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An analysis of the possible impact of the IMO 2020 regulation, in the market structure of the liner industry.

by

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The process of the thesis is the last academic venture of this year, signifying MEL's conclusion. This year has been an adventure to all of us, an adventure that assisted me to familiarize with many different cultures, to cultivate team work spirit and to comprehend in a profound level the shipping industry. On these grounds, the main idea behind this research's topic was born, through the many projects, discussion and classes that this year assigned to us.

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Abstract

Since, the irrevocable date of the enforcement of the IMO 2020, which regulates Sulphur restriction in marine fuel, has been established, to 1st of January 2020, the shipping industry is facing yet another challenge. It has been proved by various studies that environmental regulations (like MARPOL), can affect the competitiveness of the companies operating in the respective market. Thus, in the subject research it was investigated the possible impact that the IMO 2020, may ensue upon the liner market structure. Specifically, the concentration rate of the market before and post-IMO 2020 will be compared, by utilizing a widely utilized market concentration measure, the Herfindahl-Hirschman Index (HHI). Currently, the majority of the shipping companies, has adopted a reactive approach towards the regulation and has not proceeded to disclose their compliance actions yet. After investigating the possible alternatives chosen from the liners, in this paper, four scenarios were formed, based on the forecasted increase of Low Sulphur marine Fuel and the price sensitivity of the shippers towards the increased freight rates. Under all cases, the concentration rate of the market is decreasing, due to the allocation of demanded transported volumes from the fuel compliant companies to other modes or shareholders. Ultimately, the analysis concluded that the liner market will remain unconcentrated, although it will become more competitive due to the decrease in the market shares of the fuel compliant liners.

Table of contents

List of Tables

List of abbreviations

IMO	International Maritime Organization
ECA	Emission Control Area
SECA	Sulphur Emission Control Area
HHI	Herfindahl-Hirschman Index
UNCTAD	United Nations Conference on Trade and Development
HSF/HSFO	High Sulphur Fuel Oil
LSF/LSFO	Low Sulphur Fuel Oil
LNG	Liquified Natural Gas
LSD	Low Sulphur Distillates
TEU	Twenty-foot Equivalent Unit
DWT	Deadweight Tonnage
MGO	Marine Gasoil
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
PED	Price Elasticity of Demand

1. INTRODUCTION

Throughout the past decade, the various environmental regimes related to the shipping industry's induced emissions, have challenged the maritime sector. While the maritime world is seeking, both in a financial and technological manner, to follow the existing environmental regulations, a new emission restrictive has emerged. In October 2017, a new regulation, was passed by IMO after years of debate and deliberation, which enforces vessels to reduce their bunkers' Sulphur levels to 0,5% m/m (mass to mass), while sailing outside the ECA zones and to 0,1% m/m, inside the ECA zones, as of January 1st 2020 (Molloy, 2016). The relevance of the IMO 2020 regulation, can be grasped when one bears in mind the significant contribution of international shipping in the environmental degradation (Antturi et al., 2016). Nevertheless, although maritime transportation is regarded as the most environmentally friendly transportation mode in terms of environmental distortion, among the alternatives, producing 10 grams of Carbon Dioxide per ton of cargo and kilometer transported (CO_2gr/ton/km), rail, automotive vehicles and air transport, one should not disregard the tremendous volumes transported by seaborne trade (Nikolakaki, 2012 and Worldshipping.org, 2018). The rapid global growth and the constant increase of the derived demand for transportation, indicate that any attempt of reducing the vessel-generated air pollutants, will be countermanded by the aforementioned phenomenon (Johnson et al., 2013). Therefore, what remains to be examined is the impact that the regulation may inflict upon the shipping industry, by introducing yet a further time and cost restrictive challenge.

1.1 Problem identification

The enforcement of the IMO 2020 regulation is arguably one of the industry's environmentally defining moments, as it is expected to have a beneficial impact on human health and environment (IMO, 2018). However, this regulation is expected to result in an increase in costs related to maritime transport, accompanied by impacts on the operation of shipping companies and the market structure of the shipping industry itself (Gilbert, 2014).

Until recently, the pillar of shipping companies' competitiveness was to provide customized transportation services, under minimum operational cost (Haralambides, 1998). However, the new environmental framework, indicates that the companies' ability to conduct business, will be adjacent to their aptness of meeting the IMO's directive's restrictions. Evidently, the implementation of the regulation and the strict time limit under which the shipping industry has to adapt, will add more pressure to the already volatile and stressed market. Specifically, ship-owners have a time cap of merely twenty months to adjust, as the directive's enforcement date cannot be legally postponed anymore from the IMO, without defining its own rules (IMO,2018). Thus, carriers are called to select one or more of the methods among the ones currently available, in order to reduce their emissions according to the regulation (S&P Global Platts, 2017). Costs of installation of new equipment, trading routes, average age and market conditions are only a few of the factors, which companies need to consider, before concluding on the most appropriate and effective way to comply with this new directive (Lindstad, Rehn and Eskeland, 2017).

Thus, it is expected that IMO 2020 will affect the competency of many shipping companies, by introducing a new setting, in which the ability of a firm to resume its operations, will be reliant on its flexibility to impose the set environmental standards (Theotokas and Katarelos, 2000). Naturally, due to the aforementioned restrictions, a number of shipping companies will not be able to acclimate with the Sulphur cap, or will be affected from the initial uncertainty of the market, concerning bunkering prices and efficiency of the alternatives. The way in which the shipping companies will cope with this process, will ultimately define the lay-out of the shipping market. To elaborate, any expected or forecasted alteration in the operational volumes of the shipping companies, due to the aforementioned factors, can affect their respective market shares. On this ground, it is of great significance to examine, whether this outcome, can ultimately produce an outcome that will affect the overall concentration of the industry. Therefore, the aim of this paper will be to measure the impact of the regulation in the liner market structure, by forecasting the potential concentration of the market, after the enforcement of the aforementioned act.

1.2 The research question

After identifying the problem in the previous section, this paper will seek to ultimately provide an answer to the bellow research question:

“What is the possible impact of the IMO 2020 Sulphur cap regulation in the liner shipping market structure?”

Accordingly, this paper will seek to investigate and forecast the market structure of the liner shipping industry, which is reliant on the capability of companies in the sector to rapidly adapt to the regulation. It may be sufficiently deduced from various studies in present times, that liner shipping is operating under an oligopolistic structured market, with an accelerating trend of concentration, mainly due to the mergers between the companies and the formation of alliances (Sys, 2009). For this reason, it is worth examining, whether IMO 2020 will ultimately accelerate or slow down the industry towards the particular market structure. On this ground, the analysis will be narrowed down to the 30 biggest shareholders of the industry and whether their proceeding actions, can ultimately alter the market scheme. At the first stage of the research, it is of great significance to present in detail the IMO 2020 regulation and the current compliance methods that the shipping world has its in disposal. Furthermore, in combination with other decision-making factors, the announced actions that will be followed from the shipping companies that dominate the market will be presented, as their market power and innovative operations can be accounted as factors of influence for the remaining stakeholders. On a subsequent stage, the concentration of the examined industry will be computed, in order to identify the present market structure. Additionally, as the purpose of this assignment is to provide a future forecast of the liner market, the formulation of scenarios that will simulate the actions of the small companies is a necessity.

Hence, the following sub-questions will act as pillars throughout this research and will assist in building a sufficient answer for the main research question:

1. Which are the alternatives that liner shipping companies can pursue, in order to comply with the regulation?

2. Which are the factors that can influence the decision making, in regards to the alternative utilized, of the liner companies?

3 Which alternatives will the thirty (30) examined liners utilize?

4. What is the appropriate method to investigate the concentration of the liner market before and after the IMO 2020?

5. Which are the scenarios that need to be formulated?

The above-stated sub-research questions will lead to a sufficient answer of the main research question. The first question aims to describe the current situation, regarding the regulatory scheme of the IMO 2020 and its implementation methods. The second and third sub question will focus on the reaction of the examined carriers of the liner market and will be built upon the potential factors that could cast an influence on the liner firms, that have yet to announce a compliance method. The last two questions will explore the current concentration ratio and the scenarios that will need to be developed, as to generate a reliable future market assessment.

1.3 Methodology and structure of the paper

The methods that will be utilized in order to answer the sub-research questions and ultimately the main research question will be a combination of quantitative and qualitative methods. In the primary part of the research, the methodology followed will be qualitative. The chapters that will be developed using the qualitative analysis of the present scenery, will serve as the pillars on which the possible scenarios, regarding the remaining firms' reactions will be built. Subsequently, the quantitative part will play a crucial part on the final segment of this research paper.

Initially, in the first part of Chapter 3, a descriptive analysis of the IMO 2020 regulation and the challenges that will pose to the shipping industry, will be conducted. Furthermore, in the second part the chapter the compliance methods and the alternatives that ship-owners currently have in their disposal will be presented. Accordingly, their cost and technical implementation restrictions of these alternatives will also be analyzed, as determinants of the companies' reaction. This part of the research will be conducted by exploring the existing bibliography and present-day articles.

Following Chapter 4, in which the detailed methodology of the analysis will be presented, Chapter 5 will consist of the current decisions made by the large shareholders in the liner market. In this part, the latest announcements of the big companies regarding the regulation compliance will be introduced, which are pivotal for the choices of the small firms. Moreover, any existing factors that can influence the decision making of the liners, will be examined in this chapter. Thus, the focal point of the qualitative part, will be to accurately determine the elements which will affect the capability and the likely alternative utilized from the shareholders of the liner market, as to adjust within the given time limit.

Next, in Chapter 6, the most probable compliance method that might be selected from the indecisive liners, will be presented. This will act as a determinant of the variables and fixed baselines that will utilized in Chapter 7. Accordingly, in order to successfully forecast the future market structure of the liner industry, several scenarios will be formed, which will be built upon the qualitative research conducted in the previous chapters. Specifically, the hypothesis fathomed, will be two dimensional, namely fuel price difference and price-elasticity, which will be examined, under two extremes for each. Accordingly, the respective scenarios created and the criteria, under which they will be formulated, will be discussed with academic professors and market shareholders. Also, market forecasts, regarding fuel costs and latest announcements will be considered, in order to ensure that the scenarios will reflect a realistic outlook of the matter. In parallel, in the subject chapter it is of great significance to analyze the present and the potential market structure of the liner shipping industry. The first part of this chapter will introduce the most appropriate method to compute the concentration rate of the liner market. In the case of this research, the concentration of the current and future market will be computed by utilizing the Herfindahl-Hirschman Index (HHI). Specifically, the current HHI for the liner industry will be calculated, by extrapolating the data of the latest market shares from Alphaliner. Hereupon, as to reach to a sufficient conclusion, the possible HHI for the market following the enforcement of the Sulphur cap, will be determined. In that respect, the possible future alterations in market shares in every scenario developed in this chapter, will be utilized as quantitative input for the HHI index and the ultimate computation of the possible concentration rate in liner industry, after the enforcement of IMO 2020.

Finally, in the Chapter 8, in order to discover whether the regulation will ultimately influence the market structure, or not, a comparison between the initial HHI outcome and the indexes derived from the scenarios, will need to be carried out. The potential differences in the HHIs will lead to a sufficient answer of the thesis's main research question.

2. LITERATURE REVIEW

In order to answer the aforementioned questions, it is of crucial importance to explore the literature that can assist in the formation of an intact answer. The liner industry has been thoroughly examined through the years and is defined by the UNCTAD Report in 1970, as a cluster of vessels that serve the same route, following a pre-defined schedule. As Prof. Harlambides states in his conference report "Determinants of Price And Price Stability In Liner Shipping", the liner industry is highly dependent on the maintenance of a fixed schedule, which translates to containerships focusing more on completing voyages, than the loading or profit factor. Accordingly, the industry pushes its freight rates close to the operational costs, leaving small to non-existent margin profits (Haralambides, 2004). Thus, any increase in these operational costs of the liners will reflect in changes in their demanded volumes, according to the market forces, demand and supply, that define the shipping industry (Stopford, 2013). On this matter, Rennings and Rammer (2011) investigated the correlation between the enforcement of environmental regulations in the shipping industry and the profit margins and cost decrease (Rennings and Rammer, 2010). A similar research, conducted from Rassier and Earnhart (2010) showed that the environmental regulations can have a negative effect in the profitability of the companies and their competitiveness (Rassier and Earnhart, 2010).

