Master Thesis

Sustainability as a Strategic Tool in Liner Shipping

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Table of Contents

Abstract

In recent years public opinion is becoming more and more interested in sustainability related topics. As a consequence, companies in many different industries are trying to find and implement solutions to reduce their environmental impact. Shipping, and liner shipping in particular, is an essential industry to the existence of world trade as it provides long-haul carriage of virtually any kind of goods at relatively low price. However, this widespread adoption of shipping as mean of transportation results in a significant contribution to marine and air pollution. The industry, then, is experiencing some changes towards a cleaner business. This thesis discuss the possibility, by part of liner companies, to adopt a sustainability driven corporate strategy to build a competitive advantage rather than just following anti-pollution regulations and merely comply with them. Through the use of strategic management tools and theories, liner shipping industry has been analyzed in order to discuss the main forces pushing it towards sustainability, which are found to be international and local regulations and market forces, namely changes in customer's demand. The analysis of such forces suggests that sustainability can potentially be used as key point of an innovative and proactive corporate strategy meant to build a long term competitive advantage. However, the significant investments and remarkable changes in organizational routines implied by a sustainability based strategy have to be included in the analysis. Such drawbacks could be overcome by the development of an already established phenomenon in liner shipping: networks and alliances among companies. Ultimately, then, this thesis supports the conclusion that a sustainability based corporate strategy, adopted and implemented by a network of liner companies, has the potential to result in the creation of a sustainable competitive advantage.

Chapter 1. Introduction

The purpose of this thesis is to analyze and discuss the impact of new upcoming pollution prevention measures on the strategic environment of the liner shipping industry.

This topic is receiving growing attention from liner shipping companies in the last years, due to increasing concerns about the environmental footprint of the shipping industry. However, when shipping companies are forced by any external factor – as example, new regulations – to adopt new technologies and sustainable standard operating policies – both of which will be discussed in the paper – they seem to be more concerned in minimizing the loss of economic performance rather than improving as much as possible their environmental one. This can be defined as a "damage control" approach, whose main goal is to find the best compromise between economic performance and sustainability. Despite this represents a good starting point in the quest for green shipping, this approach may prevent companies to invest and commit in the research of new ways to make shipping a less polluting industry.

This thesis aims to discuss whether is it possible to create another more proactive approach towards sustainability, whose goal would be to improve economic performance through an improvement of the environmental one. The research questions driving the analysis, then, are: what will be the effects of the enforcement of a tighter anti-pollution regulation on the strategic context of liner shipping? How could the industry react to changes in the business environment as tightening of regulations or changed customer preferences? Could environmental performance ever become a potential source of competitive advantage? Would it be possible and convenient, at present and in the near future, for companies to use sustainability as source of competitive advantage rather than just considering it a potential threat to profitability?

As liner shipping is a very dynamic industry, a deep knowledge and experience are essential pre-requisites to be able to predict market variables and to prepare sound strategies at corporate level. For this reason, the thesis is meant to discuss such topic as academic research.

In order to discuss these topics, in the first part of the thesis, using relevant tools and theories, a strategic analysis of the liner shipping industry will be performed, to outline the most important characteristics of the industry itself; then, in the second part, the main shipping-related sustainability issues will be discussed, to give a general picture of what challenges is the shipping industry facing and what are the main areas in which a reduction of pollution is needed. In the third part of the thesis, the discussion will focus on the new upcoming changes that the industry is likely to have to deal with in the near future: those changes can be divided in two main categories, the new environmental regulations coming from international – and regional or national – authorities, and the changes in customers approach towards sustainability issues, which would reflect in an important change in customers' preferences and demand: this of course would be a second force pushing shipping companies towards green shipping. Finally, the last part of the thesis will contain the discussion about the main changes in the strategic environment of the liner shipping industry, driven by the above mentioned factors: while there's no doubt that the enhancement of environmental performance will require great investments to companies, the possibility of using those investments to build a competitive advantage, rather than just comply to new regulations or meeting customers' demand, is yet to be discussed.

1.1 Topic Delimitation

Sustainability in the shipping industry is a very broad topic, and in the recent years lot of research has been made on it (Balland et al,2014; Cariou and Cheaitou, 2012; Chang et al, 2014; Dinwoodie et al, 2014; Farrag-Thibault and Pruzan-Jorgensen, 2010; Kaageson, 1999; Krozer et al, 2003; Lai et al, 2011; Lun et al, 2013; Pil and Rothemberg, 2003). The shipping industry itself, if taken in its wholeness, is an extremely dynamic and complex business: it includes at least four major sub-industries (bulk shipping, tanker shipping, specialized shipping and general cargo), each one characterized by very specific features. This leads to such a differentiation between the sub-industries that in order to run the different businesses, companies operating in more than one of them create industry-specific divisions, if not even separated sub-companies, to match the corresponding characteristics of the specific environment in which they operate[1].

A comprehensive analysis of sustainability in shipping would need to consider all shipping related businesses; however, the above mentioned high degree of differentiation between

[1] An example of this is given by Maersk, which, among other businesses, operates in both general cargo-liner and tanker shipping, with the two companies Maersk Line and Maersk Tankers respectively.

them would make the whole discussion extremely complex, possibly even going beyond the focus of the research. For this reason, and in order to get more specific results, this thesis will only concentrate on the liner shipping industry, which represents the vast majority of the general cargo trades.

This choice has been primarily made due to the undisputed major weight that liner shipping has among all other shipping industries, in terms of number of ships and economic value of the involved trades: according to Stopford[2] (2007), the number of general cargo ships – of which liner ships are the vast majority – roughly accounts for the half of the total cargo ships registered in the world. Moreover, despite the average tankers and bulk carriers ships being, in terms of deadweight, larger than container ships (which, in turn, are the larger type of general cargo ships), the economic value of the cargo carried per year by liner ships is much higher than the one carried by tankers and bulk carriers. Finally, while bulk and tanker shipping are very volatile industries, with uncertain profits and very unstable environments, the empirical measures (Stopford[3], 2007) clearly show a steady growing trend for liner trade over the last 4 decades, although in recent years container shipping freight rates have shown and increased volatility as well. However, the state of the world economy seems to suggest that this trend is likely to keep growing in the next future.

Besides the choice of the industry to focus on, another important decision has been made to mainly discuss the sustainability issues related to pollutant emissions from vessel's engines: although there are many other ways in which shipping industry can damage the environment, greenhouse gas emissions seem to be the area in which regulators entities and industry stakeholder are mainly interested (IMO, 2009; IMO, 2014; DNV, 2014) , this being justified by the evidences – which will be discussed – that seem to indicate emissions as the most concerning cause of maritime related pollution. Moreover, as already noticed for the industry selection choice, a comprehensive analysis of pollution factors related to shipping would require a much broader and extensive research, beyond the scope of a master's thesis.

Despite this, as the impact of other shipping related polluting factors more than emissions is

[2] Table 2.5, pag. 69
[3] Figure 13.2, pag. 515

far from negligible, in order to perform a realistic and concrete analysis they won't be completely disregarded, but the related discussion will be limited to a brief complementary section.

Chapter 2. Methodology and Theoretical Framework

In this chapter, the methodology of research will be discussed and a brief overview will be given of the theoretical tools used in the analysis and discussion.

2.1 Methodology

The purpose of the first part of this paper is to apply established theories and models from the strategic management field to the liner shipping industry, to give an accurate picture of the competitive environment of the industry as it is at present. This will set the basis for the following discussion on the impact of the introduction of sustainable shipping practices, be it due to regulation compliance or driven by other factors, on competition among the present players in the industry.

Moreover, despite the great importance of liner shipping to the worldwide economy, there is little evidence in literature of any previous attempt to run such an analysis.

Besides this, the main topic of the discussion is to investigate the feasibility of a sustainability based corporate strategy as source of competitive advantage. In this perspective, the role of customers is crucial: it is of the utmost importance to assess the extent to which they value sustainability. For this reason, in the discussion data and information will be used gathered from sustainable working groups and networks that enclose major sustainability-oriented cargo owners. Moreover, being the thesis intended as an academic research paper, great importance has been given to academic papers covering the topic in its wholeness or with a more specific focus on some of its aspects. This choice has been made with the aim of giving sound basis to the analysis. Finally, with specific regards to numeric and quantitative data about seaborne trade, liner shipping industry analysis and shipping related pollution, they have been mainly gathered from IMO or independent third-parties institutions as UNCTAD and MARINTEK, the rationale being trying to have verified and unbiased data.

2.2 Theoretical Framework

In corporate strategy, there is a wide variety of tools, models and theories that can be used as general guidelines to understand the environment surrounding the firm.

The business environment is defined by Grant (2010) as the set of external influences that affect the decision taken by managers and, ultimately, the performance of the firm. Of all those influences, competition is the most complex to analyze, as it depends on multiple variables, in most cases beyond the direct control of the company. For this reason, the main focus of the strategic analysis will be the competitive environment that liner shipping companies are facing at present.

Given those premises, and considering that the analysis has to be fairly concise, yet comprehensive, the choice has been made to base it on two renowned and well established theories: Porter's Five Competitive Forces Model and the Game Theory. The choice of using Porter's model is backed by its inherent comprehensiveness: the model is meant to provide a thorough analysis of all the forces shaping an industry and creating a specific competitive environment. The framework, thus, despite few minor shortcomings that will be pinpointed below, is useful to get a general understanding of competitive situation of the industry. The decision to use Game Theory, on the other side, has been made with the target of correcting the biggest downside, in the specific context of this analysis, of Porter's model, that is its disregarding of collaboration and cooperation among companies. More generally speaking, Porter's model is a rather static one, this meaning that it considers industries as they are in a specific moment, somewhat neglecting relations among companies, aside competition (Grant, 2010). Thus, with the aim to provide a more realistic description of the dynamics underlying liner shipping industry, Game Theory will be used to analyze cooperative phenomenon (as networks) within it.

What follows aims to be only a brief overview of them: the wide notoriety of both theories and the limited scope of this paper render comprehensive presentation unnecessary. However, due to the above mentioned scarcity of previous application of these models to the liner shipping industry, it seems appropriate to underline what are their most interesting aspects in this specific context.

2.2.1 Porter's Five Forces Model[4]

The Five Competitive Forces Model has been proposed by Michael E. Porter in 1979 in his renowned article "How Competitive Forces Shape Strategy" and later partially amended in 2008's "The Five Competitive Forced That Shape Strategy", and has been considered one of

[4] This and the following sections are mainly based on Grant (2010), chapter 3; and Porter (2008)

the most famous and valuable strategic management tools ever since. The model describes and analyzes the forces that shape the competitive environment of an industry: competition from potential substitute products, threat of new entrants, rivalry between established companies, bargaining power of customers and of suppliers.

The model is quite accurate, as it describes in depth the various and often complex factors that have an influence on each of those forces, however, it is mainly intended to describe the situation of production or differentiable services companies. Liner shipping, instead, is rather a commoditized service, with all the companies offering comparable services: the major shipping companies often provide, directly or via controlled companies, freight forwarding services – a much more differentiable business – as well, but considering only the maritime transport, the differences between services provided by each company are negligible. For this reason, some parts of the model, namely the ones only applicable to production companies, will be disregarded, while the parts referring to product differentiation will be analyzed later in the discussion section.

As mentioned above, Porter's model identifies 5 competitive forces, whose combination shapes the environment within which the firm operates, and thus influences the strategic actions undertook by management. Those forces are:

1. *Threat of substitutes*[5]: in presence of a wide variety of potential substitute products or services, companies would face a serious threat. The extent to which availability of substitutes could become a serious threat mainly depends on customer preferences, or in other words the propensity of buyers to switch to the other product or service; and relative price and performance of substitutes.
2. *Threat of new entrants:* new companies entering the industry represent a clear threat to profitability of established players. This kind of threat, however, heavily depends on the presence and degree of importance of entry barriers, i.e. factors that can hinder the attempt of entry of new companies. There are plenty of those entry barriers, but the more relevant in the specific context of liner shipping are capital requirements, economies of scale, cost advantages, legal barriers, and possible joint reaction of

[5] A substitute product – or service – is a different kind of product or service that can replace another one, usually with some advantages to the customer, e.g. air cargo transport can be a substitute of liner cargo shipping

established companies (so called retaliation). All of these will be more extensively discussed in the industry analysis part.

3. *Rivalry between established companies*: this is a very obvious factor that any company faces. The intensity of the competition among companies in a specific industry, however, may widely vary depending on six factors: industry's degree of concentration, cost structure of companies, exit barriers and excess capacity, diversity of competitors and finally product differentiation, although the last two factors have little or no role at all in liner shipping industry.
4. *Bargaining power of customers*: in case customers are able to lobby and create a sound union, they may have enough power to put companies in a critic position. This could happen depending on buyers' level of price sensitivity and on relative bargaining power of each individual customer.
5. *Bargaining power of suppliers*: the dynamics are comparable to the previous point, however, in the specific context of liner shipping, this last force is less relevant.

2.2.2 Game Theory

The Game Theory is a very wide, complex and well known theoretical model. Introduction of modern Game Theory is conventionally attributed to John von Neumann and Oskar Morgenstern, who wrote their "*Theory of Games and Economic Behavior*" in 1944, but many others have made a major contribution to the theory, among who Nash (1950), Shapley (1953), Maynard Smith (1982) and Camerer (2003). A comprehensive analysis of Game Theory would be extremely long and well beyond the scope and purposes of this thesis, and, moreover, it has been applied with excellent results in almost any business field, this giving a more than sufficient proof of its scientific soundness. However, it seems appropriate to give a brief explanation of the main reasons why it is such a powerful tool to analyze and discuss the strategic decisions undertaken by companies in a competitive situation.

The peculiar advantage of Game Theory in this context is that it allows explaining the interactions between players, an essential step to gain a better understanding of the dynamics shaping the competitive environment of an industry. This, conversely, is something completely ignored by Porter's model: it provides a "static" analysis of the competitive forces rather than explaining the reactions and responsive strategies of one (or more) players after a specific decision being made by another. This specific consideration is at the root of the decision to adopt both models jointly to run the liner shipping industry competitive environment analysis: in this way, the major drawbacks of each model will be compensated by the use of the other one, making it possible to get more accurate results.

Moreover, Game Theory introduces a further level of analysis of the strategic choices of each player: starting from the above mentioned concept of interaction between players, a number of different strategies can be derived according to the context of an individual game. There are many different strategies that can be successfully adopted in specific context, but they all have a common point: the idea is to change one or more of the elements that define the structure of a game. Those elements, in a non-cooperative game[6] (Hendrikse, 2007), are:

- Players
- Actions
- Payoffs
- Information Structure
- Rules

As it clearly appears, each player has the potential to create and pursue a great number of possible strategies, changing any of those elements, or even combining more than one strategy.

However, the most interesting feature of Game Theory in the specific context of a very capital intensive industry as liner shipping is that it introduces the idea of cooperation as a feasible strategy, opposed to the traditional approach that, to some extent, links corporate strategy to military one. In fact, as argued by Brandeburger and Nalebuff (1995), corporate strategy has borrowed many concepts and terminology from the military idea of strategy, that is a plan of action meant to achieve victory through the defeat of the opponents. Although this “win-lose” approach does work even in business context, there are some specific situations in which too much a very competitive behavior from one player may result in all players getting lower payoffs than they could have achieved with a cooperative strategy. The “win-win” approach proposed by Brandenburger and Nalebuff, conversely, presents very

[6] A non-cooperative game is a game in which the players act independently one from another. Although this is little realistic assumption this kind of game is the simplest one, thus often taken as general example.

interesting advantages: first one is that it is very likely to be accepted by the other players, as it will result in better payoffs for them as well. Moreover, the adoption of cooperative behaviors by companies in an industry would also reduce the internal competitive pressure of the industry itself, which is the fifth force of Porter's model: this is another advantage to all the firms in the industry.

As mentioned above, cooperation seems to be an especially interesting option in capital intensive industries. In this context, the choice to pursue a very aggressive strategy is likely to cause large investments, possibly to the extent to which – in case of failure – it may even hinder the financial stability of the company.

2.3 Literature Review

In this subsection, a brief review will be given of the most important sources and literature that will be referred to throughout the thesis. Firstly, the review will focus on the topic of management within liner shipping industry, and then literature regarding sustainability issues in shipping will be presented.

2.3.1 Management Issues in Liner Shipping Industry

Lot of research has been made on management issues in the context of liner shipping, and the wide availability of literature on the topic makes it difficult to choose specific references. However, as the industry analysis in Chapter 3 is only meant to provide a general overview, mentioning the most specific features of the industry, relevant literature has been chosen covering such topics. In particular, in order to introduce liner shipping as an industry, many references have been made to Maritime Economics by Martin Stopford (2009), which is widely renowned as one of the most comprehensive textbooks about maritime transport, and to Fusillo (2006), who covers many liner shipping specific topics among which volatility, concentration and creation of conferences and networks. For what concerns more specific topics, Bernhofen et al (2013) show how containerization has contributed to an impressive increase in productivity and cost efficiency on liner shipping, while importance of economies of scale is stated, in general, by Grant (2010) and, within the specific context of liner shipping by studies from ATKearney (2013) and documents released by Maersk (2014). For what concerns market concentrations, quantitative data have been collected from ATKearney's "Balancing the Imbalances in Container Shipping" (2013), ECLAC's "Concentration in Liner

Shipping: its Causes and Impacts for Ports and Shipping Services in Developing Regions" (1998) reports. Luo et al (2012), on the other side, give a qualitative explanation of the phenomenon showing how larger companies experience higher growth rates, thus leading the market towards an ever more concentrated situation. For what concerns industry profitability, many references have been made to BCG's "Restoring Profitability to Container Shipping" (2012) report, in which major sources of low profit in liner shipping are listed and analyzed; and to UNCTAD report (2013) which provides relevant and useful quantitative data. Finally, Lun et al (2009) and Ducruet and Notteboom (2012) give valuable insights into phenomenon of liner shipping networks, which, as will be shown in chapter 5 and 6, has a major importance in the industry.

2.3.2 Sustainability Issues in Liner Shipping

Over the last years, sustainability in shipping has been receiving growing attention by part of academic researchers, international entities, stakeholders – namely cargo owners – and, ultimately, by the industry itself. This resulted in a wide availability of literature: here, the choice has been to select relevant publications with regards to the specific topics covered by the thesis. In particular, quantitative data about maritime related pollution have been collected from a number of independent entities as IMO, DNV and MARINTEK, with the aim to get as much reliable data as possible. For what concerns, moreover, international regulations, the obvious choice is to refer to IMO publications. Besides those entities, a number of scientific papers have been used to collect qualitative information about sustainability in liner shipping, as Eyring et al (2009), which shows in detail the impact of shipping generated pollution on the environment, McCollum et al (2009), which analyzes environmental impact of maritime transport listing a number of possible mitigation policies and strategies, and Chang et al (2014) which examines the possible reduction in noxious emission in a potential emission control area.

For what concerns the phenomenon of sustainability networks, many data have been gathered from official publications of such networks as BSR – more specifically, CCWG – and Clean Shipping Network. Besides this, Ponte and Cheyns (2013) provide a formal definition of sustainability networks as *"[an] assemblage of actors, objects, procedures and relations coalescing around addressing or managing social and/or environmental aspects of* *commodity production, processing, exchange and consumption".* According to the authors, they may or may not take an institutional form, but in either case their existence and dispersion demonstrates an increasing interest in sustainability from private companies, besides national and international regulations. Moreover, Fransen and Kolk (2007) argue that sustainability networks take the form of multi-stakeholder initiatives, and that their existence does not imply a deregulation, but they rather represent self-regulation instruments. Finally, BSR (2010) explains how sustainability networks enforce this self-regulation and governance activity: the whole concept of sustainability network is based on the idea of hyper-transparency. This means that members publicly share their operating policies, financial and environmental performance and any other relevant data, in order to make them completely available to stakeholders. Thus, should a company break any of the conventions agreed by network members, the other ones would be immediately aware of that and could take commercial counter-actions almost simultaneously.

For what concerns sustainable practices in shipping, Lai et al (2011) and Lirn et al (2013) provide a description and an analysis of their adoption among shipping companies, while Woo and Moon (2013) and Doudnikoff and Lacoste (2014) focus, more specifically, on the analysis of slow steaming and its consequences. Finally, Lun et al (2013), Kågeson (1999), Krozer et al (2003) and Pil and Rothemberg (2003) show the link existing between adoption of such green shipping practices and positive economic results.

