.942	$ 9.936
Median	$ 4.880	$ 838	$ 1.053	$ 691	$ 975	$ 16.564	$ 8.239
stDEV	$ 515	$ 220	$ 559	$ 175	$ 688	$ 6.798	$ 1.311
CoV	0,11	0,25	0,47	0,25	0,57	0,42	0,15
Age(AVG)	9,18	9,18	9,18	9,18	9,18	11,1	9,18

Source: Moore Maritime Index (2020).

Table 6: All type of ships that carry product oil/ chemicals. TCE and in more detail OPEX costs of them.

PRODUCT/CHEMICAL

small tankers						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	48	48	48	47	48	45	48
Average	$ 3.164	$ 414	$ 783	$ 292	$ 728	$ 7.260	$ 5.375
Lower Bound	$ 2.455	$ 239	$ 437	$ 176	$ 522	$ 4.207	$ 4.270
Higher Bound	$ 3.639	$ 583	$ 1.113	$ 370	$ 1.001	$ 10.194	$ 6.273
Median	$ 3.357	$ 396	$ 786	$ 291	$ 709	$ 6.560	$ 5.433
stDEV	$ 691	$ 156	$ 360	$ 116	$ 252	$ 2.964	$ 1.040
CoV	0,22	0,38	0,46	0,4	0,35	0,41	0,19
Age(AVG)	10,77	10,77	10,77	10,87	10,77	10,71	10,77

handy						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	129	130	129	130	130	86	130
Average	$ 3.967	$ 595	$ 914	$ 328	$ 1.006	$ 10.959	$ 6.773
Lower Bound	$ 3.637	$ 404	$ 652	$ 196	$ 774	$ 8.755	$ 6.050
Higher Bound	$ 4.440	$ 793	$ 1.080	$ 434	$ 1.169	$ 12.872	$ 7.862
Median	$ 3.898	$ 563	$ 854	$ 309	$ 956	$ 10.840	$ 6.597
stDEV	$ 433	$ 211	$ 358	$ 160	$ 315	$ 2.647	$ 902
CoV	0,11	0,35	0,39	0,49	0,31	0,24	0,13
Age(AVG)	10,85	10,93	10,92	10,93	10,93	13,05	10,93

Panamax						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	113	113	111	113	113	37	113
Average	$ 3.909	$ 595	$ 861	$ 269	$ 990	$ 11.303	$ 6.608
Lower Bound	$ 3.644	$ 472	$ 639	$ 190	$ 845	$ 9.230	$ 6.135
Higher Bound	$ 4.132	$ 748	$ 1.048	$ 370	$ 1.178	$ 14.741	$ 7.182
Median	$ 3.853	$ 564	$ 835	$ 247	$ 940	$ 11.814	$ 6.440
stDEV	$ 362	$ 153	$ 263	$ 92	$ 198	$ 2.800	$ 647
CoV	0,09	0,26	0,31	0,34	0,2	0,25	0,1
Age(AVG)	4,96	4,96	4,87	4,96	4,96	7,65	4,96

Aframax						KPI (Daily)	
OPEX	Crew	Stores	R&M	Insurance	Admin	TCE	OPEX
Observations	10	10	10	10	10	10	10
Average	$ 4.147	$ 694	$ 1.070	$ 363	$ 926	$ 11.614	$ 7.201
Lower Bound	$ 3.720	$ 486	$ 621	$ 289	$ 714	$ 6.143	$ 6.321
Higher Bound	$ 4.706	$ 1.012	$ 2.209	$ 443	$ 1.033	$ 14.768	$ 8.987
Median	$ 3.833	$ 632	$ 774	$ 361	$ 964	$ 12.606	$ 6.568
stDEV	$ 531	$ 245	$ 708	$ 63	$ 128	$ 3.907	$ 1.324
CoV	0,13	0,35	0,66	0,17	0,14	0,34	0,18
Age(AVG)	8,7	8,7	8,7	8,7	8,7	8,7	8,7

Source: Moore Maritime Index (2020).

In these two Tables, it is perceived for one more time that most ships carry crude oil (if we pay attention to the observations). It can also be seen that crude oil is transported by larger ships while product oil/chemical is transported by smaller vessels. Actually, the ships that transport crude oil are Panamax, Aframax, Suezmax, VLCC and ULCC while vessels that carry product oil/ chemical are small tankers, Handy, Panamax and Aframax. The common ships in these two cargoes are Panamax and Aframax, with the only difference that Aframax ships carry mainly crude oil while Panamax ships carry more often product oil and chemical.

Observing Table 5 (crude oil), it is inferred that the type of ship with the most observations is Aframax, then Suezmax, VLCC, Panamax and finally ULCC vessels. As mentioned above in the crude oil transport category there are 98 non-chartered vessels of which 7 are Panamax, 47 are Aframax, 20 are Suezmax, 20 are VLCC and 4 are ULCC. In the crude oil market and average bound, VLCC ships have the biggest freight rate and Panamax ships have the lowest income.