With the environmental restrictive's cost effect on the shipping companies, the main question of this research was built, on whether the selection of the compliance methods will impact the market shares, thus the liner market structure. The subject restrictive has as objective the reduction of the percentage of Sulphur contained in the maritime fuels utilized from the global fleet, with an overall aim the environmental protection and preservation. Namely, as of 1st of January the Sulphur limit will be reduced to 0.50% m/m (mass to mass), when vessels navigate outside emission control areas (ECA), and to 0.10% m/m inside the designated areas (IMO, 2016). Since the first introduction of SECA zones (Sulphur Emissions Control Areas), which were adopted at the 2008 MARPOL Convention, under Annex VI, a plethora of studies has been conducted, with an aim to investigate the impact of the restrictive on the shipping market. Notteboom et. al (2010) conducted an analysis of the impact of Sulphur restriction in marine fuel, was expected to bring upon the shipping market. The report, which was structured on behalf of the European Community Shipowners' Associations (ECSA), stressed that the derivative would have a negative impact on freight rates, due to the utilization switch from HFO to marine fuels, with a lower consistency in fuel. The increase in freight rates, also was estimated to bring decrease in the volumes transported from the shipping sector in the respective areas and a downfall in the market shares of the shipping companies, when compared to other transportation modals (Notteboom, Delhaye and Vanherle, 2010). Similarly, Dr. Lemper and his team in their report, generated for the Institute of Shipping Economics and Logistics, found that the rise in the fuel costs and consequently to the freight rates, triggered a decrease in the demanded transported volumes by vessels. The transported cargoes shifted to inland transportation modes, affecting mostly the liner companies operating in the ECAs (Lemper, 2010). Both studies concluded that the Sulphur restriction on the marine fuels, would have a negative impact on the operations of the shipping companies, both in costs and volumes transported. However, the reports did not investigate the overall effect of the environmental

regulations in the shipping market, fact that aroused the present analysis's main research question, with a focal point on the liner market.

With an aim to gain an understanding of the compliance methods available to conform with regulation, several articles regarding the alternatives that the shipping industry holds were investigated. Initially, the article from Paul Gilbert (2014) provides a deep insight in the options that the maritime sector has, in order to comply with the regulation. Accordingly, Lindstad, Rehn and Eskeland (2017) in their article "Sulphur abatement globally in maritime shipping." compare the options currently available and explore in depth the correlation between vessel's size and alternative way of compliance. The aforementioned researches assist in better comprehending the correlation between the characteristics of the companies and the best proposed alternative, accordingly (Lindstad, Rehn and Eskeland, 2017).

Next, in order to investigate the potential impact on the liner structure, different topics were investigated, in regards to the concentration of the industry and iys measures. Determinant factor of the shipping market structure is the concentration that the industry is characterized from. According to the report "Horizontal Merger Guidelines", from Department of Justice (2010), market concentration is defined as a measure of an industry's competitiveness level and is adherently linked to the market shares that the firms hold. A suitable measure that is principally utilized by the Department, that can indicate the concentration ratio of the shipping market is the Herfindahl-Hirschman Index (HHI) (Department of Justice, 2010). The index has been widely used in researches, in regards to the liner market's competitiveness degree. Particularly, journals from Sys C. (2009) and from Luo, M., Fan, L. and Wilson, W. (2012), which investigate the concentration market of the liner industry, are utilizing the Herfindahl-Hirschman Index (HHI), and will act as pillars on the computation of the concentration figure of the market. Other research articles using the HH index, such as "Contestability of Container Liner Shipping Market in Alliance Era", by Enna Hirata (2016), gives an insight on the current liner market structure, and can be of assistance in the forecast of the future market structure.

It is evident that it in order to evaluate the possible outcome of the IMO 2020, it is important to compute and compare the current index, with the probable concentration rate that the enforcement of the regulation will cause. In order to achieve that, it is imperative to outline the future scenery, concerning the compliance methods that the liners will utilize. Thus, the factors that can determine this decision need to be investigated. Chen and Ma (2017) stated in their article that the stance of the competitive companies can greatly influence the decision of the other stakeholders in the industry (Chen and Ma, 2017). Furthermore, Stopford stresses that another important factor that can define the investments that liners will proceed to do, are adjacent to the chartered proportion of the fleet (Stopford, 2013). For the later formulation of the scenarios the up-to-date research from Schieldrop and the Skandinavian Enskilda Bank (2018) will be utilized for the forecasted prices of the low Sulphur marine fuel, which indicates that an increase in the bunkering costs of the liners that will opt for LSF, is to be expected, once the regulation comes into force (Schieldrop, 2018). Lun et. Al (2014) in their book "Shipping and logistics management", state that for every level of freight rate, there is a specific amount of volumes demanded for transportation, from shippers, signifying the price sensitivity of the shippers is correlated with the freight rates, the volumes transported and the market shares of the firms (Lun, Lai and Cheng, 2014). The same can be derived from

the book of “Economics”, written by Mankiw and Taylor (2017). The book analyses the range of elasticities that consumers can hold, in our case the shippers, and also provides the readers with the formula utilized to compute the volumes demanded for the respective elasticities (Mankiw and Taylor, 2017).

To summarize, in the present thesis, literature, regarding decision making factors will be used in combination with formulation of scenarios, for the final comparison of the concentration indexes (HHI) derived from them. Accordingly, the above stated bibliography, will act as a pillar in the subject research, with an aim to combine the methods, formulas and academic information provided, in order to discover the potential impact of the IMO 2020 regulation in the market shares of the liner companies, thus in its market structure.

3. IMO REGULATION DESCRIPTION

3.1 IMO 2020 background and regulation description

The milestone for the mitigation of hazardous air pollutants, was set in September 1997, when the International Maritime Organization (IMO), incorporated the Annex VI to the International Convention on the Prevention of Pollution from Ships (principally known as the MARPOL Convention) (Airclim.org, 2017). The objective of MARPOL Annex VI was the reduction of vessel-originated emissions, specifically Sulphur, nitrous oxides (SOx and NOx) and particulate matter particles, which are considered to be root causes for several environmental and human health issues (IMO, 2016). The Annex VI came into force in May 2005 and established the first Sulphur cap, which restricted the amount of Sulphur contained in marine fuels, to 4.5%. In parallel the regulation introduced the Sulphur emission control areas (SECA), in which the sailing vessels were compelled to burn fuel with a maximum percentage of 1.5% of Sulphur (Gard.no, 2004). Presently, the sea zones identified as SECAs, are the Baltic Sea, the North Sea, the North American ECA, covering the most of the US and Canadian coastline and the US Caribbean ECA (Küng, 2018). As the aforementioned regulation was deemed not to have the desired impact on the improvement of the environmental scheme, in July 2008 the Marine Environment Protection Committee (MERC), introduced the Revised Marpol Annex VI (IMO, 2016). This amendment reduced further the maximum permitted Sulphur content in the marine fuel, to 3.5% by 2012 and to 1.0% by 2010, when sailing outside and within the ECAs respectively (Grimmer, 2018).

A step closer to the IMO 2020 regulation was taken during the same period, when the organization instructed the investigation of the availability of marine fuel, with a low content in Sulphur, as to determine the exact year of regulating the Sulphur cap outside the ECA zones (Imo.org, 2016). The assessment was conducted in 2016, by an independent research and consultancy institution, CE Delft, and concluded in its findings, that ultimately, there is a sufficiency in fuel with a percentage of 0.5% Sulphur or less. From the demand side, the assessment was developed under three scenarios, adjacent to the available compliance methods and the expected boost in the global economy. To counterbalance, in the supply side, the study fathomed a refinery supply model, to determine whether the demand for the compliant fuels will be adequately met. Resultantly, the analysis deduced that the IMO 2020-intrigued demand for marine fuel containing 0.50% and 0.10% or less, would be sufficiently satisfied from the refinery aspect (Hoen et al., 2016). Due to the numerous concerns behind the enforcement of the directive on the proposed date, parallel to the CE Delft's assessment, an opponent study by EnSys Energy and Navigistics Consulting was carried. In particular, the supplementary report, which was supported by the independent international shipping organization BIMCO, presented contrary findings. The distinct variance between the two studies conducted, was the divergent interpretation of the findings. Whilst both evaluations concluded in a highly likely event of notable deficiency of Sulphur plants, capable of producing compliant marine fuel, CE Delft study assumed that the deficit will be compensated by investments in the sector. Contrarily, EnSys/Navigistics study expressed doubts, respecting the probability that the investments placed on the refineries will be adequate to countervail the estimated shortage (EnSys Energy, 2016). Nevertheless, the International Maritime Organization (IMO) reckoned the issue of the marine fuel's availability resolved and proceeded to settle January 1st 2020, as the irrevocable date

for the regulation to come into effect. The conduction of both studies and their results, reflect the shipping industry's uncertainty, regarding the disruption of the markets affected from the regulation.

Consequently, the challenges posed from the regulation, are apparent throughout the maritime world. Shipowners are called to select, which compliance method they will implement in their fleet, in order to retain the seaworthiness of their vessels after the enforcement of the regulation. A decision of that significance may ultimately shape the market of the shipping world, as the compliance methods will increase the operational costs of the firms (Woodmac.com, 2018). In light of this, the sub-sector investigated under these circumstances, will be the liner shipping, which is distinguished by high contestability and is expected to undergo paramount changes. Hence, it is of uppermost importance to initially cite the current methods that the industry has in its disposal.

3.2 Available compliance methods.

Taking into consideration numerous factors which will be investigated thoroughly later, shipowners are already under the process of contemplating which method of compliance will be followed, if they do not have already implemented one. It is vital at this stage, to not disregard the fact that there will be a percentage of shipping companies, that will lack the investment capability to follow IMO 2020 and might be driven out of business. However, in this research, the liners that will be examined, will be the thirty biggest shareholders and will be investigated, in regards to the most probable alternative followed. On this ground, in this subchapter the alternatives that shipowners currently have available, will be discussed.

Currently the alternatives that shipowners have, as to conform with the regulation are mainly, switch to utilization of compliant fuel, with a consistency of <0.5% Sulphur, resume to burn High Sulphur Fuel, under the condition that the vessel will be equipped with exhaust gas scrubbers, and finally have an LNG-propulsion engine.

3.2.1 Low Sulphur Fuel (LSF)

As stated before, maritime companies in order to deal with the Sulphur cap, have the possibility to utilize cleaner marine fuel, in terms of Sulphur consistency. Amid the low Sulphur content fuels that can be utilized, are the Low Sulphur Distillates (LSD), blend of LSD with high or low Sulphur fuel oil (HSFO and LSFO respectively) (Seymour, 2018). Following the conducted studies, which inferred that the refinery sector is capable to adjust promptly and meet adequately the awaited demand for low Sulphur fuel, the option to switch to compliant fuels seems the most rational for the shipowners (Jordan and Hickin, 2017). Evidently, it is safe to expect an increase in the dependency of the vessels' operational cost on the anticipated rise of the LSF.

3.2.2 Scrubbers (exhaust gas systems)

Nonetheless, marine fuel with a higher Sulphur limit content, than the regulation-restricted, can be utilized, provided that the vessels are equipped with exhaust gas

equipment system, known as scrubbers (Seymour, 2018). Retrofitting scrubbers in the existing fleet enables the vessel to burn High Sulphur Fuel (fuel with a percentage of 1,5% Sulphur or higher), even when sailing in SECA zones, while conforming with the regulation. Scrubbers' utility is to remove Sulphur from the exhaust-emitted gas, by employing seawater and can be installed in new-builds, as well as in existing vessels (Kalli, Repka and Alhosalo, 2015). At the moment, scrubbers, that are fit to be retrofitted on vessels, can be divided in three categories: open loop, closed loop and hybrid systems. Open loop is the simplest wet scrubber system, due to the fact that it merely uses pumped seawater for the scrubbing process, then it undergoes filtration and eventually gets dispensed, while the sludge remains onboard, to be collected in the respective port facilities (McMenemy, 2018). In contrast with the open loop system, closed loop scrubber system discharges merely small quantity of scrubbing liquid. Instead, by chemically treating the liquid in the respective tanks, the fluid is circulated and re-used, fact that attributes to a decrease in the quantity needed and therefore in the size of the mechanism, amid with the energy required (McMenemy, 2018). Finally, the hybrid system is a combination of the two aforementioned types, which allows the transition between open and closed loop operation, providing the vessel the possibility to reap the benefits of both types of mechanisms (Valmet.com, 2018).