Chapter 3. Industry Description and Analysis

In this chapter, liner shipping industry as the object of the analysis will be introduced. Liner shipping is a sub-industry of commercial cargo shipping, a fundamental industry for the existence itself of world trade. As noted above, despite the topic of sustainability in maritime transportation would deserve a much more general and comprehensive approach, the choice of focusing on the narrower context of liner shipping is justified by the high, and ever increasing, importance that container ships have among the other forms of shipping.

3.1 The Liner Shipping Industry: an Overview

In this section a general overview of the liner shipping industry will be given, with a specific focus on its specific features and on the competitive environment. First, a definition of liner shipping will be introduced and discussed, in order to draw an overall picture of the industry; then the industry itself will be analyzed, with the purpose of highlighting its main peculiarities. This will allow a better understanding of liner shipping's business environment, setting the basis for the discussion regarding possible future sustainability-driven changes in the industry itself. The rationale behind this decision is to give an overview of what strategic tools are mostly used in liner shipping, in order to make solid assumptions on what could companies do in a new sustainability oriented industry.

3.1.1 A Definition of Liner Shipping

According to Stopford (2009), who, in turn, quotes and modifies an earlier definition by Fayle (1933), the liner service is defined as follows:

"*a fleet of ships, with a common ownership or management, which provide a fixed service, at regular intervals, between named ports, and offer transport to any goods. A fixed itinerary and schedule* […] *are what distinguish the liner from the tramp* [service]".

As mentioned, this definition was first given in 1933, some 30 years before the introduction of containers, which caused a revolution in the whole industry dramatically increasing cost and time efficiency, speed and reliability (Stopford, 2009; Bernhofen et al, 2013). Yet, it still holds and highlights the key features that differentiate liner service from tramp and bulk shipping:

- Liner companies provide a fixed service: this means that container ships don't wait for a cargo owner to request the carriage of goods between specific ports before departure, but they offer a scheduled service. In other words, while in the bulk shipping industry every detail of the voyage is agreed between the shipper and the cargo owner, liner companies provide a much more standardized service characterized by specific routes, fares and tonnage availability on a given route, with all of these being decided by the shipping company and announced in advance to cargo owners and shippers (Lun et al., 2009; Zerby and Conlon, 1978)
- A straightforward consequence, and another point of difference from bulk shipping, is that the price for the service is not continuously negotiated with the cargo owner, but it's rather fixed and given by the shipping company, although, of course, it can vary depending on a number of factors. However, those variations are of less extent compared to the extremely volatile freight rates typical of bulk shipping industry (Stopford, 2007), although in recent years the industry is experiencing an increase in volatility (UNCTAD, 2013). Moreover, the dynamics behind the pricing of container shipping are considerably different: as in containers almost anything can be carried, the price a cargo owner is willing to pay greatly depends on the nature of cargo: for example, perishable goods may need to be transported in refrigerated containers, which of course will cost more. In bulk shipping, conversely, the cargo is much more homogeneous, so that the price is more dependent on the availability of the ship and crew to operate the route.
- In order to provide such fixed and regular service, shipping companies need to operate a stable fleet of vessels; this meaning that there must always be a precise and tight management of the fleet in order to match the schedules. For this reason, liner companies are usually owners of their fleet, while in bulk shipping ships are generally chartered (Stopford, 2007). This, of course, is a major source of difference in asset composition between bulk and liner shipping companies.

The high level of standardization of the services provided by liner shipping companies is mainly due to the introduction, in the early 1960s, of containerization of general cargo, which as noted above allowed a dramatic increase in productivity. With containerization very diverse types of goods can be shipped together in a standard box, which is the only piece of cargo handled by port and ship operators during the loading and unloading procedures.

As every shipping company is willing to achieve the highest level of productivity they try to exploit as much as possible the advantages of containerization. As a consequence, the whole industry after the introduction of containers experienced a sort of convergence towards standardized operations and procedures to handle cargo. This is the reason why there is not much room for differentiation in ships design, although in recent years some significant innovations have been introduced – for example, the new Maersk Triple-E class is powered by 2 engines while the standard design would have only one (Maersk, 2014). Moreover, throughout its history the industry has shown low level of product differentiation in service provided by liner companies: traditionally, the main way in which companies try to obtain an economic advantage towards its competitors is pushing economies of scale and capacity utilization (Stopford, 2009). Economies of scale and capacity utilization are, in fact, the two most important factors that drive competition in the industry: due to this crucial role, they will be separately discussed.

3.1.2 Economies of Scale

Economies of scale are, essentially, the cost savings that stem from increasing the output of any production – or, as it's the case, of the supply of a service – with a given fixed cost. In shipping, when the fixed cost of building or buying a ship, plus the fixed component of the operating costs (crew salary, duties, insurance etc.) are spread over a bigger quantity of transported cargo, the per-unit cost is lowered and, by consequence, the profit for the companies is raised.

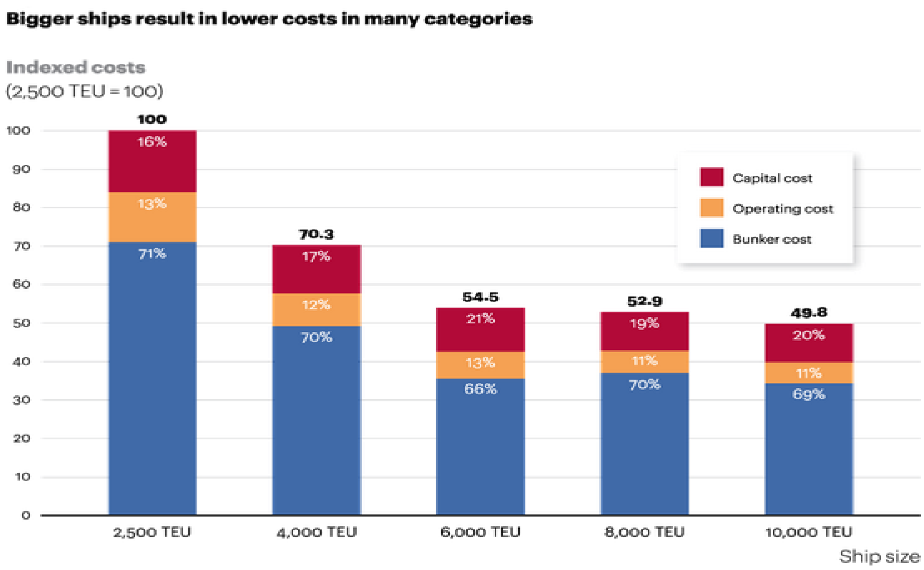


Figure 3.1 (Source: ATKearney, 2014)

As shown in Picture 3.1, as the size (measured in TEUs[7]) of the ship increases, the indexed costs are notably reduced, although the marginal rate of cost savings seems to be decreasing for larger vessels.

Moreover, an even more interesting result is that the proportion in which the specific costs contribute to the total is not significantly affected by the change in ships' size: bunker fuel cost accounts for a rough 70% and operating cost for an average 12% (ATKearney, 2014). Even the obvious increase in capital cost is far less than proportional with the increase in size: a four time larger vessel has a mere 4% higher indexed capital cost. This is a clear indication of economies of scale resulting in remarkable savings in every cost area.

Shipping companies, then, are trying to employ bigger vessels which, though more expensive to design, build and operate, allow achieving better economies of scale. An impressive example of this growing trend in vessels' size is given by the recently introduced Triple-E class ships by Maersk which, with a 18,000 TEU cargo capacity, 165,000 tons deadweight, 400 meters length and 59 meters beam, is, to the present, the biggest class of container ships ever built (Maersk, 2014).

Economies of scale, however, are not only related to vessels' dimensions: larger companies benefit from economies at corporate level as well. In other words, bigger firms often get advantages from their scale in terms of higher capital availability, higher ability to differentiate their business – thus reducing overall risks – and higher bargaining power towards competitors and customers (Grant, 2010). This holds even truer in capital intensive industries, where the ability to face large fixed and variable costs, and large investments, is just necessary for company survival. Economies of scale at corporate level then seem to provide a rather valid explanation for the high industry concentration level in liner shipping that will be discussed below.

3.1.3 Capacity Utilization

In order to exploit the advantages delivered by economies of scale, it's crucial to employ as much capacity as possible. Despite this being an apparently straightforward statement, capacity utilization to shipping companies is a much more complex problem to solve than the

[7] Twenty-Foot Equivalent Unit: indicates the number of 20ft-long containers (the standard length) that can be carried by the ship.

building or purchase of bigger ships. Liner companies by definition provide a fixed and scheduled service, this meaning that a given ship, fully loaded or not, must depart from a specific port on a specific day and time, heading to a specific destination. This shows the utmost importance of a careful planning of the routes to be served and of the frequency of the service.

Moreover, things are made even worse by the phenomenon of cargo imbalances: the perfect employment of the total tonnage provided by a company would require ships to be fully loaded on every single voyage. However, there are two major factors that make perfect capacity employment nearly impossible to achieve: firstly, the demand for cargo shipping is heavily characterized by seasonality, i.e. there are some periods of the year in which demand rises and others in which it falls to low levels. Furthermore, the other factor hindering perfect capacity employment is the geography of world trade: in the picture below, the trade balances of G-20 states are shown. This indicator shows the import/export ratio of a country: it is positive for a country that exports more goods than it imports, and negative for a country that, conversely, has bigger import than export.

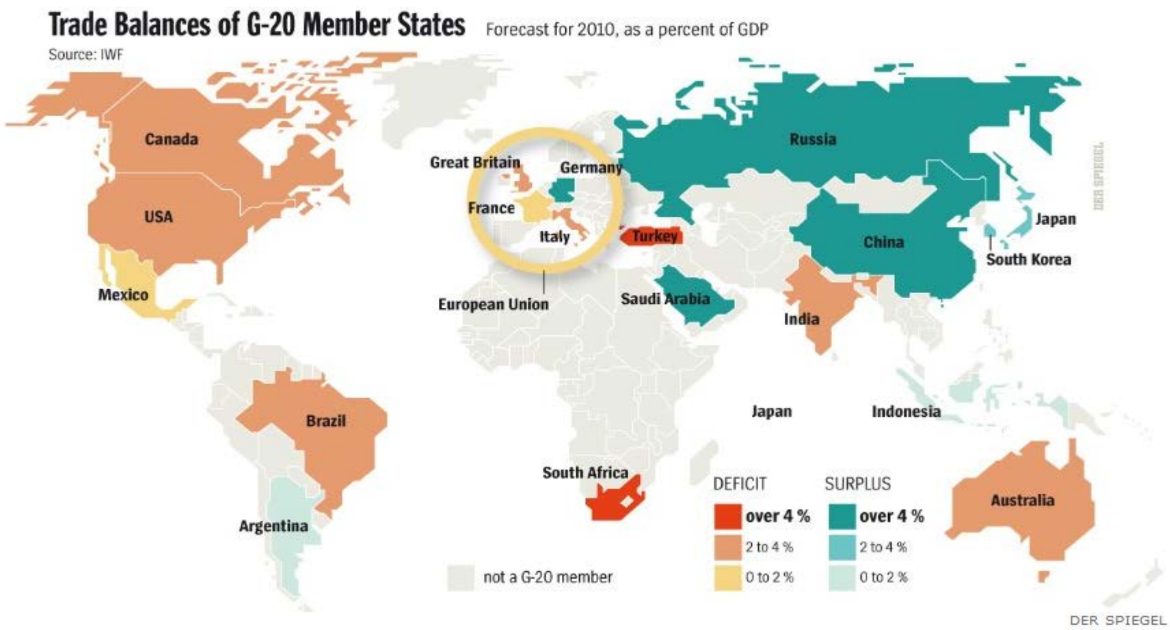


Figure 3.2: Trade Balances of G-20 Member State (source: http://www.spiegel.de/international/world/bild-727970-149693.html)

As clearly represented in Figure 3.2, there is a high imbalance between Eastern and Western countries: Russia, China, Japan, Saudi Arabia and Korea have a surplus in their trade balances, while European (with the exception of Germany) and American countries, plus Australia, have a deficit.

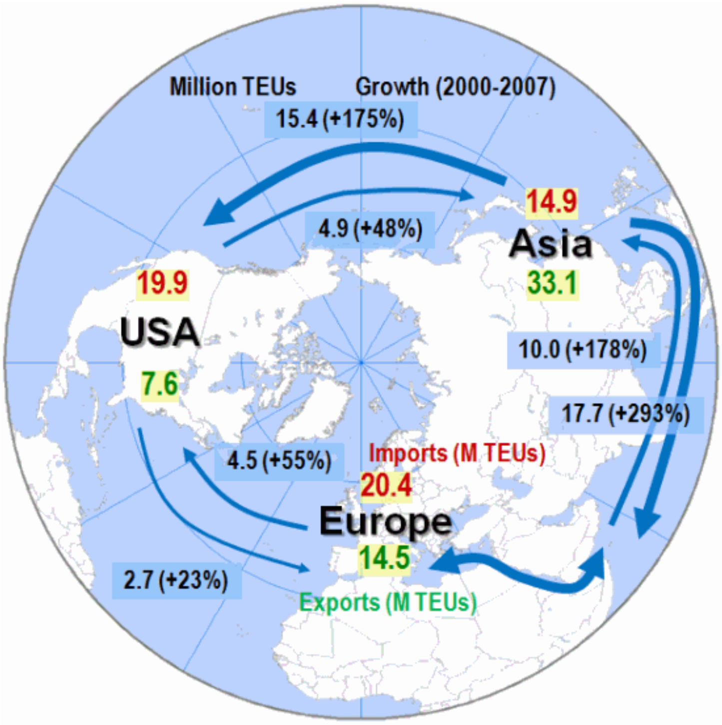


Figure 3.3 World Trade Flows (UNCTAD, Review of Maritime Transport 2007)

This, for what concerns shipping, translates in the significantly imbalanced trade flow represented in Figure 3.3: besides seasonal patterns, there is a much higher demand for sea transport on the East-West routes than on the West-East ones. Furthermore, it is safe to assume that in near future, world trade balance staying at present situation, demand on East-West route is likely to keep increasing with the increasing trend of world trade: the straightforward consequence for a shipping company is that bigger and bigger ships are needed to fulfil rising demand on the first route, while they are likely to be severely unemployed on the opposite one.

This, however, is not the only downside of the trend for bigger ships: the introduction of larger vessels also brings the problem of diseconomies of scale.

3.1.4 Diseconomies of Scale

"Diseconomies of scale" is a phrase used to describe all the negative consequences of the increase in size of the infrastructures needed to run a certain business. In shipping, the problems with too large vessels are quite easy to identify, and yet very expensive to solve: a very large ship can't operate in small ports, which often have limitations in draft, length or width. The same problem applies to strategic water-ways such as Panama and Suez canals. Panama Canal is currently undergoing some major widening construction works for this very reason, as throughout the years it has become too narrow to handle the growing ship traffic (UNCTAD, 2013).

Moreover, even when ports are large enough to allow operations of big ships, there is a significant problem of congestion: given the length of the quayside and the dimension of cargo handling gear, a larger vessel would need more space when moored and more hours of gear utilization to be loaded and unloaded. The problem of port congestion is becoming an urgent issue to solve. As previously mentioned, the optimal situation for a shipping company is to have all of its ships at sea, at full payload, for as much time as possible. Slow port operations, then, can seriously affect shipping companies' profits. Moreover, port congestion also slow loading and unloading of moored ships: this results in longer delivery times for cargo owners. In fact, as there are no such problems when ships are at sea, congestion in ports and canals is becoming a major bottleneck affecting the competitiveness of maritime cargo shipping (Journal of Commerce, 2010).

3.2 Strategic Analysis

Generally speaking, every business industry has its own specific characteristics; liner shipping, however, presents quite a unique combination of many of those: the purpose of this section is to describe and analyze them, in order to provide basis for the following discussion.

3.2.1 Recent Trends

Commercial shipping, in general, is a very growing industry. As shown in Figure 3.4 below, the trend of global container trade has been clearly growing over the last 15 years and, besides a drop in 2009 after the outbreak of financial crisis, it seems to have not been affected by the recent downturn in world economy.

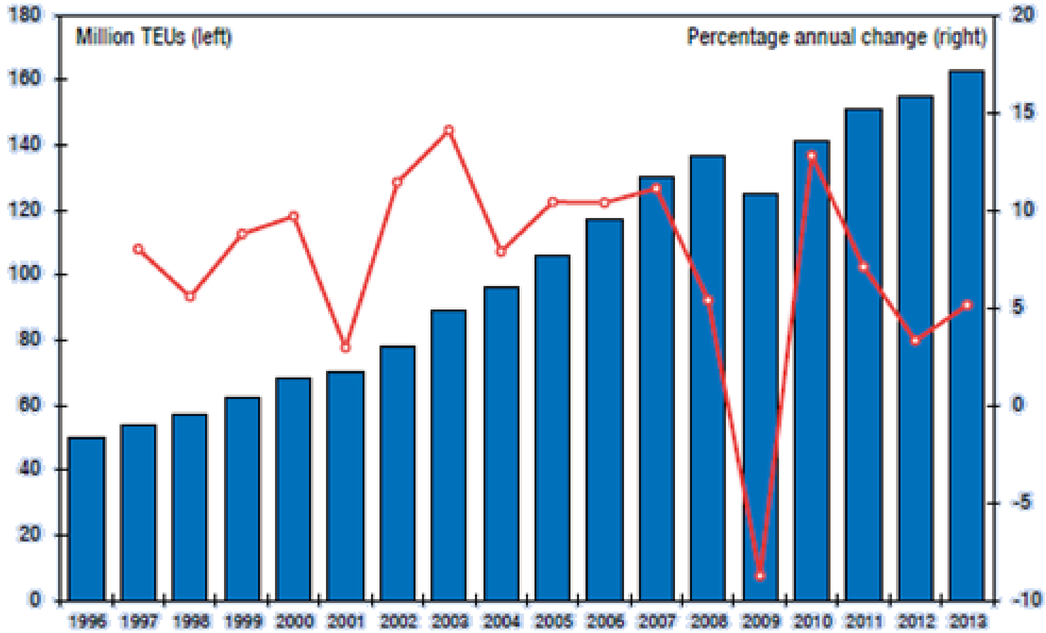
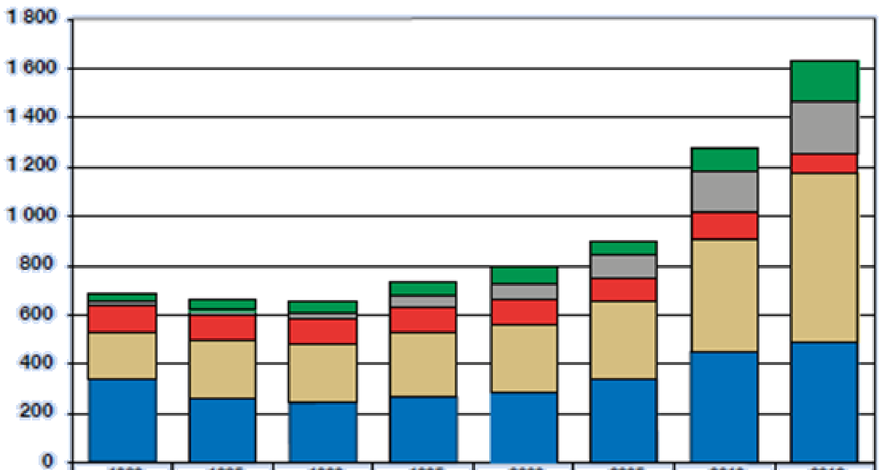


Figure 3.4 Global Container trade 1996–2013 in million TEUs (UNCTAD, 2013)

This is a direct consequence of the continuous growth over the long term of world trade: it is safe to assume that, with global trade being oriented towards more and more globalized commerce, the industry will keep on expanding. Container shipping, moreover, shows a clear steady growing trend: in Figure 3.5 the composition of world commercial fleet[8] is represented, and it's clearly visible how the total share of liner vessels has been growing at a very high and steady rate compared to other types of ships.



	1980	1985	1990	1995	2000	2005	2010	2013
Other	31	45	49	58	75	49	92	166
Container	11	20	26	44	64	98	169	207
General cargo	116	106	103	104	101	92	108	80
Dry bulk	186	232	235	262	276	321	457	685
Oil tanker	339	261	246	268	282	336	450	491

Figure 3.5 World fleet composition (millions of dwt) per major ship type, 1990 to 2013 (UNCTAD, 2013)

[8] In terms of tons deadweight

However, liner shipping is also a very complex and challenging industry: over the years, a very high number of bankruptcies, takeovers, mergers and acquisitions occurred, which is a clear sign of an unstable competitive environment (Grant, 2010). Hereafter, three of the main features of liner shipping industry will be analyzed in order to provide an explanation of these phenomena.

