

Sulphur emission regulation: changing the market for bunker fuels

**Exploring the future under new IMO-regulations
and their impact on Vopak's bunker fuel business**

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Preface

This thesis marks the end of my graduation for the study Systems Engineering, Policy Analysis and Management (SEPAM) at the Delft University of Technology. For my graduation project I did an internship at Vopak EMEA B.V.

The choice for a theme in the oil industry was a clear one for me. I have been involved in the oil industry through a series of internships and I have seen different industry segments, but the bunker market was completely new for me. When Vopak came to me with this project, I immediately accepted and found that the question they had laid down for was an excellent combination of what I had learned during my study and my personal interests. I quickly started on my research on the future of the bunker market.

The thesis project has shown to be very interesting, but also very challenging, because it was not just a sub-market or step in the value chain that was at the centre of focus, but the entire global market. But, as I always want to know the “whole picture”, this only motivated me. Especially the different perspectives I gained from performing interviews were helpful to my understanding of the subject. Articles, books and reports can only tell so much, as it is the experts' years of experience that can help to make sense out of the complexities within the bunker market. I would like to thank all the respondents who have given their time to lead me one step further towards completion of this project.

I really appreciate the opportunity Vopak has given me to graduate in their midst. I would like to show my gratitude to Boudewijn Siemons of Vopak Terminal Rotterdam, who has helped me find a suitable project within the Vopak organisation. Furthermore I would like to thank, in particular, my two supervisors, Pascal Cialdella and Juliana Manolova for their enthusiasm, their willingness to help and their support. The rest of the team at Vopak has been very interested and supportive in my research, which I have appreciated. The other members of my graduation committee also deserve a word of gratitude. Aad Correljé has been very helpful in creating a sense of how theories can be combined and applied. He was always available for questions, whether at the university or at home. I would also like to thank Rob Stikkelman for his pragmatic view on my deliverables and timely pulling me back from the sometimes complex spaghetti of theories. I would like to thank John Groenewegen for having taken part in the process towards my graduation and taking the time to help me with the theoretical foundation of my research. Finally a word of appreciation is in place for Rolf Künneke for taking place in my graduation committee on such short notice and making it possible for me to graduate according to the planning we had set out.

The process of writing a thesis has been challenging, but above all a great learning experience. Not only do you learn a lot about a certain subject or about how to do research, but you also learn a lot about yourself. And these lessons have been and will be valuable in the future.

I hope you enjoy reading the outcomes of my research.

Maurits Jager

Delft, 12 October, 2012

Executive summary

Research background

Worldwide increasing attention is being given to pollution associated with sulphur emissions. Sulphur emissions leads to acid rain and does extensive harm to the environment, causing many premature deaths around the globe. Following initiatives for reducing sulphur emissions from land-based sources the international maritime industry has adopted rules for sulphur emissions. The International Maritime Organisation (IMO) has laid down the first globally adopted sulphur emission regulation. This regulation is part of the marine pollution protocol MARPOL Annex VI. Maximum sulphur limits for marine fuels, also called “bunker fuels”, have been fixed for vessels travelling inside an outside so called Emission Control Areas (ECA’s). The first designated ECA’s are the Baltic Sea, the North Sea and English Channel and the North-American Coastline. These areas oblige ships to sail on fuel with a maximum of 1.0% sulphur, while outside the limit is set at 3.5%, which is far less strict. Currently, the global average sulphur content is 2.6%, which means that the regulation only has major effect within ECA’s. In the future, though limits will tighten towards 0.1% in ECA’s in 2015 and 0.5% globally, either in 2020 or 2025, susceptible to a review of the availability of compliance marine fuels. Fuel oil is the heavier product (or residue) of the refining process and contains much more sulphur than marine distillates, which may have only 0.1% sulphur content. It is clear that these regulations can have a significant impact on the global marine transport industry, as fuel oil may not be allowed on board ships in the future. Refineries are not yet prepared to produce large quantities of lighter marine oil; this industry will also see considerable changes. In between these demand and supply industry is where Vopak, as an independent storage company to bulk liquids, is active. Vopak stored large quantities of this bunker fuel. So if large shifts within the bunker market are to take place, this may also influence Vopak. It is thus essential for Vopak to know what the introduction of the sulphur limits for bunker fuels means for its fuel oil business. This has led to the following research goal:

“This study aims to provide understanding of the dynamics in the bunker market, of how this market may react to the IMO sulphur regulations and of the possible impact on fuel oil storage companies.”

Currently, there are many industry reports and impact analyses of the bunker market, although they mostly only focus on either the supply side or the demand side. The majority of these studies also takes on a quantitative perspective. This entails that they provide predictions of how the market might react. In this study a qualitative perspective is taken to put these number and predictions into perspective. The Old and New Institutional Economics can be useful to complement these studies to provide a broader view of the matter. It proposes a more holistic view by integrating the environment of a market with its inner dynamics. This perspective has thus been chosen as the abovementioned socio-economic perspective. Integrating this in the research goal leads to the research question which play a central role in this study:

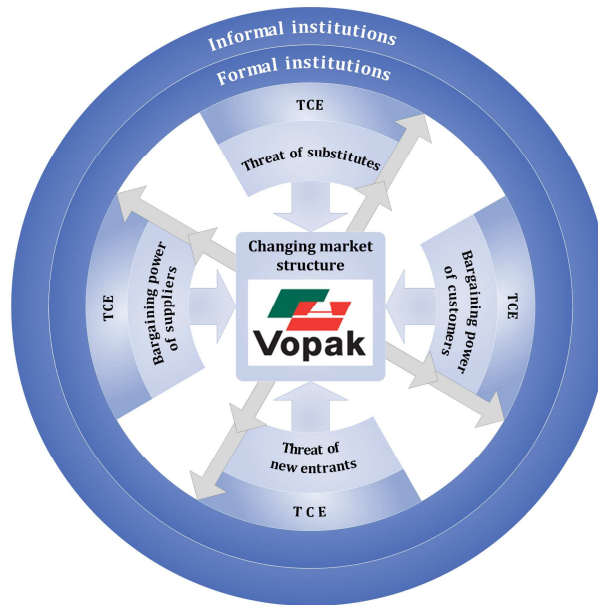
“How can the global bunker market develop in the coming decade under new global sulphur emission restrictions and how can Vopak’s global bunker fuel storage business be affected, when taking a socio-economic perspective?”

Research approach

This research combines the use of Porter’s “Five Forces” analysis with the New Institutional Economics (NIE) and the associated Transaction Economics (TCE). The NIE perspective is use to integrate the institutional environment and the market analysis into one structure. Porter’s five forces are used to give an extensive market analyses to create a broad understanding of the functioning of the bunker market, in the presence of this institutional environment. The formal and informal institutions shaping the environment argue the international and diverse character of the bunker market, with at its centre the unified sulphur regulation laid down in MARPOL Annex IV. The five-forces model is also used to analyse

the possible future of the bunker market, but does not provide explicit motivators of change. Concepts of the TCE are used to do just that. By taking the concepts of uncertainty, asset specificity and frequency, the drivers for investments in the bunker market, following the implementation of the sulphur legislation, are identified. The degree to which each of these three transaction dimensions influences investments decisions is key. Combining these theories into one framework leads to the following illustration:

The combined framework



For this study information has been gathered by performing a thorough desk research in combination with interviews. The theoretical part is covered by the large availability of sources touching upon the subject of NIE, Porter and TCE. Tacit knowledge within the industry is also of much value, as well as some more strategic information that is not found in literature are two reason to add interviews to the methods used.

Results

The bunker (fuel oil) market comprises a large value chain, including the refining sector, the shipping sector as well as many activities in the mid-stream sector. The latter includes bunker trade, supply, blending, storage and brokerage activities.

Global imbalances of fuel oil have led to large trade flows. The largest producer of fuel oil is Russia, while there are large deficits in Europe and Asia. This makes life very difficult for refiners in the Atlantic Basin, which find it hard to compete. Shut downs in this region has increased dependency on foreign fuel oil. Large trade flows have led to a healthy business for storage companies. The bunker market is thus directly impacted by changes in the refining sector.

The bunker market is characterised by overcapacities and low margins on both the supply side (refineries) as the demand side (shipping companies). The current state of the economy has put pressures on the sector; therefore, the bunker market is very cyclical as it is immediately affected by changes in the general state of the economy. Also bunker traders and suppliers – usually a profitable business in the mid-stream section of the value chain – see declining revenues, which has led to many mergers and acquisitions by the large independents.

Spot markets characterise the competitiveness in the bunker market. This creates low barriers of entry, but the current market situation is not very attractive for possible newcomers. Spot markets enhance the

bargaining space for customers, who aim to force down prices, require high fuel quality as well as additional services, mostly focusing on bunker price hedging. The latter is increasingly popular as bunker prices have skyrocketed and have shown much volatility, while freight rates are very low. Also suppliers see margins decline and increasing amounts of contaminants are being found in bunker fuel due to improper blending practices, which has led to a growing number of bunker disputes. The high level of competition is key for the structure of the bunker market.

Sulphur legislation and the future

Ships sailing in ECA's now have to use low sulphur fuel oil (LSFO), whereas high sulphur fuel oil (HSFO) is still used outside ECA's. From January 2015, the compliance methods for the 0.1% ECA limit are marine gasoil (MGO), scrubbers and liquefied natural gas (LNG) fuel systems. All three options involve high costs. MGO is more expensive than fuel oil and scrubbers and LNG systems are very capital intensive, but might be accompanied by lower fuel costs.

In 2018 the IMO has planned to review the availability of <0.5% sulphur content fuel before deciding whether the global sulphur limit of 0.5% will enter into force in 2020 or in 2025. This will impact the entire global fleet (as far as flag state is represented in the IMO), as fuel oil is not likely to be blended down to this percentage. Other measures have to be taken. But, because the decision date is 2018, there is currently much uncertainty about the 0.5% cap. This entails that shipping companies will wait until this decision to take any necessary steps, while the refining market is waiting on demand to change, before investing heavily in MGO conversion. And significant demand change is not likely without collective action. So, availability will probably be low on the review date because of the associated uncertainty. Besides this cap, there is uncertainty about the enforcement of the rules, which is essential for ship operators to comply to the limits. Hence, uncertainty can be considered a major determinant for investments.

Asset specificity is a second important determinant for investment. Time spent in ECA's is essential for a vessel when deciding the best compliance method. The longer the voyage within ECA's, the less flexible the solution has to be and the more capital investments are justified. The physical specificity of compliance methods is thus linked with site specificity of the voyage routes. If refiners want to meet demand for lower sulphur fuels in the future, they have to invest in highly specific assets, while these lower sulphur fuels are the least specific compliance method for ship operators. This mutual dependency, together with the deviating asset specificities increases uncertainties for refiners to invest (and for shipping companies to use low sulphur fuels).

Implications for Vopak

Vopak, as well as its competitors will not see major changes to their business just yet. It were to be the case if bunker volumes or bunker locations were going to shift. But the large scale shift expected in the bunker market is not likely to take place before 2025. Short term implications for Vopak mostly concern the rising demand for LSFO blending and associated storage capacity. This requires separate handling from HSFO, so perhaps expansion of capacity is needed.

Following the investment drivers, no large shift in fuel oil consumption for the bunker market is expected until the global cap of 0.5% sulphur hits the bunker market. However, if the more stringent regulation is introduced, the entire global fleet has to find ways to comply (assuming enforcement is in place to control the sulphur limits). Assuming that MGO will play the leading role, Vopak could use the same tanks, designed for HSFO, to store MGO, as these tanks have a low asset specificity. However, the heating systems attached to these tanks will become redundant.

Vopak can either proactively try to influence the formal institutions, consciously monitor developments, seize business opportunities or simply wait and see. Vopak can try to influence the decision for the global 0.5% cap in 2018, by setting up a lobby with its competitors to raise the voice of the oil storage business

for the fuel availability review. But, keeping in mind the magnitude of parties involved in taking this decision, the influence of storage companies may only be marginal, especially as they are not directly involved parties. Monitoring is seen as a very important action for Vopak. Using formal and informal channels of information, the company can make sure it is up to date and can react timely to external developments. A good example of seizing business opportunities is already given, by starting a feasibility study for an LNG bunkering terminal in Gothenburg, Sweden. Playing a role in the development of an LNG infrastructure and maybe even in the setting of safety and fuel handling procedure standards may also be an opportunity to raise demand and build the company image.

Practical and scientific relevance

The goal of this research was to provide insight in the functioning of the bunker market in order to evaluate the possible developments for the future. For Vopak this research will have practical relevance. On the other hand, the research has some scientific relevance. The results for Vopak comprise an extensive analysis of the functioning of the bunker market, but more important, drivers for future change. These drivers are useful as input for scenarios. If you vary these drivers between scenarios future states can be analysed by using Porter. The qualitative nature of the results can be of great value next to the more quantitative focused studies provided by e.g. consulting firms. When combining the two, more robust scenarios can be built or even decisions can be made. Now that Vopak knows the background of the legislation and the possible investment it invokes, it can better communicate with clients on this matter as well as think along with them.

The scientific value of this research lies in the combination of OIE, NIE and Porter's five forces. These theories are not often combined in the way they are here. NIE is often used to analyse the institutional arrangements in detail, assuming the conditions are set (i.e. the institutional environment is fixed), while it is here used to structure the institutional environment, which is dynamic as proposed by the OIE. These theories do not provide information on the competitive nature of the market in focus, which is why Porter is used. Porter's five forces, however, was originally constructed to help a specific firm gain a competitive advantage, but is often used purely to analyse markets.

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1. Introduction

On the background of increasing worldwide restrictions on air pollution from land based sources during the last decades, little attention had been given to maritime sources of pollution, notably the international shipping sector. However, the significant growth of the maritime sector and better insights in its contribution to overall emissions have led to an increase in attention in the second half of the past decade (EC, 2011).

A major point of interest became the emission of sulphur-dioxide (SO₂), which is inherent to the combustion of the sulphur rich fuel mostly used for maritime transport, i.e. fuel oil. SO₂-emissions, amongst other pollutants from maritime shipping, are regulated by MARPOL Annex VI, which was adopted by the International Maritime Organisation (IMO) in 1997, but only entered into force in 2005. This regulation depicted so called Emission Control Area's (ECA's), restricting the sulphur content of marine fuels, based on their geographical usage. Several ECA's have already been assigned, but before 2025 more regulation is expected, even outside the ECA's, which makes it a worldwide issue. A global sulphur cap is already in place, although lenient.

These emission restrictions may have significant effects on the market for fuel oil – the most common 'bunker fuel' used to fuel ships, possibly affecting multiple segments in the fuel oil supply chain. It might also have an impact on the tank storage facilities of Vopak, situated in the midstream segment of the supply chain, standing in between producers and consumers.

While many reports on the fuel oil market focus on predicting trends by using complex economic, mathematic or computational models, little research is done focusing on the actual understanding – and therewith structuring – of the market dynamics: what drives the fuel oil market? Because the fuel oil market is a complex system with many interdependent socio-economic, institutional and technical factors influencing its movements, including a multi-perspective understanding in research seems a more sensible goal than only focusing on predictions. For this reason, this study will take a neo-institutional perspective in combination with Porter's "Five Forces" model for analysing the market, in order to create a broad understanding of the current and future market developments. This perspective helps at structuring the more qualitative aspects of market analyses, aspects addressed mostly implicitly in more prediction-orientated studies. This approach will also identify possible drivers for investment, reacting to the IMO sulphur regulation. This research thus aims at being a valuable addition to the current predictive studies by using this descriptive approach and provide a structured qualitative basis on which strategy can be formed. It will do so by answering the following research question:

"How can the global bunker market develop in the coming decade under new global sulphur emission restrictions and how can Vopak's global bunker fuel storage business be affected, when taking a socio-economic perspective?"

The research is performed by means of extensive desk research and qualitative surveys. In order to provide Vopak with these different insights, a combined framework of Michael Porter's five forces model and Williamson's four-layer model is used to structure the bunker market and to provide understanding of its functioning. This descriptive representation is complemented by an analysis of future drivers of investment in the bunker market, using three concepts of Transaction Cost Economics, being uncertainty, asset specificity and frequency. By identifying these drivers for investment, the predictions provided by many existing studies can be placed in their context.

This report commences with a chapter which further defines the research. Subsequently, Chapter 3 will provide background knowledge for the use of the theoretical framework. The analysis of the institutional environment of the bunker market is given in Chapter 4. Chapters 5 and 6 use Porter's five forces model to

describe the current situation and the possible future developments in the changing legislative environment. These analyses are used as input for Chapter 7, which provides argumentation and reason for investments as a reaction to the stricter sulphur limits for bunker fuels. The output of this chapter is a collection of drivers for investment. Chapters 4 through 7 are linked in the eighth chapter, which also summarises the possible implications of the outcomes for Vopak's business. Chapter 9 contains the main conclusions alongside a reflection on this research.

2. Defining the Research

Following the introduction to the subject of this report, provided in the previous chapter, this section will further describe the basis on which this research rests. The first paragraph will give a short background sketch concerning the regulations on marine sulphur emissions. The second gives an short introduction to what bunkers exactly are, followed by a paragraph describing Vopak as a company active in the bunker market. These will lead to the formulation of the problem. Subsequently, the boundaries for this study, including the theoretical approach, are set. In the last three paragraphs the research objectives and questions are formulated together with a justification of applied research methods.

2.1. Changing environment

In 1997, following worldwide restrictions on harmful – mostly land-based – air emissions, the International Maritime Organisation (IMO)¹ decided that the existing MARPOL 73/78 convention, which deals with the prevention of marine pollution, focus also on the air emissions. The IMO's responsible department, the Marine Environment Protection Committee (MEPC), therefore worked on an annex to the convention to deal with this issue. MARPOL Annex VI (hereinafter referred to as Annex VI), which came into force in 2005, *“limits the main air pollutants contained in ships exhaust gas, prohibits deliberate emissions of ozone depleting substances and also regulates shipboard incineration and the emissions of volatile organic compounds from tankers”* (IMO, 2008). Sulphur-dioxide (SO₂) is one of these pollutants.

The most important bunker fuel used by ships all over the world, is fuel oil. Many variants of fuel oil exist, fuelling a wide variety of applications. Which types of fuel oil are produced and which qualities are suitable as marine fuel will be further explained in the following paragraph. Because fuel oil is one of the residues of the refining process (it is often referred to as 'residual fuel oil'), most fuel oil contains considerable amounts of sulphur compared to the other refining output products, depending on the crude source (ABS, 2001). High sulphur marine fuel oil usually contains around 3.5-5 % sulphur². When the fuel is combusted aboard ships, this sulphur turns into SO₂ and is emitted to the environment. Estimations on the contribution of marine sulphur emissions to global sulphur emissions range from 4% (VDR, 2008) to 9% (Vidal, 2009) and are increasing. For this reason the Annex VI has included emission area's (ECA's), geographically limiting the emission of – amongst others, but notably - sulphur. More details about the IMO regulations are described in section 4. At present, the North Sea, the Baltic Sea and the English Channel are ECA's for sulphur, under a regulation of a maximum fuel sulphur content of 1%. But from August 2012 also North America will adopt this legislation. In these ECA's, polluters are to further limit the sulphur content of marine fuel oil down to 0.1% sulphur by January 2015 (IMO, 2008). Global sulphur limits are currently in place at a maximum of 4.5% in 2010, but has been further tightened to 3.5% in January 2012. Currently, the average global sulphur content in marine fuels is around 2.6% (Kalli, Karvonen et al., 2009). Therefore it is clear that the legislation on sulphur emissions will not only lead to a lower burden on the environment, but is also very likely to have a great impact on the bunker fuel market (short: 'bunker market'). Fuel oil suppliers and/or consumers must take action to comply with the more challenging environmental regulations and play their part towards cleaner skies.

Before digging deeper into the problem at hand, the following two paragraphs will provide some more background information on what bunker fuels actually are and what role Vopak has in the bunker market.

2.2. Bunker fuels

In this second paragraph a it is made clear that there is a difference between bunker fuel and fuel oil and at the same time they are closely related. Furthermore, the link between sulphur content and sulphur

¹ A glossary of terms and abbreviations is included in Annex B

² Sulphur percentages refer to the mass percentage.

pollution is briefly described. To give an idea of the important role fuel oil has played in the international maritime transport sector as well as its magnitude, a historical background and some numbers are presented in Annex C.

2.2.1. Bunker fuels

The main topic of this study is bunker fuel. But, as briefly been touched upon in preceding text, bunker fuel is not one type of fuel. Bunker fuel is often mistaken for fuel oil. Fuel oil is the most widely used bunker fuel, but other fuels are also used, mainly distillate fuel. In this study, the focus lies on fuel oil and when referring to the bunker market, the fuel oil bunker market is meant, unless mentioned otherwise. But to give a complete overview, distillates will also be described here. Distillates will get more attention in section 6 and further.

The distinction made here is based on standards put forward by the International Organisation of Standardisation (ISO). These types of fuel oil are categorised in Intermediate Fuel Oil (IFO) 180 centistoke (cSt), IFO 380 cSt and the low-sulphur versions (max. 1.5m%) of the two. Distillates are divided in Marine Gasoil (MGO) and Marine Diesel Oil (MDO) (Platts, 2010).

Fuel oil

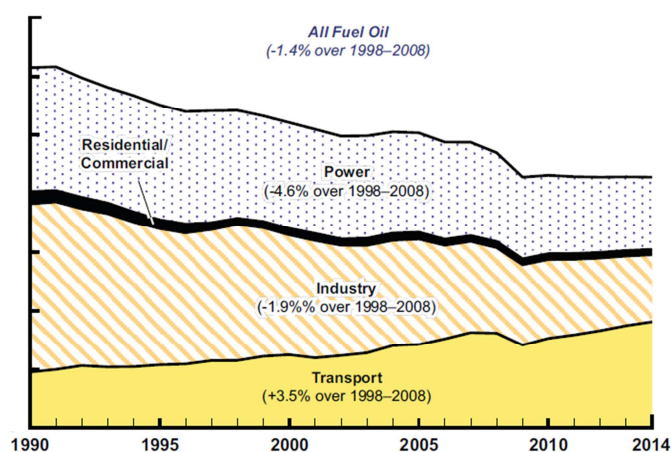
Heavy residues of the oil refining process form the basis of fuel oil. After the light products³ have been separated extracted from the crude oil by mean of distillation, the residue contains a high concentration of impurities (e.g. sulphur or heavy metals). However, there is not one specific quality of fuel oil. Fuel oil is a generic term for many, slightly differing fuels. Different applications require different specifications. These specification differ predominantly in viscosity and density. To change these properties to a certain quality, the fuel oil is diluted with what is called 'cutter stock' (Wilde, Kroon et al., 2007), which is mostly composed of the lighter products.

Fuel oil has a viscosity which ranges from 30-700cSt (mm^2s^{-1}), but nowadays also 1000+ cSt is being used. Most fuel oil used aboard ships has a viscosity of 180 or 380 cSt (Intermediate Fuel Oil, IFO), and has to be heated before it can be incinerated in the ship's engine. Too high a viscosity can create problems in fuel pumps and engines, but nowadays some new ship engines have a higher tolerance for heavier fuels and can burn fuel up to 500-700 cSt (Heavy Fuel Oil, HFO).

IFO380 usually has a high sulphur content, which reaches a maximum of 4.5%. IFO180 has a lower viscosity, due to an increased percentage of cutter stock (with a low viscosity of <10 cSt), but maintains a similar sulphur content as IFO380. Increased regulatory pressure has led to the classification of IFO380 and IFO180 with low sulphur. These fuels have a maximum of 1.5% sulphur and are also called low-sulphur fuel oils (LSFO), whereas the those with a higher sulphur content are indeed called high sulphur fuel oils (HSFO). In the light of this research this distinction is very important. More details on the specific physical properties of the types of fuel oil are given in Annex D.

Fuel oil is only suitable for larger engines and is the primary fuel used by ocean going ships. However, it is not only used for large ships, but also for fuelling large engines in mid-size or large electricity plants, industrial boilers and furnaces (this differs per country) and as feedstock for deep-conversion refining. For the latter purposes the fuel oil is shipped as a cargo to other countries as opposed to being used as fuel. The share of marine usage of fuel oil is presented in Figure 2-1 as "Transport", while fuel oil as feedstock is part of "Industry".

³ Like gasoline, gasoil, propane, butane, naphtha, lubricating oil etc. More information on the refining process can be found in paragraph 5.1

Figure 2-1 Fuel oil demand by sector

Source: (Abadie, Moehler et al., 2011)

Distillates

Where ocean going vessels use predominantly fuel oil, inland vessels sails on distillates. Fuel oil and distillates differ significantly: fuel oil is black, has a high density and is viscose, distillates is transparent and liquid. Distillates are subdivided in marine gas oil, or MGO, and marine diesel oil, or MDO.

MGO is used when cleaner fuels are required, which is thus mostly on inland routes, but also in ports and at berth. From the atmospheric distillation of crude oil (more information on refining in paragraph 5.1.1 and Annex G) MGO is the heavier middle fraction of distillate (EPA, 2008). Its properties are similar to that of conventional fuel mostly used for on- or off-road diesel engines, namely its viscosity, density, heating value and carbon content. MGO is a fuel best suited for faster-moving engines (Vermeire, 2007), like those in tugboats, crew boats, fishing boats, drilling rigs and ferry boats and it doesn't contain any trace of residual fuel oil. The sulphur content of MGO is lies between 0.1% and 1.0%. MGO is not only (significantly) more expensive than fuel oil, but it also costs more than MDO, because it is a lighter fraction and the fuel is of a higher quality.

Marine diesel oil, or MDO, is generally a blend of MGO with residual fuel oil. MDO is the lower fraction of the distillates and has a lower cetane index (comparable to the octane level in gasoline) and a higher density than MGO. But the main difference is that MDO has a higher sulphur content. If MGO picks up contaminants during storage or transfer, it is often also called MDO. As MDO is not a manufactured product, it is as such not sold at all bunkering ports. The fact that MDO is not a refined product, as pure as MGO, makes it more difficult to control the sulphur level of the fuel. This has made MDO less popular the last few years, as global sulphur limits have been tightened. In Amsterdam-Rotterdam-Antwerp (ARA), for example, MDO is no longer available (Einemo, 2010b). The future for MGO is seen as brightest of the two and MGO is able to comply with the strictest sulphur limits. So further on in the report when distillates are mentioned, MGO is meant. SO these two terms will be used interchangeably.

2.2.2.Sulphur-related air pollution

The air pollution related to sulphur (leading to acid rain) has led to many regulations limiting sulphur emissions, such as the MARPOL Annex VI of the IMO. The term "acid rain" stems from the acidification of rain by the presence of sulphur in the air. When combusted, about 90% of the sulphur in bunker fuel reacts with oxygen (O_2), forming sulphur-oxides ($SO_2 + SO_3$, or SO_x). These sulphur-oxides are dissolved in water present in the air and condenses or falls in the form of rain: acid rain. Although initial attention was given primarily to acid rain, later on the importance of particulate matter (i.e. PM or also called *aerosols*)

became more clear. These particles are formed through chemical reactions with their gas-phase precursors in the atmosphere (Finlayson-Pitts and Pitts, 2000). And it is these relatively larger particles that create health, visibility and climate issues (Vestreng, Myhre et al., 2007). Although PM and other emissions such as nitrogen-oxides (NO_x) and volatile organic compounds (VOC's) are also important aspects for the IMO, it is the sulphur restrictions that receive most attention, as the effects of these restrictions can be very large, hence this research.

2.3. Vopak

Before going into detail of what the problem is, it is wise to take a look at the company Royal Vopak (short: Vopak). Vopak is a large global provider of storage facilities for wet bulk. The company is active in 31 countries and has a network of 84 terminal around the globe summing a storage capacity of circa 28 million cubic meters. The annual turnover amounted almost 1.2 billion euros in 2011, with an operating profit of 470 million euros (Vopak, 2012). Vopak's performance has been strong the last couple of years, but always has to stay alert for any changes in the markets in which it is active. See Annex E for an historic background of the firm.

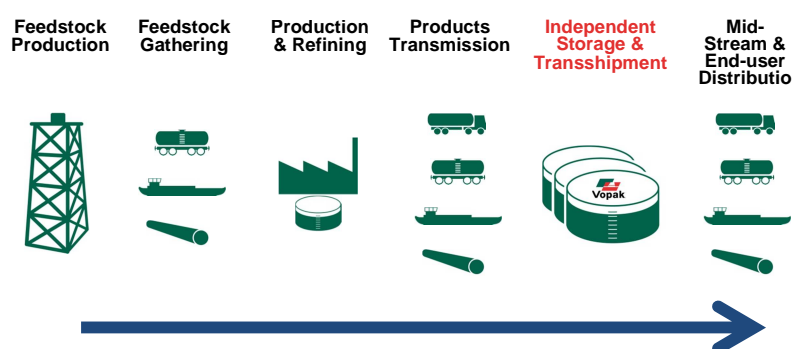
2.3.1. Activities

Vopak is predominantly involved in the storage of oil and chemicals, but also in biofuels. Their tanks provide customers with the possibility of importing or exporting bulk liquids. Because large imports cannot immediately be trans-shipped, the tanks of Vopak serve as a buffer. Other customers use the storage capacity as a part of their supply chain. Besides storing the wet bulk, additional services are provided. Different liquids require different handling and storage conditions, so tanks may be cooled or heated. Another important service is blending. This means that multiple liquids are blended to meet a certain required specification. Finally, Vopak provides logistic services, ensuring the liquids are transported on either vessels, barges, via pipelines, in tank trucks, rail wagons or drums.

The trans-shipment of products (mostly oil) can be divided in two categories: make bulk and break bulk. Make bulk entails that oil is collected at one location, originating from different (smaller) sources and subsequently is transported in large quantities. The other way around, break bulk means that large volumes of oil are segregated in smaller segments to be used for different applications of by different customers. Oil is mostly transported by vessel and shipped across the world, while chemical products are often distributed on a local scale. Chemicals storage will not get any attention in this research, as the focus is on oil.

Vopak is an independent storage company. Vopak's customers retain ownership and have a contract with Vopak to reserve storage space. The customer always has the possibility to load or unload at Vopak's terminal up to their contracted maximum. Customers for oil storage are (multi-)national petrochemical companies as well as trading companies. The position of Vopak within the oil product value chain is presented in Figure 2-2.

Figure 2-2 Vopak's position in an oil product's value chain

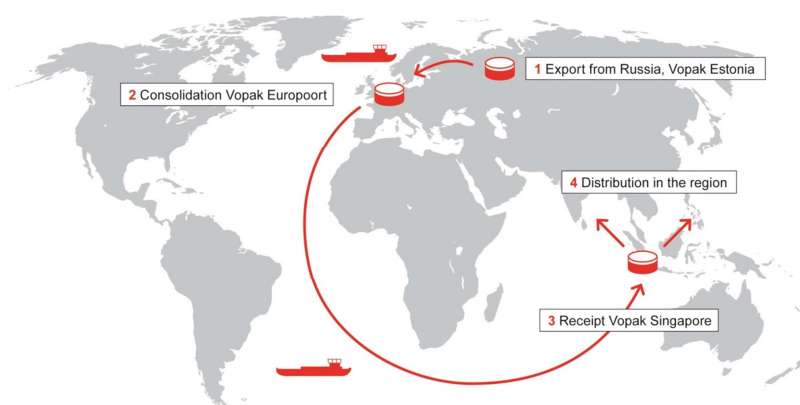


2.3.2. Fuel oil storage

Vopak is a large player in the fuel oil storage business. It is present in the large bunkering ports being, amongst others, Singapore, Rotterdam and Fujairah, but also in the smaller bunker hubs like Hamburg and Gothenburg. A strategic position is taken in Estonia with the Vopak E.O.S. terminal, which is the largest heavy fuel oil terminal in the Baltic and a major Port for the export of the large quantities of Russian fuel oil (this terminal accounts for around 25% of Former Soviet Union's – FSU's – total marine fuel terminal throughput). Vopak's presence in the strategic bunkering ports is very important for its business. Arbitrage – meaning profiting from price differences between major fuel oil markets – is very common in the ports of Rotterdam, Fujairah and Singapore. Rotterdam is essential in this network. Large quantities of fuel oil are, as mentioned, imported from Russia and the majority of these imports are also exported again, predominantly to Singapore (see Figure 2-3). Information on the volumes is not available.

At the terminal, fuel oil is stored in specially conditioned tanks, because fuel oil is different from other fuels. Fuel oil is very viscous, i.e. it does not flow at ambient temperature, and has to be heated to flow through pipes and pumps.

Figure 2-3 Fuel oil flow through major Vopak terminals



2.3.3. Competition

Vopak experiences competition directly from those parties also involved in independent storage of bulk liquids, renting their storage capacities only to third parties, thus not owning the products. In terms of volume and revenues Vopak is the largest player in the independent storage market, but across the globe several other parties are active in this field. Information on the exact share of fuel oil in this graph or in the business of Vopak is not publically available.

However it is not always as easy to draw a line, and different parties compete on different levels. Besides independent storage companies, being the primary competitors, there are also secondary competitors. These parties have storage capacity which they also use for storing their own products, such as large traders, bunker suppliers and refiners. Lastly, there are players in the oil storage market who only store their own products. These comprise refiners (major oil companies, national oil companies or large traders) or vertically integrated – often state-owned – companies. This last group of competitors are thus not direct competitors, but may be companies which could also choose to store at Vopak's facilities, and may thus be customers. If they store their own products, they may indirectly compete with Vopak.

2.4. Problem definition

Any possible turmoil in the fuel oil market is likely to affect Vopak, having large volumes of fuel oil stored in strategic locations across the globe. For Vopak it therefore seems crucial to know what the markets will

do, how the different players will react and how it can prepare for possible changes. Vopak, owner of several large bunker fuel terminals in, amongst other locations, Rotterdam, Singapore and Fujairah, is purely a service provider and is thus very dependent on the owners of the bunker fuel. For instance, with current regulatory developments in mind, it is possible that locations of supply and demand of bunker fuel may geographically shift across the globe, therefore influencing global flows and thus important storage locations. Therefore, Vopak attaches great importance to forming its own, whether active or reactive, strategy on fuel oil for the coming decade. But to be able to form strategies, one must have an understanding of the current situation and, more important, of the future.

Understanding the market of fuel oil is not easy. The most important reason for this is that it is a global market. Supply and demand are influenced by countless social, technological, economic, environmental, political and legal factors, among which many interdependencies exist. The geographical spread of all these factors as well as that of supply and demand further underlines the market's complexity. Also should be borne in mind that fuel oil is consumed in multiple consumer markets, but this report will focus on the market for fuel oil for bunkering purposes.

Concerning the future of the fuel oil market, most current literature – predominantly industry reports and presentations – focuses on predictions and gives concrete values of the future demand and supply (Avis and Birch, 2009; Kalli, Karvonen et al., 2009; FGE, 2011; Wood-Mackenzie, 2011c). Some reports advocate a certain solution to deal with the sulphur restrictions, for e.g. refineries or shipping companies, and thus shape a new future market state following the implementation of this preferred solution (Meech, 2010; Rysst, 2011). However, little variation in scenarios is used in these reports, making room for a more qualitative approach, which is also important for strategy forming in a complex environment, like the global bunker market. As stated, most future outlooks are produced by the industry, although several impact studies where commissioned by the EU (Bosch, Coenen et al., 2009; Meech, 2010). The latter do incorporate the use of multiple possible futures – or scenarios, at least from a legislative point of view, but fail to address other – less clear – market dynamics, which this research is aiming to identify, e.g. the competitiveness of the market, power relations among actors and the institutional environment.

When overlooking the existing literature, they can predominantly be categorised as 'black box'. After a literature scan, it becomes clear that little scientific literature is available on the specific topic of the bunker market comprising of more than just *inputs* and *outputs*; the 'knowledge gap' lies between them. There is still a lack of more socio-economic views, combining an analysis of the diverse underlying factors that *drive* the market with that of current and future developments around the tightening global sulphur regulations. The quantitative studies use the knowledge about more socio-economic variables for their market analyses mostly implicitly, but often lack a structured approach to explicitly address them. Although numbers are essential for policy making and monitoring purposes, they ought to be complemented by qualitative approaches to help managers comprehend the social, political, cultural and institutional context. This thus asks for a qualitative structuring of the market, including the value chain and its institutional environment. If Vopak wants to set out a strategy for the fuel oil market, a broader basis is needed than solely quantitative studies. This opens doors to a study focusing on the actual understanding of the bunker market, one that can be called a 'white box'. With this white box a broader picture can be drawn of not only the current situation but also that of the future.

Therefore the problem at hand is twofold.

- The IMO has introduced new regulations limiting the sulphur content of marine fuels. This changing legislative environment might evoke a shift in global marine fuel consumption, which is likely to influence (the usage of) Vopak's fuel oil storage facilities.

- Current literature on the status quo and on the future of the bunker market is mostly of quantitative nature. A structured, qualitative industry-wide analysis is lacking, therefore (explicit) knowledge of the drivers and dynamics of the fuel oil bunker market is insufficient.

2.5. Research delineation

The previous paragraph has provided a good idea of what knowledge void lies in describing the current and future state of the bunker market. The theoretical framework which will be used in this research might be able to fill this void. This report uses a theoretical framework which combines Old Institutional Economics with New Institutional Economics and Michael Porter's five forces of Competition. A description of the market structure is required encompassing Williamson's four-layer model as well as Porter's five-forces (including the bunker value chain). On the background of that structure, the future changes are analysed, focusing on the three dimensions of transactions – uncertainty, asset specificity and frequency – as drivers for investments.

So, as opposed to theoretical monism, not only one theory is used to analyse the phenomena of the bunker market, because, to my belief, no single theory is able to give a complete account of these phenomena. In this case I resort to theoretical *pluralism* (Groenewegen and Vromen, 1996, p. 371) to entertain several theories to explain the functioning of the market as well as possible future developments. The idea is that the variables of the different theories supplement each other in order to gain better understanding, as it is by no means the goal of this study to form an "all-embracing theory, which incorporates all (potential) explanatory variables" (ibid, p.372). This paragraph will discuss how this pluralism will help to solve the problems mentioned above.

2.5.1. Institutions

The bunker market, which is an important part of the fuel oil market, is becoming increasingly dynamic. In the past, fuel oil as a bunker fuel hasn't been the problem child it now has become. Since the 1960's motor ships using fuel oil have overtaken steam ships and made up 98% of the world fleet at the beginning of this century (Vermeire, 2007). Although in the past there had been many adjustments to ships' engines and changes to quality standards, these did not lead to the use of different marine fuels than fuel oil. The stringent legislation, which is already partly effective, may put the bunker market to the test in a more drastic way than any past developments have. The many actors in the bunker game, ranging from oil and shipping companies to governments all over the world, all have to deal with the new IMO-rules, which add to the current dynamics of the market. Precisely these dynamics of the bunker market ask for a suitable perspective for analysis of both the current and future state of the bunker market.

The previous paragraph mentioned the 'black box' character of current studies on the bunker market. This characteristic is associated with the school of Neoclassical Economics (NCE), a traditional way to analyse markets. Why is this perspective not sufficient for analysing the current and future state of the bunker market?

Neoclassical Economics

There are different ways of looking at the future of a complex system. One way is to predict the future state of the system, by constructing a model, simplifying reality in a logical and rational manner. This formal method implies the use of mathematics (Wilber and Harrison, 1978, p. 62). The product of such models is predominantly of quantitative nature. We see many industry reports and presentations on the developments in the bunker market that are of such nature, containing predictions, which give numeric values as an output of modelled logic and systemic behaviour of the future and thus depict how the system should ideally behave. In the process of simplifying or generalising, the assumption of *ceteris paribus* is often used, i.e. all other factors held constant. For, example, most graphs of bunker trends (demand,

supply, prices) show the financial crisis of 2008 as a peak, but assume a stable future in further predictions (following the pre-2008 graph) and effectively exclude these possible external influences.

This formal method of modelling economic systems is attributable to the school of neoclassical economics. Using this method could therefore – roughly speaking – solely result in predictions of fuel oil production and demand and a thereof logically derived price, given standard economic theory. The bunker market is too complex for such theory, witness the current developments in the refining sector (NRC, 2012) or in the Russian export tax regime (Wood-Mackenzie, 2011a), creating out-of-the-ordinary fluctuations in the supply side market. So, although it may be convenient to rely on numbers when forming a strategy – as it provides some sort of “grip”, the bunker market is comprised of more than a group of rationally acting, simplified variables or factors.

Institutional Economics

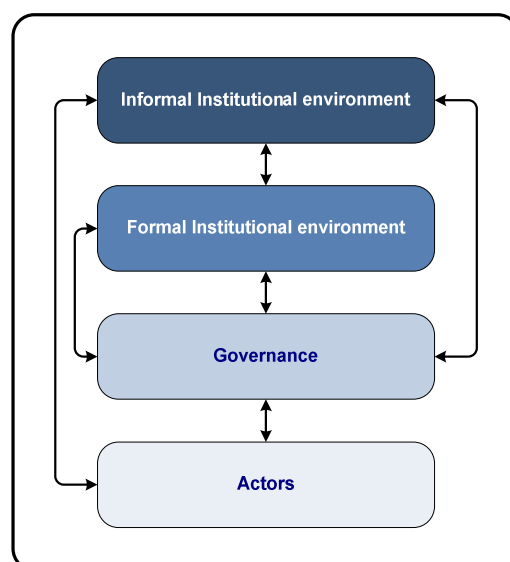
It is clear that exclusively applying NCE-theory is not in itself a suitable way to deal with the complex problem at hand. The disadvantages addressed here form the basis of the criticism expressed by scholars of the Institutional Economics. As opposed to the NCE, the institutionalists do not compare “the real-world outcomes with the hypothetical benchmark of perfectly competitive general equilibrium” (Klein, 2000, p. 457). They are interested in not only the economic, but also the social and political institutions governing everyday life.

Wilber and Harrison describe a methodological foundation of the Old Institutional Economics (OIE) (Wilber and Harrison, 1978). Their approach takes OIE as a way to analyse the complexity of systems, thereby describing instead of predicting. Behaviour of actors in the market is an essential part of the economic system, as are its complex interdependencies. In the bunker market, there is always an interaction between refineries, shipping liners, the IMO etc... And it must be said that these interactions are thus not only expressed by internal dynamics, i.e. ‘the bunker marketplace’, but also by environmental developments, which are not least dynamic by nature. A significant part of the environment is shaped by “institutions”. According to the OIE, the focus lies on the understanding of the dynamics of this *institutional environment*, while asserting the importance of the market’s history, its culture and the concept of path dependency. The OIE rejects “the notion that economic behaviour is determined solely by the rational maximising decisions of individuals. Rather, they view individuals and groups as embedded in social contexts – sets of institutions – which govern their behaviour” (Bray and Wailes, 1998, p. 56). The institutional environment consists of “both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)” (North, 1991).

The interactions between institutions and behaviour in the marine fuels market imply that this market isn’t likely to be in “*the perfectly competitive general equilibrium*”. So far, the OIE seems an interesting theory and will form a part of this research. However, when taking an OIE perspective it is difficult to structure institutions in a way that it contributes to answering the research questions. To gain more structure for analysing the bunker market, a newer school of economics is introduced: the New Institutional Economics (NIE). This school also claims that institutions matter, but provides a way to incorporate them in a theoretical framework like that of the NCE. Under NIE, some NCE assumptions are relaxed, such as perfect competition and information, full rationality and zero transaction costs. But according to the originator of the term “New Institutional Economics” (1975), Nobel prize winner Oliver Williamson, the assumption that *individuals* seek optimisation of their objective function, being subject to constraints, still holds (Kherallah and Kirsten, 2002, p. 2). And the institutions are seen as an additional constraint. It is NIE’s goal to understand and explain the means of coordination (e.g. contracts or modes of organisation) of specific transactions and focuses on individual choice. These means of coordination form the second type of institutions, the *institutional arrangements*. But we aren’t interested in individuals optimising their objection function. So why look into the NIE? To answer this question it is necessary to shortly explain the way NIE structures the wide variety of institutions.

Davis and North (1971) also make a distinction between the institutional environment and institutional arrangements, thus putting a focus on both external developments (dealt with by OIE) and configurations of the market itself (the focus of NIE). Williamson further categorised a system's institutions into his 'Four Layer Model' (Williamson, 1998, p. 26) and gives an example of a more structured institutional approach. An adaptation of Koppenjan and Groenewegen's version of his model (2005, p. 247), is presented in Figure 2-4. The perspective Williamson takes distinguishes the mentioned informal institutions imbedded in a society, formal institutions and governance structures, but adds a the fourth level, which is reserved for the NCE variable of price and output. However, I follow Koppenjan and Groenewegen (2005, p. 244) by placing the actors and their strategies on the fourth level, which seems a more suitable content for this research. This is the level of the bunker value chain, where refineries, traders, shipping companies etc. – and of course Vopak – allocate their resources in their everyday business. This NIE model thus captures the entire spectrum of high- and low-level factors of a system and appears to be a first step to deal with the bunker market's complexity. Its structure is used throughout this research. This model, however, can't in itself describe a complete market structure as it doesn't provide a specific method to do so, while that is exactly what the first part of this research aims at doing. While the institutional environment can be described according to OIE, dealing with the market, i.e. its level of competition and the analysis of future change requires more structuring.

Figure 2-4 Four layers of institutions



Source: Adapted from (Koppenjan and Groenewegen, 2005)

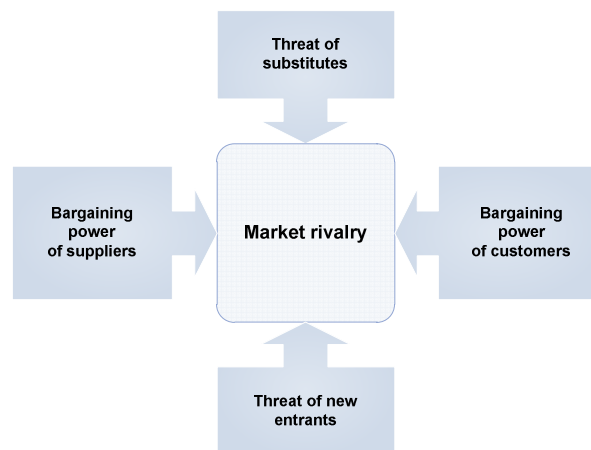
2.5.2. Porter's Competitive Forces

Now that the four-layer model has been chosen to help structure the institutions within the bunker market, we now need a framework for describing the current market structure of actors and transactions. Michael Porter's publication on Competitive Strategy seems to provide us with a guideline for sketching the competitive structure of the bunker market. It introduces the concept of the 'Five Competitive Forces' (Porter, 1980), which comprises the bargaining power of both suppliers and buyers, the threat of potential entrants and the threat of substitute products, which all influence the fifth force: rivalry among competitors. The competition within the bunker market is rooted in its underlying economic structure. The value chain of the bunker market stretches out from refineries to the end consumer, the shipping companies. The Porter theory aims to structure the market from a competition point of view, relating the different parts of the chain.

Not only can the Porter perspective be useful to describe the current market, it is also suitable to define possible developments, including challenges for the market players. Mergers, acquisitions or changing margins can impact the bargaining power of either for buyers or suppliers. Furthermore, shifts in the refining sector towards emerging markets or changing exports from fuel oil producing countries may both influence the power of suppliers significantly. Another aspect which calls for Porter's ideas is the IMO-legislation, which is expected to have a great impact on the market. The possible impact of this legislation is at the centre of attention. It may, e.g., influence the threat of potential new entrants to different parts of the bunker value chain and in different geographical markets or lead to increased competition from substitute alternatives for fuel oil, which may conquer (parts of) the market following the sulphur regulations. The latter could also have consequences for the bargaining power of customers and fuel oil prices.

This illustrates the usefulness of taking Porter's perspective on competition in the light of this research. His perspective, presented by Figure 2-5, is often referred to as the 'Five Forces Model'. This not a model in the sense that it "makes precise assumptions about a limited set of parameters and variables ... and uses mathematics and simulations to explore the consequences of these assumptions systematically on a limited set of outcomes" (Ostrom, 2005). The same goes for Williamson's four-layer model. This study does not aim at joining in this discussion, but for clarity purposes it is in this case more distinct for it to be seen as a way of categorising or describing different aspects of a market. The five forces will be described in further detail in sections 5 and 6.

Figure 2-5 The Porter Model



Source: (Porter, 1980)

2.5.3.Future change

The Porter analysis provides us with a description of the current state of the bunker market, but also gives insights in the possible future developments in the bunker market. However, these two analyses combined do not give provide us with concrete motivation or argumentation on why, and in what circumstances, these changes can occur. We need some sort of drivers which invoke change. As a reaction to the sulphur limits set by the IMO, the market must react in one way or another. Which actors are crucial and what will trigger them to act? The choices of these actors relate to their investment decisions. How can we identify the drivers that impact these investment decisions? To answer this question Williamson's Transaction Cost Economics (TCE), which is an essential part of NIE, is applied in a somewhat unconventional manner. This choice stems from the eclectic nature (relating back to the theoretical pluralism) of this research. To understand why TCE is chosen, this theory is briefly explained here.

Transaction Cost Economics

The governance or private ordering (level three of the four-layer model) is what Williamson (1975) calls "*The Play of the Game*". This private ordering analyses the way in which a market is organised. It does so through focusing on the types of contracting as a way of coordinating market transactions, the performance of the market when economising on transaction costs and the behaviour evolving from the modes of governance. Different modes of governance are the market and the hierarchy, but many "hybrids" exist. These governance modes entail different levels of transaction costs in different situations. Besides economising on production expense (economies of scale in NCE), the individual aims at minimising these transaction costs (Williamson, 1979, p. 275). The degree, to which these governance modes involve transaction costs, depends on the attributes, or dimensions, of the transaction in focus.

Williamson distinguishes the transaction dimensions or attributes of *uncertainty*, *asset specificity* and *frequency*. Here, uncertainty entails that the governance of the bunker market may be influenced by any future environmental regulations, counterparty actions or political instabilities. These all impose risks. Next, assets may have a specific nature like, for instance, technology (ships with fuel specific engines) or location (close to fuel oil producing facility or port). Which parties have specific assets and how specific are they? Finally, frequency refers to the number of transactions involved in the market. High transaction frequency can, for instance, lead to higher transaction costs when considering e.g. the necessary haggling and negotiations for every bunker transaction, although it can also lead to standardisation of contracts or even a spot market. This could thus influence choices of vertical integration along the bunker value chain.

This study takes these three attributes of transactions and links them to the investment decisions that are to be made by the critical players in the bunker market, in reaction to the changing sulphur legislation. This approach is far from what Williamson had originally envisioned with TCE, but is not uncommon in literature. Fabrizio (2012) and Kim and Kung (2011) have taken similar approaches by analysing the influence of uncertainty and asset specificity on investments. I here borrow the three attributes of transactions (in this case, investments) to help identify the driver for investments (of groups of actors) in the bunker market. Further on, the three dimensions of transactions are referred to as "TCE-concepts" or "TCE-attributes". Again, this does not concern the original function or application of the TCE as envisioned by Williamson.

Unit of analysis

As mentioned, the unit of analysis of NIE and especially TCE is the transaction. Uncertainty, asset specificity and frequency are the three critical dimensions (operationalization) of this unit of analysis. But as the choice for Porter's five forces suggests, the actual unit of analysis of this research is the industry, which is a significantly higher level unit of analysis than TCE (see Table 2-1).

Table 2-1 Comparison of units of analysis

<i>Unit of Analysis</i>	<i>Critical Dimensions</i>
Decision premise	Role; information; idiosyncratic ^a
Ownership	"Eleven characteristics" ^c
Industry	Concentration; barriers to entry
Individual Transaction	Undeclared Frequency; uncertainty; asset specificity

Source: (Williamson, 1993)

So, to put the unit of analysis in perspective of its paradigm, Williamson (1993) distinguishes five units of analysis. Each is at the centre of focus in different paradigms in the study of economic organisation. He states that Simon (1957) proposed the decision premise as the appropriate unit of analysis. Ownership is the unit of analysis for property rights theory. The industry is the unit of analysis in the structure-conduct-

performance (SCP) approach to industrial organisation. Positive agency theorists nominate the individual as the unit of analysis, whereas the transaction is that of TCE. Michael Porter's has developed his five-forces model out of the SCP tradition (Clegg and Hardy, 1999). SCP based research "either implicitly or explicitly considers the effects of competition, whereas TCE is not easily structured to fold competitors into the analysis" (Nickerson and Bigelow, 2008), but its dimensions can provide us with an extra insight. The actions or investments within the industry are analysed using the critical dimensions of uncertainty, asset specificity and frequency.

When considering the regulatory developments in the bunker market, many reactions from within the market are to be expected, be it from refiners, shipping liners or traders. These future actions are based on choices made in a dynamic environment. An analysis of future decisions is not ideally done by using a static market analysis, but more so by analysing the extent to which the drivers of these decisions are dynamic themselves. Decision making is all but static or solely price-driven. This research uses the TCE concepts of asset specificity, uncertainty and frequency and assesses the degree to which they actually function as drivers for future developments in the bunker market as a reaction to the changing sulphur legislation.⁴

2.5.4. Vopak's perspective

The current institutional environment clearly has an impact on the bunker market and so on the business of Vopak. The future changes within the market, described by Porter's five forces and driven by the three transaction dimensions, will have its consequences for Vopak. This all assumes a unidirectional relationship between the four layers Williamson's institutional model.

Williamson mentions reverse arrows in his four-layer model, because "the system is fully interconnected", but he mainly neglects these feedbacks (Williamson, 1998; Williamson, 2000). North pays more attention to these feedbacks by stating that, besides simply constraining human behaviour, institutions are interacting with organisations (players of the game) in "the economic setting of ... competition" (North, 2005). Physical and human capital are used to make choices, which will incrementally alter institutions (Nye, 2008). Koppenjan and Groenewegen (2005) suggest that institutions are not only change incrementally and through evolution, but they are (re)designed intentionally by actors. However, "often, the limited access to institutional arenas is consciously designed in order to prevent institutions from being changed easily" (Koppenjan and Groenewegen, 2005), so changing institutions is very difficult.

Koppenjan and Groenewegen (2005) further discuss the possibilities to change institutions. Actors (Level 4) could want to change the institutional arrangements (Level 3), but they may not always be the actors who decide on which arrangement is selected. In turn, these actors who decide upon institutional arrangements may not always have access to the arena's, in which the formal rules (Level 4), constraining the arrangements, are set. Level 1 institutions are the most difficult to alter, as norms, values and attitudes are the result of informal and incremental processes. These arena's where decisions are made about institutions on a particular level Ostrom (1990) calls "institutional arena's".