Aframax vessels have the least total amount of OPEX and VLCC ships have the largest total amount of OPEX. When simply analyzing vessels without the cargo they transport, it is observed that OPEX are getting higher as long as the DWT of the ship increases. In the analysis depending on the cargo, it is observed that the total OPEX for crude oil increases from Aframax to VLCC ships, but Panamax ships have bigger OPEX than Aframax (by USD 223 on Average bound). This may happen because Panamax vessels carry crude oil more rarely in short routes and there are not a lot of observations. All vessels that transport crude oil have the biggest part of OPEX in the crew ,after that in admin, then in R&M, stores and finally in insurance.

In Table 6 (product oil/chemical), it is observed that the type of ship with the most observations is handy, then Panamax, small tankers and finally Aframax ships follow. As mentioned above in the category of vessels that carry product oil there are 123 non-chartered ships of which 3 are small tankers, 44 are handy and 76 Panamax. In the product oil/ chemical market and average bound, Aframax vessels have the biggest freight rate and small tankers have the lowest income.

Small tankers have the least total OPEX (average) and Aframax have the largest total OPEX. In contrast to the crude oil market, here the OPEX of Handy ships are abruptly enhanced. Maybe this happens because handy vessels are more flexible and they have the ability to approach more ports compared with Panamax and Aframax.

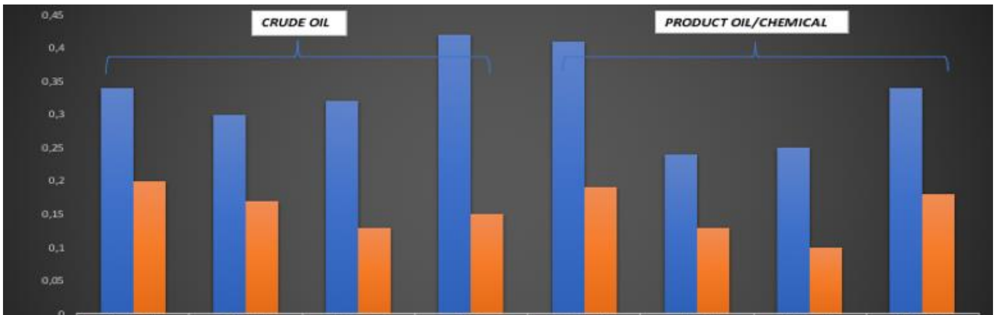
Also, in Table 6 it is noticed that Aframax ships have higher OPEX (average) than Panamax by USD 593 . This occurs because in this market (product oil) , Aframax ships carry product oil/chemicals more rarely and also there are few ships in this category.

Moreover, as in the crude oil market, here too most of the OPEX per ship is crew, then admin, R&M, stores and finally insurance. The only difference that is apparent is the fact that in small tankers and Aframax (namely the smallest ships in the category) most of the OPEX is the crew and then R&M, admin, stores and finally insurance. The fact that these two categories of ships have R&M costs from USD 60 to USD 140 higher than admin costs is caused maybe by the fact that small tankers are older ships (age) so they have bigger repair and maintenance costs. Also, Aframax ships have bigger spare costs in the product oil /chemical market maybe because they are younger ships.

Apart from the OPEX, the TCE can be seen in detail (Tables 5 & 6) and in this case it is understood that if the capacity of the ship increases then the revenues also increase. That happens regardless of the type of transported product and of the category that they belong to (either low or high bound etc.). By separating them per cargo and per ship, it can be noted that in the lower bound the small tankers have smaller TCE of OPEX. This means that these ships are forced to be chartered even if they are damaged because they will provide some income (in order to pay their costs) in contrast to the vessels that have only costs and do not operate.

In order to recognize the risk more easily, we need to compare the coefficient volatility of each one, so the next Figure 5 is created with the help of Tables 5 and 6.

Figure 5: Coefficient volatility of each cargo and each type of ship.



	Panamax	Aframax	Suezmax	VLCC	Small tanker	Handy	Panamax	Aframax
CV TCE	0,34	0,3	0,32	0,42	0,41	0,24	0,25	0,34
CV OPEX	0,2	0,17	0,13	0,15	0,19	0,13	0,1	0,18

Source: Author

In Figure 5 as for the TCE in crude oil category it is highlighted that VLCC ships have the biggest risk and Aframax ships have the lowest risk. Something that is reasonable because they are such huge vessels and they are not chartered as frequently as any other ship. Also, they may not be fully loaded and end up with a bigger freight rate while, in the product oil /chemical category, Small tankers have the biggest volatility and handy ships have the lowest variability. Irrespective of the product category, it is noticed that VLCC ships have the biggest volatility and handy ships have the lowest variability, as far as TCE analysis is concerned.

Moreover, in the same figure, as far as OPEX in the crude oil category is concerned, it is thought that Panamax vessels have the highest risk and Suezmax vessels have the smallest risk while in the product oil / chemical category, Small tankers have the highest risk and Panamax vessels have the smallest risk. Regardless of the product category, it is thought that Panamax ships have a higher volatility when transporting crude oil than when carrying product oil/ chemicals, as far as the OPEX analysis is concerned.