3.2.3 LNG-propulsion engines in new builds or retrofitting

Ultimately, the suitable option for shipowners that wish to enrich their orderbook, are vessels that have the capability to burn Liquified Natural Gas (LNG) (Grimmer and Myers, 2018). The reason behind this statement is that LNG, is an attractive alternative, which is supported by the European policy for the reduction of greenhouse gas emissions (Xu, Testa and Mukherjee, 2015). LNG fueled engines in vessels can attribute to a diminution of the CO2 emissions to nearly 0%, however sufficient bunkering stations and infrastructures in ports is regarded as an imperative prerequisite for the option to be viable in a large scale in the maritime world (European Commission, 2013). Although LNG running vessels seem to be a fitting path to be followed by newbuilds, it would be an omission not to mention, the high cost of LNG retrofitting in the existent fleet, a deterring factor for many shipowners, which will be analyzed further in a later stage of the research (Lindstad, Rehn and Eskeland, 2017).

The following table presents the properties and (dis)advantages of each compliance method.

Table 1, IMO-2020 compliance methods comparison

Alternative	Pros	Cons
LSF	• Simplest compliance method • In case of increased procurement cost, can be passed as surcharges to charterers • Applicable to all vessels, independently age, type, operational route and size • Fuel supplier legally responsible for quality of fuel to meet the regulation's requirements	• Possible that the increase of price after the regulation, will be too high • Uncertainty about the availability of LSF in a global scale
Scrubbers	• Short term competitive advantage, in case the HSF-LSF price range is too big • Availability of HSF	• Big initial capital expenditure and uncertainty of investment recovery, in case of retrofitting • High maintenance costs of the equipment • High level fuel consumption • Uncertain disposal costs for sludge in terminals • Shipowners legally responsible for the produced emissions
LNG	• Nearly no particulate matter emissions • Port fees reductions as incentive • Lower prices than LSF and HSF	• Underdeveloped global LNG bunkering network • Danger in handling the fuel • Big investment costs, both in new builds and existent fleet

Source: Author, via European Commission (2013) Acciaro (2014), Schieldrop (2018)

Having analyzed the regulatory framework of the IMO 2020 and the available compliance methods, one can comprehend the challenges that shipowners are called to face, along with the overall shipping industry. The influential factors that will drive shipowners to an ultimate choice of a method of compliance, or their lack of capability

to cope with the strict environmental regulation on time, will be examined meticulously in Chapter 5 of the research paper. The following chapter will describe the methodology utilized to forecast the possible impact in the liner shipping market structure, as a consequence of the up-coming Sulphur cap.

4. RESEARCH METHODOLOGY AND DATA

In the present thesis, which will assess the possible impact of the IMO 2020 regulation in the liner market structure, it is vital to select the appropriate methodology procedure. In light of this, in order to successfully forecast the impact of the Sulphur cap on the future liner market, a mixed methodology will be performed.

In the primary part of the research, the methodology followed will be qualitative. The investigation of the existing bibliography and present-day articles, were utilized in Chapter 3, to present an analysis of the IMO 2020 regulation and the challenges posed to the shipping industry, in regards to the alternatives available. Accordingly, in Chapter 5, the factors that can influence a market's structure and the investment capacity of the small liner shareholders to implement the respective compliance methods will be investigated. Thus, the focal point of the qualitative part, will be to accurately determine the elements which will affect the capability of small shareholders of the liner market to adjust within the restrictive time limit.

Moving on to the quantitative part of the thesis, it is of great significance to analyze the present market structure of the liner shipping industry. One measure that has been widely used from the US Department of Justice, for the approval a merger and similar research papers that have investigated the liner market's concentration, is the Herfindahl-Hirschman Index (HHI). The same purpose holds the concentration ratio (CR), which however only uses as input the market shares of the three, four or eight leading companies in the investigated industry, which makes it an unsuitable measure for the subject analysis, as it is important to investigate the overall reaction of the industry (Investopedia, 2018).

4.1 The Herfindahl-Hirschman Index (HHI)

Consequently, with the intention to examine the both the current and the post-IMO 2020 concentration ratio of the containership market, the Herfindahl-Hirschman Index (HHI) will be used. The index is a statistical measure that is utilized to evaluate the concentration rate of a specific market. In principal, HHI was used to interpret the agglomeration of industries from various economists, but it was not until 1982, when the U.S. Department of Justice and Federal Trade Commission, formally integrated the index in its Guidelines (Laine, 1995). In these Guidelines, the HHI indicates the level of concentration, by comparing the deviation between the prior and the post-merger number of shareholders and their respective market proportion (Department of Justice, 2015). Namely, the higher the outcome generated from the HHI computation, the more concentrated the examined industry is, and vice versa. Another reason justifying the selection of HHI as a suitable methodology for the present thesis is, that the index requires accurate knowledge of all the operating companies market shares. Though, in reality the outcome can be generated utilizing only the biggest market shares, as the shares below 1% barely have an impact in the result. Thus, in this thesis where only the first 30 liners will be examined, the result extrapolated from the index will be representative of the total industry's concentration.

Shepherd in his book “The economics of industrial organization” stated the index’s formula, as the sum of the squared market shares that the liner companies hold in the industry, and is represented by the below formula (Shepherd and Shepherd, 2004):

$$HHI = \sum_{i=1}^{N} s_i^2$$

Where N is the number of companies in the industry, in our case the number of liner firms and s_i the respective market share in percentages, that every firm holds. Furthermore, Rhoades states in his technical note, that the given formula is greatly affected by the companies that have large market shares, as a consequence of the squaring in the HHI (Board's Division of Research and Statistics, 1993). The HHI’s values can range from 0 to 10,000. Namely, if there is only one market operator which holds a 100% of the market share, the index’s value will be 10,000. In case that in the market are operating many liners, the value of the index will be closer to zero. The Department of justice and the Federal Trade Commission, also known as the “Agencies” utilize the index, in order to identify the possibility of mergers to interfere with the competitiveness in a market. The Agencies associate Unconcentrated Markets with HHI values that are below 1,500, Moderately Concentrated Markets, when HHI’s value is ranging between 1,500 and 2,500, and lastly, Highly Concentrated Markets are related to values exceeding 2,500 (Department of Justice, 2015).

In the present research paper, the possible impact of the IMO 2020 regulation on the market structure of the liner shipping industry, will be investigated under the aforementioned guidelines. The Herfindahl-Hirschman Index is considered as the most appropriate methodology to be followed in this particular instance, as it considers the market shares of all the shareholders in the industry, along with the inequalities that may exist between them.

4..1.2 Data input for the computation of the current HHI

With an aim to deduce a sufficient answer for the main research question, it is imperative that the HHI is calculated both for the current market, as for the post-regulation market. Taking this into consideration, the present concentration index will be calculated in regards to the 30 first liner companies, whose latest market shares will be obtained from Alphaliner. Importantly, in the vast majority of articles available in bibliography in the liner industry the capacity of a company’s fleet is a sufficient indicator of its operational segment in the market (Sys, 2009). Therefore, Alphaliner will be utilized as an online database and its suitability is based on its ability to rank on a daily basis, the “Top 100” containership companies that operate worldwide, in terms of TEU capacity and DWT (Alphaliner.com, 2018). However, liners that possess market shares, which place them in a rank below 30, will not be taken into account, due to their inability to impact the market structure. Specifically, according to the HHI formula, market shares that are below 1%, when squared, have no notable contribution to the index’s value and will be omitted from the research.

4.1.3 Scenarios for the post-IMO 2020 concentration outcome

It is not possible to reliably forecast the possible alteration in the market shares of the liner companies after the implementation of IMO 2020. Instead, several possible scenarios are compared. Several scenarios formulation techniques are applied in a variety of industries, with an aim to predict a range of possible future states and outcomes, while keeping in mind current situation characteristics and tendencies. In the present analysis, the criteria under which the scenarios that will be formulated will be of qualitative nature, which are generically accounted appropriate for researches with a large scope of investigation, such as the impact on industry's structure (Amer, Daim and Jetter, 2013). Furthermore, in order to achieve the greatest credibility of the scenarios, their formulation will have as structural pillars the concepts of plausibility, consistency, creativity and relevance with the examined object (Alcamo and Henrichs, 2009).

To elaborate, after analyzing which factors can influence the decision making of the liners, in Chapter 5, and the analysis of the possible compliance methods that the reactive liners might utilize, in Chapter 6, in Chapter 7 the scenarios will be formulated. Dependently on the most common probable alternative found to be utilized, the scenarios will be based on the extremes of price forecasts for that alternative. Moreover, in order to link the altered prices and freight rates with the respective market shares, it is imperative that the shippers' price sensitivity will be assessed. Specifically, it is found that the bunkering costs of are accounting for almost half the amount of the freight rates charged from the shipping companies (Stratiotis, 2018). Amid with the price elasticity of demand of the shippers, who act as the consumers in the seaborne trade, the new demanded volumes and the consequent altered market shares will be computed, for the companies that have to yet to announce their compliance method. The extremes of their sensitivity (price elastic and inelastic), will be studied in four sub scenarios, under each occasion. The possible future alterations in market shares that will be extrapolated from every scenario, will be utilized as quantitative input for the HHI index. In this way the concentration of the liner industry after the enforcement of IMO 2020, will be computed four times under the respective sub scenarios. A more detailed methodology, in regards to the formulation of the scenarios will be presented in the primary part of Chapter 7.

Finally, in Chapter 8, in order to discover whether the regulation will ultimately influence the market structure, or not, a comparison between the initial HHI outcome and the indexes derived from the scenarios, will be carried out. The potential differences in the current and post-regulation HHI values, will lead to a sufficient answer of the thesis's main research question.

5. DECISION-MAKING FACTORS FOR THE LINERS

The purpose of this chapter, is to cite the factors that can possibly influence the market structure of the liner shipping industry, in regards to their conformation with the IMO 2020. By analyzing the determinants of the decision making of the liners, namely the possible alternative selected to comply with the regulation, the criteria under which the future scenarios will be formed, will be structured. At this point it important to highlight that the biggest liner have announced their compliance method and for this reason the presentation of the decision-making factors, is mainly to assist in the prediction of the choices of the smaller indecisive liners.

5.1 The stance of liner leading companies towards IMO 2020 as a decision-making factor.

In the erratic environment of shipping industry, companies need to have a comprehensive overview of the competition's strategies and actions. Consequently, one of the factors that will be examined as a driving determinant of the compliance method of the small liner companies, is the actions taken by the major shareholder of the industry. As the regulation is about to come into force, the competitiveness of the companies will be contingent on their ability to choose a suitable compliance method, amid with their investment capacity to do so.

Several theories argue that the decision-making of the small-scale companies, is adjacent to the investment policies that fellow companies follow. A determinant drive of the peer interaction between the firms of the industry are the outcomes of their investment strategies, such as profitability, market share etc. Besides firms that do not hold large market shares are more likely to have inadequate information, making them more prone to imitate the investment behavior of the industry's leaders and take advantage of the spillover effect derived from the disclosure of their strategies. Thus, liner companies that are market followers or are under restricted financial capability are more susceptible to be influenced by the leader firms (Chen and Ma, 2017). At this point, it is safe to assume that the aforementioned characteristics and the influence of peer-firms' action, apply in the liner shipping industry, as well as in any other industry.

On this ground, as a significant decision factor of the possible path that small liners will follow is the compliance strategies that liner leader companies have announced, their standpoint will be investigated. For the purpose of this research paper, the first five liner companies in terms of consolidated market share, APM-Maersk, Mediterranean Shg Co (MSC), CMA CGM Group, COSCO Shipping Co Ltd and Hapag-Lloyd, will be examined regarding their announced actions as to conform with IMO 2020. The market shares are computed in terms of deployed as obtained from Alphaliner.

The below table depicts the biggest liners along with their announced compliance method, while a detailed analysis of their options will follow.

Table 2, 5 Biggest liners and their choices

Liners	Market share in %	Compliance method
APM-Maersk	18.2	Low Sulphur Fuel
Mediterranean Shg Co (MSC)	14.7	Scrubbers
CMA CGM Group	11.8	LNG on new builds
COSCO	9.2	Scrubbers
Hapag-Lloyd	7.2	LNG on new builds and LSF on existent fleet

APM-Maersk

APM-Maersk it the leader company in the liner industry with a total market share of 18.2 %, which translates to a total of 4,068,919 TEU operating capacity (Alphaliner, 2018). It is important to highlight that the share is consolidated, including the group's subsidiaries, Maersk Line, Hamburg Süd (including Aliança and CCNI), Safmarine, MCC-Transport and Seago Line. The Danish container shipping firm, as a board member of the Trident Alliance is supporting the enforcement of the regulation and prefers to take a long-term approach in the subject. After installing scrubbers for a trial period in vessels, Maersk reached to the conclusion that scrubber might prove a deteriorating factor of the energy efficiency of the vessel (Ship & Bunker, 2018). In justification of their decision is the fact that scrubbers are a technology that requires relatively costly and regular maintenance, while the diminution of the harmful exhaust gas is not significant (Ship & Bunker, 2018). Hence, the firm announced the utilization of cleaner fuels and distillates, such as MGO and MDO, which will secure its thoroughgoing compliance with the Sulphur cap (Hand, 2018).