3.2.2 Industry concentration

The first specific feature of liner shipping industry is that its industry concentration level shows a steadily growing trend (ECLAC, 1998; Luo et al, 2012). Industry concentration is defined by Grant (2010) as "*the proportion of industry output accounted for by the largest firms*". It is generally measured by Concentration Ratio (CR_n) which calculates the market share of larger "n" firms[9] (Shughart, 2008).

This parameter is a very useful tool to give a general overview of the competitive environment of an industry: a very low concentration level means that there are many companies, usually with similar sizes, each accounting for a low percentage of the total industry output. This is close to a perfect competition situation, in which each company has the same weight within the industry. On the opposite, a high concentration level means that few big firms produce the largest part of the total output, which often also implies that the most important companies have a very high bargaining power in regards to other players as well. This is recognized as an oligopoly, a situation which can allow the creation of cartels[10] by leading firms: as will be discussed later, something of similar actually happened in the liner shipping industry (Fusillo, 2006; Stopford, 2007).

The above mentioned growing pattern in market concentration in liner shipping is clearly shown in Figure 3.6, which covers a timeframe of roughly a decade: the market share of top 5 companies was, in 2011, little less than 50%, while the aggregate market share of companies in places 15 to 30 was 15% and the one of bottom 10 analyzed companies fell short of 5%. As a comparison, in 2004, top 5 companies' market share was 35%, aggregate share of companies from 15 to 30 was almost 18%, and one of bottom 10 companies was

[9] Most commonly used is CR_4 which measures aggregated share of top 4 firms.
[10] A cartel is a private agreement among a limited number of firms to limit competition, create a steady oligopoly situation and split the resulting profits

little less than 10%.

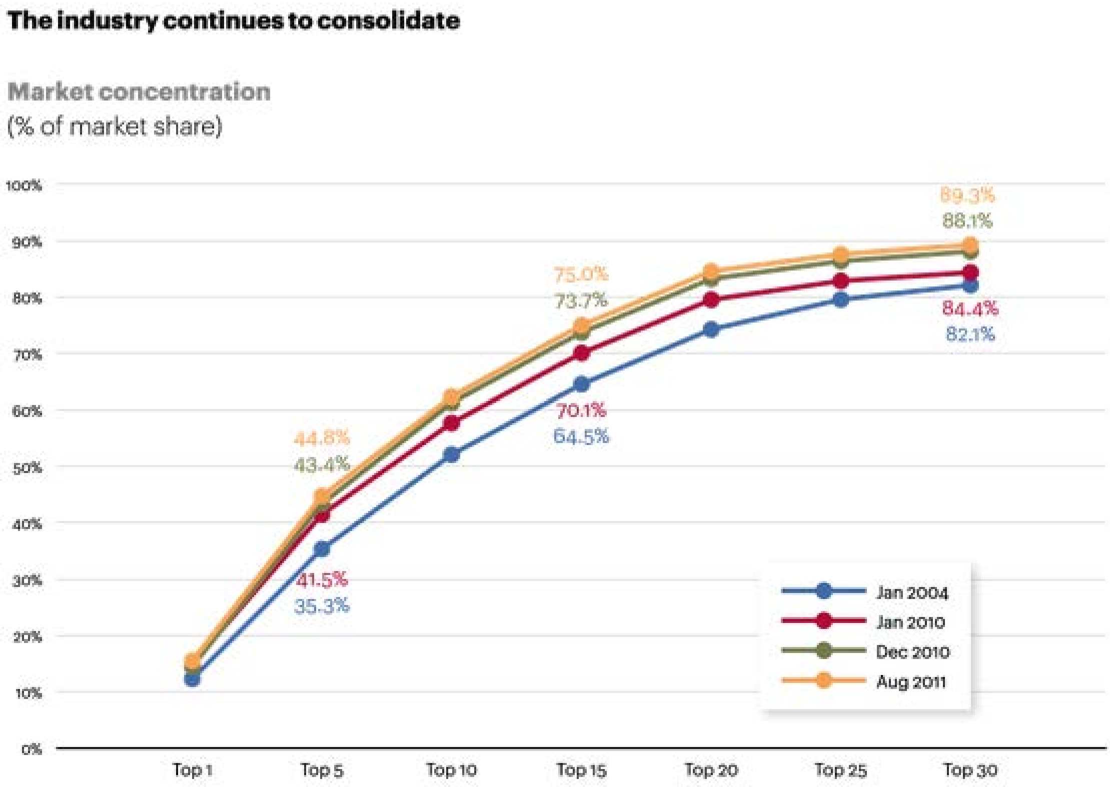


Figure 3.6 (ATKearney, 2014)

Moreover, this growing trend seems to be unaffected by any macroeconomic change: even in 2010-2011, two years in the middle of the world crisis started in 2008, market concentration kept on growing roughly at the same rate it used to grow in years from 2004 to 2010. Despite the chart does not include figures for the last 2 years, then, it seems reasonable to assume that, at least in the short run, market concentration in liner shipping will keep growing.

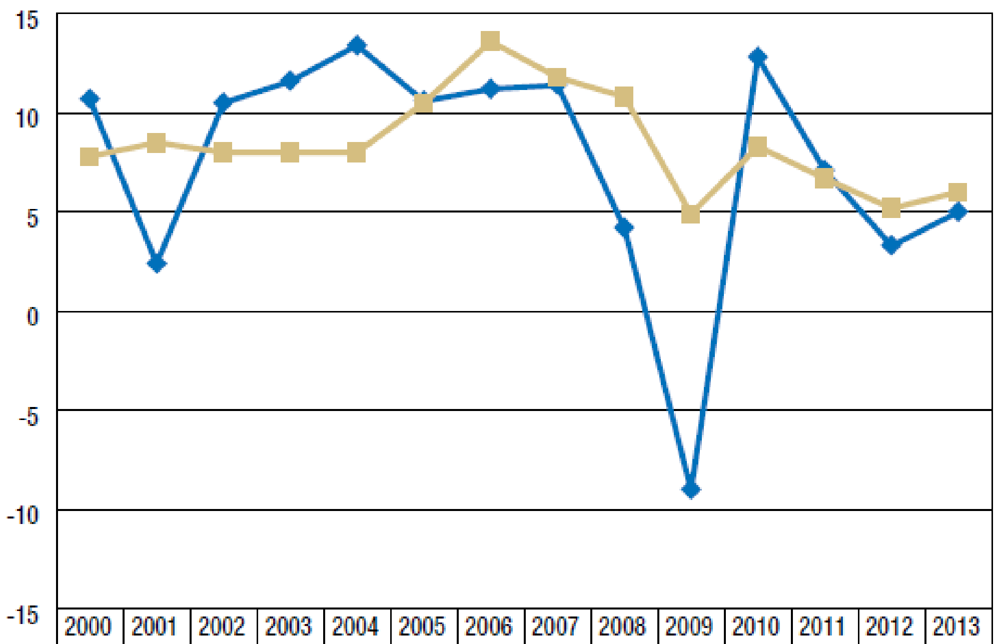
Luo et al (2012) show that larger liner companies experience higher growth rates, which gives a sound explanation of the ever growing concentration trend in the industry. As already noted, increasing industry concentration seems to stem from the above discussed pursue for economies of scale (Fusillo, 2006): in order to reduce the impact of fixed costs increasing the volume of carried cargo, a company must face extensive capital investments. In fact, the costs of building and introducing new ships are so enormous that they could potentially hinder the stability of even well established companies.

Furthermore, those investments are extremely risky due to the long time elapsed between the cash outflow and the availability of the result, be it a new ship or a significant upgrade of existing vessels. This, of course, implies that smaller companies have a serious disadvantage towards bigger competitors who have access to larger financial resources. Thus, not only there is a very strong incentive for them to merge, but even leader companies often prefer an expansion via creation of networks, merge or acquisition rather than pursuing aggressive price-cutting commercial policies. However, this is not always necessarily the case: in fact, since 2011 very few mergers or acquisition took place, and none of them involving top players in the industry. Yet, the growing concentration trend seems to be unaffected by this, meaning that larger companies as Maersk, MSC and CMA CGM are growing through asset expansion as well (Sea News, 2013).

3.2.3 Industry Profitability and Volatility

Liner shipping is a very critical industry with regards to profitability. Generally speaking, earnings in maritime transportation are very volatile and subject to cyclical patterns (Stopford, 2009). Despite container market being relatively more stable than bulk and tanker shipping, this is a serious threat to liner carriers' profits.

According to Stopford (2009), both volatility and cyclical patterns are due to an inherent mismatch between demand and supply of shipping. In particular, the problem is that while demand for shipping may change even very abruptly, as a consequence of mutations in local, regional or world economy and trade, shipping companies are, for reason beyond their control, unable to react with the due agility: carriers may add new capacity in response to an increase in the demand, but buying and employing a new ship takes time, not to mention building a brand new one. For this reason, the tonnage availability is somehow delayed from the time when it would be needed by cargo owners: this in turn causes oversupply problems when demand is low, which consequently makes freight rates drop. From shipping companies' point of view, this situation is very hazardous: when peaks of demand happen, they should invest a high amount of capital in deploying new capacity, facing the risk that by the time it will be available, demand and freight rates will be lower, making it extremely hard to recover the invested capital. On the opposite, whenever demand for shipping is low, carriers may want to dispose of some of their unused capacity: this would either mean to sell, scrap or lay up one or more ships. However, each one of these solutions has a drawback: in a low-demand market, it will be very unlikely to find a buyer for a ship; scrapping would be a rather drastic solution, usually feasible when the ship is very old or facing some significant maintenance issue; and finally before laying up a ship, the opportunity cost has to be considered.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Demand	10.7	2.4	10.5	11.6	13.4	10.6	11.2	11.4	4.2	-9.0	12.8	7.1	3.3	5.0
Supply	7.8	8.5	8.0	8.0	8.0	10.5	13.6	11.8	10.8	4.9	8.3	6.7	5.2	6.0

Figure 3.7 Growth in Demand and Supply in Container Shipping (source: UNCTAD, 2013)

In Figure 3.7, the annual growth of demand and supply in container shipping (in percentage) is shown, which strongly confirms the delayed response of shipping companies to market falls and peaks: for example, in years from 2001 to 2004 demand kept rising at a rather steep rate, while the supply was growing at a steady 7-8% to take a sharp upshift only in 2005, when the demand, on the opposite, entered in a 2 stable years period before plummeting due to the 2008 financial crisis.

Moreover, industry reaction to demand variation was not only delayed, but even inadequate: in 2010, as example, the response of liner companies to the rebound of the demand was rather accurately timed, but while demand experienced a 12.8% growth after the recession in 2009, which makes a stunning 22% difference in growth rate from one year to another, supply grew only by a mere 4% compared to the previous year. Maybe even more noteworthy is the fact that in 2009, the worst year of the recession, the supply of tonnage kept growing, albeit at a lower rate, while not only demand for shipping, but even world GDP decreased. This is a further indication of a marked tendency to oversupply in liner shipping market. This mechanism of delayed and often inadequate response to market shifts is what creates the above mentioned volatile and cyclical patterns in freight rates and, ultimately, in shipping companies' profits (UNCTAD, 2013).

Given this background, it's not surprising that a profound shock as the 2008 financial crisis had, and still has, very deep consequences on the profitability of such an unstable industry. According to data from Boston Consulting Group (2012), the combination of low freight rates due to the general bad state of world economy and high bunker costs, due to the crisis, led to an aggregate negative operating result in 2011 in liner shipping.

Figure 3.8 High Bunker Costs and Low Freight Rates Led to Losses (BCG, 2012) https://www.bcgperspectives.com/content/articles/transportation_travel_tourism_charting_new_course_restoring_profitability_container_shipping/

As shown in Figure 3.8, throughout the whole year the gap between bunker price, which is one of the biggest components of variable operating costs for companies, and freight rates – which, of course, represent companies' profits – kept on widening, this inevitably leading to an average operative loss for shipping companies. The situation was made even worse by the aforementioned problem of capacity oversupply, which, during most of the year, has averaged over 200,000 TEUs. Moreover, the trend shown by capacity surplus clearly indicates the existence of seasonality, which, despite being an easily predictable phenomenon causes another kind of problem to ship operators: in order to achieve full capacity utilization, smaller vessels should be employed in low demand phases, but this would deny the possibility to exploit economies of scale.

However, besides these macro-factors, the crisis also highlighted some critical points in the way companies reacted to it: these mistakes are worth being discussed, not only for their contribution to the overall market downturn, but also because they are the expression of the prevalent attitude of shipping companies towards the market.

The first of these strategic mistakes is linked to the above discussed topic of economies of scale: although the cost savings that they can allow are undeniably important, and even more in a very capital intensive industry, liner companies' behavior seems to indicate that they did rely too much on economies of scale as their major strategic tool. According to data from BCG (2012), in the 4 years between 2008 and 2012 the average size of container vessels grew up by 24%, their average capacity by 35%, and all this despite the total number of container ships only increased by 8%.

This is a clear indicator of the fact that companies kept on ordering, and deploying, more tonnage in the hope to reduce the incidence of their fixed costs. However, when the demand fell due to the crisis, this had the effect to worsen the oversupply problem. In order to fill up the ships and employ this capacity, companies had no choice but to lower freight rates, which in turn had the straightforward consequence of reducing their profits. This, combined to the important investments needed to order new, and very large, vessels, set the basis for a very rough period with regards to companies' profitability.

The second problem is in some way linked to this quest for more capacity: historically, the market shares of companies in the container shipping industry have always been measured by the capacity each company could provide, rather than by the volume of cargo actually carried by them. This was a further incentive to expand through the acquisition of new cargo capacity, while, in low-demand situations, companies would have been better off focusing on the utilization of the already available capacity. What is very important to note is that this is not a specific mistake made by one company, but a sort of common attitude of all the players in the industry stemming from a long established tradition. This is one of the reason why all the companies were affected by the overcapacity problem. Moreover, the legacy of this capacity-oriented mindset is one of the causes of another phenomenon, which is companies trying to make profits via asset management rather than their core business of carrying cargo.

This may appear as an attractive option in low-demand situation, when, as seen above, the combination of low freight rates due to oversupply and the rising operating costs results in companies struggling to break even. In such a situation, the price of new-built vessels would fall to very low levels, as the demand for new ships in an already oversupplied market is very low. Thus, a company willing to speculate may consider ordering new ships at low prices, under the assumption that by the time the ship will be delivered (which, as previously mentioned, may normally take up to 2 years) the demand for shipping, and thus freight rates, would come back to higher levels. However, this is a quite risky activity: as widely shown (BCG, 2012; Stopford, 2007) in a very volatile industry as shipping is, making accurate predictions is an extremely difficult task and, obviously, when such high amounts of capital are invested, there is very little room for errors. Asset management may yield extremely high returns, but may as well turn out to lead an established company straight to financial distress.

The last factor is the incapacity of shipping companies to differentiate their offer: while it's unquestionable that in liner shipping, as seen above, there is little room to differentiation; shipping companies, in order to standardize their offer and operating procedures, have been offering the very same service on all the routes they serve (BCG, 2012). This was another factor that pushed competition in the industry to be completely price-based: as companies kept lowering freight rates to catch the low demand, this in turn reduced their profits.

3.2.4 Alliances and Strategic Networks

Another very important factor in the strategic context of liner shipping is the presence of alliances between companies (Stopford, 2007; BCG, 2012; UNCTAD, 2013) and networks that enclose shipping companies and other players as port operators, freight forwarders, third-party logistics operators and even cargo owners (Lun et al, 2009; Fusillo, 2006).

Alliances in liner shipping have existed since the very beginning of the industry itself: shipping has always been a very cost intensive and high risk industry, it is then easy to see the large extent of the advantages that companies can find in partnerships and alliances with competitors. This, actually, has always been a rather controversial topic: in any industry, whenever there are too many agreements and arrangements among the major players (in terms of market share), there is the possibility that firms may set up a cartel, an organization meant to artificially stabilize the competitive environment of the industry, mainly by setting the prices (and, in general, the conditions) at which the participant companies agree to sell, thus canceling any form of competition in the market. Those cartel agreements, in general, have the main goal to achieve a pre-determined distribution of the profits among the firms, obviously damaging any company outside the cartel, and are thus generally banned by international anti-trust legislation (Sullivan and Sheffrin, 2003; Connor, 2008).

However, cartels in general cargo shipping have always been a more disputed topic: the companies themselves traditionally used to claim that when setting prices via their agreements, the goal was not to limit competition, but rather to hedge the high risks inherent to shipping, especially with regards to the already discussed high volatility of freight rates (Stopford, 2007). Despite this being a controversial statement[11], it is undeniably true that shipping companies play a vital role in world trade: a very unstable shipping industry, with many new entrants, bankruptcies and takeovers every year, coupled by even more volatile freight rates would be a way larger damage to the world economy than a situation of limited competition caused by a regulated cartel in the industry.

According to Fusillo (2006), what caused the end of cartel-like agreements in shipping has been a series of reforms like the Ocean Shipping Reform Act (OSRA) in the USA (1998) which encouraged shipping companies to engage in long-term cooperative agreements rather than in cartels which, empirically, were usually enforced only over short periods of time. Nowadays, rather than creating cartels to control the prices, liner companies tend to establish partnerships as vessel-sharing agreements which are much more effective in driving the whole industry to a higher efficiency level, allowing (albeit only to some extent) the sharing of capacity that would otherwise considered in excess, in low demand situations.

On the other side, networks are a completely different kind of agreements, which enclose even players outside the liner industry, as freight forwarders, port operators and cargo

[11] The easiest objection to this argument is that cartels always cause a limitation of competition, even if only as a side-effect.

owners. The rationale of these networks is to achieve the highest possible level of efficiency in maritime transport, with a global perspective that goes beyond the core business of carrying goods from one port to another typical of liner companies, to include also activities as cargo handling in ports, logistics management and any other part of the transportation chain that could affect the efficiency of the whole shipping process (Lun et al, 2009).

As will be discussed later, the existence of networks in liner shipping can potentially have even more important consequences with regards to the environmental impact of maritime transportation: the point will be widely developed and discussed in the following section, but from a strategic point of view, what can make networks so effective is that they include players from outside the liner shipping industry. More specifically, networks can, and in fact do, include cargo owners, i.e. customers of liner companies, and port operators, logistics providers and the like mentioned above, which, as they provide services (cargo handling, etc.) to liner shippers can be considered (stretching the definition a little bit) their suppliers. Thus, the bargaining power of the participants in the network tends to be evenly divided, as every player would try to get advantages from the network: the best way to achieve this is cooperation among the members (Lun et al, 2009).

3.3 Findings

Summing up the results of the industry analysis, the main features of liner shipping can be listed: with regards to profits, it is a rather volatile industry subject to cyclical and seasonal patterns which, although not difficult to foresee, harm to some extent company profitability. For what concerns corporate strategy, at present, the most critical factors for a liner company are economies of scale and ability to employ as much available capacity as possible: this, coupled with liner shipping being a rather capital intensive industry, seem to be a major cause of increasing industry concentration and of network phenomenon. These findings will provide useful insights for the following discussion: impact of sustainability driven investments may be another contributing factor to the increase in concentration level and importance of networks.

Chapter 4. Shipping Related Pollution Issues

This section of the paper will focus on the analysis of the factors of environmental impact related to the shipping industry.

Moreover, despite the previously mentioned intention to focus on the exhaust gas related problems, it has to be specified that the overall effects of shipping related polluting factors combine themselves, and, in some cases, a specific countermeasure to one pollution factor may even have negative side-effects and increase pollution in another way (Eyring et al, 2009; Kaageson, 1999). For this reason, in order to give a more comprehensive picture of marine pollution a choice has been made to list and give a brief separate analysis of all of them.