4.5. Aframax vessels per flag

As commented before, the only ships that are common in both product categories are Panamax and Aframax vessels. For this reason and because Panamax vessels are more famous and have been hyper analyzed, it has been decided to continue our analysis based on Aframax ships. So, some other filters from the MMI are utilized and extra results are extracted.

Table 7: TCE and OPEX respectively on Aframax vessels per flag.

tankers:	Aframax	Marshall Islands	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	19	61	
Average	$ 14.081	$ 6.846	0.49
Lower bound	$ 7.729	$ 6.251	0.81
Higher bound	$ 22.764	$ 7.630	0.34
Median	$ 14.231	$ 6.602	0.46
stDEV	$ 5.216	$ 767	0.15
CV	0,37	0,11	0.30
Age(AVG)	9,42	4,54	

Marshall Islands					
OPEX	Crew	Stores	R&M	Insurance	Admin
Observations	61	61	61	61	61
Average	$ 3.972	$ 670	$ 916	$ 347	$ 941
Lower Bound	$ 3.772	$ 478	$ 657	$ 288	$ 804
Higher Bound	$ 4.337	$ 859	$ 1.149	$ 424	$ 1.127
Median	$ 3.904	$ 590	$ 856	$ 321	$ 887
stDEV	$ 275	$ 259	$ 336	$ 70	$ 178
CoV	0,07	0,39	0,37	0,2	0,19
Age(AVG)	4,54	4,54	4,54	4,54	4,54

tankers:	Aframax	Malta	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	19	19	
Average	$ 15.167	$ 8.842	0.58
Lower bound	$ 12.125	$ 7.299	0.6
Higher bound	$ 18.086	$ 10.298	0.57
Median	$ 15.169	$ 8.186	0.54
stDEV	$ 3.369	$ 1.665	0.49
CV	0,22	0,19	0.85
Age(AVG)	8,89	8,89	

Malta					
OPEX	Crew	Stores	R&M	Insurance	Admin
Observations	19	19	19	19	19
Average	$ 5.055	$ 718	$ 1.149	$ 376	$ 1.544
Lower Bound	$ 4.424	$ 487	$ 536	$ 338	$ 915
Higher Bound	$ 5.525	$ 956	$ 2.053	$ 438	$ 2.823
Median	$ 4.982	$ 707	$ 985	$ 355	$ 1.026
stDEV	$ 648	$ 171	$ 602	$ 90	$ 779
CoV	0,13	0,24	0,52	0,24	0,5
Age(AVG)	8,89	8,89	8,89	8,89	8,89

tankers:	Aframax	Liberia	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	63	63	
Average	$ 13.129	$ 6.805	0.51
Lower bound	$ 9.143	$ 6.321	0.69
Higher bound	$ 16.434	$ 7.055	0.43
Median	$ 13.318	$ 6.604	0.50
stDEV	$ 4.067	$ 783	0.19
CV	0,31	0,12	0.37
Age(AVG)	11,41	11,41	

Liberia					
OPEX	Crew	Stores	R&M	Insurance	Admin
Observations	63	63	63	63	63
Average	$ 3.918	$ 638	$ 847	$ 394	$ 1.009
Lower Bound	$ 3.693	$ 487	$ 632	$ 299	$ 936
Higher Bound	$ 4.147	$ 833	$ 1.040	$ 474	$ 1.116
Median	$ 3.885	$ 572	$ 785	$ 369	$ 995
stDEV	$ 281	$ 209	$ 347	$ 113	$ 253
CoV	0,07	0,33	0,41	0,29	0,25
Age(AVG)	11,41	11,41	11,41	11,41	11,41

Source: Moore Maritime Index (2020).

Applying the flag filter to MMI for Aframax vessel, it is noticed that this type of ship uses in its majority (87%=143/164) 3 types of flags. These flags are : Marshall island , Malta and Liberia. So, Table 7 shows for each flag of Aframax ships, all the necessary data either TCE or OPEX.

In Table 7, it can be seen that the average TCE for the Marshall Island flag is USD 14,081, for Malta is USD 15,167 and for Liberia USD 13,129. The ships chartered under these 3 flags are 101 in total. So, it is marked that the average of all these vessels is about USD 13,691=(14,081*19+15,167*19+13,129*63)/101. From Tables 5 & 6, viewing only Aframax for 2018, it is noticed that the daily average TCE is USD 14,034 with 117 total chartered vessels. After observing the data of these two Tables, it becomes obvious that 21 Aframaxes, with a flag other than the three mentioned above, have TCE average bigger than USD 13,700.

Moreover, freight rates with the Marshall Island flag have a wider range of prices (7,729-22,764) in comparison to the ones with Malta's and Liberian flags. In OPEX/TCE index, it is pointed out that Aframax ships with the Marshall island flag have lower risk, then come Aframax with Liberian flag and the ones with Malta's flag follow with 0.30, 0.37 and 0.85 of CV respectively. Especially, in Aframax with Marshall island flag 0.30 per TCE unit is OPEX while in the ones with Malta's flag 85% per TCE unit cover the OPEX. After this, it is understood that OPEX in the ones with Malta's flag is more expensive and it is reasonable for Aframax vessels to ask bigger freight rate because if OPEX are not covered and have no profit then they will not be chartered and it is not in their interest not to be chartered.