Mediterranean Shg Co (MSC)

Mediterranean Shipping Company, with its headquarters in Geneva, Switzerland, is the second liner in the investigated market, in terms of market share, with 3,287,766 TEU capacity. Its total share accounts for 14.7% of the industry's operational volume, including its subsidiary, WEC Lines (Alphaliner, 2018). MSC's announced path regarding its compliance with IMO 2020 is retrofitting scrubbers in the majority of the existing fleet. This initiative is anticipated to rise to a cost of 250 million Euros (Ikic, 2018). Furthermore, in June 2018, the company proclaimed that their newbuilt Ultra Large Container Vessels (ULCVs) will also be equipped with scrubber technology, indicating the firm's willingness to resume utilizing HSF, due to the current looming uncertainty of the industry, in respect to the LSF and distillates availability from the refineries in the early years of the enforcement of the Sulphur Cap (Wackett, 2018).

CMA CGM Group

CMA CGM Group is the world's third liner carrier, holding at the moment, a market share of 11.8% with an operating capacity of 2,623,451 TEUs. The Group comprises CMA CGM MacAndrews, Mercosul Line, APL, ANL, includes Cheng Lie Navigation Co, Feeder Associate System, Cagema, CoMaNav and SoFraNa (Alphaliner, 2018).

In contrast to the first two liners, Maersk and MSC, CMA CGM opted in 2017, sooner than all the liners to have a proactive approach in the regulation. The firm selected to reap the benefits of LNG utilization for its vessels' propulsion, both for the accomplishment of energy efficient performance and to comply with the IMO's derivative. Specifically, the Group is expecting the delivery of nine 22,000 TEU capacity containerships, that will be equipped with LNG powered engines, by the time IMO 2020 comes into force (Ramphal, 2017). In order to tackle the LNG availability issue that had been addressed from IMO and other organizations before the adoption of the legislation, CMA CGM parallel to the order of the LNG vessels, signed an agreement with Total Marine Fuels Global Solutions for bunkering purposes (Halff and Boersma, 2018). The object of the agreement is the future supply of LNG, as a marine fuel to the new-builds, namely for a ten-years period. Total will provide the vessels with approximately 300,000 tons of LNG (CMA CGM, 2017). Since there is no announcement, regarding the compliance method that will be followed from the existent fleet, the synergy with Total and the lack of announcement of investments on retrofitting, it will be assumed that the remaining vessels will utilize LSF.

COSCO Shipping Co Ltd

Fourth in the ranking of Top 100 liner in Alphaliner is the COSCO Shipping Co Ltd. (formerly known as COSCO Container Lines). The firm operates a fleet of container vessels with a total deployed capacity of 2,055,501 TEUs, which translates to a market share of 9.2% (Alphaliner, 2018). The percentage is associated with the prior CSCL fleet, which integrates Shanghai Puhai Shipping Co (SPS), Golden Sea Shipping (GSS) and Shanghai Pan Asia Shipping. The Chinese interests' company has yet to disclose the ultimate alternative method which will be followed, both for its current fleet and the newbuilds, in order to meet the upcoming Sulphur ceiling. However, on June 2018, the company announced its collaboration with Mitsubishi Heavy Industries Ltd (MHI) with an aim to trial rectangular scrubbers on the applicable part of the fleet (Ship & Bunker, 2018). The venture of the company to experiment with the scrubber technology, can be translated to an indication to secure their future operations from the unpredictable fluctuations in the prices of the marine fuels, after 2020. It is the firm's outlook that there will be an oversupply of HSF from the refineries, which translates to lower prices per barrel, fact that could provide a comparative advantage to liners operating with scrubber systems (Coscol.com.cn, 2018).

Hapag-Lloyd

Hapag-Lloyd is the fifth biggest group in the liner industry possessing a market segment of 7.2% and employs a fleet of 1,599,638 TEUs, taking into account the capacity added, after its merger with the United Arab Shipping Company (UASC) (Alphaliner, 2018). In like manner with APM-Maersk, Hapag-Lloyd deems scrubbers as a short term and inadequately efficient alternative method. Nonetheless, in light of the volatile ambience of the industry, due to the Sulphur cap, the company will reach and disclose its decision in few months, without eliminating the possibility of taking a different approach on the scrubber technology (SAFETY4SEA, 2018). In regards to the firm's current fleet, Hapag-Lloyd acquired from the merger with UASC, seventeen (17) container vessels, which are equipped with LNG-powered engines and thus already compliant with the IMO restriction. According to the latest sustainability report

of the company, the fleet is already burning marine fuel with an approximate content of 2.26% of Sulphur outside the ECAs (Hapag-Lloyd AG, 2018). Given that the Sulphur's proportion restricted from the organization at the moment within the restricted areas is 3.5%, combined with the acquisition of the LNG propelled vessels, one can assume that Hapag-Lloyd will most likely choose between LNG and LSF/distillates, or a combination of both, to meet the Sulphur limit.

Evidently, the five biggest companies of the container market have opted for compliance methods that are adherent to the characteristics of their fleet, their previous operational strategies and investment capacity. To summarize briefly, APM-Maersk announced that it will utilize cleaner marine fuels, while MSC will choose retrofitting and scrubber technology. CMA CGM on the other hand, took the initiative to comply with the regulation by operating vessels that are LNG-powered and it is assumed that the existent fleet will utilize LFS, due to the deal between the firm and Total. Lastly, the world's fourth and fifth liner companies, COSCO and Hapag-Lloyd are yet to take a concrete stance in regards to the Sulphur Cap, a behavior that mirrors the "wait and see" attitude observed in the majority of the remaining firms in the industry.

5.2 Chartered proportion of the fleet as a variable for decision making

Another factor of great significance, in regards to the decision making of the alternative method to comply with the IMO 2020, is the chartered proportion of the fleet and the type of charter contract. The liner shipping industry, is a market that is mainly characterized by long term contracts between the shipowners and the charterers of the vessels. Namely, the agreements between the parties are usually time charter contracts, which allow the charterers to fully deploy the vessel for a period of five (5) or more years, or bareboat contracts, where the charterer leases the vessel unmanned and steps into the role of the shipowner (Global Ship Lease, 2018). Under a time-charter contract the charterer pays the agreed hire and embodies the operational costs of the voyages, fact that implies that the longer the duration of the contract the more risk lays on the charterer of the vessel. Similarly, in bareboat charter the risk, in regards to the vessel's operations and the shipping market in general is born by the charterer altogether (Stopford, 2013).

The liability that arises from the operational deployment of a vessel can be a determinant factor in the outcome of the decision making about the alternative method utilized, or the lack of it. To elaborate, liner firms that charter vessels under a voyage contract, will not proceed in any investments as it is not cost beneficial, instead they will opt for already compliant vessels or utilize LSF. On the other hand, firms that operate vessels under time charter or bareboat contracts, are obliged to take responsibility for the full compliance of the ships with the regulation, meaning that they might proceed to equipment investments, such as scrubbers or LNG-engines. The primary reason behind this, is that these types of contracts extend the exposure of the charterers to any risks deriving from the shipping operations. Explicitly, the companies will be held liable for any fines derived from the unlawful conduct of the voyages, hence their disobedience to the Sulphur restriction regarding the marine fuel utilized (Westpandi.com, n.d.).

In the occasion that the biggest percentage of the fleet operated by the company is owned vessels, then for the simplicity of this research it will be assumed that the decision will be formed according to other factors, such as the simplicity of the alternative utilized and the average age and capacity of the fleet.

5.3 Fleet's average age and capacity as a variable for decision making

Another noteworthy characteristic of the company that can play a crucial part in the alternative method used by the liner company, is the average age of the fleet. According to the age of the vessels the firm needs to identify which is the most beneficial path to be followed, in order to conform with the directive. On this ground the average fleet's age of the investigated companies will be examined, for the purpose of its utilization as a structure criterion in the upcoming scenario formulation.

When considering the older containerships, one can comprehend that retrofitting, either scrubber technology or LNG fueled engines, is not a vital solution. The investments on these vessels will not be rationalized, since the procedure demands replacement of fuel tanks and alterations or complete replacement of the engine equipment. Evidently, the assets will hardly bring a positive return of investment during their remaining operational life. In this case, several studies have concluded that the most fitting compliance method for older vessels, is to burn distillates or low Sulphur fuels (Lindstad, Rehn and Eskeland, 2017). Accordingly, LNG engine installation is considered an appropriate compliance method for newbuildings and the most environmentally friendly, in terms of a long-term investment approach, in comparison to installation of scrubbers or utilization of cleaner marine fuels. Yet, as any other marine fuel's price, LNG forecast is contingent on several other market factors, such as supply and demand of substitutes fuels like shale gas, resulting to uncertainty about the future bunkering costs (Acciaro, 2014).

Similarly, the installation of exhaust gas system in new builds is a more justified investment, due to the perception that the scrubbers have an operational lifespan of approximately 15 years, when installed to newbuilding's. Later though, the companies will have to choose between reinstalling scrubbers or being fuel compliant. On the contrary, the scrubber technology retrofitted on the already existent fleet, is considered to have a utilization time-cap of 12 years, while the installation procedure is estimated to cost 40% more than in the newbuildings (Jiang, Kronbak and Christensen, 2014). Understandably, the remaining operational life of the vessels, determines the attractiveness of the investment and the benefits that can arise from it. Presently, the global fleet of containerships is quite young with an average age of 11.55 years (UNCTAD, 2017). With an estimated four-year return of investment (ROI) of the technology, retrofitting appears as sensible solution to meet the regulation's requirement, provided that the vessel has a remaining service lifespan of more than four years (Jiang, Kronbak and Christensen, 2014). Thus, the average age of the fleet is an aspect that needs to be taken under consideration in the shipowner's ultimate selection.

The TEU capacity of the vessels is another element that should be taken into consideration, in the process of determining the most suitable compliance method. For instance, the installation of scrubbers is adjacent to high investment expenses. On top of that it requires sufficient space and is heavy, fact that can result to

restrictions in the loading capacity and consequently to the reduction of the vessel's profitability (Hilmola, 2015). Similarly, the installation and integration of LNG-running engines in the current fleet, will induce the same outcome. Keeping this aspect in mind, liner firms that fit the loading capability of an average containership sailing between European ports (5,000 TEUs), cannot afford to reduce their operating capacity and will most likely opt for the utilization of Marine Gas Oil (MGO) as an alternative to HSFO, instead of choosing retrofitting (Jiang, Kronbak and Christensen, 2014).

5.4 Investment capacity of the companies as a variable for decision making

For a 20,000 TEU containership the average retrofitting cost for exhaust gas equipment, will rise to 8 million USD, which translates to an approximate time period of 6 to 7 months for the return of investment (Vis, 2018). Accordingly, installing the scrubber's equipment, produce a high installation and maintenance cost which is difficult to estimate, as it is dependent on factors, such as age and size of the subject vessel (Acciaro, 2014). Being fuel compliant on the other hand, requires absolutely no installation of equipment and the cost difference in bunkering expenses that the liners will face, can be passed on to the charterers in form of surcharges in the freights (UNCTAD, 2010). However, the majority of the liner companies, especially the Asia operating firms, do not disclose their investment information, nor their annual financial reports, deeming this variable as unfit to be applied to the whole list of investigated firms.

6. INVESTIGATION OF THE POSSIBLE COMPLIANCE METHODS FROM THE LINERS

The purpose of the subject chapter is to investigate possible alternative that the indecisive liners will select. The analysis will take place in two subsequent phases. Initially, the examined liner companies will be investigated under the decision-making criteria mentioned in the former Chapter. Then, according to the potential selection of alternative to conform with the regulation, the formulation of scenarios regarding the decisions that the liners will make, will ensue the new possible future market concentration.