Finally, an important premise has to be made: compared to other forms of transportation, shipping is the most efficient one, in relative terms. This means that shipping has the lowest level of emission per unit of cargo moved per kilometer. In Figure 4.1 below CO_2 efficiency of the various sectors of maritime transportation is compared to rail and road:

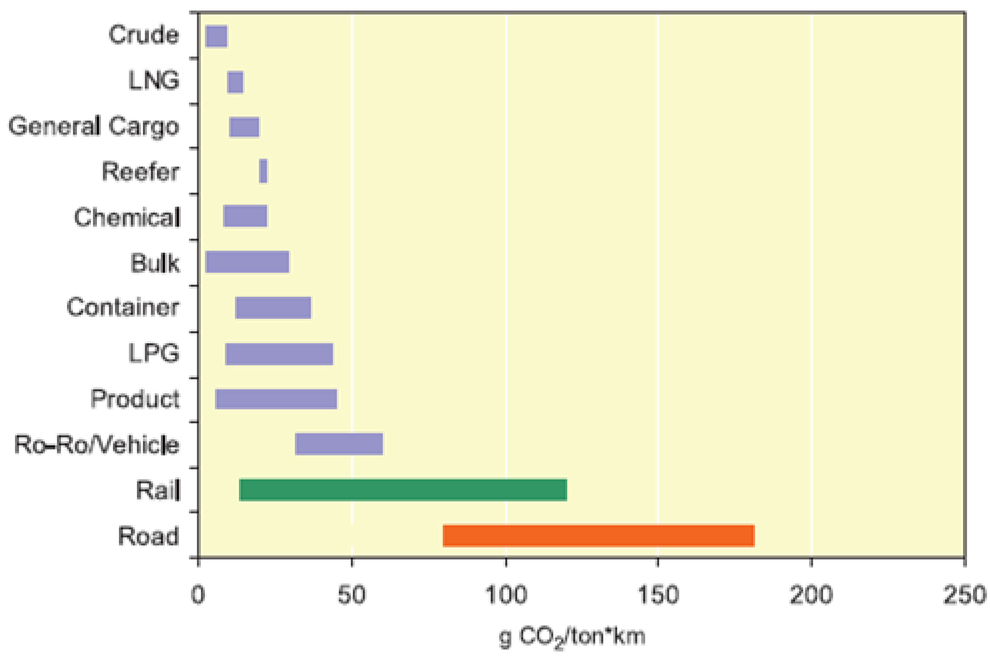


Figure 4.1 Typical ranges of CO_2 efficiencies of ships compared with rail and road transport (IMO, 2009)

As will be widely discussed later, CO_2 efficiency is just one out of many parameters that contribute to global assessment of environmental impact, yet the significantly higher efficiency of shipping is undisputable. This high efficiency can be explained looking at its measure unit, that is, grams of CO_2 emitted per unit of cargo moved (measured in tons) by a kilometer: the low final value (index of high efficiency) is due to the high denominator, as a single ship, generally speaking, is able to carry a much larger amount of cargo compared to a truck or a train, let alone aircrafts. This higher cargo capacity then overcompensate the lower per-vehicle emission of road and rail transport.

This being noted, due to the crucial importance of shipping to world trade discussed in chapter 2, despite such high efficiency level, shipping is responsible for very high absolute amount of noxious gas emission (IMO, 2008). In the following subsections, then, a detailed description of such environmental issues will be given, in order to provide a deep understanding of what are the causes of ship related pollution and how they can be countered.

4.1 Greenhouse gas emissions

The first and most evident factor of environmental impact related to the transportation business, be it terrestrial, airborne or maritime, is the emission of greenhouse and noxious gas from the engines of the vehicles providing transportation.

As shown in Table 4.2 below, it's been estimated that roughly 3% of human generated CO_2 emissions comes from marine transportation, and its radiative force accounted for 2.8% of the total coming from anthropogenic CO_2. Despite the proportion may look low, the absolute amount of CO_2 emission is enormous, estimated to be around a billion tons a year.

	Low bound	Consensus estimate	High bound	Consensus estimate % Global CO_2 emissions
Total ship emissions[1]	854	**1019**	1224	3.3
International shipping[2]	685	**843**	1039	2.7

[1]Activity based estimate including domestic shipping and fishing, but excluding military vessels

[2]Calculated by subtracting domestic emissions estimated from fuel statistics from the activity based total excluding fishing vessels

Table 4.2 Consensus estimate 2007 CO2 emissions [million tons CO2] (IMO, 2008)

Moreover, researches (IMO, 2008) show that the emission trend, driven by the increasing trend in world trade and thus in demand for international shipping, will be growing in the next future: as visible in Table 4.3, the growth in GHG emission from marine transport is estimated to be at least as high as 120% over less than 50 years.

Sector	Market	Total Growth from Current Levels
Aviation	U.S. passenger and freight (domestic + international)	31–35% by 2030
	Global passenger and freight (domestic + international)	60% by 2030 300% by 2050
Marine	Global shipping	120–220% by 2050

Table 4.3 Aviation and Marine Greenhouse Gas Emission Projections (IMO, 2008)

The data in Table 4.3 are only referred to CO_2, which accounts for the largest part of maritime related GHG emission: however, they also consist of other gases. These include methane (CH_4), nitrous oxide (N_2O), sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (HC) and others compounds as particulate matter (PM) (McCollum et al, 2009). In particular, it has been estimated that 15% of global anthropogenic NO_x emission and 4 to 9% of SO_x is caused by shipping (Eyring et al, 2009). As will be discussed later, the emission of those chemicals results in very diverse consequences, which do not limit to greenhouse effect.

The origin of GHG and other noxious gases released by any internal combustion machine is twofold: as they are the natural product of fuel combustion in the engine, their quantity and quality mainly depends on the characteristics of engines and fuel.

For what concerns maritime industry, all liner vessels are equipped with the same type of engine, that is, low speed two-stroke diesel engines (Stopford, 2009). This is, in general terms, the most efficient type of internal combustion engine, as it can easily reach an efficiency of over 50%, some 15% higher than an ordinary automotive diesel engine (McCollum et. al, 2009). This means that roughly the half of the energy stored in fuel is actually transformed in power during the combustion process. Such high levels of efficiency are achieved because liner ships sail at a constant speed, almost without any variation of engine load, the best operating condition for a diesel engine.

However, over the lifetime of a cargo ship, its engine performances experience a physical decay. Moreover, as the average commercial life of a vessel is around 25 years (Stopford, 2007), it’s inevitable that a significant part of the world cargo fleet is composed by technologically outdated ships.

Inefficient engine technology, then, is a major source of air pollution: an imperfect combustion of fuel in the engine results in the creation and emission of CO (carbon monoxide) and VOC (volatile organic compounds), and in a significant increase in production of other pollutants as NOx and PM (Chang et al, 2014).

The other major source of cargo ships emissions is the kind of fuel that vessels use. This fuel is HFO (Heavy Fuel Oil), roughly a residual product of crude oil refining: this means that it's a low quality product, with a very high content of sulfur, ashes (metallic or non-metallic), heavy metals as vanadium and other contaminants (American Bureau of Shipping, 1984). Such a low quality fuel is used due to its low cost, compared to any other more refined product, but this has a negative impact on ship's emissions: the three main gases originated by HFO combustion are CO_2, SO_x and NO_x.

These pollutants harm the environment in two ways (Chang et al, 2014): GHG and otherwise noxious gas (hereafter, NG) have a local and regional impact, as well as long-lasting global consequences. Local and regional impact is related to the localized consequence of air pollution in a certain area, usually close to a major pollution source (e.g. a port, canal or water-way). Local pollution is mostly connected with the immediate effects of noxious or poisonous gas, which cause significant threats to the health of population living nearby polluted areas. The problem of local pollution is not to be considered of minor importance in comparison to global warming: as shown by Corbett et al (1999), nearly 70% of ship emissions occur within 400 km from coastline which, taking into account the effects of winds, is close enough to significantly affect the coastal areas.

In detail, SO_2 (sulfur dioxide) is responsible for acid rains, a phenomenon that significantly endangers the environment and can have long-lasting consequences to human health as the noxious rain infiltrates groundwater or hinders agricultural cultivations. CO is a notorious poisonous gas, even if it's mostly dangerous only when concentrated in close spaces, but has also an effect as greenhouse gas, while the most important immediate danger to health is caused by VOCs and PM. While CO_2 is an inevitable byproduct of any combustion, VOCs and PM are aerosols formed by microscopic particles of heavy metals, ashes and other impurities that are left unburned as a consequence of an imperfect combustion. They are dangerous because those small particles composing them can infiltrate lungs when inhaled and cause, even just in the medium term, lung cancer and other serious respiratory diseases (Cullinane and Edwards, 2010). Moreover, due to their composition, VOCs and PM tend to concentrate in small areas close to pollution source, so that nearby harbors and ports they represent a major issue. Another factor that contributes to the local pollution of areas close to ports is the very high level of emission caused by ships maneuvering in harbors. As marine engines are designed to run at a steady speed during cruise, they are not operating in their optimal conditions during the slow phases of maneuvering the vessel in the port. The engine working outside its optimal range, then, result in higher emission: according to Corbett and Fischbeck (1997), 6% of NO_x total shipping related emission and 10% of SO_x are caused by port operations.

The global consequences of gas pollution, on the other side, are more related with the long-term effects they have on climate: CO_2, which is a natural result of oxygen combustion, is widely known as responsible of global warming; while NOx contribute to the creation of O_3 (ozone) in the atmosphere. While atmospheric ozone is not a dangerous gas by itself, its uncontrolled increase due to man-made pollution has been recognized as another contributing factor to global warming (MARINTEK, 2000). Furthermore, it has been proven (Eyring et al, 2009) that combustion related gases also have an effect on climate that goes beyond global warming: in fact, gas can modify the size and composition of clouds, specifically enlarging them and thus creating a sun-shield effect that may even overcompensate the greenhouse-effect induced warming, possibly resulting in an overall cooling effect.

4.1.1 Direct and Indirect Greenhouse Gas Emission

A very simple, yet effective classification can be introduced with regards to the way in which shipping industry contributes to GHG release in the atmosphere: a ship can create GHG directly or indirectly. This distinction will prove to be very useful when discussing the areas of improvement, i.e. those pollution mitigation techniques that are currently being investigated and assessed.

Directly produced GHG is the one resulting from the combustion process in the ship engine, or in the auxiliary generators needed for the normal operations of the ship, such as loading and unloading in ports. There are a number of factors which have a significant effect, in qualitative and quantitative terms, on the way those gases are created.

The first important parameter is engine speed: when the engine works faster, more fuel is consumed and more exhaust gas is released into the air. The connection between speed and pollution, however, is less obvious and direct than it may appear. While there is a direct relation between fuel consumption and CO_2 emission, it's not necessarily true that slow sailing is more economically and environmentally efficient. Ships, in fact, are designed to sail at a specific optimal speed, at which the engine is working at its maximum efficiency speed, thus optimizing the power output to fuel consumption ratio (McCollum et al, 2009). This means that running engines at lower speeds, while will reduce CO_2 emissions, may not be enough to achieve significant economies. For this reason, as will be discussed later, most recent ships are designed to sail at a lower optimal speed.

While CO_2, as seen above, can be reduced simply by slowing engine speed, emissions of other noxious gases as SO_x and NO_x depend on other factors: in fact, the amount of SO_x generated by an engine almost entirely depends on the quality of the fuel, in particular, on the percentage of sulfur contained in fuel (MARINTEK, 2000; American Bureau of Shipping, 1984). As shown in Figure 4.5 (IMO, 2008) below, the most popular fuel used in ships all over the world is the previously mentioned HFO, which, being an almost unrefined product, among all kind of fuels usable by marine engines, is the one with the highest sulfur content, up to 4.5% (IMO, 2013; MARINTEK, 2000).

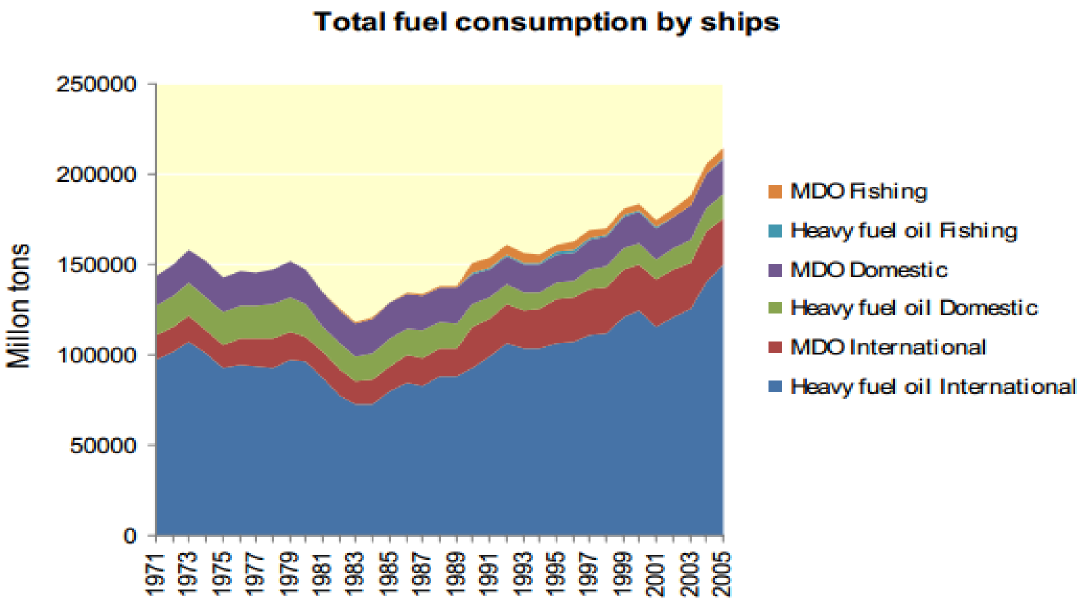


Figure 4.5 Total Fuel Consumption by Ships per Fuel Type (IMO, 2008)

For what concerns, on the other side, the indirect contribution to maritime related air pollution, there are a wide number of factors that, in any way, harm the overall efficiency of the ship, this meaning that some of the power delivered by the engine is wasted due to various causes.

Among these, the conditions of all the parts of the ship beneath the water line are very important: in particular, the friction of water on the hull is the most powerful force opposing to the forward movement of the ship. It is therefore crucial that the hull be as smooth as possible, which is achieved via a special antifoul treatment that prevents deterioration of the surface caused by the corrosive effect of salty marine water. However, the antifouling paint is subject itself to deterioration over time, and requires then periodical checks and in case maintenance. According to MARINTEK researches (2000), a good hull design coupled with a proper antifoul maintenance may allow energy savings up to 20%.

The design of the propeller is another important factor, as it needs to be chosen in accordance with the desired engine configuration installed on the ship. An improper combination of engine operating speed and propeller design, in fact, may result in significant loss of efficiency. Furthermore, as seen above, as the useful life of a vessel is quite long, it's obvious that engine performances, in particular with regards to fuel consumption and mechanical efficiency, will decay over time. Even if the ship undergoes a thorough maintenance program throughout its life, it's inevitable that this reduction in engine efficiency will result in higher emissions.

Finally, it's important to notice how besides the main engine, onboard any ship there are auxiliary generators, meant to provide power to all the ship equipment and systems. The need for electricity and power aboard a ship is not to be underestimated: the total power output of auxiliary generators, on a typical 8,200 TEUs container vessels, can reach more than 12,000 kW (Stopford, 2007). Despite these generators typically burn a cleaner fuel than HFO, their emissions cannot be neglected, especially because they are often kept running when the ship is moored, as the ship's systems still need power even during loading and unloading procedures: thus, emissions from moored ships' auxiliary generators significantly affect populated areas nearby ports.

4.2 Environmental impact of marine accidents

Under the broad definition of "ship accidents", a number of events as oil spills from tankers, sinkings, ship collisions and impact of ship wrecks can be included.

Fuel spill is only the most infamous of the polluting results of a shipwreck: another one of them is the possibility of a fire consequent to the accident, or as the main cause of it. Even though ships are, by their nature, surrounded by water, fires and explosions are not an uncommon element in maritime accidents: it can be fueled by tank fuel or by dangerous cargo that, if undeclared, could be inappropriately handled by the unaware crew - as it's believed to have happened on the Hyundai Fortune in 1996 and, more recently, on the MSC Flaminia in 2012, with both container ships being severely damaged by explosions and subsequent fire. This great propensity of fuel for ship fire makes it even more dangerous, as these fires can last for days before consuming, releasing enormous quantities of noxious and toxic gases in the air, with the obvious negative consequences especially when the accidents happen in ports or nearby inhabited land.

Although these catastrophic accidents are statistically rare, if compared to the number of ships safely sailing the seas daily, they have enormous impact on the environment, and not to be disregarded, cause an equally great economic damage to the involved shipping companies: for this reason, as will be shown in part 3, both companies and regulatory authorities have introduced, in a continuous attempt to reduce the possibility of accidents, rules and operational policies to prevent similar catastrophes to happen again.

4.3 Environmental impact of port operations

A significant environmental issue related to the maritime industry is caused by port operations: as already mentioned, despite shipping being a very volatile business, the increase in world trade is creating a long term upwards trend for shipping demand. The resulting congestion in ports and waterways is not only an economic problem, as discussed in the previous section: slow operations means that ships have to spend more time at berths, or waiting for their turn to enter or exit the port (or transit a canal). As noted above, even if ships could turn off their main engines while not moving[12], they still need electrical power

[12] This is not easy as it may appear, as big diesel engines due to their high compression ratio; high displacement and slow operating speed require specific and time-consuming procedures to be turned on and off.

even when moored, which is generated by auxiliary diesel engines. Moreover, whenever ships have to move they need to use their main engines, and in some ports they need to sail slowly for quite a long distance before reaching open sea: port of Hamburg is a typical case, as ships need to sail in the Elbe river for more than 100 km before reaching the sea.

Another source of air pollution in ports is provoked by the engines of vehicles needed for port operation and trucks or, less frequently, diesel locomotives moving cargo outside of the port. Emissions generated by those vehicles, although not directly caused by ships, in very congested ports can account for a large amount of the total air pollution, especially because trucks and trains going out of ports carrying cargo typically head to the nearby cities, bringing pollution directly in the inhabited areas.

The combined emissions of vehicles in land side of ports, auxiliary engines of moored ships and main engines of moving ships, of course, cause high level of air pollution in the nearby areas, which are often densely inhabited as most ports are situated close to big cities.

4.4 Environmental impact of bad practices

Marine pollution is not only related to technical factors or accidents: the wide adoption of bad practices by ships' crews has had, throughout the years, a major impact on the sustainability of the whole industry. There are many examples of those wrong operating procedures: tank washing onboard oil and chemical tankers is probably the most dangerous to the environment. Another example of how ships can harm the environment is release of sewage: while this is not a major issue in open seas, the dumping of sewage and waste in general close to coasts has very unpleasant effects on the environment and, in case of touristic countries, local economy as well. Similar problems are caused by the release of garbage or, in case of container vessels, by containers being thrown overboard: this practice is, of course, not common, but it can be of great help in case of very rough sea, in order to stabilize the ship. Despite it being obvious that it's preferable to have some containers thrown in the sea rather than a full ship sinking, this creates a two-sided environmental issue: in first place, the goods carried in the container may be dangerous in any way, and secondarily, containers can often float even when full, which creates a not negligible danger to navigation.

As will be discussed below, despite the fact that all of these practices have been banned or at least regulated by IMO, there is still a problem in monitoring the compliance of all the vessels to regulations when they are at open sea.

4.5 Environmental impact of ship scrapping

Ship scrapping is another highly environmental damaging shipping related activity. This is not, differently from spills and other highly emphasized accident, a well-known problem for general public, especially because scrapyards are typically located in developing countries (the two major scrapyards are located in Alang, India and Chittagong, Bangladesh) where environmental regulations are far less tight, thus allowing both companies willing to dismiss ships and shipbreaking companies to make more profits. Of course, on the other side this causes great environmental damage in the shipbreaking sites and high hazards for the health of workers and inhabitants of the nearby areas. This happens especially because ships are just pulled to rest on the shore while being dismantled, this allowing dangerous substances to penetrate in water (during high tide), sand and soil, resulting in poisoning of large areas, mainly inhabited by scrapyard's workers' families: this causes indirect long term safety issues for the whole population of affected areas.

4.6 The problem of ballast water

The last polluting factor to be analyzed, as the issues related to shipwrecking, is scarcely considered by public opinion, due to its "hidden" nature and almost invisible effects, at least in the short term.

Ballast water is used, in basically any kind of large motorized ship, to stabilize ships when they are not fully loaded and, thus, too high on the water and more sensitive to waves and wind. This problem is much more significant on large cargo ships: they are designed to operate at full load, in order to achieve maximum economies of scale, but, for evident safety reasons, the ship design must allow it to safely sail even when completely empty. To achieve this, ships are provided with ballast tanks, located in specific areas, to be filled with sea water through pumps. When the ship is empty, or when a proper balance of the cargo is not achievable only with repositioning of cargo itself (this could happen especially on large container ships, as tankers and bulk carriers can easily move cargo from one hold to another), ballast water is loaded until the right balance is achieved. Ballast water management is also important in order to set the correct level of the waterline (in other words, to set the correct height of the ship above sea level): there is a compromise to be achieved, as a ship too high on the water will be, as seen above, dangerously unstable, but a ship too low on the water will be less fuel efficient and slower, due to increased water friction on the hull. By using ballast water, the crew can always set the level of waterline to the optimal value.