Moreover, in the right part of Table 7 the OPEX can be seen in more detail . In it, it is inferred that the biggest cost (comparing average prices) is the crew, then admin, R&M, stores and finally insurance follows. In all three cases the crew costs have the lowest risk since they are expected and they are less volatile even though they form the most part of OPEX. OPEX of Aframax ships with Marshall island has the biggest risk at the stores part while Aframax vessels with Malta's and Liberian flag have the biggest risk at the R&M part. Provided that values of CV are less than 0.5 these options are not deemed dissuasive.

It is also noticed that ships with the Marshall flag are young (with an average age of 5 years), which shows that this flag is preferred for new ships because it is a flag of opportunity, it covers many ports and is trustworthy in order to make charter easier even though they are new and they are not so reliable.

Ships with the Marshall island flag are younger while those with the Liberian flag are older. At the average bound, those that have the highest income are the ones with Malta's flag while those with the Liberian flag have the lowest income (per day and per ship). As for OPEX, those with Liberian flag have the lowest fixed costs while those with Malta's have the highest fixed costs (per day and per ship). As for volatility both OPEX and TCE, ships with Marshall island flag have the lowest variability (CV of OPEX/TCE index) and those with Malta's have the highest volatility.

4.6. Shipyards of Aframax vessels.

One more factor thought to affect the incomes and costs of ships is the shipyards that vessels are built in. Some clients are looking for the shipyard of vessels in order to trust either the vessel or the shipping firm. For this reason, it is necessary to analyze it, through the filters of MMI.

According to MMI (for the year 2018) the total number of Aframax ships is 164. In the left part of Table 8, it can be seen that 158 of them were built in either China, Japan or South Korea. More specifically 16,5%=(27/164)% of Aframax were built in China, 22%=(36/164)% of them were built in Japan and finally 58%=(95/164)% of them were built in South Korea.

With the help of Table 8, it is understood that vessels which were built in China are young. As a result, it is observed that China is new in the market of building ships. For this reason, vessels, which were built there, have higher freight rate than those that were built in South Korea. This shows that these ships are not trustworthy and in order to be chartered, bigger freight rates were agreed. Also, it is recognized that South Korea is the market leader (Newbuildings) with a lot of ships in its possession. Moreover, shipyards of Japan have built fewer ships but these are older than the vessels of the South Korean shipyards.

Generally, the Average and Lower bound bigger freight rate shows up in Aframax ships which were built in Japan. While the Higher bound bigger freight rate is seen in Aframax which were built in China. In contrast to TCE, it can be seen that in all bounds OPEX are higher only in vessels which are built in Japan.

At the average bound, Aframax built in Japan have higher income and those built in South Korea have lower income. The exact opposite is true for operating costs.

Table 8: TCE and OPEX at Shipyards of Aframax vessels.

tankers:	Aframax	Built: China	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	13	27	
Average	$ 14.284	$ 6.992	0.49
Lower bound	$ 9.593	$ 5.705	0.59
Higher bound	$ 22.764	$ 8.348	0.37
Median	$ 13.213	$ 6.728	0.51
stDEV	$ 4.471	$ 1.448	0.32
CV	0,31	0,21	0.66
Age(AVG)	8,54	5,48	

Built: China					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	27	27	27	27	27
Average	$ 3.846	$ 681	$ 1.083	$ 414	$ 968
Lower Bound	$ 3.581	$ 481	$ 447	$ 340	$ 649
Higher Bound	$ 4.412	$ 859	$ 1.591	$ 494	$ 1.151
Median	$ 3.875	$ 656	$ 875	$ 389	$ 859
stDEV	$ 591	$ 288	$ 603	$ 96	$ 374
CoV	0,15	0,42	0,56	0,23	0,39
Age(AVG)	5,48	5,48	5,48	5,48	5,48

tankers:	Aframax	Built: Japan	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	36	36	
Average	$ 15.913	$ 7.578	0.48
Lower bound	$ 10.998	$ 6.376	0.58
Higher bound	$ 20.922	$ 8.761	0.42
Median	$ 15.159	$ 7.468	0.49
stDEV	$ 4.229	$ 1.148	0.27
CV	0,27	0,15	0.57
Age(AVG)	10,69	10,69	

Built: Japan					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	36	36	36	36	36
Average	$ 4.221	$ 876	$ 908	$ 441	$ 1.133
Lower Bound	$ 3.617	$ 650	$ 585	$ 301	$ 778
Higher Bound	$ 4.809	$ 1.052	$ 1.391	$ 554	$ 1.199
Median	$ 4.176	$ 836	$ 874	$ 420	$ 1.077
stDEV	$ 570	$ 239	$ 363	$ 131	$ 512
CoV	0,14	0,27	0,4	0,3	0,45
Age(AVG)	10,69	10,69	10,69	10,69	10,69

tankers:	Aframax	Built: South Korea	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	62	95	
Average	$ 12.900	$ 6.933	0.54
Lower bound	$ 8.904	$ 6.309	0.71
Higher bound	$ 16.136	$ 7.104	0.44
Median	$ 13.198	$ 6.595	0.5
stDEV	$ 3.770	$ 1.205	0.32
CV	0,29	0,17	0.59
Age(AVG)	10,85	8,29	