This study focuses on the developments in the bunker market, seen by Vopak as external events. But it is interesting to explore not only the effects which the different developments have on Vopak, but also to explore which resources or options for (re)action Vopak has to deal with them. Considering the difficulty of changing/designing institutions, it is not likely that Vopak can actually change the institutional environment, but it may have many options to manage these developments. Influencing decision making in institutional arenas or simply coping with inevitable change are two way to deal with the situation. This

⁴ It must be noted that TCE-analysis is in itself static. A change in the institutional environment, which Williamson (1991b) calls "a shift", can be dealt with by intertemporally comparing the transaction costs under both sets of shift parameters leading to different optimality, i.e. governance mode. This is called a "static-comparative analysis" and is an "adaptation toward a new equilibrium after an exogenous shock" (Groenewegen and Vromen, 1996).

research will therefore also explore (broadly) which possibilities Vopak has to manage the changes in the bunker market. Also, the extent to which Vopak is alone in this or if other players have the same options, will be briefly discussed. In the perspective of the four-layer model of Figure 2-4, the arrows do not only flow top-down, but also bottom-up.

2.5.5.A framework is born

Porter's five forces can be useful for describing the current structure of the bunker market (section 5 of this study), following the institutional environment (section 4). Also, using this same perspective for future developments (section 6) can set a basis for a more in-depth analysis using the mentioned TCE-concepts (section 7). The four-layer model serves as a structure throughout this report.

The market structure is partly shaped by the institutional environment, by different norms, values and cultural inheritance across the different parts of the world expressed by a variety of legislative systems. So the institutional environment, being dynamic according to OIE, can be seen to influence every of the five competitive forces within the current state of the bunker market. The possible future developments can again be described using Porter's forces, but this does not give any motivation of the any of the future developments. Without any further argumentation about how and why developments are to occur, this description would either be an attempt to predict or be a mere assumption. This argumentation can be based on the terms uncertainty, asset specificity and frequency and in the author's belief these are useful to provide a motivation of the changing market structure in the future by identifying the drivers for choice. The drivers for decision making by essential parties in the bunker market, considering the changing sulphur limits, can be related to any of the five forces influencing competition.

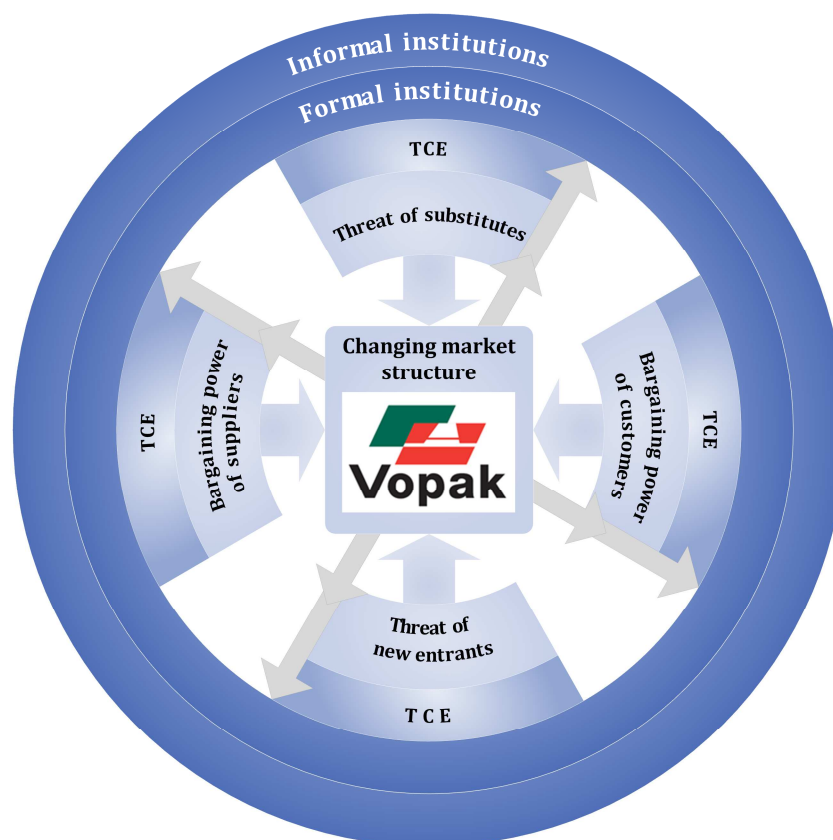
However, the five forces are not bound to one of Williamson's four layers or his concepts within TCE. Each of the five forces actually has all four layers influencing them. The same goes for the TCE-attributes, as they cannot be assigned to a specific force within Porter's model. Porter's forces will function as a body for describing the functioning of the bunker market and are used to give an overview of the current status of the bunker market, i.e. in the current institutional environment. The same perspective is used to describe the different future developments in each of the five forces, both as a consequence of the changing legislative environment and changing market structures.

These descriptions of the market will form the basis of the TCE-concept analysis for the drivers for future developments, focusing on uncertainty, frequency and asset specificity. This analysis as opposed that according to Porter's forces, will focus on what drives the parties involved in the bunker market in their reactions to the changing legislation, i.e. their choice to invest/divest according their perceptions of the three concepts of TCE.

The view taken in this study will aim at being a valuable addition to the current, more mathematically driven, analyses of the bunker market. An in-depth qualitative analysis provides insight in the processes underpinning socio-economic changes and may back quantitative researchers with contextual knowledge, providing additional support for their quantitative findings.

The theory, being a combination of Williamson's four-layer model, Porter's ideas of the 'Five Competitive Forces' and Williamson's Transaction Cost Economics leads to the framework presented by Figure 2-6. The institutional environment is omnipresent, which means that it serves as a foundation for much of the market structure. The arrows go two ways, emphasising that the environment and market changes have an influence on Vopak, but that Vopak may also impact these. At the beginning of each analytical chapter (i.e. chapters 4-7) this figure is presented in the top-right corner of the page, emphasising *that* part of the framework which is of interest in that chapter.

Figure 2-6 Combining theories for analysing future developments (sections 4-7)



2.5.6.Scope

This research project will combine the current literature on the state and future of the bunker market with the proposed theoretical framework. Using NIE and Porter, a broad description of the global bunker market is made by identifying the most important actors, relationships and drivers of the market as well as influential environmental factors.

Product, geography and time

The motivation for this study lies in the recent developments in global environmental legislation. In this, the IMO-regulations are unique as they are set globally, thus effective in all 170 member states. In this paper the same global perspective is taken. However, because it is impossible to describe all developments in the bunker market across the globe, it is important to set boundaries to what extent I will include or exclude subjects or factors. Therefore I have chosen to take a high level view, meaning that only the most significant variables or developments (in the field of economics, politics, social background, environment and legislation), essential to describe the functioning of the bunker market, will be a part of my research. Detailed analyses of price dynamics in specific regions would, for example, would fall out of scope. Which factors are essential, however, is a significant part of the study itself.

To narrow the scope of the bunker market, only the fuel oil is discussed. Although other fuels are also currently in use for international marine transportation, only fuel oil is the fuel of interest here. I will look only into the relevant part of the fuel oil market, which is bunkering.

When describing future developments the focus will lie more on the ECA's, thus discriminating somewhat on geographic areas, because ECA's are where the most significant impact is expected to be seen on the market. However, the global character of the bunker market will not be neglected.

In consultation with Vopak, a time span for the analysis has been chosen that starts at present (2012) and ends in 2025. The rationale behind this choice is that the current plans for global sulphur limits only reach to 2025. As mentioned, the major drive for this study is the implementation of these limits. It is therefore chosen not to dig deeper into the future than the planned global cap of 0.5% sulphur, in 2025 at the latest. Although the sulphur limits can – and will – have their effects after this year, following the approach of this research would only lead to speculations about this distant future.

Output

I will refrain from forming a robust set of scenarios for the future. This in itself is worth a study, as they require a great amount of data and information as backup. To avoid the risk of simplifying possible scenarios, only a description of the most likely developments is provided. Thus, after identifying the most important drivers for future changes in the bunker market, these drivers are given a range within which they are most likely move in the future. This information can be of great value for Vopak when trying to set up a strategy for its bunker business. Because no concrete set of scenarios is given, no concrete strategic advice will be given either. However, possible implications for and possible reactions of Vopak are discussed in the final section of this paper.

I will thus not focus on providing strategic advices for Vopak, so the company itself is not subject of extensive review in my analysis. Therefore I will speak of independent storage companies in general. In the concluding sections of this paper, however, the impact for Vopak as an independent storage company will certainly get attention.

Furthermore, when looking at the use of theory, the framework briefly described in the previous paragraph will solely serve the purpose of describing and analysing the market on a relatively high level. Thus it is not the aim of this research to observe and measure specific transaction costs or pricing schemes, which is very difficult and time consuming. The theoretical framework is therefore supportive to this research. This aspect further underlines the overall perspective of this research, that is, it takes a qualitative point of view. The reasoning behind the qualitative nature has been explained earlier. However, this does not mean that no quantitative data will be used. If possible, findings or statements will be backed up by numbers. Thus the output of the analysis will be qualitative, but input will be a combination of the two types of data.

2.6. Research objectives and questions

Given the problem definition provided in section 2.4, the following main objective of this study is presented:

Research objective

This study aims to provide understanding of the dynamics in the bunker market, of how this market may react to the IMO sulphur regulations and of the possible impact on fuel oil storage companies.

This study aims to provide understanding of the dynamics in the bunker market and of how this market may react to the IMO sulphur regulations by taking a new - socio-economic - perspective

The goal of the first part of this study is to provide understanding of the current dynamics of the bunker market. This description of the status quo is to be mostly of qualitative nature. This will be expressed by looking further than just simple supply and demand figures and emphasising that, through the

identification of the most important institutions, players and relations, there are both many external influences and internal dynamics in the bunker market.

This analysis also incorporates a scientific goal, which is to explore the extent to which the NIE and Porter theory are complementarily useful in describing and analysing the structure and dynamics of the bunker market. I thus aim to find out whether using the theoretical framework – described in this paragraph 2.5, but further explained in the next chapter – can help to create the qualitative understanding.

Because the new IMO rules have been introduced, significant movements on the bunker market are expected in the next decade. These could impact the refinery business, the ‘midstream’ business and also the world of maritime transportation. For that reason the second part of this study aims at exploring the possible future developments in the various segments of the market and providing a certain range or space in which the market *could* develop by also exploring the likeliness with which the developments are to occur. As mentioned, the aim is not to construct scenarios, but provide sense of what can happen. This analysis will then filter out the main drivers for change. These identified drivers are an important output, being the main factors influencing the market movements, either small or extremely large, and thus important to focus on for Vopak. This study can be a valuable – qualitative – addition to the more quantitative studies focusing on prediction.

The final goal is to provide a scan of the possible impacts of the IMO rules on Vopak’s business by reflecting on the outcomes of this study.

Now that the goals are set, concrete research questions are formulated, referring back to the problem description. To give a better insight in the sub-questions, they are explained by several supporting questions (a, b or c). The sub-questions together will answer the main research question, which reads as follows:

Main research question

How can the global bunker market develop in the coming decade under new global sulphur emission restrictions and how can Vopak's global bunker fuel storage business be affected, when taking a socio-economic perspective?

Sub-questions

Theoretical perspective for market analysis

1. How can the New Institutional Economics framework together with Porter’s ideas be helpful in creating a broader understanding of the bunker market when we keep a socio-economic perspective?
 - a) Which aspects of NIE make it suitable for analysing complex global markets?
 - b) In what way can Porter’s views be used in the light of this research?
 - c) What is the strength of the combined framework?

Exploring the bunker market

2. How does the global bunker market currently function?
 - a) Who are the most important players on the bunker market?
 - b) How is the bunker market structured and coordinated?
 - c) What is the level of competition along the value chain?
3. Which developments are likely to occur until 2025?
 - a) Which developments are to be expected in global sulphur regulations?

- b) Who is likely to react to the changing regulations and how?
- c) What are the drivers for future change?

Effects for Vopak

4. What do the developments in the sulphur regulations mean for Vopak's bunker fuel business?
 - a) Which drivers for change can impact Vopak?
 - b) To what degree can Vopak react/act proactively to cope with the developments?

The relationship between the research questions is illustrated in the figure presented at the end of this section (Figure 2-7).

2.7. Methodology

This research will be conducted through the use of two research methods. The methods comprise of desk research and qualitative surveys, i.e. interviews.

2.7.1.Desk research

When focusing on the theoretical framework, there is an abundance of academic literature on New Institutional Economics; from Williamson's four-layer model, which is often used or discussed, to the concepts within the Transaction Cost Economics (e.g. Gibbons, 2010; Steenkamp and Geyskens, 2011). Porter's theories are also widely assessed in literature (e.g. Stonehouse and Snowdon, 2007; Ormanidhi and Stringa, 2008). So with this vast collection of articles and books, the first sub-question is answerable through desk research.

Although there isn't much academic literature on the market of bunker fuel, many reports and forecasts have been written by various industry parties and are readily available. This material will be useful for the answering of the second, descriptive, sub-question listed above. Furthermore, it can give suggestions of important aspects of the market structure, e.g. significant variables, actors and relationships.

The third question is perhaps not so easily dealt with by looking at current literature. This is probably because little research is done using a broad and structured socio-economic view on this market. However, available reports and presentations from the industry do provide a scan of possible developments in the market by providing forecasts (numbers) for e.g. fuel oil demand and supply or the emergence of alternative fuels or abatement methods. This is where the second method comes in useful.

2.7.2.Qualitative surveys

Using qualitative surveys, expert information is retrievable that is not written down, but which has been collected by people from experience. Interviewees for this research are (or were) either active in the bunker industry or have some role in the development of the applicable regulations. Respondents include:

Table 2-2 List of respondents

W. Dijkstra and J. Kolpa	Ministry of Infrastructure and Environmental Affairs	February 9, 2012
Maersk		February 15, 2012
B. Van Holk	Former professional in the refining industry. Currently employed at COVA, Netherlands National Petroleum Stockpiling Agency	February 29, 2012
C. de Keijzer	Chairman of the Rotterdam Branch of the World Ship Society	March 8, 2012
M. Vink	Netherlands Shipping Inspectorate	March 19, 2012

Further personal communication related to (informal) meetings with employees at Vopak, representatives of the Port of Rotterdam and a bunker trader at E.ON.

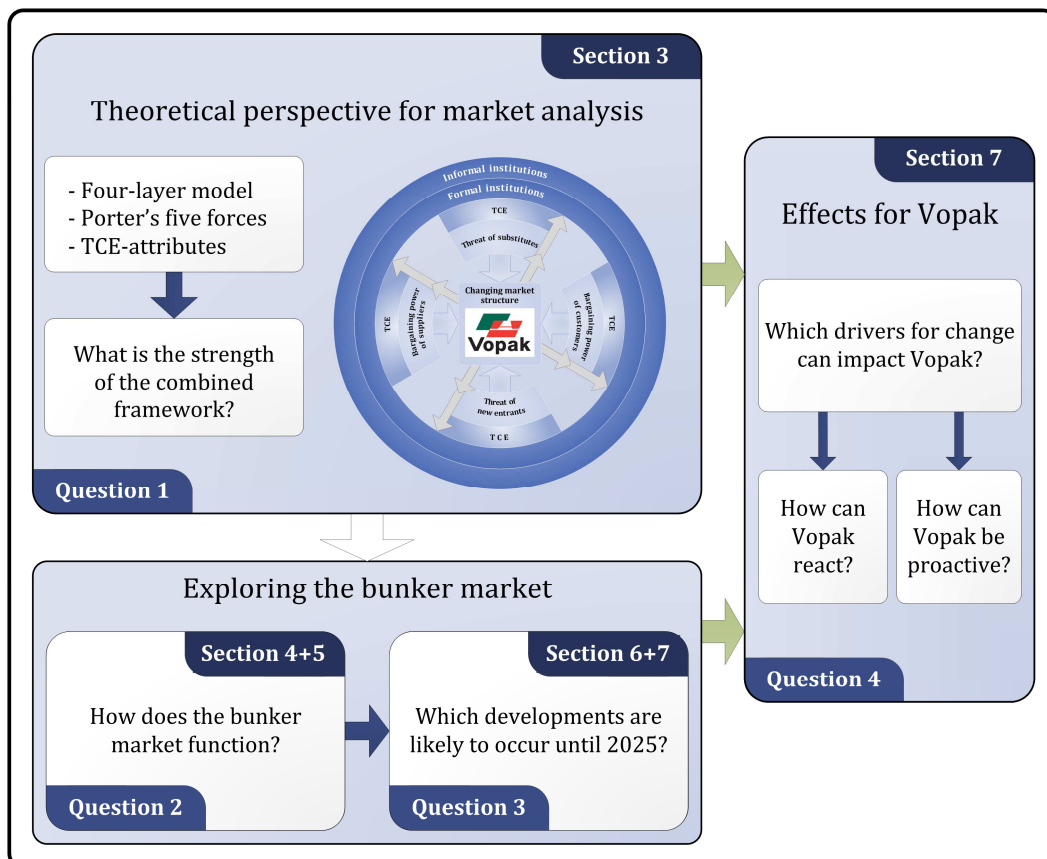
One advantage of surveys is that one can get a feeling of the expert's tacit knowledge, knowledge not easily gathered from literature. Another is the fact that it is possible to ask open questions, the answers to which are not found in literature, and thus get a specific answer. This makes it a suitable method for qualitative research. A disadvantage may be that the respondent holds back strategic information, which in a competitive market like the bunker market is conceivable behaviour. Because all of the respondents have their own agenda and interests, their position has to be kept in mind to put statements in perspective. All of the respondents showed much interest in this research and were very cooperative. This study can of course be very interesting for them as well. It is thus a game of give-and-take.

When performing interviews it is important to make a careful selection of interviewees, because in the light of this project, it is crucial that a broad understanding of the subject matter is formed. So no important stakeholder may be left out. An overview of roughly which questions were asked during the different interview is provided in Annex A.

2.8. Conclusion

It is clear that the legislation put in place by the IMO can have a significant impact on the dynamic and complex bunker market. It is thus interesting to analyse the possible consequences of these measures and provide Vopak with a qualitative study, complementing the current mostly quantitative information. By using the NIE-Porter framework a new perspective is given on the market, aiming at identifying the market dynamics and structure and therewith incorporating both the internal and external elements. This section thus gives a sound overview of the problem at hand, describes the necessity and boundaries of this study and justification of the chosen methods. The relations between the research questions and the section in this report are presented in Figure 2-7 below.

Figure 2-7 Relationship between research questions and report sections



3. Theoretical background

The problem, goals and scope are now defined and they will serve as a basis for the rest of the research. Also the theories and methods have been described, especially the NIE-Porter framework. However, this framework deserves some more attention. This section will therefore give more information on the chosen theories, their backgrounds and their suitability for reaching the goals. At first, the emergence of the field of New Institutional Economics is described in its context. Secondly, we will go deeper into Williamson's Four-Layer-Model and the concept of Transaction Cost Economics. Thirdly, Porter's Five Forces are explained as well as why this theory is chosen. These theories will come together in a framework, which is drawn up subsequently. Finally, this section will conclude with how this framework is used further on in the report.

3.1. Away from the neoclassical paradigm

The traditional starting point for market analyses is the usage of the neoclassical economics (NCE) (Furubotn and Richter, 2010). Although this term isn't necessarily used in many studies on the structure of the market, there are several concepts that these studies all have in common. They all assumed markets to be a collection of rationally behaving individuals in perfect competition with each other, having perfect information and seeking optimisation of profit through standard micro-economics. The formation of prices was their main focus. The institutions that are present are only exogenous and only provide a framework or a set of rules for market activities and are not part of the actual economic analysis (Grusevaja, 2006). With the use of mathematics, economics thus seems completely rational and predictions could be made (Johnson, 1996). Keeping the optimisation goal in mind, these predictions seemed perfectly suitable for basing a firm's strategy upon. The entire economical system was treated as a black box. Taking on a firm's perspective Williamson (2008) states that "*The chief mission of neoclassical economics is to understand how the price system coordinates the use of resources, not the inner workings of real firms*".

NCE summarises results, with demand and supply being in equilibrium, or are at least tending in that direction, and for that reason change is not needed to be understood (Lynne, 1986). This characteristic of NCE entails that in market analyses external factors are held constant, in economics often called the *ceteris paribus* assumption. This is one of the main criticisms of another school of economists who called themselves Institutional Economists (IE), nowadays referred to as the Old (or Original) Institutional Economists (OIE). Following the *ceteris paribus* assumption, factors which may be of importance to the understanding of the system, would be held constant, for instance, political decisions or market coordination mechanisms. These often have underlying socio-economic aspects, and are indeed subject to change (Nagelkerke, 1992). When considering the bunker market, the largest changes in the last decade were related to the economic situation and it is clear that the major causes of the 2008 financial crisis are all but explicable through the NCE. Exactly the most impactful changes can arise in those aspects that are held constant for a neoclassic economist, because irrational behaviour is actually of influence. Moreover, the motive to perform this study is the changing legislative environment. Changing sulphur regulations are seen as an external factor to the purely NCE market view of demand, supply and according rational price formation. So, it is exactly the "*ceteris*" which is actually interesting to look into, in the light of the interactions that are actually involved in the changing legislation and changing bunker market.

Besides that, there is a big difference between how a system *should* behave and how a system actually behaves or *can* behave. The first presumes a more prescriptive model, while the second is more descriptive (Bray and Wailes, 1998). The Institutional Economists increasingly criticised the neoclassical way of looking at an economic system; a market is more than thus perfectly rational actors simply acting on supply and demand optimums.

Old Institutional Economics

Wilber and Harrison's describe the methodological foundation of the Old Institutional Economics (Wilber and Harrison, 1978). They advocate the use of OIE as a way to analyse the complexity of systems: describing instead of predicting, leaving open a range of possible outcomes of a more social analysis. This social character of the theory presumes that humans act irrational and it therefore focuses on (collective) behaviour. This behaviour is an essential part of the economic system, as are its complex interdependencies. As Wilber and Harrison (1978) conclude, the formal model of the NCE cannot deal with "the large range of variables, the specificity of institutions and the non-generality of behaviour".

So it is clear the institutionalists take a different view on economics than the traditional (NCE) economists. This view can be characterised as belonging to the social sciences: the formal analyses should get more substance. The OIE incorporates the general scientific desire to find out why things happen. In analysing markets it is inevitable that general models do not fit on every situation and thus tend to lose meaning. There is always an interaction between suppliers, customers, legislators etc.. They continuously act and react, leading to foreseen, but especially unforeseen consequences. And it must be said that these interactions are not only expressed by internal dynamics, i.e. 'the marketplace', but also by external developments, which are not least dynamic by nature. The importance of the environment and the circumstances in which markets function is emphasised by Giddens (1986), referring to Marx: "Men (let us immediately say human beings) make history, but not in circumstances of their own choosing".

As the name suggests, the OIE proposes the incorporation of institutions in economic analyses. But what are institutions? When consulting the Collins English Dictionary (n.d.), the following definitions are given:

- *"an organisation ... devoted to the promotion of a particular cause ... of a public character"*
- *"a well-established and structured pattern of behaviour or of relationships that is accepted as a fundamental part of a culture"*
- *"any established law or custom."*

Although many institutions are organisations (e.g. firms or co-operatives), some are not (laws, money) (Kherallah and Kirsten, 2002). In OIE institutions are thus not seen as specific organisations, but more as structures: structures of culture or structures of law. These can be classified as external institutions. The external institutions can be of social, economic or political nature. To these, I add the internal institutions, focusing more on (social) interactions, i.e. norms and attitudes in a specific market or industry (Hodgson, 2006). However, individuals or individual behaviour cannot be seen as institutions, because institutions must have a certain degree of durability (Goodin, 1996). Institutions are both intended/controlled (e.g. sulphur legislation, fuel standards) and determined/unintended (e.g. differences between cultures) and can have a formal and informal character.

To summarise these definitions, Nagelkerke (1992) describes institutions as "intentional or unintentional norms, rules and structures that control, prescribe and make possible (economic) action". Institutions are therefore able to describe the entire system in which the simple supply and demand functions of the formal NCE methods are calculated.

Now that the term 'institutions' is defined, a final distinction between NCE and OIE is made. It concerns the fact that NCE focuses on individual action, where OIE tends towards collectivism. There is a principal difference between individuals making economic choices based on egoistic motives or based on socially established principles. In the latter case, one can speak of collective action.

Criticism on OIE

However, this collectivism of the OIE, this high degree of abstraction, has become subject of criticism. This can be seen in the same light as the holism portrayed by Wilber and Harrison. No theory tells us what

specific generalised method or tool to use for a holistic approach, as “holists allow the nature of the subject matter to dictate the specific method most appropriate”. This is one of the reasons why the Old Institutional Economics, of which this approach is a part, seems somewhat anti-theoretical to some (Stigler, 1983; Coase, 1984), although this claim is debated by others (Hodgson, 2001; Williamson, 2008).

Of course, every development in bunker fuel market – being changing regulatory environments, fuel choice for shipping or bunker price increases – is interconnected with a large amount of variables and every relation may be interesting to discuss. Therefore, in describing and analysing the bunker market, a structure of theory is needed. As mentioned in chapter 2, this structure is required to include both the different levels of institutions and the level of competition within the market. But to keep a structure and to prevent getting lost in the amount of information, the attention is shifted to the New Institutional Economics, which provides us with a way to structure institutions.

3.2. Neo-institutional structure

OIE focuses on institutions as being essential to explain, but also to influence economic behaviour. NIE also stresses the importance of social, economic and political institutions. Institutions, as meant by the OIE, are referred to as the institutional environment by NIE, as opposed to the institutional arrangements introduced by NIE. The emergence of NIE is briefly discussed, before diving into the four-layers of institutions.

3.2.1.Origins of NIE

The emergence of the NIE is commonly attributed to Coase's article “The Nature of the Firm” (1937). Together with his article “The problem of Social Cost” (1960), Coase focused the attention towards the cost of transacting as “being the key to economic performance” (Kherallah and Kirsten, 2002). Davis and North (1971) depict the institutional environment and institutional arrangements as the driving forces of transaction costs. Logically, the NIE, as OIE, thus also incorporates the use of institutions in economics and stresses its importance. Focusing on the effects of the IMO rules in relation to sulphur emissions, institutions, in fact, are essential to incorporate. However, unlike the OIE, NIE does not discard the use of NCE and argues that the economic system can be analysed through the inclusion of some aspects of the NCE framework. Where the OIE takes a broader view on the individual and generalises towards collective behaviour, NIE takes on the NCE-argument that individuals are acting on their own interest by only focusing on maximising their objective function, of course subject to the constraints the institutions impose (Kherallah and Kirsten, 2002). But some NCE assumptions are relaxed, such as perfect competition and information, full rationality and zero transaction costs. However, the incorporation of the notion of individuals maximising their objective functions, has become one of the criticisms of NIE, it seems to lack the ability to adapt to contextual dynamics (referred to as *shifts* by Williamson (1991b)). These criticisms further back up the choice not to engage in the calculation of the quantitative issues. NIE is not used here to reach an optimum for bunker fuel procurement for shipping lines nor to justifying any make-or-buy decision in the bunker trading business. It is applied here to help structure the institutional environment and its interactions with the market by using the four-layer model. TCE-concepts of uncertainty, asset specificity and frequency can help argument the possible choices (of shipping lines, refineries, traders etc.) in reaction to the changing legislative environment.

Oliver Williamson (1998) makes The distinction between institutional environment and institutional arrangements is also made by. He explicitly splits the NIE theory in the two, but renames them “the rules of the game” and “the play of the game”, referring to Coase (1937; 1960). These institutions will be further categorised in paragraph 3.2.1 according to Williamson's four-layer model. During the play of the game transaction costs arise. Incorporating these transaction costs in economic analyses is an essential aspect of NIE. In any economic activity transactions take places and optimising on the costs of these transactions has led to many different modes of governance, being contracts or private organisations coordinating the

transactions. The transaction characteristics (or dimensions) that determine which mode of governance is suitable, are valuable for the analysis within this study and will be dealt with in paragraph 3.2.2, which explains the theory of transaction cost economics (TCE).

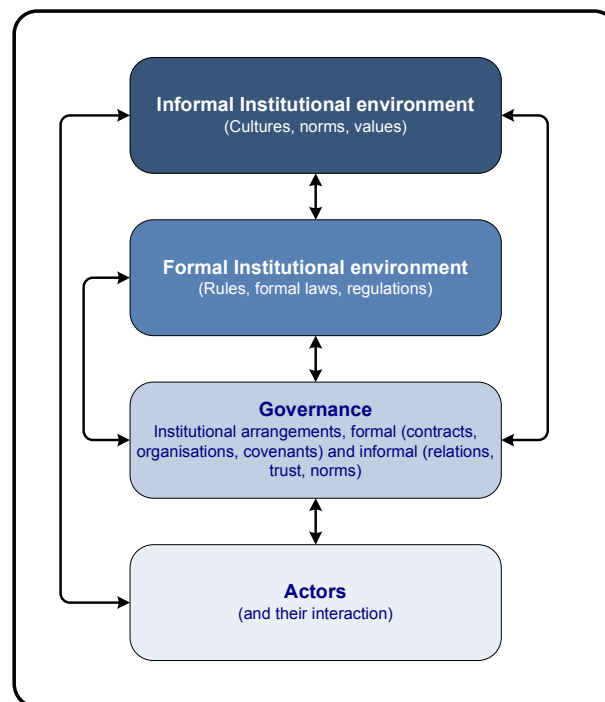
3.2.2. Williamson's four-layer model

North (1991) states that institutions are “the humanly devised constraints that structure political, economic, and social interactions. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)”. He further explains this by arguing that the latter are constraints on behaviour, but that the former are “moral, ethical, behavioural norms which define the contours constraining the way in which the rules and regulations are specified and enforcement is carried out” (North, 1984).

Williamson (1998) takes this notion as a significant distinction. Koppenjan and Groenewegen (2005) follow him in this with their version of the four-layer model. They split the institutional environment in two: the informal and the formal institutions. These two form the top two levels of his four-layer model, the informal institutions being level 1 and the formal being level 2. It is these two levels of the model that receive special interest in this study. The third and fourth level form part of the five-forces analysis and are not elaborated upon in a separate section.

The third level of institutions concerns the institutional arrangements, with which we are also by now familiar. This level deals with the structure in which a market is organized and how it is coordinated by means of e.g. contracts and organisations. This level is of great significance for this study and being the ‘home base’ for Transaction Cost Economics, it is dealt with separately later on in this section. The final level consists of individual actors and their interactions. This layer is shaped by the upper three levels of institutions, but as advocated in chapter two, there is room for interactions between the layers.

Figure 3-1 The four-layer model: levels of institutional analysis



Source: Adapted from (Koppenjan and Groenewegen, 2005)

This four-level model is presented in Figure 3-1, after which it is further explained. It must be noted that the boundaries between the layers aren't always as clear, so the layers aren't necessarily exclusive. Furthermore each layer interrelates with one another, which emphasises institutional dynamics.

Informal Institutions

This level deals with the social embeddedness of the economic system under study. Matters we would consider to be part of a culture, i.e. norms, values, traditions, are located at this level. An important role is given to religion, which has historically shaped many of these matters (Williamson, 1998). These informal rules of the game influence the way in which actors on the actor level see problems or solutions, i.e. their mind set (Koppenjan and Groenewegen, 2005). They are mostly treated as a given, because of their spontaneous origin. As it concerns aspects embedded in (a) society, change occurs very slowly, according to Williamson (1998) on the order of centuries to millennia. However, the institutions form constraints that significantly influence the direction in which society develops.

The global character of this study can illustrate this by emphasising the differences between countries. These differences are visible when, for instance, developing countries are compared to developed countries. In the developed countries the emphasis on environmental damage of our current habits has led to increasing awareness towards a cleaner and more sustainable world – with lower sulphur emissions from international shipping. This is a mind-set that has grown for decades and this development is not seen to the same degree in the developing countries. Why this is the case can be interesting and maybe be related to the social embeddedness of environmental awareness. This example stresses the important background on which the bunker market evolves: the informal institutions. The variety among nations or continents is not designed, but indeed evolved through time. On this background, Majumdar and Ramaswamy (1994) argue that “in other geographical market domains such as Asia or Africa incentives may differ” to those in ‘the West’. An example of this view is given by Hennart (1988) in a study on vertical integration in the aluminium and tin industry. He found that the level of vertical integration in Indonesia and Bolivia were very high, while it was low in Thailand, Malaysia and Australia and he attributed these differences to the different historical paths and state interventions. Human actions within different cultures, in either the form of rules and laws or behaviour, determine differently evolving economic situations (Byars, 1991; Hamilton, 2009). Although the informal institutions are not the primary focus of this research, the cultural differences will be briefly addressed.

Formal Institutions

Furubotn and Richter (2010) repeat that the market is not just “supply and demand that determines the price”. To be able to function properly, the market requires a set of rules “that regulate not only the price mechanism, but also the other basic functions of trade like search, inspection, contract execution, control, and enforcement”. These rules are the formal rules of the game within which the economic activities are organised (Williamson, 1998). These laws are in place to deal with market imperfections or failures, as well as with environmental or social issues. The way in which these laws develop are constrained and shaped by the abovementioned cultural aspects. In turn they influence the way in which markets are coordinated, the type of network relations and the degree of vertical integration of firms. The effect of formal institutions on market performance – and thus on economic growth – can be profound, but on the other hand, the economic development may require a change in legislation. When looking at global markets, for example, the international trade has led to the development of international standards and grades (Kherallah and Kirsten, 2002). This underlines the interrelatedness between the different levels. Competition law or price regulations are not so much in focus here, but more so the environmental legislation. Standards have been mentioned as important, but the changing limits to air pollution from global maritime transport are at the heart of this study. The development of sulphur limits in emissions control area's (ECA's), but also globally, is likely to have an impact on many links in the bunker value chain.

Governance

The third level relates to the institutional arrangements, meaning the governance of the market. Parties within a market or network design a way to coordinate the transactions between them (Koppenjan and Groenewegen, 2005). They do so because it is very costly to design an entire legal system that can enforce every type of contract. One must compare the cost of a public (court) ordering with that of a private ordering. The fact is that private ordering is most often a less costly way to coordinate transactions (Williamson, 1998). As, mentioned earlier, this level is called the play of the game. What it entails is that parties choose a form of organisation, a mode of governance. Different modes of governance are market, firms, hybrids of the two and bureaus. The question of governance often leads to the question whether to vertically integrate, but this is not given much attention as such, as this does not help to answer the main research questions (although the concept of “vertical integration” might nonetheless play a role within the market analysis). This question is narrowly tied to the form of contracting, which might be more interesting when describing the structure of the market. Is the market characterised by frequent, short term (spot) contracts or less frequent long-term contracts? The type of contract says much about the relation between the different actors. Are there long-term agreements between bunker suppliers, traders and/or shipping lines? If so, it could be the case because of market uncertainty, e.g. price fluctuations and security of supply, or it can simply be a matter of trust. Spot-markets can coordinate a market in a way that reflects a high degree of competition and may influence the power relationship between buyer and seller. These themes are all important elements of Transaction Cost Economics.

Individual actors

The final level concerns the individual actors and their interactions. This level is predominantly reserved for NCE. The concepts are price and output, as a function of resource allocation and employment. A main question here is how prices are set, considering the institutional environment as well as the governance within a market. This all seems straightforward. However, NIE touches upon two different characteristics of human behaviour. The first questions in how far individuals behave rationally and the second the possibility to behave opportunistically.

The ability to act efficiently – i.e. minimise costs and maximise profits – assumes total rationality with the actor. However, it is not difficult to understand that decisions cannot be made on the basis of complete information. NIE assumes no individual party has complete information, be it about pricing, local bunker supply or demand or any other factor influencing behaviour within the bunker market. Their rationality is bounded, hence the term “bounded rationality”. Even if all information is to be available, actors do not have the capacity to absorb and use all this information to make ex ante calculations (Groenewegen and Lemstra, 2007). This same bounded rationality can be seen in the process of contracting. This link with the third level of the framework suggests that contracts are thus inherently incomplete. This entails that ex ante no contract can be set up that is complete, which can avoid unanticipated ex post costs. Therefore, if one actor is dependent on another, this incompleteness can lead to power. And this power can be abused – affecting prices and/or output – which brings us to the second characteristic of human behaviour: opportunism. Incomplete information or information asymmetry about, for instance, near-future large deliveries or purchases of fuel oil in a bunkering port may, for instance, temporarily lead to the exertion of power by the information owner. Local supply and demand balances can be disturbed by large players (suppliers) and this therefore influences prices. However, according to Groenewegen and Lemstra (2007), this does not mean that all actors always try to behave in this way. Actually the contrary is true. Most parties tend to optimise their efficiency by relying on an informal aspect of contracting, which is trust. If everyone trusts each other, no transactions costs (in this case the costs of abusing the incomplete information) are incurred. This further accentuates the grey area that exists between layers.

These two factors are not found in a specific section or paragraph within this study, but do play a role throughout the entire market analysis. Again, the dimensions of TCE impact this role to a large extent. Why this is the case is further explained in the following paragraph as well as section 7, which analyses

the future of the bunker market. But the question will be whether or not the current market situation provides room for opportunistic behaviour or – on the contrary – it relies on a certain amount of trust.

3.2.3.Transaction Cost Economics

Often the term TCE is used interchangeably with NIE. Within this research, however, I would like to make a distinction between the two. TCE can be seen as a branch of NIE. For this reason, TCE is described separately.

The concept of TCE: prediction and analysis of dynamics

Coase (1937) was the first to mention the economics of transaction costs. His views considered the “nature of the firm”, describing the predictive way of using TCE. This proposes that decision makers are able to define the most suitable mode of governance by focusing purely on costs and comparing the extent to which the different modes economise on costs, specifically on the transaction costs. This, however, is still a broad term. Transaction costs can be, amongst others: costs of information, negotiation, monitoring, coordination, and enforcement of contracts (Kherallah and Kirsten, 2002). Coase's perspective on transaction costs, as being used to select an optimal mode of governance, is the most common.

However, it has already become clear that in this study we will refrain from taking a single firm's perspective and working a way to the most optimal mode of governance, neither is the focus on prediction. The focus is shifted away from actual transaction costs and the TCE-concepts of uncertainty, asset specificity and frequency are used in a broader sense; the question whether or not to vertically integrate, to “make or buy” is put aside and we take a look at future decision making of the most important (groups of) actors within the bunker market. The transaction dimensions are placed in a context of future actions and developments within the bunker market, resulting from industry trends and changing sulphur legislation. Dynamics – as mentioned earlier – thus plays a central role.

An analysis of future decisions is not ideally done by using a static market analysis, but more so by analysing the extent to which the drivers of these decisions are dynamic themselves. Decision making is all but static or solely price-driven. This research applies the TCE concepts of asset specificity, uncertainty and frequency and assesses the degree to which they actually function as drivers for future developments in the bunker market as a reaction to the changing sulphur legislation and perhaps if they are dynamic themselves. However, TCE-analysis is in itself static. A change in the institutional environment, which Williamson (1991b) calls “a shift”, can be dealt with by intertemporally comparing the transaction costs under both sets of shift parameters leading to different optimality, i.e. governance mode. This is called a “static-comparative analysis” and is an “adaptation toward a new equilibrium after an exogenous shock” (Groenewegen and Vromen, 1996). But here, I step away from this static characteristic of TCE and use the three transaction (or investment) attributes in a dynamic environment, in a more descriptive, OIE way. I here re-emphasise that this application is not what Williamson had originally envisioned with TCE.

Attributes of transactions

The attributes of investments play a central role in analysing future actions by industry parties in the bunker market. Originally, TCE is a theory that proposes that an actor will organise itself in such a way “that is conditioned by the underlying nature of the activities it pursues” (Lamminmaki, 2009). Here, the nature of the activities is directly linked to that of investments. The strategy (of which investments form a part) on how to act in a changing environment may have the same underlying arguments as an individual transaction. Shipping liners, for instance, can have similar arguments for setting up a transaction for a specific cargo as for their entire global strategy.

Although there are many attributes one can think of, the three dimensions which are especially instructive (Williamson, 1998) are:

- Uncertainty
- Asset specificity
- Frequency

It is not hard to understand that uncertainty plays an important role in the strategies of companies. It is a characteristic of transactions which any player within the bunker market would like to minimise. Here, uncertainty is divided in environmental uncertainty and behavioural uncertainty. Environmental uncertainty, as in 'the environment' described in section 4, does not refer to the ecology but to the surroundings as a whole.⁵ The environment in which the bunker market functions can influence actions of individual players, but it is the unanticipated changes in this environment that can form risks in transactions. The uncertainty can be expressed by non-foreseeable changes in formal institutions, such as the sulphur regulations and product standards, but also by changes in the state of the global economy. A good example of the latter are the shocks the bunker market had to endure following the financial crisis, which arose in 2008. The economic situation determines, for a significant part, the change in demand or supply for bunker fuel, as can legislation. Security of supply or demand may therefore be an important issue within the bunker market.

Behavioural uncertainty concerns the actions of counterparties within the bunker market. The aforementioned bounded rationality concept, that parties have limited capabilities to process all information, can lead to opportunistic behaviour. More specific, the uncertainty stems from *ex post* opportunistic behaviour by one of the contracting partners. So it is a matter of trust, because not all possible behaviour can be incorporated in contracts (as a way to eliminate uncertainty). This uncertainty relates to the length of contracts, and also to the frequency of contracting, which will be discussed later in this paragraph. The governance structure of the bunker market, e.g. the price setting scheme, is closely related to individual's ability to behave opportunistically. Spot markets leave little room for contracts dealing which can deal with behavioural uncertainty, but then again there also seems little need for them in highly competitive, short-term trading markets. Opportunistic behaviour is more common in situations where actors can get locked-in by their investments, because it is reliant on the counterparty. Investment decisions can be delayed because of this uncertainty. With refineries, storage tanks and ships, the bunker market is a capital intensive market and investment decisions may be dependent on the contracts with suppliers or buyers, or in the case of spot markets, the demand or supply projections (collective counterparty action). Future investments may be put off by uncertainty, as players want to avoid the risk of lock-in.

The second dimension of transaction is asset specificity.⁶ Although Williamson distinguishes six types of asset specificity (Williamson, 1991a), but I will depict three of those six types that are of interest in the case of the bunker market: site specificity, physical asset specificity and human asset specificity. Site or location specificity relates to the importance of a specific location to the business of a company. Often it concerns access to infrastructure or transport modes and distance to the customer or supplier. But site specificity can have other dimensions. One is the local government policy. A refinery, for instance, can face much stricter environmental legislation in Europe than in Africa. So, the location of a company or an asset also brings along a certain legislative environment that may be different to others. Physical asset specificity deals with the physical assets of a company and to what extent those assets can be used for other purposes or other customers. Highly specific refineries may only be suitable to process one type of crude or to produce only a certain product output. In the same way, ships have specific engines, engineered to handle only a specific range of bunker fuels. So along the bunker value chain, physical asset specificity may play a role in the future changing market. Finally, there is human specificity. This aspect

⁵ As opposed to when we refer to environmental legislation. In that case the ecological sense of the word is meant.

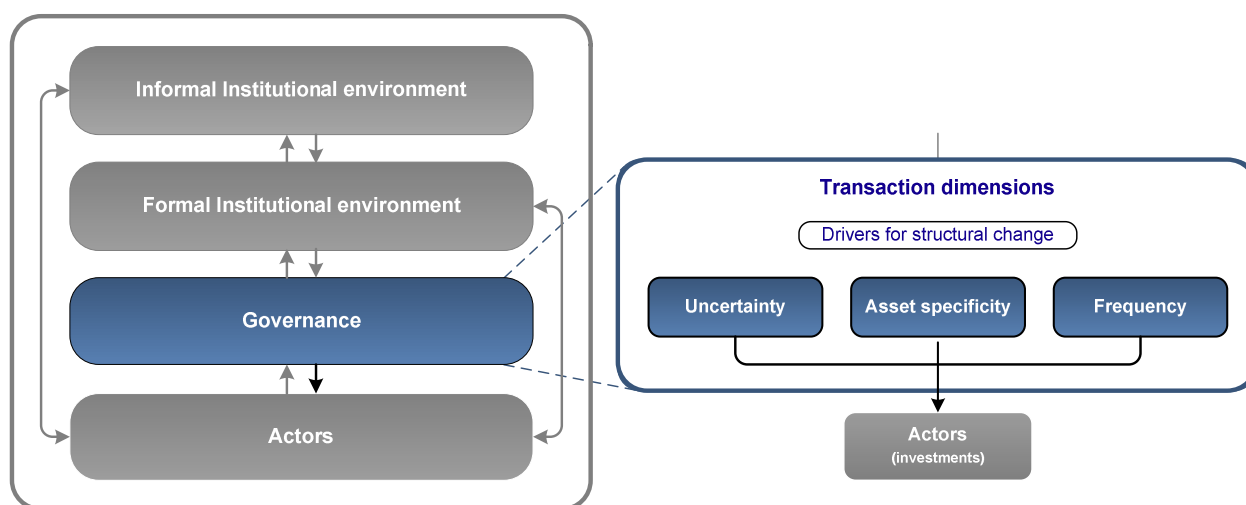
⁶ There is a difference between specialised and specific assets. Specificity implies that the asset is not usable or valuable outside the purpose it is being used for. This does not apply to specialised assets. This distinction is not of primary concern here, so will not get any further attention. The term 'specificity' is the one under study here.

will play a less significant role in the analysis of the future bunker market. This asset specificity concerns the combination of knowledge, experience and relations with counterparties. With the lack of these three, transaction costs may be higher than when there is a long-living trusting relation with the counterparty, being either a supplier or a customer. It is all these asset specificities that may serve as a lock-in for the choice of a form of governance or investment, and can invoke a certain path-dependency (North, 1990).

The third and final dimension of transactions is their frequency. Frequency means how often the transaction takes place. With an increasing amount of transactions, the transaction costs will logically rise. The frequency of transactions may justify certain modes of governance (Haase, 2009). High frequency can ask for vertical integration (due to the high transaction costs), when taking a firm's perspective, while taking the market's perspective it may ask for a spot market in order to efficiently coordinate the transactions. Spot market prices give powerful incentives "for exploiting profit opportunities and market participants are quick to adapt to changing circumstances as information is revealed through prices" (Klein, 2000). Spot markets therefore help to counter possible information asymmetry. Long-term agreements, however may encourage withholding information, but could be more suitable to handle uncertainties. Ships for international trade travel many miles on many voyages each year and they need regular refuelling, often in many different locations. So, it is unlikely that ship operators sign long-term delivery contracts. Long-term delivery contracts, however, would be beneficial for those parties, as fewer contracts have to be negotiated, which means less transaction costs.

So, how do these concepts relate to the earlier presented four-layer model? NIE theorists place TCE in the third level, that of governance (see Figure 3-2). These three concepts influence the investment decisions made on the lowest level, that of the actors.

Figure 3-2 Transaction (investment) attributes



3.3. Porter's Competitive Forces

Filling in the Porter model is important for the market description provided in section 5. It is a good model to help illustrate the current competitive situation for bunker fuels, i.e. the status quo. The "five forces driving industry competition", as Michael Porter depicts them, are helpful to formulate competitive strategy for a firm (Porter, 1980). The combination of these five forces determine the potential for profit making within an industry. Determining the strength of competition for this study on the bunker market does not focus on seeking profit possibilities for a specific firm, but is used to identify the structural elements that give shape to the bunker market. The aim is to describe, as opposed to forming strategy. The following explanation given of the five competitive forces is also used as a structure for section 5 and will

also play a role in section 6, covering future analysis. For the explanation the theory from Porter's book *Competitive Strategy* (1980) is taken as a guideline.

The five forces depicted by Michael Porter are:

- Market rivalry
- Threat of new entrants
- Threat of substitutes
- Bargaining power of suppliers
- Bargaining power of customers

3.3.1. Market rivalry

Rivalry in markets occurs because one or more competitors experiences the pressure of other competitors or sees a chance to improve its or their position. Mutual dependency triggers reaction from other competitors and this game of action and reaction leaves the market in a state in which it remains the question whether or not the first actor (or the market as a whole) actually benefits. Competition can be seen on the level of pricing, but also in advertisements or product differentiation. This competition, if it were to be seen in a static way, leads to a certain balance or market state. This market state is what will be described in section 5. Four factors play a role in determining the degree of rivalry within the bunker market.

At first, the playing field is mentioned. The bunker market has a number of players, which all have certain market shares and may be concentrated or not. The value chain (see section 5) distinguishes the refining industry, the mid-stream part of the chain and the global shipping industry. The playing field is also dividable into these three categories, because shipping companies cannot be mixed up with refineries, although both active in the bunker market.

Secondly, the industry growth gets considerable attention. This emphasises the potential of the market, high growth perspectives may give rise to many opportunities of e.g. capacity expansions. This aspect also elaborates on whether the market is difficult or tight and may ask for cost cuts or divestments.

The third aspect relates to fixed costs within the market. High fixed costs may lead to substantial exit barriers, especially if the asset are very specific (like refineries), because firms want to recover those costs and conversion or liquidation may be very costly. Overcapacity or shortages are terms often associated with this aspect of the market rivalry.

The final aspect refers to the ownership of the competitors. Is it mostly oil majors, national oil companies or independents who dominate the refining or even the bunker trade and supply market? The different types of players may have different strategic goals and thus play a different role.

3.3.2. Threat of entry

The ease or difficulty for new competitors to enter a market is important to the current players. New competitors can threaten their position, so incumbents will try to keep others from entering their market. The threat of entry therefore depends on the barriers to entry and on the reactions from the existing players if new competitors were to enter the market. This threat is thus explained by summing up the major barriers to entry for the bunker market. Five barriers to entry are mentioned in this study: economies of scale, product differentiation, required capital, location and government policy.

Economies of scale arise whenever the costs per product decline as more of the product in a specific period is produced. Incumbents that enjoy economies of scale would want to produce as much of the

product as possible as long as it raises marginal profit. This leads to companies being too large for a small potential new entrant to compete with, without incurring some sort of cost disadvantage. This can be a considerable barrier to entry. An important aspect touching the subject of economies of scale is vertical integration. Assuming companies integrate with the aim to minimize cost of the end product, this integration itself can form the barrier to entry (however, not all integration leads to cost minimising).

Another barrier to entry could be the need to differentiate in the product produced or service provided. This barrier is especially important in markets where existing competitors have long lasting relations with their customers, who have become loyal. If a new entrant would want to persuade the customer they would have to come with a unique product or service that is attractive enough for the customer to switch. So, for shipping liners high switching costs to other fuel types mean higher barriers to entry. The product for the bunker market is mostly fuel oil and the varying qualities can be the only product differentials. If the market is highly standardised, there is no real entry barrier that relates to product differentiation.

The third barrier to entry is capital investments required to enter the market. In the bunker market one can look at the capital investments for refineries, storage tanks or on-board fuel systems for ship owners. Many services in the bunker market might only require human capital. High capital requirements for doing business is clearly a significant barrier. Correlated with the capital investments is the capital position of the competitors. If incumbents have a very strong cash position, entering might be even more risky. The capital position of the existing competitors is strongly related to their ownership (e.g. they have governments backing them up or not).

The location the players are stationed can be very important for their position in the market. Being situated in important bunkering ports may be a significant advantage for players in the bunker market. But not everybody can build their office, refinery or storage tank in these popular locations, due to rising land prices or simply lack of free space. If activities in the bunker market are location specific, this can form a severe barrier to entry.

Finally, governments can play a role in the barriers to entry. One can think of environmental regulations, which can lead to increased costs, which may be hard to recover for new entrants. Strict emission requirements can impose barriers to a specific (geographical) market. In the case of the bunker market, the sulphur limits can play a role for future entrants. Competition law is another way for governments to raise a barrier. Governments can be protective of their home market, therefore blocking access for foreign players.

3.3.3. Threat of substitutes

Competition in a market is not only visible between the competitors themselves, but can often also be noticed between the products or services they offer. This competition between substitute products can lead to lower prices and impact the degree of profitability in a certain product market. Substitutes are products (or services) that can perform the same function. In market with high profits (and where barriers to entry are high) the threat of new substitutes is considerable, as players invest in R&D to develop another product with the same function. In the light of the bunker market, there are not many dimensions along which substitutes can be developed. Shipping as a mode of transport may be substitutable, as well as financial services in bunker trade, but the main threat of substitutes will probably be seen in the fuels market. Fuel oil is currently the most widely used fuel for large marine diesel engines, but other fuels may take its place, possibly turning the entire bunker market around. When looking at the threat of substitutes, collective industry action is probably the largest threat. If the entire customer base within the bunker market would choose to buy other fuel types, the impact can be huge.

3.3.4. Bargaining power of suppliers

The bargaining power of suppliers refers to the ability of suppliers to raise prices or reduce quality of the product or service in question. This power becomes apparent if the customer is not able to recover the cost increase in their own prices. There are three situations in which the possible power of suppliers is worth looking at. The first is supplier concentration, the second is the lack of alternatives and the third relates to the product-customer relation. Within this research, suppliers may be either refineries, as producers of fuel oil, or the bunker supplier, being the party that blends the fuel oil up to specification.

In a market with only few suppliers and many customers, there will undoubtedly be enough incentive for those suppliers to bargain. Popular product qualities may only be available with a small group of suppliers, which could be the case when considering crude qualities as input for refineries. Countries may even have the possibility to exert power in negotiating prices, because of their natural resources and competition policies. In the oil industry this is not uncommon.

Products may take up a large part of the variable costs for customers or may be essential for their business. In this case, the supplier is in a bargaining position, it can lower prices or product quality, as the customer has little choice than to accept the product and prices, because they rely heavily on the supplier. The other way around, if the specific customer is essential for the sales of the supplier, there is little room left to exert power, especially if the switching costs for the customer are low. So the importance *for* and *of* the customer is essential in defining the suppliers bargaining power. In a perfect competition there is no room at all to bargain. So the question is to what extent is the bunker market perfect?

3.3.5. Bargaining power of customers

The final force influencing competition, as defined by Porter, is bargaining power of the customer. In this study this force is divided in three reasons for customers to bargain: customers aim at forcing down prices, they demand high product quality and lastly, they ask for more services.

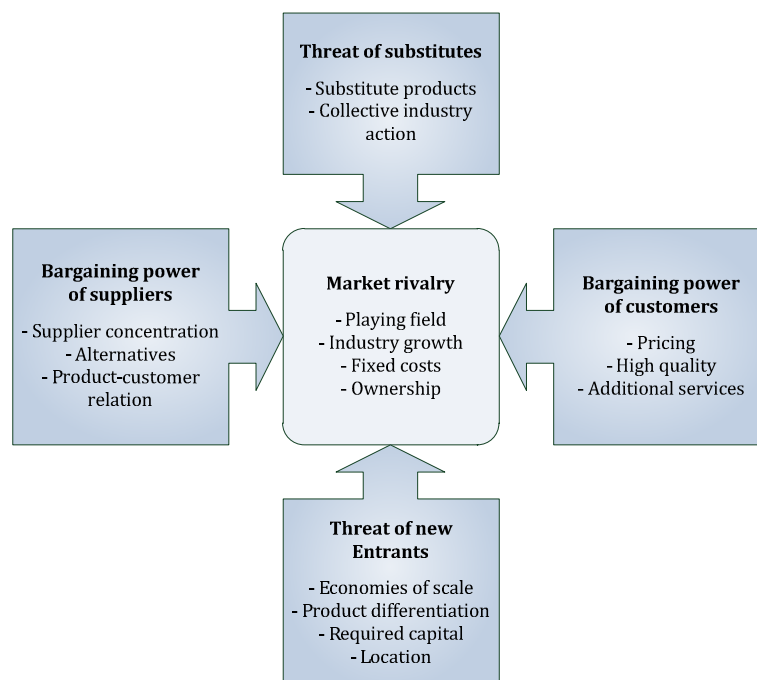
One important aspect when considering the ability of customers to force down prices, is the way in which prices are set. A very clear example of this is the presence of a spot market. If prices were to be set on spot markets, any possible information asymmetry between sellers and buyers is eliminated. Standardised products leave little room for suppliers to ask higher prices than the spot market prescribes. Switching costs are related to this. In spot markets, switching costs are (in general) low, which gives some power to the customer. Closed or protective markets, with less transparent price formation, leave less room for bargaining by customers. Another factor might give customers a sense of power and that is their size. If the customer size is large if compared to the supplier, this may leave the customer with the upper hand when it comes to prices setting.