In this segment of the research liner companies from the 6th until the 30th, as ranked by Alphaliner, will be explored in respect of their market share, the chartered proportion of their fleet and their average age and capacity. The initial five (5), were analysed in the precious chapter as a part of the first decision-making factor, which was the stance of the leader companies. As stated in Chapter 5, these trades are significant in the decision making of the companies regarding the alternative method that will be selected, thus the classification of the liners according to these, is deemed vital for the purpose of this research. The numerical data, regarding the market share and the number of chartered vessels per company, will be obtained from the available information in Alphaliner that were accessed in one specific date (19th of July 2018), in order to avoid any fluctuations in the TEU capacities, as the information are subject to minor yet frequent alterations.

The majority of the smaller liners have adopted a wait-and-see approach, regarding their compliance method, as uncertainty about the marine fuel prices, both low and high in Sulphur and the returns of investment for scrubbers and LNG-propelled engines, is currently characterizing the market. However, some of the examined companies have already announced or implied which alternative method will be utilized. For that reason, a segment of this chapter will be dedicated to the companies' published compliance methods and the clarification of the assumed alternatives that firms, that have not yet disclosed, will follow.

Specifically, the below table represents the 25 examined liner companies and their respective market shares, chartered proportion of fleet and finally the announced compliance method or lack of it, which is indicated by "na" (not available). Expressly, in case that the liners have not announced the alternative which will be pursued, then the presumed method will be derived from their aforementioned attributes or other core indications derived from their investigation.

Table 3, Characteristics and announced alternatives of the 30 biggest liners

Rank	Name	Capacity in TEUs	Market share in %	Chartered proportion of fleet	Announced method
6th	ONE (Ocean Network Express)	1,565,438	7.005	62.3%	LNG propulsion engines
7th	Evergreen Line	1,117,788	5.002	48.60%	Exhaust gas system
8th	OOCL	691,531	3.095	23.3%	LNG (retrofit) and compliant marine fuel
9th	Yang Ming Marine Transport Corp.	629,334	2.816	70.8%	Low Sulphur Marine fuel
10th	Zim	409,434	1.832	92.5%	Low Sulphur Marine fuel
11th	PIL (Pacific Int. Line)	405,503	1.815	34%	na
12th	Hyundai M.M.	400,849	1.794	67.7%	Exhaust gas system/ LNG propulsion engines in new builds
13th	Wan Hai Lines	257,545	1.153	34.5%	na
14th	X-Press Feeders Group	138,984	0.622	71.9%	na
15th	Korea Maritime Transport Co. (KMTC)	137,087	0.613	56.1%	Low Sulphur Marine Fuel
16th	Antong Holdings (QASC)	134,603	0.602	24.4%	na
17th	Zhonggu Logistics Corp.	130,602	0.584	38.5%	na
18th	SITC International Holdings Co.	113,287	0.507	35.2%	na
19th	Islamic Republic of Iran Shipping Lines (IRISL Group)	96,383	0.431	0%	na
20th	SM Line Corp.	83,386	0.373	35.4%	na
21st	TS Lines	74,561	0.334	87.2%	na
22nd	Arkas Line / EMES	73,946	0.331	19.7%	Low Sulphur Marine Fuel
23rd	Sinotrans Limited	64,945	0.291	54.7%	na
24th	Sinokor Merchant Marine	57,930	0.259	47.3%	na
25th	Salam Pacific Indonesia Lines	52,273	0.234	0%	na
26th	Regional Container LinesPublic Company Limited (RCL)	50,927	0.228	40.9%	na
27th	Grimaldi Lines (Napoli)	44,773	0.200	0%	Exhaust gas system
28th	Emirates Shipping Line	43,943	0.197	100%	na
29th	Matson	42,546	0.190	5.90%	LNG propulsion engines in new-builds
30th	Simatech	41,632	0.186	73%	na

Source: Author via Alphaliner.

Following the in-depth analysis of the companies, depicted above, will be stated below. The liners where investigated in the before-mentioned characteristics, however in many a case this information was unavailable or inaccessible. In the case

were the liners follow a wait-and-see approach, conclusions or assumptions will be made, concerning the alternative method, which will be based on other elements that are available through the research. These elements are the financial status of the companies for the listed liners, the average operational capacity of the fleet, previous compliance method patterns with similar environmental regulations, regional regimes and partnerships or alliances.

6.1 Examined liners, from 6th to 10th

Starting with the sixth company in the Alphaliner Top 100 ranking, Ocean Network Express (ONE), holds a market share of 7% in the liner industry. Recently, the group disclosed that will opt for LNG-propulsion in their newbuilds and proceed with retrofitting in the existent part of the fleet. This decision was reached as a part of a bigger bunkering agreement, in order for the company to assure the abundance of the compliant marine fuel for their operations (Porttechnology.org, 2018). Evergreen line in the seventh position, with a market share of 5%, integrated in its latest sustainability report its intention to proceed with the installation of exhaust gas technology in all the newly ordered vessels (Evergreen Marine Corp., 2017). However, no financial data were available in order to make an estimate for the capability of the company to retrofit the current fleet. Next, Orient Overseas (International) Limited (OOCL), holding a 3% market stake has not divulged the specific strategic plan which will be taken. Nevertheless, in the latest annual report of the group, the newbuilds design description refers to enclosed spaces, specifically designed for the possible installation of LNG-burning engine and to fuel tanks suitable for storage of MGO and LSF (OOCL Overseas (International) Limited, 2018). Yang Ming on the other hand, with an approximate percentage of 2.8% of the liner industry, has taken a more cautious approach and announced that it will initially utilize low Sulphur marine fuel and will not proceed at the moment to any investments, concerning scrubbers or LNG-propulsion systems (Boonzaier, 2018). Similarly, to Yang Ming, ZIM shipping line (including Gold Star Line) which stands in the tenth position in the list with a 1.8% share, will conform with IMO 2020, by following the same strategy (ZIM, 2018). Consequently, Low Sulphur marine fuel, seems the appropriate alternative for the liner, since 92% of its fleet is composed by chartered vessels, thus there is no incentive for investments on the respective vessels.

6.2 Examined liners from 11th to 20th

Moving on to the next ten of Top 100, the Singapore based Pacific International Line (PIL), is right below ZIM and holds approximately the same market share, including Advance Container Line (ACL), Pacific Direct Line (PDL) and Mariana Express Lines Ltd (MELL). The firm has yet to announce their compliance plans regarding the regulation. Closing the fiscal year of 2017 with an EBITDA of USD 507 million (Pacific International Lines (PTE) Limited, 2018). For the formulation of the scenarios that will follow later it will be assumed that compliant marine fuel will be utilized from the company, in regards to its compliance to the regulation, since no retrofitting strategies have been made public. The 12th position in the ranking, is occupied by Hyundai Merchant Marine, which translates to a market share of approximately 1.8%. Although the firm, as stated in its official financial statement, suffered a loss of USD 1 billion on the previous year, it announced its intention to proceed in the order 20 mega

containerships, as a way to conform with the IMO 2020 and the new builds will be equipped with LNG engines and scrubbers (Kwasawneh, 2018). Upcoming in the Top 30 liners, is the Taiwan based firm, Wan Hai Lines. The shipping company presented a profit after tax of USD 70 billion, according to its financial report. Though the liner has not announced any concrete plans, in regards to the Sulphur cap, its moto "Stable and steady", along with its repeatedly mentioned utilization of low Sulphur in the present ECA areas, we will assume for the sake of the research that the firm will opt for LSF (Wan Hai Lines LTD, 2018). The Singapore-based company, X-press Feeders Group holds a percentage of 0.6%, including the fleets of Sea Consortioum, X-press Container Line and Rederi Transatlantic. However, at the moment there are no information available for the firm and its IMO 2020 compliance plan. For the sake of the research we will assume that the company will opt for LSF.

Following, the Korean Maritime Transport Co. (KMTC), holds a market share of 0.6% and is positioned in the 15th place in the Top 100 ranking. Due to the fact that the majority of the firm's fleet is consisted from small sized vessels, retrofitting exhaust gas or LNG-running propulsion systems will reduce the caring capacity of the vessels and will ensue an increase in the operational costs. On this ground, KMTC gravitated towards the utilization of low Sulphur marine fuel (Ufsoo.com, 2018). The 16th position is occupied by Antong Holdings Ltd (QUASC), a China based logistics company which operates in the liner industry and holds an approximate market share of 0.6% (Bloomberg, 2018). The firm has not disclosed any strategic plan regarding its fleet's compliance with the regulation. Similarly, to Antong Holdings Ltd, Zhonggu Logistics Corp., the 17th company with a market share of 0.58%, has not disclosed any leads regarding the alternative which will be used. Anew, for the present research, it will be assumed that the compliance method followed by both companies, will be Low Sulphur Marine Fuel. SITC International Holdings Company Limited, in the eighteenth position of the ranking, is a logistics and container transportation provider, with its main focus the Intra-Asia market. The firm made a strong profit of USD 1.348.385 in the past year, although it has not announced the alternative method which will be utilized (SITC International Holdings Company Limited, 2018). Anew, for the present research, it will be assumed that the compliance method followed by all of the three above-mentioned companies, will be Low Sulphur Marine Fuel. The next company in the investigated Top 100 liners, is Iran's national maritime carrier and Tehran-based Islamic Republic of Iran Shipping Lines (IRISL Group). The IRISL group is occupying around 0.4% of the container seaborne market, a consolidated share that includes the fleets of HDS Lines, Valfajre Eight Shg Co and Khazar Shipping Co. Even though the company has not officially announced its stance about the upcoming Sulphur Cap, there are reasons to believe that the group will go with the utilization of cleaner marine fuel. This supposition can be based on the fact that in 2016 the group formed a bunkering alliance with the Italian Fratelli Cosulich. The bunkering services will be offered in the Bandar Abbas in the Persian Gulf, on behalf of the IRSL group (Capuzzo, 2016). Next in the 20th liner in the industry's ranking is SM Line Corp. The Korean firm is operating 21 containerships, from which the majority are feeders (SM Line Corporation, 2018). As there is no information available, in regards to its compliance method, in order to speculate the utilized alternative, we will consider the operational characteristics of the fleet. As mentioned the vessels are mainly feeders, fact that signifies that any retrofitting of scrubbers or LNG-engines in the feeders, would restrict their operational capacity. Thus, for the formulation of the scenarios, it will be assumed that SM Line will conform with the derivative, by burning marine fuel with low Sulphur consistency.

6.3 Examined liners from 21st to 30th

The first company from the final ten companies which will be investigated, is the Taiwanese liner, TS Lines LTD. Founded in 2001, TS lines is holding a market share of around 0.3% and operates 32 vessels, from which merely 2 are firm-owned (Tslines.com, 2018). As many other firms in the above rankings TS lines is exhibiting a wait-and-see approach, concerning the IMO 2020 regulation. In this particular case in other to speculate the alternative which will be utilized, one needs to investigate the proportion of the fleet which is chartered. The majority of the fleet chartered are feeders and are mostly chartered from CMA-CGM, Evergreen and KMTC among others (Vgm.tslines.com, 2018). Since, 87.2% of the TS Lines' fleet is chartered, the firm will conform with the derivative with any way the chartered vessels are equipped to. However, since they are feeders, for this research it will be presumed that the alternative method followed by the company will be Low Sulphur Fuel. In the 22nd position, is Arkas Line, former EMES, which possesses around 0.3% of the liner industry. Whilst there is no IMO-2020 oriented announcement, the firm describes as one of its environmental preservation strategies, the procurement of LSF for the propulsion of its vessels. Hence, it is safe to assume that compliant marine fuel will be the method to be followed for the regulation (Arkas Line, 2018). In the 23rd rank is the Hong Kong listed logistics services provider, Sinotrans Limited, which holds a market share of almost 0.3% of the liner industry. The firm has taken various initiatives for the preservation of the environment from the hazardous air emissions, during the past years, as a part of its sustainability strategy. Specifically, on 2017 it reduced the fleet's Sulphur emissions, after a period of uprising. However, the company does not provide any numerical and statistical data regarding the Sulphur reduction portion (Sinotrans Shipping Limited, 2018). Similarly, there is no statement available about the upcoming Sulphur cap. With more than half of the containership fleet to be chartered from other companies, it will be assumed once more, that Sinotrans Ltd. will utilize Low Sulphur marine fuel, as all the firms with similar characteristics analysed previously. Moving on to the South Korean liner, Sinokor Merchant Marine, it is evident that companies with a small portion of the market, exhibit the same passive approach towards the upcoming restrictive. Sinokor M.M. at the moment, occupies 0.2% of the industry, although after 2019, when the merger with Heung-A, another intra-Asia liner operator, the share is expected to increase (Platts.cn, 2018). Keeping in mind that the firm's profile is basically feeders' operation, thus vessels of relatively small capacity, it will be once again assumed that the alternative utilized in 2020, will be compliant marine fuel, due to the capacity and investment restrictions that the other available options pose. Another case of possible utilization of LSF for the conformation with the IMO 2020, is one of the major carriers in the Indonesian region, Salam Pacific Indonesia Lines (SPIL). The firm has a market share of approximately 0.2%, according to the latest Alphaliner and has yet to disclose any future compliance strategy (Spil.co.id, 2018). Nevertheless, a new regime outlined from the Indonesian Ministry of Environment and Ministry, that will come into force in the region on September of 2018, which will restrict the limits of Sulphur both in diesel and gasoline on vehicles (Transport policy, 2017). Accordingly, the enforcement of the EURO 4 emission standards, can be a step towards promoting cleaner marine fuel in the Indonesian liners, with an aim to be line with the IMO Sulphur cap. Conclusively, in this research it will be assumed that Salam Pacific Indonesia Lines, will utilize LSF for its future operations. Next in the list is the Thailand-registered liner, Regional Container Lines (RCL). Due to the fact that the company operates feeder vessels with a capacity range between 500 TEUs to 2.732 TEUs, and there is no