However, this also creates an environmental problem, especially in the case of big, long-haul container ships: these ships typically load ballast water at source port, when the cargo hold is empty (or not completely loaded), and then discharge it at destination port, while loading cargo. This means that a significant amount of sea water is loaded and then discharged in a port in a very distant geographic area, thus allowing sea organisms, contained in the water, to populate areas extremely far from their natural habitat, this of course resulting in a significant threat to biodiversity (Freda and Otremba, 2012).

Chapter 5. Discussion: Forces Pushing Liner Shipping Towards Sustainability

In this section, the discussion will focus on the upcoming potential changes of liner shipping competitive and strategic environment coming from the ever increasing attention that the topic of sustainability is receiving. Adopting a corporate strategy oriented point of view, it is possible to analyze the way in which such changes could affect the industry. Keeping as basic reference framework environmental analysis (Grant, 2010) and Porter's model, it's easy to note how any industry is subject to a number of external factors as governments, state of world/country economy and so forth that contribute to shape the competitive environment (Grant, 2010). In the specific context of liner shipping, external factors are mostly related to international regulations (IMO, 2014b), which may force liner companies to introduce new pollution reducing measures and operating policies. This of course will require significant investments by shipping companies themselves, possibly creating yet a new source of costs in an already capital intensive industry. Of course, any macroscopic changes in world economy would have a role as well, but being extremely complicated to predict and, furthermore, less relevant to sustainability, the role of world economy will be disregarded for this thesis' purposes.

Internal factors, on the other hand, can be identified among Porter's five forces: in the specific context of sustainability in shipping, they are mainly related to shipping companies' stakeholders' increasing interests in sustainability. The emergence of sustainability networks and the creation of studies on the topic are a clear indication that cargo owners companies, which buy the transport service from liner companies, are becoming more and more interested in reducing the overall footprint of their activities, including the reduction of emission caused by shipping their products all over the world.

In the following subsection, those two factors will be analyzed and then the discussion will, through an analysis of liner shipping market dynamics, try to assess the extent to which they are likely to impact on the liner shipping industry.

5.1 Current anti-pollution rules and legislation[13]

The major threat that the above discussed shipping related polluting factors cause to the environment has not been overlooked by international authorities. IMO[14] has, since 1973, set a series of rules and international conventions with the target of reducing the extent to which maritime transportation harm the environment.

The main convention regulating marine pollution is the "International Convention for the Prevention of Pollution from Ships"; known as MARPOL, introduced in 1973 and continuously updated ever since by various amendments, the most important of which were released in 1978 and 1997.

MARPOL convention in its original formulation included 5 annexes, covering what, at the time, were considered to be the five major ways in which commercial shipping could harm the environment. In the following subsections, a short overview will be given of the regulative framework.

MARPOL Annex I

Annex I regulates the prevention of oil pollution in seawater: as previously discussed, the most catastrophic maritime accidents, in terms of environmental damage, are the ones involving crude oil tankers.

Annex I made it mandatory to segregate ballast tanks, so that ballast water could never be mixed to the oil cargo, and set some specific tank-washing procedures like crude oil washing[15] that prevent, or in worst case minimize, the amount of oil released into the water.

The major amendments to Annex I were introduced in 1978, to lower the minimum size (in deadweight) of tankers subject to the regulations, and in 1992, to make double hull structure for tankers mandatory, after a series of catastrophic accidents in which some single-hulled tankers were involved.

MARPOL Annex II

Annex II is, in its formulation and structure, similar to Annex I, but it sets rules for chemical

[13] This section mainly refers to IMO – Focus on MARPOL 25 years (1998), IMO website http://www.imo.org/OurWork/Environment/PollutionPrevention and Second IMO GHG study (2009)

[14] International Maritime Organization

[15] This procedure requires the tanks to be cleaned by a high-pressure jet of crude oil, which is then stored in the tanks itself and unloaded only in purposed facilities.

tankers. With regards to chemicals four categories were introduced classifying chemicals by their environmental hazard (A being the most hazardous) plus a residual one, enclosing all the substances considered not dangerous. A limit of maximum discharge amount was set for categories B, C and D, while the discharge of category A chemicals is banned altogether and no limits are set for the release of non-hazardous substances. For any category, however, release within the allowed limits is only permitted outside specified areas and in any case at a certain minimum distance from the coast. Finally, any disposal operation of chemicals has to be registered in a specific logbook.

MARPOL Annex III

Annex III bans the jettisoning of harmful goods in packaged form from vessels, thus regulating another potentially dangerous practice. However, it is allowed to throw even dangerous cargo overboard under the sole circumstance that this is necessary for safety reasons, that is, to preserve ship balance in very rough waters and avoid capsizing.

MARPOL Annex IV

Annex IV regulates the release of sewage from commercial ships. The guideline of this annex is the fact that, as already noted, sewage does not create a significant hazard in open sea, while it does along coasts and, even more, close to inhabited land. Therefore the regulations, besides requiring specific treatment to sewage before release, ban its discharge within a certain distance from the coastline and in specific preserved areas.

MARPOL Annex V

Annex V regulates the disposal of waste at sea and on-board incineration. The main points behind the annex are very similar to ones at the root of Annex IV: the extent of the damage created by discharge of waste at sea depends on some factors. Some materials take extremely long time to dissolve at sea: according to IMO studies (1998), a simple plastic bottle thrown into the sea would take up to 400 years before dissolving. Annex V, then, completely bans the release of plastic materials and sets limits to the discharge of other less dangerous types of waste. Moreover, Annex V regulates the incineration of waste onboard, and completely forbids the disposal of waste close to coastline and in certain protected areas.

5.1.1 MARPOL Annex VI[16]

Annex VI is, chronologically, the last part of MARPOL convention. It regulates the emission of pollutant gas from ship and, for its importance, it deserves a specific analysis. In fact, Annex VI rules, namely the ones that will come into force in the near future, are so tight that require some major changes in the whole shipping industry. Those changes, as will be discussed, may be so deep that they could even shape the whole competitive environment of shipping – and, keeping the analysis within the research field of this thesis, liner shipping industry.

Therefore, in order to understand how this could happen, it's important to understand what are the new rules set by Annex VI. Of course, a complete technical discussion of the new regulations and of their impact would be far beyond the scope of the thesis, thus the analysis will briefly focus on the limits set by Annex VI rules, with a special regard to the forthcoming ones.

As previously seen, the most dangerous gas emitted by marine engines are SO_x, NO_x, CO_2 and aerosols as PM. Besides this, Annex VI also considers the problems of ozone depleting substances (hereafter, ODS) as HCFC and halon[17], volatile organic compounds (VOCs) emitted by oil tankers cargo, emission from shipboard incineration (here somewhat amending Annex V) and includes a section about quality of fuel oil. Furthermore, a later amendment contained in IMO Resolution MEPC 212/(63), released in 2012, added a further regulation about ship energy efficiency, with the aim of reduce what was previously defined in subsection 4.1.1 as "indirect" CO_2 emission, that is, created due to operative inefficiencies of ship equipment. Finally, Annex VI introduced the concept of Emission Control Areas (ECAs), that is, specific areas – usually close to inhabited land or natural reserves – in which the emission of noxious gas would be subject to tighter limits. Hereafter, a brief yet comprehensive overview of Annex VI previsions will be given.

5.1.1.1 PM and SO_x

As previously shown, PM and SO_x emission are mainly dependent on fuel quality,

[16] This subsection is mainly based on IMO Resolution MEPC 176 (58), Revised Annex VI (2008), and on DNV – MARPOL Annex VI Technical and Operational Implications (2009)

[17] HCFC – hydrochlorfluorocarbons are mainly used as refrigerant gas, but are extremely volatile with a high risk of being released by old equipment. Halon – a very volatile gas as well – is used in fire extinguishers.

respectively, in terms of impurities and sulfur content. Thus, Annex VI regulates those emissions by setting a limit on sulfur content in fuel oil: this must not exceed 4.5% before 1/1/2012, 3.5% before 1/1/2020, and 0.5% from 2020 on. Moreover, in SECAs (Sulfur Emission Control Areas) as the Baltic and North Sea, the limit was 1.5% before 1/7/2010, 1% before 1/1/2015 and will be lowered to 0.1% from 1/1/2015 onwards (DNV, 2009; IMO, 2008). The reason of the declining limits over time, of course, is to give some time to shipping companies to adapt their ships and, in this specific case, to find cleaner fuel. As drastic as the future limits may appear, it is worth to note that the current maximum sulfur content allowed in automotive diesel fuel is 0.001%, that is, 100 times lower (IMO, 2009).

5.1.1.2 NO_x

The process that leads to NO_x creation and emission in an internal combustion engine is quite complex. It depends on a vast number of factors; most important ones being pressure and temperature in the cylinder at the moment when air-fuel mixture is ignited. Even disregarding all other variables, it is evident how those two parameters are inherently dependent on the type of engine (MARINTEK, 2000). Thus, as the world fleet is composed by many different types of ships, powered by different type of engines, Annex VI set a variable limit with regards to NOx emission, calculated by a formula based on the operating speed of the engine in rpm (revolutions per minute). As the focus of this thesis is liner shipping, the choice has been made to report only the limit that applies to engines operating at or below 130 rpm, which encloses the totality of container ships fleet[18]. Besides the operating speed, Annex VI introduced a 3-tier classification for the engines, based on their construction date. Given all this, the limit for NO_x emission for liner vessels is: 17.0 g/kWh[19] for engines installed on ships constructed before 1/1/2011 (Tier 1) and 14.4 g/kWh for ships constructed before 1/1/2016 (Tier 2). From that date onwards, ship will be required to comply with Tier 3 limits of 3.4 g/kWh. This limit is the one designated for ECAs, which will also be enforced from January 2016 (DNV, 2009; IMO, 2008).

[18] As previously reported, the engines of liner vessels operate at no more than 110-120 rpm (Stopford, 2007; MARINTEK, 2010).

[19] Grams on kilowatt-hour, measures the quantity of NO_x emitted given the power delivered by the engine in a time unit (hour)

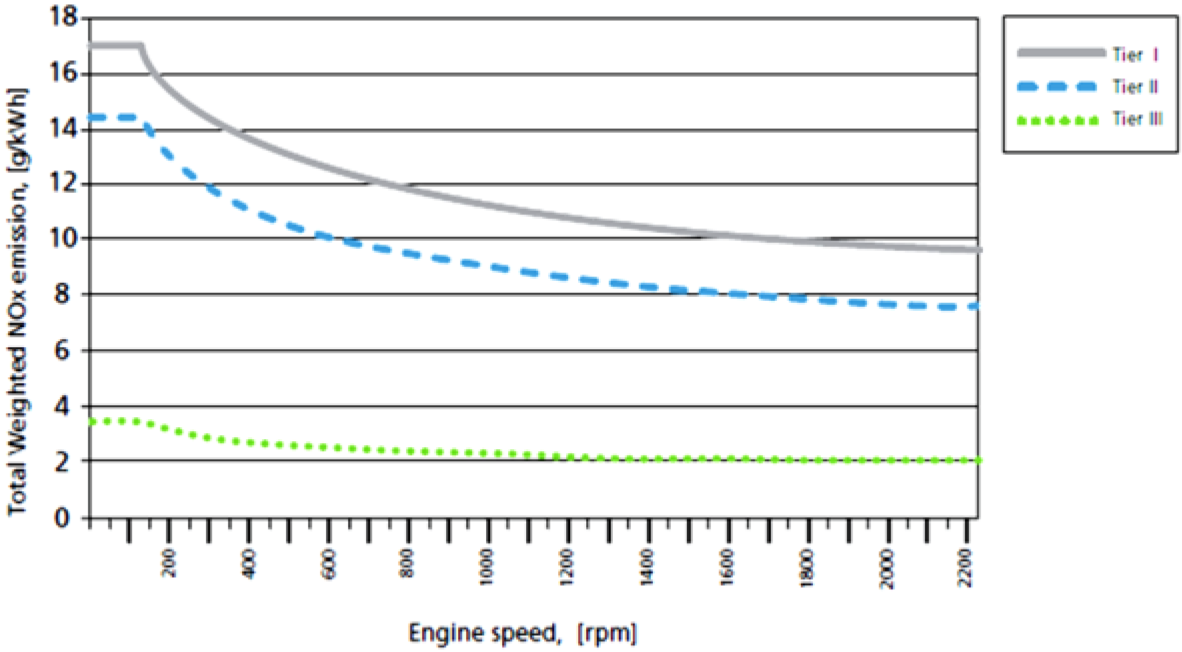


Figure 5.1 NO_x limit as function of engine speed (DNV, 2009).

The graph in Figure 5.1 shows the great extent of the NOx reduction that will be achieved with Tier 3 regulations. It is also noteworthy the fact that liner vessels, powered by lower-speed engines, are the ones for which the highest amount of NOx emission is allowed, partly due to the technical difficulty of reducing emission in such engines.

5.1.1.3 Ozone Depleting Substances

Ozone depleting substances are those chemicals as CFC, HFCF and halon, which are proved to have a negative effect on atmospheric ozone. The installation of equipment requiring use of those substances, mainly refrigerators and fire-fighting gear, will be completely banned by Annex VI from 2020 on, while the use of such equipment already installed onboard is allowed, but release of ODS is completely forbidden. Lastly, the regulation of Annex VI dealing with ODS also rules the practice of shipboard incineration, which must be carried out in specific equipment, and it’s banned altogether for certain materials.

5.1.1.4 CO_2 and Energy Efficiency

The topic of energy efficiency is regulated by the 2012 amendment to Annex VI, contained in IMO Resolution MEPC 212(63). Energy efficiency is closely related to indirect emission of CO_2: if any equipment onboard a ship is technically obsolete, or operated in an inefficient way, a higher amount of energy would be needed for the normal operations of the ship, resulting in more load for auxiliary power units and ultimately in higher CO_2 emission. As onboard a ship there could be a vast number of sources of energy inefficiency, Annex VI provide a tool to assess the overall level of efficiency of the vessel: the Energy Efficiency Design Index (hereafter, EEDI). This index is calculated via a rather complex formula, which encompasses valuation of every component of the ship. The formula, moreover, has been designed to be applicable to the majority of commercial ships, and indeed, according to IMO, it is inapplicable only to a few categories of vessels. Despite the complexity of the formula, the idea behind EEDI calculation is quite simple: energy efficiency is calculated as the total CO_2 emission per transport work provided by the ship[20], quantified in tons-mile of cargo carried. For what concerns the regulative purpose of EEDI, Annex VI simply requires commercial vessels to score a minimum efficiency level. Furthermore, starting in 2013 the minimum level will be periodically lowered every 5 years, with the aim of making world commercial fleet progressively more efficient over time, while the 5 years period would grant shipping companies a fair timeframe for developing and installing energy-saving equipment onboard their ships.

However, EEDI is not just a quantitative tool for regulations: due to the very nature of its formula, it can be used, as example, to compare the overall efficiency of similar ships and to calculate the average fleet efficiency of a shipping company. Furthermore, EEDI's nature is not prescriptive, this meaning that it does not force shipowners to install any specific equipment, but it's a pure performance based index: this allows shipping companies to enhance energy efficiency in any possible way, thus stimulating research and technological improvement in this area. In 2008, IMO estimated that 45 to 50 million ton CO_2 could be removed following the introduction (in 2011) and enforcement (in 2013) of EEDI.

Finally, MEPC 203(62) introduced the Ship Energy Efficiency Management Plan (SEEMP), an operational measure meant to establish a cost-effective energy efficiency improvement of a ship, and the Energy Efficiency Operational Indicator (EEOI), a facultative tool to monitor the efficiency of the ship during operations. The EEOI, moreover, can also be used to gauge the effectiveness of any modifications or improvements to the ship in terms of efficiency gain.

5.1.1.5 Emission Control Areas

As already mentioned, Annex VI includes the creation and enforcement of special Emission

[20] The measure unit of EEDI is then gCO_2/ton*nm

Control Areas (ECAs), in which GHG emission limits will be significantly lower. The effectiveness of ECAs has been demonstrated by Chang et al (2014) who analyze the potential reduction in noxious gas (namely, SO_x NO_x and PM) emission yielded by the possible introduction of an ECA in the port of Incheon (South Korea) area. The analysis, summarized in Figure 5.2 below, show that the combination of two measures, creation of a Reduced Speed Zone and introduction of the sulfur limit in fuel currently adopted in enforced ECAs, would lead to a SOx emission reduction higher than 59% adopting the current ECA 1% sulfur content limit, and to a stunning 93% reduction with the future 0.1% limit.

Reduction of NG emissions in a future ECA with various measures. Unit: ton.

	Current	RSZ (12 knots)[a]	RSZ (12 knots) (%)[b]	ECA (1.0%)[c]	ECA (1.0%)	ECA (0.1%)[c]	ECA (0.1%)
SO2	990	668	32.47%	404	59.18%	68	93.16%
NOx	1551	1021	34.14%	-	-	-	-
PM	142	97	31.67%	-	-	-	-

[a] Reduced Speed Zone (RSZ) with 12 knots speed limit is enforced within 25 nautical mile zone.
[b] Reduction percentage with RSZ system.
[c] 1% or 0.1% sulphur content regulation is enforced in an ECA.

Figure 5.2 (Chang et at, 2014)

5.1.2 Enforcement Issues

After having described international sustainability legislative framework, it is necessary to discuss its effectiveness and potential impact on the industry. In particular, as seen above, new regulation enclosed in MARPOL Annex VI set very tight limits in a quite near future, but it will achieve significant results in lowering maritime related air pollution only if effectively enforced. Enforcement of international maritime regulations is quite a complex topic: there are some factors that are likely to somewhat diminish the strategic consequences of new regulations. As widely discussed in Chapter 4, with special regards to pollutant gas emission MARPOL limit will be progressively made stricter with a step-by-step mechanism, over a fairly long timeframe. This policy has been chosen by the IMO, as previously reported, with the purpose of containing the negative side-effects on companies' profitability and give them more time to green their fleet. This, of course, will to some extent limit the economic and organizational costs, to companies, of complying with MARPOL. Furthermore, due to the above mentioned international and generic nature of MARPOL regulations, there is also an enforcement problem to be considered: container ships spends most of their time at open seas, and while IMO regulations still apply there, it is clearly extremely difficult to establish monitoring and control mechanisms to verify that operation of a given ship is at any time carried out in accordance to MARPOL previsions. As in most cases operating out of the rules (for example, using cheaper high sulfur content fuel) brings an immediate economic advantage to the operator, it would be unrealistic to imagine that every ship will be operated in full respect of international rules. It can be assumed, then, that aggregate effects of regulations being violated, especially in less controlled areas or by part of less controlled companies, may result in a further countering factor allowing some operators to avoid, at least to some extent, the costs of compliance. Finally, a last factor potentially harming the effectiveness of regulation is uncertainty about its deadlines: enforcement of Annexes I to V has been all but smooth and easy process, and before all annexes came into force almost 25 years were elapsed (IMO, 2014b). It is questionable, then, whether the established deadlines for Annex VI will be maintained or postponed: it's easy to see how this uncertainty is likely to cause shipping companies to wait before complying with all regulations, in order to postpone investments as possible.

5.2 Market Forces Leading to Sustainability

In the previous section, international regulations regarding sustainability of shipping have been presented and discussed. However, regulation is not the sole factor pushing shipping companies to invest in research and implementation of anti-pollution technologies and policies: as in any other industry, customers' behavior plays a crucial role in determining strategic choices of firms. While companies have to comply with regulations to avoid penalties, the connection between customers' preferences and corporate strategy is way deeper: the inability to properly understand customers' expectations and to meet their demand may be a serious problem even for well established companies.

In the specific context of container shipping, the most important customers for liner companies are large manufacturing companies, who need a high amount of semi-products and finished products to be shipped. Another example is given by companies producing complex products, as ones in the automotive industry, which purchase a wide range of semi-products from many different suppliers and thus have a strong need for shipping services. As noted in subsection 3.1.1, liner companies provide a fixed service, with fixed routes and schedules. Importance of such big customers for them, thus, is quite evident: if a liner company has an agreement with a company that needs to ship a fairly high and stable volume of cargo per year, this is a great advantage as it helps to deal with the inherent volatility of the industry.

It is then safe to assume that, in case major customers of shipping companies begin to require more environment-friendly shipping, liner companies would face a significant market driven incentive to reduce their environmental impact. As will be discussed in the following sections, the emergence of so called sustainability networks and of dedicated studies (Lai et al, 2011; Lirn et al, 2013; Lun et al, 2013; Pil and Rothemberg, 2003; Krozer et al, 2003; Dinwoodie et al, 2012) to the link between environmental and economic performance in commercial shipping seem to indicate that the topic of sustainability is indeed receiving more and more attention.