Besides price, the second reason for customers to bargain is that customers demand a certain quality. This sounds contradictory to what was described earlier: bargaining power for suppliers manifests itself in too high prices and/or too low a quality. But customers can indeed be in the position to not only want, but also demand products or services at a specific quality. This can be the case when standards apply to the product and customers can contest the quality of the delivered product to the specification written down in the standards. Further quality aspects relate to environmental legislation, which would require the supplier to meet certain emission or waste limits, in this case perhaps the sulphur content of marine fuels.

Finally, in highly competitive markets with many suppliers if price setting is done on the spot market and quality is standardised, there is one more aspect left to bargain for, which are additional services. These additional services have a personalised character and can be part of a long-term relationship between supplier and buyer. In the bunker market, besides delivering bunker fuel, additional services could include price hedging or priority purchasing.

The following figure (Figure 3-3) summarises the factors that make up these five forces and will be used in the bunker market description.

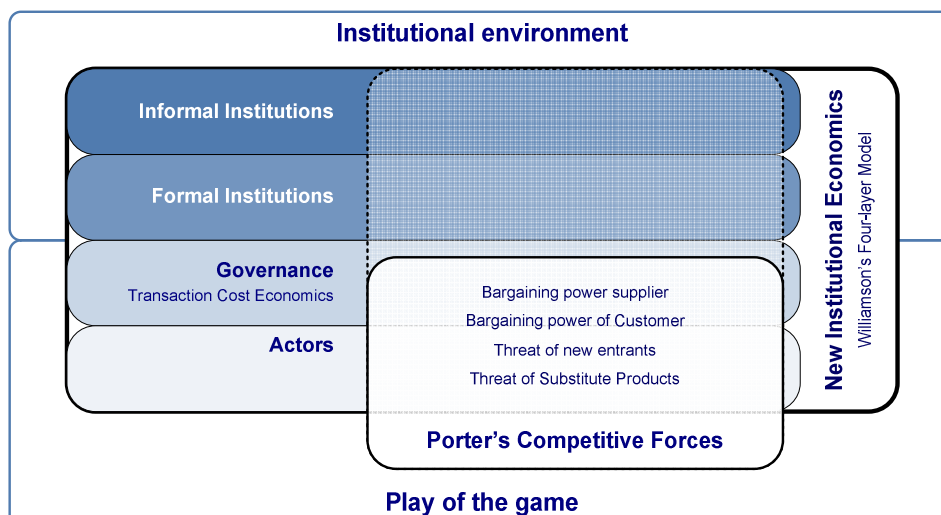
Figure 3-3 Porter's Five Competitive Forces



3.4. The NIE-Porter framework

The two theories described in this section can be combined by laying the one on top of the other. The five forces are not bound to one of Williamson's four layers or his concepts within TCE. Each of the five forces actually has all four layers influencing them, as is shown in Figure 3-4. The same goes for the TCE-attributes, as they cannot be assigned to a specific force within Porter's model. Porter's forces will function as a body for describing the functioning of the bunker market.

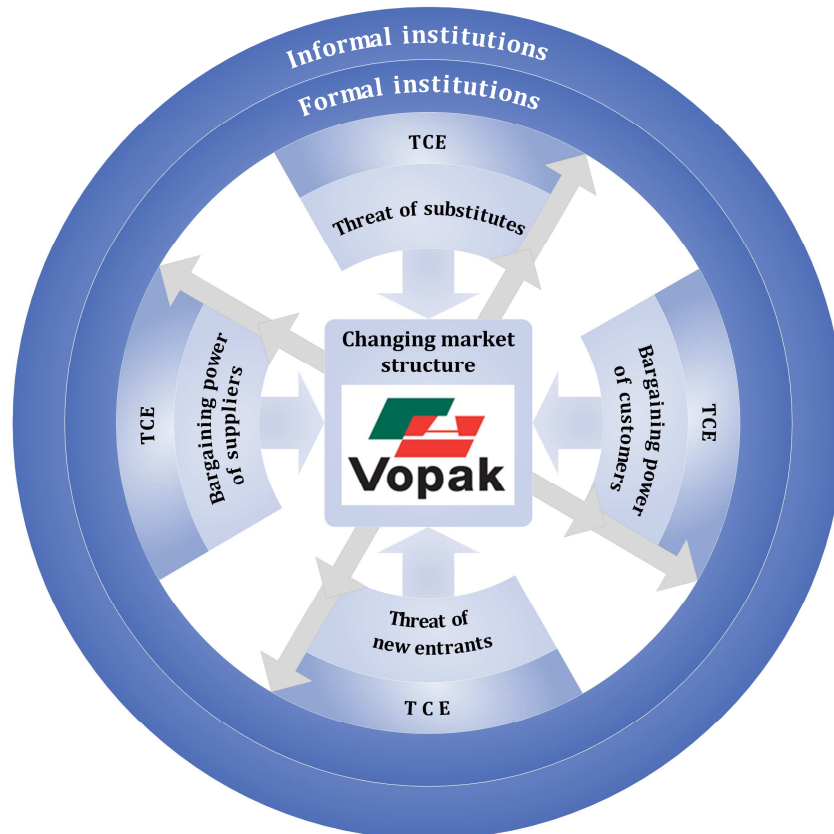
Figure 3-4 Relating the four-layer model to Porter



The market structure is bounded by its institutional environment, i.e. norms, values and cultural inheritance that vary across different regions of the world, leading to varying legislation schemes. The omnipresent environment will be influencing each of the five forces. The TCE concept have, of course, the same environment influencing the investment decisions to be made in response to changing sulphur limits. These decisions are based in the third level of Williamson four-layer model and have an impact across the market, as described by Porter.

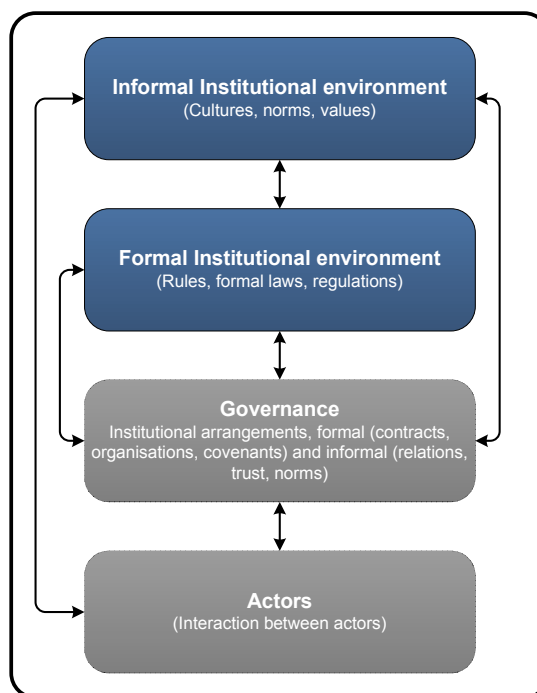
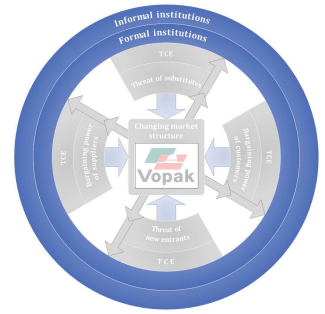
Again, the five forces are not bound to just one of Williamson's four layers and this is neither to his concepts within TCE. Uncertainty, asset specificity and frequency can also not be assigned to a specific force within Porter's model. The body of the research is given by Porter's forces, while TCE incorporates the market description provided by Porter and analyses industry action, in turn influencing the future market according to Porter. This all is summarised in Figure 3-5. The influence of all mentioned concepts on Vopak is shown by arrows pointing inwards, while possible influence of Vopak on its environment is represented by outgoing arrows.

Figure 3-5 Combining theories for analysing future developments and their impact



4. Institutional environment

Following the explanation of the bunker value chain, it is time to apply the first part of the NIE theory on the bunker market. The theory discussed in this section concerns the institutional environment, which comprises both the informal and formal institutions (see the figure below). These institutions form the background on which the market functions, but are also an integral part of the market, however some more than others. One can imagine that extensive regulations impact the market's functioning considerably. The first paragraph will go into the informal institutions, touching on the cultural subjects. The second paragraph is divided in the sulphur regulations and fuel standards, both having a significant impact on bunkering. Thirdly, the impact of the state of the global economy is described, after which a final paragraph will sum up the role of the institutional environment.



4.1. Informal institutions

The informal institutions, as described in section 3, touch on the more socially embedded aspects of the market. What is interesting with respect to the bunker market is to identify the differences between countries. This is emphasized by its global character, while at the same time the bunker market is also a collection of local markets, the geographical sub-markets. However, it is difficult to pinpoint certain social or cultural characteristic of a country or region and lay down direct causal relations with the local market functioning. There don't seem to be any differences in the physical processes around the world, but the cultural differences can be felt on a higher level, mostly concerning the way of governing the different markets.

4.1.1. Economic transition and government control

The first aspect that marks a difference between countries with a substantial bunker market is government intervention. Protectionism, information availability and ownership of companies within the

bunker market are just a few results of varying economic cultures. The degree of government intervention and, with it, the degree of liberalisation is a product of different economic transition paths. Although these aspects are not directly related to general values or norms and cannot be seen apart from formal institutions, the development of “economic cultures” is important to get an understanding of the differences in doing business in the oil industry (and thus the bunker market) between countries.

The twentieth century has been crucial for the development of the current economic systems. Currently, capitalist societies dominate the global economy, but there are some important differences in transition paths of especially capitalist and socialist countries. The OECD countries, especially the U.S. and Europe have a (relatively) long history of democracy and free market. Most of the past century was marked by the development of free trade and little government intervention. Japan had seen a similar development in the second half of the twentieth century. The former Soviet Union, however, underwent an economic reform only in the last decade of the twentieth century. Via democratisation and liberalisation, these countries switched from publically owned companies to privatisation. China, however is undergoing enormous economic reforms and their transition to a market economy has occurred without democratisation and privatisation is still not common (Qian, 1999).

Russia has seen a considerable economic transition in the past two decades. However, the Russian transition has been very difficult (Rittenberg and Tregarthen, 2008). Among other former soviet countries, like the Czech Republic or Poland, this transition has gone a lot smoother. Why is this the case? Despite the advances made, there is still some doubt as to whether these developments are sustainable in the long term, because the crucial role of oil. The power within the oil industry remains with the president and a small group of oligarchs. Much of the oil industry is state controlled and foreign investors must always leave a majority of new projects in hands of a domestic player, making foreign investments often unattractive. Russia is also protective to some extent when it comes to taxes. The tax regime in Russia influences the (primarily) the export market and this is exactly what the bunker market is concerned with. A similar influence is seen in India.

China has long been a communist state, with a communist economy. Although the communist still rule the country, their economy has seen considerable reform and is improving towards a capital market. But the government's control over the economy is still deep-rooted. Private investments are all but daily practise as most large companies active in global markets (especially in the oil industry) as well as investment funds are state owned. Within the bunker market only two players own more than 95% of the bunker sales within China's territory and, yes, these are both state owned. This stresses the Chinese urge to keep the entire market in their own hands. This thus leads to a considerably different market situation in Chinese ports than in a free and open bunker market like Singapore, witness the price difference in favour of the latter. China is however starting to ease the access to its bunker market, however the changes go slowly.

As in the example of China can be seen, the ownership of companies in bunkering across the globe can be important. In countries that produce large amounts of oil traditionally have a large share of that production in government's control. Examples are Saudi-Aramco (Saudi-Arabia), Rosneft (Russia), Iranian National Oil Company (INOC) and Sinopec (China). These state ownerships all come down to power over own supplies, which is embedded in the oil industry and dates back to the early stages of the “Oil Imperialism” in the first half of the twentieth century (Maugeri, 2007). So, it is clear that the politicisation has always been part of the oil industry culture.

4.1.2.Environmental awareness

When it comes to environmental awareness, not all regions in the world have the same mind set. In the light of sulphur emission restriction, it is wise to take a look at the commitment and willingness to enforce the legislation across the globe. With development comes awareness of the environment. This is common

belief and there is a certain amount of logic in this. Along the twentieth century, Western countries have developed from heavy industrialised countries to high-tech, mostly services oriented economies. The heavy industry moved from “the West” to “the East”, as the wages were far lower there, especially in Asia. With The Club of Rome, the first major worries arose about the depleting oilfields and the climate change due to greenhouse gas emissions (Club of Rome, 2012). Initiators of international climate policy came from predominantly OECD countries. Developing countries have had other priorities than a clean environment and sustainable energy sources, as the economic growth is crucial and ‘green’ policies are not thought to fit in the picture. For example, China’s air quality is very poor and the environment has not gotten that much attention. However, in recent years China’s attitude towards pollution is rapidly changing, following a change in mind set (W. Dijkstra; personal communication, February 29, 2012). In this light, China has a culture of strict governmental policy and associated compliance, so more strict environmental policy could have a great impact. Another example of lacking environmental policy is Africa. At first, these countries have far lower levels of emissions than developed countries and have limited budgets to combat emissions. This is also reflected in the lower responsibilities and financial obligations these countries have been given concerning future climate goals, like the Kyoto Protocol’s Clean Development Mechanism (UNFCCC, 2012). Other reasons for less environmental legislation in these countries can be given, such as poverty, unstable governments, corruption etc.; all of which have been associated with developing countries for a long time.

Europe, and more specific the EU and its predecessors, has been the largest proponents of green technologies and have focused many policies on reducing pollution. Already in 1970 the EEC introduced legislation regarding transport pollution (EC, 1970), which shows that the environmental awareness is more embedded in European society. Following the policies – which have evolved along the years – the road transport sector has been forced to innovate towards lower emissions (e.g. more efficient engines).

The United States have never been very progressive when it comes to environmental legislation, witness e.g. the rejection of the Kyoto Protocol. The U.S. have historically been dependent on oil and their oil supplies have committed the consumer to fossil fuels. Past ecological advances have predominantly been technology driven instead of policy driven, which has been the case in the EU (W. Dijkstra, J. Kolpa; personal communication, February 29, 2012). In the last decade, however, with rising oil prices and increasing worldwide attention on the environment, the U.S. have also seen a shift in mind set.

These developments in environmental awareness have played an essential role in the development of the IMO-MARPOL rules. It is the shift in mind set that has led to the ratification of so many countries worldwide. Any future developments in legislation is largely dependent on the mind-set regarding pollution, especially in non-OECD countries.

4.2. Formal Institutions

As emphasised in section 3, economy and the institutional environment are inherently linked. Constructing, implementing and enforcing sulphur regulations are both political and economic activities. It is the legislation that shapes the differences between countries, following more informal, cultural variations described in the previous. In this paragraph it is the rules and laws that shape the bunker market, focusing especially on sulphur emissions that play a central role. A short introduction to the history of sulphur legislation is followed by the description of the MARPOL process and its contents. Standards also play an important role and are discussed subsequently. More information on enforcement issues and other developments in the formal environment will conclude this paragraph.

4.2.1. Maritime sulphur emission regulation

The organisation behind international maritime sulphur regulations is the International Maritime Organisation (IMO). On the background of growing awareness for the negative effects of air pollution, the

IMO wrote and amended the MARPOL 73/78 Convention up to the regulations now ratified by all Member States representing the vast majority of international shipping. Additional information on the past developments of sulphur emission regulation is provided in Annex F.

The IMO

Currently, the IMO has 170 Member states and three Associate Members, encompassing over 98% of the world fleet. So, in fact, every nation with considerable interests in international shipping is represented in the Assembly of the IMO. Besides Member States there are also other organisations involved with the IMO. Also non-governmental organisations and intergovernmental organisations cooperate with the IMO.

The IMO is an international organisation, however it does not have any legal power of its own. It is primarily an arena where all 170 Member States can discuss and negotiate on maritime affairs and subsequently take decisions on (writing new or amending existing) any of the IMO conventions. This thus leaves the responsibility of developing and maintaining the regulatory framework with the Member States.

The committee responsible for environmental affairs within the IMO is the *Marine Environment Protection Committee* (MEPC) and it plays a central role in the IMO rules on pollution. The main task for the MEPC is to design new conventions to be ratified as well as amending the existing conventions.

Establishment of MARPOL: a lengthy process

In 1973, in the same year and month in which the MEPC was established, the first convention on marine pollution was held. Seventy-one Member States were present and ended up adopting the *International Convention for the Prevention of Pollution from Ships* (MARPOL – short for *marine pollution*) (IMO, 2012b). Before entering into force, however, it had to be ratified by all Member States. This process seemed difficult as by 1978 it was still not into force. Several oil spill disasters in the years 1976-1977 led to adopting a new protocol, which absorbed the parent convention of 1973, creating the MARPOL 73/78. Finally, MARPOL 73/78 entered into force, ten years after the first Convention, on October the 2nd 1983 (IMO, 2012b). The first annex (Annex I) within the MARPOL Convention concerned the prevention of oil pollution. In the following years the MEPC increased their focus on maritime air pollution, including fuel oil quality - and started a long-term work programme on this issue in 1990 (IMO, 2012a).

Finally, in 1997, a new Protocol, MARPOL Annex VI was adopted. This Annex focuses especially on air pollution. It sets limits for the emission of sulphur oxides and nitrogen oxides from the exhausts of ships and it prohibits “deliberate emissions of ozone depleting substances” (IMO, 2012h). It was the first marine pollution agreement that limited the sulphur content of fuel oil. It included a global cap of 4.5% m/m sulphur in fuel oil and the IMO was to monitor the global average sulphur content. The global cap was deliberately set at modest levels in order to be accepted by enough Member States to be ratified (Vagstad, 2007). Sulphur oxide emissions were set in Regulation 14 of MARPOL Annex VI. Within this regulation, specially designated *Sulphur Emission Control Areas* (SECA's, later named ECA's as they are to include other emission as well) areas were established. These areas would have more stringent sulphur emission regulations (IMO, 2012h). The cap of sulphur within the fuel oil used on board was set at 1.5% m/m. Equivalent technological measures were allowed to reach the same goal, namely exhaust gas cleaning systems, also named scrubbers. These clean the SO_x emissions out of the exhaust, and thus not require low sulphur fuel oil. The first designated SECA's were the Baltic Sea and the North Sea, the same two areas which had been the most progressive in reducing marine air pollution in the past. But it took another eight years for the Protocol to enter into force, when it was ratified by 25 States, representing 50 % of the world tonnage (Vagstad, 2007), on May 19th 2005. At present, 70 States have ratified the Protocol, accumulating to more than 93% of the world tonnage (IMO, 2012i). In October 2008 a revision of the Protocol was adopted and entered into force on July 1st 2010 (IMO, 2008). This revision further tightened emission limits, e.g. a global cap of 3.5%. The status quo of the MARPOL Annex VI and the specific limits will be elaborated upon in the next paragraph.

It is clear that the establishment of concrete regulations concerning sulphur emissions has been a lengthy process. From the first talks on marine air pollution in the 1980's until the development of the 1997 MARPOL Annex VI protocol and the subsequent entering into force in 2005, it showed a time span of over two decades. The fact that the global average sulphur content in marine fuel oil is around 2.6% (Kalli, Karvonen et al., 2009) makes the current global cap, set at 3.5%, seem negligible. So, real progress still has to be made. Besides, the existence of ECA's suggests that a single global approach is not a realistic one and that steps (by adding ECA's and lowering caps) are taken in the process of reducing the sulphur emissions world-wide.

Uniform character

The IMO has set up a procedure for amending the annexes of MARPOL. This procedure allows amendments to be made only if a majority of two thirds supports the amendment, preventing just a few States blocking the amendment. Such amendments have been made in 2008 and came into force in 2010. MARPOL's requirements are, as is the case with other IMO treaties, uniformly applied to ships sailing under any flag of the Member States, so there is no distinction between developed and developing countries (Bodansky, 2011) as opposed to the climate goals laid down in the Kyoto Protocol, which does make this distinction (UNFCCC, 2012). Of course, there is a distinction between ECA's and non-ECA's, but this is because the ECA's have initiated stricter regulations themselves. The reason why the IMO uses this uniformity, is that the shipping industry has such a global character (Bodansky, 2011). Bodansky (2011) cites a note by the IMO stating that "shipping is a global industry and ships are competing in a single global market, it must be regulated at the global level for any control regime to be effective and to maintain a level playing field for all ships irrespective of flag (nationality) or ownership". Each of the States have the responsibility of enforcing the regulations set out by MARPOL. Considering that over 98% of the world fleet is owned by the 170 Member States, there is no real possibility to circumvent the regulations by registering vessels under non-Member flag states.

4.2.2.MARPOL Annex VI Regulation 14

The status quo of the Protocol refers to the revised MARPOL Annex VI Regulation 14 of 2008, which entered into force in July 2010 (IMO, 2008) and focuses on sulphur and PM. It is largely comparable with the earlier 2005 version, but most significant changes were made seen to the tightening of the sulphur limits, while some smaller details were also modified. Other regulations in MARPOL Annex VI are not explained here, as the focus lies on the sulphur regulation and the effects of sulphur limits to fuel usage in the shipping sector. Another, often mentioned type of air pollution are NO_x emissions, but these are combustion related and not fuel related. The possible impact of the regulation on NO_x (Regulation 13), but also of measures combating CO₂ emissions⁷ will get more attention in section 6.

As described in section 2 the emission of sulphur also leads to secondary pollution, particulate matter, (PM). Sulphur oxides (SO_x) and PM are controlled via Regulation 14. The regulation applies to all the fuels used as fuel for ships, as well as combustion machinery and other devices on board. The thus regulation includes all main and auxiliary engines, together with boilers and gas generators (IMO, 2012e). The sulphur limit is applicable globally, but also to specific Emission Control Areas (ECA's)⁸. The latter have stricter limits and additional legislation is in place in these areas, but they are in excess of the MARPOL protocol.

⁷ CO₂ emissions are climate-related (greenhouse gasses, GHG) and do not fall under "air pollution". They are not (yet) part of MARPOL Annex VI

⁸ Previously known as SECA's, specifically designated areas for *sulphur* limits, but nowadays these areas are also under control for other types of emissions, therefore simply named ECA's.

Sulphur content

Regulation 14 of MARPOL Annex VI describes the limits to the sulphur content of the fuel oil as it is bunkered. The fuel oil supplier is to state this content on the bunker delivery note (BDN). Once loaded on board, the ship's operator (either the vessel owner or the ship charterer, see section 6) is responsible for complying with the limits. This means that when ships sail partly inside and partly outside ECA's – i.e. ships must comply with different limits, ship operators need to ensure different fuels are used and stored separately, thus avoiding mixing, which would bring the risk of not complying with the stricter ECA limits.

The sulphur limits represent the maximum sulphur content “of the fuel oils as loaded, bunkered, and subsequently used on-board” (IMO, 2012e). Note that the limits are expressed in mass percentage, presented in % m/m and are subject to change over the years. Table 4-1 shows the applicable sulphur limits as stated in MARPOL Annex VI Regulation 14.

Table 4-1 Sulphur limits outside and inside ECA's

Outside ECA's	Inside ECA's
4.50% m/m prior to 1 January 2012	1.50% m/m prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020 ⁹	0.10% m/m on and after 1 January 2015

Source: (IMO, 2012e)

The global cap of 0.5%, which is planned for 2020, is not fixed as the Regulation mentions that this date depends on a review taking place in 2018. This review will determine the availability of fuel oil (or gasoil) to comply with the sulphur limits, taking into account the global supply and demand for the fuels and an analyses of trends at that time.

Besides providing limits to the sulphur content, Annex VI (Regulation 4.1) also mentions that there are different means to comply. There are equivalent measures which could be taken to reach the same SO_x and PM levels as with lowering the sulphur content of the fuel oil. In general the means to comply is divided in two categories. The primary method is to avoid forming pollution, which means low sulphur content, while the second method allows for the pollution to be formed, but removes it prior to the discharge of the created exhaust gasses to the environment. For these secondary control methods, guidelines have been set up for exhaust gas cleaning systems, which use water to wash out the sulphur, before discharge to the atmosphere. In this case there wouldn't be any constraint as to the sulphur content of the fuel oil used on board. The equivalent allowable sulphur emissions (expressed in the ratio between SO₂(ppm) and CO₂(%v/v) emissions) when using secondary methods to comply are presented in Table 4-2.

Table 4-2 Sulphur limits and exhaust gas equivalent¹⁰

Fuel oil sulphur content (% m/m)	Ratio emissions SO ₂ (ppm)/CO ₂ (%v/v)
4.50	195.0
3.50	151.7

⁹ Susceptible to review in 2018, may be delayed to 2025

¹⁰ The higher the sulphur content within a fuel (ratio S/C), the higher also the ratio SO₂/CO₂ emissions. CO₂ is the primary exhaust gas (volume percentage of exhaust gas), in which a certain amount of SO₂ particles (parts per million, ppm) can be present.

1.50	65.0
1.0	43.3
0.5	21.7
0.1	4.3

Emission Control Areas

In very early stages the States around the North Sea and the Baltic Sea have had problems with the slow ratification process of MARPOL Annex VI Protocol, as well as with the global sulphur limits that were proposed. These limits were deliberately set high to ease the ratification of the Protocol. The mentioned States increasingly acknowledged the devastating effects of sulphur oxide emissions and attributed acid rain and the role the shipping industry plays. Studies showed that estimates of about 70–80 per cent of all ship emissions occur within 400 km (248 miles) of land, and that the global shipping industry accounts for 4-9 per cent of global emissions (Corbett and Koehler, 2003; IMO, 2009).

Parallel to the IMO these countries started to develop their own, much stricter, sulphur limits. By the time the MARPOL Annex VI came into force, the first two SECA's were already adopted (the Baltic Sea already in 1997 and the North Sea and the English Channel in 2005), and so Annex VI added ECA's to the Protocol. The United States coast line followed in 2010. Table 4-3 presents the current ECA's and when they will take effect.

Table 4-3 Annex VI: Prevention of air pollution by ships (Emission Control Areas)

Special Areas	Adopted	Date of entry into force	In effect from ¹¹
Baltic Sea (SO _x)	26 Sept 1997	19 May 2005	19 May 2006
North Sea (SO _x)	22 Jul 2005	22 Nov 2006	22 Nov 2007
North American (SO _x and NO _x and PM)	26 Mar 2010	1 Aug 2011	1 Aug 2012
United States Caribbean Sea ECA (SO _x , NO _x and PM)	26 Jul 2011	1 Jan 2013	1 Jan 2014

Source: (IMO, 2012f)

For ships that sail both inside and outside ECA's and operate on different fuel oils as to comply with the different limits it is obligatory to have switched between fuels completely to ECA compliant fuel before entering the ECA. In the same way, ships aren't allowed to change-over until after leaving the ECA. On-board personnel is thus to be fully instructed on how to do this. Both change-overs need to be fully documented in a logbook, i.e. fuel quantities, date, time and position of the ship.

Implementation

The revised Annex VI has entered into force in July 2010, but it is still up to the Member States to enforce the Protocol, as the IMO itself does not have any power to do this. First the Member States have to incorporate the IMO regulations into their own legislation. The best examples of states implementing the IMO rules are the European Union and the United States. The IMO sulphur limits from Regulation 14 of

¹¹ During the first twelve months immediately following an amendment designating a specific Emission Control Area under paragraph 3.2 of this regulation, ships operating in that Emission Control Area are exempt from the requirements specific for ECA's (IMO, 2008)

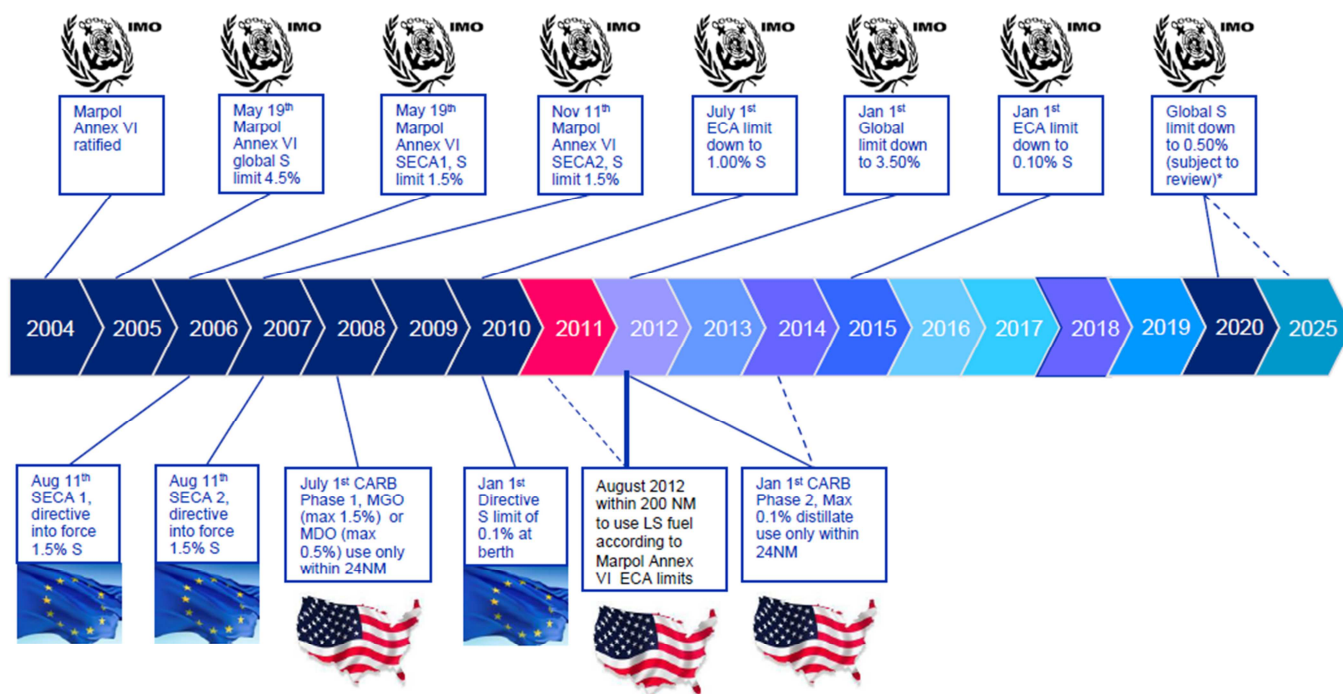
Annex VI presented in Table 4-1 are also laid out across a timeline in Figure 4-1, in which also the implementation steps of the EU and the U.S. are presented.

European Union

The Directive 1999/32/EC was the translation of the MARPOL Annex VI regulation, which was adopted in 1997 (EC, 1999). In 2005 this directive was amended by Directive 2005/33/EC, which is the directive being currently in place (EC, 2005b). There are slight differences between this directive and Annex VI. They address the same issues, but, for instance, the 2005/33/EC directive described different implementation dates for the North Sea and English Channel ECA (August 11 2007, instead of May 19 2007, as written in Annex VI). But more important, the EU directive has specific sulphur limits for ships on regular service, i.e. passenger vessels (set at 1.5%). Furthermore, ships at berth and at inland waterways within the EU territories are to sail on fuels with a sulphur content that does not exceed 0.1%.

Currently, the EU is in the middle of a legislative procedure for a second amendment of the 1999 directive. On May 23rd 2012, the Committee of Permanent Representatives agreed upon the compromise proposal directive amending 1999/32/EC, which incorporates the Annex VI amendments of 2008, but adds that the 0.5% sulphur cap outside ECA's will enter into force in EU waters by 2020, thus not being subject to further review in 2018, as is the case with the 0.5% global cap of Annex VI. The same would go for the passenger vessels operating outside ECA's to which currently a limit of 1.5% applies. Like with Annex VI, the use¹² of marine fuels with a sulphur content in excess of 3.5% will not be allowed, with exception of those ships that are equipped with exhaust gas cleaning systems (scrubbers) (EU Council, 2012). A plenary voting in the European Parliament on the adoption of the proposal is planned for September 11th 2012.

Figure 4-1 Global sulphur limits timeline



Source: (IMO, 2008; DNV, 2011)

¹² Fuels with sulphur limits exceeding 3.5% are still allowed to be traded as cargo. It is the actual usage, i.e. loaded into ship's fuel tanks, which will be prohibited.

United States

On March 26th, 2010, the IMO amended MARPOL by designating specific portions of the U.S. as well as Canada and French waters as an ECA. The first two states proposed for ECA designation on grounds of “common interests, shared geography and interrelated economies” (EPA, 2010). The island territories of Saint-Pierre and Miquelon were added, by initiative of France, as they lie off the coast of Newfoundland.

One year later, on July 15th 2011, areas in U.S. Caribbean waters were added to the ECA, including the U.S. Virgin Islands and Puerto Rico. The lead time associated with the amendment process of the IMO means the added ECA will enter into force in January 2014 (EPA, 2011).

4.2.3. Standards

In the 1960's and 1970's the only means of identification of different types of heavy fuel oil was by their maximum viscosity (Vermeire, 2007). With most fuel oil being produced by atmospheric refineries, this was not a problem. The problems arose when refineries started upgrading their facilities from straight run to more complex during the late 1970's. This called for more specification requirements, as the qualities varied increasingly. The British Standardisation Organisation (BS MA 100) and the Conseil International de Machines à Combustion (CIMAC) first published standards for marine fuels in 1982 (Vermeire, 2007).

The first international standard was established by the ISO in 1987, which was ISO 8217. The purpose of this standard is to define specific requirements for fuels used in marine diesel engines and boilers, which would serve as a guidance for parties involved in the designing of the equipment, fuel suppliers as well as fuel purchasers. This standard is still the most widely used for marine fuels, but has been adjusted several times to fit the technological developments main in marine diesel engines. The ISO 8217:2010 is presented in Annex D. Vermeire (2007) mentions the two most important specifications to ensure reliable operation. These are the upper density limit and upper Al+Si limit (so called ‘cat fines’, see section 5.1.1). The former is important to ensure satisfactory ignition quality, while the latter avoids abrasive damage to the ship's fuel system and engine.¹³ The statutory requirements on sulphur content from MARPOL Annex VI are applied to the ISO standard.

The ISO 8217 standard plays a crucial role in providing internationally recognised information as well as quality assurance about marine fuels and therefore moderates the international trade in bunker fuels. The ISO 8217:2010 is an international standard, which is not based on a legal regime, so it is not legally binding. While it is non-mandatory, it is essential that ship operators and fuel suppliers are aware of it value as a quality benchmark. Standards are therefore weak formal institutions, and may even be seen as an institutional arrangement within Williamson's four-layer model, as it eases the trade of bunker fuels and enabling global communication of the fuel quality. It is thus not formal in the sense of Annex VI, but it is partly set up according to it. Besides, the standards are not drawn up by the market parties themselves (suppliers/purchasers), but by an external, International Standardisation Organisation. For this reason it forms part of the institutional environment. So it is clear we see the linkage and interdependence between the environment and the bunker market itself.

4.2.4. Enforcement

It is up to the states within the ECA areas to make sure ships comply with the tighter sulphur limits, and the same counts for the states outside ECA's. The Port State Control (PSC) within the Member States is responsible for controlling the sulphur content. The tasks of the PSC are to inspect foreign ships calling at national ports, to verify that the condition of the ship along with its equipment and on-board fuel comply

¹³ It must be noted, however, that the cat fine limits laid down in the ISO 8217 standard are still too high to avoid any possible damage completely. As the table in Annex D shows, the maximum levels written down in the standard range from 25 to 60 mg/kg, while to avoid any problems, the level of cat fines is not to be higher than 15 mg/kg (DNV, 2011)

with the requirements of IMO regulations and that the ship is operated and staffed according to these rules (IMO, 2012g). Originally, these PSC inspections served as a back-up to the flag state's implementation of the rules and regulations, but experience has learned that cooperation on a regional basis can be very effective. Ships visiting one port often also visit other ports in the area before returning and coordinating the inspections can save time and money as unnecessary inspections can be avoided (IMO, 2012g).

Memoranda of Understanding

In 1978, a group of European countries agreed on a memorandum for auditing the labour conditions on board ships. Later also safety and pollution issues were added. This memorandum led to the Paris Memorandum of Understanding (Paris MoU) in 1982, which established a regional PSC consisting of (currently) 26 European countries together with Canada. This MoU was essentially a reaction to the failure of the inspections of flag states. In the follow-up of this first MoU on PSC, many MoU's were established, nowadays covering almost all of the world's oceans: Asia and the Pacific (Tokyo MoU); Latin America (Acuerdo de Viña del Mar); Caribbean (Caribbean MoU); West and Central Africa (Abuja MoU); the Black Sea region (Black Sea MoU); the Mediterranean (Mediterranean MoU); the Indian Ocean (Indian Ocean MoU); and the Riyadh MoU (IMO, 2012g). The U.S. is not part of any MoU; U.S. coastal waters are under inspection of the U.S. Coast Guard, which performs the same tasks as any other PSC.

Sulphur content inspections

The PSC job is to register the local suppliers of fuel oil, check the ships' logbooks containing information on the change-over operations if in ECA as well as verifying the requirements of the Bunker Delivery Note (BDN). Finally, the PSC analyses fuel samples. Suppliers of the marine fuels are obliged to provide a BDN with the delivery as well as a fuel sample. The sample is taken only for determining compliance with MARPOL Annex VI. In total, however, at least four samples are to be retained: one by the supplier, one on board, one for a testing service¹⁴ and one for MARPOL.

It is up to each individual State to inspect ships and performs the mentioned tasks. But not all States perform them to the same extent. The United States are more active than most countries under the Paris MoU. On August 1st, the North-American ECA has come into force and it seems that the U.S. Coast Guard is more determined to perform inspections than Canada (Chew, 2012). Also the Netherlands stands out when it comes to actively inspecting ships¹⁵, as samples in other countries are only carried out upon suspicion, e.g. in case of an accident, while the Dutch already carry out such testing to verify if ships comply with the low sulphur requirements to marine fuels (DNV, 2009). These inspection are only carried out at ships which stay in the port for more than a day.

What makes the uniform enforcement of the IMO regulations extremely difficult is that it is each State's own responsibility. There are no sanctions for countries with lacking control. And although MARPOL Annex VI applies to all Member States in an even manner, not all countries have the same means or will to enforce the rules in the same way. Poorer countries have less money disposable and less experience with these issues than, let's say, OECD-countries. Besides the differences between States in enforcing the sulphur regulations, there is also a lack of sampling outside ECA's, therefore there is no active enforcement of the global 3.5% cap. The only sampling is performed at random by testing firms such as DNV.¹⁶

¹⁴ For testing by independent third party testing firms, such as Det Norske Veritas (DNV). Bunker testing is a larger process than just sampling by local authorities. Frequent sampling also takes place to determine the presence of heavy metals or other impurities (such as water, cat fines or silicates) which can be damaging to marine equipment.

¹⁵ M. Vink, Dutch Inspection Authority, personal communication, March 19, 2012

¹⁶ Ibid.

Penalties

The enforcement of MARPOL Annex VI is also difficult, because there is no uniform punishment policy in case of a breach of the requirements. PSC *should* take action against fuel oil suppliers found to have delivered non-complying fuel when compared to what was stated on the BDN. The courses of action a PSC may impose on a ship in case of non-compliance comprises, in order of ascending gravity, are summed up below (Özçayır, 2004).

1. Deficiencies can be rectified within 14 days for minor infractions
2. Under specific conditions, deficiencies can be rectified when the ship arrives at the next port
3. Deficiencies must be rectified before the ship can depart the port
4. Detention of the ship

Beside detention of ships, there have also been cases where fines have been imposed. Repeat offenders could also be denied access to the port in question. These measures are of a whole different calibre. They require the application of criminal law and for most PSC's this is too time-consuming and expensive. For example, the Dutch inspection agency does not have the man power, nor the financial means to impose these penalties on parties in breach of the regulations. Giving the ship the opportunity to rectify the deficiencies before departing the port (nr. 3) is in most cases effective, as experience learns in the Netherlands.¹⁷ Detention of ships (nr. 4) is already a very strict measure, as delays are very expensive for ship operators.

In case of possible fines are any other penalties, the proposal for amending the 1999/32/EC Directive suggests that "as part of the effective, proportionate and dissuasive penalties to be set by member states in implementing the directive, possible fines should at least be equivalent of the benefits deriving from the infringements to the provisions of the directive" (EU Council, 2012). Again, it will still be up to the port in question to determine the appropriate penalties.

Chemical waste

Bunker fuel samples are not being tested for chemical waste. And although (and perhaps because) MAPROL Annex VI and ISO 8217 do not check for presence of a wide range of contaminants, there have been several cases of dumping chemical waste into bunker fuel oil (Currie, 2012). Suppliers earn big money with blending in chemical waste, as they sell the fuel oil as pure fuel oil. This waste is not only dangerous for the environment, but also detrimental for ship's engines. Vessels found having illegal contaminants on board can continue on their way and increasing calls for stricter rules and inspection are heard.

4.2.5. Other formal institutions

Besides the sulphur-related rules and regulations, which are of the course at the centre of focus in this study, there are many other formal institutions that are or can be of influence to the bunker market. In describing the different informal institutions, several important types of formal institutions have already been touched upon. These concerned laws associated with competition. China and Russia, but also India, have examples of state intervention in the market. These are formalised in the legislation of those countries.

Russian tax regime change

Russia changed its tax regime in 2011 (also known as the 60-66 tax regime), levying the darker oil products to a larger extent than the lighter products, therefore invoking upgrades of domestic refineries. The commercial incentives for refiners will change with less profit to be made with fuel oil. The idea is that more lighter products will be produced to become less dependent on other countries for supplying

¹⁷ M. Vink, Dutch Inspection Authority, personal communication, March 19, 2012

the growing market for diesel and gasoline in Russia (Fattouh and Henderson, 2012). Other tax regimes influencing competition in the oil product market, like that in India (Meijknecht, Correljé et al., 2012), are of less influence specifically to the bunker market, which is why they are not given any further attention.

China's protectionism

Private investments by foreign players are prohibited in the Chinese bunker market. Almost the entire bunker supply market is in hands of only two state owned players, being Chimbusco and Brightoil Petroleum. China has seen an enormous growth in seaborne trade the last decades and the market for bunkers is also growing steadily (Back and Galbraith, 2011). Since 2006, four new licenses were issued permitting sales of bonded marine fuels (Brightoil, 2011), however foreign investments are still forbidden. Developments are seen, though, in respect to the foreign access to Chinese markets, now that joint-ventures with Chinese oil incumbents are allowed (Back and Galbraith, 2011). This protectionist behaviour is still greatly impacting the competitiveness of the bunker market in Chinese territory, which share of global bunker market sales will in the coming decades only grow further.

4.3. Global economic trend

The final very important aspect of the environment is the global economic situation. Although the state of the economy is shaped by markets, as well as informal and formal institutions, for the bunker market it is seen as an external trend. The financial crisis of 2008 has largely impacted the global economy. Large banks went bankrupt, the housing market collapsed in large parts of the OECD-area and global consumption has declined. These external developments have had a direct impact on the demand for bunker fuel. As will be discussed in section 5.1, the markets for refining and shipping have seen significant drops in profit margins as well as lower volumes. Rodrigue (2010) emphasises the impact of the economy on global transportation by stating that:

"... economic growth and global trade have been significant vectors for the growth of mobility. Yet this process is subject to cycles of growth and recession and limits in credit based consumption. The level of activity and the structure of national economies, as well as their trade patterns, are important influence on national and global transport systems."

The global economy, and especially the bunker market, has also been influenced by fluctuating oil prices. Steeply rising oil prices, as a consequence of political tensions in the Middle East, have added to the price increase in bunker fuels, which were seen in the years 2008 and 2009-2012. Rotterdam prices fluctuated from around \$720 per tonne in July 2008, to \$180 per tonne in January 2009 and to almost \$730 per tonne on the 15th of March 2012. Of course not all of the price increase is attributable to the crude oil price changes, because the demand and supply for fuel oil play another major role. The tensions in the Middle East, particularly those concerning Iran, were political. They were the product of both the evolution of relations in the world and the sudden political decisions, thus emphasising that politics are part of both the informal and the formal institutional environment. Although these developments are not directly part of the bunker business, on the background they have a certain weight in the economics of the oil product market.

4.4. Vopak in the institutional environment

The informal institutions which are described stresses the geographical differences in terms of government control over competition as well as the environmental awareness. These institutions will not have the same implications for all players in the bunker market. When considering the restrictions some governments pose on foreign investments, this is likely to affect actors with fixed (or "site-specific" – see Chapter 7) assets in another fashion than shipping companies calling ports for bunkering. Also, the formal institutions have different impacts on the actors. So what is the impact on Vopak and can it influence the institutional status quo?

Informal institutions

Refineries will have difficulties entering local market in India or China, where governments are still relatively protective to their domestic markets and restrict foreign investments. The same goes for traders or suppliers, as sales licenses are limited for domestic and usually state-owned parties. Shipping companies do not have assets that are fixed to a location, so they are less likely to be impacted by this like the aforementioned actors are. Closed markets, however, do have a price increasing effect, due to the lack of competition.

Vopak is in a comparable position as the refineries. It has physical assets that are fixed to one location. In between the aforementioned locations Singapore has played the most important role as a bunkering port, as well as served as an attractive location for Vopak's terminals. A gradual opening of these geographical markets is currently seen in, for instance, the supermarkets market in India (Jack, 2012). But until the refining and bunker sales market is still closed, the supply of bunkers in these protective markets will still be in hands of domestic players and prices will remain significantly higher than, e.g. Singapore. When the market becomes stronger, with larger bunker sales, this could provide Vopak with opportunities to invest in new large bunkering facilities. Vopak can, as it currently does in China, try to form joint ventures with incumbents as far as that is possible. But not much can be done to influence this institutional aspect itself.

When it comes to environmental awareness, both the supply and demand side of the bunker market feel similar consequences. Refineries' emissions are taxed in roughly the same regions where the ECA's are designated for shipping emissions. The environmental awareness in these regions is something that has evolved during the last decades and is becoming a common mind-set. Its effects for bunker industry players, including Vopak, are felt through the increasing importance of environmental legislation. Green image is increasingly important and working on this green image can slightly impact the environmental awareness.

Formal institutions

The processes of developing the applicable legislation on sulphur emissions, standards and enforcement policies, have been external affairs for Vopak. Large shipping companies as well as the refining industry, being direct stakeholders, have been involved in the shaping of the IMO rules on sulphur emissions. The result – MARPOL Annex VI – is a product of the input of governments, Port Authorities and the mentioned market parties. But Vopak is not a direct stakeholder in the sulphur legislation for ships and was not present in the 'institutional arenas' (see section 2.5.4) in which it was shaped.

The effects of this legislation have also been indirect for Vopak. The increased use of LSFO in ECA's which entered into force in recent years, does require additional storage tanks, separate from the HSFO tanks, as well as separate handling systems. The effects are mostly dependent on the developments in the demand and supply of bunker fuels, so Vopak more or less follows the market in their reaction to the sulphur limits. If and in what way Vopak can play another role in the future is more extensively elaborated upon in chapter 6.

5. The bunker market

This section will provide an in-depth description of the bunker market, following the supply chain for bunker fuel, i.e. fuel oil. The value chain for fuel oil is divided in supply, mid-stream and demand. This distinction is illustrated in Figure 5-1. The supply side of the chain is dominated by refiners and in a lesser extent some traders (although important when it comes to imports). Blend component suppliers will not be dealt with in detail in this report, but are presented because blend components (cutter stocks) are crucial for the quality of the fuel. The mid-stream part of the chain is composed of the traders, brokers and storage companies. The demand consists of shipping companies (vessel owners or charterers). A description of how the physical chain is built up, together with that of the economic structure is presented through the “five forces”-framework, laid out by Michael Porter.

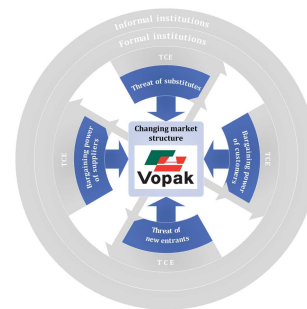
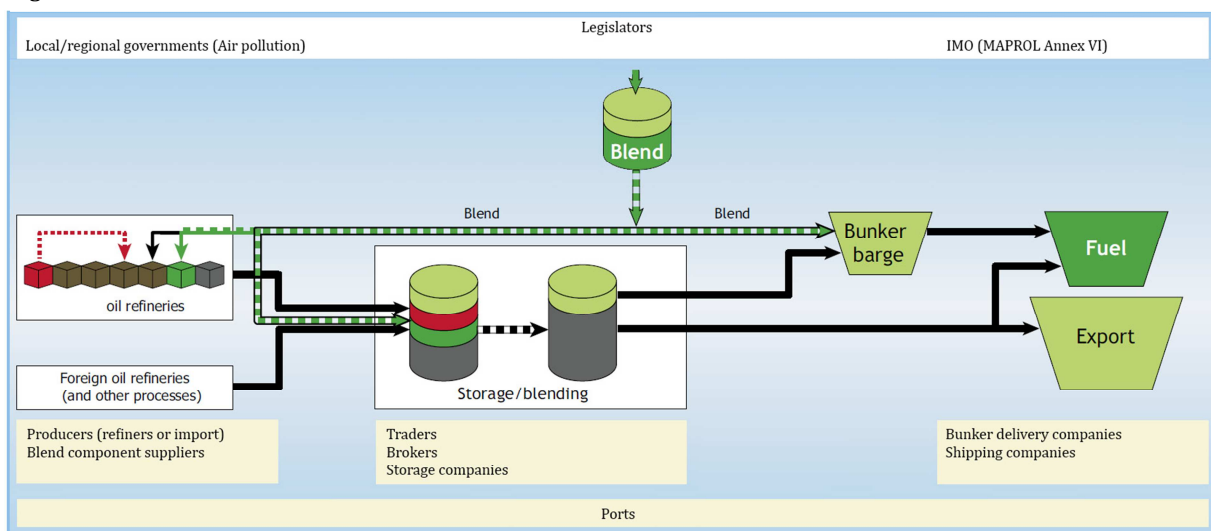


Figure 5-1 The bunker value chain



Source: (Buck, Smit et al., 2011)

5.1. Market rivalry

Rivalry in markets occurs because one or more competitors experiences the pressure of other competitors or sees a chance to improve its or their position. Mutual dependency triggers reaction from other competitors and this game of action and reaction leaves the market in a state in which it remains the question whether or not the first actor (or the market as a whole) actually benefits.

5.1.1. Refining industry

The production of fuel oil is inherently attached to the production of other, mostly lighter oil products. Refineries don't solely produce fuel oil and for this reason the fuel oil refining market cannot be seen separately from the refining industry as a whole. To get a feeling of the market rivalry in fuel oil production markets, the broader field of oil refining is described here. Before we go into the economic structure of the market, it is interesting to take a look at the refining process. The physical process of refining determines the configuration and thus the products of refineries. Different crude sources and different configurations have an important influence on the structure of the market, as will become clear later on. Refineries can thus vary in complexity, but also use different types of crude oil. The crude oil is refined into many products groups, through many different processes. After distillation of the lighter fractions of the crude, residuals are produced that may or may not meet the specifications for fuel oil. Most

residual fuels need blending to comply with standards for fuel oil, but this is generally not done at the refinery. Sometimes the refining company supplies the fuels directly to the shipping company, but more often the fuel is sold to a fuel supplier. Blend component suppliers supply the products needed to blend the fuel oil up to a certain specification, but they will not be treated separately in this study. The question of how fuel oil is actually produced, which steps are involved from crude oil to leaving the refinery as oil product is answered in Annex G.

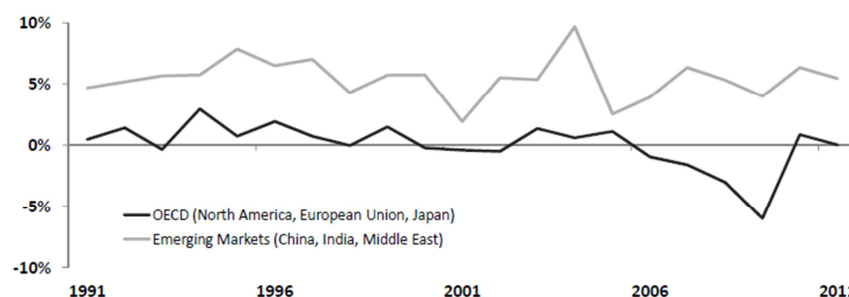
Past developments in refining

Traditionally the global refining market was the domain of few large players. Especially in the beginning of the twentieth century, the refining market was dominated by the oil majors. In the second half of past century (around the 1960's), national oil companies (NOC's) started to break with the status quo by nationalizing production. Following this trend, a free market for crude oil developed. This opened up opportunities for the establishment of independent refiners. Most independents grew during the 1980's and 1990's (Pervin & Gertz, 2009). Refineries now predominantly operate as a separate business, partly because of different tax regimes preventing oil producers from transferring crude to their refineries at below market price. Where in the past market prices of crude oil or oil products were kept secret, nowadays the market are becoming more and more transparent. Cross-subsidising is therefore easily exposed via transfer pricing. Refiners now seek the most suitable sources of crude at the lowest price.

Reactions to demand changes

In recent years the construction of refineries in developed countries has been brought to a halt. Lowering demand (see Figure 5-2) for crude oil and oil products, as well as increasing competition from emerging countries has discouraged investments of capital in new refining capacity in the OECD regions. The recent economic downturn has been of great influence on the tough position of refineries in these countries, but in the future, when the economy is back in the lift, no large growths are to be expected here.