information available or leads, regarding the company's future plans, the same pattern as above will be followed, meaning that it will be assumed that the company will utilize the compliant marine fuel, in order to conform with the regulation (RCL Group, 2018). Ranked as the 27th sea carrier in the world, with the exact market share of 0.2%, Grimaldi Group (Napoli), is active in a variety of shipping operations, as it provides cruise, passenger liner, trump and container transportation services, while sailing more than 100 vessels (Grimaldi Group, 2018). In contrast to the other liners examined before, which demonstrate alike characteristics, Grimaldi Group took a proactive approach in regards to the upcoming Sulphur cap and placed itself among the carriers that will ultimately choose scrubbers as their alternative method. Apart from the new-builds, which are to be delivered by the time the regulation will come into force, the company since 2016 had already installed exhaust gas technology, in order to mitigate the hazardous air emissions, to more than 25 vessels of its fleet and it will proceed in the complete fleet installation (Grimaldi Group (Napoli), 2017).

Following, the Emirates Shipping Line (ESL)is a Dubai-registered shipping company which operates 9 vessels with an aggregated capacity of approximately 44,000 TEUs, namely roughly 0.2% of the industry's capacity (Emirates Line, 2018). In the case of the ESL, in order to predict the alternative utilized, the chartered proportion of the fleet will be taken under consideration. At the moment, the firm provides transit services solely by operating chartered vessels and has no new-builds orders placed. The absence of no firm-owned vessels indicates that the company will not proceed in any investments to retrofit compliant equipment to the chartered vessels. As a result of this it will be assumed that the company will supply the vessels with LSF, in order to resume its operations, even after the enforcement of the IMO 2020. In the 29th rank is the American shipping company Matson, which holds about 0.2% of the market share. The firm chose to comply with the Sulphur cap, by installing duel fuel engines which can also process LNG, in its two Aloha-class containerships, which are scheduled to be delivered and deployed right before the regulation's enforcement date (MATSON, 2018). Notwithstanding, there has been no further information regarding the compliance method that the rest of the fleet will apply. Right above Matson and last liner company that will be examined for the said research is the Dubai-based feeder operator Simatech, with an approximate market share of 0.2%. As the company is operating relatively small capacity-wise containerships, with the largest to reach 4,400 TEUs, it will once again be assumed that due to the high investment costs and capacity restriction of LNG and exhaust gas equipment retrofitting, that the liner will select Low Sulphur Marine Fuel (Simatech, 2018).

Ultimately, the assumed compliance methods which are derived from the above investigation, are clearly depicted in the below table, along with the grounds on which the presumed alternatives were selected. In the respective table, only the companies that had not announced an alternative and were found to opt for fuel compliance, are depicted, as its their market shares that will be altered and possibly influence the concentration index. Furthermore, Maersk and Hapag-Lloyd are included in the table, due to their announcements regarding the utilization of compliant fuel.

As a supplementary comment, at this point it is highlighted that none of the indecisive companies are assumed to invest on scrubbers' technology or LNG retrofitting, due to the substantial lack of information regarding the investment capacity of the liners. Moreover, the examined liners, when applying the decision making criteria, showed an inclination towards the LFS, fact which is evident in the below table.

Table 4, Possible compliance methods of the indecisive examined liners

Firm's Name	Assumed compliance method	Justification of assumption
PIL (Pacific Int. Line)	LSF/MGO	For the sake of the research
Wan Hai Lines	LSF/MGO	Indications of compliance method from the latest annual report
X-Press Feeders Group	LSF/MGO	For the sake of the research
Korea maritime Transport Co. (KMTC)	LSF/MGO	Average size of fleet and latest articles
Antong Holdings (QASC)	LSF/MGO	For the sake of the research
Zhonggu Logistics Corp.	LSF/MGO	For the sake of the research
SITC International Holdings Co.	LSF/MGO	For the sake of the research
Islamic Republic of Iran Shipping Lines (IRISL Group)	LSF/MGO	Bunkering alliance with Fratelli Cosulich
SM Line Corp.	LSF/MGO	Restricted loading capacity of the fleet
TS Lines	LSF/MGO	Majority of operated fleet is chartered
Arkas Line/EMES	LSF/MGO	Indications of compliance method from the latest annual report
Sinotrans Limited	LSF/MGO	Large chartered proportion of fleet
Sinokor Merchant Marine	LSF/MGO	Restricted loading capacity of the fleet
Salam Pacific Indonesia Lines	LSF/MGO	Regional environmental regime; EURO 4 emission standards, for Sulphur restriction in fuel
Regional Container Lines Public Company Limited (RCL)	LSF/MGO	Restricted loading capacity of the fleet
Emirates Shipping Line	LSF/MGO	Only operating chartered vessels

Simatech	LSF/MGO	Restricted loading capacity of the fleet

7. HHI AND FORMULATION OF SCENARIOS

7.1 Current market concentration index, HHI.

Having analysed the factors which will be considered from the various liners, in order to reach a decision concerning the compliance method utilized or their inability to conform with the IMO 2020, it is imperative to examine the current concentration ratio of the containership market. At this point the Herfindahl-Hershman Index (HHI) will be computed in respect with the top 30 liner companies, as ranked by the Alphaliner. According to the index's formula, any containership company holding a share less than 1%, cannot affect the final result of the index, thus the remaining companies will be disregarded in this segment of the research due to their inability to alter the outcome.

The HHI will be computed by calculating the sum of the squared market shares, utilizing the proportion of the industry the companies represent, in respect to their TEU capacity, as stated by the Alphaliner, as per the below formula (Shepherd and Shepherd, 2004):

$$HHI = \sum_{i=1}^{N} s_i^2$$

Where N =30, as this analysis focus on the thirty (30) biggest liners and s_i^2 the squared market share in percentages, of each investigated firm. The market shares that are inserted in the formula and in the scenarios that will follow, are extrapolated from the Top 100 Liner companies ranking, from the exact date, 19th of July 2018.

When inserting the market shares in the HHI formula, the outcome generated is that $HHI_{current}$ = 918. According to the Department of Justice Agency's guidelines, the liner market at the moment is to be considered as an Unconcentrated Market, since the value of the index is < 1,500 (Department of Justice, 2015). Specifically, the industry's market structure is considered as perfect competition, defined by a low level of differentiation in the provided services (Pavic, Galetic and Piplica, 2016).

Following, with an aim to forecast the impact that the regulation, will possibly have in the market structure of the liner shipping industry, it is imperative to formulate several scenarios, in regards to the compliance method the 30 biggest companies, in terms of market share. Later on, the outcomes derived from the scenarios will be compared and discussed in order to discover whether there will be deviations between the concentration rates.

7.2 Scenario formulation methodology

In this segment two sets of scenarios will be structured based on two dimensions, the compliant marine fuel's cost and the price sensitivity of the shippers. As can be seen from the above-stated analysis of the liners, in regards to the alternatives that will most likely be utilized, the majority of the firms, which are placed in the lower ranks, are assumed to opt for compliant marine fuel, in order to be in line with the Sulphur Cap.

7.2.1 LSF future price as scenarios' aspect

Accordingly, the companies for the purpose of the scenarios, will be divided in two categories, which will be formed, based on the compliance method utilized. The first group of companies will be constituted from the liners that, as announced, will be in line with the Sulphur cap, by retrofitting their fleet or have ordered new-builds, with LNG-propulsion engines or exhaust gas systems. During the research their market shares will remain fixed, as other factors influencing their market shares, such as LNG forecasted prices and availability cannot be taken into account in the subject scenarios. Understandably, the liners that have announced or are assumed from the prior research, that will meet the restriction by being fuel compliant, will fall to the second category. The reason behind this is that the latter group is the one that will be susceptible on the price changes of the LSF, thus it will be the one examined, as for market share changes.

Based on this presumption, the first dimension under which the market will be investigated is the forecasted LSF price. To illustrate, the IMO Sulphur regulation, will impel the majority of the firms that have adopted a reactive approach to utilize compliant marine fuel, such as Low Sulphur Fuel and MGO, due to uncertainty and time, capacity and investment restrictions to deploy the remaining alternatives. Thus, the Sulphur cap is expected to produce an increase in the demand on the low Sulphur fuel, which will be understandably accompanied by an escalation in the fuel's price (Alshammari and Benmerabet, 2017). Bunkering costs and the fuel consumption of the engine, are the most determinant factor for the voyage cost of a vessel. Accordingly, any substantial alteration in the prices of the bunker, can affect the freight rates that the liner charges for the provision of the transportation services (Stopford, 2013). The increases in bunkering prices and in most operational and voyage costs, take the form of surcharges to the shippers and consequently will alter the transported volumes and market shares of the respective firms (UNCTAD, 2010). This outcome will be the core objective of the first set of scenarios.

With an understanding that an increase in the cost of the compliant fuel, due to the forces that set the equilibrium price in the market, demand and supply, the first scenario will be based on this most-anticipated development. To elaborate, in the supply side, the refineries are already under significant pressure to provide the industry with the amount of low Sulphur fuel that will be needed (Ship & Bunker, 2018). The forecast that there will be shortage in the supply of compliant fuel, is not only the impression of the market, but is also reflected in the studies that were conducted by research centres, as a supplemental study to the IMO. Even though the study was in alignment with the IMO's report, which was conducted by CE Delft, it raised several

concerns regarding the ultimate fuel availability. Both studies, as mentioned in Chapter 3 of the research, concluded that the IMO 2020 Sulphur restriction is feasible, in regards to the availability of the Low Sulphur marine fuel. However, these studies took as a fixed baseline that the refineries will invest in the upgrade of their produced capacity, fact which is not certain, due to the strained market conditions, leaving in doubt the findings from both studies (EnSys Energy, 2016). Shipping companies on the other hand, which represent the demand side, will drastically increase the volumes of marine fuel required, in order to conform with the regulation, as shown in the above analysis of the liners (George, 2018).

The switch of the demand from the HSFO to the LSFO and the price increase, that the inequality between the supply and the demand of the compliant fuel will bring, has been researched by several organizations. The Nordic Corporate Bank (SEB), investigated the possible future price difference between HSFO and the compliant fuel, due to the market forces, and they resulted to a price range difference that will shape the bunkering costs in 2020. The maximum difference it was found to be $150/ton, whereas the minimum $50/ton (Schieldrop, 2018). These extremes will be utilized in the below scenarios. For the purpose of generating credible results in all the scenarios, the HSFO price which will be utilized as input, will be fixed at USD 463.50 per ton and is extrapolated from the average price of the 20 biggest ports worldwide (price extrapolated from Ship & Bunkers, on 6th of August) (Ship & Bunker, 2018).

7.2.2 Shippers' price sensitivity as scenarios' aspect

In order to link the increase in bunkering costs with the new freight rates, it will be considered in the scenarios that the fuel costs reflect approximately 50% of the freight rates in the seaborne trade (Stratiotis, 2018). Next, the sets of scenarios will consider the price sensitivity of the shippers in any alterations in the freight rates, which will reflect in the demanded volumes. To elaborate, in a multilinked market, like seaborne trade, volumes, freight, customers and suppliers are adherently connected, meaning that every alteration in any of the components of the industry it will distort the market. Specifically, the supply and demand of shipping, are determining the equilibrium price of the market, while the demand curve, represents the prices that the carriers are willing to pay for each level of freight rate (Lun, Lai and Cheng, 2014). In our case, as customers of the liner companies, are considered to be the shippers/carriers, which will ultimately bare the surcharges of the increased bunkering prices in the forms of augmented transportation freights.