5.2.1 The Role of Sustainability Networks

The main concept behind the creation of customer networks is quite simple: in general, whenever customers of a certain industry are aware of having a low bargaining power, they will try to unite to gain a stronger position towards their supplier. This, of course, will allow customers to negotiate the conditions of the commercial relationship with the supplier starting from a better base. Sustainability networks are the result of the union of companies and other entities willing to cooperate to create a more sustainable way to make business, usually as a consequence of the implementation of CSR policies in the firm.

Basically, through the creation of sustainability networks companies begin introducing voluntary environmental standards, which goes beyond mere compliance with regulations. This self-regulation, of course, comes at the price of investing capital into – and committing companies' mission to – sustainability: it is then evident that this behavior reflects an increasing importance of environmental care in customers' preferences (Pil and Rothermberg, 2003).

In most cases, sustainability networks take the form of multi-stakeholder initiatives (Fransen and Kolk, 2007). This means that those networks are created with the participation of different stakeholders as companies, NGOs, governments and/or other organizations working together to create the basis for more responsible business behavior.

5.2.2 BSR: Business for Social Responsibility

Business for Social Responsibility (BSR) is a sustainability network founded in 1992. It was born with the aim of filling a gap between companies that had not yet embraced CSR concepts and ones who did, but lacked the instruments to effectively enforce changes in their businesses (BSR, 2014). Nowadays, BSR is a global nonprofit business sustainability network, whose activities range across different sectors and industries, with the participation of over 250 among the most influential companies in their respective fields. The existence of such a developed organization is a further demonstration of the importance that networks can gain in contemporary business environment, and, furthermore, of the above mentioned increasing care for the environment by companies themselves.

Since its foundation, BSR has shown big interest in shipping, and particularly in liner shipping. The result of this has been the creation, in 2003, of the Clean Cargo Working Group (CCWG), a dedicated project aiming to improve the environmental performance of liner shipping, which will be thoroughly presented in the next subsection.

5.2.3 CCWG: Clean Cargo Working Group

The Clean Cargo Working Group is "*a global, business-to-business initiative dedicated to improving the environmental performance of marine container transport, dedicated to environmental performance improvement in marine container transport through measurement, evaluation, and reporting*" (BSR, 2014). The aim of CCWG is the creation and introduction of industry approved emission calculation methodologies to fulfil the increasing demand from the plurality of liner shipping stakeholders for a cleaner industry (CCWG, 2014). 23 liner shipping companies – 18 of which are among the 20 largest ones, accounting for over 85% of global container fleet by volume – are members of CCWG. Besides them, 11 among the most important global shippers and 6 top ranking logistic provider and freight forwarding companies participate in the network (CCWG, 2013).

For what concerns liner companies, joining CCWG they commit to provide vessel-level data every year, while cargo owners agree to integrate the sustainability standards set by the network in their procurement policies. It is then clearly evident that the multi-stakeholder nature of the initiative demonstrates a real interest, by part of all members, in investing time and capitals in the joint research for a cleaner shipping industry. This is a particularly significant factor: as ocean carriers joining CCWG are doing that voluntarily, it is clear how they perceive the networks' activities and internal rules not as further restrictions, besides IMO regulations, to their operations, but rather as powerful strategic instruments to improve their environmental and possibly economic performance.

The main mechanism through which CCWG works is, as stated in the project's description above quoted, based on a self-measurement and assessment of environmental performance by carriers, that is then reported to shippers and used to benchmark liner companies. In order to provide realistic and certified results, standard tools are used which are previously agreed between CCWG's members.

As noted above, throughout the years CCWG has developed a number of tools and indicators to accomplish its mission: the first one, introduced in 2003, was the Environmental Performance Survey (EPS), which includes a set of questions meant to provide qualitative data on liner companies' environmental focus areas. In 2007 and 2008, then, the Intermodal Carbon Calculator (ICC) and the Environmental Performance Metrics (EPM) were introduced. The first is a CO_2 calculation methodology that allows assessing the total carbon dioxide emission of the transportation supply chain in its wholeness, thus providing valuable data to assess the overall carbon footprint of transportation of a specific good between origin and destination. The latter is a benchmarking tool used to compare different carriers' performances with regards to emission of various noxious gases – as SO_x, NO_x, PM and CO_2 – and other sustainability related parameters like use of chemicals and waste disposal practices. Furthermore, EPM is designed to encompass in the analysis the whole fleet operated by a given company, also including chartered vessels. The index is then updated yearly, to keep up with any improvement introduced in the carrier's fleet. Finally, the CCWG Validation Protocol is an auditing tool that allows liner companies to have their emission performances (especially with regards to CO_2 and SO_x) independently verified with a standardized methodology.

CCWG's quantitative tools for CO_2 emission measurement are similar to the above mentioned IMO's EEOI indicator. However, while IMO's indexes are meant to cover the largest possible part of world fleet, CCWG's ones are specifically targeted on liner shipping industry, thus they feature some minor modifications to be perfectly relevant for the specific family of container ships. Beside those minor differences, CCWG's tools are, like IMO's ones, based on a quite simple methodology: given as main parameters the total fuel consumption, the distance traveled and the capacity of a given ship, the indicator is calculated as gCO_2/ per TEU moved by a kilometer. In this way the index, continuously improved since its introduction, gives an assessment of the amount of CO_2 – but, of course, the methodology is valid for any other noxious gas – produced to move a container over a given route.

The above described activities by CCWG have, over the years, yielded some results: CCWG itself (2013) claims that, based on data collected on vessels operated by network's members, 19 out of 25 analyzed sea routes showed a CO_2 emission reduction, quantifiable as 16% over the 2005-2012 period and 7% over 2011-2012.

Moreover, the CCWG assessment and reporting mechanism brings benefits to all the participants: for what concerns carriers, they can use results of the reporting process to assess their carbon footprint in a credible and reliable way and compare themselves to other participating carriers, thus opening the possibility for a peer-to-peer cooperation within the network. Furthermore, the constant tracing of environmental impact can lead to development of new pollution-reducing tools and standards. On the other side, cargo owners and logistic service providers can effectively use the large amount of data collected to review and compare carriers' performances, which will allow them to make informed buying decisions (CCWG, 2013). This, of course, is a significant step for companies willing to reduce carbon footprint of their supply chain. As discussed in chapter 4, maritime shipping is the cleanest way to transport cargo in relative terms, but due to its dominant importance compared to other forms of transportation it is also the one responsible of the higher amount of emission. For cargo owners, then, showing a serious interest in "greening" maritime transport is a powerful way to signal to their respective customers – and in general to the general public – their commitment to CSR and environmental policies. Finally, by working side by side for a common objective, strong relationships could be built among the members, who go beyond the traditional supplier-customer dynamics. This allows creating much more personalized services by part of liner companies and freight forwarders. This closer relationship with business partners is a great strategic advantage for both sides: from one side, cargo owners benefit from the higher degree of service customization. Conversely shipping companies' advantage is given by the long-term nature of such commercial relationship, which allows them to reduce and control, to some extent, the inherent volatility and instability of liner shipping industry.

5.2.4 The Clean Shipping Network and the Clean Shipping Index

The Clean Shipping Network, founded in Sweden in 2006, is another private sustainability network that has developed a quantitative tool to rank and compare liner carriers' environmental performances. Differently from CCWG, however, the network is mainly formed by cargo owners, thus its configuration is more focused on the demand for clean transportation side.

The Clean Shipping Network's tool is the Clean Shipping Index, a comprehensive measurement methodology meant to assess the environmental performance of a ship. Furthermore, aggregating the vessel-level data, it is possible to measure the overall performance of a shipping company, and then use it to rank and benchmark different carriers.

As in the case of EEDI, EEOI and CCWG's index, the logic beneath CSI is quite simple: the ship is valued in terms of noxious emission (CO_2, NO_x, SO_x, PM) and of other source of environmental impact as policies regarding use of chemicals onboard, release of sewage and waste disposal, somewhat reflecting the topics covered by MARPOL Annexes. However, it is calculated in a stricter way than IMO's indexes, to promote continuous research and development of anti-pollution solutions. The index is calculated collecting data voluntarily released by shipping companies, via compilation of a questionnaire divided in equally-weighted sections related to the 5 areas of relevance (Chemicals, SO_x-PM, NO_x, CO_2 and water-waste management). The total score is calculated summing all the partial scores and indexing the final value to a base of 500 (the highest possible score). In Figure 5.3 below, taken from the Clean Shipping Index Brochure (2014), result of the elaboration of such collected data is shown: the graph is an example of how the overall ship performance is calculated.

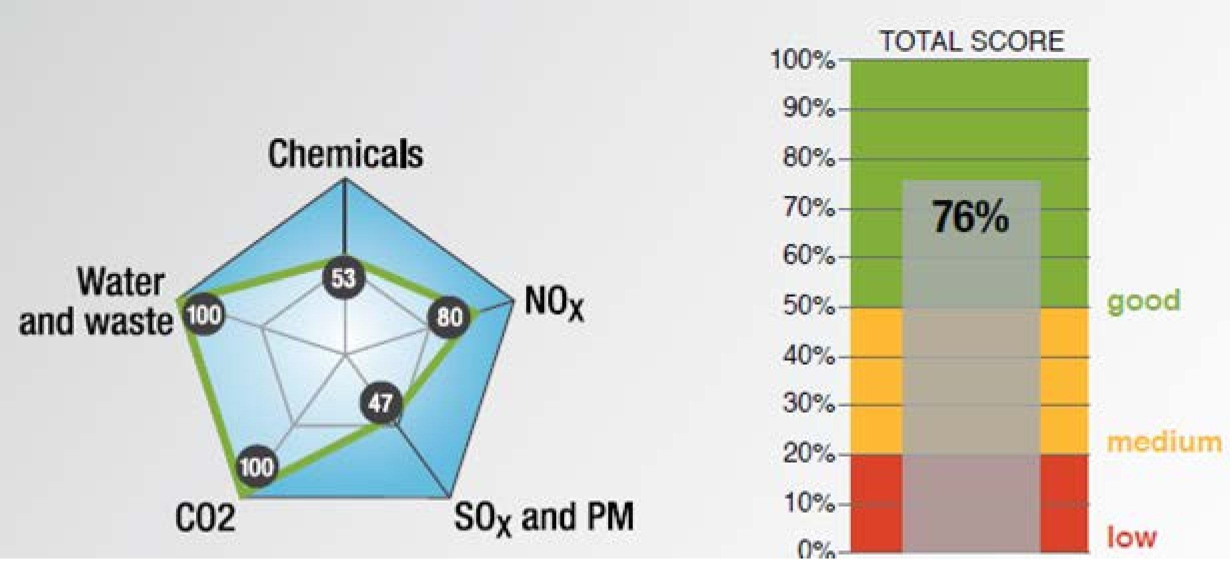


Figure 5.3 Example of a vessel's Clean Shipping Index score (Clean Shipping Brochure, 2014)

First, the scores of the 5 areas are displayed on a radar-type chart, which allows a quick valuation of the vessel's environmental strengths and weaknesses. Then, as shown in Table 5.4, the total score is calculated, represented on a 3-level scale and classified as "low"(red) if the score is below 20%, "medium"(yellow) if comprised between 20% and 50% and "good"(green) if above 50%. Furthermore, in order to get a "good" ranking, a vessel must score at least 35% in each partial field and have its rankings verified (CSI, 2013). For what concerns carriers' ratings, the "good" mark is awarded to companies who report data for at least 90% of their operated fleet and whose vessel score at least an aggregate weighted score of 40%. The "medium" grade is given to carriers who report not less than 20% of their vessels, scoring at least an aggregated 10%, while carriers not complying with "medium" criteria are granted the "bad" score.

	Carriers	Vessels
GREEN	≥90 % vessels reported, the carrier verified, ≥ 40% weighed total score	The vessel verified, total score ≥ 50%, ≥ 35% score in all five fields
YELLOW	≥ 20% vessels reported ≥ 10% weighed total score	Total score ≥ 20%
RED	< 20% vessels reported or, < 10% weighed total score	Total score < 20%

Table 5.4 Clean Shipping Index Ranking Criteria (Clean Shipping Index Guidance Document, 2013)

Finally, the Clean Shipping Index has other two interesting features: it can be verified by independent third parties as Lloyd's or DNV, and, due to its very design, it credits maintenance or improving works on the vessel, via a comparison between the two calculated indexes before and after the works.

Given the above noted demand-side oriented membership structure of CSI, the index's main purpose is clearly to provide information to cargo owners in order to make informed selection of clean shipping companies, while it lacks the network advantages, to liner companies, that have been discussed above in the CCWG description. However, carriers still benefit from engaging in the index and rank their fleet CSI score: firstly, as the participation to the index is on a voluntary basis, they signal their commitment to CSR policies and to a cleaner way of doing business in shipping. Secondly, as Clean Shipping Network members include a good CSI performance in their procurement decisions, having such good rank allows a carrier to enter as supplier of companies who greatly value sustainability. As discussed in previous subsection, this means the possibility to establish a long-term commercial relationship. Customer, once it finds a carrier who satisfies its sustainability requirements, will be less likely to change shipping company for its transport necessity. Finally, it is worth to report that in May 2014 a Memorandum of Understanding has been signed between Clean Shipping Network and Clean Cargo Working Group to explore the potential for merging their activities, in particular, to integrate Clean Shipping Index in CCWG's quantitative analysis tools (CSI website, 2014).

5.2.5 Effectiveness of Market Forces

As it has been done with regards to regulations, it is important to determine whether there are any factors or element that may hinder the activity of sustainability networks and thus diminish their effectiveness as self-regulation and governance entities. The most critical point of sustainability networks is data collection: as shipping companies join networks on a purely voluntary basis, so they do with regards to publication of their environmental performance results. Even if networks could take some measures, as mandatory certification of environmental reports by independent third parties, companies may just decide not to join the networks: should this decision be made by many companies, the overall effectiveness of networks would be severely compromised. Furthermore, there is another problem with regards to cargo owners: joining the network, they implicitly declare to give a prominent value to sustainability in their procurement decisions. However, there would be no mechanism to avoid them selecting the cheaper carrier, disregarding sustainability issues, and continue joining the network just as a marketing move. This is not an easy problem to solve, as any agreement forcing cargo owners to select a liner company within the members of a network would be very likely to be banned by antitrust authorities.

For these reason, despite sustainability networks have a great potential as self-regulation and governance institutions, it is questionable whether they would be a strong enough force to achieve results in the short term, without the combined effect of international regulations.

5.3 How International Regulations and Market Forces Shape the Industry

So far, in Chapter 5 the sustainability related factors that can potentially shape the business environment of international liner shipping have been presented, analyzed and discussed. It has been noted that they can be divided in two main categories: regulations, released by IMO, international entities as EU and national authorities; and market forces, which mainly enclose customers' preferences, their changes and, in general, the bargaining power of a multitude of stakeholders. However, in order to discuss how liner companies should react to those changes, it is necessary to analyze what are the mechanisms through which those two factors shape the industry. As will be shown, regulations and market forces combine themselves to create complex effects: in the following subsections, the direct consequences of both factors will be analyzed.

5.3.1 The Effects of International Regulations

First and most immediate consideration to be made about IMO regulations is their international and generic nature. As obvious as this appears, there are some implications worth to be pinpointed: firstly, they are enforced all over the world, this also including international waters, and they must be respected by any commercial ship.

The main effect of such regulations, generally speaking, is to increase costs faced by companies: complying with MARPOL requirements, to a carrier, means investing capitals in improvement of vessels' environmental impact, via maintenance works, installation of new anti-pollution equipment (some of which will be discussed in Chapter 6), or lay up of older ships and consequent purchase of new less polluting ones. Besides this, changes in a carrier's operating policies may be required, which also come at the cost of developing, introducing and implementing new internal rules, which is likely to cause, in the short term, organizational problems due to the change of routine.

However, as noted above, each liner company will be required to comply with the same rules. While there is room for developing original ways to do that, and some companies may act differently from others, as noted in Chapter 3 shipping is a very commoditized industry: companies are providing basically the same services often on the same routes and at a very similar price. In such a scenario, it is quite safe to predict that the most likely outcome of the introduction of stricter regulations is companies undertaking similar measures to reach MARPOL compliance at the lowest possible cost. This does not mean that the competitive situation of the industry would be left unchanged. The same operational improvements required on a fleet may represent just temporary lower profits for a leading company, but could as well be a major threat for the economic survival of a smaller one. Given this, it is likely to assume that the main effects of the periodical tightening of MARPOL pollution limits will result, if separately considered, in an even higher degree of industry concentration as smaller companies are brought out of the market, or forced to merge or be acquired by larger ones to survive.

5.3.2 The Effects of Market Forces

Market forces, of course, affect all the companies in a certain industry as regulations do. However, there are many differences in the way this happens: firstly, market dynamics as customer preferences and their modifications, can be – and often are – challenging to understand, while, of course, regulations explicitly state what standards and/or limits have to be respected. Moreover, while the normal process of introducing and enforcing a new regulation takes a significant amount of time, market equilibrium can experience sudden variations which consequences are much more difficult to forecast. For these reason, whenever a market variable changes the competitive environment of an industry, there is much larger room for personal and professional ability of managers to respond in the proper manner.

Another significant difference, coming to the specific context of sustainability networks, is that those organization are joined by companies on a voluntary basis: despite, as reported above, sustainability networks in liner shipping industry include the vast majority of largest carriers, it is still possible that companies may decide not to take part and exploit the short term cost advantages stemming by not being forced to introduce tighter standards. This, of course, is likely to be a poor strategic move, but it may still be a feasible strategy for small companies ore ones with established long term relations with their core customers.

Sustainability networks, furthermore, may be even more effective than entities enforcing regulations: as stated in BSR document (2010), the whole concept of private governance networks is based on hyper-transparency. Thus, should a member refuse to demonstrate its environmental results, to avoid publishing negative data, all stakeholders would be instantaneously aware of that, and possibly set up some form of retaliation. This is obviously just impossible in regulation enforcement context: commercial fines or any other sanction cannot be decided and applied in such short time.

Finally, the analysis would not be complete without a further consideration: are there any market forces or factors of any other type that incentivize liner companies to go the opposite way and disregard sustainability? This question is less obvious than it may appear: business environment, in any industry, is shaped by forces that determine its competitive equilibrium. Changes in those forces continuously occur and, of course, the new equilibrium is created by the combination of all the forces. If, then, there are any factors that may favor shipping companies which act against sustainability, this would to some extent counter the effects of both regulations and private governance networks. However, this doesn't seem to be the case. Basically, the only incentive to avoid clean practices is the economic factor: converting ships and operating policies to sustainable business involves large and significant investments. By using older and obsolete ships, adopting bad practices and disregarding regulations a liner company may get a notable profit. Despite this, such a strategic choice would be, at best, very shortsighted: given the increasing bargaining power of customer networks, this would likely result in self-exclusion from the market in the medium to long term, letting alone that breaking international regulations on a systematic basis would lead to heavy fines and possibly revocation of carrier's licenses or alike sanctions by local governments and authorities.

Given all this, it clearly appears that shifts in market variables are more likely than enforcement of new regulations to create unpredictable situations. This holds even truer considering the inherently instable and volatile nature of liner shipping industry competitive environment. However, as mentioned in subsection 5.2.5, market forces alone are not likely to be a determinant factor in pushing a whole industry towards sustainability, at least in the short term. It is the combination of both factors that will ultimately affect the industry: in the following chapter, the discussion will embrace the possible strategies and solutions that the industry could implement in order to deal with upcoming changes.

Chapter 6. Sustainable Shipping Policies and their Economic Effects

In the previous chapters, liner shipping industry structure and features have been presented and its market dynamics and competitive environment analyzed. The main causes of environmental impact related to shipping have been discussed, and the external factors pushing the industry towards enhancement of its sustainability have been presented in Chapter 5.

Starting from the premise that liner companies will experience, in the near future, increasing pressure to reduce their emission and environmental impact, in this chapter the discussion will focus on how will be possible for companies to achieve that without harming their economic performance. Furthermore, the main research questions will be then discussed and developed: will sustainability become a potential source of competitive advantage? How could companies exploit it? In order to answer this, the chapter will be structured as follows: firstly, pollution mitigation policies will be discussed, with a specific focus on ones that could potentially bring efficiency or economic advantages as well. Subsequently, the research will investigate the existence – and, in case, the extent – of a link between green shipping practices and economic performance of carriers who employ them. Then, the strategic environment of liner shipping will be analyzed assuming higher environmental performance in the customer preferences and the adoption, by part of one or more companies, of green practices. Finally, in the conclusion all the significant findings and key points will be listed and summarized.