Figure 5-2 Oil demand growth in OECD vs. Emerging Markets



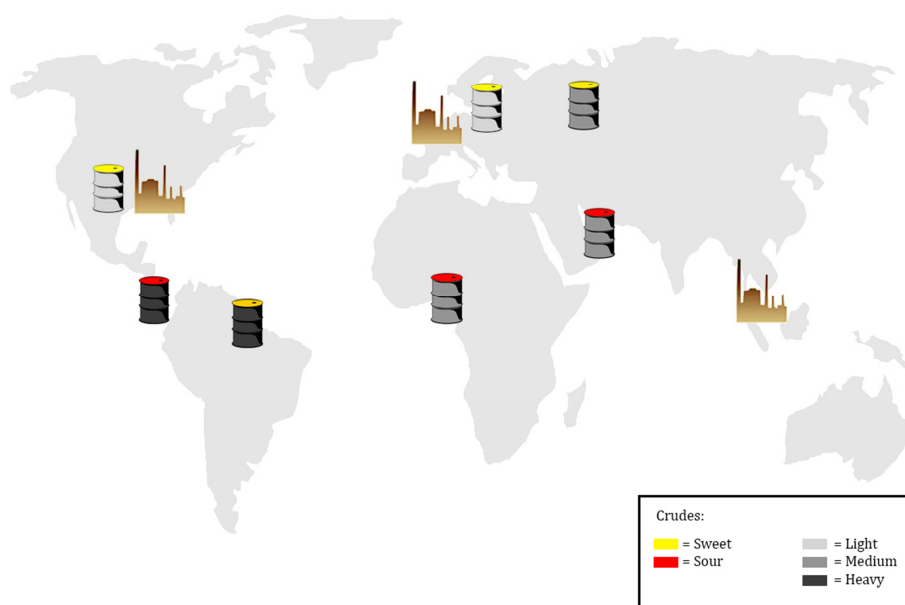
Source: (BP, 2011)

Demand is thus not equally spread across the globe. But refined products are sold on a global market, so with equally complex and efficient refineries, European refineries would not have to worry. But since 1980 no new refinery has been built in either the U.S. or Europe (Meijknecht, Correljé et al., 2012). Meanwhile, because of a steady average demand growth of around 7% between 1991 and 2010, increasing numbers of refineries are being erected in emerging markets (being China, India and the Middle East). These refineries are mostly greenfield projects, i.e. refineries without constraints of prior construction, work or land use. These refineries have the advantage that they can be purpose built for the “most recent crude supply and product demand patterns and are state-of-the-art, highly complex and enjoy low operational costs” (Meijknecht, Correljé et al., 2012).

Global market

The industry is geographically highly dispersed. The availability of crude supplies is one of the major reasons for this. Countries with major oil reserves often have large oil refining capacity. Not only supply determines the location for refining centres, but also the access to refined product markets. The imbalances between these two has resulted in large trade flows and markets developed for crude oil, but especially for refined products. The major markets for oil products now also serve as reference market for their pricing. These major markets are located in the U.S. Gulf Coast, Northwest-Europe (notably Rotterdam or the ARA area, Amsterdam-Rotterdam-Antwerp) and Singapore (Pervin & Gertz, 2009). The qualities of crude sold on these markets vary considerably. One of the major differences in crude quality is the sulphur content, another is the density (expressed in “API Gravity” measured in degrees or ° API). Crudes with a high sulphur content are referred to as “sour” crudes, while low sulphur crudes are “sweet”. Sour crudes require extra desulphurisation and dense (heavy) crudes requires extra treatment. The degree to which these crude qualities vary across the world is presented in Figure 5-3 as well as Annex G. This variety is also reflected in the output of the main refining centres. Every region has a specific product demand and supply balance (see Annex H). There is thus a geographical imbalance between supply and demand. European refineries have been producing large amounts of gasoline, as this fuel was until recently the most important fuel for road vehicles.

Figure 5-3 Global refining centres and crude qualities



The same goes for the United States. The refineries in these regions have been modified during the past decades to meet the demand of lighter fuels. They have a history of complex, deep conversion refining. Also in Asia refineries are increasingly upgraded as the demand for lower value products diminishes. Recently, more and more new deep conversion refineries have been built in the Middle East, as well as in Asia. Also, when analysing the demand and supply imbalances, we see that most trade concerns lighter products.

However, there is one exception, which is of specific interest in the light of this study. This exception is Russia. The majority of Russian refineries consists of old straight-run refineries, producing a narrower range of products, notably diesel/gasoil and fuel oil. This enhances export trade to, predominantly, North America, Europe and Singapore. At this moment there does seem to be a slight shift in the output configuration of Russian refineries as the production of lighter products is more profitable and domestic

demand for these products rises. This shift has also been triggered by recent export tax increases on fuel oil by the Russian government, as discussed in section 4.

So, we see that the configuration, i.e. the degree of refinery complexity and the specific product output, is dependent on many factors, of which the refinery location is the most important. Locational characteristics include access to crude quality, (environmental) regulation and local demand and supply.

Because the facilities in Europe and the U.S. have been in production for several decades, they have a disadvantage when it comes to the production of clean products, as still a fair amount of fuel oil is produced. But although the demand for distillates is rising, these regions are still a large consumer of fuel oil and their domestic production is, by far, not sufficient. Russia has been the major supplier of fuel oil for decades, because of the simple configuration of their refineries. Yearly, Russia exports 70% of its fuel oil production, which translates to around 55 Mt per annum (mtpa), of which 15 mtpa to North America (mostly Houston), 4 Mt to China and 7 mtpa to Amsterdam-Rotterdam-Antwerp (ARA) (Wood-Mackenzie, 2011a). The latter often functions as transit port, collecting large amounts of fuel oil before shipping it to other destinations. Singapore is another major export destination. As it is difficult to say for what applications which shipment of fuel oil is used, an amount of fuel oil exported from Russia for the bunker market can't be given.

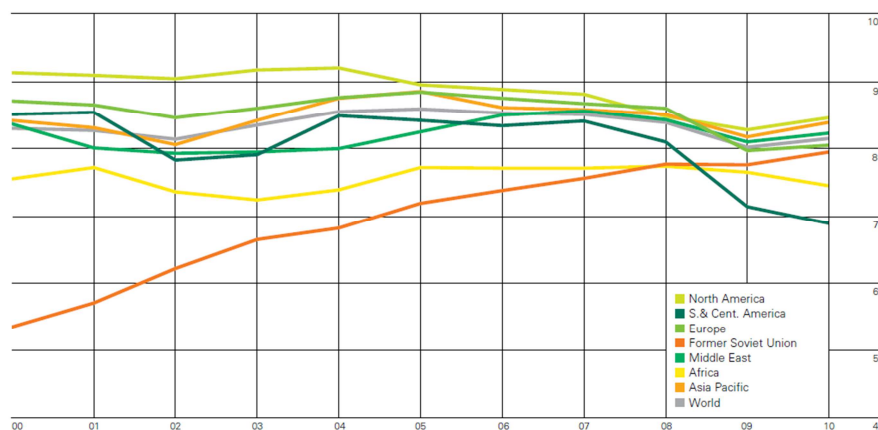
Other major fuel oil producing regions supply their own markets, but most often these amounts aren't enough to meet demand (e.g. Asia). Upgrades of refineries in North America, Europe and East Asia, but also shut downs of older refineries, lead to lower domestic production, therefore increasing their dependency on fuel oil exporters like Russia.

Other developments, such as the switch to more fuel oil usage by Japan, following the tsunami in 2011, have driven up prices for fuel oil, along with the high demands, sliding supplies and rising crude oil prices.

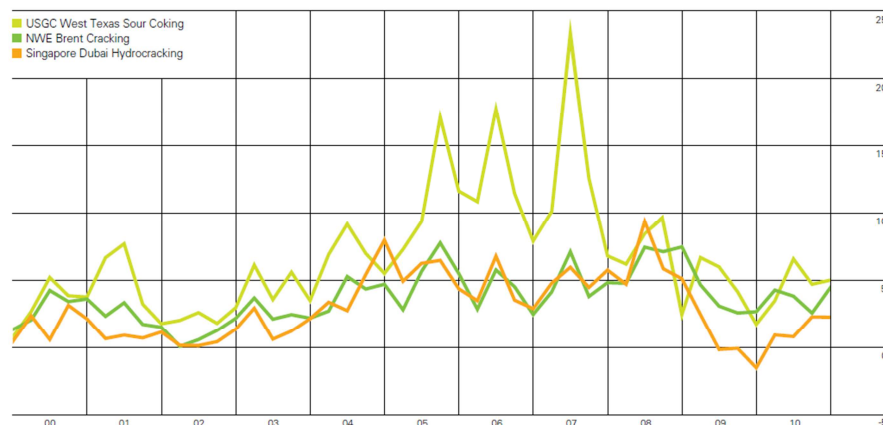
Overcapacity

Demand has a great influence on the level of investment in refining capacity. The global demand of oil products is easily met by current refining capacity and the construction of many new refineries in China and the Middle East has even led to overcapacity. In recent years utilisation rates have gone down, due to this increasing overcapacity in the global refining sector (see Figure 5-4). Furthermore, margins are very slim (Figure 5-5) and many refineries in Asia (especially Japan) and Europe even face negative margins and many are forced to shut down. An example is Petroplus, one of the largest independent refiners, which was declared bankrupt at the beginning of 2012. This fits in one of two major trends which can be depicted in the global refining sector.

Figure 5-4 Refinery utilisation in %



Source: (BP, 2011)

Figure 5-5 Refining margin, US\$/barrel

Source: (BP, 2011)

This trend is that refiners choose to focus on less sophisticated refineries, retrofit refineries into storage terminals or put them up for sale. The other trend is to invest in and upgrade plants to be able to handle heavy oils and convert them to higher value products (HPC, 2011). The latter is something that, unfortunately for them, is not done by European refiners. Russian refiners, however, take large steps to upgrade their straight-run facilities suited for high value product processing. This tendency is also visible in the Asian continent, especially countries like South Korea and Japan, due to the increasing demand for cleaner oil products as opposed to that of fuel oil.

In the refining business exit barriers are high, which make decisions to divest very difficult. The fact that divestments in this industry are no longer unheard of, stresses the difficult situation in which this industry is currently in. Refineries are highly specialised assets, having high conversion costs and they have relatively low liquidation value – assuming the plant is shut down due to competitive reasons. Besides the technological and economical restrictions of shutting down refineries, social restrictions play a role as well. In some cases, some refineries are being kept online via state intervention, because shutting down a refinery would lead to large job losses. Until recently, these assets thus kept running, leaving the excess capacity in the market, creating the overcapacity. But finally, the exit barriers did not hold in some cases.

With ownership changes in the European refining sector, the market share of the traditional oil majors (IOC's) is shrinking. According to Meijknecht et al. (2012) national oil companies (NCO's) from emerging markets are gaining market share – even in Europe – at the expense of the IOC's. This creates more diversity in the market in the sense that their strategies may differ. Different refinery owners may have different objectives. For instance, publically owned non-OECD based companies do not necessarily have the same goals as privately owned OECD based companies. The latter may be more profit and efficiency prone than the former, which are more likely to aim at security of supply for their home markets.

Legislation

Further distress in the refining markets in the U.S. and the European Union is caused by tight environmental legislations. Regulations to reduce toxins, air pollution and greenhouse gas emissions are far stricter in these regions than in other areas of the world, as has been discussed section 4. Reduction of emissions is costly and thus further deteriorates the competitive position of these refineries.

Environmental legislation is not as strict in emerging Asian countries than it is in the aforementioned regions, but even countries like China are facing some kind of regulation in this respect. Power generation plants are being forced to switch from heavy fuel oil to lighter, more environmentally friendly products like natural gas (Bloomberg, 2012b). This shift has had an impact on domestic fuel oil production in China. However, the on-going economic growth leads to higher volumes of fuel oil needed for marine transport.

Formal institutions can have a significant effect, thus emphasising how intertwined the institutional environment is with the functioning of the market. Another example is the new tax regime set up in Russia in 2011. Higher export levies for heavy oil products (including fuel oil) as compared to crude, mean lower margins for straight-run refineries, as prices on the global market stay the same. This enhances the upgrading of many refineries in Russia to produce higher quality oil products. In the future, these increased taxes to ensure the security of supply of cleaner products to the Russian domestic market are expected to lower production and exports of fuel oil. This would create problems for the global fuel oil supply and thus drive up prices. At this moment, no decrease in Russian fuel oil exports are to be seen, in fact the first quarter of 2012 showed an increase in exports. At this moment, lower exports (which account for 70% of the fuel oil production in Russia) would mean oversaturation of fuel oil on the domestic market. So, until major refining projects finalise, no decrease in fuel oil flows from Russia are to be expected (Turner, 2012), especially as long as the prices for fuel oil stay high.

Tough competition

The refining industry is unarguably under pressure. Rivalry among competitors is extremely intense. Overcapacity, low – or even negative – margins, high fixed costs and high barriers for exit make the refining business incredibly tough to compete in. European refiners have the biggest challenges ahead, while several have already been or soon will be shut down. Fuel oil production will decrease at the expense of cleaner and lighter products, especially in the largest fuel oil exporting country, Russia. This could leave room for other countries to produce more fuel oil, as prices rise, but the margins on distillates are far more appealing in the current market. This industry is thus to see major changes in the coming years.

5.1.2.Mid-stream

The midstream bunker market is composed of different activities and there is no easy line to draw between them, especially when we try to study the market structure and its functioning. Many players in the midstream market have multiple interests and are involved in multiple activities. As compared to the refining sector, the market is less transparent, especially when it comes to trading and financial services. Why this is the case will not be analysed in detail. The products and services provided in the mid-stream bunker market are so intertwined with those of many other oil products and markets. It is thus difficult to support the analysis with numbers. This argument is supported by the difficulty of finding information of, for instance, market shares in the bunker trading business in public literature.

The actors are, amongst others, traders, brokers, storage companies and bunker delivery companies. They are involved in trading bunker fuel, blending the fuel to specification, storing and delivering the fuel. They thus all function in between the actual producers of heavy oils and the users, i.e. the shipping companies (as far as this distinction can be made sharply). This study makes a rough distinction in the different activities involved in the mid-stream section of the value chain.

Trading

With the development of increased competition in the oil market in the second half of the twentieth century, companies sought opportunities to trade between buyers and sellers. The companies involved in this process, can be categorised in traders and brokers. The difference between the two is that traders actually own the traded oil products, while brokers only facilitate the transaction. Brokers will be discussed further on.

Traders buy and trade fuel oil and the necessary blend components. Traders are either oil majors (e.g. Shell, BP and Total) or independent commodity traders, but also shipping companies have their trading desks. Oil companies do so mostly for profit reasons and shipping companies do so to hedge a part of the risk of bunker fuel price fluctuations they are exposed to. Independent traders usually buy their bunker fuel on the local barge market, whereas the oil major are more vertically integrated, using their own

bunker fuel. Traders own the products, but at the same time they are initiators of market transactions to trade the fuel oil. This gives them an important position in the bunker market. Traders are very often involved in the import and export of fuel oils. The geographical market on which the fuel oil is bought, depends on the specifications of the customer. Worldwide, large amounts of fuel oil are imported, blended and subsequently exported to another country by traders.

Some of the largest companies in the world in turnover are commodity traders. Companies as Glencore and Vitol are the major players in this market. Although they cover all types of commodities, they represent almost 4% of the entire world oil market (Pervin & Gertz, 2009), including an important bunker fuel market. They are often vertically integrated, owning large refineries, but also large storage terminals – although they also tend to rent storage capacity at independent storage terminals – and tankers. They often form part of a larger organisation involved in more aspects of the bunker fuel business (i.e. logistics and production), but also in other industrial or financial sectors (Bankes-Hughes, 2010). These aspects of vertical (and horizontal) integration is what makes these firms so powerful. But they do not own the entire trading market for bunker fuel, because trading bunker fuel is already possible if one charters a vessel and then ships the fuel to another port to sell with profit. This is called arbitrage and has attracted many small players to the market. This activity is triggered by price differentials in different ports. Although this is not bunkering as such, because it is merely shipping fuel from one port to the other without the intention to fuel other ships, it is an important activity of traders in the fuel oil market.

Bunker supply

The actual bunker suppliers are those parties that arrange sales of bunker fuels directly to the customer or indirectly through a trader or a broker. They buy the fuels from refineries, blend them to the required specifications and/or store the fuels (either at their own or at third party storage sites), before they sell to customers. As said, the refineries can also be suppliers, but the majority is made up of independent suppliers. Suppliers communicate with brokers (see further on) both timely and accurate information concerning price, fuel qualities and geographic availability, which is essential in a highly competitive market.

In the bunker supply business, the large independent companies are also dictating. Chemoil, Argos and OW Bunkering are important players, but also IOC's as BP Marine, Shell Marine Products and Lukoil play a significant role. Market shares are not publically available. At every bunkering port there are also many smaller parties involved in the supply of bunker fuel. The vertical integration of companies in the bunker market are often part of a larger integration of complex and interdependent operations (Bankes-Hughes, 2010). They do so, because they want to reduce exposure in parts of their business which are susceptible to economic downturns. This may be why many companies currently engage in mergers and acquisitions within the bunker market (Ladekjær, 2012). Currently, many takeovers in the bunker sector seem to be motivated by geographical expansion, as they often concern purchasing of local suppliers or setting up local alliances, therefore they avoid having to build up a business from scratch in a new geographical market.

Not only refineries feel the pressure of lower demand due to the current economic downturn. Bunker suppliers also see margins get increasingly thin and even negative in cases where suppliers try to gain market share. The demand is also slowing down, because shipping companies are trying to increase efficiency on their ships to minimise bunker costs, predominantly by “slow steaming”, which means sailing at lower speeds to increase engine efficiency.

Besides low margins, bunker suppliers have to deal with increasing counterparty risk, as an increasing number of shipping companies has difficulties with their payments. Vice versa of course, shipping companies experience increasing counterparty risk from suppliers. The financial capacity to cope with a possible default by the counterparty is becoming a necessity, and many smaller players are facing the

threat of failure. And with significantly lower barriers of exit than in the refining industry, these parties are more likely to sell their assets.

Financial activities

Financial services in the bunker market are provided by brokers. The basic activity brokers are involved in is facilitating sales and purchases of bunker fuel, although they provide many other financial services. The majority of transactions concerning bunker procurement are run via brokers. Brokers thus never take ownership of the bunker fuel.

The buyer – being either the ship owner or the charterer – puts out an inquiry to one or more bunker brokers, which in turn will contact multiple suppliers or traders and ask them to make an offer to supply the bunker fuel. What follows is a negotiation between these parties, resulting in one accepted offer. Once an offer is accepted, the terms of the bunker delivery are laid out in a document called 'a confirmation of stem'. In this confirmation of stem the purchaser mentions the price, the place and date of supply, the amount of bunker fuel ordered, the quality referencing to a standard specification and of course the detailed (standard) terms and conditions (T&C's). The T&C's are usually those of the supplier and the bunker broker thus functions as an agent of the fuel purchaser. Because of this, bunker brokers have limited liability on the contract in the case of a dispute. Usually the purchaser bares the risk of any contract breach of the supplier and can only claim against the broker if they have not carried out their work, as written in the contract. These parties are extremely important for shipping companies, as they organise the procurement of bunker fuels with suppliers, with expertise of local bunker markets and price setting.

Many firms also engage in other financial services, such as credit provision, spot purchasing, fuel contract design services, forward purchase contracts (e.g. options), arbitrage arrangements and, very important, price risk management (Komlenic, Zuo et al., 2008). These services focus mostly on risk hedging for purchasers. Because of the fluctuating, high bunker prices and low freight rates, shipping companies increasingly seek refuge in hedging instruments. So when it comes to financial services, there are clear signs of growth. Many different parties (e.g. traders, brokers, banks) can provide these financial services, making the bunker market increasingly complex.

Blending

One important physical step in the value chain is blending the fuel oil to the desired specifications, because not all fuel oil is suitable for marine usage. Blending takes place at fuel oil storage locations. Many qualities of fuel oil circulate around the globe, but for a ship to use the fuel oil as bunker, the fuel oil must meet certain specifications. Different crude sources and different refinery configurations or complexities lead to considerable differences in fuel quality. This thus raises potential compatibility issues, such as sludge formation. The viscosity, density and sulphur content are often essential quality parameters.

Less desirable, very low quality cracked fuel oil can be made more attractive to use on-board. This fuel therefore has to be blended with lighter products, such as distillates or cutter stock. The majority of the marine fuel bunkered as residual fuel oil originating from regions with mostly complex refineries is a blend of this kind (ABS, 2001). This is obvious, as deeper conversion of oil concentrates the total amount of harmful residues to an even smaller portion of the output stream. Residual oils from straight-run refineries often hardly require blending, but the share of fuel oil from atmospheric distillation facilities is declining. The amounts of blending components added to the fuel oil is in the range of a few per cent to around 50%. Residues from complex refineries are not as suitable for bunker fuels as straight-run residual oil, which, with current upgrades of refineries across the world, is a worrisome fact.

Most common blend materials – or cutter stocks – are MGO, heavy cycle oil (HCO) and light cycle oil (LCO). For more information on blending materials, see Annex G. Cutter stocks are higher priced than residual oil, which encourage fuel blenders to use a little blending material as possible. For this reason more and

more unconventional cutter stocks are added to the fuel. These can be organic, energy-containing streams from other industrial processes than refining. Even waste is blended into fuel oil, as long as the percentage of harmful components is within the limits of the ISO 8217 standards. However, this adding of waste is becoming a big problem for marine diesel engines as the combustion properties of the fuel oil worsen. Fuel oil used on-board is tested, for sulphur, viscosity, density, and etcetera. But they are not tested for all possible molecules, which is why it is unknown to what extent (dangerous) waste is “blended away” in fuel oil ¹⁸ (Buck, Smit et al., 2011).

Storage

Bunker fuel (here: fuel oil) is stored in large storage tanks, mostly located in major bunkering ports. The function of oil storage tanks can be diverse. In the light of this study, the local supply of bunker fuels is important, as is blending. But other functions are transshipment to the hinterland and overseas, strategic oil storage for states and contango (see Figure 5-6).¹⁹ The latter takes up a significant part of storage terminal capacity.

Figure 5-6 Activities of storage terminals



Source: (Wood-Mackenzie, 2011d)

Many types of crude as well as many different oil products are stored. Most require the same type of tanks. But for fuel oil, this is different. Because fuel oil has such a high viscosity, it doesn't flow at low or average ambient temperatures. It thus has to be heated to at least 50 °C to keep it liquid (Badran and Hamdan, 1998). These heating systems require additional costs for constructing a storage tank for fuel oil.

The importance of storage companies is clear for demand and supply unbalances. Large amounts of (fuel) oil are traded, because of the supply and demand mismatch. And this is what gives storage companies their right to exist: continuous flow from refineries and non-continuous shipment, loading large quantities at a time. Suppliers need some sort of flexibility in the physical supply of bunker fuel to respond to the volatility of bunker prices and storage tanks thus form that buffer.

Many different players are active in the oil storage market, as illustrated by Table 5-1. In this table the distinction is made between captive, semi-captive and independent oil storage asset owners. Captive

¹⁸ In this case blending companies cut down costs in two ways: costly waste disposal is avoided and instead of costing money, the waste earns money, as it is blended in fuel oil and sold.

¹⁹ Contango is a situation when the futures price of crude oil is above the expected future spot price (Contango, n.d.). Consequently, the price will decline to the spot price before the delivery date. This price difference is a reason for traders to buy at spot price and immediately resell at the futures price (at a given date). In the meantime they store the oil, paying less for storage than they earn with the price differential.

parties handles exclusively their own oil, semi-captives handle both their own oil as that of third parties and independents solely handle third party oil.

Table 5-1 Players in large scale oil storage

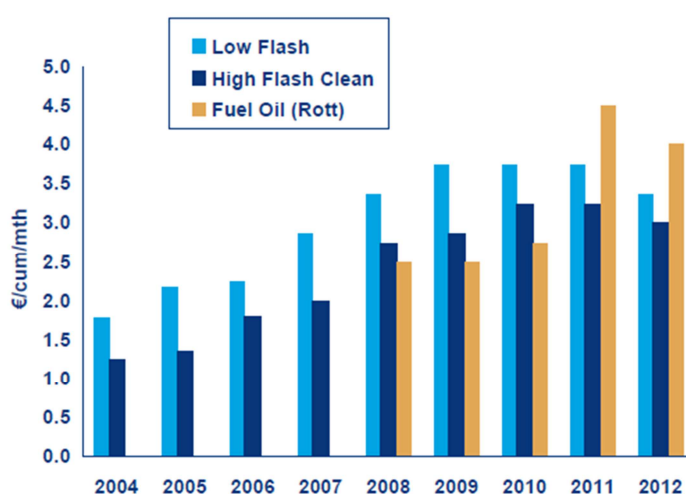
Class	Business Model	Players	Objective
International Oil Companies	Captive	BP, Shell, Total, ExxonMobil	Disposal with downstream assets
Independent operators	Independent	Vopak, Oiltanking, Kinder Morgan	Organic and acquisitive growth
Trading company operators	(Semi-) Captive	VTTI, Vesta, Puma	Expand with strategic partner
Export refiners	Captive	LITASCO, SK Energy	Gateway to markets
National stockholding agencies	Captive	COVA, EBV	Comply with reserve directives
Private equity funds	Independent	Terra Firma, First reserve	Turnarounds
Infrastructure funds	Independent	EQT, ALinda, 3i	Low risk income, steady growth

Source: (Holt, 2012)

New refineries as well as increasing imbalances in demand and supply has required large storage capacity expansion projects worldwide. Especially the Middle East and the Asia-Pacific region have been responsible for a large part of the growth. These regions stood for over 60% of total capacity of the top ten emerging oil storage markets in 2012 (Wilde, Kroon et al., 2007). The growth was seen in particular in Fujairah, the Malacca Straits and in China with an important role for bunker fuel. Also the Mediterranean is seeing capacity increase, especially in the port of Algeciras. Current expansions of major independent storage companies amount to around 20% increase in their capacity (Holt, 2012).

In recent years the tariffs for independent oil capacity has increased significantly (see Figure 5-7). Demand-supply imbalances, shortage of storage capacity, but also general contango, were reflected in the unregulated market rate setting. However, through 2011, the rates – at least in the ARA region – have temporarily dropped. The end of a long period of contango is seen as a major reason for this, as well as new capacity coming online. The rates for fuel oil storage, however, have increased more than those of other products, due to increased demand for fuel oil – mostly for bunkering purposes, as the use of fuel oil for other purposes has declined. This indicates that there is an above average demand for bunker fuel storage.

Figure 5-7 Independent oil storage rates in the ARA region



Source: (Holt, 2012)

The storage capacity additions are not only seen at the “standard” oil terminals, but also at refineries which increase their storage capacities or are completely converted to new storage terminals. Besides, the past few years has seen a rise in floating oil storage. Low freight rates and overcapacities in the oil tanker market have led to the usage of oil tankers for storage purposes. Although storage rates are still higher than land-based storage, tankers provide the flexibility to deliver the oil wherever the customer wants.

Fuel oil tanks are more specialised assets than other product tanks, leaving the liquidation value of the tank significantly lower than the initial investment, if it subsequently were to be used for storing other oil products. These potential losses are not high enough, however, to form substantial barriers of exit, as the highly capital intensive storage companies currently have a strong financial position. Besides, under these market conditions, who would want to leave the market?

Intense rivalry

Squeezing margins, increasing quality requirements and increasing bunker disputes has led to many takeovers in the trading business. These takeovers are leading to more geographic expansion and vertical integration among the large traders and suppliers. Whereas in the past traders could easily grow along with the expanding oil trading business, recent years have shown a downturn in economic growth, which now seems to have its effect on the bunker trade and supply business. Although these parties will allow some elbow room for smaller players seeking to earn a profit on a ship’s load of fuel oil, the market power of the large independents is increasing in the negotiating position between demand and supply.

As opposed to the refining industry, where overcapacity is an industry-wide problem, the oil storage market is seeing shortage of capacity. This shortage is driven by growth in demand, attributable to a great diversity of players, with different objectives and strategies. This diversity, along with the current capacity expansions, is a sign of increasing market rivalry.

5.1.3. Shipping industry

The end users of bunker fuel are the shipping companies. These are either the vessel owners or charterers. Some parties are owner of the vessel, but also that of the cargo. Others solely own the vessel for investment purposes or function as the charterer. There are two main types of chartering: a time-charter and a voyage charter. With a time charter, the ship is hired for a certain amount of time. Here, the vessel owner is still the manager of the ship, but the charterer is responsible for the employment of personnel as well as the bunkering of the ship. With a voyage-charter, the ship is hired for a single journey (voyage), where the owner of the vessel is responsible for everything from on-board personnel to bunkers.

Time-chartering is a way for ship owners to mitigate the risk of fluctuating freight risks. If they expect the freight rates to decline, they prefer to rent their ships out on a time-charter and receive a fixed rate for the use of their ships. At the same time they don’t have to worry about being exposed to the, currently not uncommon, bunker fuel price fluctuations. In a bullish market view of ship owners (when they expect freight rates to rise), they will choose to operate the ship on a spot basis (voyage-charter), focusing more on short-term profits. The consumer of bunker fuel is thus either a vessel owner or a charterer and this can vary along with market expectations. The party responsible for bunkering will be referred to as ship operators further on in the report. They facilitate the delivery of the bunker fuel from the pier (of the storage facility) to the ship. In so far the fuel is not already blended at the storage site, it is blended on-board the barge during transportation and loading of the bunker fuel. These barges are the most common mode of bunkering. They load their cargo tanks with bunker fuel and deliver the fuel to the ship requiring bunkering.

On board

Most large ships are propelled by so called “category 3” engines. These are very large diesel engines, specially designed for use on large oceangoing vessels, such as bulk carriers, containerships, cruise ships and tankers. They have a per-cylinder volume of around 30 litres (EPA, 2008). Because of the large displacement of the cylinder, they operate at very low revolutions per minute (rpm). The fuel thus has a longer time to combust than in smaller engines. For this reason marine diesel engines (on-board large oceangoing vessels, taken as standard in this study) have a much higher tolerance of fuel types²⁰, and are thus perfectly suitable for fuel oil. Even contaminants are in most cases combusted completely, without damaging the engine. However, more often chemical waste with considerable damaging potential is found in ships' fuel tanks.

Smaller vessels (not discussed any further in this report) use so called “category 1 and 2” engines, which are marine diesel engines used on, amongst others, fishing vessels, tugboats, small (inland) cargo vessels and supply vessels. On board larger vessels these engines are usually used as auxiliary engines, powering pumping systems or winches.

Sulphur content

Bunker fuels contain sulphur and their sulphur level depends on the origin of crude used as well as on the refining process. As described in paragraph 5.2.1, the sulphur level in crude oil varies considerably over the world and many different refining complexities exist. When the fuel is combusted, about 90% of the sulphur in the fuel reacts with oxygen (O₂) and thereby form sulphur-oxides (SO₂ + SO₃, or SO_x). Due to the lack of exhaust gas treatment, the molecules that are emitted directly to the environment depend solely on the sulphur content of the fuel. They are hazardous as they react with water in the air and form acid rain. These environmental consequences are considerable in densely populated areas, with accompanying large volumes of road and marine transport.

Changeover

Some vessels sail between areas with different environmental regulations (predominantly concerning the sulphur level of bunker fuels), requiring the use of different types of bunker fuels. The changeover is mostly between high sulphur fuel oil (HSFO) and low sulphur fuel oil (LSFO) or marine gasoil (MGO). This poses some challenges for the physical process, both engine-wise and timing-wise.

Challenges for the engine are, for instance, the difference in viscosities between fuel oil and MGO. The heating of the fuel to make it flow can lead to a too low a viscosity of the MGO for the engine to handle. Timing the changeover is also a challenge. Because an immediate changeover between fuel oils and MGO is not possible, the changeover is actually a timely process. Once a vessel enters the new area (with stricter sulphur requirements), the fuel used must fully comply with the stricter requirements, while vessel owner will refrain from switching too soon, as MGO is considerably more expensive than HSFO.

Players in the industry

Not surprising, the shipping industry is highly globalised, not only in operation, but also in ownership. The players in this industry have multinational assets, with around two third of the world fleet sailing under a flag of convenience.²¹ This industry is characterised by a few large private players (although some are publically owned by sovereign wealth funds, but still compete as if they were privately owned), the largest being APM-Maersk, CMA-CGM and MSC, but also has a large number of smaller players, when combined composing almost 30% of the market.. The shipping industry is divided into three types groups of

²⁰ Modern ship engines can tolerate higher viscosities of up to 500 and 700cSt, but as currently the majority of fuel consists of IFO 180 and IFO 380 and the bunker pricing market uses these viscosities as standard, these higher viscosities will not be treated in detail in this study.

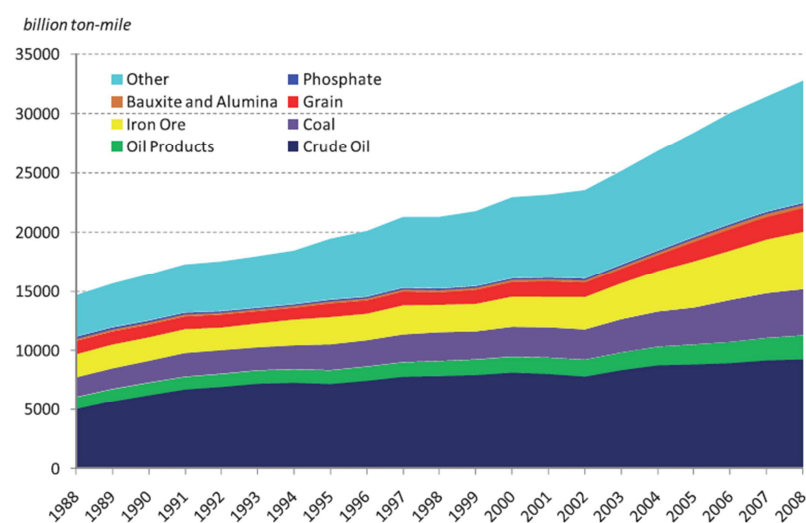
²¹ A flag of convenience means that ship owners have their merchant ships registered in a sovereign state different from that of the owner, shown by the merchant flag of that state on the ship. They do so to reduce operating costs or avoid the more expensive tax regimes of the owner's country. Most common “flag states” are Panama and Liberia.

transport, wet bulk (crude oil and other petroleum products), dry bulk (iron ore and coal) and liners (general freight in containers).²²

Industry growth and bunker demand

Within the fuel oil market, the only segment that has shown steady growth in the last decade was marine bunkers. During the first years of the current economic slowdown, 2008 and 2009, the demand had shown a decrease, but in 2010 and 2011 the demand for bunker fuel has been spurred somewhat by both the fast growing demand for maritime transport in Asia and also by the continuing expansion of the global fleet. Global maritime transport is strongly related to the world gross domestic product (GDP) growth and thus also to international trade (Mazraati, 2011). Before the 2008, the growth in the world seaborne trade was very strong, as Figure 5-8 shows. This had triggered the construction of many new ships, of which most have now entered into service.

Figure 5-8 World seaborne trade (1988-2008)



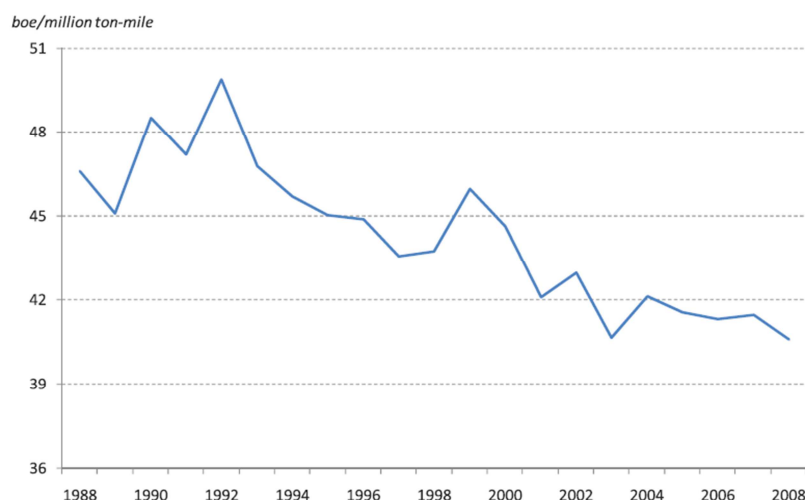
Source: (Fearnleys, 2009)

However, there are efficiency gains in the maritime sector, pressing the demand for bunker fuel somewhat. These are of technological and operational nature and concern the fuel intensity of maritime transportation (see Figure 5-9). Over the last decades the fuel intensity has declined, due to more efficient engines and increasing vessel size. Due to the rise in bunker prices of the last few years, ship owners (or charterers, whoever is responsible for the bunkering) have lowered vessel speeds, which has also contributed to more efficient fuel usage.

Although demand for bunker fuel has not decreased significantly in the past few years of economic turmoil, the demand for maritime transport has taken a beating. The newly built vessels, which were ordered when demand was much higher than now, have, along with lower utilisation levels of the existing fleet, led to an overcapacity in the shipping industry, lasting still in 2012. This overcapacity has in turn triggered shipping lines to remove vessels from operation, by May 2012 amounting to around 5 per cent of the world fleet (IEX, 2012). Nevertheless, the demand for maritime transport still grows, but this growth amounts to around 5%, as opposed to an average growth of 10 to 11 per cent in the last 25 years and is lower than the added capacity of newbuilds (IEX, 2012).²³

²² Although the offshore oil and gas industry as well as fishing vessels consume considerable amounts of bunker fuel, these mostly use distillates. These sectors are not discussed any further and the focus will remain on maritime transportation vessels.

²³ The demolition activities have had an impact on the overcapacity in the first months of 2012, as still growing demand is currently outpacing the growth in the world fleet. The supply of tonnage has increased only slightly and shipping lines have cancelled many order for new builds since the start of the economic downturn in 2008. This has led to a rise in freight rates. These developments,

Figure 5-9 Average fuel intensity in maritime transportation

Source: (Fearnleys, 2009; OPEC, 2010)

Margins

The financial crisis has had an enormous impact on the shipping industry. It has increased competition significantly and the overcapacity has put great pressure on the margins for shipping companies. Lower freight rates and historically high bunker prices have made life difficult for many shipping companies. At the same time, customers demand faster and cheaper transport for their goods.

Freight rates have dropped some 11 per cent for dry bulk in the last year and the rates for VLCC's have dropped to around half of the five-year average (Sowkar, 2012). The bunker prices (for fuel oil) have more than doubled in the last three years as a reaction to the rising crude oil prices. Figure 5-10 shows the climb in fuel oil bunker price of IFO380 from 2008 to 2012. The oversupply and the current economic situation obstruct shipping lines to pass the rise in bunker costs on to the customer. Bunkering costs now make up around 70% of a ship's operating cost (although estimations vary somewhat) and with the lowering freight rates, there is little room for profit making in the current maritime transport sector.

Figure 5-10 Average Rotterdam bunker prices for IFO380, 2008-2012

Source: (Bloomberg, 2012a)

however, are being witnessed over the months of March-May 2012, which is a somewhat short period of time to be able to speak of a definite trend. For this reason these developments are not analysed in detail.

New challenges

In response to these developments shipping companies have tried to lower their costs elsewhere, but in an industry which is already dominated by very large vessels (VLCC's and large containerships), mergers, acquisitions and strategic alliances, potential cost savings are becoming scarce (Rodrigue, 2010). Shipping lines therefore increasingly evaluate their fleet configuration and refer to demolition if vessels are not up to efficiency standards or general customer requirements. However, this is only possible for the larger companies, the smaller players will see even tougher times ahead, and for them exit barriers are often not high enough to let them keep playing the game (although they were high enough to have kept them in the market for too long).

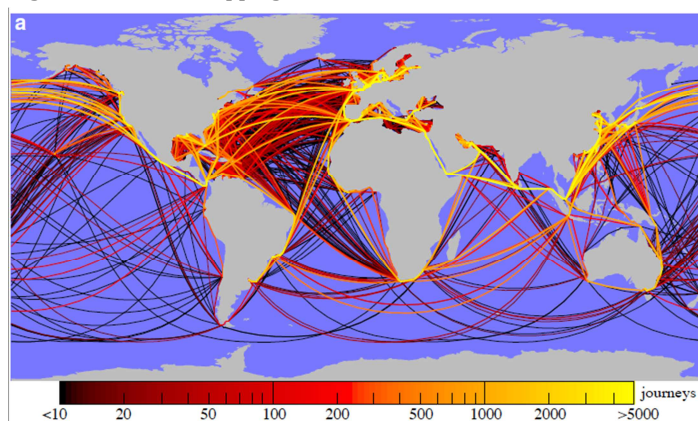
Because bunker costs are that big a percentage of operating costs, only a slight saving in fuel consumption would significantly impact the liner's financial performance. The procurement has thus become extremely important for these companies. The pressure to minimise fuel consumption and improve procurement strategies is very high. Shipping liners engage in hedging bunker prices more and more and invest in their relations with suppliers to ensure the quality and price of their bunker fuel is satisfactory.

5.1.4. Bunker Ports

Bunkering takes place in different (around 400) ports around the world. Ports are the hubs for trade and all ocean going cargo is loaded or unloaded at ports. Logically, this is the place to fuel a ship. Bunkering ports are situated near the supply sources of bunker fuels, i.e. the refineries, and near the consumer of the transported goods, but their location is also determined by density of shipping in the area. The most dense shipping lanes have major ports located along them. Figure 5-11 illustrates the density of shipping across the globe.

This is why it is not strange that a port like Singapore is the largest bunkering port. The other major bunker ports described in this study are Rotterdam and Fujairah, not surprising also (situated near) major refining centres. Large bunker terminals are located at these ports and fuel testing practises take place here. At these large bunkering ports, pricing centres have emerged, and the prices at these ports are reference prices for the rest of the world (more information and numbers of these major bunkering ports is provided in Annex I). Although Houston is one of these pricing centres, it is not a large bunkering port, with only 2 million tons of bunkering sales in 2008. Other ports such as Panama, Hong Kong and Busan sold more than twice the bunker volume sold in Houston (Liang, 2009).²⁴ Houston's large refineries do not produce any bunker fuel, which is imported from, amongst others, Venezuela and Mexico. Other important bunkering ports include Gothenburg, Antwerp, Hamburg, Los Angeles, Shanghai, Gibraltar and Piraeus.

Figure 5-11 Global shipping movements



Source: (Kaluza, Kölzsch et al., 2010)

²⁴ These figures are not all publically available and some are based on estimates.

Singapore

On the strait of Malacca, Singapore is located strategically on one of the busiest trading route in the world. Singapore is home to one of the largest ports (after Shanghai and Ningbo, both in China) in the world in terms of throughput of cargo and the largest when it comes to bunker fuels sales. Singapore is also one of the major refining centres. Singapore functions as the oil hub of Asia, with an important share in refining capacity, and is home to a large trading market and has a strong logistical network. Because of the large amounts of bunker fuels passing through this port, it has become an important pricing centre for these products. Many oil companies have their regional headquarters in the port of Singapore, because of the oil refining and trading. The bunker market in Singapore is quite diverse as bunker fuels from all over the world are delivered in its port, with the majority originating in South America and Russia.

Rotterdam

Rotterdam is the largest port in Europe and functions as the main bunker hub in the region. Rotterdam has become such an important players due to the production of bunker fuels at its refineries, the depth of the harbour allowing the largest ships to enter the port and its strategic geographical location in North-West Europe. Rotterdam is both located along the busiest shipping lanes in Europe and on the export route from Russia and the Baltic countries, where most of the fuel oil is produced. For this reason bunker fuel can be delivered at a lower price in the ARA region than other major bunkering ports (Wilde, Kroon et al., 2007). As in Singapore, this area has established itself as an important pricing centre for bunker fuel.

The bunker traders in the port of Rotterdam are – as in Singapore – both the refiners and the independents. Rotterdam has several designated bunkering areas, of which Europoort and Botlek are the most important. The physical supply of bunker fuels is conducted in these areas by small bunkering barges. The fuel in these barges is loaded from large storage facilities (e.g. from Vopak).

Fujairah

In the recent years Fujairah has become the fastest growing bunkering port, and is currently second, behind Singapore. The Fujairah bunker market comprises three port areas, namely the port of Khor Fakkan, Fujairah and Kalba (EPA, 2008). Khor Fakkan is located in the north, Fujairah in the middle. But here, when we mention Fujairah, we mean the entire area. As opposed to some other important Arabian ports, Fujairah is located outside the Strait of Hormuz, the gateway to the Persian Gulf.²⁵ Fujairah is located near the Middle Eastern oil production (which accounts for around 20% of global oil production) and of all seaborne oil trade, 35% passes by Fujairah (EPA, 2012). For this reason the most important customers are not, as is the case with Singapore and Rotterdam, containerships, but large crude carriers (VLCC's and ULCC's), which often are anchored offshore waiting for cargo from the Persian Gulf.

Bunkering takes places via bunker barges that load from storage tanks or tankers (i.e. off shore) and supply the passing carriers passing the Fujairah port. The storage capacity of the oil terminal is increasingly rapidly, reaching 6.5 million m³ this year and up to 8 million m³ in 2014. Vopak Horizon is the local market leader with a storage capacity of 2.1 million m³.

5.2. Threat of new entrants

The threat of new entrants depends on the barriers in place to enter the market. Barriers are set by large economies of scale, large product differentiation, capital intensive assets, locational importance and (certain) strict government policies.

Economies of scale

²⁵ This strait has been in the news early 2012, when Iran threatened to close this passage to Saudi-Arabian and Qatari oil and gas, as a response to global pressure on Iran following its plans for a nuclear programme, resulting in sanctions on Iranian oil. This drove up oil prices, and subsequently fuel oil prices (Hunter and Gienger, 2012).

One type of an economies of scale entry barrier occurs when there are economies to vertical integration, that is, operating in successive stages of production or distribution (Porter, 1980). In the bunker market there are increasing signs of vertical integration. This vertical integration is mostly seen in the mid-stream activities, where large trading companies as well as independent suppliers integrate backwards towards producing. These players have also been investing largely in storage, giving them multiple advantages. Another trend is seen the other way around, with (upstream) NOC's investing in forward integration, from production to sales. Also shipping liners broaden their scope as they increase their trading and even supply activities. They hereby secure an up-to-standard procurement of bunker fuel, hedging volatile bunker prices and ensuring satisfactory. In the refining business, the vertical integration, which was so prevalent in the mid twentieth century among oil majors, has decreased substantially. Refining has become more and more a standalone business, although players (mostly NOC's) in emerging countries are often still vertically integrated.

However, surprisingly the level of vertical integration is not the major barrier for entry in the bunker market. In large scale trade and supply of fuel oil it is difficult to compete with the more integrated companies, but trading is still possible on a small scale, without the need for large storage terminals or production assets.

The contribution of vertical integration put aside, economies of scale do in fact form a substantial entry barrier. Mergers and acquisitions in the mid-stream market have left the majority of the bunker market in hands of the large players and in the shipping industry the major shipping liners dictate the maritime transportation sector. Economies of scale give the big traders and suppliers purchasing power for both bunker fuel and storage capacity. In the shipping industry the players have fleets of enormous carriers or tankers and due to their size, these companies have cost advantages, e.g. when it comes to fuel procurement. This creates a considerable barrier to entry.

In the production of bunker fuel there are significant barriers to entry due to the size of refineries. To be able to earn a profit in the refining business large quantities must be produced. However, many of these facilities designed to raise economies of scale have also become too inflexible to deal with technological advances, leaving opportunities associated with these technologies for potential new entrants. This can be seen in the addition of new refining capacity in Asia and the Middle-East (so called greenfield refineries).

Product differentiation

The market of bunker fuel does not show any significant differences between products. Bunker fuels comprise many different fuel qualities, although most are standardized. The majority of bunker fuel on the market is either IFO380 or IFO180, with increasing (but not very large) shares of 500, 700 and even 1000 cSt fuel oil. Also distillates have a small share. But all these fuels have standards, which entails that suppliers of bunker fuel find it hard to differentiate their product from that of a competitor. Traders, suppliers and brokers are trying more and more to provide extra services, e.g. financial (hedging) services. As for refiners, where fuel oil is often seen as a by-product, they don't go through much trouble to differentiate their products. Because the products are to a large extent standard and most suppliers or blenders have the capability to deliver most kinds of fuel oil, there is not much loyalty to suppliers, unless long-term contracts for delivery are signed either between refiner and supplier or supplier and shipping company. The lack of general loyalty towards suppliers leaves some room for new parties to enter, but this may be mitigated by other barriers to entry.

The degree of product differentiation is connected to the level of switching costs. The arguments given support the fact that switching costs are quite low. Suppliers can easily buy fuel oil from other refiners, as long as the distance for transport is surmountable. In the same way, traders can easily switch to other exporting or local refineries or suppliers. The fact that brokers exist and support ship operators with their fuel procurement by negotiating the best bunker price, entails that bunker purchasers can choose another supplier without consequences. The large scale in most segments of the bunker market and the associated

lower costs involve a trade-off with other potentially valuable barriers, in this case the product differentiation (Porter, 1980).

Required capital

The bunker market is very capital intensive for some parties and not capital intensive at all for others. Players dealing with physical assets have assets that require large amounts of capital. For instance, upstream, refiners have refineries costing over a billion euros, in the midstream, storage companies invest hundreds of millions in storage terminals and downstream, shipping lines must invest substantial amounts of money to acquire their vessels. All these segments of the bunker market are very hard to enter without a very strong financial position of the entrant.

There are also less capital intensive areas within the bunker market and these include, for instance, brokerage, delivery services, fuel quality testing. Financial services (facilitating transactions or providing price hedging services) are the least capital intensive, as the strength of companies relies on a whole different type of capital, which is human capital. Human capital is becoming increasingly important in the mid-stream segment as fuel procurement is gaining priority with vessel operators. High bunker prices and low freight rates have triggered these parties to increase their focus on buying fuel at the lowest possible prices, while making sure the quality of the bunker fuel is still up to standard. Their experience, local knowledge and long-lasting relationships in the local markets are becoming increasingly valuable “assets” for traders, suppliers and brokers. These assets can be reckoned among the human capital. However, experience and knowledge can only be called an entry barrier if it can be kept proprietary and this may not always be the case as new entrants may acquire the knowledge much quicker than current competitors. The latter can be the case with new entrants in the refining industry, who may be aligning on new experience curves associated with highly complex, state-of-the-art refining technologies. Traders, however, might have more difficulties acquiring the knowledge easily when entering a new market. For this reason, many trading companies, but also suppliers choose to acquire local players and therefore “buy” the local knowledge and experience.

Location

Another barrier to entry may for some parties be the location. In some cases, especially with the traditional large ports, there is not unlimited land available for refineries or storage facilities. For example, companies had to tender for the construction of a tank terminal in Europoort-West in the port of Rotterdam (Birkett, 2011). This tender was sought for by several very large players, and for a newcomer, or smaller party, it was almost impossible to win the tender. The location of the major ports can also be explained as an entry barrier in another way. It could be the case that established firms have located themselves in favourable locations before market forces bid up the prices capturing their full value (Porter, 2008). Locations with access to deep water and with distribution flexibility are quite limited and thus can form a barrier to entry.

Government policy

Government policy as a barrier can manifest itself in two different ways. At first, government policy in some countries is focused on stimulating local markets or on protectionism (protecting the local market and/or the national companies) therefore limiting access from foreign players. Secondly government policy can lead to restrictions for all players in that geographical area, for instance environmental regulations, often making the area unattractive to do business.

An example of the first is India. Meijknecht et al. (2012) mention that India is establishing itself as a major global oil product exporting hub. National policy in India is focused on exports and is even providing large amounts of funds (mostly in the form of guarantees) or tax exemptions for companies involved in oil product export. This leads to high entry barriers to the Indian market for foreign players, but large changes in oil product trade are not expected as most of the Indian export is heading only as far as neighbouring countries. The same goes for the bunkering business in China, where only five players are

granted a bunker license for the Chinese bunkering market, none of which are foreign. Another example of government intervention in the free market is Russia. The increase in export taxes on heavy fuels is meant to raise the production of distillates from domestic refineries and therefore decreasing dependency on the import of distillates. These measures raise barriers to entry for foreign players in these markets. In addition, individual national regulations can require a partnership with an indigenous operator as a condition for market entry (Bankes-Hughes, 2010).

On the other hand, governments can also be non-discriminatory and more subtle, as is the case with environmental regulations and standards. Especially in the European refining sector, environmental regulations are strict. Pollution control requirements can increase the capital need for entry, which might refrain foreign players from investing. Although these regulations have considerable social benefits, the economic consequences can be costly. Strict sulphur regulations from MARPOL Annex VI has led to higher bunker costs for vessels sailing the ECA's and therefore, again, increased the required capital to enter this shipping market.

Due to considerable economies of scale, high capital requirements and expensive locations, the bunker market provides some high entry barriers for newcomers. The fact that standards for fuel oil are in place, however, could ease entry into the market of refining, if it weren't for the exceptionally low margins in the refining industry, stemming from the substantial oversupply. Barriers are lower for smaller players who trade fuel oil on a small scale, but this is mostly related to arbitrage and thus not directly part of the bunker market.

5.3. Threat of substitutes

The threat of substitutes is can emerge on different levels in the bunker market, but the most prevalent and logical possibility of coming across substitute products is the choice of fuel for shipping. The other possible area that may experience competition from other alternatives is the area of maritime shipping as a way of transporting goods. The first will be in the spotlight, as it is an important element in this research (especially in the compliance with environmental regulations).

Alternatives for shipping

The shipping industry itself faces competition of other modes of transport. Especially short-sea shipping – e.g. in Europe – has to compete with road transport. Long distance transport can also be facilitated by aviation and medium-distance transport of oil or gas can take place via pipelines. The shipping industry, however, has taken an established position in the global trade, being the most efficient and environmentally friendly per ton of cargo. Around 90% of world trade is carried by sea (UNCTAD, 2011; IMO, 2012c). Aviation is not a real threat for maritime transport, as predominantly small and valuable cargo is transported as air cargo. Road transport is also much more expensive than shipping and pipelines cannot and will not play a significant role as a substitute for large distance transport and will not be built by the dozens.

If other modes of transport were to be a threat to transport by sea, the demand for bunker fuel could also be in danger, as the road transport and cargo airplanes use gasoline, diesel and kerosene as fuel and will not be fuelling at bunker ports.

Different fuels for shipping

Other fuels for shipping could be a threat for the (fuel oil) bunker market. There is definitely a group of alternative fuels that could be used aboard ships (section 4.1 explains the range of fuels used as bunker fuel). Marine diesel engines have a tolerance for a wide range of fuel grades. However, not all of these fuels can be used in all engines. Engines built for usage of high viscosity fuel oil may have problems with the much lighter MGO or MDO. But in general, for fuel oil used as bunker fuel, MGO is definitely a possible substitute. Another possible alternative could be liquefied natural gas (LNG), but currently the number of

vessels which are equipped to handle LNG as a fuel is marginal, considering completely different installations are required on-board.