Thus, it is imperative to understand the elasticities of demand that characterize the shippers, in order to compute the new volumes, that will ensue from the additional charges from the fuel compliant companies. The term elasticity of demand refers to the changes that the demanded quantities of a product or service, which are derived from any alterations in the price. The price range of elasticity can vary from 0 to infinity (Mankiw and Taylor, 2017). Due to the lack of information regarding the shippers' exact elasticity of demand, attributed to the variations in shipped cargo, routes, socio-political events and substitute transportation modes, in this research case, we will investigate the extremes (Oum, Waters, II and Yong, 2018).

The shippers in each set of scenarios, will be considered to be initially price inelastic and then price elastic. Namely, the shippers can be price inelastic, when any percentage change in prices, results to a lower or non-existent percentage change in the demanded volumes, which translates to an elasticity value less than 1 (Mankiw and Taylor, 2017). The value of price elasticity of demand in this case will be taken equal to 0.1, as it is close to zero.

On the contrary, the price elasticity of demand can be considered elastic, when a percentage change in the price, ensues to a greater percentage alteration in the demanded volumes and can take prices equal or greater to 1 (Mankiw and Taylor, 2017). The value of price elasticity of demand in this case will be taken equal to 1.1. Hence, both cases will be examined under the main scenarios and the values of the elasticity used will be as per below:

The formula utilized to compute the new demanded volumes from the shippers, under the sets of scenarios, is the below:

$$Price\ elasticity\ of\ demand\ (PED) = \frac{\Delta Q\%}{\Delta P\%}$$

where numerator is the percentage change in the quantity demanded, over the percentage increase or decrease in the freight rates (Mankiw and Taylor, 2017).

It would be an omission not to mention that the volumes demanded from the shippers, are subject to numerous other factors apart from the freight rates of the liners. These are for example, the alternative transportation modes, the urgency of their shipment, the routes and other factors, that will not be part of this analysis. Thus, the shippers reaction will be investigated, in terms of the freight rates increase, due to the augmented bunkering costs.

The two sets of scenarios will be structured with the below characteristics and values:

Table 5, Scenarios Overview

	Scenario set 1		**Scenario set 2**	
	Scenario 1.1	Scenario 1.2	Scenario 2.1	Scenario 2.2
LSF increase	\$150/ton		\$50/ton	
Shippers Elasticity	Inelastic: PED = 0.1	Elastic: PED = 1.1	Inelastic: PED = 0.1	Elastic: PED = 1.1

These scenarios will generate the possible alterations that will be imposed on the market shares of the firms and that might contribute in the change of the industry's concentration index (HHI).

7.3 Formulation of the scenarios

7.3.1 Scenario set 1: \$150/ton price range

Initially, we will assume the maximum difference between the two types of fuels to be $150/ton, with LSF being the more expensive fuel for the shipowners. Thus, the prices in the first set of scenarios will be as below:

Table 6, Scenario set 1 input

Type of marine fuel	USD per ton of marine fuel
HSFO	463.5
LSF	613,5
Increase in marine fuel price	32%

Considering that the fuel compliant companies will face an increase in their bunkering costs, in the level of 32%, as computed above, it goes without saying that the freight rates will see an upward trend as well. This will be based on the fact that the difference in price between the fuels, that firms will have to pay will be passed on to the shippers in forms of surcharges (Ramsey, 2017). Keeping in mind that bunkering expenses are almost half of the freight rate we compute the below calculations:

$$Bunkering\ costs = 0.5\ x\ freight$$

$$New\ Bunkering\ costs = 0.32\ x\ 0.5\ x\ freight + 0.5\ x\ freight = 0.66\ x\ freight$$

The new freight rate will be:

$$\frac{0.66\ x\ freight}{0.5} = 1.32\ x\ freight$$

Which means that the new freights will be 32% increased, compared to the initials.

Hence, in the first set of scenarios the biggest potential increase in the compliant fuel, will ensue a 32% raise in the freight rates of the companies that will utilize it. Next, is imperative to investigate how the shippers will react in this freight increase and in what extent will the demanded volumes and market shares of the fuel compliant companies be impacted.

7.2.1.1 Scenario 1.1: Price-inelastic Shippers

In the first sub scenario of the first set, the shippers will be considered to be price insensitive, meaning that an increase in the freight rates will bring a proportionally smaller decrease of the demanded volumes. As the shippers are assumed to be price inelastic, the PED inserted in the equation, will be the lowest extreme, 0.1. From the PED formula we get that:

$$\Delta Q\% = (0.1)\ x\ 0.32 = \ 0.032 = -3.2\%$$

Thus, when the shippers are price inelastic, a 32% increase of the bunkering costs, due to the regulation compliance from the companies, will ensue a 3.2% decrease in the demanded volumes and consequently in their market shares.

Table 7, Sub-scenario 1.1: New volumes/market shares of fuel compliant liners

Fuel compliant companies	**New demanded volumes in TEUs**	**New market shares**
APM-Moller Maersk	3,896,881	18.01%
CMA-CGM	2,537,306	11.73%
Hapag Lloyd	1,548,963	7.14%
PIL (Pacific Int. Line)	392,527	1.81%
Wan Hai Lines	249,304	1.15%
X-Press Feeders Group	134,537	0.62%
Korea maritime Transport Co. (KMTC)	132,700	0.61%
Antong Holdings (QASC)	130,296	0.60%
Zhonggu Logistics Corp.	126,423	0.58%
SITC International Holdings Co.	109,662	0.51%
Islamic Republic of Iran Shipping Lines (IRISL Group)	93,299	0.43%
SM Line Corp.	80,718	0.37%
TS Lines	72,175	0.33%
Arkas Line/ EMES	71,580	0.33%
Sinotrans Limited	62,867	0.29%
Sinokor Merchant Marine	56,076	0.26%
Salam Pacific Indonesia Lines	50,600	0.23%
Regional Container Lines Public Company Limited (RCL)	49,297	0.23%
Emirates Shipping Line	42,537	0.20%

Simatech	40,300	0.19%

Keeping the market shares of the other companies constant and altering the shares of the fuel compliant firms, as per the darkened cells in the table, we recompute the HHI. The new value of the concentration rate, under this sub-scenario is $HHI_{1.1} = 719$.

7.2.1.2 Scenario 1.2: Price-elastic Shippers

Under the same scenario that the freight rates of the fuel compliant liners, will increase at a 32% rate, respective to the price of the Low Sulphur Fuel, it is of great significance to investigate the possible change in the demanded volumes, in the case that the shippers are price elastic. In this segment the new demanded volumes and market shares, that will be generated, will be computed considering that the shippers' elasticity of demand is equal to 1.1. Hence, the percentage decrease of the new transported volumes demanded for the said companies will be computed as per below:

$$\Delta Q\% = (1.1)\ x\ 0.32 = \ 0.352 = 35.2\%$$

When the shippers are price elastic (PED=1.1), it is evident that the new demanded volumes and market shares, from the firms will follow a drastic decrease of 35.2% rate. The exact figures are depicted on the below table.

Table 8, Sub-scenario 1.2: New volumes/market shares

Fuel compliant companies	New demanded volumes In TEUs	New market shares
APM-Moller Maersk	2,608,656	11.67%
CMA-CGMA	1,698,527	7.60%
Hapag Lloyd	1,036,909	4.64%
PIL (Pacific Int. Line)	262,766	1.17%
Wan Hai Lines	166,889	0.74%
X-Press Feeders Group	90,062	0.40%
Korea maritime Transport Co. (KMTC)	88,832	0.39%
Antong Holdings (QASC)	87,223	0.39%
Zhonggu Logistics Corp.	84,630	0.37%
SITC International Holdings Co.	73,410	0.32%
Islamic Republic of Iran Shipping Lines (IRISL Group)	62,456	0.27%
SM Line Corp.	54,034	0.24%
TS Lines	48,316	0.21%
Arkas Line/EMES	47,917	0.21%
Sinotrans Limited	42,084	0.18%
Sinokor Merchant Marine	37,539	0.16%
Salam Pacific Indonesia Lines	33,873	0.15%
Regional Container Lines Public Company Limited (RCL)	33,001	0.14%
Emirates Shipping Line	28,475	0.12%
Simatech	26,978	0.12%

Similarly, to the prior investigation, the non-fuel compliant companies' volumes and market shares are fixed and the changes due to the increase in LSF are mirrored in the decreased figures of the remaining companies. As anticipated the decreased market shares have an impact on the concentration index of the liner market. The new value of the index computed is $HHI_{1.2} = 616$

7.2.2 Scenario set 2: USD 50/ton price range

In the second scenario, the lowest anticipated increase in the price of LSF will be investigated. Namely, it will be assumed that the increase in LSF, in comparison to the HSF will be approximately USD50 per ton (Schieldrop, 2018). Thus, the prices utilized for this scenario will be as below:

Table 9, Scenario 2 Inputs

Type of marine fuel	**USD per ton of marine fuel**
HSFO	463.5
LSF	513.5
Increase in marine fuel price	10.8%

In this case, the liners that will utilize low Sulphur marine fuel to meet the compliance restrictions, will also face about 10.8% increase in their bunkering costs. Considering that half of the freight rate is consisted by the fuel burning costs, the possible increase in the amount that shippers will be charged will be computed similarly to before.

$$Bunkering\ costs = 0.5\ x\ freight$$

$$New\ Bunkering\ costs = 0.108\ x\ 0.5\ x\ freight + 0.5\ x\ freight = 0.554x\ freight$$

Which translates to a 10.8% increase in the freight rates that fuel compliant liners will charge.

7.2.2.1 Scenario 2.1: Price-inelastic shippers

Again, the shippers are assumed to be price inelastic in this scenario, the PED inserted in the equation, will be the lowest extreme, 0.1 as in the first part of the scenario. Accordingly, from the PED formula we get that:

$$\Delta Q\% = (0.1)\ x\ 0.108 = \ 0.0108 = 1.08\%$$

From the price elasticity of demand formula, it can be derived that a 10.8% surcharge in the shipping freights, due to the augmented LSF bunkering costs, will ensue to a 1.08% decrease in the demanded volumes and consequently in the respective market shares. The new demanded volumes and market shares of the liner companies that opt for the fuel compliance can be found in the following table.

Table 10, Sub-scenario 2.1: New volumes/market shares

Fuel compliant companies	New demanded volumes In TEUs	New market shares
APM-Moller Maersk	3,982,225	16.07%
CMA-CGM	2,592,875	10,46%
Hapag Lloyd	1,582,886	6.39%
PIL (Pacific Int. Line)	401,124	1.62%
Wan Hai Lines	254,764	1.03%
X-Press Feeders Group	137,483	0.55%
Korea maritime Transport Co. (KMTC)	135,606	0.55%
Antong Holdings (QASC)	133,149	0.54%
Zhonggu Logistics Corp.	129,191	0.52%
SITC International Holdings Co.	112,064	0.45%
Islamic Republic of Iran Shipping Lines (IRISL Group)	95,342	0.38%
SM Line Corp.	82,485	0.33%
TS Lines	73,756	0.30%
Arkas Line/EMES	73,147	0.30%
Sinotrans Limited	64,244	0.26%
Sinokor Merchant Marine	57,304	0.23%
Salam Pacific Indonesia Lines	51,708	0.21%
Regional Container Lines Public Company Limited (RCL)	50,377	0.20%
Emirates Shipping Line	43,468	0.18%
Simatech	41,182	0.17%

Considering the decrease in the market shares of the fuel compliant companies, while retaining the remaining market shares, the index computed is $HHI_{2.1} = 812$.

7.2.2.2 Price-elastic shippers

On the other hand, shipper may be more price elastic in the growth of the freight rates that will be asked from the companies. In that case, similarly to before the price elasticity of demand that will be utilized in order to compute the possible impact on volumes and market shares will be, PED= 1.1. The percentage decrease will be computed as below:

$$\Delta Q\% = (1.1)\ x\ 0.108 = \ 0.1188 = 11.88\%$$

Consequently, the decrease expected, when the shippers are price elastic, namely more price sensitive to any freight rate changes, will spring a cut of 11.88% in the demanded volumes.