6.1 Pollution Mitigation Measures

In Chapter 4, the main factors affecting the environmental impact of the shipping industry have been listed and discussed. The analysis will now turn its focus on the areas of improvement related to each of these factors, i.e. on technical and operational solutions that have been introduced, or which introduction is being considered, to contain pollution.

As noted above, the aim of this thesis is not to find measures to reduce pollution, but rather to discuss if, and to what extent, they can be implemented in a profitable way for liner shipping companies. Therefore, the technical analysis of each solution hereafter discussed will be limited to the essential, while economic feasibility will receive more attention. It is important to note, however, that assessment of potential economic advantages brought by sustainable practices is a long term analysis: a certain amount of time is needed to let the positive economic side-effects of sustainable practices to cover the significant investments needed for their introduction and then create profit. This consideration backs the choice to adopt a wider corporate strategy-oriented view while assessing economic effects of sustainable practices, rather than a more formal and narrow scoped cost-benefits analysis. Many policies and technical operations, in fact, may lead to sudden profits but cause a larger loss in the long term: the easiest example may be laying up older and obsolete vessels without investing in new cleaner ones. This would instantaneously lower average emission of the carrier and, due to the reduction of the fleet, operating cost as well, but of course cannot represent a feasible long-term strategy. The analysis in this chapter, on the other side, will be as long term oriented as possible, in coherence with a sound corporate strategy approach.

Finally, it is important to note how within each area of improvement solutions to environmental issues can be divided in two main categories: technological improvements and operational policies. While new technologies may have a greater positive impact (for example, more efficient engines can reduce emissions and fuel consumption, all at a time), they typically require higher capital investments, and a certain lead time before being fully applicable; on the other side, new operational policies as slow steaming, use of cleaner fuel or enforcement of energy saving practices onboard can be introduced at a lower (though, in certain cases, still relevant) cost and in almost real time. The downside is that changes in operational policies are, generally speaking, less likely to bring large cost savings. This happens for a number of reasons, most important of which is a phenomenon called organizational inertia (Grant, 2010): any company, throughout its life, develops internal policies and practices that become rooted in every process, leading to the creation of so called organizational routines. This is a powerful mechanism to improve efficiency, but at the same time, as individuals in the organization absorb those routines, becomes a major barrier to change. Thus, between the introduction of a new policy and the actual creation of the advantage it brings some time is elapsed, which is needed to let the new process become a routine, but obviously reduces the short term effectiveness of new policy.

6.1.1 Reduction of Greenhouse Gas Emissions

As discussed in Chapter 4, GHG emission is the most important way in which shipping harm the planet's environment. MARPOL regulation, as well as internal policies promoted by private governance networks, set rather tight limits with regards to emission, which will be further restricted over the next future. Not surprisingly, thus, research on this topic has received great attention. Hereafter, the most promising solutions yielded by such researches are discussed as well as their economic potential advantages.

6.1.1.1 SO_x-PM

As widely discussed above, the main and by far most important cause of SO_x and PM emission from internal combustion engines is low quality fuel: briefly, high sulfur content is responsible for creation of SO_x while impurities as particles of heavy metals (vanadium, lead and others) provoke creation of PM (Eyring et al, 2009; MARINTEK, 2000; IMO, 2009). The logic solution, then, would be switching to another cleaner fuel. This is a feasible strategy, but it also brings many different technical and economic difficulties that will be discussed in subsection 6.1.3.2. Other solutions are mainly divided in two categories: exhaust gas treatment or use of alternative clean energy sources. In the first case, engine is operated normally, but the gases it produces are treated to reduce their PM and SO_x content. This is made with the adoption of anti-pollution equipment as scrubbers, which reduce SO_x emission, and anti-particulate filters to reduce PM. For what concerns scrubbers, they allow an up to 75% reduction in SO_x, but require high amounts of energy and are quite large, which reduces vessel's payload and thus carrier's profits. On the other side, anti-particulate filters slightly affects engine's overall efficiency and require periodic maintenance and cleaning to keep their best performance level, which is a not negligible cost for ships' operators (Eyring et al, 2009; IMO,2009). Ultimately, then, exhaust gas treatment is effective in reducing noxious emission, but it causes an increase in fuel consumption (Eyring et al, 2009) and it also involves implementation costs that, despite not unbearably high, may keep some operators to adopt it unless if coupled with other efficiency improving solutions.

6.1.1.2 NO_x

NO_x emission can be considered one of the most difficult problems to overcome in the research for cleaner engines. The main reason is that NO_x creation is inherent in Diesel-cycle combustion, and even worse, it is directly related to engine's efficiency. Over the years, the constant technological progress has led to development of many solutions to improve energy efficiency of diesel engines, as turbo or supercharging, high pressure and scavenging fuel injection. The common aim of such solutions is to raise the temperature and pressure in the cylinder in the moment when fuel is ignited: in this way, the maximum possible power is extracted from fuel. Unfortunately, high pressure and temperature are also responsible for the creation of NO_x. Many technologies have been developed to reduce NO_x emission, which involve air-fuel treatment before injection, engines modification or exhaust gas filtering, but all of them bring significant drawbacks (Eyring et al, 2009; Kaageson, 1999). In detail, water injection and exhaust gas recirculation (EGR) in the cylinders to lower operating temperatures have been experimented, but lower temperature and pressure, anyway they are achieved, mean lower efficiency and higher CO_2 emission. This is not the case for hybrid diesel-electric engines, in which an electric engine is coupled to the main diesel to reduce the latter's operating load and exhaust emission[21]. However, this solution besides being quite expensive and involving significant implementation problems would not be very effective on container ships: the positive contribution of the electric engine is very useful to win large diesel's inertia at transitory regimes[22], but this is a negligible advantage for engines that operate steadily at a fixed speed for most of their operating time. Lastly, selective catalytic reduction (SCR) can be used to treat exhaust gas and reduce NO_x emission, but this involve adoption of large catalyzers in which very rare and expensive metals must be used, which may raise doubts about economic overall benefit – harmed by reduced payload and initial investments – and ecologic considerations about the complex mining works needed to extract such metals.

6.1.1.3 CO_2

CO_2 is a natural and inevitable product of any combustion (IEA, 2013). Therefore, there is no way in which it may be eliminated by exhaust gas, and there are only two way of reducing it: a proper maintenance to make the engine operate at its best and the research for engine efficiency. In both cases, the background idea is to minimize CO2 emissions given the amount of cargo carried over a distance unit. In other words, this means to improve the vessel's

[21] Hybrid engines allow emission reductions with regards to any noxious gas, not only NOx, but this technology has been included in NOx reduction paragraph as it is one of the very few equally effective to any pollutant.
[22] Transitory regimes is operating condition when engine's speed is continuously changed, as often happens in automotive engines

energy efficiency: there are many different ways in which this can be done, that will be further discussed later. The noteworthy factor is that any efficiency improving policy or technology would have a twofold effect, reducing CO_2 emission and fuel consumption as well. The positive economic consequences are straightforward: not only liner companies are incentivized to invest in CO_2 reduction by the ever increasing interest in sustainability by their customers, but they have another direct incentive in form of bunker costs saving over the medium to long term – that is, once the initial investment is recovered.

6.1.2 Technical Measures

In the following section a more technical – yet brief – overview on technical pollution mitigation measures will be given. Despite the aim of this thesis is not a technical one, in order to concretely show how companies may profit from investments in sustainability even from an operational point of view, it is important to give an understanding of what technologies are available and ready for implementation onboard ships, and what others are not yet ready to be introduced or just give too low an advantage to be economically convenient.

6.1.2.1 Improvements in Ship Engine Technology

Marine engines are, at present, the most efficient internal combustion machines available. This does not rule out possible further improvements: examples are the introduction of waste heat recovery systems, which allow recovery of energy produced by hot exhaust gas flowing out of the engine that can be used, for example, for fuel pre-heating. Although this system does not reduce pollutant emissions from main engine, it allows a significant improvement in engine's efficiency: according to data released by engine manufacturer MAN (2011), an amount of electrical power up to 11% of total power output of main engine can be recovered in this way. The potential economic advantages are clearly visible: energy recovered from exhaust gas means less load on auxiliary power generators, which in turn leads to fuel savings. As fuel for auxiliary engines is usually more refined and expensive than one used in main engines, this could result in not negligible savings.

A more radical solution could be the use of a completely different type of engine, for example gas turbines conceptually similar to turbo-prop engines used in small aircrafts[23]. The

[23] In such engines aircraft's propeller is powered by a gas turbine through a gearbox, needed to adjust propeller

main advantages of turbines are much smaller dimensions compared to diesels delivering the same power, which would allow increasing ship's deadweight for a given rated power output, significantly lower emission of NO_x and almost no PM at all. Conversely, their major drawbacks are the need of much more refined fuel than HFO, slightly lower shaft thermodynamic efficiency (around 40-42% compared to the above mentioned 50% of most recent diesels) and much higher operating speed which may virtually create technical issues, even though their widespread use in aircraft industry witness the reliability of gas turbine engines. Such drawbacks mean notable obstacles to the adoption of turbines: the lower efficiency coupled with need for refined fuel would imply higher operating costs, and in order to fill the efficiency gap, significant R&D investments may be needed (MARINTEK, 2000).

6.1.2.2 Improvements in Ship Design

In the previous subsection technical improvement of engines has been discussed. However, ship's overall energy efficiency is affected by many other factors: there are many ways in which power delivered by engine is wasted and not converted to forward thrust.

With regards to this, as briefly noted in Chapter 4, main components of the ship which impact vessel's performance are the hull, rudder and propeller. Hull's surface should be designed and maintained to be as smoothest as possible, in order to minimize viscous friction of the water which tends to counter the forward movement of the ship. Rudder design is very important as well: every time the rudder is moved to adjust ship's heading, it creates a certain amount of drag against the water and more power is wasted to keep a steady speed. This is an inevitable phenomenon, but it can be to small extent limited by introduction of new rudder design. Propellers, finally, are the last element of a vessel's drivetrain, which convert the rotating movement of crankshaft in straight forward movement of the ship. Propeller design, then, is crucial to minimize efficiency losses in this process.

According to MARINTEK studies (2000), the combined effect of retrofitting more efficient propellers and using of special paints on the hull to restore the original smoothness of the hull[24] on existing ships could grant an improvement of the vessel's performance (in terms of fuel and CO_2 savings) of about 3 to 8%; while on new ships, the use of specific hull shape

speed.

[24] During the life of the ship, the continuous exposition of the hull to air and water will inevitably result in deterioration of the hull surface

designs, combined to new materials and paints able to minimize the "scratching" effect of water, and the choice of propeller optimized for the specific speed at which the ship will operate could lead to improvements up to 30% of fuel and CO_2 emissions. Lastly, a vessel's superstructure also has its contribution to overall efficiency: despite ships sail at a far too low speed to be subject to a significant aerodynamic drag, a proper superstructure design could minimize the side-slipping effect caused by crosswinds that, in normal operations, is countered applying opposite rudder[25] and thus creating even higher drag.

6.1.3 Operating Policies

Another significant way to achieve a reduction in ship's emissions is related to operational policies: this broad definition includes all the internal procedures that every ship owner - or operator - chooses to adopt with regards to the operation of the ship by the crew. In general, such policies are designed to maximize efficiency onboard and/or to avoid dangerous situations for the crew, but changing them may have a deep impact on shipping's sustainability. Hereafter most important policies are listed and discussed that have been adopted, or which adoption is being considered.

6.1.3.1 Slow Steaming

Slow steaming is probably the favorite policy by liner companies at present. It just consists in operating the ship at a reduced speed in order to save fuel and reduce pollutant emission. This policy has been enforced after fuel costs became to rise in 2007 and it's particularly effective, as the reduction in fuel consumption is more than proportional to the reduction in speed (Woo-Moon, 2013): a 20% reduction in speed can result in up to 40% fuel consumption and 20% CO_2 emission reduction.

Adoption of slow steaming is becoming so wide spread that new ships, as the Maersk Triple E class - the largest container ships at present - are specifically designed to get the maximum advantage from slow steaming (Jørgensen, 2011). Downside of this practice is quite straightforward: reducing speed means that the delivery of goods will be slower than it used to be. This may not be an important factor as long as demand for shipping on a given route decreases due to the crisis or cyclical market patterns, but assuming a fairly stable demand,

[25] This means that the rudder is moved to turn ship's heading towards wind direction and compensate wind force.

operating ships slowly would require to use larger ships on the route to compensate the loss in terms of employed capacity over a given timeframe. Moreover, cargo owners may not be satisfied of longer delivery times: this is a factor that shipping companies have to take into consideration. The ultimate consequence, then, is the need to plan future investments in order to meet possible demand variations, which implies the risk of worsening the inherent cyclical patterns in shipping industry.

Furthermore, the above mentioned trend of designing new ships to operate slowly, could be a risky decision: as new ships have a commercial life of about 25 to 30 years, if a company has in its fleet slow ships, it will be committed to slow operations for a long time, during which, in a very volatile industry as shipping is, changing market conditions could create demand for faster ships. Slow steaming, then, seems to be an effective strategy with both regards to sustainability and economic profit, but its application over the long term needs an accurate modeling and forecasting activity to predict market variations.

6.1.3.2 Use of alternative fuels

As widely discussed above, the use of HFO as fuel in marine engines has many downsides: due to its high viscosity, it needs to be pre-heated before injection in the engine; being an unrefined product it contains high amounts of impurities, which during the combustion process release high quantities of noxious gas and finally it set some serious constraints to possible developments in engine technology as anti-particulate filter and high-pressure injection (American Bureau of Shipping, 1984).

Given all this, it’s not surprising that the use of alternative fuel is being considered by the industry. Those alternative fuels could be more refined oil-derivate products, as MDO[26], which belonging to the same class of oil products, can be easily used on present engines with little or even no modifications. With regards to this, new international regulations, tighter than existing ones, could force shipping companies to switch to a cleaner, but of course more expensive, fuel.

Another possibility is to use a completely different fuel, as LNG[27], which could still be used in

[26] Marine Diesel Oil, a more refined type of diesel fuel
[27] Liquid Natural Gas, usually refers to a mixture of methane (mainly) and other natural gases, stored at liquid state – which requires high pressures and low temperatures

marine engines with little and relatively cheap modifications. LNG is, in absolute terms, the less polluting fuel for internal combustion engines, as it generates significantly less CO_2 and NO_x and negligible quantities of SO_x and particulate (King, 1998). The main problem with LNG, then, is the storage onboard the ships: to achieve the same range, an LNG-powered ship will need fuel tanks 2,5 to 3 times bigger than a normal HFO ship (MARINTEK, 2000) and this, of course, is a major downside as bigger tanks means less room for cargo holds.

6.2 Green Shipping Practices and Economic Advantages

Having seen in detail some of the most common techniques and policies meant to reduce shipping related pollution, a discussion is needed to answer the main question: is it possible for companies to get a strategic advantage adopting sustainable practices? Few researches have been made on this topic, and none of them in a long term corporate strategy perspective. However, results of such researches agree to show a positive correlation between the establishment of green shipping practices (GSP) by a carrier and financial performance. In particular, Lirn et al (2013) divide the capability of a liner company to reduce its environmental footprint in three main areas: green ships, green suppliers and green policy. Briefly, green ships and green policy means, respectively, the introduction of pollution mitigation technologies onboard ships and the implementation of sustainable policies in their operations. Green suppliers, on the other side, means the ability of the carrier to make pressure on its suppliers – as terminal and port operators – to make them introduce sustainable policies themselves, with the aim to reduce the overall environmental impact of the whole liner shipping supply chain. The findings prove that adoption of green practices, introduction of sustainable technologies and a sustainability-based selection process of suppliers have a positive effect on environmental and financial performance, mainly due to efficiency gains achieved thanks to sustainable practices (Lirn et al, 2011; Lai et al, 2011; Pil and Rothemberg, 2003). Furthermore, the benefits of increased energy efficiency with both regards to sustainability and financial profit are shown by Krozer et al (2002), while Woo and Moon (2013) show how slow steaming can be a powerful tool to cut operating costs of a vessel, besides allowing a drastic GHG emission cut.

For what concerns CO_2 efficiency the positive relation between sustainability and financial gains, then, seems to be proved, at least for what concerns short term operating costs.

However, sound management practices advice not to overvalue short term costs savings, but rather to have a more long term oriented mindset, in order to try and find the basis for building a stable strategic advantage. This topic will be further developed in next section.

6.3 The Adoption of Green Shipping Practices: Strategic Consequences

So far, researches have shown that adoption of green shipping practices can result, and often does, in short term cost savings primarily stemming from improved operational efficiency of a vessel and, at company level, of the fleet. However, when the changing competitive scenario of liner shipping is enclosed in the analysis, it clearly appears that in such dynamic environment liner carriers cannot settle to exploit some marginal cost savings. The quest for creation of a sustainable competitive advantage is necessary, in any industry, to ensure company survival and profitability under possible future adverse circumstances. This holds even truer in an industry characterized, as seen in Chapter 3, by high volatility level. Furthermore, economic feasibility of sustainable shipping is in the interest of all stakeholders: shall carriers fail to find a long term profitable way to reduce their pollution levels this would be an incentive for other companies to disregard sustainability and just pursue economic advantage. On the other side, if a liner company is able to successfully couple profits and sustainability, with all likelihood this would generate a domino effect forcing other companies to follow to avoid being pushed out of the market. Therefore, an analysis is needed to show how sustainable shipping practices can lead to long lasting advantages. Hereafter, such strategic analysis of liner shipping industry is proposed which encloses stakeholders' pressure towards green shipping and possible competitive scenarios following the introduction, by part of one or more companies, of sustainable practices.

6.3.1 Strategic Analysis: Long Term Consequences of Sustainable Practices

In order to assess variation in shipping industry competitive environment Porter's model and Game Theory will be used. The starting point is liner shipping industry as it is at present, assuming a higher – and increasing – environmental care by part of all stakeholders and regulators, which seems, based on what seen in Chapter 5, well documented.

In such scenario, main forces shaping the new competitive environment would be bargaining power of customers, rivalry between established companies and, to a lesser extent, threat of new entrants. The other forces theorized by the model, threat of substitutes and bargaining power of suppliers seem to play a marginal role: there are no industries that can substitute liner shipping, and the introduction of a need for lower environmental impact in the model does not affect this in any ways. For what concerns suppliers, they are shipbuilders, port and terminal operators and oil companies: none of this categories is likely to play a decisive role in pushing liner companies towards more sustainable shipping, and in the case of oil companies, their economic interest would be exactly opposite.

Keeping the analysis to the first three forces, then, it is evident how bargaining power of customers is the most powerful among them. As seen in Chapter 5, the emergence of private governance and sustainability networks joined by most important cargo owners and shippers is a clear indication of mutating customer preferences. It is then safe to assume that this will have long lasting consequence on the industry, as companies will have to try and meet the increased demand for clean shipping. Under this scenario, however, it will not be sufficient, for companies, to show a reduction in their global environmental impact: the critical success factor would be being the market leader in pursuing sustainability. This means not only being the first to achieve an emission reduction, but being able to demonstrate the lowest emission level among competitors. Moving on with the analysis, rivalry among companies is likely to become, then, a catalyzer in the research and development of clean shipping practices and technologies: given a scenario in which ability to reduce environmental footprint becomes a crucial success factor, liner carriers are likely to adopt a proactive approach to the topic to avoid the risk of losing time. Lastly, whenever business environment of a given industry experiences heavy changes, there is the possibility for new companies to exploit the new opportunities and enter in the industry. This of course represents a threat to established players; however, it is questionable whether liner shipping faces this risk. In first place, threat of new entrants is more likely when traumatic changes happen, and the shift to a cleaner shipping does not seem to be a sudden and unexpected factor but rather a "work in progress" process, although somewhat accelerated by contingent elements as 2008 financial crisis. Moreover, liner shipping is characterized by a certain degree of entry barriers: most important one is the heavy investments needed for a start-up to enter the industry. For these reasons, entry of new players doesn't seem to be a dangerous threat, but it should be considered as a possibility.