The most important considerations in fuel choice for ship operators are price and quality. Assuming suppliers all deliver the required quality (according to standards and requirements of ship operator), leaves us with price as the only way to differentiate. The bunker market is an extremely price-driven market. The reason to choose for an alternative fuel would logically follow from a possible price advantage for the ship owner. The price differential between the most common fuel, i.e. heavy fuel oil – IFO380 and up, and MGO is around \$270 per tonne (\$840 - \$570). Using (ultra-low sulphur, < 0.1%) MGO would thus increase the bunkering costs with around 50%. In terms of price competition, MGO is not a competitive alternative for fuel oil and is thus not a threat for vessel with large marine engines. The IMO sulphur regulations, however, have restricted the use of high sulphur fuel oil (> 1.0% sulphur content) in the ECA's of the Baltic and North Sea. Therefore ships have to buy LSFO. LSFO also sell at a premium to HSFO (ranging from \$40-\$100 per tonne), but its use is mandatory. In this case, LSFO is substituting HSFO, but it is still the same type of fuel, i.e. fuel oil for bunkering purposes, but the sulphur content is different. However, the source of LSFO supply is different, as much LSFO for the European ECA's is produced in Brazil (Jameson, 2012a) (most LSFO produced in Europe is still used for inland power generation), so in that sense it is a substitute for e.g. Russian fuel oil.

LNG is not yet a realistic substitute, as entire ships have to be retrofitted or newly built, as well as the entire infrastructure to facilitate the distribution and delivery of LNG. LNG is nonetheless far cheaper fuel than fuel oil. Some ship owners in Norway have started experimenting with LNG fuelled vessels, although only on a small scale in small vessels.

The impact of substitutes would be felt by predominantly the ship/barge owners and operators, as well as the refining industry. However, oil storage terminals would in the case of a shift away from fuel oil no longer need special heating systems for fuel oil.

Collective industry action

A real threat to the bunker market requires collective industry action, otherwise there will be no significant impact. Alternative fuel as a substitute for fuel oil would pose a real threat if it were adopted by the majority of the shipping industry. In other industries these shifts have been seen before. For example, road transport is seeing a large shift from gasoline towards diesel, especially in the EU and the United States, where the environmental regulations have demanded lower emissions from road transport. Also in the power generation a shift has been made, where fuel oil is used less and less in favour of especially gas. As mentioned before, often the trigger for collective action is government policy. Environmental regulations or subsidy programmes could promote the use of other fuels, especially if the legislation is supranational. But currently, there is little likelihood that any other fuel will be a real substitutes for fuel oil, or any other form of fuelling could substitute the role of marine bunkering in international trade and shipping.

5.4. Bargaining power of suppliers

Suppliers can exert bargaining power over the consumers of their product by threatening to raise prices or reduce quality, thereby squeezing profitability out of an industry which is not capable of recovering these costs in their own prices.

Market concentration

Market concentration is an important indicator of supplier power. When we look at the refining industry, there is little room for players to exert this power on a global scale, as it is a low margin business, with high fixed costs and substantial overcapacity. The large number of players, from the traditional IOC's to NOC's and integrated supply and/or trading companies, make the refining industry very competitive.

Exerting power in such a consolidated market seems just about impossible. The refiners themselves thus do not have any power over customers. On a local scale, however, the situation may differ, as a single refinery often covers a relatively large geographical demand area. Especially when considering NOC's, often vertically integrated and mostly located in emerging economies, there is a certain amount of market concentration.

Large trading companies and bunker suppliers are often vertically integrated and cover a significant part of the midstream. These players have a strong financial position and because of increasing counterparty risk in the bunker market, these players might be able to bargain, as their service, financial strength and experience are worth something in premium of the spot market price. Another aspect of supplier's bargaining power concerns the possibility of influencing local prices by altering available supply levels. Although prices are based on what the fuel "does" on the spot market, local demand and supply imbalances may also temporarily change price levels. Suppliers or traders with large storage capacity can, for instance, buy the majority of locally available bunker fuel if they have reasons to believe some large vessels requiring bunkering will enter that particular port soon. They thus trigger a local deficit in bunker fuel supply, therefore raising prices. However, these are short term and irregular events.

In China, the bunker market is supplied by only five players, as the Chinese government has only granted five licenses for selling bunker fuels. These licenses are all in Chinese hands, with Chimbusco and Brightoil owning 95% of the market. These parties are heavily integrated, owning large storage terminals and even VLCC's. This substantial bunker market of around 15 mt, is thus an oligopoly and the government plays an important role. In China, prices have therefore historically been quite a bit higher than the largest bunker market in the area, Singapore. The expectation is that the Chinese market will open up for foreign investors eventually, but this is not likely on the short term. Similar situation can be seen in most other BRIC countries.

However, clusters of refineries, especially those located in specific countries, may be in a bargaining position. In the wider refining industry, the Middle East, for instance, has built many greenfield refineries, able to convert all sorts of crudes with the latest technologies, relatively low costs and without the burden of environmental legislation. These refineries currently operate at low utilisation rates, but overcapacity could in the future lead to more cheap exports, reaching the traditional refining markets, such as Europe. These refiners would have much certain advantages over the local plants. This shows the power of a certain area within the global refining market. For bunker fuel, there are also states with advantages. Russia, as the biggest exporter of fuel oil, but also Venezuela (fuelling large parts of the Chinese fleet), have the privilege of having large numbers of straight-run refineries in operation. These refineries produce high quantities of practically on-spec marine fuel oil. The world market for fuel oil is, to some degree, concentrated in these countries. Thus not the individual refining facilities have supplier's bargaining power, but whole nations. The question of course is how long this situation will last.

The ultimate bargaining power of suppliers can be witnessed in the price setting of crude oil. OPEC determines the oil price by adjusting the production volumes. Political tensions or other unforeseen circumstances put aside, they have the power to increase prices, whereas in all subsequent steps in the value chain these increased costs cannot be recovered by increasing the price. The crude price increase (and thus for some part that of bunker fuel) in the last few years has predominantly enriched the oil exploration and production companies, and not so much the refiners and the suppliers of bunker fuel, who suffered from declining margins.

Product and customer

Bunker fuel is an essential input to the purchaser's business. Without fuels oil, ships can't sail and cargo can't be transported. Especially now that bunker prices have risen and freight rates are low, bunkers make up for around 70% of the operational costs. Often when this is the case, customers choose to store the product and build up an inventory to secure their product. Because ships sail the world's oceans and trade

between many different ports, they do not choose to do so. They would have to have storage locations in all ports they visit, which is quite impossible. They are thus dependent on the bunker suppliers in a specific port. And that is exactly what brokers are for: find the most affordable stem of bunker fuel for the customer by negotiating with different suppliers. In doing so, the broker reduces the bargaining power of suppliers.

The switching costs in the bunker market are very low. Prices for bunker fuels, such as IFO380, IFO180, MDO and MGO are very transparent and are quoted on several commodity and oil information platforms. These platforms provide reliable price information, and this “narrows the degree of separation between buyers and sellers” (Vactor, 2004). Furthermore, fuel oil is traded between various locations evening out price differences between ports. So, for bunker traders, many options are available when sourcing for fuel oil, while for shipping companies the prices of different suppliers will be about the same. In the same way, standards for fuel oil have made the switch to another supplier easier, as the specifications of the fuels will broadly be the same (of course unless a ship operator has specific fuel requirements).

From the supplier's point of view, the importance per customer can be high, when looking at the volumes the large bunker suppliers purchase from refiners and the volumes shipping liners purchase from suppliers. But the customer group as a whole, they are essential for the business of a bunker supplier. Logically, without ships sailing there is no market for bunkers. For producers, this might not be that straightforward. Of the total fuel oil supply only a part is determined for the bunker market. The rest is used as feed stock for deep-conversion refining or as a fuel for power generation. The demand for these two other applications is however declining, as opposed to the bunker market for fuel, which is the only fuel oil market showing growth. So, for the producers of fuel oil the bunker industry is definitely important.

There is low market concentration in both the refining market as the bunker supply and trade market. High levels of competition (with the exception of several “protected” ports), fuel standards and transparent pricing leave little bargaining power in the hands of suppliers. The supplier markets are characterised by low margins, with overcapacity predominating the refining industry. Supplier's bargaining position can however be strengthened by their individual experience, knowledge and financial position, ensuring reliable supply for customers. Large exporting countries of fuel oil seem to have significant bargaining power, as supply of fuel declines globally, while demand still rises.

5.5. Bargaining power of customers

The bargaining power for buyers depends on the degree to which they can force down market prices, bargain for higher quality or demand more services. This subsection throws light upon the characteristics of bargaining power in the bunker market.

Force down prices

In the highly competitive market of bunker fuels, it is not possible for individual bunker purchasers to negotiate prices. Prices are formed on spot markets. This therefore does not necessarily seem to help the bargaining position of individual buyers. Nevertheless, the fact that there is a spot market and that prices are transparent, reduces the ability suppliers to exert any form of market power through overpricing (because of inequality of information regarding prices) and lowers overall bunker prices. So transparent price formation (market pricing) protects the customer and lets him/her receive the most favourable price in any given bunkering port.

Due to the overcapacity and associated low margins and low utility rates of refiners, one would expect a certain bargaining power for the trading company or bunker supplier buying fuel oil at a refinery. The overcapacity in the refining industry, however, is not as apparent when we look at fuel oil supply. The demand for fuel oil is still growing and the amount of heavy fuels supplied is decreasing due to numerous

refinery upgrades. It is conceivable though, that the larger players in the mid-stream market engage in long-term contracts with refineries to secure fuel oil delivery and that a certain price negotiation is possible, but there seems to be little room to do so.

Not all bunker markets in the world are as competitive and transparent as e.g. Singapore and Rotterdam. In China, only five suppliers have a license to operate in the bunker sales business. The competition is mainly between Brightoil and Chimbusco, but each focuses on their own market segmentations. The former focuses more on foreign vessels, while the latter serves the domestic market. With few other options in China the prices remain high, on average some \$20/mt above Singapore. So, the bargaining power of customers is quite low in this specific market.

Within the most important bunkering hubs, where prices are determined by market powers the individual players in the bunker market have little control of, customers have little bargaining power when it comes to bunker prices. With the low freight rates, the power seems to flow further downstream.

The size of the customer plays a small, but meaningful role. Although prices are practically non-negotiable, the larger shipping liners can acquire some bargaining power due to their size, especially when it comes to long-term relationships towards security of supply. Signing a long-term agreement with a player like APM Maersk, may secure business for a supplier for a considerable time, with counterparty risks being extremely low. The same goes for the major trading/supply companies when they enter into such relations with refineries. Their size thus does not give immediate room for price negotiations, an advantage can be that they get priority based on their volume, ensuring swift sales and delivery for *their* customer.

For cost and security of supply considerations, some of the larger shipping companies have integrated backwards, entering in the bunker supply market, getting more competitive prices for their own fleet. Some traders move in the same direction and enter the refining market.

Fuel quality and disputes

The position of ship operators towards bunker suppliers is to some extent determined by formal institutions. Two important formal institutions are fuel standards and the sulphur legislation. Because of fuel standard, there is no discussion about the quality of different fuel types. The product is supposed to be within the same limits, being in Singapore or Houston or any other bunkering port. The customer can therefore demand that the fuel bunkered is up to standard. Because of this, there is no significant product differentiation possible, except for additional services. Standards therefore 'protect' the customer. Standards reach further than just the quality of the fuel, as there are even standard bunkering contracts and most terms and conditions are the same within the bunker market.

The other formal institution is the sulphur regulations. Besides the standards, there are other additional requirements for bunker fuels in ECA's on which they can be tested. The most important requirement is the sulphur content. Assuming the ECA's have a full functioning enforcement scheme in place, the quality will not only be tested in name of the bunker fuel supplier and purchaser, but also in name of the relevant port authority. In the current ECA's an increase in fuel disputes has been reported relating to LSFO. But also outside ECA's there has been a rise in disputes, because ship operators are much more keen on having the highest quality of fuel on board due to the soaring bunker costs. These disputes sometimes concern the sulphur content, but also viscosity, density and the amount of cat-fines (Al and Si) in the fuel. These off-spec disputes can arise because LSFO often requires larger amounts of blend materials (cutter stock) and some suppliers have hard times blending the fuel up to spec for as low a price as possible. Ship operators risk being tested for fuel compliance by the port state control (PSC), so they want to be sure their fuel is on-spec, as non-compliance can lead to penalties, detention or even demands for de-bunkering of the non-compliant fuel. Sometimes, the claims are not entirely genuine. Bunker purchasers can hold back payment of a particular bunker stem on just the slightest concern about the fuel, and sit on that cash

for as long as possible, therefore easing their cash flow. This could enable the survival of a shipping company, especially in these difficult economic times.

More service

Shipping companies nowadays seek more often long-term relationships with bunker suppliers, with bunker costs accounting for more than half of the operating costs. These relationships can be formalised in long-term contracts, in which, for instance, a price cap is fixed for a longer period of time or a comparable clause to hedge price volatility is incorporated. This, of course, comes at a price. As mentioned, the bunker quality plays an increasing role, and trust, local expertise and a track record are aspects the buyer seeks in a supplier. This added value from the supplier may reduce the bargaining power for the ship operator and increase prices. Increased value for bunker purchasers can also be obtained by providing financial services focusing on price hedging, being either futures, swaps or options. Many players are active in the financial services business, ranging from financial institutions to supplier and traders.

The fuel standards as well as the existence of a bunker spot market give the customer the power to easily switch from one supplier to another. Low switching costs give customers the opportunity to shop around for acceptable prices, qualities and levels of service. Added services increase supplier value and makes them attractive to engage in long-standing relations with, leading to somewhat higher switching costs and reduced bargaining power for the customer.

5.6. Conclusion

It is clear that the current economic developments have a large influence on the bunker market. Low margins across the value chain lead the players at different stages in the chain to increase focus on costs, while revenues are under pressure. The global supply of fuel oil is slowly shrinking as refiners all over the world shift their investments towards upgrading their facilities in order to produce lighter, higher value oil products at the expense of fuel oil. Demand gradually rises, and together with a rise in crude oil prices, the bunker costs for shipping companies has risen dramatically, now accounting for almost 70% of their operational costs. Refinery shutdowns characterise the current state of the refining market, especially in Europe. Also some smaller shipping companies cannot keep up with developments and older part of the global fleet are being demolished. Increasing concentration and integration is also seen in the trade and supply business as more numbers of mergers and acquisitions have been seen.

5.6.1. The five forces

At the end of this paragraph, the five forces are summarised in Figure 5-12.

Rivalry

Recapitulating on the five forces analysis of Porter, the following conclusions can be drawn. Pressures are rising in the refining sector, as rivalry between competitors is extreme. The industry is characterised by low margins, high fixed costs and high barriers to exit, all leading to substantial overcapacity. These developments have led to several shutdowns. Russian exports are at the centre of attention as, following the global trend, the Russian refineries are investing largely in upgrades in favour of the production of middle distillates. Bunker suppliers are expanding across the globe, seeing many acquisitions in foreign markets. Also vertical integration is reducing the number of players in the mid-stream market. The margins are also being squeezed, following more quality requirements and consequently more bunker disputes. However still leaving some room for smaller players, the large independents are grasping an increasingly large piece of the bunker pie. In contrast, the oil storage business is seeing larger demand for storage capacity than there is available, triggering a rise in prices as well as large investments by many different parties in storage capacity across the globe.

As with the refining industry, the shipping industry also has to deal with overcapacity. This is the consequence of both low demand and a growing fleet, due to ship orders from before the economic crisis entering into service. In combination with high bunker prices, these developments have led to the exit of several smaller players as well as the demolition of a part of the older, less efficient fleet.

Entry barriers

Large economies of scale provide a large entry barrier into the more capital intensive sub-markets, in combination with high prices for strategic locations in major bunkering ports. Certain governments still engage in market protection activities and deny foreign investments in the bunker market, creating the ultimate barrier to enter in some cases. China is a very good example of this counter competitive action. The amount of vertical integration can in some cases provide barriers to entry, for instance if suppliers of traders acquire large storage terminals, creating an advantage over competitors having little or no storage. The less capital intensive activities do not seem to have such substantial barriers to entry, e.g. financial services, where human capital is more important than cash to enter the bunker market. Experience, knowledge and trust are increasingly valuable. Standardised bunker fuel qualities could trigger new market entries, but historically low margins seem to cancel this out completely.

Substitutes

No other mode of transport can really compete with maritime transport. Trade over sea makes up the majority of international trade, especially for long-distance voyages. Air, train, road or pipelines do not seem to pose any threat to the shipping industry's position, thus securing the demand for bunker fuels.

Refiners currently see opportunities to upgrade their facilities in favour of lighter, more profitable distillates. They look for alternatives for producing fuel oil to improve their margins. On the other hand, there are currently no significant alternatives for fuel oil in the bunker business. MGO is far too costly for ship operators as a bunkering fuel as the premium to fuel oil is around \$270/mt. LSFO is an alternative within the fuel oil business, ensuring lower emissions, which is required in ECA's. At the moment, these ECA's do not so much lead to the use of alternative fuels for shipping, but more to the selection of different fuel oil supplying countries. Even so, this effect on the entire bunker market is little. Real threat of substitutes arises when there is collective action, i.e. when the global fleet shifts to other fuels.

Supplier's position

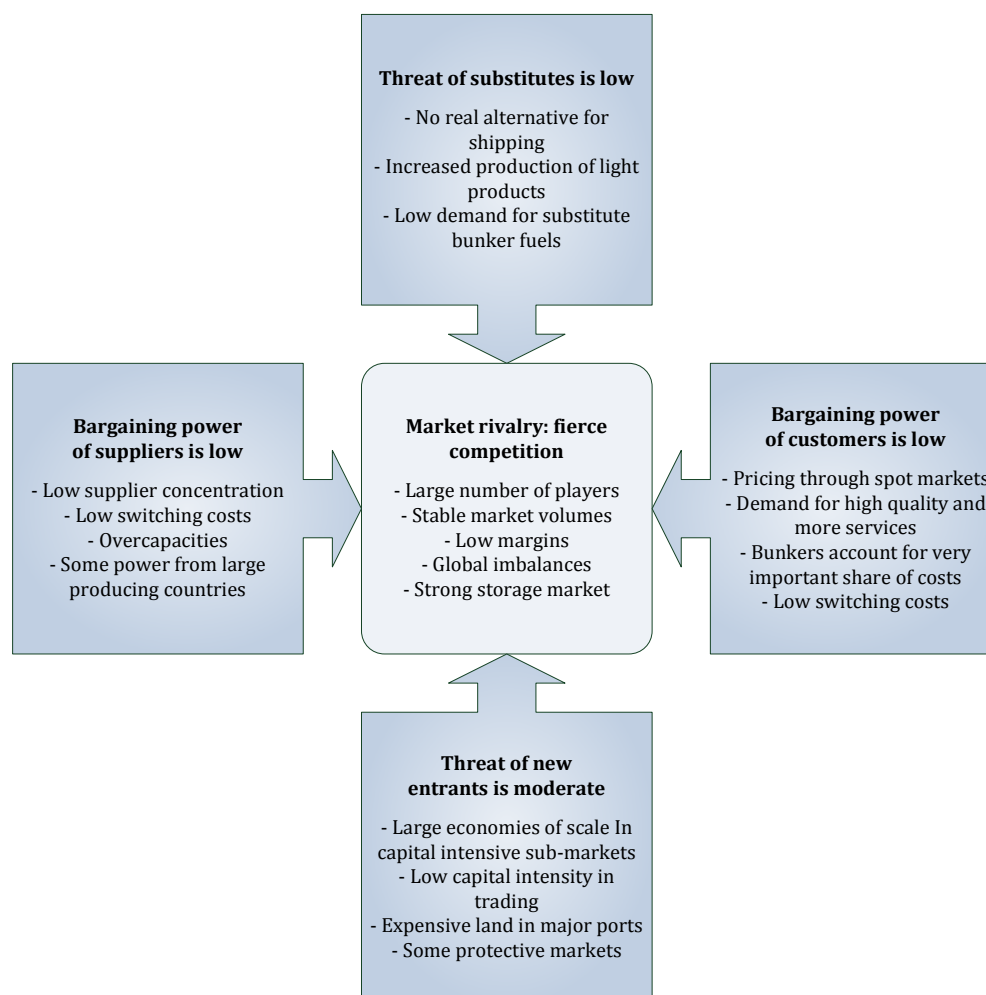
The bargaining power of suppliers in the bunker market is little. Market concentration in the refining sector is low, with hundreds of refineries spread out over the globe. The same goes for the large independents, who may own significant market shares in some bunkering ports, they are not at all the only players in the supply or trading of bunker fuels. Most ports are sufficiently competitive, with some exceptions such as China. The price of fuel oil is transparent and together with fuel standards this fact deprives substantial bargaining power of the suppliers. Low margins across the entire bunker chain are low and in the case of refining there is even a great deal of overcapacity. Increasing focus on bunkering costs for ship operators also increases competitiveness at the other end of the chain, thus emphasising the limited power of bunker suppliers within the value chain. On a supranational levels, there are however some suppliers who are definitely in a bargaining position, as most of the bunker fuel supply relies on major fuel oil exporting countries.

Customer bargaining power

The transparent nature of the bunker pricing, decreases the ability of suppliers to overprice bunkers and exert some sort of power over the bunker purchasers. This transparency provide the customer with some sort of protection. In combination with low switching costs and strongly price-driven fuel procurement strategies, this entails that at all times, the customer can choose for the lowest available price. On the other hand, bunkering costs form the majority of operating costs for shipping companies. The fuel is an essential part of their business, decreasing their bargaining position.

Ship operator nowadays demand higher fuel quality, partly because of new sulphur regulations and partly because of the increased focus on bunker procurement, due to the high prices. As a consequence, the chance of bunker disputes rises, with the power of customers to leave a claim with the suppliers. Finally, the desire for additional services by ship operators and their tendency towards long-term relations with suppliers, can give some power back to the supplier.

Figure 5-12 Summary of the five forces



5.6.2.A complex market

Bunker fuel is not as easy a product as might seem at first. Bunker fuel is not one fuel. Fuel oil makes up the largest share in the bunker market, but many developments across the world (more about this can be read in section 6), including the shift in refinery complexity of the last couple of years, are changing the historically stable position of fuel oil for the marine transportation sector.

Bunker fuels pass through many hands before ending up in the fuel tanks of oceangoing ships, and not always even physically. The world of bunker trading can be a very complex one, with many different parties taking on many changing roles, but in this section I have tried to simplify these for better understanding of all the activities involved in the bunker market.

As is clearly put forward in this section, the bunker market is both international and local and comprises more than one sub-market. The value chain ranges from the refining industry, blending, trading and

brokerage activities to bunker fuel storage and the shipping industry. It can thus be said that it is not a simple, physical market, where buyers and supplier meet at one location. The spread of refining capacity, the refineries' configurations, shipping centres and -lanes make this a truly global market. Surpluses in one region and deficits in another as well as arbitrage lead to trade in many different oil products, especially fuel oil.

Vopak

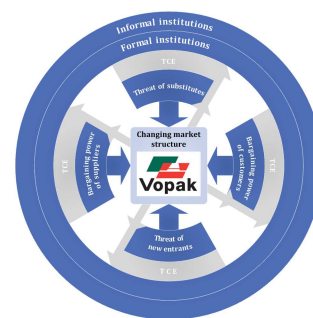
Vopak currently has firm positions in the three major bunker ports, Singapore, Fujairah and Rotterdam. The five-forces analysis has shown that there is currently a strong market for oil storage and volumes show that fuel oil as a bunker fuel is not of declining interest. Although rates have stabilised somewhat after years of unregulated rising storage prices, a strong market is expected. Because low sulphur fuels have seen increased interest, there is more demand for crude storage of different origins (sweet crudes). Imbalances are increasing due to rising demand for HSFO in, predominantly, Asia and rising demand for LSFO in ECA's. On the supply side of the story, HSFO is (for a significant part) produced in Russia and LSFO is mostly produced in Brazil, where there is a sweeter crude available. These imbalances have led to a strong demand for bunker fuel storage. Besides the imbalances, the fluctuating prices have led to an increased demand for storage capacity. This demand for lower sulphur fuels, especially for the bunker market, requires more blending to reach the specs laid down in ISO 8217. This, however also requires separate handling of these fuels, which may possibly imply adding capacity. The major locations for bunkering have steadily been the same over the last decades, although attention is still increasing for the Middle Eastern market of Fujairah, also by Vopak with its joint venture terminal Vopak Horizon.

Dynamics

This analysis of the market using the five forces of Michael Porter has clarified many aspects of the competitive environment of the bunker market. Although Porter's approach can be explained as being a static snapshot of the status quo, this section has touched upon many developments that are everything but static. These include many of the aspects discussed in previous chapter on the institutional environment, such as government protectionism, sulphur regulations, fuel standards and economic trends. It is these aspects that make this analysis not just a static representation of the market situation.

6. The future of bunkering

The previous section has given a broad overview of the bunker market, with all its internal dynamics and external influences. The analysis along Porter's model is an excellent starting point for analysing the future developments and its implications. The first paragraph explores possible developments in legislation. The second is linked to the previous section as it uses Porter's model to elaborate on the possible, but also the likely, advances in the different sub-sectors depicted in the value chain and their reactions to changing (sulphur) legislation. This section is mostly of descriptive nature.



6.1. Changes in legislation

When looking at the future of the bunker market, the majority of predictive studies agree on the crucial role to be played by legislation. This paragraph will briefly scan the possible developments that can take place in new sulphur legislation, its enforcement and in other emission legislation that may impact the bunker market.

6.1.1. New sulphur legislation

As we have seen in section 4, history tells us that establishing globally binding institutions is not an easy task as it took over three decades for the MARPOL Annex VI Regulation 14 on sulphur oxides entered into force. The dynamics of the process show us that what is now written down in the Annex VI is by no means fixed for the coming decade. The institutions are all but static and constantly require adaption to a changing global environment (Goldthau and Witte, 2010). There are two major aspects of Annex VI that are likely to be subject to change in the period up to 2025. The first is the 2020/2025 global cap decision and the second aspect is the designation of additional ECA's.

2020/2025 decision

The 2008 revision of MARPOL Annex VI Regulation 14 states that the sulphur limits mentioned in the regulation (i.e. the global sulphur cap of 0.5%) shall be reviewed in 2018 to determine the availability of the fuel oil that complies with the standards, taking into account (IMO, 2008):

- The supply of and demand for fuel oil complying with the standards;
- An analysis of the fuel oil market trends; and
- Any other relevant issues.

This review will be done by experts from all relevant fields. Finally the Member States are to decide upon whether or not it is possible for ships to comply with the new sulphur limit of 0.5% in 2020. If not, then the 0.5% global cap will become effective five years later, on January 1st 2025. Sulphur limits of 0.5% would require the use of MGO instead of fuel oil. Global availability should be satisfactory to power the entire world fleet (in so far falling under the IMO). This decision is thus, for a large part, dependent on the developments in the refining sector.

In the European Union, the proposal for amending the 1999/32/EC directive on sulphur emissions – which is likely to pass through parliament later this year – includes the rule that no matter the decision of the IMO, areas within the Union, but outside the ECA's, will be obliged to comply with the 0.5% sulphur cap. Therefore the 2020/2025 decision would have no influence on the sulphur limits within the EU.

New ECA's

The other possible changes in MARPOL Annex VI legislation, though not touching the sulphur limits themselves, focus on new Emission Control Areas. It is currently unclear what the next ECA's will be.

There are many sources claiming that number of states are considering ECA's. Several possibilities are the Mediterranean Sea, the Black Sea, Tokyo Bay, Singapore (Malacca Straits), South Korea, Australia and New Zealand, Mexico and Hong Kong (Meech, 2005; MotorShip.com, 2011).²⁶ Some are more concrete than others in developing their own ECA. An example of a State which has concrete plans to submit a proposal for ECA designation is Hong Kong (Hong Kong is an Associate Member as it is still part of China). Hong Kong has stepped up efforts aimed at exploring the possibilities of setting up an ECA in the Pearl River Delta (Perez, 2012).

No proposals for new ECA's have been submitted since the U.S., so it is a guess as to which States will set up an ECA. The procedure for submitting a proposal is as follows (IMO, 2008):

1. A proposal is submitted by a Member State, or if two or more countries have a common interest in a particular area, a coordinated proposal is submitted for designation of an ECA for SO_x and PM or NO_x or both.
2. The IMO considers the proposal by evaluating each of the abovementioned criteria and adopts or rejects the proposal. An ECA will be designated by adding an amendment to Annex VI
3. During the first twelve months immediately after an amendment designating a specific ECA, ships operating in that ECA are exempt from the requirements specific for ECA's

It is clear that the sulphur limits have the largest impact in ECA's, at least until the global cap of 2020/2025. So, if many new ECA's were to be designated within the next five to ten years, the lowering sulphur contents will become even more serious business. The impact would be particularly large (at least for short-sea shipping) if the major ports would be designated ECA's, such as the port of Singapore. But as long as the global limits stay relatively high, fuel change-over would still be common practice as the majority of total global voyage kilometres are sailed outside ECA's, out in the open ocean.²⁷

Time consuming process of decision making

As has been noted several times, supranational decision making is a long and slow process. Although large steps have been taken which the ratification of Annex VI, the implementation process is still in starting phase. The coming into force of the Protocol took from 1997-2005 (Vagslid, 2007) and perhaps the 2020/2025 decision in 2018 may take some time as well. As for new ECA's, the Member States themselves have to decide upon their ECA ambitions and submit the proposal on which the IMO then has to make a decision. Especially now that there are no concrete plans yet for new ECA's, let alone proposals, it might take several years until new designations. And even if new areas are designated, it takes another twelve months to fully enter into force.

6.1.2. Enforcement

We have seen how difficult it has been to set up the rules. It is their enforcement is what makes them effective or not, and this seems even more challenging. The IMO has no power over individual States to check if they live by the rules. Currently, hardly any inspection is reported around the globe. Only within ECA's there are some States that test the sulphur content. Parties that do not enforce the regulation cannot be punished by the IMO. The sulphur limits are already in place, and even in the four ECA's. But as experience has shown, implementing Annex VI is also not a very quick and easy process, witness the delay in enforcement in Canadian waters (Chew, 2012). Particularly the 2020/2025 global cap will require a significant extension of control worldwide, but again the question remains who will monitor the implementation (Abadie, Moehler et al., 2011).

²⁶ W. Dijkstra and J. Kolpa, Personal Communication, 29 February 2012

²⁷ Only around 8-15 per cent of global marine fuel demand is consumed inside ECA's (EPA, 2009b; Kalli, 2011; Lewis, 2011)

Costs

Strict enforcement may be very costly. Referring back to Williamson – when seeing government control of fuel sulphur content as a switch to a hierarchical governance mode in a market environment, “...*the move from market to hierarchy (and the reverse) is always attended with a trade-off between the benefits of added coordination ... on the one hand and the costs of added bureaucracy on the other*” (Williamson, 1998). This is the choice port administrations and their national governments have to make.

There are different options for these parties to enforce Annex VI, given that they perform inspections. The first are warnings. Once warned, offenders are more likely to be inspected again. Even in case that frequent prosecutions are absent, the probability of being inspected could have a deterrent effect, so warnings could reach the same goal (Heather, 2004). However, when no penalties are imposed at all, these warnings and inspections can lose their effectiveness. The second method of enforcement focuses on penalties, of which a couple have been mentioned in section 4.2, which focus on ultimately on detention of ships. Detention can be very costly, as can be the requirement to switch the content of the fuel tanks, because of exceeded sulphur limits. Other penalties are fines, which have occasionally been imposed on offender, likely in the Port of Trieste, Italy (Einemo, 2010a). Also the U.S. has plans for fining in case of violations, according to U.S. Pacific Merchant Shipping Association (PMSA) (Bruckner-Menchelli, 2012).

Role for ports

The ports at which is bunkered and loaded/unloaded can also play a role in stimulating shipping companies to comply with environmental regulations.²⁸ This is already going on, witness the Ports of Stockholm and Gothenburg. Ports can foster initiatives, support developments.²⁹ An example is a discount on harbour dues once a ships complies with certain environmental goals.

An initiative called The Environmental Ship Index (ESI) identifies ships that outperform current emission standards required by the IMO. It evaluates the amount of both nitrogen oxide (NO_x) and sulphur oxide (SO_x) emissions released by a ship, but it also lays a focus on greenhouse gas emission of the ship (WPCI, 2012). So, the environmental performance of a ships can be objectively measured and represented by the ESI. With the index ports can reward ships if they choose to participate in the ESI. ESI can on the other hand be used by ship owner to promote their environmental performance. There is a close link with another initiative, the Clean Shipping Index (CSI), which also measures the performance of oceangoing vessels, but goes a step further by focusing on CO₂, SO_x and NO_x emissions, as well as on chemical products and water and waste control. The CSI started as a Swedish initiative and is winning ground worldwide. The index can increase the business opportunities with cargo owners who are seeking greener transportation mode

Waste blending

Finally there is the problem of blending waste materials in fuel oil. There is no regulation on these materials yet, even though blending chemical waste into fuel oil causes damage to both the engines and the environment. If there were to be more inspections on e.g. heavy metals, and if the penalties would be significantly high, maybe some suppliers who are now active in illegal blending would be encouraged to do so in the future. But then again, it is very difficult to test a fuel sample for all possible contaminants. Besides, if the 0.5% global sulphur cap is introduced in 2020, the majority of the world fleet could be sailing on MGO, which doesn't lend itself for blending as fuel oil does. Setting up new legislation would miss its goal if it were no longer of major importance after 2020, also considering the lengthy process of shaping regulations,

²⁸ W. Dijkstra and J. Kolpa, personal communication, February 29, 2012

²⁹ Maersk, personal communication, February 15, 2012

6.1.3. Other emissions

Other emission regulation by the IMO may also have an impact on the bunker market. Areas of interest are, in line with other worldwide initiatives, the reduction of carbon dioxide from maritime transport, as well as the reduction of nitrogen oxides. The former relates to the efficiency of ships, while the latter is associated with the combustion in marine diesel engines.

Carbon dioxide regulations

In line with worldwide carbon combating efforts, the IMO has adopted amendments to Annex VI. Reason is the share of total global carbon emissions by the maritime sector. Carbon emissions are fuel-related, but the total carbon dioxide emissions emitted by ships are not so much related to the type of fuel oil (high sulphur/low sulphur) or distillate. This might sound confusing, but carbon molecules in the fuel are those providing the energy, so their combustion is necessary for generating power to drive engines. With sulphur, this is not the case as the sulphur in fuels is not useful. CO₂ is an inevitable emission from combustion. Therefore the emission reduction is mostly reached by efficiency measures, a trend which has also been going on for quite some time in the car manufacturing industry.

A 2009 study performed by the IMO estimated emissions from maritime shipping to be over a billion tons of CO₂, accounting for 3.3 per cent of global carbon emissions, in 2007. Of this figure 870 million tonnes is accountable to international shipping (representing 2.7 per cent of global emissions). This might seem insignificant, but this amount is about the same as the entire country of Germany. Furthermore, the IMO expects the maritime shipping sector to double in the next 50 years and emissions could soar (IMO, 2009).

These numbers have thus asked for drastic measures. In the 62nd session of the MEPC (11-15 July 2011), the present Member States adopted amendments to MARPOL Annex VI regarding the reduction of carbon emissions (Hon and Wang, 2011). It is the first globally applicable CO₂ reducing regulation. The focus of the newly added Chapter 4 lies on the energy efficiency of large ships and requires new builds to score satisfactory on the Energy Efficiency Design Index (EEDI). The new Chapter will be applicable to all ships larger than 400 gross tonnage, irrespective of flag state, as of January 1st 2013. The regulation requires a 10% increased efficiency for new build ships in 2015 as compared to the baseline EEDI (calculated by a formula), 20% efficiency increase by 2020 and a 30% efficiency improvement in 2025 as compared to the baseline EEDI. Estimates show that the EEDI efforts will lead to a CO₂ emission reduction of 263 Mt annually by 2030 (Hon and Wang, 2011). The possible benefits of the amendment can be compromised due to a condition included into the regulation. It states that individual States can waive the requirement for EEDI for newly built ships under registration of their country for up to 6,5 years beyond implementation date. This entails that some ships may not meet EEDI requirements until halfway 2019. This concession is especially included for countries being concerned about their ship yard's capacity to develop such new technologies (Hon and Wang, 2011).

On the other hand, nowadays fuel efficiency is ever high on the agenda of shipping liners, as considerable fuel – and thus financial – savings are possible. Besides, it is very likely that charter companies demand cleaner ships³⁰, so ship owner will have to go with the trend to serve the demand.

Besides EEDI there is a Ship Energy Efficiency Management Plan (SEEMP) for all ships, thus not only for new builds. The SEEMP requires all shipping companies make plans for maximizing the efficiency of their ships' operations, as studies show that 10-15% of efficiency increase can be reached by optimizing operations (e.g. slow steaming) (Hon and Wang, 2011). to develop and maintain a plan to maximize the efficiency of ship operations.

³⁰ M. Vink, Dutch Inspection Authority, personal communication, March 19, 2012

Although there is no direct link to the sulphur content requirement³¹, shipping companies which focus on increasing their ships' efficiencies may also be more prone to take measures towards sulphur limit compliance.

Nitrogen oxide regulation

Nitrogen oxides (NO_x) are particles emitted mostly when combustion takes place at very high temperatures. NO_x is not a fuel related pollutant but has to do with the characteristics of the diesel engine on board the ship and to a lesser extent with the fuel used (e.g. oil and gas require different combustion temperatures). Regulation 13 of annex VI is devoted to the reduction of these emissions. Within this regulation, there are three "Tier's" representing NO_x limits. The Tier I emission limit has long been in place (1990) and is not very ambitious. Tier II is an emission limit that is applicable to all engines installed on or after January 1st 2011. The Tier III emission limit is the most stringent and is applicable to any installed engine in ECA's from January 1st 2016 onwards (IMO, 2012e). It is expected that the only options to comply with the Tier III limits in ECA's are exhaust gas purification by Selective Catalytic Reduction (SCR, removes after combustion, just as scrubbers) or LNG fuel³² (Longva, 2011). Installing SCR's is a post-combustion measure, which may be possible to integrate with a scrubber, but they will in essence remain two different pieces of equipment, a scrubber and a catalyst. It may be an option to install both on new builds after 2016 in order to comply with all future rules, but also for a clean image or reputation. But, as mentioned, nitrogen oxide reduction is accomplished by measures related to the combustion system and its exhaust gasses and does not mingle directly in the debate of which fuel oil is used, as with Regulation 14 on sulphur emissions.³³ However, perhaps the NO_x emissions regulation is an argument for switching to LNG as a bunker fuel for the future.

6.2. The future described with Porter

Following the first paragraph of this section on the future of the bunker market, this paragraph is a scan of the possible future developments in the bunker market. Of course, the possible developments are legion, but following the same structure as section five, i.e. Porter's Five forces, only those options or developments are described that are somewhat in the line of expectation or following a trend. Again, the aim is not to provide predictions, but the scan of possible developments serves as an objective basis for the analysis of TCE-related drivers of investments in the bunker market. The centre of this paragraph is the analysis of the substitutes (6.2.3), because the impact of the sulphur limits on the heavy fuel oil market is dependent on the development of alternatives. These alternatives – or substitutes – form the heart of the possible future of bunkering. This broad description of the possible choices that lie ahead in the bunker market, enable the reasoning of action in paragraph 6.3.

6.2.1. Market rivalry

Refining industry

For describing the future of the refining industry we will need to focus first on general trends in the refining industry, after which a focus on the possible reaction of the industry to challenges arising from the implementation of MARPOL Annex VI.

Demand and supply for oil products

section 5 has given an description of the status quo of the refining industry. Keeping that description in mind, there are several developments trends that might be extended in the future. Some developments

³¹ Nevertheless efficient ships consume less fuel and thus also less sulphur oxide is emitted. Sulphur regulations are however focused only indirectly on total emissions and direct on sulphur content.

³² LNG is combusted at lower temperatures, hence less incomplete combustion

³³ W. Dijkstra and J. Kolpa, personal communication, February 29, 2012

are investment-related (investments that have already been made) and can be named with certainty, but other factors are very uncertain and depend to a large extent on the economic situation and developing demand.

Demand for oil products is tightly related to the state of the economy. After four years of economic downturn, studies expect the demand to start growing again in the coming years. Just to give an idea, Wood-Mackenzie expects demand to grow around 1.6% up to 2017 (Wood-Mackenzie, 2012a). As now is the case that the demand growth is predominantly attributable to Pacific Asia, the projections for the coming years are to follow the same trend, with the Middle East taking up a significant share of the oil product demand growth. In line with increasing energy efficiency in developed countries demand growth in these countries will likely be minimal.

In Western Europe, closings have not been uncommon and, following the findings of Meijknecht et al. (Meijknecht, Correljé et al., 2012), there will be more refineries shutting down in the near future. This development is also referred to as “capacity rationalisation”. Even more pressure on the European refining industry will come from Phase III of the emission trading system (ETS) in the EU. From 2013 carbon dioxide permits must be purchased (whereas in the first two phases they were given for free), with available permits shrinking until 2020 (Milhenn, 2011), further rising costs and further deteriorating the competitive position of European refiners. In the coming years heavy investments by ‘East of Suez’ NOCs are projected, apart from the current capacity increase, of which the largest part will come online in 2014 (Wood-Mackenzie, 2012a). The United States have also seen declining utilisation rates in the last few years, but since 2009 they see both domestic and Latin American demand grow, somewhat limiting the damage, with positive outlooks for the near future.

The products deficits and surpluses will increase globally. Where OECD countries primarily had a large demand for light distillates (i.e. gasoline and kerosene), the demand is shifting towards middle distillates (i.e. gasoil and diesel). This has led to, but will be likely to further lead to, a growing surplus of gasoline, while the deficit of diesel and gasoil will also increase. This also entails that utilisation rates in Europe will remain low. Current and expected global demand growth for oil products in the last year will most probably be countered by large capacities coming online in the particularly the Middle East, resulting in, again, lower utilisation rates (see, Table 6-1).

Table 6-1 Additional Refinery Capacity '11-'17

	New	Expansion	Total
Asia Pacific	3,084	1,601	4,685
Middle East	2,177	428	2,605
North America	-	73	73
Latin America	735	430	1,165
Greater Europe	214	-710	-496
FSU	236	200	436
Sub-Saharan Africa	55	30	85
Total	6,501	2,052	8,553

Source: (Wood-Mackenzie, 2012a)

Fuel oil

The demand for fuel oil is in decline, as fuel oil prices have reached levels at which industry and power generation demand, especially in China, will switch to the use of other fuels. This will, however, not have a downward pressure on fuel oil prices. The global fleet of bulk container ships and tankers will grow with a fast pace the coming years, mostly offsetting the decline in industrial demand for fuel oil. Prices will

probably even rise, because the refinery output will shift more and more towards middle distillates (Bloomberg, 2012b). Upgrades of Russian refineries (following the change in tax regime), together with the highly complex refineries being constructed in the East, lower the supply of fuel oil, at a faster rate than the slight demand decline. The decline in Russian fuel oil production might be detrimental to the global fuel oil supply. Fattouh and Henderson (2012) see Russian fuel oil exports decline sharply, possibly already by 2016 (although the timing of the reduction may be unclear), with maybe hardly any Russian fuel oil left on the global markets in 2020. The supply of LSFO is stable and will remain so until 2015, as the largest share of its consumption is attributable to ships sailing in ECA's. LSFO demand is currently around 15 Mt (EPA, 2009b; Kalli, 2011; Lewis, 2011) and is mostly shipped in from Brazil, which produces the fuel from sweet crudes found in that area.

Distillates

Worldwide efforts to combat polluting emissions have to and are leading to higher demands for clean fuels, especially in those region that have low distillate production. Road transport is seeing an enormous shift towards diesel, while a global cap in sulphur content for bunker fuels will likely discourage the use of fuel oil and encourage that of gasoil (what could happen within the bunker market more specifically receives more attention further on). Global balances of diesel/gasoil will be heavily skewed towards the countries with large greenfield refineries. Asia Pacific and the Middle East are investing huge amounts in complex refineries, decreasing fuel oil output, while increasing that of middle distillates. The result of these imbalances for regions with large middle distillate deficits (in particular Europe and the U.S. East Coast, together the "Atlantic Basin") have several options to meet the rising demand. At first, their imports could rise (which is likely). Secondly, to decrease dependency on other countries, they could invest in refineries to increase distillate production. However, the margins are already very low in these regions, which makes investments unattractive. Besides, these practices involve extra CO₂ emissions and will thus, in times where CO₂ emissions become more costly (the ETS in the EU), further weaken the EU's competitive position (Wilde, Kroon et al., 2007; Lewe, Alberich et al., 2012).

The economies of China and India will grow in such a pace that the added refining capacities may not lead to the required export capacity of distillates at the end of this decade. China, in particular, will be more or less self-sufficient, while India (as the Middle East) has invested heavily in export oriented refineries. The latter two regions are thus likely to be the supplier of distillates for Europe and maybe even China, if they reach the desired – export-oriented – distillates refining capacity at all.

Reactions to sulphur regulations

In a market situation where bunker fuel demand will increase with the ever growing global fleet of oceangoing vessels (see further on in this paragraph), it remains the question how the refining market will serve the changing bunker fuel demand characteristics. The demand for bunker fuels may rise up to more than 420 Mt in 2020 (Meyer, 2011). How this demand is divided between fuels remains uncertain. The sulphur regulations will definitely have a major impact on the bunker fuels market. Dependent on the implications the regulations will have for the shipping companies, the refineries may just follow a possible shift in demand for specific oil products. On the other hand, the shipping companies are also dependent on the available supply of those oil products, hence the 2018 review of availability by the IMO for the 25020/2025 decision. Significant developments concerning these issues will occur over a course of multiple years. Refinery investments may take around five years to take effect, while possible retrofitting of ships for other bunker fuels can also take years.

Due to the relatively small share of ECA's in the total bunker demand (around 8-15 per cent, see paragraph 6.1.1) and uncertainty about any new ECA's in the next decade, the demand for MGO from 2015 onwards (with the introduction of the 0.1% cap in ECA's, for which MGO is the only option³⁴),

³⁴ LNG and scrubbers are also an option (see paragraph 6.2.3), but before 2015 it is unlikely that many vessels will be equipped with LNG systems or scrubbers

amounting around 45 Mt compared to the current 30 Mt, will be easily met (Meyer, 2011). Challenges arise with the global cap of 0.5% sulphur in 2020 or 2025. The main options for the refining industry are to either be proactive and anticipate the changing sulphur limits or simply wait and see and follow the rest of the industry as demand (slowly or quickly) shifts. How the industry can react to specific alternative fuel demands, is described in section 7. But it is likely that if the majority of the global fleet shift to the use of distillates towards the global 0.5% cap, some difficulties will arise around the availability of MGO, especially if the cap is to be introduced in 2020. Such an enormous shift in demand will put very large pressures on the limited³⁵ supply of distillates (Meyer, 2011; Hughes, 2012). This possible shortage of MGO may lead to the delay of the stringent global sulphur limits to 2025 when the availability of fuel complying with the new limits is reviewed in 2018. Unless, of course, players really start to move far before that date (Speares, 2012b). Demand for LSFO will probably drop almost completely once ships will be required to use distillates with a maximum sulphur content of 0.1%. HSFO may re-enter these markets if the development of scrubbing technology takes a flight around 2015, maybe partly offsetting the rise in MGO demand.

Mid-stream

Trading

Trading business has taken a flight in the past decades and this growth in does not seem to stagnate in the near future. The last couple of years, increased attention has been given to the Middle East, and more specific Fujairah. Oil majors, as well as independents, have increased their trading businesses here and large growth is predicted for the coming years. The business model is two-sided (Reuters, 2011). The first is to provide increased flexibility to one's fuel oil business, being situated right in between the two major trade regions: Europe and East Asia. The second is to sell the fuel oil in the local bunker market, which is showing significant growth numbers. BP has established their presence in Fujairah recently and has thereby joined Shell, independent traders Vitol and Trafigura as well as Singapore-listed Chemoil (Reuters, 2011). Russian, American and Chinese parties are also expected to establish their trading arms in the Middle East. Other developments for the trading business will focus on further geographical expansion, with raising hopes for the Chinese market, usually accomplished by taking over local players.

Especially in the trading and supply business there is a trend towards mergers and acquisitions. Larger players who are able to weather the storm currently hitting the bunker market are likely to turn out as winners, while many smaller players will have to close or scale down (Ladekjaer, 2012). For the players in this market it is vital to have both a sustainable and a robust business model supported by long-term financing, which is something many smaller operators do not have (Meyer, 2011). With expected recovery of the global economic situation these developments may slow down and competitiveness within the number of trading businesses will rise again at the end of this decade.

Supply

Singapore is the largest bunker port in the world and the main bunkering hub in the region. However, this position looks set to be challenged by ports in the Southern China (George, 2011). These ports are looking to confiscate significant portions of the market by providing bunkering services closer to where the actual demand is. Opening of the market in China is essential, but as we can see, currently the first steps are now being taken towards opening the bunker supply market for foreign parties, enhancing competition and lowering prices. At the moment, bunker fuels are sold at relatively high prices if compared to Singapore.

Blending

Large opportunities lie ahead in the blending business. The entry into force of the ECA sulphur limits in both Europe and the North America has led to an increased demand for low sulphur fuel oil (LSFO). The

³⁵ Refineries cannot anticipate such a demand rise in the short term, unless shift is more gradually

sulphur content of crudes are of course essential for the sulphur levels in fuel oils. So, naturally fuel oil produced from sweet crudes is attractive for the supply of LSFO. Brazil is one of the major suppliers of 1.0% LSFO. But for other crude sources, blending is the way to go. Higher sulphur fuel oils require blending with distillates. Blending is even required for the global 3.5% sulphur limit for a small portion of available fuel oils. This concerns mostly fuel oil produced from Arabian crudes. So, there is a growing demand for blending. With increased blending, not only distillates are used to reduce sulphur levels, but more and more other materials are used. This brings along quality issues affecting the combustibility and the engines. Increased inspection might bring these quality issues to light.

There are rising worries concerning this blending of contaminants from unknown cutter stock sources, as well as high amounts of cat fines, originating from the addition of HCO (heavy cycle oil) in the complex refining process (Speares, 2011; Tongue, 2011; Speares, 2012a). The cause of these issues lies in the expectation that “unscrupulous suppliers to enter the market seeking to boost volumes by putting some pretty nasty stuff in” (World Bunkering, 2012). Tight margins, as well as increased need for blending may encourage these practices. Therefore it is very important for suppliers and shipping operators to gain a certain amount of mutual trust that, on the one hand, these incentives for illegal practices will not take place, while counterparty risk is decreased, on the other hand.

Financial and consulting services

The fluctuation of fuel oil prices which we have seen in recent years are likely to remain, which is why more and more shipping companies seek ways to hedge their price risk. An example is fixed forward pricing, which may avert too much exposure to price volatilities. Hedging instruments are at the centre of a growing business, as many parties in the mid-stream industry start providing these services. The other increasingly important risk is that of counterparties. Both for shipping companies and suppliers, counterparty risk is something they want to avoid. On the one hand the credit situation of the counterparty is centre of concern, which means either the ship operator requiring financing from banks or suppliers who are required to take on more counterparty credit. Parties want some sort of understanding of the counterparties' creditworthiness and that is why the focus within the industry has moved to more financial transparency. On the other hand, shipping operators are often concerned with the fuel oil quality and with the increase in blending processes, the risk of off-spec bunker fuel has risen. Both financial services such as guarantees and consulting services for fuel procurement are more and more accepted tasks of bunker suppliers or traders. These consulting services could comprise providing strategic counsel, technical analysis, risk management, advice of managing energy efficiency, etc. (Meyer, 2011).

Storage

The oil storage business is seeing many parties interested in investing in additional storage capacity, as is mentioned in section 5. The oil product market is seeing growing imbalances across the world, with increasing surpluses of distillates in the Middle East and India and growing deficits of distillates in the Atlantic Basin, with increasing gasoline surpluses. The high storage rates, as a consequence of capacity shortage following an increase in production and growing imbalances, have attracted the conventional oil companies as well as largely integrated trade and supply companies in building more storage. The independents are also looking to expand, mostly in new markets. Fujairah will see the largest terminal growth, but parties are trying to enter the Chinese market as well, being one of the most interesting region of growing bunker demand in the coming decade, with varying success. The hopes are high that the Chinese storage market will also completely open up for foreign investors. For independent storage companies, the coming years will increased competition from storage terminals invested in by private equity funds or infrastructure funds, who buy into “well-positioned growth opportunities” (Wood-Mackenzie, 2011d) as they seek easy” turnarounds and low-risk income flows.

A changing bunker fuel market will also impact the storage sector. The differences in sulphur limits, inside and outside ECA's, varying from 0.1% MGO at berth in the EU to 3.5% HSFO outside ECA's. The future will

bring more product differentiation and thus require more complex product handling. This is expressed in increased segregation of fuel grades, requiring separate storage and handling for LSFO and HSFO, increased blending practices and a more flexible infrastructure. These requirements will be location specific as local bunker markets will demand for different levels of flexibility and service. For the future it is unclear what the major source of bunker fuel will be. If the entire global fleet were to switch to MGO in 2020 or 2025 (assuming all parties will directly want to comply with the IMO rules) the most important bunker hubs may shift as prices may vary between locations due to skewed availability. Within ECA's HSFO storage tanks will partly be freed up to accommodate the rise in distillate storage capacity demand. Storage companies should thus follow the developments in the bunker market with a close eye to act upon possible changes and optimise their storage services for each geographical location.

Shipping industry

Industry developments

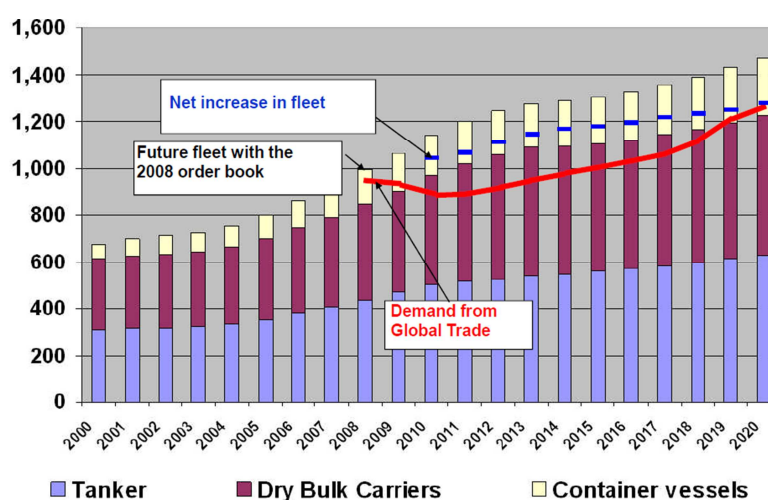
The past few years have seen devastating market conditions for the international shipping industry. Risen fuel costs and lower freight rates have narrowed the margins to such an extent that many shipping companies went bankrupt. It is estimated that around 5 per cent of the total global fleet has been taken out of business (IEX, 2012). And in the near future this trend does not seem to pass. The rough times for shipping companies are likely to last another two to three years before the first signs of recovery come to light (Jameson, 2012b). Referring back to the large number of vessel that were scrapped, one would expect some release of pressure on the freight rates, but the problem is that many ships ordered in or before 2008, when the economy was still booming, are coming online within the next few years. There is also a wave of new orders to be expected (see Figure 6-1), especially for fuel efficient vessels, so that when the market regains its lift, competitive advantage can be reached. This, of course, is only possible for the large shipping liners, which have enough capital to invest, therefore further diminishing the position of the smaller, struggling shipping companies.