Built: South Korea					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	95	95	94	95	95
Average	$ 4.045	$ 581	$ 895	$ 358	$ 1.066
Lower Bound	$ 3.742	$ 461	$ 695	$ 285	$ 845
Higher Bound	$ 4.184	$ 709	$ 1.077	$ 447	$ 1.145
Median	$ 3.904	$ 556	$ 818	$ 321	$ 989
stDEV	$ 529	$ 143	$ 324	$ 92	$ 415
CoV	0,13	0,25	0,36	0,26	0,39
Age(AVG)	8,29	8,29	8,27	8,29	8,29

Source: Moore Maritime Index (2020).

However, regardless of the OPEX, it has to be mentioned that in terms of the CV of the OPEX/TCE index, vessels that are built in Japan are less risky than these of China. This may occur because China is a new player in this market, so it is more dangerous than others. In all three cases they have CV of OPEX/TCE bigger than 0.5 which shows that there is volatility both OPEX and TCE depending on the country of origin. Also, this fact also shows that the shipyard is an important factor that affects incomes, costs and generally the revenues of firm.

From the right part of Table 8,the OPEX can be analyzed in the main three shipyards. At any bound and in any shipyard, it is pointed that crew costs are the biggest part of OPEX and insurance costs are the lowest part of OPEX. Observing the coefficient of variability of each case, it is detected that ships, which are built in Japan and South Korea, have the lowest risk at crew , then stores, insurance, R&M and finally admin. While vessels from China have the lowest risk at crew, then insurance, admin, stores and finally R&M. Furthermore, it is acknowledged that the CV in R&M of Aframax which were built in China is the only one higher than 0.5. From these two situations, it can be deduced that China's shipyards are risky because they do not have the know-how.

4.7. Age of Aframax vessels.

Time is of vital importance in any sector of our life. Generally, time is a factor that affects many things. All the data, that MMI shows, are reported in 2018. For this reason, the only way to control the influence of time is to see how the data change depending on the year that the Aframax ships were built. The first data found regarding the year of manufacture of Aframax ships is that of 1997 (according to MMI).

Table 9: TCE and OPEX regardless of the transported cargo by Aframax vessels, all the data from to 1997 to 2018 per five years (based on built year).

CRUDE AND PRODUCT

tankers:	Aframax	Built 97-02	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	14	14	
Average	$ 13.780	$ 8.219	0.60
Lower bound	$ 10.542	$ 6.891	0.65
Higher bound	$ 16.964	$ 9.323	0.55
Median	$ 13.178	$ 7.831	0.59
stDEV	$ 4.625	$ 1.982	0.43
CV	0,34	0,24	0.72
Age(AVG)	17,71	17,71	

Built: 97-02					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	14	14	14	14	14
Average	$ 4.583	$ 882	$ 1.150	$ 442	$ 1.162
Lower Bound	$ 3.994	$ 686	$ 633	$ 342	$ 991
Higher Bound	$ 5.015	$ 1.013	$ 2.053	$ 535	$ 1.140
Median	$ 4.366	$ 852	$ 960	$ 434	$ 1.075
stDEV	$ 870	$ 263	$ 593	$ 100	$ 569
CoV	0,19	0,3	0,52	0,23	0,49
Age(AVG)	17,71	17,71	17,71	17,71	17,71

tankers:	Aframax	Built 02-07	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	50	54	
Average	$ 13.865	$ 7.032	0.51
Lower bound	$ 9.219	$ 6.373	0.69
Higher bound	$ 16.964	$ 7.987	0.47
Median	$ 14.524	$ 6.764	0.47
stDEV	$ 3.807	$ 1.241	0.33
CV	0,27	0,18	0.64
Age(AVG)	13,66	13,5	

Built: 02-07					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	54	54	53	54	54
Average	$ 3.992	$ 659	$ 967	$ 428	$ 1.007
Lower Bound	$ 3.732	$ 485	$ 585	$ 306	$ 784
Higher Bound	$ 4.260	$ 871	$ 1.390	$ 550	$ 1.139
Median	$ 3.972	$ 604	$ 837	$ 411	$ 1.003
stDEV	$ 527	$ 247	$ 492	$ 129	$ 310
CoV	0,13	0,37	0,51	0,3	0,31
Age(AVG)	13,5	13,5	13,55	13,5	13,5

tankers:	Aframax	Built 07-12	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	47	50	
Average	$ 13.423	$ 7.133	0.53
Lower bound	$ 9.172	$ 6.336	0.69
Higher bound	$ 16.055	$ 8.358	0.52
Median	$ 12.990	$ 6.668	0.51
stDEV	$ 4.392	$ 1.082	0.25
CV	0,33	0,15	0.46
Age(AVG)	9,04	9,1	