Table 11, Sub-scenario 2.2: New volumes/market shares

Fuel compliant companies	New demanded volumes in TEUs	New market shares
APM-Moller Maersk	3,547,449	15.87%
CMA-CGM	2,309,787	10,34
Hapag Lloyd	1,410,068	6.31%
PIL (Pacific Int. Line)	357,329	1.60%
Wan Hai Lines	226,949	1.02%
X-Press Feeders Group	122,473	0.55%
Korea maritime Transport Co. (KMTC)	120,801	0,54%
Antong Holdings (QASC)	118,612	0.53%
Zhonggu Logistics Corp.	115,086	0.52%
SITC International Holdings Co.	99,829	0.45%
Islamic Republic of Iran Shipping Lines (IRISL Group)	84,933	0.38%
SM Line Corp.	73,480	0.33%
TS Lines	65,703	0.29%
Arkas Line/EMES	65,161	0.29%
Sinotrans Limited	57,230	0.26%
Sinokor Merchant Marine	51,048	0.23%
Salam Pacific Indonesia Lines	46,063	0.21%
Regional Container Lines Public Company Limited (RCL)	44,877	0.20%
Emirates Shipping Line	38,723	0.17%
Simatech	36,686	0,16%

The value of the concentration index, under the subject scenario is $HHI_{2.2}$= 802.

8. RESULTS AND DISCUSSION

In this chapter the outcome of the analysis, will be stated and summarized, in order to provide the readers with a clear idea of the current and the future concentration in the liner industry, as generated from the scenarios. The investigated subjects in the previous chapter were initially the research of the compliance methods that the liners, which followed a reactive approach to the IMO 2020 regulation, will utilize. In parallel the current concentration ratio of the containership industry was computed, in order to be compared with the HHI results derived from the scenarios. After determining that the possible compliance method followed from the respective liners will be marine fuel with low consistency in Sulphur, the scenarios for the possible impact on the market shares were formed.

As a first step, the current concentration market was computed, utilizing the HHI index. The sum of the squared market shares of the 30 biggest liner companies, as presented in Alphaliner were extrapolated, in order to compute the index, which will act as baseline for the comparisons followed. The computation, showed that the market had a concentration index of $HHI_{current}$= 918. The value generated, indicates that the current liner market is unconcentrated (Department of Justice, 2015).

The sets of scenarios and their generated outcomes, in terms of HHI values are depicted in the table below:

Table 12, Scenarios: Input and HHI results

	Scenario 1.1	**Scenario 1.2**	**Scenario 2.1**	**Scenario 2.2**
Elasticities (PED)	0.1	1.1	0.1	1.1
Freight increase	$150/ton or 32%	$150/ton or 32%	10.8%	10.8%
Decrease in volumes / market shares	3.2%	35.2%	1.08%	11.88%
HHI values	719	616	812	802

In the first set of scenarios, the expected increase in the demand for Low Sulphur Fuel, due to the switch from High Sulphur Fuel, will ensue to an increase in the bunkering costs of the companies. The maximum price increase, in comparison to the currently utilized HSF, that is anticipated, is USD 150 per ton.

In Scenario 1.1 the HHI was investigated, when the shippers that transport their goods via the liner firms, have an inelastic price elasticity of demand. Namely their demanded quantities are affected less, in proportion to the freight rate changes (Mankiw and Taylor, 2017). A PED equal to 0.1, showed that the volumes that shippers will demand from the fuel compliant companies will decrease by 3.2%. As the TEUs utilized from the liners are reflected in their market shares, there will also be an equal decrease. By recomputing the HHI, with the altered market shares from the companies that will utilize LSF, the new HHI index generated, was $HHI_{1.1}$ = 719. Both HHI values, current and from the first sub scenario, indicate that the liner industry

remains an unconcentrated market, as the indexes are bellow 1500 (Department of Justice, 2015).

Accordingly, in the second sub scenario under the USD150/ton increase, the shippers are considered to have a higher price sensitivity in the fluctuations of price, translated to an elastic price elasticity of demand. A PED equal to 1.1, generates a significant decrease of 35.2% in the demanded volumes and the respective market shares of the firms. The concentration ratio computed in that case, was $HHI_{1.2} = 616$. Like the first sub scenario, the industry remains unconcentrated and even becomes more competitive, as large market shares from the fuel compliant companies, will allocate to the remaining firms (Department of Justice, 2015).

Moving on, the second set of scenarios is based on the minimal anticipated increase of LSF, which is USD 50 per ton. In contrast to the previous scenario, the increase in freight rates is expected to be 10.8%, which is approximately thrice lower than before. The input for the two sub scenarios, under the minimum price increase, and the indexes' results, are depicted below:

Similarly, to the first set scenario the freight increase is the same for both instances. The 10.8% freight increase however has different results, depending on the price sensitivity of the shippers that opt for the respective companies. Shippers characterized by a PED of 0.1, will merely demand 1.08% less transported volumes from the firms. The downfall in the volumes translates to a concentration index value of $HHI_{2.1} = 812$. In this occurrence, it is evident that the concentration of the market is decreasing, again due to the fact that the market shares are allocated to the other firms operating without the additional bunkering costs.

When the price elasticity of the shippers is elastic, specifically PED equals to 1.1, the volumes that shipper wish the fuel compliant companies to carry, see a decrease of 11.88%. Accordingly, the market shares decline, resulting to a concentration value of $HHI_{2.2} = 802$. One can observe that the concentration ratio has decreased more, compared to instance of price inelastic shippers.

To summarize, the two scenarios have analyzed the possible concentration index, under the maximum and minimum estimated increase of the Low Sulphur Fuel. When the projected increase of LSF, is USD150 per ton in comparison to HSF, that the other companies will utilize, the HHI is decreasing, more when the shippers are price elastic and less when they are price inelastic. The same result can be observed in the scenario of the minimum anticipated increase in the price of LSF, USD50 per ton. Namely, the concentration rate of the liner market is decreasing under both sub scenarios.

Finally, in case that the liners do not opt for LSF as generated from the subject research then the concentration index of the market will not be as presented above. If most of the liners opt for scrubber or LNG, depending on their investment capacity and the prices of the respective fuels, the index will change accordingly.

9. CONCLUSIONS AND FURTHER ANALYSIS

To conclude, the purpose of the subject research, was to explore and forecast the possible impact of the new IMO 2020 legislation on the liner shipping market structure. This query immerged from the challenge that the shipping world phases, due to the regulation's immense enforcement. Shipping companies in liner market, especially the small shareholders, followed a reactive approach due to the uncertain efficiency of the compliance methods and the doubtful availability of compliant marine fuel in a global scale. For this reason, the way that the firms will react to the regulation can affect the volumes transported and change the market shares. An alteration in the liners' market shares can potentially ensue to a respective alteration in the industry's structure.

In order to provide a sufficient answer to the main research question, five sub questions were formulated, in order to make the final possible assessment of the market structure. The first sub question, has an aim to present the currently available alternatives that the liner industry has its in disposal and which are their characteristics, in regards to the containership market. These are installation of scrubbers or LNG-propelled engines and utilization of cleaner marine fuel (LSF).

The second sub question was segregated in two parts. Initially, the factors that could influence the decision making of the liners, considering the alternatives utilized were investigated. Namely, the stance of the leading liners in respect to the Sulphur cap, the characteristics of the firms' fleets, such as average capacity and age and chartered proportion of fleet. Following on those, the announced actions of the 5 leading companies, in terms of market shares, AP Moller Maersk, MSC, CMA CGM, COSCO and Hapag Lloyd, were analyzed, as competitors' behavior is considered to be one of the most determinant factors for the remaining companies.

Next, by studying the factors that can influence the actions that individual shareholders will take, and later apply them to the 30 first liners, in terms of market shares, it was possible to forecast their compliance method and answer the third sub question raised. Specifically, 17 of the companies that had adopted a reactive approach towards the regulation were found to possibly opt for Low Sulphur Fuel, as to conform with the restrictive, fact that is later utilized in the structure of the scenarios. Amid with these companies, the market shares of three major liners which will be fuel compliant, APM-Maersk, CMA-CGM and Hapag Lloyd, were added to the scenarios, due to their announcements that they will utilize LSF.

Moving on to the fourth sub research question, the assessment of the possible impact of the IMO 2020 regulation on the liner market structure, Herfindahl-Hirschman Index was utilized, for the computation of the industry's concentration rate and is deemed the most appropriate method for the market analysis. The initial HHI showed that the liner industry is currently an unconcentrated market, with a value of 918.

The fifth sub question is relevant to the scenarios that need to be formulated, in order to explore the various possible alterations in the market shares. On the grounds that

the majority of the liners, as derived from the analysis, is expected to be fuel compliant, the sets of scenarios were based on the estimate increase in the LSF prices. In a subsequent dimension, the price sensitivity of the shippers was examined. Under a price increase of USD150 and USD50 per ton, and according to the price elasticity of demand that the shippers hold, four probable future HHIs were calculated. The concentration indexes under all four cases, when compared to the initial value, indicated that the market shares, will react to the enforcement of the regulation. In all four cases the market is expected to become even more unconcentrated. To elaborate as the demanded volumes from the fuel compliant companies will be reduced and allocated to other carriers, the index indicates that the industry will become more competitive. It is of great significance to mention that the biggest decrease in the concentration index, is forecasted to be triggered under the maximum expected increase in the bunkering costs and in the case that the shippers are extremely price sensitive.

One is difficult to determine what the most likely scenario be in terms of elasticity; however, the distortion of the market indicates that the LSF price range will most likely be closer to the first set of scenarios, where the LSF increase will be great. In this set of scenarios, where the volumes decreased, the concentration index fell more than the second set of scenarios, meaning that in the most probable outcome from the enforcement of the regulation is the increase in the competitiveness of the industry.

To conclude, the enforcement of the IMO 2020 regulation, is expected to produce a downfall to the concentration rate of the liner shipping companies, namely increasing the competitiveness in the industry. Considering all scenarios, the market shares of the companies are expected to alter, as an inflict of the restrictive due to the tight time and cost challenge that it imposes to the industry. Overall, it was discovered that the container shipping industry will sway into a more competitive character under all scenarios formulated, due to the decrease of the concentration index generated in all cases.

9.1 Limitations of the research

After cautiously examining the results of the research, in regards to the possible impact of the Sulphur cap to the liner market structure, it would be an omission not to mention the limitations of the analysis. Initially, the reactive and secretive approach of the liners, to disclose their compliance method, complicated the future scenery and the selection of the criteria, on which the scenarios were based. Furthermore, the lack of adequate information disclosed from the liners, in terms of investment capacity and compliance methods for similar regulations, was an obstacle in the accurate forecast of the compliance methods that will be ultimately used. Moving on to the quantitative part of the research, the Herfindahl Index is subject to various limitations, mainly due to its simplicity. For instance, the results of the analysis indicated that the liner market will move towards a more competitive structure. However, the smaller shareholders could not be considered, due to the index's formula, which sums the squared market shares, instantly disregarding companies with minor shares. Ultimately, the increase in the bunkering costs of the fuel compliant companies and the respective freight increase for the subject liners, was found to result to decrease in their market shares. Nevertheless, it cannot be forecasted how and in which companies will the shippers turn and consequently increase the volumes transported. For this reason, the

remaining companies' shares were kept fixed throughout the research. As a consequence of the above research restrictions, the market's inclination towards a more competitive environment, has to be assessed as a short-term outcome of the regulation. In a generic view, there will be a period of fluctuations in the market shares, as the fuel compliant liners, might lose market shares at the beginning, but their chosen alternative, is considered to be proven the most efficient solution in the long term.

9.2 Proposals for further analysis

The subject research had as a purpose the investigation of the market structure change, due to the enforcement of the IMO's Sulphur cap. However, the research would be interesting to be duplicated, once the restrictive comes into force. A clear picture of the compliance methods that all liners will utilize, will provide the researcher with ground pillars, on which forecasts can be built, such as proportion of fuel compliant companies, exhaust gas scrubbers and LNG equipped vessels. Moreover, it is of great significance the investigation of the possible alteration in the market, by utilizing the concentration ratio (CR), which investigates only the market shares from the largest companies, and its comparison to the outcomes generated from the Herfindahl-Hirschman Index. Also, the price sensitivity of the shippers, is a factor that needs to be examined further, as it is subject of variations, due to the diversity of the commodities transporter, the geographical position and the complexity of the shipping industry as a whole. Finally, a similar analysis which will include the forecasted prices for LNG fuel, post-regulation era needs to be conducted, in order to generate a wholesome scene for the future bunkering costs and their possible impact on the liner market structure.

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