A major development for the coming decade is the increased efficiency of ships. The most inefficient ships will probably go out of service, while new builds are projected to save up to 30% on fuel costs (Corkhill, 2012). This efficiency gain can be reached partly by implementing the EEDI guideline for efficient design. Another efficiency measure, which will also concern existing ships, is slow steaming. Slow steaming entails that ships no longer sail at full speed the entire voyage and increase the voyage duration with around 10%, while reducing fuel costs with around 20% (although higher reductions are possible) (MET, 2011). In practice, the delay in arrival time has not been a significant issue among cargo owners, because shipping liners promise higher reliabilities of their expected arrival times.

The coming years will see a growing number of vessels, due to the investments in new vessels, and even though a percentage of ships will commit to slow steaming, the demand for fuel oil will increase. This trend is more certain for the first five years, but once the 0.1% cap inside ECA's enters into force, the first large quantities will be added to distillate demand at the expense of LSFO, now estimated to be amount around 15 Mt.

It remains the question, however what shipping companies will do once the global sulphur limits will drop to 0.5%. As it is impossible to blend fuel oil for the entire world fleet down to 0.5%, the probability of enormous increases in MGO demand rises. However, the shipping industry also has other options, such as sailing on LNG, which will get more attention in paragraph 6.2.3. The total demand for bunker fuels, along with the expected global economic growth, will grow with estimates averaging around 420 Mt in 2020 (Meech, 2010; Meyer, 2011), from an estimated 235-330 Mt today (see section 2.2).

Figure 6-1 Projection of growth of the global fleet



Source: (Meech, 2010)

Challenges for shipping

Shipping companies operate in a high volume, but very low margin business at the moment. Intense competition, combined with fluctuating prices and quickly changing opportunities are the challenges shipping companies face in the next couple of years. At the same time, emissions regulations increase difficulties concerned with fuel procurement. Which fuel will be the best option for one's fleet or what will be the best SO_x-abatement method? In such a volatile environment shipping companies need to be flexible to adapt to change. Shrinking mismatches between demand and supply for shipping towards the end of this decade might give shipping companies some air, but it is likely that many, smaller and less financially strong players in market will have gotten the worst of it.

6.2.2. Threat of new entrants

In line with the analysis of the threat of new entrants – or better, the degree to which barriers to entry exist – presented in section 5, this paragraph describes potential future changes in the entry barriers on the different sub-sections of the bunker market. Currently, the bunker market is experiencing tough times. Not only the refining sector, but also traders, suppliers and shipping companies have noticed intense competition, low margins and rising costs.

Economies of scale

The refining sector will continue to be a difficult market to enter in, at least in the Atlantic Basin, where the outlooks for business opportunities are negative. Building new refineries to meet the increased demand for distillates may be a possibility, but investments would be too high to be competitive with the large capacities coming online in the Middle East and Asia Pacific. It is mostly NOC's who invest in refining capacity and they are even expected to further invest in shut-down European refineries, therefore expanding their global presence. Other parties investing in refining capacity are large trading companies. This emphasises the increase in economies of scale of these parties. Now that future expansions and greenfields are also planned in the same areas in Asia and the Middle East, the scale of refining companies will only increase. Also in the trading and supply business, it is the smaller competitors who are experiencing the largest difficulties as required working capital and rising counterparty risks force many of them out of the market. This counterparty risk reflects the same difficulties many shipping companies are seeing. Again, it is the larger player who survives. All these enlarged barriers of entry may, however, shrink once opportunities arise in growth conditions. The bunker market, along the entire chain, is a very cyclical market reacting quickly to changing economic situations. As many studies predict the economy to

recover in the second half of this decade (I am careful to adopt predictions) the shipping market as well as the refining market will immediately notice this, increasing the use and trade of bunker fuels.

Product differentiation

New sulphur legislation entails different fuel procurement strategies among shipping operators. Stricter limit requires more drastic measures. As will be explained further on, there are several options for shipping operators to comply with lowering sulphur limits (either its content in fuels of the emissions themselves). Larger demand for LSFO following the entering into force of the first ECA's has provided opportunities for countries exporting LSFO (mostly resulting from sweeter crude sources). Brazil has strengthened its position in this market. Bunker suppliers can add substitutes for fuel oil to their product base, e.g. LNG bunkering in Northern-Europe. Although the market situation is not desirable for ship owners, new entrants in the market may have the advantage – as do refiners active in greenfield projects – that they own the state-of-the-art assets, which are more adjusted to changed demand patterns. More flexible and complex refineries are better to meet increasing distillates demand. In the same way, newly designed ships can perform far more efficiently than many older ships and are therefore more attractive for charterers or cargo owners. These modern assets can thus be seen as a differentiated product from the majority of the industry.

Capital intensity

Most changes in capital intensity concern the retrofitting of current installations. New refineries, new storage tanks or new ships are not necessarily more capital intensive than before, but it is the switch that has to be made by many parties, with tightened regulations and changing demand patterns, that increases capital intensity. It is the current players that have to invest significantly in more flexible oil infrastructure (storage companies) or in retrofitting ships with scrubbers.

Location

With expected large growth in countries like India (and Pakistan) and China, establishing oneself in these countries may provide a significant advantage. However, these markets are not completely open yet to foreign investors, so those locations have considerable opportunities, but government policy restricts access. Once these markets open, and this is projected to happen within the next decade, timely positioning in these bunker markets can be a great plus. Investments in oil infrastructure will shift to new bunkering markets as the conventional bunkering ports will be saturated, with no more space to build on.

6.2.3. Threat of substitutes

It is the shipping companies who are directly confronted with the sulphur regulation and are expected to comply with the lower sulphur content in their fuels. With varying limits across the world and across time, it is more than reasonable to suggest that not one option will suit the entire global fleet. Therefore it is prudent to scan the possibilities for compliance to the IMO rules. It also becomes clear that these possibilities do not only concern the choice of shipping companies, but also the actions of refiners. Countless studies conclude that it is not only the shipping sector that is to take action, but a significant role is laid down for the refining sector as well (amongst others, Avis and Birch, 2009; Stockle and Knight, 2009; Hälsig, F.Baars et al., 2010). However, the possibility of substitutes will be felt as a threat for the fuel oil market, they may also be an opportunity for current and new players as long as parties adapt to the changes. Finally, it is worth noting that because different areas have different sulphur limits, many ships will engage in fuel change-overs. This entails that ships switch between fuels when entering an ECA or a port. There are many fuel options for ships, but not all are as promising to help comply with the Annex VI sulphur limits within an acceptable period of time, so only those options are discussed that are likely to help reach the goals.

Low Sulphur Fuel Oil

The first alternative to the heavier fuel oil mostly used aboard oceangoing vessels, is low sulphur fuel oil (LSFO). LSFO is fuel oil with a lower sulphur content. Currently LSFO supplies are available predominantly for vessels operating in ECA's, where there is a sulphur limit of 1.0%. LSFO is usually traded at a higher price than HSFO (expected range is 40-100\$ above HSFO), but the LSFO-HSFO premium is relatively low at the moment, because of a tighter HSFO market during the rise in demand during the summer of 2012 and prices of bunker fuel have dropped over 100\$/tonne in May/June. This trend, however, is not likely to be prolonged as the first signs of rising fuel oil prices are visible at the time of writing (Bloomberg, 2012a).

LSFO has less potential as the 2015 ECA deadline for 0.1% compliance passes. LSFO can be blended down with distillates of other cutter stock, but when blending with 0.1-1.0% distillates, under 1% LSFO seems unrealistic.

Much of the LSFO supplies have been blended, and as mentioned earlier, there have been problems with the blended products. The low quality of some LSFO supplies show poor ignition and combustion quality or become unstable. The problem is that these fuels mostly meet the ISO 8217 specifications (as these do not take account of all possible contaminants). Most stability problems are related to the use of unconventional blend components. Also, more ship operators purchase 500-1000cSt fuel oil and these are unlikely to be blended to low sulphur specs.

There are different issues arising in the supply of LSFO related to the possible ways to produce LSFO. The first production method is the aforementioned blending of HSFO with cutter stock (mostly distillates, but also increased levels of unknown and often damaging cutter stock are added). Blending takes place either at refineries or storage terminals. The second is using a sweet crude slate. Crude containing low amounts of sulphur (see Annex G) results in low sulphur fuel oil, when refined. The final method is desulphurisation of fuel oil products at the refinery.

Marine distillates

The second option to comply with MARPOL Annex VI is to sail on marine distillates (or MGO³⁶). Distillates are a lighter product traded at significantly higher prices than HSFO; the premium is around \$270 per tonne (\$840 - \$570). In general, this fuel can be used in the same engines as HSFO, but may cause problems in some cases, also in auxiliary systems. MGO is a much lighter, cleaner, but also less stable fuel than HSFO. MGO is traded with sulphur levels of up to 1.0%. When looking at the timeline of Annex VI, MGO is the only fuel for existing marine diesel engines that can comply with the 2015 ECA cap of 0.1%. It is also the only oil product mentioned to accommodate the shift towards the global 0.5% cap. The IMO described the purpose of the 2018 review as an analysis of available fuels complying with the new limits that are to be applied at that time. Although the IMO doesn't mention a specific fuel (because LNG is also an option), this fuel is mostly likely to be MGO.

If ship operators also operate outside ECA's they have to switch fuels between areas. And if they engage in fuel change-overs, they have to pay attention to the technical challenges associated with it. Switching between fuel oil and MGO may lead to significant operating risks, including damage to the engines, unplanned downtimes and extra costs, therefore investment is required in properly equipped fuel systems, clear operating procedures and thoroughly trained crews (Meyer, 2011).

MGO is not a standard oil products leaving refineries. All refineries produce middle distillates, but they are not all the same fuel. The growth in demand for land-based diesel has led to an increase in the production of middle distillates. MGO, although similar to road diesel, is not the same fuel. MGO has a different flash point than land-based diesel (60 degrees versus 55 degrees Celsius) (Meyer, 2011). The standards for

³⁶ Marine diesel oil (MDO/DMB) is also considered a marine distillate, but the sulphur levels in MDO are often too high to meet the regulatory requirements. So with distillates, this study refers to MGO/DMA unless mentioned otherwise.

MGO are different. Refineries can configure their facility set up to produce MGO instead of road diesel, but would also have to build additional storage for this different type of fuel. Another option is to blend road diesel to MGO specifications (Rogozen and Lin, 2008), but at the moment road diesel is more profitable than MGO. Future increases in distillates refining capacity will probably be seen in the Middle East and Asia Pacific (through upgrading or new installations), while MGO demand will rise in ECA's, thus requiring the produced fuels to be shipped to ECA's, raising prices.

Scrubbers

Sulphur oxide scrubbers can be installed aboard ships to remove the sulphur emissions ex-post, i.e. from the exhaust gasses. This options allows for HSFO to still be used within ECA's. The systems uses seawater to absorb the SO_x . These systems are not new, as they have been widely installed on land-based applications (EPA, 2009a). Scrubbing technology is fairly new to the maritime transport industry. Only several scrubbers have been installed as demonstration project. These projects have shown that scrubbers can be installed within the space occupied by the exhaust silencer units and that they function as desired in marine applications (EPA, 2009a).

There are two types of scrubbing installations, the first being the open-loop system and the second is the closed-loop system. Both systems have been tested through demonstration projects (Leigh-Jones, 2009; Axelrod, 2011). In open-loop systems, seawater is used as wash water for the exhaust and finally disposes of the treated wash water by discharging it back to sea. In these systems the seawater is either sprayed on the exhaust gases or the gases are routed through a water bath. The produced SO_2 reacts which oxygen in the exhaust gas and subsequently reacts with water, forming sulphuric acid. This acid in turn reacts with carbonate and other seawater salt to create sulphates. These particles are then removed from the wash water, after which the pH is raises before discharging the treated wash water to the sea. Removed solids are stored on board as sludge and are to be properly disposed of ashore (EPA, 2009a)

Closed-loop scrubbers uses fresh water as wash water. An alkaline solution of caustic soda (sodium hydroxide – which has a high pH and is therefore basic) neutralizes the sulphur oxides in the exhaust gas, after which it is dissolved in the wash water (Axelrod, 2011). A small portion of the waste water in the closed-loop system is discharged after being treated to remove sludge. The sludge is stored in a holding tank for later disposal ashore. Most of the treated effluent is kept on board if needed and fresh water is added when needed. In essence, it is not entirely a closed system, but is has the option to operate with zero discharge for a considerable amount of time.

Scrubber can also remove most of the PM. The mentioned sulphates form the largest part of PM. Removing most of the SO_x form the exhaust gas stream prevents much of the PM to be formed after release in the atmosphere. Ash and metals, however, will most likely not be removed from the exhaust gases with scrubbers.

Scrubbers are not used on a large scale and there are considerable costs related to the retrofitting (including time spent in docks) of ships. Large scale retrofitting may also be halted by the limited capacity of shipyards. On the other hand, if scrubbers are installed, high premiums for alternatives fuels as compared to HSFO are avoided, thus saving a fuels costs.

LNG

Liquefied Natural Gas (methane) as a ship's fuel will reduce NO_x to clearly below Tier 3 level (for four-stroke engines), SO_x to zero, particulate matters to about zero and CO_2 by about 20% without any after treatment of combustion gases or exhaust gas recirculation (actual higher CO_2 reduction is partly mitigated by possible methane leakages, a far more impactful GHG). Using LNG as a fuel for ships is not new as Norway has over a decade of experience with LNG, mainly on small ships, like ferries and offshore supply vessels. LNG seems a good option.

There are, however, considerable difficulties associated with LNG bunkering. These comprise on board technical challenges as well as insufficient infrastructures and lacking regulations. One basic disadvantage of the use of LNG as bunker fuel, is its low density (Harperscheidt, 2011). Compared with fuel oil, LNG takes around twice the volume for the same energy content. Storing the LNG thus requires more space, but also the storage conditions poses a challenge, as not all containment systems can handle movement (sloshing), refrigeration³⁷, high pressures and small space requirements at the same time. Other challenges arise when using LNG in combination with oil based fuels in dual-fuel engines, due to their different characteristics.

Besides on board technical challenges, infrastructural-related issues are very difficult to tackle on the short term. At present, apart from several small scale LNG terminals in Norway, there is no existing infrastructure for LNG bunkering. Other options than bunkering LNG at fixed onshore tanks are bunkering via trucks, the use of switchable LNG tanks, floating storage facilities or bunker ships. At present the small scale terminals are located away from the busy ports, so are not attractive for a large part of the North-Western European fleet. Some claim that LNG bunkering will need to be located as close as possible to areas of traditional bunkering, if it is to raise acceptability amongst the mainstream shipping industry (Harperscheidt, 2011). So, the larger ports, such as Rotterdam and Singapore, are currently establishing their first LNG receiving points (Abadie, Moehler et al., 2011) and other efforts in Europe are made (see Annex J). The amount of LNG terminals is expected to be much higher in Asia, where LNG is widely used, but these areas are not within the most strict ECA's. Besides delivery points, distribution logistics are also to be set up (a retail network), including installation for LNG transfer systems.

Finally, work is to be done on the safety issues arising when bunkering LNG. There must be industry standards for handling LNG in bunker ports. Also, offshore and onshore safety regulations must be harmonised (Bech, 2011).

The LNG price relative to that of other fuels is very important. Decisions to shift towards LNG usage will be made on the comparison between the high costs for LNG equipment and the LNG-LSFO (or MGO) premium. Therefore, as LNG is expensive, the use of LNG will probably be restricted to ECA's, at least until the introduction of the global 0.5% cap³⁸. The price of LNG, of course, is for a large part linked to its availability, which is, at this moment, is very low. But future projections of the LNG price are positioned somewhat lower than that of fuel oil.

But the most important factor today for the shipping industry is the availability of the gas itself. Many indices foresee LNG as being a relatively cheap fuel.

LNG has a lot of potential, but it is too soon to declare it as the fuel of the future. There are many unanswered questions about the supply network, infrastructure, cost and return-on-investment period, as well as health and safety

6.2.4. Bargaining power of suppliers

Market concentration

In the fuel oil supply market, i.e. refiners, traders and suppliers there is an on-going trend of mergers, acquisitions and expansions. An example is the overseas expansion of Chinese PetroChina in the Americas, Singapore and Europe (Yan, 2012). Another is the larger trading companies, like Gunvor, Glencore and Vitol, which are investing heavily in refining and storage. It is these developments that can increase their bargaining power.

³⁷ LNG needs to be stored at temperatures below -162 °C to remain in liquid state.

³⁸ With the exception of gas carriers

Bunker fuel producing countries

Other possible changes in supplier bargaining power lies in the origin of bunker fuels. Russian fuel oil is expected to lose ground on the bunker market, as major upgrades decrease fuel oil outputs following rising export taxes for heavier fuels. Russian distillates will see demand rise, and although supply is currently high, not all Russian refineries supply distillates with sufficiently low sulphur levels to be able to comply with approaching sulphur limits in the marine fuels (Meijknecht, Correljé et al., 2012). Increasing (though still little) amounts of MGO is exported from the Middle East, but especially India is expected to strengthen their position for distillates on the European market post-2015 as they are investing in highly sophisticated export-oriented refineries, while growing Chinese capacities are mostly for domestic consumption. Once specific countries, likely being India, have a large share in global MGO supply, the bargaining power will gradually shift towards these countries. Once ECA's enter into the 0.1% sulphur limits in 2015, the demand for MGO will rise considerably. Supply, on the other hand, will thus probably not be located in these areas, therefore raising the amount of supplier power in the MGO market.

6.2.5. Bargaining power of customers

The developments in customer bargaining power for the future are related to pricing, quality requirements and the desire for more services.

Fuel pricing

With EEDI and SEEMP regulations taking a lift-off in 2013, the drive to improve efficiency on ships will become stronger. But the regulations are not the most important consideration for shipping operators when it comes to efficiency. Prices are the main driver for this. The low freight rates and the plummeted bunker prices, have led to very narrow margins, even squeezing out many players in the shipping business. Therefore, fuel costs are receiving more and more attention. Efficiency improvements of up to 20-30% on existing ships and even more for new builds are possible. Although complying with the efficiency regulations and boosting the company image, efficient sailing save a lot of money. These developments will temper the fuel oil demand growth and will lead to smaller individual purchases. Shipping operators are therefore in a bargaining position as they are forcing down prices with their actions.

Quality requirements

The rise in bunker disputes (mentioned in section 5.5) will potentially continue, because stories of damaged engines or faulty bunker samples are more an everyday reality in the bunkering world. The risk in terms of the product performance is entirely felt by the bunker purchaser, creating a weak bargaining position. As incidents have proved, it is no longer sufficient to simply trust the ISO specifications and the lowest available bunker price, but it is increasingly essential to invest in good relation and trust with bunker suppliers, so that product quality is assured. With more sulphur limits lying ahead, quality requirements will be higher and shipping operators will be more prone to sample their bunkered fuels with sampling institutions. This may strengthen the customer's bargaining position somewhat.

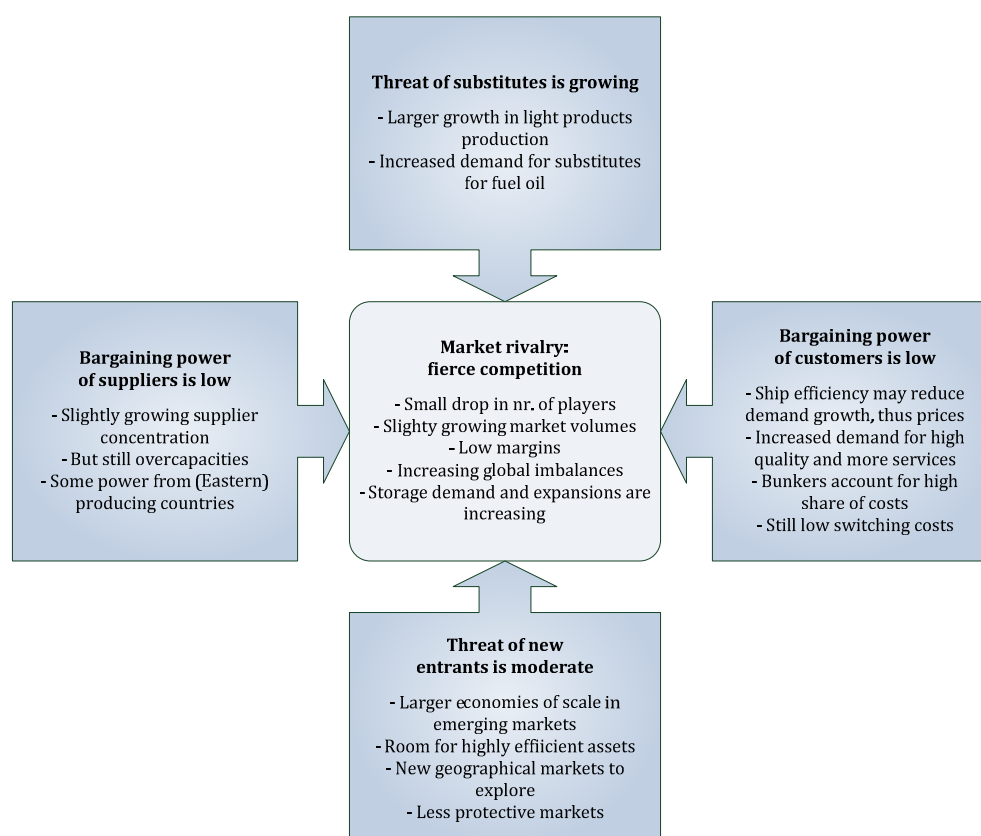
Services

Shipping operators' fuel procurement strategies will thus receive more attention. But they cannot do this alone. It requires a transparent relationship with the supplier. Customers will require more services from suppliers, but referring back to paragraph 6.2.1, they are happy to do so, as it provides new areas of income. Bunker purchasers should evaluate the role suppliers can play in ensuring product quality, hedging price risk, jointly preparing for legislative change and maintaining HS&E standards. Suppliers have the opportunity to meet these desires and differentiate themselves by building close relations with shipping operators. Together they can work to optimise fuel procurement, meet environmental requirements and increase profitability.

6.2.6. Use of the five forces

Up to now, the aim was at giving a clear view of the future functioning of the bunker market, together with its institutional environment. Porter's model has given a convenient framework along which the developments in competitiveness of the different sub-sectors within the bunker market could be described. The first part of this section followed the line of reasoning of section 5, but took a glance of what is to happen in the future, with an emphasis on the possible developments (see Figure 6-2). The Porter-analysis of future developments has not involved making any claims or predictions of what *will* happen, but has given a broad view of the *possible* competitive changes in the market, on the background of global trends in the refining, the mid-stream and the shipping sector.

Figure 6-2 Summary of the future five forces



6.3. Changes for Vopak

The future developments in the bunker market are here analysed in two parts, being the changes in the institutional environment and those in the competitive environment of the bunker market. Some or all of these developments can impact Vopak. These implications for Vopak are discussed in this paragraph.

6.3.1. External developments

As the analysis has emphasised, the developments in the legislative environment may play a large role in the future of the bunker market. Possible new ECA's and efficiency measures can influence future demand and supply for fuel oil, but they will probably only have a local or marginal impact on the bunker fuels used globally. Global changes in legislation are more likely to trigger developments in the bunker fuel market. The decision for the entry into force of the global 0.5% sulphur limit is to taken in 2018. But this

decision mostly relies on the availability of 0.5% compliant fuels. The cap will enter into force in either 2020 or 2025. If both shipping companies and refiners will steer for a delay to 2025, the change for Vopak worldwide will come after this date. But would it really have an impact? The bunker *volumes* would not be rigorously different, but the product itself. Vopak stores its fuel oil in specially heated tanks, but MGO is also storable in these tanks (low asset specificity)³⁹, so this does not imply new investments are required. There would be some loss in revenue, as fuel oil heating is also profitable.

So, Vopak and other storage companies will not feel any direct pressure from the sulphur regulation included in MARPOL Annex VI. It is not these companies that have to comply and are not under inspection for these matters. Once demand volumes as well as demand locations for certain fuels changes, this would definitely impact Vopak's business. So the effect will be indirect, through changes in the market.

6.3.2.Changing fuel oil balances

In the near future, Russian fuel oil transshipments are projected to decrease due to the large scale upgrading of Russian refineries following the 60-66 tax regime, which lays higher charges on fuel oil exports and thus indirectly supporting refinery upgrades to produce more distillates which can be sold with larger profits. In this way the Russians become less dependent on foreign distillate imports, but also their fuel oil export will decline. Rotterdam, as an important port for transshipment of Russian fuel oil, will definitely see a decline in Russian fuel oil imports. The question is when this will happen. Significant reductions are expected around 2016-2017 (Wood-Mackenzie, 2011a; Fattouh and Henderson, 2012). This means that Rotterdam will see a lower demand for fuel oil storage as well, unless other sources are found that can ensure the current volumes of fuel oil store and transhipped to other markets, Asia in particular. However, the ECA shift to 0.1% sulphur restrictions in January 2015 will lead to an increased demand for distillates in Europe and the U.S., creating opportunities for distillate storage capacity demand.

Other parts of the world (non-ECA's) are not yet under strict sulphur regulations and still allow 3.5% HSFO. This still forms the majority of the bunker fuels market, so there will still be a large demand for fuel oil, especially when keeping in mind the growing fleet in the coming years. The imbalance in fuel oil demand and supply is also likely to grow. ECA's will switch to the use of distillates and the fuel oil demand will only grow in the emerging economies in Asia, while supply will remain to be located outside these areas of growth. Imbalances will ask for more fuel oil storage. China is a promising market for fuel oil storage if it were to open up completely to foreign investments. Until the global cap of 0.5% fuel oil is still expected to form the majority of the bunker market. But, if the majority of the global fleet will sail on MGO after the global 0.5% enters into force, the bunkering locations might change. Distillates are produced in the U.S. and in Russia, but the lion's share of future MGO supply will (following current investments in refining capacity) come from the Middle East, China and India. China may potentially just be self-sufficient and the Middle East and India are seeing large export-oriented capacity additions come online from 2014 onwards. This may put a heavier importance on the ports in these areas, especially Fujairah. Although Rotterdam is an important bunker market, it is not unthinkable that vessels trading between Europe and Asia will stop and bunker at these Eastern ports instead of Rotterdam. Distillates would logically be cheaper in locations around India and the Middle East than those transported all the way to Rotterdam. So, post 2025 there might be a shift in the importance of Rotterdam as a bunkering port.

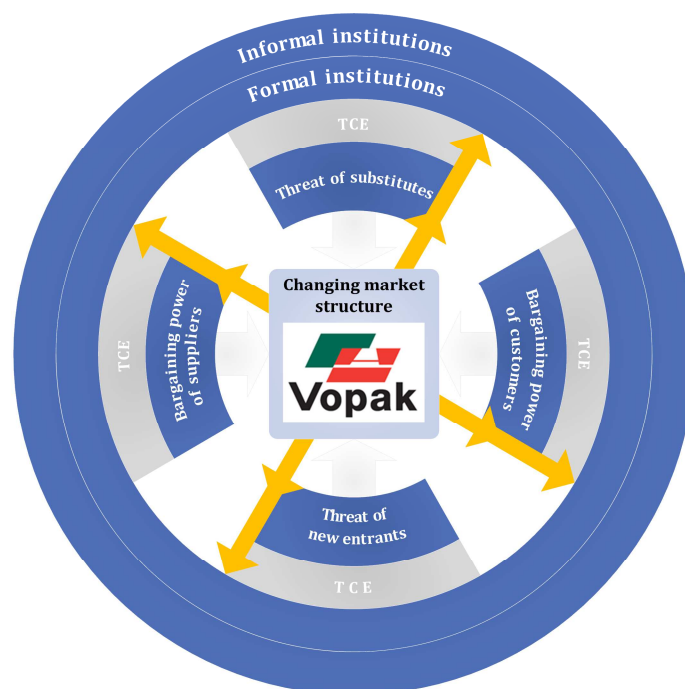
6.3.3.Dealing with changes

The mid-stream players are, as the analysis shows, not the critical actors that will shape the market towards sulphur limit compliance, but they could play a role. Of course it is interesting for Vopak to know how it can manage the outcomes of future IMO legislation. Vopak can either proactively try to influence

³⁹ The physical asset specificity of these tanks would be higher if the switch was from MGO to fuel oil, as the latter requires heating and different handling systems.

the formal institutions, consciously monitor developments, seize business opportunities or simply wait and see. In this last case, Vopak incurs the developments and has to adapt *ex-post* to changes in bunker fuel demand, i.e. the wait-and-see attitude. In former three cases, Vopak acts to influence the developments by proactively playing along with changing demand *ex-ante*. Figure 6-3 refers back to the theoretical framework discussed in chapters two and three.

Figure 6-3 Vopak: managing the environment



Influence sulphur legislation

Vopak, along with other independent storage companies, is an indirect stakeholder in the whole issue (see section 5). With influence one could think of lobbying organisations, because one single firm is not likely to be taken seriously by the IMO. A lobby of the entire oil storage sector may be of some influence for future decision making. A large scale transition towards MGO could be helped by the storage sector, as they could play a crucial role in establishing storage capacity, which would be required in possible new refining and bunker centres. So, towards the 2018 decision on compliant fuels availability, an independent storage sector lobby could ask for involvement of the sector in this review. This can however be more difficult than it sounds. The IMO rules have taken several decades to become adopted by all the Member States. In fact, MARPOL Annex VI Regulation 14 is the first globally applicable sulphur emissions regulation⁴⁰, and has been a process in which many parties were involved: all of the 170 Member States, shipping companies, major oil companies and intergovernmental organisations. This shows the magnitude of this decision making process and it is not surprising that the process took as long as it did. So lobbying is all Vopak (and its fellow storage companies) can do to influence the rules themselves.

On enforcement levels, action does not seem very beneficial for Vopak. Vopak could increase cooperation with PSC's to enhance inspections at its terminals, but it is not likely that Vopak's clients would be very happy about this. Still, there is a possibility that shipping companies do not view this with disfavour, because they rather have a level playing field with clear consequences in case of non-compliance, than live in uncertainty about potential inspections and penalties.

⁴⁰ The same counts for the EEDI of Chapter 4 of Annex VI focusing on the carbon dioxide emissions

Monitor developments

Another option for Vopak to manage the changes in the legislative environment is to closely monitor the developments. Although this seems a straightforward option, this is an aspect in which Vopak can be one step ahead of its competitors. Monitoring could be done through informal and formal channels. An informal way of monitoring developments is to proactively consult clients and organise discussions with involved parties. Keeping tight relations with clients is thus essential if Vopak wants to be up to date. Formal ways of monitoring developments include reading industry magazines and newspapers, stay up to date with reports from governments or industry players or hire consultants to calculate future changes in the market. Vopak can assign an employee as primary responsible for updating the management board.

In any case, it seems prudent to monitor the environment, because change is always happening, especially now. Keeping a focus on good relations with clients as well as formal information will reduce the possibility of surprises.

Seize business opportunities

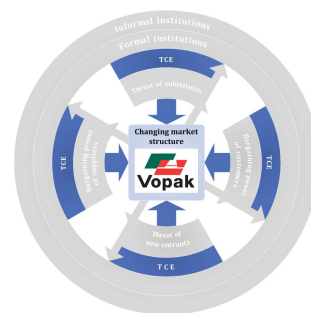
The changes in the market can provide new business opportunities. It is already Vopak's strategy to expand to where profitable and secure business opportunities arise. Investing in areas of growing demand, be it fuel oil or whatever other oil product, is something which is obviously good to pursue. But there are other possibilities for Vopak. LNG as a bunker fuel has received some attention in this study and the infrastructure was still regarded as being in its infancy. Because Vopak already has experience with LNG at its Gate Terminal at the Tweede Maasvlakte in Rotterdam, this may be an area of opportunities. The Gate Terminal is one for break bulk, which is similar to what bunkering entails: distribution and consumption of LNG in small volumes. Experience with this fuel can be put to use by playing a proactive role in the development of an LNG infrastructure, including bunkering facilities. As being such a large player in the independent storage market, Vopak has the potential to help in establishing LNG bunkering procedure standards as well as safety standards. It is thus interesting to see that Vopak is already exploring the possibilities of an LNG terminal in Gothenburg, Sweden. By signing a letter of intent (LOI) with Swedegas, Vopak entered into a feasibility study which will explore the potential of such a facility, which could be used for bunkering purposes in an already established fuel oil bunker port.

Wait and see

The final strategy Vopak can take on is that of wait-and-see. Acting upon the developments in the market as described above can also include risks. Investing in a LNG, for instance, may not be fuel of the future choice and may lead to significant losses. Vopak can leave the risk taking or the responsibility to act with its competitors and save the costs of influencing legislation, monitoring the market and investing in new technologies. This option, however, is not risk-free either, as by not being proactive, Vopak can miss the boat and/or be too late to react to new the emergence of new bunker fuels. The relationship with its customers can also suffer from the tardiness of Vopak.

7. Drivers for investments

To be able to give a better idea of how and why the market will react in the future, the actions of the critical industry players should be argued, and, more specifically, their investment decisions. This is where the terms uncertainty, asset specificity and frequency – all three related to TCE, being the three dimensions of transactions – comes in. The section is an essential part of this research. After having analysed the entire bunker market, as well as its possible future developments, it is time to analyse the factors that actually drive the choices to be made in the near future. It will give reasoning to the (re)actions of industry players that will eventually shape the future bunker market. Who will take the first steps? Who will make investments and what drives actors in their investment decisions? Because it is clear that following MARPOL Annex VI, actions are required. Market drivers are trends, innovations and external circumstances that change the way a market operates. Market drivers thus create change, but many factors can evoke change and the possible market drivers are numerous. Markets can grow naturally (where actors react simply on price fluctuations), can be incentive driven or driven by a legal framework. It is clear that the latter plays a major role, although not exclusively. This section aims to give a different view on the future and applies the TCE-related variables. It does so, not by simply evaluating production costs and market prices, but to use the three dimensions of transactions to give reason to the actions of the critical industry players.



TCE and the future of the bunker market

As explained in section 3, according to Williamson every transaction has three attributes or dimensions: uncertainty, asset specificity and frequency. So what is the transaction we want to inspect? Well, the investment is the transaction, the investment that has to be made to transform the bunker market from one based on fuel oil, polluting the atmosphere with harmful sulphur emissions to a cleaner, more sustainable market, which the IMO originally envisioned when adopting MARPOL Annex VI. Along the three dimensions of transactions, the investment decisions within the shipping, mid-stream and the refining market to comply with the sulphur regulation will be argued. The main focus will lie on the leading role of shipping companies, as they are the actors that fall directly under Annex VI regulations. The following will provide arguments on whether or not, and to what degree, the three dimensions will drive crucial decisions.

Dynamic character

The choices that lie ahead have a very dynamic character. The same goes for the investment attributes, which are not and cannot be the same through time. Investment decisions have to be made towards compliance, while bearing in mind the dynamic character of the underlying arguments. This is expressed by the term “path dependence”. Prior decisions and their influence on the environment can limit the possible alternatives for new decisions. These dynamics of the market thus make it inherently difficult to make predictions, which is why certain flexibility of the used terms is required. That is why the transaction attributes are given a more dynamic character, as opposed to the static analysis Williamson originally used these concepts for. This stresses the importance of the interdependencies which for the basis of OIE analyses.

7.1. Uncertainty

The first transaction attribute, or better, investment attribute is uncertainty. Uncertainty can be expressed in many ways. Here, uncertainty is divided in environmental uncertainty and behavioural uncertainty. Between these the same distinction is made as with the institutional environment and the Porter analysis, however it is sometimes difficult to draw a line between the environment and the market. So, to what extent does uncertainty influence investment decisions?

7.1.1. Environmental uncertainty

The environmental uncertainty is composed of the direct sulphur legislation, associated other legislation and price uncertainties. The first relates to enforcement issues as well as the uncertainty surrounding the 2020/2025 decision. Other legislation focuses on possible new ECA's and rules and standards concerning LNG bunkering. Finally, price uncertainty is related to external prices developments, i.e. crude oil prices.

Enforcement of Regulation 14

The IMO rules are the first every globally adopted pollution regulations, which is quite an achievement. But success depends completely on their enforcement by individual Member States. If States want full compliance of the applicable Annex VI regulations, they have to be clear about the penalties of violation. At first, it is important for shipping operators to know what the consequences are of violating the sulphur limits, so they know what they are up against if they were to ever fail compliance. Secondly, if strict enforcement is in place, one can presume that his competitors face the same penalties in case of violation (a level playing field). The other way around, there is no reason to invest large sums of money in any type of compliance method if violations remain unpunished.⁴¹ At the moment, inspections are scarce and many PSC's are currently not willing or able to inspect and enforce on a large scale, witness the fact that the Netherlands is one of the only countries to actively inspect ships. Most fuel sampling is currently done by commercial testing institutions for quality purposes. The U.S. has announced strict enforcement, with inspections and fines in case of non-compliance and it looks like they will do exactly that.

Finally, measures to stimulate the use of compliant fuels can also play a role, as long as states are clear on this. Clarity about the enforcement of legislation is thus very important for shipping operators. If countries within a MoU, e.g. MoU of Paris, synchronise their enforcement policies and form a clear and consistent enforcement programme, this reduces future uncertainty in this respect, as new regulations will probably be enforced in the same way.

The 2020/2025 decision

The second large regulatory uncertainty is whether the 0.5% global sulphur limit will enter into force in 2020 or 2025. In the eyes of many this choice, which will be under review by the IMO and involved actors in 2018, is made far too late.⁴² This is not strange that the industry feels this way in the light of the consequences of this uncertainty. If the decision were to be made now, parties can take precautionary measures and build up to full compliance when this is necessary.

The argument of the IMO to make the decision in 2018 is that a 'timely' review of the availability of post-2020/2025 compliant fuel leads to a more realistic implementation timeframe. The availability of 0.5% MGO by that time can naturally not be reviewed now. But there is something wrong with this reasoning, because the availability of 0.5% MGO is dependent on the expected date on which the fuel is needed. Ship owners will demand a delay for the introduction of these limits to 2025 by not creating demand for MGO and without demand, refiners will not invest in upgrading their facilities to accommodate the rise in MGO demand. Lack of clarity may thus even increase behavioural uncertainty throughout the whole supply chain (Meyer, 2011). If the choice is made now, all the stakeholders will have eight years to prepare for the mass use of MGO, including refineries.

Other legislation

New ECA's are also uncertain. But this uncertainty is less anticipatable, because it is up to individual Member States to submit ECA proposals and this could be any state. Currently, there are no concrete proposals ready for adoption by the IMO. Possible ECA's will therefore not influence investment decisions in the same way as the two previously mentioned regulatory uncertainties. The share in bunker sales

⁴¹ Maersk, personal communication, 15 February 2012

⁴² W. Dijkstra, personal communication, 29 February 2012

within current ECA's is relatively small to total sales, so one or two new ECA's will not lead to great shifts in the bunker market, especially as by 2020/2025 the entire global fleet will be subjected to low sulphur emission regulations. They could function, however, as transition 'projects' towards global MGO (or LNG) use.

Furthermore, the development of LNG powered ships depends for a large part on the standards concerning health and safety of LNG bunkering. Several LNG terminals are already used as bunkering stations, but more clarity on the bunkering procedures will trigger investments in terminals, infrastructure and finally in more LNG powered ships.

Prices of bunker fuel

Bunker prices are formed through a combination of two factors. The first is an external factor, namely crude prices, while the second is an internal factor, being the local/regional supply-demand balance for bunker fuel. Oil prices and fuel oil bunker prices are partly correlated, as past trends have shown (Wilson-Roberts, 2009). Higher fuel costs trigger action from shipping companies, especially when freight rates are low. Fuel procurement is already receiving increasing attention and shipping companies' strategies will be focused on cost, but also fuel quality optimisation. The developments in the crude oil price therefore have an impact on the bunker market. But does it trigger investments for sulphur compliance? This is less likely to happen than one would expect. Although ship operators will engage in slower steaming with higher fuel oil bunker costs, this does not directly affect the sulphur compliance. The alternatives for HSFO that *will* comply with future sulphur limits (LSFO and MGO), are also linked to crude oil prices. Abatement methods, i.e. scrubbers, would still require the use of HSFO. So, it is not the crude oil price itself that may trigger switching from HSFO to these other fuels, but the relative price spread, and these depend on supply-demand balances.

For LNG, things may be different. In the past, gas prices and oil prices were closely linked, as prices in (long-term) gas contracts were partly based on oil price developments. Increased production of unconventional gas as well as a possible flight of LNG, with the forming of a LNG spot market, the ties with crude oil prices are expected to loosen in the future (Bock and Gijón, 2011). Less linkage between crude oil prices and LNG prices may lead to increased investments in LNG bunkering at rising crude oil prices. As price formation and optimisation is not an integral part of this study, it is interesting to further explore these effects in further research.

7.1.2. Behavioural uncertainty

Now that the effects of environmental uncertainty on investments have been analysed, the behavioural uncertainties deserve at least as much attention. Investing in solutions towards future sulphur limit compliance is seen by many as a wait and see game. Wait and see, partly because of the aforementioned legislative uncertainty, but to a large extent because actions of counterparties and competitors are uncertain. In a market where bunker fuels are traded on the spot market, the risks associated with these uncertainties are not likely to be mitigated through contracts. The uncertainties will not be reduced by actions of one particular party, because the behavioural uncertainty stems from the difficult projections of future collective action. Firms want to delay investments as long as possible, so until they are forced to invest, they will wait and see what the market – and not just one counterparty – does. The market, again, is more likely to act in the presence of clear and enforced formal institutions.

Refining industry: where is demand?

Refineries are not directly under supervision of the IMO. It is the maritime industry that directly feels the limits that are laid down. Refineries, therefore, need not act at all, unless the customer demands it. The industry will only *react*. So what are the uncertainties for refiners?

Refiners need security of sales. Refineries may invest on the short term to meet the LSFO requirements by installing desulphurisation units or change to a sweeter crude slate. The current supplies, however, are sufficient to meet demand, so there is no pressure to invest. The demand for LSFO is not particularly high, as it is predominantly used in ECA's (although new ECA's may be designated) and desulphurisation units are far too costly as compared to the expected extra demand. Investments on the longer term will be made by refiners to meet MGO demand by upgrading their existing facilities or building new ones. Refineries are highly capital intensive, so without security of sales, i.e. security of demand, investment would bring along too much risk. In markets with more bilateral contracting and associated price formation, the sales can be secured through long-term procurement contracts (which has been common practise in LNG projects, although rising demand for LNG will ask for more sales through spot markets in the future⁴³). But long-term contracts to secure sales are not possible in the case of MGO. MGO, like fuel oil, is purchased on the spot market.

A distinction must be made between existing older and new refineries. New refineries are better equipped to react to possible product demand uncertainties. They are more flexible to adapt to product demand shifts than e.g. European refineries (Rozhnov and Gross, 2012). This increases the likelihood of OECD-dependence on East-of-Suez located refineries with developing demand patterns.

Uncertainties of MGO demand can thus not be reduced by long-term contracting. The demand for middle distillates will be dependent on the deadline for 0.5% sulphur compliance. Once shipping companies will be forced to sail on MGO (or use scrubbers or use LNG), the demand will be secured. Let that be the whole problem. The deadline for the global 0.5% cap depends on the availability of fuels complying with the new limits. Ultimately, when refiners invest, they want to pass on these costs on to the purchases, thus raising prices. MGO is far more expensive than fuel oil at the moment, so shipping companies will wait as long as possible before buying these more expensive fuels. Refinery investments will therefore likely be held off, at least until 2018, when more clarity will be given by the IMO on when the stricter global cap will come into force. Uncertainty about demand for MGO will be high until that date, discouraging refinery investments and ultimately influence the decision by the IMO. After 2018 the uncertainty will sharply decrease as both 2020 and 2025 are close deadlines for investment before demand suddenly plummets.⁴⁴ There is, however, no full guarantee that ships will all sail on MGO, as perhaps scrubbers or LNG are more attractive alternatives.

Demand for fuels doesn't only depend on the IMO decision directly, but also indirectly. With technological advances and increased efficiency in scrubber manufacturing, scrubbing may become a more attractive option for IMO compliance than the use of MGO. If this is the case, more shipping companies will choose to invest in this technology, therefore maintaining HSFO demand after the introduction of the global cap.

The demand for refining products also depends on the adoption of LNG as a bunkering fuel. As natural gas is increasingly mentioned as the transition fuel towards a more sustainable world, a bright future is projected for LNG. LNG bunkering could therefore also take a flight. The uncertainty relating to LNG is low at the moment, because there is a significant lack of LNG infrastructure, at least in Europe, to enable LNG bunkering. LNG import terminals have been built around the world, but bunkering LNG requires more research concerning on-board and on-shore (and/or offshore) installations, as well as the adoption of regulations and standards taking on safety issues related to LNG bunkering. So, at the moment, LNG bunkering will not become a widely employed alternative. The uncertainty will rise, though, as the issues mentioned are surmounted and LNG becomes a viable alternative.

Shipping industry

⁴³ B. van Holk, personal communication, 29 March, 2012

⁴⁴ Refinery upgrades or new builds will take around 5 years according to Maersk (personal communication on 15 February 2012)

Behavioural uncertainty for shipping companies lies in the possible actions of suppliers, but also in that of competitors.

The uncertainty regarding the availability of oil products is related to changes in the refining industry. For the near term, worries are expressed about the investments in Russian refinery upgrades, because the fuel oil output of the largest fuel oil exporter will decrease significantly towards 2020. Fattouh and Henderson (2012), however, argue that the reduction in demand for fuel oil for non-marine uses will compensate for the decreased production. But enough production of satisfactory quality HSFO until either 2020 or 2025 is all but certain. At the moment shipping companies are confident that HSFO will still be produced in the short term, as a large proportion of the world's refineries still produce fuel oil, being a significantly large by-product of their cleaner fuels production. Fuel oil will make up a smaller part of the refined oil production in the future and it will remain the question if this can and will be offset by lower fuel oil use on-land. The market for LSFO is currently quite healthy, with price spread between LSFO and HSFO even decreasing. But the market for MGO may be very different once the use of this fuel is an important (probably critical) fuel for ships once the global 0.5% rule enters into force. At the moment ships have no problem to bunker MGO, and at the start of a possible large shift this will still be the case. But if investments in MGO production lag behind the (whether or not sudden) demand growth, MGO will become scarce and rising MGO prices will become unsustainable. The 2018 decision may thus be a measure to prevent this, as refineries then have seven years to complete investments in MGO production. If you take this in mind, one could suspect the IMO from having already made the choice for delaying the 0.5% implementation to 2025, to ensure a smoother transition by raising awareness with refineries that they have to invest.⁴⁵ Until that day come, there is no central direction coordinating refineries and there are no sufficient incentives yet to encourage producers to invest in MGO production. Refiners will not be penalised for the lack of investment, but they would take considerable risks if they prematurely invest in additional conversion capacity to meet the assumed growing MGO demand. So, for ship operators the supply of MGO will be increasingly uncertain towards the end of the decade, but supply security may increase after the 2018 decision.

The same uncertainty is attributable to the supply of LNG. LNG bunkering facilities will not be in place in the near term. This is a fact. But on the longer term the availability of LNG as a bunkering fuel is more uncertain. This is a classic example of the 'chicken-and-egg' problem. Without demand, no enormous investments will be made in construction an LNG bunker infrastructure. The other way around, if there is not infrastructure, the demand will remain low. The development of LNG bunkering will probably be incremental and evolutionary, like the development of electric cars in the last five years, and will not take flight (if at all) before the end of this decade.

Besides (re)action from fuel producers, the behaviour of competitors is essential to follow closely. Companies are usually not prone to be first-movers and the wait-and-see game is also played within the shipping industry. If other competitors gradually shift towards another fuel (MGO or LNG) or scrubber usage, they will incur the start-up problems associated with them. The mentality is to let the competition explore, and when the initial difficulties have been smoothed out, the step towards collective action can be a small one. But competitor behaviour is uncertain and so is significant (coordinated) collective action, especially towards the global sulphur limit.

7.1.3. Uncertainty and investments

Uncertainties are definitely important for the industry players to decide on investing in sulphur complying alternatives. The analysis shows that legislative uncertainty is the most important factor hindering investment. Based on a review of the availability of compliant fuels, the 2020/2025 decision in 2018 will reduce the uncertainty. But as the availability depends on demand and this demand in turn depends on

⁴⁵ This is the authors opinion, based on the arguments given, and not based on facts or other's opinion.

the regulatory certainty, it looks like the IMO decision is in the end dependent on itself. Because the capital intensity of the required actions is very high, no one will want to risk overinvesting or wrongly acting upon projected demand or supply figures. Finally, it is the collective action that will drive investments. It is uncertain who will act first and when, but once start-up problems associated with either of the alternatives have been addressed, only little is required to trigger collective action.

What has become very clear is that the identified uncertainties are not static variables, but that in an ever changing environment, the uncertainties themselves are also subject to change.

7.2. Asset specificity

Now that the influence of uncertainty on investment decision is analysed, it is time to focus on the second transaction dimension, which is asset specificity. To what extent can asset specificity promote or maybe hinder investment in a compliance method? The degree of site specificity, physical specificity and human specificity may be crucial for making investment decisions.

7.2.1. Site specificity

Site specificity is apparent at different levels. Those mentioned here comprise location-specific legislation, distillate bunker hubs and LNG infrastructure.

Legislation

The IMO are globally applicable, at least in the Member States, comprising more than 98% of the world fleet. For the global sulphur cap of 3.5%, no distinction is made. However, within the ECA's there are more stringent sulphur limits. Besides, currently, the ECA's are the only areas that have active enforcement of the rules (although inspection are still scarce). So the legislation is location specific and ships sailing within these waters feel the consequences. Some ships sail strictly within ECA waters, also named 'short-sea shipping', while others operate partly in ECA, only visit ECA's occasionally or never enter ECA's. Routes between A and B can differ (although ships tend to sail an optimal route), but still have to sail from A to B and if either is situated within an ECA, they are bounded to comply with ECA rules, for at least some part of their journey. The extent to which ECA legislation applies to a certain ship, depends on the time they spend within these areas. So, until there is no more, or little, distinction between sulphur limits inside and outside ECA's (2020/2025), the time spent in ECA's will likely determine the investment decision to a large extent. The choice of compliance method therefore rests – for a significant part – on this factor. Short-sea shipping within ECA's will have to comply with 1.0% and in 2015 with 0.1% sulphur limits at all times, while ships sailing inside ECA's for only, e.g. 10% of the time, will require investment in dual-fuel systems. These systems can change-over when entering or exiting control areas. Separate fuel tanks and multi-fuel engines make this possible. Because almost all HSFO sales have a sulphur limit of under 3.5%, ships partly operating within ECA's could simply use HSFO when at open sea and switch to LSFO of distillates (after 2015)⁴⁶ when entering an ECA. Therefore the impact of Annex VI is limited to the time spent in the control areas.

If operating in ECA's for the largest part of the journey, and if MGO prices are considerably higher than those of LNG, investments in dual-fuel LNG systems (assuming sufficient availability) can be very attractive. In the end, the success of scrubber will also be determined by weighing the costs of scrubber installation against higher price premiums of MGO-HSFO, of course assuming a certain desired pay-back period. Full time ECA operation would require investments in permanent compliance methods, on the short term being most likely MGO, while scrubber and LNG technology may take a flight within ten years from now.

⁴⁶ In practice often three separate fuel tanks are installed on board. One tank for HSFO, another for LSFO for when sailing within ECA's and one tank for MGO 0.1% for when at berth in EU and Californian ports.

Region-specific availability

A whole different site specific issue is the availability of fuels in a certain area. Rotterdam, for example, has a very high availability of Russian fuel oil, because of its location. This fact has triggered many investments in the area to exploit this abundance of high quality Russian fuel oil. If alternatives for fuel oil were to gain market share, the availability of these fuels could perhaps create room for new bunkering ports.

The shortage of distillates in Europe and a surplus in the Middle East, India and Russia entails that distillates have to be imported. The moment that these imports start to rise significantly, this can cause a considerable disruption in the market. Large shares of transports leaving Rotterdam sail towards Asia and back, it might seem strange to import all necessary distillates into Rotterdam, when many journeys pass the Middle East and India. These possible developments may trigger investments in these other markets than the traditional bunker ports, such as Rotterdam, which could lose its prominent position in the bunker market to other port better suited to accommodate the changing demand. Hence, the convenience of a port may also play a role in choosing an alternative.

Two notes must be added to this. The first is that the growth in MGO demand will not be so significant that it will trigger these large scale developments (at least before the introduction of the 0.5% cap) unless the majority of the world fleet is to sail on MGO. The second is that Russia will also raise its distillate exports, considering its current and projected refinery upgrades. This, together with the continuing transshipment of Russian fuel oil for bunkering, will keep Rotterdam's competitive position high. Altogether, the possibility of losing market share of existing world leading bunker ports is there, but is not likely to take shape before 2025. Therefore the importance of this aspect as a driver for investments before that date will supposedly be marginal.

Also the adoption of LNG may lead to the emergence of different bunker hubs than the current fuel oil bunkering hubs. Growing LNG demand will go side-by-side with the developments of an LNG infrastructure. These investments will naturally be location specific, as they are fixed in situ. However, there have been several proposals of floating storage facilities and floating bunker practises, which would both decrease the location specificity substantially.

Most current (small scale) LNG terminals, focusing on fuelling offshore support vessels (OSV's) in Norway are not situated in the most ideal locations for larger maritime applications. The location for LNG infrastructures must be chosen on the busiest shipping routes and in the most accessible ports for it to become an attractive alternative to MGO to comply with ECA 0.1%, or later on when global sulphur limits drop to 0.5%.

7.2.2. Physical asset specificity

Physical asset specificity may be experienced differently by refiners as they are by ship owners, although they can be linked to the same compliance method. To what extent physical asset specificity can influence investments is now discussed.

Refiners

For meeting sulphur requirements for LSFO, often the option of desulphurisation is presented, enabling sulphur extraction from the HSFO. Desulphurisation is a very expensive installation, which would only be added to a refinery for means of producing more LSFO. Refineries are hesitant to build desulphurisation units, because they are so specific. Large investments will have to be made to increase LSFO production, which demand is likely to decline just after the ECA's switch to other options following the introduction of the 0.1% limit. Especially now that margins are low, refiners are reluctant to add to the costs. For overall compliance, it would be more financially feasible to remove sulphur ex-post, i.e. through on-board scrubbing (MET, 2011). Besides, desulphurisation units emit higher values of CO₂, which can also be a

costly matter in the light of the European ETS. For a fuel, which is often seen as an unprofitable by-product of the refining process, these asset specific investments do not seem to be very beneficial. The other option for lowering the sulphur content of HSFO is blending, which doesn't require such investments. If the desulphurisation unit could be used for other purposes after LSFO demand drops, the decision to invest might be different. The asset specificity of a refiner's current configuration might also restrict options to change crude slate, which is another option to produce LSFO. More flexible refiners might have less problems handling other lower sulphur crudes.