As noted in Chapter 2, however, a Porter model-based strategic analysis would fail to include a potentially crucial element as cooperation among companies. In fact, cooperation seems to be well present in liner shipping industry: throughout its whole history, conferences and cartel-like agreements have been documented (Stopford, 2007; Fusillo, 2006) and the existence of liner shipping networks (Lun et al, 2009) is yet another factor showing how, in the context of a volatile and uncertain industry, companies are willing to cooperate rather than fight in order to make profits. This factor is extremely important, because, to some extent, it counters rivalry among companies as a competitive force introducing an alternative way of making business in a difficult environment. In this scenario, it is likely that very few large networks will arise among companies willing to share resources rather than many small scaled initiatives by part of small firms: as soon as leading companies will start cooperating actively on sustainability topic, smaller ones would have all to gain by joining those networks.

Assuming the above described model as a likely outcome of a scenario with higher sustainability preferences by part of customers, a company willing to create a sound competitive advantage may decide to found it on sustainability: at present, liner shipping is an extremely commoditized service, but as demand for cleaner maritime transport is introduced, room emerges for sustainability-based product differentiation. In other words, a company introducing and implementing credible measures to reduce its footprint may be able to meet a changed demand, possibly even creating the conditions, at least in the short term, for slightly higher freight rates reflecting the premium price to be paid to help the company recover the notable investments it had to undertake (Eriksson, 2004). The high investments involved, and the high organizational complexity degree inherent in both development of new cleaner technologies and introduction of green policies, represent the greatest obstacle to this strategy: cooperation among companies could be a feasible solution to this, involving the merging of capital availability, know-how and internal organizational capability of major companies. On the other side, however, the very complexity of such a strategy is one of the factors guaranteeing its long term success: once a company or, with more likelihood, a network of companies succeeds in pursuing a total sustainability strategy, any other company trying to replicate it would be in a very difficult position facing huge investments and having to rush to recover time gap. It is true that, for second comers companies, there is the concrete possibility to learn from innovators' mistakes, but this requires time and once a competitor enforces a completely new strategy other players should try to minimize innovator's lead time.

Furthermore, as previously discussed the choice of a sustainability based strategy, despite its concrete economic advantages, is tightly related to a company's CSR policies: given this, company reputation assumes a crucial role among potential sources of competitive advantage. The importance of company reputation is even higher in incomplete information situations (Weigelt and Camerer, 1988) and, despite the transparency required by customer networks, this seems to fit the situation of liner shipping where the sources of pollution – ships themselves – spend large part of their operating time at open sea where any type of control on their real emission is remarkably difficult. The first company – or network – to pursue a total sustainability strategy would thus profit from increased reputation and even if any competitor should be able to show, after a certain lead time, lower environmental impact, the leader would keep its positive reputation as an innovating company. This would have a number of positive long term side effects as higher ability to attract investors, motivated workers and, in case of high bargaining power of a large network, possibly even the ability to influence to some extent the creation of future regulations: an example could be the adoption of a brand new technology able to allow a remarkable reduction in pollutant emission, that over time may be made mandatory by international entities with new regulations. It is easy to see, then, how long term consequences of a sustainability based strategy are potentially way more interesting than immediately achievable cost savings and, despite the technical and organizational complexity, it is safe to argue that sustainability in the near future may become a feasible and attractive strategic tool.

Chapter 7. Conclusions

The research points driving analysis and discussion in this thesis were the effects of new environmental regulations and increased demand for clean shipping by customers on international liner shipping business environment. In particular, the aim was to discuss whether introduction of new sustainable shipping policies by part of liner companies could be used as a strategic tool rather than just as a necessary action to comply with new regulations.

After having described liner shipping industry as a strategic environment and having analyzed the ways in which it contributes to worldwide pollution, the discussion has highlighted the two main forces pushing shipping industry towards the research for a more sustainable way of making business. Those forces are new regulations introduced by IMO's MARPOL Annex VI, which will become tighter over next future, and a progressive change in customers' preferences, testified by the increasing diffusion and bargaining power of sustainability networks. The ways in which those two forces combine to create a more sustainability-oriented industry have been then described and discussed, highlighting how market forces – i.e. bargaining power of customers – is more likely to be the key factor pushing a company to use sustainability as a strategic tool. This is due to the very nature of international regulations: whenever a new emission limit is introduced, or a specific bad practice is banned, every liner carrier has to comply with the rule. Even considering that compliance to the same regulation may have different consequences for different companies; it is clearly hard to build a competitive advantage only following regulations. On the other side, market forces seem to have the potential to create a more complex situation within the industry. This is because companies, in this case, can freely choose what strategy to undertake as a response: for example, joining a sustainability network or renewing the fleet are choices made on a completely voluntary basis. Furthermore, a shift in market variables requires a relatively fast response from companies, while on the other side a longer time is elapsed between the introduction of regulations and their actual enforcement, in order to give companies some time to study how to comply with them. The combination, then, of increased costs caused by compliance to new regulation and of increased market complexity due to shift in market forces could result in companies being forced to undertake new strategies, or invest in sustainability, in a relatively short timeframe.

Given this, the discussion has shown how a company, adopting a proactive approach to sustainability and trying to anticipate customers' requests, may profit in a twofold way from the introduction of "green" shipping practices.

More specifically, the research for more energy efficient vessels would result in an immediate reduction in CO_2 emission and bunker costs due to the decrease in ship's fuel consumption. The second, and possibly greater, advantage stemming from a sustainability-pursuing corporate strategy would be the possibility to de-commoditize liner shipping introducing an element of product differentiation. As shown by Grant (2010), competitive advantage may be based on cost advantage or product differentiation. In the specific context of liner shipping, cost advantage, that is gaining market share by lowering prices, does not seem to be a feasible strategy: due to inherent high volatility and uncertainty, to cut the prices would be an extremely risky decision. On the other side, product differentiation seems to be a more attractive strategy: given the above mentioned shift in customer preferences, the first companies to meet the demand for cleaner shipping may be able to establish long term relationship with a core of loyal customers. However, a sustainability based strategy also presents some drawbacks: the most important problem is represented by the large investments needed to pursue such a strategy in an effective way. Firstly, and obviously, a company needs to be in a good financial situation in order to be able to afford such investments. Besides this, there is a concrete possibility of other companies choosing another cost reducing strategy, which could put companies pursuing sustainability in a difficult competitive situation, at least in the short term.

Ultimately, then, the research has shown that, under the assumption of an increased environmental awareness by part of customers and given the progressive tightening of international anti-pollution regulations, the choice of undertaking a sustainability oriented corporate strategy has the potential to result in the build-up of a competitive advantage. However, such a decision would imply some significant organizational changes and financial investments, which may prevent single companies to commit to sustainability. Therefore, a total sustainability strategy seems to be more appropriate for large, leading companies or for companies creating – and joining – a network or another form of business cooperation. In this way, members could exploit a reduction of investments to be undertaken due to network and scale economies, Furthermore, the creation and consolidation of networks and alliances would contribute to lower uncertainty level in the industry, thus creating the basis for a stabilization of freight rates and, consequently, companies' profits. Finally, the discussion has shown how the large investments implied by commitment to a sustainability oriented strategy, both from a financial and organizational point of view, while represent a serious obstacle to the adoption of such strategy, can be considered a sort of barrier to imitation by part of competitors. While competitors would have the real possibility to learn by innovators' mistakes, the long timeframe required to overcome organizational inertia and fully implement the new corporate strategy, would guarantee a certain lead time to the leaders.

7.1 Further Research

This thesis has analyzed and discussed the topic of strategic advantages of sustainable shipping from a theoretical only point of view. This choice is backed by the obvious lack of concrete evidence of liner companies achieving better results than competitors exploiting sustainability based strategy. Despite this, a quantitative research analyzing profits and revenues of liner companies over time and their relation to the introduction of regulations would add valuable insights to the topic. This would allow assessing if, and in case the extent to which, there is a correlation between the tightening of environmental regulations and the overall profitability of liner shipping industry. Furthermore, the same kind of research could be made with regards to shifts in customer preferences or other competitive forces pushing companies to embrace the cause of sustainability: the joint results of these analyses would add significant quantitative background to the discussion about strategic implications of sustainability in liner shipping.

References

Cover Photo Source: http://gcaptain.com/efficient-operations-game-maersk/ [Accessed Septemper 2014]

AMERICAN BUREAU OF SHIPPING (1984), *Notes on Heavy Fuel Oil*

ATKearney, *Balancing the Imbalances in Container Shipping,* available at http://www.atkearney.com/it/paper/-/asset_publisher/dVxv4Hz2h8bS/content/balancing-the-imbalances-in-container-shipping/10192 [accessed May 2014]

BALLAND, O., GIRARD, C., ERIKSTAD, S.O. and FAGERHOLT, K., 2014. Optimized selection of vessel air emission controls—moving beyond cost-efficiency. *Maritime Policy & Management The flagship journal of international shipping and port research, DOI: 10.1080/03088839.2013.872311* pp. 1-15.

BERNHOFEN, D.M., EL SAHLI, Z. and KNELLER, R., 2013. Estimating the effects of the container revolution on world trade. *Working Paper Series* 4136. CESifo, Center for Economic Studies and Ifo Institute.

BOSTON CONSULTING GROUP, *Restoring Profitability to Container Shipping 2012-last update*. Available at: https://www.bcgperspectives.com/content/articles/transportation_travel_tourism_charting_new_course_restoring_profitability_container_shipping/ [Accessed June, 2014]

BRANDENBURGER, A.M. and NALEBUFF, B.J., 1995. The Right Game: Use Game Theory to Shape Strategy. *Harvard business review,* **73**(4), pp. 57-71.

BSR, Clean Cargo Working Group Overview, available at http://www.bsr.org/consulting/working-groups/BSR_Clean_Cargo_Working_Group.pdf, [accessed June 2014]

CAMERER, C., 2003, *Behavioral Game Theory: Experiments in Strategic Interaction*, Russell Sage Foundation, pp. 1-25

CARIOU, P. and CHEAITOU, A., 2012. The effectiveness of a European speed limit versus an international bunker-levy to reduce CO2 emissions from container shipping. *Transportation Research Part D: Transport and Environment,* **17**(2), pp. 116-123.

CCWG website http://www.bsr.org/en/our-work/working-groups/clean-cargo [Accessed July 2014]

CCWG, Clean Cargo Working Group Progress Report, 2013, available at http://www.bsr.org/en/our-insights/report-view/collaborative-progress-clean-cargo-working-group-progress-report-2013 [accessed July 2014]

CHANG, Y., ROH, Y. and PARK, H., 2014. Assessing noxious gases of vessel operations in a potential Emission Control Area. *Transportation Research Part D: Transport and Environment,* **27**(0), pp. 12-18.

CLEAN SHIPPING INDEX, Clean Shipping Brochure, available at http://www.cleanshippingindex.com/downloads/ [accessed May 2014]

CLEAN SHIPPING INDEX, Environmental Opportunities for Shipping - The Clean Shipping Index. Available: http://www.s1137723-4240.crystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf [Accessed February 22, 2014] .

Congestion Strains European Ports. 2010. *Journal of Commerce (15307557),* **11**(30), pg. 8.

CONNOR, J.M., 2008 *Global Price Fixing,* Springer.

CORBETT, J.J., FISCHBECK, P.S., 1997. Emissions from ships. Science 278 (5339), 823–824.

CORBETT, J.J., FISCHBECK, P.S., PANDIS, S.N., 1999. Global nitrogen and sulphur inventories for oceangoing ships. Journal of Geophysical Research 104 (3), 3457–3470.

CSN, Clean Shipping Index Guidance Document, Version 4.0 January 6th, 2013, [Homepage of Clean Shipping Index]. Available: http://www.cleanshippingindex.com/wp-content/uploads/2013/06/Guidance-doc-CLEAN-SHIPPING-INDEX-4.0-2013-01-06.pdf [Accessed February, 2014]

CULLINANE, S., EDWARDS, J., 2010. Assessing the environmental impacts of freight transport. In: McLinnon, A., Cullinane, S., Browne, M., Whiteing, A. *Green Logistics: Improving the Environmental Sustainability of Logistics.* Kogan Page, 2010.

DINWOODIE, J., TUCK, S., KNOWLES, H., BENHIN, J. and SANSOM, M., 2012. Sustainable Development of Maritime Operations in Ports. *Business Strategy and the Environment,* **21**(2), pp. 111-126.

DNV, MARPOL 73/78 Annex VI Regulations for the Prevention of Air Pollution from Ships2009-last update [Homepage of DNV] Available at: http://www.dnv.com/binaries/marpol%20brochure_tcm4- 383718.pdf [Accessed February 2014] .

DOUDNIKOFF, M. and LACOSTE, R., 2014. Effect of a speed reduction of containerships in response to higher energy costs in Sulphur Emission Control Areas. *Transportation Research Part D: Transport and Environment,* **27**(0), pp. 19-29.

DUCRUET, C. and NOTTEBOOM, T., 2012. Developing Liner Service Networks in Container Shipping, in Song, D.W. and Panayides, P. *Maritime Logistics: a Complete Guide to Effective Shipping and Port Management.* 1st edn. London: Kogan Page, pp. 77-100.

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN, 1998; *Concentration in Liner Shipping: its Causes and Impacts for Ports and Shipping Services in Developing Regions*. FAL Bulletin # 147. ECLAC.

ERIKSSON, C., 2004. Can green consumerism replace environmental regulation?—a differentiated-products example. *Resource and Energy Economics,* **26**(3), pp. 281-293.

EYRING, V., ISAKSEN, I.S.A., BERNTSEN, T., COLLINS, W.J., CORBETT, J.J., ENDRESEN, O., GRAINGER, R.G., MOLDANOVA, J., SCHLAGER, H. and STEVENSON, D.S., 2009. Transport impacts on atmosphere and climate: Shipping. *Atmospheric Environment,* **44**(37), pp. 4735-

4771.

FARRAG-THIBAULT, A. and PRUZAN-JORGENSEN, P.M., 2010. *Sustainability Trends in the Container Shipping Industry.* BSR Reports.

FAYLE, E.C., 1933. *A Short History of the World's Shipping Industry.* London: George Allen & Unwin.

FRANSEN, L.W. and KOLK, A., 2007. Global Rule-Setting for Business: A Critical Analysis of Multi-Stakeholder Standards. *Organization,* **14**(5), pp. 667-684.

FREDA, W. and OTREMBA, Z., 2012. *Maritime Transport – An Environmental Problem with Ballast Water: Technical Preventive Measures*, Journal of KONES Powertrain and Transport, Vol. 19, No. 2 2012

FUSILLO, M., 2006. Some notes on structure and stability in liner shipping. *Maritime Policy & Management,* **33**(5), pp. 463-475.

GRANT, R.M., 2010. *Contemporary Strategy Analysis.* 7th edition edn. London: Wiley.

HENDRIKSE, G., 2003. *Economics and Management of Organizations: Coordination, Motivation and Strategy.* London: McGraw-Hill.

IEA, 2013. *CO_2 Emissions from Fuel Combustion – Higlights*, available at: http://www.iea.org/publications/freepublications/publication/co2emissionsfromfuelcombustionhighlights2013.pdf [Accessed June 2013]

IMO, 1998. *Marpol – 25 years*, in "Focus on IMO", available at: http://www.imo.org/KnowledgeCentre/ReferencesAndArchives/FocusOnIMO(Archives)/Documents/Focus%20on%20IMO%20-%20MARPOL%20-%2025%20years%20(October%201998).pdf, [Accessed June 2014]

IMO, 2008. Updated Study on Greenhouse Gas Emissions from Ships, International Maritime Organization (IMO).

IMO, 2009. Second IMO GHG Study2009-last update. Available at: http://www.imo.org/blast/blastDataHelper.asp?data_id=27795&filename=GHGStudyFINAL.pdf [Accessed February 2014]

IMO, 2014a. *IMO and the Environment*. Available at: http://www.imo.org/OurWork/Environment/Documents/IMO%20and%20the%20Environment%202011.pdf [Accessed February 2014].

IMO, 2014b. International Convention for the Prevention of Pollution from Ships (MARPOL)1978-last update [Homepage of International Maritime Organization]. Available at: http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx [Accessed February 2014]

JØRGENSEN, R., 2011. *Slow Steaming, the Whole Story,* Maersk publication, available at http://www.maersk.com/Innovation/WorkingWithInnovation/Documents/Slow%20Steaming%20-%20the%20full%20story.pdf [accessed May 2014]

KÅGESON, P., 1999. *Economic instruments for reducing emissions from sea transport.* Air Pollution and Climate Series no. 11 / T&E report 99/7. Solna, Sweden: The Swedish NGO Secretariat on Acid Rain.

KROZER, J., MASS, K. and KOTHUIS, B., 2003. Demonstration of environmentally sound and cost-effective shipping. *Journal of Cleaner Production,* **11**(7), pp. 767-777.

LAI, K., LUN, V.Y.H., WONG, C.W.Y. and CHENG, T.C.E., 2011. Green shipping practices in the shipping industry: Conceptualization, adoption, and implications. *Resources, Conservation and Recycling,* **55**(6), pp. 631-638.

LIRN, T., LIN, H. and SHANG, K., 2013. Green shipping management capability and firm performance in the container shipping industry. *Maritime Policy & Management, The flagship journal of international shipping and port research, DOI: 10.1080/03088839.2013.819132*pp. 1-17.

LUN, Y.H.V, LAI, K. and CHENG, T.C.E., 2009. A Descriptive Framework for the Development and Operation of Liner Shipping Networks. *Transport Reviews,* **29**(4), pp. 439-457.

LUN, Y.H.V., LAI, K., WONG, C.W.Y. and CHENG, T.C.E., 2013. Green shipping practices and firm performance. *Maritime Policy & Management, The flagship journal of international shipping and port research, DOI:10.1080/03088839.2013.819133* pp. 1-15.

LUO, M., FAN, L. and WILSON, W.W., 2012. Firm Growth and Market Concentration in Liner Shipping. *Journal of Transport Economics and Policy,* **48**(1), pp. 171-187.

MAERSK LINE, *Designing it,* Available: http://worldslargestship.com/designing-it-part-2/, [Accessed July 2014]

MAN DIESEL-TURBO, 2011. Propulsion Trends in Container Vessels-last update [Homepage of MAN Diesel Turbo]. Available at: http://www.mandieselturbo.com/files/news/filesof4672/5510-0040-01ppr_low.pdf [Accessed February 2014]

MARINTEK, 2000. *Study of Greenhouse Gas Emissions from Ships. Final Report to the International Maritime Organization*, performed by Norwegain Marine Technology Research Institute (MARINTEK) for the International Maritime Organization

MAYNARD SMITH, J., 1982. *Evolution and the theory of games*, Cambridge University Press

MCCOLLUM, D; GOULD, G. and GREENE, D., 2009. *Greenhouse Gas Emissions from Aviation and Marine Transportation: Mitigation Potential and Policies*, Prepared for Pew Center on Climate Change

NASH, J., 1950. Equilibrium points in n-person games, *Proceedings of the National Academy of Sciences of the United States of America* **36** (1): 48–49,

PIL, F.K. and ROTHEMBERG, S., 2003. Environmental Performance as a Driver of Superior Quality. *Production and Operations Management,* **Vol 12**(n°3), pp. 404-414.

PONTE, S. and CHEYNS, E., 2013. Voluntary standards, expert knowledge and the governance of sustainability networks. *Global Networks,* **13**(4), pp. 459-477.

PORTER, M.E., 2008. The Five Competitive Forces that Shape Strategy. *Harvard business review,* **86**(1), pp. 78-93.

SHAPLEY, L.S., 1953. Stochastic Games, *Proceedings of National Academy of Science* Vol. 39, pp. 1095–1100

SHUGHART, W.F., 2008. *Industrial Concentration,* 2nd edition, available at http://www.econlib.org/library/Enc/IndustrialConcentration.html# [Accessed August 2013]

STOPFORD, M., 2009. *Maritime Economics.* 3rd edition. London: Routledge.

SULLIVAN, A. and SHREFFIN, S.M., 2003. *Economics: Principles in Action Upper Saddle River,* New Jersey 07458: Pearson Prentice Hall

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, 2013. *Review of Maritime Transport.* 2013. UNCTAD.

VON NEUMANN, J., MORGENSTERN, O., 1944. *Theory of games and economic behavior*, Princeton University Press

WEIGELT, K. and CAMERER, C., 1988. Reputation and Corporate Strategy: a Review of Recent Theory and Applications. *Strategic Management Journal,* **9**(5), pp. 443-454.

WOO, J. and MOON, D.S., 2013. The effects of slow steaming on the environmental performance in liner shipping. *Maritime Policy & Management, The flagship journal of international shipping and port research, DOI: 10.1080/03088839.2013.819131* , pp. 1-16.

ZERBY, J.A. and CONLON, R.M., 1978. An Analysis of Capacity Utilization in Liner Shipping. *Journal of transport economics and policy,* **12**(1), pp. 27-46.