Built: 07-12					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	50	50	49	50	50
Average	$ 4.004	$ 720	$ 961	$ 412	$ 1.056
Lower Bound	$ 3.581	$ 511	$ 639	$ 319	$ 700
Higher Bound	$ 4.434	$ 976	$ 1.391	$ 545	$ 1.172
Median	$ 3.868	$ 654	$ 867	$ 377	$ 1.006
stDEV	$ 495	$ 270	$ 372	$ 100	$ 439
CoV	0,12	0,38	0,39	0,24	0,42
Age(AVG)	9,1	9,1	9,06	9,1	9,1

tankers:	Aframax	Built 12-17	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	15	53	
Average	$ 16.615	$ 6.885	0.41
Lower bound	$ 13.821	$ 6.289	0.46
Higher bound	$ 19.878	$ 7.503	0.38
Median	$ 16.371	$ 6.589	0.40
stDEV	$ 2.681	$ 899	0.34
CV	0,16	0,13	0.81
Age(AVG)	2,87	2,66	

Built: 12-17					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	53	53	53	53	53
Average	$ 4.091	$ 590	$ 835	$ 326	$ 1.042
Lower Bound	$ 3.776	$ 458	$ 652	$ 283	$ 833
Higher Bound	$ 4.666	$ 685	$ 975	$ 396	$ 1.205
Median	$ 3.904	$ 576	$ 800	$ 311	$ 915
stDEV	$ 460	$ 137	$ 224	$ 57	$ 422
CoV	0,11	0,23	0,27	0,17	0,4
Age(AVG)	2,66	2,66	2,66	2,66	2,66

tankers:	Aframax	Built 12-18	
KPIs(daily)	**TCE**	**OPEX**	**OPEX/TCE**
Observations	20	62	
Average	$ 16.629	$ 6.824	0.41
Lower bound	$ 13.701	$ 6.123	0.45
Higher bound	$ 19.953	$ 7.503	0.38
Median	$ 16.383	$ 6.562	0.40
stDEV	$ 3.157	$ 949	0.30
CV	0,19	0,14	0.73
Age(AVG)	2,15	2,27	

Built: 12-18					
OPEX	**Crew**	**Stores**	**R&M**	**Insurance**	**Admin**
Observations	62	62	62	62	62
Average	$ 4.071	$ 579	$ 791	$ 329	$ 1.054
Lower Bound	$ 3.770	$ 457	$ 545	$ 283	$ 833
Higher Bound	$ 4.526	$ 685	$ 964	$ 393	$ 1.205
Median	$ 3.901	$ 565	$ 786	$ 314	$ 915
stDEV	$ 448	$ 144	$ 257	$ 57	$ 430
CoV	0,11	0,25	0,32	0,17	0,41
Age(AVG)	2,27	2,27	2,27	2,27	2,27

Source: Moore Maritime Index (2020).

It has been chosen to analyze per five years of construction because the first data were found in 1997 and it is important to check if this time influences the data relative to 2008 crisis. But after 2017 there is a narrow sample, for which reason in the two last boxes of the table, there are the data between 2012 and 2018 in order to compare the changes between 2012 and 2017 and to come to a conclusion about 2018 ships.

Firstly, Table 9 shows the observations of OPEX from 1997 to 2018 and it is recognized that while in the period between 1997 and 2002, 14 Aframax have been built and every 5 years later, observations are increasing, except for the period of 2007-2012. This means that the 2008 crisis had an impact on the newbuilding's market. This influence is also evident on the income side. This impact may not be reflected in how many ships are chartered but it is certainly evident in the freight rates that have been made. The TCE ranges from USD 13,780 in the first five years and ends at USD 16,629 in the last five years (daily). This shows how much the market for Aframax ships has grown. From the second to the third five-year period, which includes the crisis of 2008, the reduction of TCE is USD 44.The reduction is small but it is there. Over the next five years not only did the production of Aframax ships increase, but even though fewer ships were chartered, the freight rate managed to increase by more than USD 3,000.

In this analysis we may not be able to refer to today but it can be discerned what happened in 2018, since the MMI shows the data of 2018. By choosing as a filter only the year of construction of 2018 we do not have any results because the sample is small. However, from the boxes of the Table 9 that refer to 2012-2017 and 2012-2018 we can get some general results for the year of 2018. Initially, it can be seen that for 2018, 9 Aframax were built, 5 of which were chartered. Since in the average bound of TCE they have almost the same price, it is understood that these five ships were chartered at a similar price and are moving according to the market.

In contrast to incomes, it is observed that OPEX decrease as time changes. This shows that the appropriate know-how has been acquired. More specifically, in the right part of Table 9, it is evident that in the average bound, regardless of the time of a ship's built, the most part of OPEX is the crew, followed by the admin, R&M, stores and finally the insurance. Also, with the passage of time, it is obvious that the costs for crew and administration are almost unchanged and that the remaining costs are reduced. This reduction makes sense as the number of ships increases and materials and spare parts are known, as are their suppliers, and so there is reliability.