Another asset specific investment is increasing MGO production. Producing more MGO does not entail the up scaling current road diesel production. Road diesel is different from MGO and significantly more expensive to produce and both specifications differ (MGO flashpoint is at 55 °C as compared to 60 °C for road diesel). If refiners were to choose to sell road diesel to the marine industry they would first have to validate the diesel is in compliance with standards set for MGO, which is not economically attractive to do. On the other hand, MGO production can be increased by modifying their facilities, i.e. configuring their set up to produce low sulphur MGO. Older refineries will have to increase their conversion capacity with cracking as well as coking to increase lighter product yields. Greenfield refineries, of which many are now under construction, can simply be built to meet a certain product demand. Most existing greenfield refineries are initially built for yielding more light or middle distillates. A switch to MGO production would require less investment than older refineries.

Besides the actual production installations, and as they will then be producing a fuel which is currently not in their product slate, these production facilities should also invest in the infrastructure for this new fuel, e.g. storage tanks. Refurbishing a refinery can be a very capital intensive matter, and investing in this would require security of sales. However, demand is still very uncertain, so refiners will be hesitant – to say the least – to invest in these asset specific upgrades. New refineries, however, are better suited for to cope with demand uncertainties. These refineries are more flexible to adapt to shifting demand patterns, than for instance refineries in the Atlantic Basin. Incorporating flexibility would reduce the specificity of the asset, there reducing the risk of miss-investment. These refineries in the Middle East, China and India are thus in an advantageous position.

Shipping companies

Scrubbers and LNG installations are the most capital intensive alternatives for shipping companies. But are they also specific? Scrubbers are only an option when the investments can be earned back through fuel cost savings. Scrubbers are installations that are only useful if the fuel used is high in sulphur content, i.e. HSFO. The price spreads with other fuels (and of course the previously mentioned 'time spent in ECA's') will be decisive for investing in the technology. Ships need to be retrofitted or new builds can be equipped with scrubbers, either way costs will be high. So if in any case HSFO would no longer be an option, scrubbers would lose their function.

LNG installations, comprising modified engines and LNG containment systems, are installations that are designed specifically for handling liquid gas. Retrofitting ships with LNG installation is highly capital intensive, because the entire fuel and propulsion system would have to be altered. For this reason, LNG is expected to only be used by new builds, specifically design for sailing on LNG. These ships are then very asset specific as they would not be of any use in the absence of LNG. Currently, the availability is limited, so only short-sea shipping near Norway seems an option. LNG is an option for vessels operating within ECA's, or after 2020/2025 also outside ECA's, both assuming enough availability and sufficient infrastructures. Because outside ECA's using HSFO is still allowed until the 0.5% cap decision, LNG would be predominantly used by vessels operating in ECA's for the majority of their journey, unless LNG is cheaper than HSFO. The more fuel costs saved, the more the investment will earn itself back. A *reduction* of asset specificity for LNG installations can be achieved by increasing its flexibility. Wärtsilä has been fitting dual-fuel engines in LNG carrier with success (Wärtsilä, 2012). These engines can switch between

LNG and fuel oil or MGO. If LNG supplies were to fail demand, or if LNG prices are higher than MGO or HSFO, these ships could still be used with distillates.

One of the most important considerations that shipping companies have to make concerns the age of their fleet. In a sense this is also a form of asset specificity, since the vessels age makes them eligible for certain compliance options e.g. vessels which are nearing retirement are not suitable candidates for LNG or scrubber retrofitting. These technologies cannot simply be removed from a retired vessel to be installed on another. So, ship owners will only choose to retrofit (assuming the technology and availability are in place) if the vessel has enough years left to earn back the costs. For scrubbing the maximum age for vessels eligible for scrubber installation would be 20 years (Speares and Roos, 2012).

A link can be made between the site specificity of shipping routes. i.e. the 'time spent in ECA's, and the physical asset specificity of each of the compliance options. Distillates, for instance, are a more flexible option than scrubbers and LNG, which are more specific. The time spent in ECA's is also specific. The relation that can be seen is that the longer the operation time within ECA's, the more specific the assets can be. Another interesting notion is that the most specific investments for refineries (i.e. that for LSFO and MGO) are the least specific for ship operators, for whom scrubbers and LNG installations make up the most specific assets. This created even more uncertainty for the refineries, as ship operators have little long-term commitment for a specific fuel.

7.2.3. Human asset specificity

In section 3, human asset specificity was considered as an integral part of the asset specific characteristics of transactions within the bunker market. Though human asset specificity certainly plays a role in bunkering, especially now that shipping companies lay more importance on their fuel procurement strategies. Good relations with their suppliers could avoid quality-related or financial disputes, which, in times of rising bunker costs, are more frequent. However, since the bunker market is a spot market, only local relations matter in terms of trust, but price setting happens centrally and openness of information reduces specific ties between suppliers and buyers of bunker fuel. In this line of reasoning, the majority of the interviewees in the qualitative surveys held for this research, have stressed that investment choices will be solitary choices and investment cooperation between buyers and suppliers of bunker fuel is highly unlikely.⁴⁷ Human asset specificity, therefore, will not receive any further attention as an investment decision determinant.

7.3. Frequency

Frequency is the final transaction attribute discussed here. Section five and six have analysed the functioning of the bunker market, and one specific characteristic of the bunker market, is that it is highly competitive. This competitiveness is expressed by the existence of a bunker spot market. Bunkers are sold on a bilateral contract, but these contracts are standardised and prices are set on the spot market, meaning there is little space for negotiation for any of the counterparties. Prices are thus non-negotiable, although local supply and demand balances can be distorted, often leading to opportunistic behaviour and rising prices. Spot markets help counter information asymmetry, but also provide incentives "for exploiting profit opportunities and market participants are quick to adapt to changing circumstances as information is revealed through prices". This means that long-term agreements are more difficult to engage in, which entails that there is little commitment between buyer and supplier besides selling and buying bunker fuel. When linking frequency to investment decision making, this commitment becomes important.

⁴⁷ B. van Holk, 29 March, 2012/W. Dijkstra and J. Kolpa, 29 February, 2012/Maersk, 15 February, 2012/C. de Keijzer, 8 March, 2012

Purchasers of bunker fuel are not committed to buying from one specific seller, which makes it impossible for refiners to secure sales. Long-term agreements are not possible in the fuel oil bunker market. So what about MGO? Well, MGO is also traded on the spot market. The fact that there is little commitment from buyers, they can easily switch supplier (and maybe even fuel type) if they wish to do so. Investment in MGO production capacity will not take place at refineries without any certainty about the future demand. Securing several shipping companies (or traders and suppliers) for their fuel procurement may be possible. The success is nonetheless dependent on the relation between these parties.

Long-term contracting occurs more often with LNG. This is done to secure sales for exploration and production companies, e.g. the large LNG projects in Qatar's North Field. But growing demand for LNG and global diffusion of the gas may soon ask for spot market trading as well. So, in reaction to the declining sulphur limits, it is not at all likely that production capacity (for either MGO or LNG) will be secured through long-term contracts. This feeds the wait-and-see attitude of refiners or potential LNG suppliers.

The existence of spot markets makes the frequency attribute to investment decision not very impactful. As compared with the two other attributes, uncertainty and asset specificity, frequency does not seem to influence investment that much, although the lack of long-term contracting possibilities adds to the delay in investments.

7.4. Drivers of future change

This section has focused on what drives the critical market players in their decision whether or not to invest towards compliance of the IMO-imposed sulphur limits. A short recapitulation of the identified drivers for investment is given before analysing the relevance or usefulness of the TCE concepts for reaching the goal of this section. Finally, the value of the analysis presented in this section is put in perspective.

7.4.1. Drivers for investment

The key phrase from the analysis of uncertainties is 'wait and see'. In the end, it is the shipping companies that will have to take some sort of action so that their ships comply with MARPOL Annex VI. The most heard argument given by these parties is that rules need to be enforced, including penalties, in order to make investments necessary. No or weak **enforcement** will lead to large scale non-compliance: "is the competitor is not punished for non-compliance, why should one invest in compliance?".

A second very important environmental uncertainty concerns the **2020/2025 decision**. As long as there is no decisive answer to the global 0.5% cap question, the entire bunker industry, comprising both the production side and shipping industry, will not have an incentive to invest. The fact that the 2018 decision depends on the availability of fuels complying with the future sulphur limits only feeds the expectations that the 0.5% global cap will be delayed to January 1st 2025. If more certainty could be given for a possible earlier entry into force, all players in the industry could make preparations anticipating the approaching crucial deadline.

Thirdly, it is the **availability** of fuels that comply with the sulphur limits which plays an important role. The interrelatedness of actions from both refineries and shipping companies is expressed in this crucial aspect. The availability of LSFO is not so much the problem, as currently there is enough supply. But the availability of MGO, a promising alternative fuel for compliance with the 0.5% cap, is dependent on the demand. And on the demand side, competitors will wait on each other and so not triggering large demand. It is the large demand that triggers investments in refinery conversion, hence, **collective action** is essential, constituting the fourth investment driver.

The **time spent in ECA's** represents the fifth driver. The specificity of shipping routes has consequences for the attractiveness of compliance methods if calls are made at ECA ports. Vessels sailing on short-sea routes within an ECA (time spent in ECA = 100%) would provide a larger incentive to invest in more specific (and capital intensive) compliance method, being scrubbers and LNG, than ships of which time spent in ECA constitutes only a small percentage of their voyage.

The sixth and final driver of investments relates to the **physical specificity of compliance methods**. The specificity is expressed in the flexibility of the assets or in potential lock-in of investments. Refiners are required to make very specific investment to produce LSFO and MGO, while on the demand side, LSFO and MGO and the least specific options for compliance. This creates even more uncertainty for refiners. The most asset specific investments for ship owner are scrubbers and LNG installations, but these technologies are still in their infancy and not likely to take flight before tightening the global cap. In the end, investments will be made taking into account the age of the shipping company's fleet. Older vessels will be less likely equipped with expensive scrubbers or LNG installations, while new builds can be designed including these technologies and save retrofitting costs.

7.4.2. TCE-concepts as drivers of change

Three concepts of TCE are used here to evaluate investment decisions. As described in the theoretical background of section 3, transaction cost economics is widely used to help individual firms choose the optimal mode of governance by minimising transaction costs. The area of interest is then often focused on make-or-buy decisions. In this study TCE has been helpful in a whole different way. The TCE-concepts are used to analyse behaviour of the most important players market. The focus was not on a mode of governance, but purely on motivations for investments. The traditional equation of costs and revenues has been put aside to make room for less quantitative arguments. The goal of using mentioned concepts was to reason certain investment decisions of critical market players that could shape the future of the bunker market. This created understanding of what could motivate refineries and shipping companies to invest in certain fuels or technologies in order to comply with the sulphur limits laid down in MARPOL Annex VI.

At the start of this research the three attributes of transactions were equally placed in the centre of focus of the investment analysis. After analysing the uncertainties, asset specificities and frequency and their influence on decision whether or not to invest, it became clear that the latter of the three has much less of an impact than the former two. Frequency seems not to be of any real significance, because of the existence of a spot market. Only in the case of LNG, there could possibly be a role for frequency-related reasoning, i.e. long-term contracts for LNG sales. The main (groups of) factors influencing investment decisions are clearly the uncertainties and the asset specificities.

What is interesting to see, is that the different uncertainties and specificities are all susceptible to change. With the perspective taken in this study, they are "allowed" to change without the need for a completely new analysis, as would be the case when pursuing the optimisation goal originally envisioned for TCE. The dynamic nature of the transaction attributes broadens the view on investment decisions. It emphasises the need to re-evaluate these attributes through time (see next paragraph) in order to keep track of market players' reasoning to invest in compliance methods that could change the entire bunker market. Besides being dynamic, the three attributes are very much intertwined. Different examples have been given that show, for instance, how asset specificity can create uncertainty and vice versa.

7.4.3. Vopak and the TCE-dimensions

The critical actors within the bunker market are situated on the demand side and the supply side of the value chain. They are influenced in their choice to invest by the three dimensions of transactions as discussed in this chapter. Their influence on the market has also become clear. But a short analysis of to which degree Vopak can influence uncertainty and asset specificity is also interesting. Frequency does not

seem to be of any major importance in the investment climate and will therefore not be discussed here. Finally, the usefulness of this analysis for Vopak is touched upon.

Uncertainty

The environment is uncertain for a large part because it comprises the top levels of the four-layer model and these levels are the most difficult to influence. Because market players have limited power to change the – in this case – formal institutions, this uncertainty will remain. This counts even more so for Vopak. The previous chapter has discussed the possibilities for Vopak to influence the 2020/2025 decision, but more than trying to come close to the *institutional arena* through lobbying seems impossible. Vopak's influence on the environmental uncertainty surrounding investment decisions is therefore negligible.

More is possible when it comes to reducing behavioural uncertainty, but still the options are limited. Collective actions is not something one can trigger on its own, but organising alliances or even joint ventures in certain (future) strategic bunkering ports, may trigger action from neighbouring competitors. Long-term storage contracts for new fuels (MGO or LNG) at very large scale terminals with bunkering facilities may be a way to do enhance the availability of those fuels. This, however, is still a long shot, considering the magnitude of the global bunker market, and is not a strategy that is currently prudent to pursue on the short term. It seems clear that uncertainty is not something Vopak can handle alone.

Asset specificity

The time spent in ECA's is an important site-specific driver which is mostly dependent on the route shipping operators choose. The route, in turn, is dependent on the where the demand for and supply of the cargo is located. Unfortunately for Vopak, the choice of these locations is out of its reach and trying to influence this would be too farfetched.

Physical asset specificity related to the installations refineries have to construct to produce specific fuels or to desulphurise, as well as those technical installations required on-board ships to be able to sail on MGO or LNG and to remove sulphur emissions from the exhaust gases. These specific assets are of concern at the far ends of the bunker value chain and there is nothing Vopak, or any of its competitors in the storage market, can do to reduce or increase the specificity of these assets.

It has become clear that the drivers for investment in the future bunker market are all mostly out of reach for Vopak. Altering these drivers is almost impossible and it is wiser to focus on those actions that were described in section six.

Use of this analysis

Now, how can these drivers be used, besides giving reason to possible investment decisions within the bunker market? Well, one very good way to put these drivers to use, is to apply them as input variables for building concrete scenarios. One can vary the values of each of the drivers to argue the different routes towards 2025 or further. The drivers can in this way function as criteria for scenario building. For individual firms, these scenarios can help making the investment decisions, but they could also be used as an analysis of the changing environment in further research by Vopak, so that its own strategy can be tested along these scenarios. While the five-forces analyses present the current, as well as the possible future status of the bunker market, the investment drivers analysed by means of TCE have a more dynamic character and function as determinants for change. The five-forces analyses thus provide the playing field, a certain environment in which the investments have to be made, while the drivers analysed through TCE are those aspects that create deviation between scenarios. Using the five forces analysis combined with the proposed drivers of development, this research may provide a strong basis on which to build robust and, especially, *internally consistent* scenarios of the bunker market.

8. Results and implications

This section integrates the outcomes of this study and place each in perspective of the whole. The outcomes summarise the each of the steps taken to reach the research objective. And in the end this research is to be of value for Vopak, so here the developments are also linked to their impact on Vopak's business. The second part of this section focuses on the possible actions and reactions for Vopak to minimize negative or take advantage of positive effects of the IMO sulphur regulation.

8.1. The bunker market

A good way to summarise the results of this research is to fill in the framework presented in section 2. In essence, this entails the recapitulation of sections 4 through 7, which come together in the figure. The three essential elements are the institutional environment, the bunker market analysis with Porter's Five forces and the TCE analysis of investment drivers.

8.1.1. The institutional environment

After the research was introduced with all of its definitions, goals and theoretical background, the analyses started with a scan of the institutional environment. The institutional environment is described in two ways, one focusing on the informal developments of the world around bunkering, while the other digs deeper into the formal aspects of the environment.

The informal institutions circled around two themes. The first is the cultural differences across the globe leading to more or less openness in markets, the second is the growing awareness of our environment and how we impact the environment around us. Different developments in history, mostly in the twentieth century, have led to different economic visions. This is expressed in more socialist societies, such as Russia and China, and 'capitalist' societies, i.e. the OECD. These two different economic systems have a significant impact on the openness of the market. China has a very closed bunker market and Russia is increasingly protectionist, to give two examples of less open markets within a mostly open world market for oil products. The environmental awareness also varies across the globe. The 'Western' countries have a higher awareness, while there is a considerable difference between the EU and the U.S., the former laying a larger significance on environmental protection. Developing countries have a lower awareness, but are catching up fast, as development goes fast.

The formal institutions are constituted by MARPOL Annex VI – together with its enforcement, ISO standards and by the formalisation (in legislation) of aforementioned restricted access to markets. MARPOL Annex VI Regulation 14 is by the most impactful formal institution. It lays down sulphur limits which are applicable globally as well as solely within Emission Control Areas (ECA's). Globally, ships registered in IMO Member States are restricted the use of marine fuels with a higher sulphur content than 3.5%, while in ECA's this limit is 1.0%. These areas include the Baltic Sea, the North Sea and English Channel and North America. Currently, the sulphur limits are laid down in the ISO 8217, a standard that ensures roughly the same quality bunker fuel around the world, preventing equipment damage and stimulating sulphur limit compliance. Future sulphur limits are 0.1% in ECA's from 2015 onwards and a global cap of 0.5% in 2020 or 2025, to be decided in 2018. The regulation is to be enforced by the port state control (PSC) of a Member State, but currently they lag behind in implementing frequent inspections policies.

The future of IMO legislation on sulphur emissions remains uncertain to some extent. Although sulphur limits are clear, there are some worries concerning the decision whether or not to postpone the global 0.5% gap from 2020 to 2025, the designation of new ECA's and the extent to which the rules will be enforced. The 2020/2025 decision will be made in 2018 after reviewing the availability of compliant fuels.

New ECA's are also uncertain, as no concrete proposal for new ECA's has been submitted. Finally, the enforcement of the rules should get enough attention, as active inspection by PSC is not as common as desired. The regulation concerning sulphur limits evolves alongside other emissions-related legislation by the IMO. The most important are NO_x emissions and CO₂ emissions. Nitrogen emissions are associated with the combustion properties of engines and are not directly related to the fuel used, so these regulations are not likely to impact the sulphur issues. Carbon emissions are also not so much related to the type of fuel (LSFO, HSFO or MGO) as they are to efficiency of ships. Guidelines for new builds will have to increase ships' efficiency (EEDI), while existing ships also have to increase efficiency (SEEMP). Using LNG, however will lead to lower SO_x, NO_x and CO₂ emissions.

8.1.2. The bunker market's five forces

The bunker market is very international, but also local. The value chain ranges from the refining industry, blending, trading and brokerage activities to bunker fuel storage and the shipping industry. It can thus be said that it is not a simple, physical market, where buyers and supplier meet at one location.

Current market

Bunker fuel, most widely used in the form of fuel oil, is produced at refineries across the globe. But different crude types and different refinery configurations have led to a global imbalance of fuel oil. Russia has many older, straight run refineries with a large fuel oil output and the major supplier of fuel oil in the world. Much of this fuel oil is transhipped in the larger ports where this fuel oil is widely used as bunker fuel. Atlantic Basin refineries are seeing more difficulties than their Russian competitors and see increasing competition from more complex refineries in the Middle East and Asia. Low demand and large overcapacity has led to very slim margin in the refining business. This trend can also be seen in the shipping industry as well as in the mid-stream sectors on the value chain. This has led to many mergers, acquisitions and bankruptcies. Large independent traders become larger and even choose to integrate backwards in refining. Shipping companies are increasingly paying attention to their fuel sourcing as bunker prices have skyrocketed and freight rates are very low.

The bunker market is a very open market when it comes to price setting, but locally there is some opportunistic behaviour of suppliers. This openness and the associated competitiveness would be expected to lower barriers of entry, but the current market situation is worrisome and very low margins discourage potential competitors from entering the bunker market at the moment. Spot markets enhance the bargaining space for customers, who aim to force down prices, require high fuel quality as well as additional services, mostly focusing on bunker price hedging. Besides demand for services from shipping companies, also the producers require services: bunker storage. Storage terminals see high rental rates and a shortage of capacity. This development asks for more capacity additions in the coming years. The business has also attracted private equity and infrastructure funds.

Bunker fuels pass through many hands before ending up in the fuel tanks of oceangoing ships, and not always even physically. The world of bunker trading can be a very complex one, with many different parties taking on many changing roles. The spread of refining capacity, the refineries' configurations, shipping centres and -lanes make this a truly global market, where surpluses in one region and deficits in another as well as arbitrage lead to trade in many different oil products, especially fuel oil. However, the market is experiencing tough economic times

Future market

The future will likely see an increase in global product deficits and surpluses. OECD countries are seeing a shift from lighter distillates (i.e. gasoline and kerosene) to fuel their transport sectors to middle distillates (i.e. gasoil and diesel). Gasoline surpluses in these countries are growing while the distillate demand is steadily rising without additional gasoil and diesel distillation capacity, raising dependency on other

regions for their supply. Utilisations rates will remain low as large capacity additions in the Middle East and Asia will be coming online.

Fuel oil supplies from Russia are expected to drop, following the changing Russian tax regime, which stimulates domestic distillate production at the expense of fuel oil. Lower demand from other sectors than marine transport counter this lower supply, thus not raising any major concerns for the fuel oil supply for bunker purposes. Distillates will be a more important fuel for the marine fuels market as sulphur legislation prohibits high sulphur content in fuel. Large investments in the Middle East, China and India in refining capacity will lead to are larger distillates production as these refineries are far more complex than those having difficulties in Europe and the U.S. East Coast.

The impact of the sulphur limits have had some impact on the local ECA markets There is a growing demand for LSFO, but the effect on the global bunker market are not that large. The supply of LSFO is satisfactory and no real difficulties are seen. But towards a global cap of 0.5% sulphur content, the supply-side of the value chain will see more significant issues.

In the mid-stream sectors there are also important developments to be expected. Trade in the fastest growing bunker markets will skyrocket, especially in the Middle Eastern port of Fujairah. Traders and suppliers are hoping that the Chinese bunker market will open up soon, because this market will become one of the largest in the world and companies are standing in line to take a piece of the cake. Also blending practise are increasingly profitable as more fuel qualities are demanded from the market. The 1.0% sulphur limit in ECA's is a major boost for blending demand. This blending, however, is expected to raise problems in the future, as already many examples of off-spec fuel oil are known. To customers it is not clear what cutter stocks are used, but non-petroleum blending materials are increasingly found in fuel samples, including chemical wastes. This will lead to more bunker disputes in the future. More disputes are also to be expected related to counterparty's financial situations. Hedging of this risk, as well as that of the high bunker prices will be more important services for bunker suppliers or brokers. Higher capacities of oil storage are needed, because of increasing oil product consumption, product imbalances and uncertainties. Storage companies need to invest in product segregation, as every fuel type with a different sulphur content requires separate handling.

Many new builds will flush the shipping market in the coming years, requiring older, less efficient and profitable vessels to be scrapped. This will enhance overcapacity in the short term, but rising demand for shipping in the second half of this decade will counter this development. Ships will become more efficient in the future, now that ships are obliged to follow EEDI rules and reduce fuel consumption. With further operational measures, especially slow steaming, ships' efficiency is expected to increase by 10-30% until 2020. Higher efficiency will partly offset the expansion of the world fleet, leading to a small growth in fuel oil demand.

In order to comply with future sulphur limits, there are several alternatives (or substitutes) for current fuel oil usage. LSFO is a fuel oil that is either desulphurised or produced from a sweeter crude slate. It is a solution for vessels sailing within ECA's who have to comply with a 1.0% sulphur limit until 2015. After that MGO will become a more attractive option, as it can have a sulphur content of only 0.1% (or lower if required). MGO, however, is far more expensive than fuel oil and is only limited available. Scrubbing technology can allow HSFO to still be used in stricter legislative environments by removing sulphur emissions ex-post. It includes high investment costs, but clouds save fuel costs. Another option is LNG, which is a gas and requires different engines and containment systems. It is a clean alternative, but lacks sufficient infrastructure and safety regulations.

8.1.3.TCE drivers for change

The three attributes of transactions have been linked to investments and especially to the motives of industry players to invest in order to reach lower sulphur emissions as the IMO envisions. Uncertainty, asset specificity and frequency were analysed to see if they had any impact on player's decisions to invest.

Uncertainty

Of the environmental uncertainties, two were found to play an important role: the future **enforcement** of the sulphur regulation and the **2020/2025 decision** on the global cap. Shipping companies demand strict enforcement of compliance, with clear penalties, before investing in costly measures for compliance. The uncertainty about the future global cap of 0.5% creates significant concerns for both shipping companies and refiners. The fact that the 2018 decision depends on the availability of compliant fuels only feeds the expectations that the 0.5% global cap will be delayed to January 1st 2025, because no one will want to risk overinvesting or wrongly acting upon projected demand or supply figures.

Besides the environmental uncertainty, the behavioural uncertainty must receive at least as much attention. It is not individual behaviour that is of concern, but it is **collective action** that will create a shift in the bunker market. The interrelatedness of actions from both refineries and shipping companies is expressed in the crucial aspect of **availability**. LSFO supply is not likely to pose major problems, but for the availability of MGO, a promising alternative fuel for compliance with the 0.5% cap, demand is needed and shipping companies will wait on each other and so not trigger large demand. It is the large demand that triggers investments in refinery conversion, hence, collective action is essential.

Asset specificity

Asset specificity is an important determinant for investment. Site specificity is expressed by the time spent in ECA's. Shipping routes are mostly fixed and ECA's have far stricter regulations, so the time spent in ECA's has an important influence on the attractiveness of either of the compliance methods. More specific, capital intensive options of compliance (scrubbers and LNG installations) are more attractive if a vessel is to spend the majority of its time in ECA's, because flexibility is not really an issue. Once vessels spend more time outside ECA's they want to be more flexible in their fuel use. The physical specificity of compliance methods is thus linked with site specificity of the voyage routes. If refiners want to meet demand for lower sulphur fuels in the future, they have to invest in highly specific assets, while these lower sulphur fuels are the least specific compliance method for ship operators. This mutual dependency, together with the deviating asset specificities increases uncertainties for refiners to invest (and for shipping companies to use low sulphur fuels).

Frequency

After analysing the uncertainties, asset specificities and frequency and their influence on decision whether or not to invest, it became clear that frequency has much less of an impact than the former two. Frequency seems not to be of any real significance, because of the existence of a spot market. Spot markets make it difficult, if not impossible, to sign long-term sales contracts. Refiners would want to secure sales, to reduce demand uncertainties, but these long-term contracts are not an option for LSFO nor MGO. Only in the case of LNG, there could possibly be a role for long-term contracts, unless LNG spot markets take a lift off. So, the main (groups of) factors influencing investment decisions are clearly the uncertainties and the asset specificities.

Dynamics

The analysis of the TCE-attributes emphasises the evolving, dynamic character of the investment drivers. This entails that a continuous re-evaluation of the potential drivers is needed to keep a realistic and anticipative view on the market. This process of iterating study should be designed to track market players' motivation to invest. The dynamic character of uncertainties and asset specificities is expressed in their interdependent nature.

8.1.4. Combined into the framework

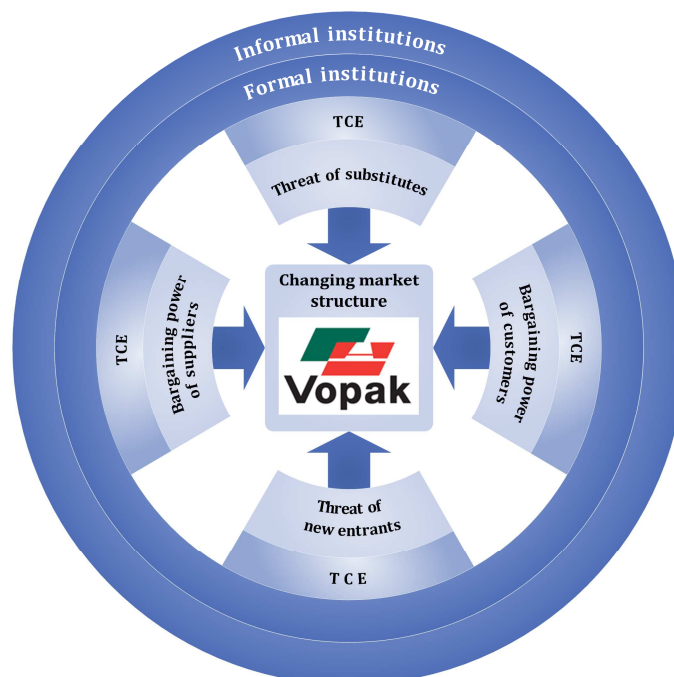
The institutional environment, presented in section 4, plays an important role within the framework. It is omnipresent in both the analysis of the current state of the bunker market, its future state and the TCE analysis. The differences in legislation and enforcement, together with varying market situations across the globe are significant. In the TCE analysis on investment determinants it has become clear that developments in the institutional environment form a large part of uncertainty in the market, even influencing the asset specificity.

The current and the future state of the bunker market are described using Porter's Five forces. This model, however, does not give any motivation of the any of the future developments. Without any further argumentation about how and why developments are to occur, this description would either be an attempt to predict or be a mere assumption. Although the five-forces analysis presents a certain state of the bunker market, there are drivers for change influencing many aspects of that market. So, the framework presented below is difficult to fill in conclusively at a certain point in time. If TCE – i.e. the drivers for investment – were to be filled in in the framework, the subsequent state of the bunker would already be different. This stresses the dynamic character of this approach. It may for that reason be useful in the process of constructing scenarios, where there is a certain status quo which will be changed by varying an amount of drivers. And scenarios evolve just as the market does. Clear analyses of the market environment and of drivers for change, like those following from this research, could help in making scenarios more internally consistent and robust.

8.1.1. Possible impact on Vopak

Now that the outcomes of this study have been combined, the implications for Vopak are discussed (see Figure 8-1). The bunker market has always been an important part of Vopak's fuel oil storage business. Will the changing environment, through developments in the global refining market and through the IMO sulphur regulation, affect storage volumes or maybe even locations?

Figure 8-1 Impact on Vopak



External developments

As the analysis has emphasised, the developments in the legislative environment may play a large role in the future of the bunker market. Possible new ECA's and efficiency measures can influence future demand and supply for fuel oil, but they will probably only have a local or marginal impact on the bunker fuels used globally. Global changes in legislation are more likely to trigger developments in the bunker fuel market. The decision for the entry into force of the global 0.5% sulphur limit is to be taken in 2018. But this decision mostly relies on the availability of 0.5% compliant fuels. The cap will enter into force in either 2020 or 2025. If both shipping companies and refiners will steer for a delay to 2025, the change for Vopak worldwide will come after this date. But would it really have an impact? The bunker *volumes* would not be rigorously different, but the product itself. Vopak stores its fuel oil in specially heated tanks, but MGO is also storable in these tanks (low asset specificity)⁴⁸, so this does not imply new investments are required. There would be some loss in revenue, as fuel oil heating is also profitable.

So, Vopak and other storage companies will not feel any direct pressure from the sulphur regulation included in MARPOL Annex VI. It is not these companies that have to comply and are not under inspection for these matters. Once demand volumes as well as demand locations for certain fuels changes, this would definitely impact Vopak's business. So the effect will be indirect, through changes in the market.

Changing fuel oil balances

In the near future, Russian fuel oil transshipments are projected to decrease due to the large scale upgrading of Russian refineries following the 60-66 tax regime, which lays higher charges on fuel oil exports and thus indirectly supporting refinery upgrades to produce more distillates which can be sold with larger profits. In this way the Russians become less dependent on foreign distillate imports, but also their fuel oil export will decline. Rotterdam, as an important port for transshipment of Russian fuel oil, will definitely see a decline in Russian fuel oil imports. The question is when this will happen. Significant reductions are expected around 2016-2017 (Wood-Mackenzie, 2011a; Fattouh and Henderson, 2012). This means that Rotterdam will see a lower demand for fuel oil storage as well, unless other sources are found that can ensure the current volumes of fuel oil store and transhipped to other markets, Asia in particular. However, the ECA shift to 0.1% sulphur restrictions in January 2015 will lead to an increased demand for distillates in Europe and the U.S., creating opportunities for distillate storage capacity demand.

Other parts of the world (non-ECA's) are not yet under strict sulphur regulations and still allow 3.5% HSFO. This still forms the majority of the bunker fuels market, so there will still be a large demand for fuel oil, especially when keeping in mind the growing fleet in the coming years. The imbalance in fuel oil demand and supply is also likely to grow. ECA's will switch to the use of distillates and the fuel oil demand will only grow in the emerging economies in Asia, while supply will remain to be located outside these areas of growth. Imbalances will ask for more fuel oil storage. China is a promising market for fuel oil storage if it were to open up completely to foreign investments. Until the global cap of 0.5% fuel oil is still expected to form the majority of the bunker market.

But, if the majority of the global fleet will sail on MGO after the global 0.5% enters into force, the bunkering locations might change. Distillates are produced in the U.S. and in Russia, but the lion's share of future MGO supply will (following current investments in refining capacity) come from the Middle East, China and India. China may potentially just be self-sufficient and the Middle East and India are seeing large export-oriented capacity additions come online from 2014 onwards. This may put a heavier importance on the ports in these areas, especially Fujairah. Although Rotterdam is an important bunker market, it is not unthinkable that vessels trading between Europe and Asia will stop and bunker at these Eastern ports instead of Rotterdam. Distillates would logically be cheaper in locations around India and the Middle East

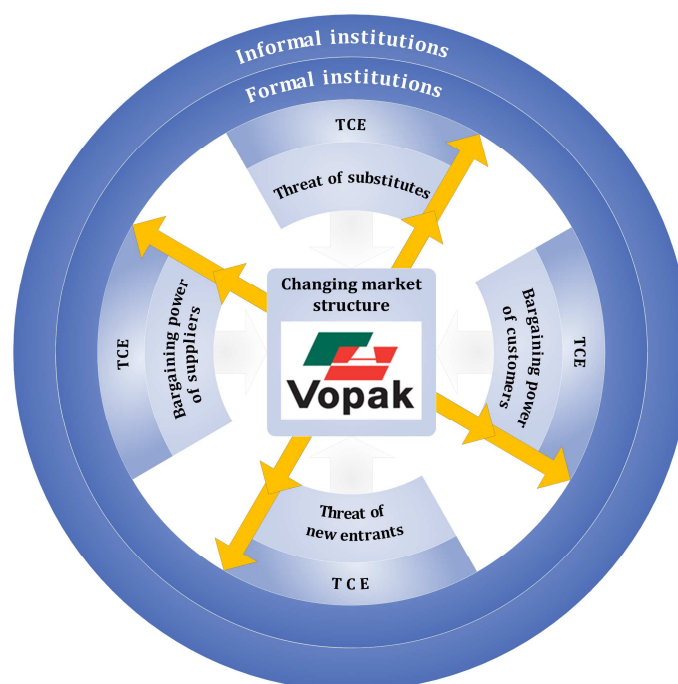
⁴⁸ The physical asset specificity of these tanks would be higher if the switch was from MGO to fuel oil, as the latter requires heating and different handling systems.

than those transported all the way to Rotterdam. So, post 2025 there might be a shift in the importance of Rotterdam as a bunkering port.

8.2. Vopak: Action or reaction?

The previous has described the possible implications of the developments identified in this study on the potentially changing demand for fuel oil storage. But considering the possibilities in the bunker market, what can Vopak do to act or react to these changes? Figure 8-2 shows Vopak at the centre of the market, with its possible influences (yellow arrows) on the different layers of the framework.

Figure 8-2 Vopak in its environment



8.2.1. Influence sulphur legislation

Vopak, along with other independent storage companies, is an indirect stakeholder in the whole issue (see section 5). With influence one could think of lobbying organisations, because one single firm is not likely to be taken seriously by the IMO. A lobby of the entire oil storage sector may be of some influence for future decision making. A large scale transition towards MGO could be helped by the storage sector, as they could play a crucial role in establishing storage capacity, which would be required in possible new refining and bunker centres. So, towards the 2018 decision on compliant fuels availability, an independent storage sector lobby could ask for involvement of the sector in this review. This can however be more difficult than it sounds. The IMO rules have taken several decades to become adopted by all the Member States. In fact, MARPOL Annex VI Regulation 14 is the first globally applicable sulphur emissions regulation⁴⁹, and has been a process in which many parties were involved: all of the 170 Member States, shipping companies, major oil companies and intergovernmental organisations. This shows the magnitude of this decision making process and it is not surprising that the process took as long as it did. So lobbying is all Vopak (and its fellow storage companies) can do to influence the rules themselves.

⁴⁹ The same counts for the EEDI of Chapter 4 of Annex VI focusing on the carbon dioxide emissions

On enforcement levels, action does not seem very beneficial for Vopak. Vopak could increase cooperation with PSC's to enhance inspections at its terminals, but it is not likely that Vopak's clients would be very happy about this. Still, there is a possibility that shipping companies do not view this with disfavour, because they rather have a level playing field with clear consequences in case of non-compliance, than live in uncertainty about potential inspections and penalties.

8.2.2. Monitor developments

Another option for Vopak to manage the changes in the legislative environment is to closely monitor the developments. Although this seems a straightforward option, this is an aspect in which Vopak can be one step ahead of its competitors. Monitoring could be done through informal and formal channels. An informal way of monitoring developments is to proactively consult clients and organise discussions with involved parties. Keeping tight relations with clients is thus essential if Vopak wants to be up to date. Formal ways of monitoring developments include reading industry magazines and newspapers, stay up to date with reports from governments or industry players or hire consultants to calculate future changes in the market. Vopak can assign an employee as primary responsible for updating the management board.

8.2.3. Seize business opportunities

The changes in the market can provide new business opportunities. It is already Vopak's strategy to expand to where profitable and secure business opportunities arise. Investing in areas of growing demand, be it fuel oil or whatever other oil product, is something which is obviously good to pursue. But there are other possibilities for Vopak. LNG as a bunker fuel has received some attention in this study and the infrastructure was still regarded as being in its infancy. Because Vopak already has experience with LNG at its Gate Terminal at the Tweede Maasvlakte in Rotterdam, this may be an area of opportunities. The Gate Terminal is one for break bulk, which is similar to what bunkering entails: distribution and consumption of LNG in small volumes. Experience with this fuel can be put to use by playing a proactive role in the development of an LNG infrastructure, including bunkering facilities. As being such a large player in the independent storage market, Vopak has the potential to help in establishing LNG bunkering procedure standards as well as safety standards. It is thus interesting to see that Vopak is already exploring the possibilities of an LNG terminal in Gothenburg, Sweden. By signing a letter of intent (LOI) with Swedegas, Vopak entered into a feasibility study which will explore the potential of such a facility, which could be used for bunkering purposes in an already established fuel oil bunker port.

8.2.4. Wait and see

The final strategy Vopak can take on is that of wait-and-see. Acting upon the developments in the market as described above can also include risks. Investing in a LNG, for instance, may not be fuel of the future choice and may lead to significant losses. Vopak can leave the risk taking or the responsibility to act with its competitors and save the costs of influencing legislation, monitoring the market and investing in new technologies. This option, however, is not risk-free either, as by not being proactive, Vopak can miss the boat and/or be too late to react to new the emergence of new bunker fuels. The relationship with its customers can also suffer from the tardiness of Vopak.

8.2.5. Altering the drivers of investment

It has become clear that the drivers for investment in the future bunker market are all mostly out of reach for Vopak. Altering these drivers is almost impossible.

The environment is uncertain for a large part because it comprises the top levels of the four-layer model and these levels are the most difficult to influence. Because market players have limited power to change the – in this case – formal institutions, this uncertainty will remain. This counts even more so for Vopak.

Collective actions (related to behavioural uncertainty) is not something one can trigger on its own, but organising alliances or even joint ventures for large scale storage of "new fuels" (MGO or LNG) in certain (future) strategic bunkering ports, may trigger action from neighbouring competitors, but the chances of success are very slim. The time spent in ECA's and physical asset specificity are also not worth focusing much attention on as the developments in these occur far away (in the industrial chain) from Vopak.

Altering these drivers is almost impossible and it is wiser to focus on those actions that were described in the previous.

9. Conclusions

This final chapter will draw the conclusions from this research as well as reflect on the outcomes and the concepts used. At first, the research design is evaluated by analysing the suitability of the design and the research as a whole to answer the research question. Subsequently the research sub-questions are discussed in order to answer the main question. The second part of this chapter is reserved for reflections on the approach used for this research as well as on the results, including recommendations for further research.

9.1. The research design

As was stated in at the beginning of this report, the current studies and industry reports predominantly focus on providing numbers, quantifying costs and supply or demand volumes following the MARPOL Annex VI sulphur regulation. Not all of these studies provide understanding behind the numbers. For this reason the aim of this study was to “*provide understanding of the dynamics in the bunker market and of how this market may react to the IMO sulphur regulations by taking a new - socio-economic – perspective*. To be able to makes choices, with the future developments in mind, one needs more than mere number to do so. An understanding of why developments happen as they do can be a valuable addition to the majority of predictive studies. So, a different perspective is needed. To refrain from numeric research, the perspective chosen for this study is a socio-economic one. However, not many theories are able to capture the dynamics, variety and interdependencies of a specific market. The combined socio-economic theory, as argued in chapter 2 and 3, can do just that. These considerations have led to the main research question:

How can the global bunker market develop in the coming decade under new global sulphur emission restrictions on the basis of the current market structure and dynamics and how will they affect Vopak's worldwide bunker fuel storage business, when using a New Institutional Economics approach?

The methods to perform this research were chosen in line with the qualitative nature of the question. Desk research and interviews have provided the necessary information that helped create understanding of the bunker market and its institutional environment. Porter's Five forces model has provided a framework to described the functioning of the market as well as the possible market situation in the future. Using these market analyses, Transaction Cost Economics concepts were applied to determine the drivers for investment of the critical market players towards compliance with the current and future sulphur restrictions. The filled-in framework, which is used to combine the theories, gives arguments for how and why developments will take place. Therefore Vopak can better use the information provided in this research as well as that of other, more quantitative studies.

This study has taken an institutional approach that formed the basis for a structured qualitative analysis. It is complementary to many of the available qualitative studies by exposing the social interactions within the ever changing environment. It therefore has the potential to contribute to an increased comprehension and to provide a robust evidence base for qualitative researchers.

9.2. Answering the research questions

This paragraph answers the four research questions. Each of the questions is discussed separately before ending with a main conclusion.

9.2.1.Theoretical perspective for market analysis

1. *How can the New Institutional Economics framework together with Porter's ideas be helpful in creating a broader understanding of the bunker market when we keep a socio-economic perspective?*

Williamson's four-layer model has provided a useful starting point of the theoretical perspective. It provided a way of categorising the institutions and helped structure the market analysis. The first two layers of this model constitute the institutional environment, which has formed an important part of the analyses performed in this research. The third "governance" layer is where transactions take place. This layer is associated with the Transaction Cost Economics. TCE is often used to determine the most suitable mode of governance for a specific transaction by optimising on transaction costs. Optimising happens on each of the three dimensions of a transaction, namely uncertainty, asset specificity and frequency. It is these three concepts that are interesting for this research. Instead of optimising on a single transaction, the goal was to analyse the transactions of a whole market, or more specifically, the investments made in the bunker market. TCE helped to identify important determinants for investment, although this was an unconventional application of these concepts. These determinants provide understanding of the investments that lay ahead in the bunker market. Uncertainty and asset specificity proved to be very useful, while frequency was of less interest. This is the case, because the high level of competitiveness, expressed by the existence of spot markets, have minimised the opportunity to sign long-term contracts and – on the short-term – restricted opportunistic behaviour. The omnipresent institutional environment is integrated into both Porter's five-forces model and TCE, where the Porter model serves as basis for the TCE analysis.

When referring back to the scheme provided in section 2.5.3, we see that the institutional environment, Porter's five forces model and TCE are indeed intertwined. The drivers for decision making by essential parties in the bunker market can be related to any of the five forces influencing competition. The iterative process of analysing the drivers for investment, because their dynamic nature (which is paradoxical with Williamson's 'static' approach to the original TCE), can also be integrated with Porter's five forces. Porter provides a framework to describe a state of an economy. The same is done twice in this research, as the framework has been used to present both the present as the possible future state of the bunker market. Although the dynamics of the market have been attempted to incorporate into these analyses, they still represent the perspective of "today". The drivers for investment and thus for change in the market structure are here identified as being themselves dynamic determinants of a future state of the bunker market. The drivers which were identified using the three dimensions are mostly based on long-term rational decision making by the actors. This entails that there might be other drivers for investments which are not addressed when solely following the TCE-dimensions. For example, the neoclassical approach of pricing through demand and supply (especially price premiums between fuels) might provide new drivers of investment. This may be a good starting point for further research.

The chosen theoretical perspective is suitable to answer the research question as the goal of creation a better understanding has been reached. However, there are some drawbacks to the chosen framework. This study deliberately did not focus on numbers, and the chosen framework did provide understanding from a socio-economic perspective, but one can ask the question if that perspective is (suitable) enough to completely understand the market. To my opinion, understanding of a market can be reached through both quantitative and qualitative methods. So, my filled in framework all but tells the complete story, but it is thorough enough for the means the research was performed.

9.2.2.Exploring the bunker market

2. *How does the global bunker market currently function?*
3. *Which developments are likely to occur until 2025?*

The bunker market is characterised by overcapacities and low margins on both the supply side (refineries) as the demand side (shipping companies). The current state of the economy has put pressures on the sectors; therefore, the bunker market is very cyclical as it is immediately affected by changes in the general state of the economy. Also bunker traders and suppliers – usually a profitable business in the mid-stream section of the value chain – see declining revenues, which has led to many mergers and acquisitions by the large independents. Bunker fuels thus pass through many hands before ending up in the fuel tanks of oceangoing ships, and not always even physically.

Global imbalances of fuel oil have led to large trade flows. The largest producer of fuel oil is Russia, while there are large deficits in Europe and Asia. But Russian refineries are upgrading and in the Middle East and Asia new, complex refineries are coming online, make life very difficult for refiners in the Atlantic Basin. Shut downs in this region has increased dependency on foreign fuel oil. Large trade flows have led to a healthy business for storage companies. The bunker market thus directly impacted by changes in the refining sector

Spot markets characterise the competitiveness in the bunker market. This creates low barriers of entry, but the current market situation is not very attractive for possible newcomers. Spot markets enhance the bargaining space for customers, who aim to force down prices, require high fuel quality as well as additional services, mostly focusing on bunker price hedging. The latter is increasingly popular as bunker prices have skyrocketed and have shown much volatility, while freight rates are very low. Also suppliers see margins decline and increasing amounts of contaminants are being found in bunker fuel due to improper blending practices, which has led to a growing number of bunker disputes. The high level of competition is key for the structure of the bunker market.

The spread of refining capacity, the refineries' configurations, shipping centres and -lanes make this a truly global market, where surpluses in one region and deficits in another as well as arbitrage lead to trade in many different oil products, especially fuel oil.

Sulphur legislation and the future

Currently, the ECA's are seeing the tightest sulphur limits, being 1.0%, while the global sulphur cap is set at 3.5%. Ships sailing in ECA's now have to use LSFO, whereas HSFO is still used outside ECA's. In January 2015, the sulphur limit within ECA's will decrease to 0.1%, forcing more drastic or costly measures to be taken. The compliance methods for the 0.1% limit are MGO, scrubbers and LNG fuel systems. All three options involve high costs. MGO is more expensive than fuel oil and scrubbers and LNG systems are very capital intensive, but might be accompanied by lower fuel costs.

In 2018, the IMO has planned to review the availability of <0.5% sulphur content fuel before deciding whether the global sulphur limit of 0.5% will enter into force in 2020 or in 2025. This will impact the entire global fleet (as far as flag state is represented in the IMO), as fuel oil is not likely to be blended down to this percentage. Other measures have to be taken. But, because the decision date is 2018, there is currently much uncertainty about the 0.5% cap. This entails that shipping companies will wait until this decision to take any necessary steps, while the refining market is waiting on demand to change, before investing heavily in MGO conversion. And significant demand change is not likely without collective action. So, availability will probably be low on the review date because of the associated uncertainty. Besides this cap, there is uncertainty about the enforcement of the rules, which is essential for ship operators to comply to the limits. Hence, uncertainty can be considered a major determinant for investments.

Asset specificity is a second important determinant for investment. Time spent in ECA's is essential for a vessel when deciding the best compliance method. The longer the voyage within ECA's, the less flexible

the solution has to be and the more capital investments are justified. The physical specificity of compliance methods is thus linked with site specificity of the voyage routes. If refiners want to meet demand for lower sulphur fuels in the future, they have to invest in highly specific assets, while these lower sulphur fuels are the least specific compliance method for ship operators. This mutual dependency, together with the deviating asset specificities increases uncertainties for refiners to invest (and for shipping companies to use low sulphur fuels).

9.2.3. Implications for Vopak

4. *What do the developments in the sulphur regulations mean for Vopak's bunker fuel business?*

Vopak, as well as its competitors, will not see major changes to its bunker business just yet. It were to be the case if bunker volumes or bunker locations were going to shift. But the large scale shift expected in the bunker market is not likely to take place before 2025. Short term implications for Vopak mostly concern the rising demand for LSFO blending and associated storage capacity. This requires separate handling from HSFO, so perhaps expansion of capacity is needed.

The impact on Vopak's business is analysed, not by zooming into Vopak, but through logical reasoning of what effects the external developments could have on a large oil storage company. I refrained from performing an in depth analysis of Vopak's competitive position, its strengths and weaknesses, because the scope of the research was significantly high and the unit of analysis – the industry instead of the firm – didn't lend itself to do so. In this way the developments in legislation and, following, in the bunker market itself were part of a macro-economic market analysis. The impact on Vopak is described somewhat "vaguely" due to this high level approach, although efforts have been made to make them as concrete as possible within the scope of this study. Vopak's position as an actor in the market and its possible power to influence institutions and investment drivers for shipping and refining companies can neither be narrowed down to concrete recommendation of action steps. Although it was not the original intention of this research to provide concrete strategic advice, one tries to provide as much a grasp as possible for Vopak.

However, this study does provide Vopak with enough grip to enter in new research projects in order to convert these outcomes into operationalized factors, recommendations or actions. In the end, the question of what the sulphur regulations mean for Vopak's business is properly dealt with, considering the above. Possible actions for Vopak include aspects of all the layers of the framework, ranging from attempts to alter the formal institutional environment, to monitoring developments, seizing new business opportunities and wait-and-see behaviour.

A large shift towards MGO can be seen after 2020 or 2025, possibly leading to a decline in fuel oil bunkered in the Port of Rotterdam, which is significant location of Vopak's business. Not only the decline of fuel bunkered, but also that of fuel transhipped can be affected by the shift of using Russian fuel oil to using distillates produced in the Middle East and Asia. Ports such as Fujairah may, on the other hand, see its importance increase. However, these (for Vopak very important) developments may not be seen until after 2025 and are thus not thoroughly discussed in this study. This therefore calls for a research which either assumes earlier adaption of MGO in the bunker fuel market or takes a longer time span.

9.3. Reflection

The reflection on this study is focused on two areas. The first concerns the approach taken to perform this study, while the second focuses on the results and what the mean in its context.

9.3.1. The research approach

The research approach is described in section 2, and it is useful to evaluate this approach as it has shaped the entire study, by taking a certain perspective or mind set. It is now interesting to see if the choices made in the approach have been suitable for answering the research question.

Qualitative nature

This study has taken a mostly qualitative perspective to the research problem. It has avoided moving into a situation in which a certain approach – i.e. the qualitative – found it necessary to claim superiority over other approaches. The different strengths should therefore be respected as to reach a more thorough and robust analysis than either qualitative or quantitative approaches would do on their own. Qualitative studies provide a sense of understanding of the socio-economic aspects of behaviour in a dynamic environment, but often lack the strength to persuade actors to make strategic decisions. Findings from quantitative studies have the legitimacy of science and precision computational models and numbers and are therefore more likely to influence policy. But they can rarely deal with the dynamics of a markets in any depth, so they are restricted to concepts and factors that are often quite limited and may give only a partial explanation of the issues that are at stake. So how can this qualitative research be used in combination with the quantitative studies (often performed by consultants)? This is an important input for further study.

Scope

The scope of this research was very wide. The focus was not on one sub-market or on one aspect of bunkering, but on the entirety of the market worldwide, including globally varying circumstances. This made a clear and accessible representation of reality, through the application of the theories, challenging. For this reason, what this study often refrains from going into specific detail. Most other studies focus on just the shipping industry or on the refining industry, which leads to more concrete findings.

The chosen timeframe seems suitable for the research goal. The study focuses on the possible implications of the sulphur legislation on the bunker market, and the legislation is only set until 2025. The investments towards compliance with stricter sulphur limits will most likely take place around the date on which the global 0.5% cap enter into force. So, looking further than 2025 would imply making too many assumptions. On the other hand, the largest changes in the bunker market might only show after 2025, but this is what remains uncertain.

Theories used

The choice of theories has focused primarily on the qualitative aspects. NIE is very suitable to combine structure the more holistic view of OIE, which was also argued in section 2. The aim of this study was to provide understanding of the developments, mostly predicted in other studies; a qualitative perspective in addition to the quantitative reports.

Porter five forces and TCE are used separately, as they serves different goals. But it is the integration provided at the end of this study that emphasises the usefulness of combining the two. The interesting thing about the theories used, is that they can both form an integral part of scenario building. Porter's description of the bunker market can serves as a base case scenario, while the TCE concepts, i.e. the investment drivers, are altered to create different scenarios. Porter can then be used to argue the future state of each of these scenarios. It is thus also interesting to see how the TCE analysis leads to a changed five-forces view of the market. TCE is used to identify investments drivers, but it might be interesting for further research to put this into perspective by looking for other theories that may provide additional, or otherwise presented, drivers for change.

Strategy should not be solely based on this study, because quantitative analyses should also be incorporated policies. Together, one can make more robust choices. Besides strategy forming, this study

can also be very useful to understand clients, or clients of clients, an lead to a better dialogue and perhaps cooperation in acting upon the changing sulphur limits.

Research methods

The methods to perform this research were chosen in line with the qualitative nature of the question. Desk research and interviews have provided the necessary information that helped create understanding of the bunker market and its institutional environment. The theoretical background was widely discussed in current literature. Information on the bunker market, however, was not always as well documented, as much information is of strategic importance, so interviews were needed to get a better understanding on the actual functioning of the market. These proved to be insightful and have helped creating my line of reasoning in this research.