So, when this filter is applied at Aframax, regardless of the cargo that it carries, it is concluded that as the five-year period changes, the ship's revenues increase except for 2007 to 2012, where the 2008 crisis intervened. The exact opposite is true for fixed costs and the risk (CV of OPEX/TCE index).

This approach was considered because initially it was the only way to have tangible data of a company regardless of its name and its portfolio. Also, the report was for a specific year (2018) and was a way to have some information on the freight rate earned regardless of the type of charter (time charter or voyage, etc.). Finally, because these results should have some basis and not be theoretical ,as they should also be comparable. This approach was also chosen because it gives data on OPEX costs and analyzes everything. There is always the unbalanced factor and the fluctuating costs, but the operating costs are the ones that are always present in all ships.

Generally, through all this research, it has been made clear that every change of parameters, filters or even characteristics of ships has an impact on every market (crude oil and product oil/ chemical market) and this impact changes the incomes, costs, profits, risks or even strategic choices.

5.Conclusions

The aim of this study was to investigate the revenue and cost behavior in the tanker sector and mainly regarding Aframax vessels. This was achieved via an analysis of revenues and the operating costs of tankers.

Revenue (defined as Time Charter Equivalent rates) and costs either fixed or variable are the most essential elements for a company's profitability. Variable costs are more difficult to define, are not the same for every ship and therefore cannot be compared with other variable costs or with the respective incomes of each vessel, in order to obtain an accurate numerical result. For this reason, OPEX (Operating Expenses) are analyzed in this research, as costs.

The analysis of operating costs and TCE for tankers will provide useful information not only for shipowners, but also for shippers and charterers. The issue, of which vessel is more profitable and how certain values, influenced by various factors, are changing, is covered in this study. After resolving these issues, both shipowners and shippers have the unique opportunity to make the right choices for their own interests. The data of TCE, OPEX, and OPEX/TCE index are the most important elements in order to identify a good or bad market and whether or not, a company can be profitable. Furthermore, the factors that affect each ship and how these factors can simultaneously influence the respective sector (crude oil or product oil/ chemicals) are also indicated.

The data for the research was obtained from the Moore Maritime Index database and the information on income (TCE), operating costs and OPEX/TCE index for each tanker ship type in particular situations, is presented.

The variety of situations which were demonstrated, emerges from the use of MMI filters. The filters that were used are per vessel type, per cargo sector (crude oil, product oil/chemicals), per vessel type and per cargo sector simultaneously. Consequently, the research focused on Aframax vessels and the filters utilized were per flag, per country of built, and per year of built.

The research compares these yields (OPEX, TCE, OPEX / TCE) in all cases, drawing some conclusions for the tanker sector in general and for the Aframax ships in particular.

First of all, the general research without filters revealed that in 2018, 408 ships have TCE data and 629 ships have OPEX data, according to MMI database. They accrued a daily income of USD 12,735 with a daily OPEX cost of USD 7,035 on average. In general, the OPEX/TCE index shows that this market has medium variability due to the fact that CV of this index is 0.47, which indicates that both OPEX and TCE can be modified but are not so easily controlled.

In the research per type of ship, it has been concluded that income increases as ship's DWT (Deadweight tonnage) increases. It is also evident that OPEX improves as the ship's DWT increases. In addition, it is observed that ships with small DWT capacity run more risk (higher CV of OPEX/TCE index - as long as both their costs and revenues are more volatile) compared to the bigger vessels.

Although the Aframax is the next largest ship after Panamax, as revealed, there is an increase in the CV of OPEX/TCE of 0.10 while the ship's DWT is increasing. A reason for this, might be the fact that Aframax vessels transport mainly crude oil and sometimes product oil, while Panamax ships transport mainly clean and dirty oil products and are sometimes hired for short-haul crude oil transportation.

When analyzing vessels per type of cargo, it was highlighted that the crude oil sector has better yields than the product oil /chemical sector. It was observed that 230 tankers were chartered in the crude oil sector, whereas 178 vessels were chartered in the product oil/ chemical sector. As a result, it was noticed that more ships were chartered in the crude oil sector, therefore the greater the demand for these ships, the better their daily incomes. This is visible by observing the respective freight rates. Vessels in crude oil sector had an income USD 14,749 on a daily basis, while in product oil/chemicals sector their daily income was USD 10,132, even though both cases presented almost the same volatility both OPEX and TCE (CV of both OPEX/TCE index is around 0.5).

By applying the filters of the type of cargo and type of ship at the same time, it was determined which ship belongs to which cargo sector (crude oil, product oil/chemicals). Both Panamax and Aframax ships are identified in both categories of cargo, crude oil and product oil/ chemical.

In a more detailed analysis, it is noticed that in crude oil sector Suezmax ships have the biggest freight rate and Panamax ships have the lowest income. Also, VLCC ships have the biggest OPEX and Aframax vessels have the lowest costs. In addition to this, Panamax ships have the highest volatility both OPEX and TCE (CV of OPEX/TCE index is 0.58) and VLCC vessels have the lowest volatility at 0.35.

In the product oil/chemical sector, it is recognized that Aframax vessels command the highest income and small tankers the lowest. Also, Aframax ships have the biggest OPEX and small tankers have the lowest. Moreover, Handy ships present the biggest volatility (CV of OPEX/TCE index is 0.54) and Panamax tankers the lowest at 0.40.

Regardless of the type of cargo, Aframax vessels present almost the same volatility both OPEX and TCE. More extensively, as for crude oil, Aframax ships have 0.56 variability (CV of OPEX/TCE index), while in the case of product oil/ chemicals, they have 0.52 volatility.

The rest of this research focused on Aframax ships as they belong both in the crude oil sector as well as product oil/ chemical sector. One factor that influences the yield of ships is also their flag of convenience. It has been noticed that the Marshall island's, the Maltese, or the Liberian flags are used, with the latter having the highest preference. Vessels that yield the highest income are the ones with Malta's flag which has a freight rate of USD 15,167. On the other hand, those with the Liberian flag have the lowest income at USD 13,129 (per day and per ship). Regarding the OPEX, those with the Liberian flag present the lowest costs at USD 6,805 while those with Malta's flag the highest at USD 8,842 (per day and per ship). The ships with the Marshall island flag show the lowest volatility (CV of OPEX/TCE index is 0.30) and those with Malta's the highest at 0.85.

Moreover, vessels with the Marshall island flag (whether they are chartered or not) are younger than others and those with the Liberian flag are older. It can be observed from the chartered Aframax ships that the younger vessels are those with Maltese flag and they appear to have bigger freight rates than others. But they have high volatility both OPEX and TCE, maybe because they are not so reliable.

After researching the Aframax vessels, it is noted that another factor that influenced this investigation is the country where the ship was built. In this case it is highlighted that Aframax vessels built in Japan have higher income (at USD 15,913) than the others, even though they have medium variability (CV of OPEX/TCE is 0.57) and higher OPEX (at USD 7,578).

One more factor that influenced the data is the year that the vessel was built. For this reason, ships built between 1997 and 2018 are analyzed per five-year period. It is concluded that the younger the ships, the higher their income. This is obvious due to the fact that the TCE of Aframax ships built between 2012 and 2018 was USD 16,629 while the income of the ones built from 1997 to 2002 was USD 13,780. Apart from the period between 2007 and 2012, where the 2008 crisis intervened and revenues are almost stable (at USD 13,423) compared to the Aframax ships built in the previous five years. The exact opposite applies to OPEX and the volatility both OPEX and TCE (CV of OPEX/TCE index). The OPEX of Aframax vessels manufactured between 2012 and 2018 was USD 6,824, while the operating expenses of the ones constructed between 1997 and 2002 was USD 8,219 . Vessels manufactured between 2007 and 2012 present the lowest variability (the CV of OPEX/TCE index is 0.46) of all.

In all the above cases, the OPEX were analyzed thoroughly and it was concluded that the biggest part of them is attributed to the crew (is around 57%) and the smallest part is attributed to insurance (is around 5%), in every case.

Regardless of the time period, the number of ships, etc. it is observed that there are fluctuations in the tanker sector regarding either on incomes or costs.

Furthermore, with this research it was determined that some factors that affect the operation of the ship can also affect its profitability. These factors are the age of the ship, the type of cargo, the flag of the country they have been registered in and the shipyard where it was built. All these affect not only their TCE but also their OPEX.

In the analysis of cost, it was possible only to study and analyze the OPEX. A limitation of this analysis is the lack of a holistic approach that could lead to accurate numerical results and data. However, the analysis provides some useful data and shows that apart from the volatility of freight rates, volatility of OPEX also exists, but not at the same pace or in the same direction.

The findings of this study can be used in practice by tanker owners and tanker charters when negotiating tanker freight rates and contracts and by cargo owners while demanding more efficient ships.

As United Nations Conference on Trade and Development - UNCTAD (2018, pg. 1) mentioned, world seaborne trade is predicted to expand at a compound annual growth rate of 3.8 per cent between 2018 and 2023.Volumes across all segments are set to grow, with containerized and dry bulk commodities trades recording the best performances. Tanker trade volumes are also projected to increase, although at a slightly slower pace than other market sectors, a trend that is consistent with historical patterns.

At the end of this research, a number of recommendations for future research are presented. Firstly, since we deployed official data for 2018, a suggestion would be to create a similar comparison and investigation for the following years. Also, it could be analyzed if the provisions of the UNCTAD report have been accomplished nowadays, namely regarding enhancement of chartered tankers as tanker trade volumes are forecast to increase.

Some issues emerge for further research due to the fact that some unpredictable parameters exist, such as the economic crisis or the pandemic. One topic for analysis is how the freight rates and OPEX are affected by the Covid-19 pandemic. Another issue is which of all known unpredictable parameters have affected our incomes and expenses, and how.

Finally, petroleum has seasonality, both winter and summer the demand for this is increasing. Therefore, it would be a good idea to study if there is any seasonal fluctuation of freight rates and OPEX in the tanker sector and if this has an impact on the sector (either the crude one or product oil one), which will help shipowners, charterers, and cargo owners even more regarding their growth strategy.

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