9.3.2.The results

Value of results

The goal of this research was to provide insight in the functioning of the bunker market in order to evaluate the possible developments for the future. For Vopak this research can be useful for shaping their strategy on fuel oil or create better understanding of its clients towards, perhaps, increased cooperation. On the other hand, the research has some scientific value. To my opinion, these two goals have been reached. The results for Vopak comprise an extensive analysis of the functioning of the bunker market, but more important, drivers for future change. These drivers are useful as input for scenarios. If you vary these drivers between scenarios future states can be analysed by using Porter. So, in in this respect the results are satisfactory. The qualitative nature of the results can be of great value next to the more quantitative focused studies provided by e.g. consulting firms. When combining the two, more robust scenarios can be built or even decisions can be made. Now that Vopak knows the background of the legislation and the possible investment it invokes, it can better communicate with clients on this matter as well as think along with them.

The scientific value of this research lies in the combination of OIE, NIE and Porter's five forces. These theories are not often combined in the way they are here. NIE is often used to analyse the institutional arrangements in detail, assuming a the conditions are set (i.e. the institutional environment is fixed), while it is here used to structure the institutional environment, which is dynamic as proposed by the OIE. These theories do not provide information on the competitive nature of the market in focus, which is why Porter is used. Porter's five forces, however, was originally constructed to help a specific firm gain a competitive advantage, but is often used purely to analyse markets.

TCE is usually used to analyse individual make-or-buy decisions, to look for the most appropriate mode of governance by optimising on transaction costs. The perspective taken in this research has taken a much higher level view and takes the concept of collective industry action as the main transaction. This approach is not what Williamson originally intended to take, but has provided me with insight, comparable to earlier studies, that the transaction dimensions can be successfully linked to investment decisions: investments by either the shipping or the refining industry are characterised by both the presence of uncertainties, both environmental and behavioural, and that of physical and location-related asset specificity. Where frequency might play an important role for investment in other sectors, it has no major influence on the investment decision made by the bunker market's critical actors.

So, the theoretical perspective has provided Vopak with a broad understanding if the functioning of the bunker market, as well as a set of drivers that will determine the change in the industry.

Encountered problems

Setting boundaries for such an extensive and broad global market is very difficult. Information on certain market movements requires knowledge of other processes, which in turn require more information. In the end, the boundaries for this research have been set very widely, to give a market analysis that would be as complete as possible. In some instances it may seem like a lot of information, but all (at least most) the important aspects of the market can be found in this study.

It has proved to be difficult to find literature on the actual functioning of the bunker market. Many reports and studies presume a certain level of knowledge with the reader, while, for me, this was not present at all. For this reason it was a very good option to talk to people, within Vopak, but also in the interviews performed much information was shared.

9.3.3. Future research

Of course, there are several aspects that deserve more attention in future research. These relate to practical research for Vopak, but also to the scientific content of this study.

Practical issues

What would be interesting to know, is what the exact share of bunkering within the oil storage business is, to be able to put this research in perspective of this storage sector together with other quantitative studies. This knowledge is, of course, present at these companies, so their own conclusions can be drawn.

The previous paragraph touched upon the combination of qualitative and quantitative studies. This is definitely an important subject for further study. How can these approaches be used alongside each other? Firstly, qualitative research can be seen as complementary to the quantitative research, by answering questions that might otherwise not be accessible. In this case, both studies are not performed by the same person and therefore the two may have different outcomes. They thus serve as mutual validations, as they can neutralise a certain bias, which is inherent to a particular data source, researcher or method. As quantitative and qualitative studies have differing preoccupations, it is unlikely that they are touching upon the same thing even though they examine the same issue. If there are discrepancies between the two results, it is very interesting what that actually implies and comprises. This is interesting material for consultants of Vopak who focus on quantitative studies. If this study is combined – as it is performed by a different and independent researcher – with their findings, this study may provide those consultants with new insights concerning actors' decision based on less rational aspects. Although these consultants probably have the same knowledge – i.e. of the institutional environment and actor's behaviour – and use it tacitly, it is more likely that they do not have these socio-economic aspects structured in a thorough market analysis. That is where the value of this research comes in. The most important findings of this study (impact of legislation on choices, drivers for investment) could be provided to the consultants, which may create a different opinion on these matters.

Secondly, the qualitative study can serve as an input for quantitative modelling. In this case the quantitative model parameters are put into their socio-economic context and may be re-evaluated. For instance, the drivers identified in this study may lead to different 'control buttons' in the computational models. Aspects that were held constant (the *ceteris paribus* assumption) may turn out to be more interesting to consider as input variable than previously thought. It is therefore prudent to study the effects of the qualitative aspects of this study on the model parameters of quantitative models.

To give an example of what is discussed here; interesting material for Vopak is the possibility of a shift in bunkering ports, due to the decreasing Russian fuel oil exports and possible drastic increase in MGO demand when the global 0.5% sulphur cap enters into force. What will happen in that case might be a good question for the consulting firm, who could calculate possible scenarios of where these bunkering ports might be located in the future. But what would be the specific factors of attention? Shifting locations for bunkering would entail that there are different flows of marine fuels across the world. These flows are

fuel oil and MGO flows (assuming this will be the way to comply to future sulphur limits). And if we assuming there will be enough availability of MGO in 2018 to ensure a smooth entering into force of the global 0.5% sulphur cap in 2020 (mostly used timespan for quantitative studies at the moment), then MGO will be produced on such a large scale that it has almost banned fuel oil from the bunker market. The original producers of fuel oil, especially those countries with predominantly lower complexity refineries like Russia, might not be the same as the producers of MGO. To be able to argument a shift in bunkering ports, not only would the local production of bunker fuels play a role, but also the proximity and density of shipping routes. If there is local production, but no demand, then the fuels will be transported to those locations where ships drop or load their cargo, unless prices a significantly low. The factors that are important to be able to clarify what the future fuel flows may look like and where bunkering ports will be located, on the background of the discussed dimensions or drivers (uncertainty, asset specificity and frequency), are:

- The date on which the 2020/2025 global cap enters into force
- The current investments in high quality, clean refineries (including upgrades) capable of (profitably) producing MGO
 - o Their size
 - o Their location
 - The bunkering infrastructure on site
 - The openness of the bunker market (from a competitive point of view)
- The expected investments until the entry into force of the strict global cap
- The identification of the major shipping routes (now and in the near future)
- The assumption of unitary full enforcement of the sulphur limits
- Expected growth of the world fleet
- The specific influence of uncertainty, asset specificity and frequency of each of these factors

Scientific issues

A next step for what this study has offered can be to create scenarios in which the effects of the investments (resulting from the drivers for change) suggested by TCE are reflected in new states of the bunker market. So operationalizing the link between the investments made and each of Porter's five forces can be very insightful. Furthermore, the analyses methods proposed by this study, combined into the presented framework can be subject of further research, being either applied to other industries or challenged for its proposed use.

The comparison of qualitative versus quantitative studies has already been discussed, but besides the practical implications, this issue has a significant scientific value. This discussion is also far from new and the effects of combining the two approaches in the case of bunker markets is interesting to look into. Perhaps a more general conclusions can be drawn from the possible combining of this study with quantitative studies that can serve as a basis for other industry analyses.

The drivers, for instance, which were identified using the three dimensions, are mostly based on rational long-term decision making by the actors. Investment drivers may be legion and those discussed in this study may not tell the whole story. For this reason another approach to investment decisions can be taken by focusing on e.g. short-term irrational arguments. Besides the question of (ir)rationality, it is interesting to apply to TCE-concepts to other studies on investment decisions. Especially the dimension of frequency may deserve more attention, as past studies, including this one, lay the largest focus on uncertainties and asset specificities (and their interaction). Frequency has – to my knowledge – not been directly linked to investment strategies.

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Annex A: Personal communication

List of interviewees

W. Dijkstra and J. Kolpa	Ministry of Infrastructure and Environmental Affairs	February 9, 2012
Maersk		February 15, 2012
B. Van Holk	Former professional in the refining industry. Currently at COVA, Netherlands National Petroleum Stockpiling Agency	February 29, 2012
C. de Keijzer	Chairman of the Rotterdam Branch of the World Ship Society	March 8, 2012
M. Vink	Netherlands Shipping Inspectorate	March 19, 2012

The outline of the interviews is provided below. Except for the interview with Maersk they are all in Dutch.

**Ministerie van Infrastructuur en Milieu/Ministry of Infrastructure and Environmental Affairs
February 9, 2012**

Wieger Dijkstra, DGM / Directie Klimaat en Luchtkwaliteit, Afdeling Mobiliteit en Verkeersemisies
Jaap Kolpa, Afdeling Zeevaart

MARPOL Annex VI:

1. Wat is de actuele status rondom de doorvoering van Annex VI in Europese en Nederlandse regelgeving?
 - Doorvoering in wetgeving
 - Tegenstand (lobby's, vooral uit Scandinavië)
2. Klopt het dat stookolie met meer dan 3,5% zwavel ook niet meer verhandeld (commodity trading) mag worden binnen de EU?
3. Welke gebieden denkt u dat voor 2025 ook zullen worden aangewezen als SECA?
4. Ziet u naast de zwavelrichtlijnen, ook andere emissierichtlijnen die van invloed zijn op de bunkermarkt en, zo ja, hoe zal de markt daardoor worden beïnvloed?
5. Welk aspect van de regelgeving zal volgens u de grootste uitdaging voor de industrie (raffinage/scheepvaart) zijn om aan te voldoen?
 - Wereldwijd t.o.v. Europa

Market drivers:

6. Is de bunkermarkt een open of een gesloten markt?
7. Wie ziet u als de belangrijkste spelers in de bunkermarkt/shapers van het speelveld?
8. Welke factoren zijn volgens u belangrijke drivers van de markt als u verder kijkt dan prijsvorming?

Oplossingen:

9. Welk alternatief/welke alternatieven zou(den) volgens u gebruikt *moeten* worden om aan de strenger wordende emissie-eisen te voldoen, en waarom? Voor rederijen en voor raffinaderijen? (Wat is het standpunt van het Ministerie?)
 - En welke *zullen* het naar verwachting gaan worden, als we het hebben over een tijdsbestek tot 2025, en waarom?
10. Welke rol ziet u weggelegd voor technologie?
11. Verwacht u veel samenwerking tussen marktpartijen of juist individueel gedrag bij het oplossen van de 'emissieproblemen'?

Externe ontwikkelingen:

12. Bent u op de hoogte van de recente ontwikkelingen rondom het belastingregime op de export van olieproducten van Rusland?
13. Ziet u culturele of politieke verschillen tussen landen (binnen en buiten de EU) die van invloed kunnen zijn op het voldoende invoeren en naleven van de emissieregels?
 - Bijvoorbeeld dat Europa vaak voorop wil lopen als het om het milieu gaat
 - China voelt waarschijnlijk weinig voor de invoering mogelijke SECA's (suggestie)

Overige opmerkingen:

Maersk
February 15, 2012

Legislation:

1. Are you familiar with the directives on reducing sulphur emissions, defined by the IMO?
i.e. MARPOL Annex VI
2. Do you/does your organisation support the tightened marine sulphur emission regulation?
3. Which other areas do you expect to be a designated SECA before 2025?
4. Which aspect of MARPOL Annex VI is going to be the biggest challenge to comply with?
 - For either refineries
 - For shipping companies
5. Do you see any other emission restricting legislation that could be of influence on the bunker market, beside that on sulphur?
 - CO₂, NO_x, PM

Market drivers:

6. Is the bunker market a closed or an open market?
 - Transparent price formation
 - Information distribution?
7. Who would you consider the most important players in/shapers of the bunker fuel market?
8. Does Maersk play an important role in the market? If yes, how does it take shape?
9. According to you, which factors are important drivers of the bunker market, when you look beyond pricing?
10. Would you say the bunker market is a push-driven or a pull-driven market? That means, driven by the suppliers or by the customers?
11. Would you say the following apply to the bunker market? And if so, how do they manifest?
 - bargaining power
 - strategic behaviour
 - opportunism

Alternatives:

12. Which alternative(s) would *you* seem fit to comply with the increasingly stringent emission requirements, and why? For shipping companies and for refineries?
 - And which do you *expect* to do so in the period until 2025, and why?
13. Are there other parties, besides refineries and shipping companies, who can take action towards the new regulations?
14. Are there any state-of-the-art technologies currently under evaluation at Maersk? E.g. new types of fuel? Oil/water emulsion?
 - Which role would you assign to technology? Active or reactive?
15. What considerations does Maersk make when dealing with the new legislation?
16. Do you expect much cooperation among industry players in solving the emission difficulties? Or will parties mostly act individually?

External developments:

17. Are you aware of the recent developments in Russia concerning the new tax regime for the export of oil products?
 - Would you know of any other (geo-)political developments in the world that could influence the functioning of the bunker fuel market?

Refining industry
February 29, 2012

Bart van Holk, Managing Director at COVA and former professional in the refining industry

IMO, MARPOL Annex VI:

1. Bent u bekend met de huidige en voorgestelde regelgeving rondom zwaveluitstoot in de maritieme sector?
2. Ziet u naast de zwavelrichtlijnen, ook andere emissierichtlijnen die van invloed zijn op de (stookolie-) bunkermarkt en, zo ja, hoe zal de markt daardoor worden beïnvloed?
3. Waar liggen volgens u de grootste uitdagingen wat betreft het voldoen aan de strengere regels: bij raffinagesector of scheepvaartsector?
 - Wereldwijd t.o.v. Europa

Marktanalyse (structuur van de markt):

Raffinaderijen produceren en importeren stookolie. Deze stookolie wordt ofwel direct verkocht aan afnemers ofwel indirect via traders. Raffinaderijen, maar ook traders slaan op (raffinaderijen hebben vaak eigen opslag, traders soms, maar maken vaker gebruik van een 'Vopak'). Dus er is direct channel en indirect channel sales, itt benzine neigt de balans meer naar indirect channel sales.

4. Is de bunkermarkt een open of een gesloten markt?
 - Hoe transparant is de markt?
5. Wie ziet u als de belangrijkste spelers in de bunkermarkt/shapers van het speelveld?
 - Denk hierbij aan de hele supply chain
 - Hebben bepaalde bedrijven sterkere onderhandelingsposities? (enige vorm van marktmacht)
 - o Door het bezit van bepaalde assets?
 - o Informatie(a-)symmetrie?
 - o Zo ja, leidt dit tot strategisch gedrag/opportunisme?
6. Werkt men in de bunkermarkt vooral met langetermijncontracten of juist korttermijncontracten (bv. levering/opslag)?
 - Gaat het daarbij puur om het afdekken van risico's?
7. Welke factoren zijn volgens u belangrijke drivers van de markt als u verder kijkt dan prijsvorming?
8. Zou u zeggen dat de bunkermarkt een push-markt is of een pull-markt? D.w.z. of de markt wordt bepaald door de aanbodkant (raffinagesector) of door de vraagkant (rederijen)?
9. Wat is in het verleden de invloed geweest van ontwikkelingen binnen de raffinagesector op het functioneren van de bunkermarkt?

Oplossingen:

10. Welke rol ziet u weggelegd voor de raffinagesector bij het terugdringen van de maritieme zwavelemissies?
 - Moet er meer stookolie met een laag zwavelgehalte worden geproduceerd (of juist meer schone distillaten) of moet de consument (rederijen) zelf zorgen dat ze aan de eisen voldoen (overgaan op LNG of gebruik scrubbers)?
 - In welk alternatief/welke alternatieven zou(den) ziet u de beste oplossing voor de komende jaren?

11. Welke problemen voorziet u omtrent compliance? Gaat het alle partijen lukken om aan de emissie-eisen te voldoen vanaf 2015?
12. Verwacht u veel samenwerking tussen marktpartijen of juist individueel gedrag bij het oplossen van de 'emissieproblemen'?

Externe ontwikkelingen:

13. Bent u op de hoogte van de recente ontwikkelingen rondom het belastingregime op de export van olieproducten van Rusland?
 - Wat ziet u als de belangrijkste gevolgen van die verhoogde exportbelastingen op stookolie voor de bunkermarkt?
 - Weet u nog andere ontwikkelingen op (geo)politiek gebied in de wereld die van invloed kunnen zijn op de werking van de bunkermarkt?
14. Ziet u culturele of politieke verschillen tussen landen (binnen en buiten de EU) die van invloed kunnen zijn op het voldoende invoeren en naleven van de emissieregels?
 - Bijvoorbeeld dat (NW-)Europa vaak voorop wil lopen als het om het milieu gaat
 - China voelt waarschijnlijk weinig voor de invoering mogelijke SECA's (suggestie)
15. Zijn er nog andere onzekere factoren (uncertainties) voor de komende jaren die van belang zijn voor/bij het ontwikkelen van scenario's voor de bunkermarkt?

Cees de Keijzer
March 8, 2012

IMO, MARPOL Annex VI:

1. Bent u bekend met de huidige en voorgestelde regelgeving rondom zwaveluitstoot in de maritieme sector?
2. Ziet u naast de zwavelrichtlijnen, ook andere emissierichtlijnen die van invloed zijn op de (stookolie-) bunkermarkt en, zo ja, hoe zal de markt daardoor worden beïnvloed?
3. Op welke sectoren weegt de nieuwe regelgeving het zwaarst? Raffinagesector of scheepvaartsector?
 - Wereldwijd t.o.v. Europa

Marktanalyse (structuur van de markt):

4. Is de bunkermarkt een open of een gesloten markt?
 - Hoe transparant is de markt?
 - Welke delen van de stookoliemarkt zijn meer/minder transparant dan andere?
5. Hoe verloopt de waardeketen van stookolie, van raffinage tot consumptie?
6. Wie ziet u als de belangrijkste spelers in de bunkermarkt/shapers van het speelveld?
 - Denk hierbij aan de hele supply chain
 - Hebben bepaalde bedrijven sterkere onderhandelingsposities? (enige vorm van marktmacht)
 - o Door het bezit van bepaalde assets?
 - o Informatie(a-)symmetrie?
 - o Zo ja, leidt dit tot strategisch gedrag/opportunisme?
7. Werkt men in de bunkermarkt vooral met lange-termijn contracten of juist korte-termijn contracten (bv. levering/opslag)?
 - Tussen raffinaderijen, traders, opslag, rederijen?
 - Gaat het daarbij puur om het afdekken van risico's?
8. Welke factoren zijn volgens u belangrijke drivers van de markt als u verder kijkt dan prijsvorming?
9. Zou u zeggen dat de bunkermarkt een push-markt is of een pull-markt? D.w.z. of de markt wordt bepaald door de aanbodkant (raffinagesector) of door de vraagkant (rederijen)?

Oplossingen:

10. Welke acties moet de consument (rederijen) nemen om te voldoen aan de richtlijnen?
 - In welk alternatief/welke alternatieven ziet u de beste oplossing voor de komende jaren?
11. Welke rol ziet u weggelegd voor de raffinagesector bij het terugdringen van de maritieme zwavelemissies?
12. Welke problemen voorziet u omtrent compliance? Gaat het alle partijen lukken om aan de emissie-eisen te voldoen vanaf 2015?
13. Verwacht u veel samenwerking tussen marktpartijen of juist individueel gedrag bij het oplossen van de 'emissieproblemen'?

Externe ontwikkelingen:

14. Bent u op de hoogte van de recente ontwikkelingen rondom het belastingregime op de export van olieproducten van Rusland?

- Wat ziet u als de belangrijkste gevolgen van die verhoogde exportbelastingen op stookolie voor de bunkermarkt?
 - Weet u nog andere ontwikkelingen op (geo)politiek gebied in de wereld die van invloed kunnen zijn op de werking van de bunkermarkt?
15. Ziet u culturele of politieke verschillen tussen landen (binnen en buiten de EU) die van invloed kunnen zijn op het voldoende invoeren en naleven van de emissieregels?
- Bijvoorbeeld dat (NW-)Europa vaak voorop wil lopen als het om het milieu gaat
 - China voelt waarschijnlijk weinig voor de invoering mogelijke SECA's (suggestie)
16. Zijn er nog andere onzekere factoren ('uncertainties') voor de komende jaren die van belang zijn voor/bij het ontwikkelen van scenario's voor de bunkermarkt?

Inspectie Leefomgeving en Transport
March 19, 2012

Meindert Vink

MARPOL Annex VI:

1. Wat is de actuele status rondom de doorvoering van Annex VI in Europese en Nederlandse regelgeving?
 - Doorvoering in wetgeving
 - Tegenstand (lobby's)
2. Welke gebieden denkt u dat voor 2025 ook zullen worden aangewezen als SECA?
3. Ziet u naast de zwavelrichtlijnen, ook andere emissierichtlijnen die van invloed zijn op de bunkermarkt en, zo ja, hoe zal de markt daardoor worden beïnvloed?
4. a) Hoe ziet de inspectie van schepen er nu uit als het gaat om de kwaliteit van de gebruikte brandstoffen?
b) Wat staat er in de (voorgestelde) wetgeving (IMO en EU) over de inspectie en controle van zwavelgehalten in brandstoffen voor schepen?
 - Hoe moet dit gebeuren als een schip de haven in vaart?
 - Hoe vaak moet het plaatsvinden?
 - Wat zijn de sancties voor het niet naleven van de geldende zwavelnormen?
 - Hoe is de inspectie organisatorisch geregeld?
5. Zijn er veel kosten gemoeid met het de strengere zwavelnormen?
 - De inspectie (handhaving) – mankracht/administratie/communicatie
 - Eventuele sancties opleggen (juridische kosten)
6. Wat zijn uw verwachtingen omtrent de ontwikkelingen van de inspectie (korte/lange termijn)?
 - SECA landen en niet-SECA landen binnen EU
 - Andere continenten (Amerika vs. Azië etc.)
 - Zullen de inspectiediensten van alle landen ervoor zorgen dat er ook daadwerkelijk werk wordt gemaakt – door rederijen en/of raffinaderijen – van de opgelegde regels?
7. In hoeverre vormt de regelgeving en de mate van handhaving van de regels een mate van onzekerheid voor rederijen?
16. Wat zijn volgens u andere onzekere factoren die van invloed zijn in de scenario's voor de bunkermarkt voor stookolie?

Annex B: Glossary of Terms and Abbreviations

The definitions of terms and abbreviations on this page are meant as a guideline to help understand some of the terminology used in this study.⁵⁰

<i>Bunker fuel</i>	Fuel used for the propulsion of ships
<i>CO₂</i>	Carbon dioxide
<i>cSt</i>	Centistokes is a measure of viscosity
<i>ECA</i>	Emission Control Area. An area where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce and control air pollution from SO _x (and particulate matter) and/or NO _x .
<i>EEDI</i>	Energy Efficiency Design Index. It requires a minimum energy efficiency level for new ships; by stimulating continued technical development of all the components influencing the fuel efficiency of a ship; and by separating the technical and design-based measures from the operational and commercial ones
<i>Fuel Oil</i>	The heaviest commercial fuel that can be obtained from crude oil that is burned in a furnace or boiler for the generation of heat or used in an engine for the generation of power
<i>GHG</i>	Greenhouse gas
<i>HSFO</i>	High sulphur fuel oil with > 1.5 wt % sulphur content
<i>IFO180</i>	Intermediate Fuel Oil 180 cSt
<i>IFO380</i>	Intermediate Fuel Oil 380 cSt
<i>IMO</i>	International Maritime Organisation is the United Nations specialised agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships
<i>IOC</i>	Independent oil company is a non-integrated company in the exploration and production segment of the industry, with no downstream marketing or refining within their operations
<i>LSFO</i>	Low sulphur fuel oil with < 1.5 wt % sulphur content
<i>MARPOL 73/78</i>	International Convention for the Prevention of Pollution from Ships
<i>MARPOL Annex VI</i>	Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances
<i>MEPC</i>	The Marine Environment Protection Committee, a subcommittee of the IMO, is empowered to consider any matter within the scope of the Organization concerned with prevention and control of pollution from ships. In particular it is concerned with the adoption and amendment of

⁵⁰ This glossary is composed of information extracted from organisations' websites and online dictionaries and encyclopaedias, such as Wikipedia.org

	conventions and other regulations and measures to ensure their enforcement.
MDO	Marine diesel oil is a type of fuel oil and is a blend of gasoil and heavy fuel oil used for ship propulsion
MGO	Marine gasoil is a light and 'clean' distillate fuel similar to diesel for road transport.
NCE	Neoclassical Economics is an approach to economics, which focuses on the determination of prices, outputs and income distributions in markets through supply and demand, often mediated through a hypothesized maximization of profits by firms employing available information and factors of production, in accordance with rational choice theory
NIE	New Institutional Economics is an economic perspective that attempts to extend neoclassical economics by focusing on the social and legal norms and rules that underlie economic activity
NOC	National oil company is an oil company fully or in the majority owned by a national government
NO_x	Nitrogen oxides is a generic term for mono-nitrogen oxides NO and NO ₂ (nitric oxide and nitrogen dioxide). They are produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures
OECD	Organization for Economic Co-operation and Development is an international economic organisation of 34 (mostly high-income) countries to promote policies that will improve the economic and social well-being of people around the world
OIE	The Old (or Original) Institutional Economics focuses on understanding the role of the evolutionary process and the role of institutions in shaping economic behaviour
PM	Particulate matter or particulates are tiny pieces of solid or liquid matter associated within the atmosphere. They are often oxidations of SO _x and NO _x and can adversely affect human health and also have impacts on climate and precipitation
PSC	Port State Control is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules
SO_x	Sulphur oxides refers to all sulphur oxides, the two major ones being sulphur dioxide (SO ₂) and sulphur trioxide (SO ₃) formed by combusting sulphur containing fuels, causing damage to the environment in the form of acid rain
TCE	Transaction Cost Economics is part of NIE and it addresses questions about why firms exist in the first place (i.e., to minimize transaction costs), how firms define their boundaries, and how they ought to govern operation

Annex C: The bunker market, its history and numbers

This Annex provides additional information on the history of bunkering and emphasises the important role fuel oil has played in the international maritime transport sector in the past century. Some numbers of the bunker market will subsequently also reflect this important role.

Historic background

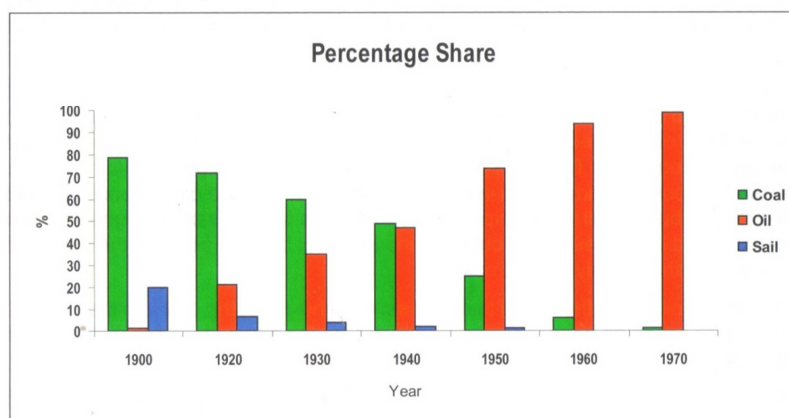
This short description of the historic background of bunkering is based on those made by Draffin (2008) and the EC (2002). The term 'bunker' as a name for the fuel used to power ships, stems from the compartments in ships that were originally used to store coal, which was the first fuel used aboard ships. These compartments were called bunkers, the same name that was given to storage facilities on land. The content of the compartments, which was the coal, were called 'bunkers'. Steam propelled ships made up the majority of merchant and naval vessels in the late nineteenth century and taking on coal (or any type of fuel later on) at the cargo loading and discharging ports was referred to as 'bunkering'.

In the beginning of the twentieth century the transport of oil led to the use of the oil itself as a fuel for transport. The transport between oil fields in Mexico and the USA was done by means of both the railway and ships. Railway locomotives started using fuel oil and oil tankers followed not long after that. The use of fuel had advantage above coal in terms of labour costs (stokers were no longer needed to shovel coal), cargo space and fuel efficiency.

Sir Marcus Samuel, founder of Shell, did business in oil transport and refining and produced mostly gasoline and kerosene. However, he was left with large quantities of fuel oil at various locations and needed to create demand for it. When the British Royal Navy saw the potential of oil fuel, they gave a contract to BP and Shell to establish fuel depots for the warships in World War I, situated in the same locations as the coal depots. Other navies followed and a worldwide network of oil 'bunkering' stations emerged. After the WWI, the stations were increasingly used by merchant ships, giving them the opportunity to sail greater distances, allowing also for smaller crews and creating greater efficiency. The majority of the bunkering stations was owned by we now call the Oil Majors. The switch by merchant shippers to oil fuel went very quickly, which meant that by 1940 almost half of the worldwide fleet was oil fired (see Figure C-C-1).

By 2000 only 12 commercial coal fired ships were in service worldwide. The use of fuel oil for bunkering purposes has thus become the standard for fuelling merchant ships. This happened over the course of an entire century and this stresses the embeddedness of fuel oil in the international maritime transport sector.

Figure C-1 The change from coal to oil



Source: (Draffin, 2008)

Some numbers

To get an idea of its magnitude, we take a look at some figures of the bunker market. These figures are not used for exact analyses or conclusions in this study, but are provided to get a feeling of the market size.

- The entire production of refined oil products is approximately 4250 million tons (mt) in 2011 or on average 85 million barrels per day (mbd) (MathPro, 2011)
- Of this total amount of refined products, the total market share for fuel oil is estimated at 550-650 mt or 11-13 mbd (IEA, 2010; Abadie, Moehler et al., 2011)
- Not all fuel oil is product to serve as bunker fuel. About 190-240 mt or 4-5 mbd of the fuel oil market is made up of bunker fuels (Meech, 2010; Abadie, Moehler et al., 2011; Mazraati, 2011), but some estimates are much lower: 150 mt or 3 bd.
- Total production of middle distillate refining products is about 35% of total oil product production, i.e. approximately 1500 mt or 30 mbd. Only small share, though, is accounted for by marine demand, which is 40-50 mt or 1 mbd.⁵¹ (Meech, 2010; Abadie, Moehler et al., 2011; MET, 2011)
- The total bunker fuel demand thus ranges between 235 mt and 330 mt.
- The bunker market has been growing on average almost 4% a year since 1995 (Pervin & Gertz, 2010)
- Total amount of individual bunker deliveries per annum is in the order of 100.000 (Buck, Smit et al., 2011)

Table C-1 Supply and demand ⁵²

	Million tons per annum (mtpa)	Million barrels per day (mbd)	Growth in %/yr	# of bunker deliveries
Refined products output	4250	85	*	*
Fuel oil demand	550-650	11-13	*	*
Fuel oil bunker demand	190-240	4-5	*	*
Middle distillate demand	1500	30	*	*
MDO/MGO demand	40-50	1	*	*
Bunker fuel demand	230-290	4.5-6	*	*
Bunker fuel demand growth (1995-2010)	*	*	4	*
Bunker deliveries	*	*	*	100.000

The growth rate of bunker demand is an average of the period 1995-2010. But the last three years, the bunker industry faced a decline in demand due to the global economic downturn. It is not unthinkable that the coming years demand is to grow slightly slower than the period mentioned.

⁵¹ When considering middle distillate bunkers, almost half of the demand is accountable to fishing vessels, offshore vessels and other small vessel. These do not fit very well in this study, as the focus lies on changes in the fuel oil consumption due to environmental policy by the IMO. So it thus concerns large oceangoing vessels like tankers, dry bulk carriers, general cargo and container ships as well as Ro-Ro ships (roll-on-roll-off ships transporting rolling vehicles). In this part of the market, the distillate demand is around 40-50 mt instead of 90-100 mt, when using the most common estimates. This means a bunker market share of 80-85% for fuel oil and 15-20% for middle distillates.

⁵² As these numbers show, there is some discrepancy between the estimated values for the size of the bunker market and the shares of which are accountable to fuel oil or middle distillates. Mazraati (2011) refers to different studies by EnSys (2009), which shows the total bunker demand being between 2.7 and 5.8 mbd, corresponding with 135-290 mt for the year 2003. These discrepancies can be caused by the research method used. There are many ways of estimating the bunker usage, so one should not attach too much value to just one of these numbers. However, these numbers are exactly those on which many regulators base their studies on. Under- or over-estimation can mislead impacts of international environmental policy (Mazraati, 2011).

Annex D: Fuel types – properties

Fuel types

Distillates and/or residual fuel oil stocks are blended with blending components or cutter stocks to achieve internationally accepted product specifications provided by the international standard, ISO 8217 that defines the requirements for fuel grades for use in marine diesel engines. Marine fuel grades carry three letters: the first “D” or “R” specifies “distillate fuel” vs. “residual fuel.” The second “M” signifies “marine fuel” use. The third letter designates the individual grade (EPA, 2008). Distillate marine (DM) fuels have four grades from A, B, X and Z. Residual marine (RM) fuels have 11 grades depicted by letters A, B, D, E, G and K (plus sub-grades). For example, RME-180 stands for “residual marine fuel E at a maximum viscosity (at 100° C) of 180 centistokes. The four most important fuel types are (ISO, 2010):

IFO 380: Specifications generally conform with that for RMG 380. It is a blend of distillate and about 98 per cent residual fuel (Platts, 2010).

IFO 180: Specifications generally conform with that for RME 180. It is a blend of distillate and about 88 per cent residual fuel (Platts, 2010).

Marine Gasoil: Marine gas oil is the result of blending LCO (light cycle oil) with distillate oil to produce one of the highest marine fuel grades and it corresponds to fuel type DMA (but also includes DMX and DMZ). MGO is more expensive because it is a lighter fraction and better quality fuel than diesel fuel. MGO is a fuel best suited for faster-moving engines (Vermeire, 2007).

Marine Diesel: MDO is manufactured by combining kerosene, light, and heavy gas oil fractions. It corresponds with DMB (Vermeire, 2007). MDO is more expensive than the more common intermediate fuel types.

Fuel standards

Marine distillate fuels (ISO, 2010)

Parameter	Unit	Limit	DMX	DMA	DMZ	DMB
Viscosity at 40°C	mm ² /s	Max	5.500	6.000	6.000	11.00
Viscosity at 40°C	mm ² /s	Min	1.400	2.000	3.000	2.000
Micro Carbon Residue at 10% Residue	% m/m	Max	0.30	0.30	0.30	-
Density at 15°C	kg/m ³	Max	-	890.0	890.0	900.0
Micro Carbon Residue	% m/m	Max	-	-	-	0.30
Sulphur ^a	% m/m	Max	1.00	1.50	1.50	2.00
Water	% V/V	Max	-	-	-	0.30 ^b
Total sediment by hot filtration	% m/m	Max	-	-	-	0.10 ^b
Ash	% m/m	Max	0.010	0.010	0.010	0.010
Flash point	0°C	Min	43.0	60.0	60.0	60.0
Pour point, Summer	0°C	Max	-	0	0	6
Pour point, Winter	°C	Max	-	-6	-6	0
Cloud point	°C	Max	-16	-	-	-
Calculated Cetane Index		Min	45	40	40	35
Acid Number	mgKOH/g	Max	0.5	0.5	0.5	0.5
Oxidation stability	g/m ³	Max	25	25	25	25 ^c
Lubricity, corrected wear scar diameter (wsd 1.4 at 60°C ^d	um	Max	520	520	520	520 ^c
Hydrogen sulphide ^e	mg/kg	Max	2.00	2.00	2.00	2.00
Appearance			Clear & Bright ^f			^{b, c}
^a	A sulphur limit of 1.00% m/m applies in the Emission Control Areas designated by the International Maritime Organization. As there may be local variations, the purchaser shall define the maximum sulphur content according to the relevant statutory requirements, notwithstanding the limits given in this table.					
^b	If the sample is not clear and bright, total sediment by hot filtration and water test shall be required.					
^c	Oxidation stability and lubricity tests are not applicable if the sample is not clear and bright.					
^d	Applicable if sulphur is less than 0.050% m/m.					
^e	Effective only from 1 July 2012.					
^f	If the sample is dyed and not transparent, water test shall be required. The water content shall not exceed 200 mg/kg (0.02% m/m).					

Marine residual fuels (ISO, 2010)

Parameter	Unit	Limit	RMA ^a	RMB	RMD	RME	RMG				RMK		
			10	30	80	180	180	380	500	700	380	500	700
Viscosity at 50°C	mm²/s	Max	10.00	30.00	80.00	180.0	180.0	380.0	500.0	700.0	380.0	500.0	700.0
Density at 15°C	kg/m³	Max	920.0	960.0	975.0	991.0	991.0				1010.0		
Micro Carbon Residue	% m/m	Max	2.50	10.00	14.00	15.00	18.00				20.00		
Aluminium + Silicon	mg/kg	Max	25	40		50	60						
Sodium	mg/kg	Max	50	100		50	100						
Ash	% m/m	Max	0.040	0.070			0.100				0.150		
Vanadium	mg/kg	Max	50	150			350				450		
CCAI	-	Max	850	860			870						
Water	% V/V	Max	0.30	0.50									
Pour point (upper) ^b , Summer	°C	Max	6		30								
Pour point (upper) ^b , Winter	°C	Max	0		30								
Flash point	°C	Min	60.0										
Sulphur ^c	% m/m	Max	Statutory requirements										
Total Sediment, aged	% m/m	Max	0.10										
Acid Number ^e	mgKOH/g	Max	2.5										
Used lubricating oils (ULO): Calcium and Zinc; or Calcium and Phosphorus	mg/kg	-	The fuel shall be free from ULO, and shall be considered to contain ULO when either one of the following conditions is met: Calcium > 30 and zinc >15; or Calcium > 30 and phosphorus > 15.										
Hydrogen sulphide ^d	mg/kg	Max	2.00										
^a	This residual marine fuel grade is formerly DMC distillate under ISO 8217:2005.												
^b	Purchasers shall ensure that this pour point is suitable for the equipment on board, especially in cold climates.												
^c	The purchaser shall define the maximum sulphur content according to the relevant statutory requirements.												
^d	Effective only from 1 July 2012.												
^e	Strong acids are not acceptable, even at levels not detectable by the standard test methods for SAN. As acid numbers below the values stated in the table do not guarantee that the fuels are free from problems associated with the presence of acidic compounds, it is the responsibility of the supplier and the purchaser to agree upon an acceptable acid number.												

Annex E: History of Vopak

History

In 1616 the first foundations were laid down for the company we now known as Vopak. The company provided storage and logistic services to the Dutch East Indies Company. The products were predominantly coffee, tea and spices and were stored and distributed inland. The first barrels of oil were stored in 1862, following discoveries and production in the United States. This oil was imported into Europe, where its role as fuel increased in significance. In the Port of Rotterdam the first oil storage facility was built. The first oil tanker was unloaded at these facilities in 1888. After a series of mergers, the company Pakhoed was formed (the “pak” in Vopak). The other part of the company's current name originates from the company Van Ommeren, which had been involved in oil storage since the beginning of the twentieth century. Van Ommeren had built several oil terminals, the largest being in the United States and the Netherlands. These two companies, Van Ommeren and Pakhoed, with a firm position in the tank storage, shipping and distribution sectors started focusing their business to several core activities in the late twentieth century. Pakhoed was specialised in chemical distribution, logistics and tank storage, while Van Ommeren focused on oil storage and seagoing transport. In 1999 the two firms merged and formed Vopak.

Annex F: Development of maritime sulphur legislation

The IMO

This organisation, which was initially named the Inter-Governmental Maritime Consultative Organisation (IMCO) when it was set up in 1948 as a United Nations (UN) advisory and consultative agency for international shipping. While the functions of the IMO initially primarily focused on safety issues (hence the International Convention for the safety of life at sea, in short the SOLAS Convention), with the adoption of the MARPOL Convention in 1973 the pollution issues also became a focus of attention. The organisation's name was changed in 1975 to the IMO (IMO, 2012d). The agency was set up because in the years after the Second World War, every shipping nation had its own maritime law. There was a lack of international treaties and collective rules, requirements or standards were not in place that dealt with maritime safety, environmental issues and associated legal issues and technical cooperation. This led to considerable variation of these requirements and standards, even contradicting in many cases. The assembly of the IMO and the ratified conventions have made cross-border standard setting more common practice. The importance is stressed by the "accepted fact that regulations can be effective and fair only if undertaken by reference to well considered and generally agreed international standards and regulations applicable uniformly to all ships and all shipping operations, regardless of where they may take place" (Schröder and Hebbbar, 2007). The IMO treaties thus "apply uniformly to ships of different flags, without any differentiation between developed and developing countries" (Bodansky, 2011).

Currently, the IMO has 170 Member states and three Associate Members, encompassing over 98% of the world fleet. So, in fact, every nation with considerable interests in international shipping is represented in the Assembly of the IMO. Besides Member States there are also other organisations involved with the IMO. To date, there are 78 non-governmental organisations affiliated with the IMO and have a consultative status. Also 63 intergovernmental organisations cooperate with the IMO. Their role concerns matters of common interest "with a view to ensuring maximum coordination in respect of such matters" (IMO, 2012f).

The committee responsible for environmental affairs within the IMO is the *Marine Environment Protection Committee* (MEPC) and it plays a central role in the IMO rules on pollution. It started out as the *Sub-Committee on Oil Pollution* of the *Marine Safety Committee* (MSC) in 1965 and was charged with assisting in oil pollution matters. A major oil spill of the Torrey Canyon near the coast of England in 1967 appeared to be critical in shaping the efforts by the IMCO to combating pollution from ships. It led to the establishment of an official committee for environmental matters, the MEPC, in 1973. In this form environmental issues were dealt with more efficiently than as a sub-committee of the MSC. The main task for the MEPC is to design new conventions to be ratified as well as amending the existing conventions.

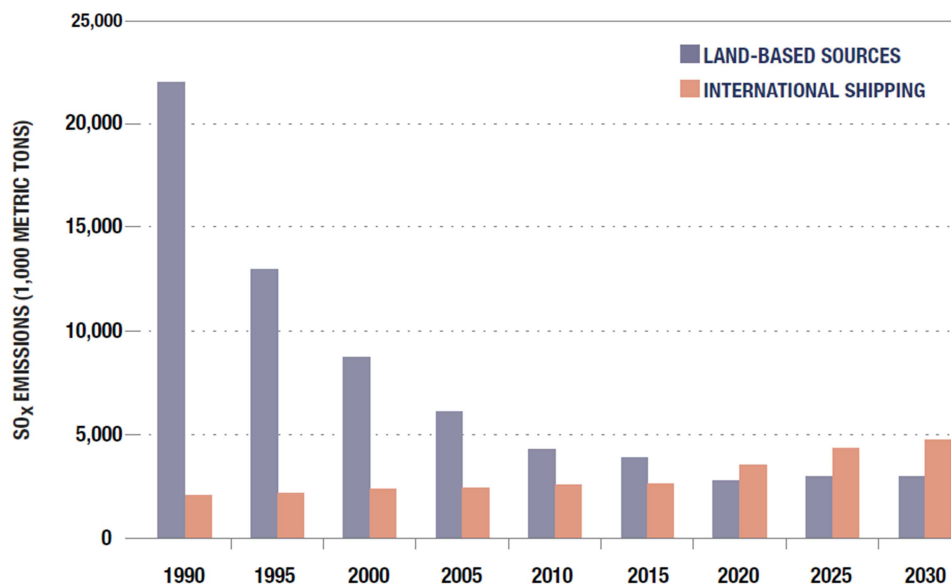
Growing awareness towards air pollution

In the lead up to the adoption of the MARPOL Convention, which ended up being the guideline for marine air pollution, the emission of harmful gases from ship's exhausts had been discussed, but at the time it was decided not to include any regulations on air pollution (IMO, 2012d). In other areas air pollution did become an important topic. In 1972, the United Nations held a Conference on the Human Environment, which led to the first international cooperation in fighting acid rain. The next five years, studies starting shows results that air pollution could travel thousands of kilometres before deposition and any possible damage to crops or forests as a consequence (IMO, 2011). As described earlier, acid rain is caused by particles of sulphur oxide in the air (but also by nitrogen oxides), which dissolve in the water in the air. The largest sources of sulphur oxides are power plants running on coal and oil, whereas nitrogen oxides mostly originate from transportation, i.e. from the exhausts of cars, truck and ships. The first internationally binding instrument dealing with cross-border air pollution issues, was the Convention on Long-range Transboundary Air Pollution, which was signed in Geneva in 1979 by 34 governments plus the European Community (IMO, 2011). This Convention has been expanded with protocols on reducing

specific emissions, and those aimed at regulating land-based sulphur emissions were signed in 1985 en 1994 (stricter reductions) (IMO, 2011).

High-sulphur content fuels used on land were increasingly controlled, due to the establishment of international agreements, leaving these fuels to be sold for shipping. The first questions on the contribution of shipping to the global sulphur emissions, and thus acid rain, were asked in the 1980's (Okamura, 1995; Tan, 2006). When reviewing Annex I in the mid-1980's in relation with fuel discharging issues, the quality of fuel oil in came onto the agenda. At the same the countries around the North Sea (CONSSO, 2002) and later the Baltic Sea (Schröder and Hebbar, 2007) became increasingly concerned with the air pollution caused by ships. They started their own reviews of the effects of marine pollution and sulphur content of fuels was discussed. By 1988, the MEPC decided to include air pollution in their agenda. The development of European SO_x emissions from land-based and international shipping sources is presented in the figure below.

Figure F-2 Past/future SO_x Emissions in Europe from land-based and international shipping sources



Source: (EC, 2005a; Freidrich, Falk et al., 2007)

Annex G: Refining

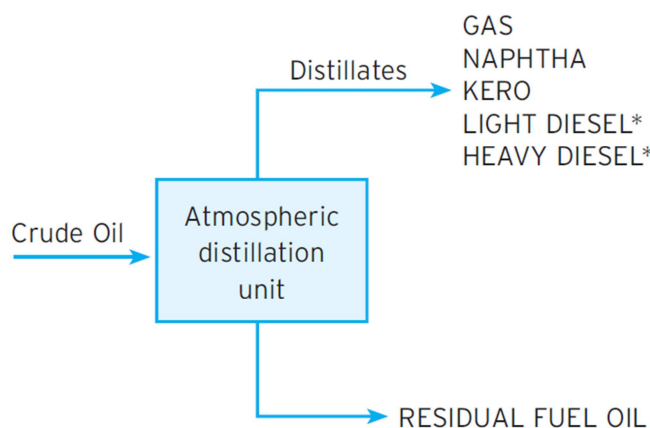
The process

We will not go into too much detail here about the specific refining processes, but a distinction is made here between straight-run refineries and complex refineries. This is because the type of refining process determines the quality or contamination of the fuel oil. The specific quality of the fuel oil is becoming increasingly important towards the more stringent sulphur regulations.

Straight-run refineries

Straight-run refineries are relatively simple refineries, as they solely comprises of one major process: atmospheric distillation. In an atmospheric distillation unit the crude oil is heated and separated into different product streams according to specific boiling ranges of the products, see Figure G-1. These streams – also named crude fractions - have specific unique boiling point ranges and consist of many distinct compounds of hydrocarbons (MathPro, 2011). Most older refineries are of this type and have a heavy fuel yield of around 50%. Because the demand in most industrialised countries does not correspond with this output and focuses increasingly on lighter products (gasoline, diesel, kerosene) modern refineries are, many refineries are being upgraded to further process the product stream. The conversion of these streams leads to a higher yield of lighter, more valuable products. This happens in a complex refinery.

Figure G-1 Atmospheric distillation



Source: (Vermeire, 2007)

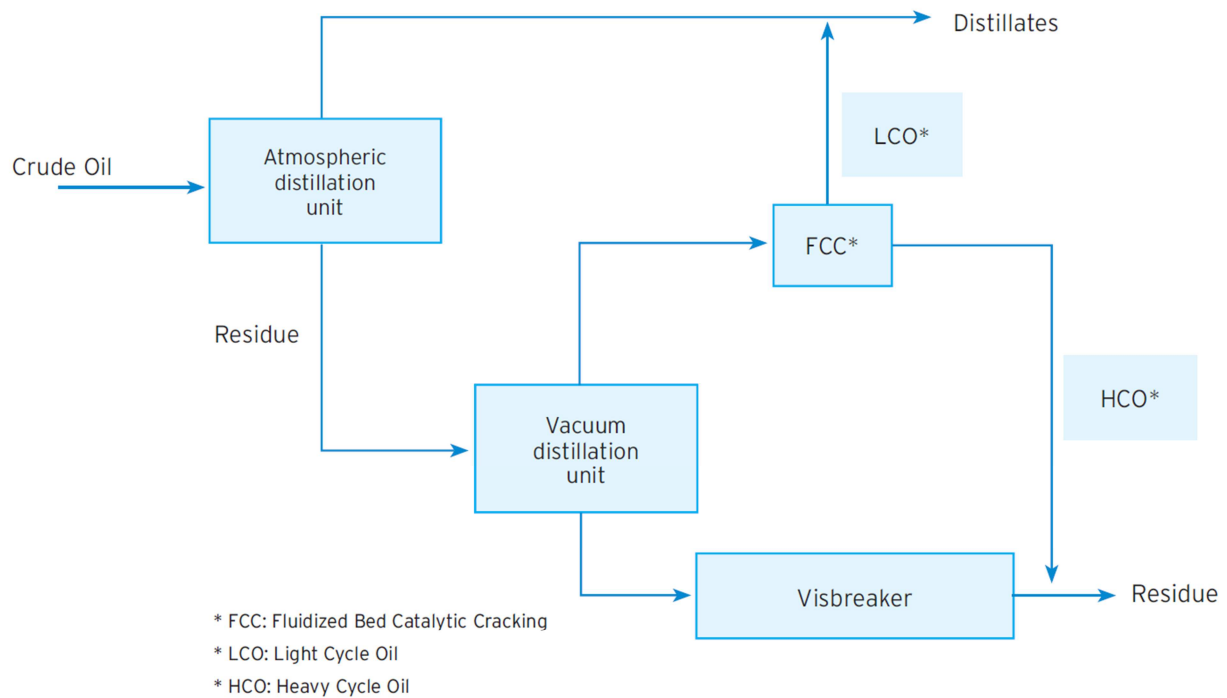
Complex refineries

Complex refineries (see Figure G-2) thus consist of the same front end process as a straight-run refinery: the atmospheric (or vacuum) distillation unit. What makes them complex are the conversion units using catalytic cracking or thermal cracking. Since the 1980's this type of refinery has been favoured. The rising demand for gasoline was one of the major causes of this. A complex refinery is roughly divided in two sections, the first being the distillation unit, the second the conversion of streams through catalytic and thermal cracking.⁵³ Cracking means fracturing large hydrocarbons into smaller molecules, suitable for a wide range of transportation fuels.

⁵³ Catalytic cracking is mostly done by Fluidised Bed Catalytic Crackers (FCC's), while thermal cracking is usually done in the "visbreaker".

Catalytic cracking uses catalysts of aluminium silicate and these can leave residues in the lower product streams (called “cat fines”), which affects the quality of the fuel oil. During thermal cracking, molecules are broken thermally, which can affect the molecular structure of the residue. Because more light products are extracted from the residues, the sulphur contents, but also that of metals and other harmful substances like asphaltenes, are 3 to 3.5 times higher than in atmospheric residue (Vermeire, 2007).

Figure G-2 Example configuration of a complex refinery



Source: (Vermeire, 2007)

So we can conclude that the refining configuration definitely has an influence on the quality of the residual fuel oil. These quality differences in fuel oil can affect the performance of the marine engines. For most distillates, the differences (mostly regarding density) do not prove to be that big of an influence on engine performance, except for the lower end of the distillates coming from the FCC, which is of lower quality and can contain amounts of cat fines.

Fuel oil is thus just one of the oil products that leave oil refineries. There are many types of configurations a refinery can have. The configuration and performance of a refinery depends on many factors, including its location, available crude oil qualities, investment capacity, age, local or export demand, product quality requirements and safety and environmental regulations. These factors are explained in this paragraph and their interdependence of these factors with the actual physical design of refineries will get sufficient attention.

Globally, there are more than 660 refineries in 116 countries producing more than 85 mbd of oil products or 4250 mt (MathPro, 2011). Fuel oil makes up around 12 mbd (640 mt) of this amount, with almost 5 mbd (240 mt) bound for marine fuel usage. Middle distillates as marine fuel make up around 1 mbd (or 55 mt).

Crude qualities

Figure G-3 °API Gravity and Sulphur Content of important Crude Oils

Crude Oil	Country of Origin	Crude Oil Class	Properties	
			Gravity (°API)	Sulfur (wt.%)
Brent	U.K.	Light Sweet	40.0	0.5
West Texas Intermediate	U.S.A.		39.8	0.3
Arabian Extra Lt. Export	Saudi Arabia	Light Sour	38.1	1.1
Daqing	China	Medium Medium Sour	33.0	0.1
Forcados Export	Nigeria		29.5	0.2
Arabian Light Export	Saudi Arabia	Medium Sour	34.0	1.9
Kuwait Export Blend	Kuwait		30.9	2.5
Marlim Export	Brazil	Heavy Sweet	20.1	0.7
Cano Limon	Colombia		25.2	0.9
Oriente Export	Ecuador	Heavy Sour	25.0	1.4
Maya Heavy Export	Mexico		21.3	3.4

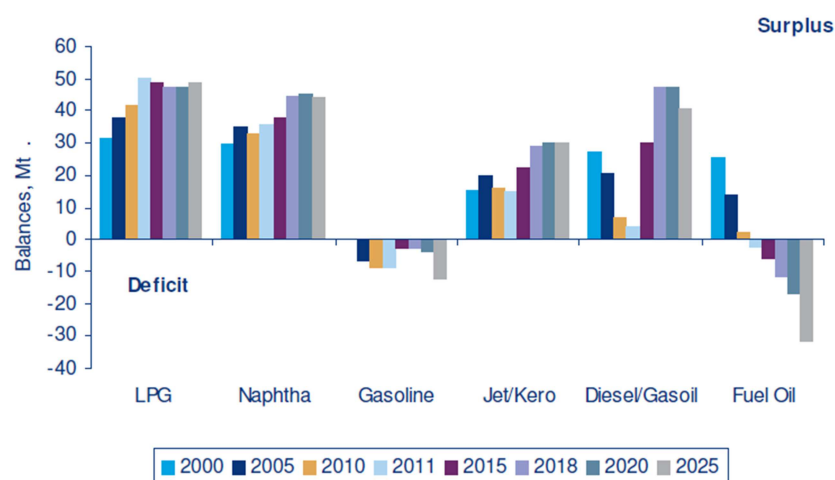
Source: (MathPro, 2011)

Blending

Most common blend materials are MGO, heavy cycle oil (HCO) and light cycle oil (LCO). MGO is a clean, low sulphur, low viscosity fuel, but very costly to blend into lower priced fuel oil. For this reason often HCO and LCO are blended into the fuel. HCO and LCO are streams coming from the catalytic cracker (see Annex for information on complex refineries). HCO has a high density residue, containing considerable amounts of aluminium and silicates (Al and Si) which function as catalysts in the catalytic cracking process. These contaminants are called cat-fines. Although most of these cat-fines are removed, enough remains in the HCO flow to bring potential damage to ship's engines. LCO is gas oil, thus lower in density than HCO. Both HCO and LCO are high in sulphur. It is thus clear that these materials are to be blended in controlled amounts. Residues from complex refineries are not as suitable for bunker fuels as straight-run residual oil, which, with current upgrades of refineries across the world, is a worrisome fact.

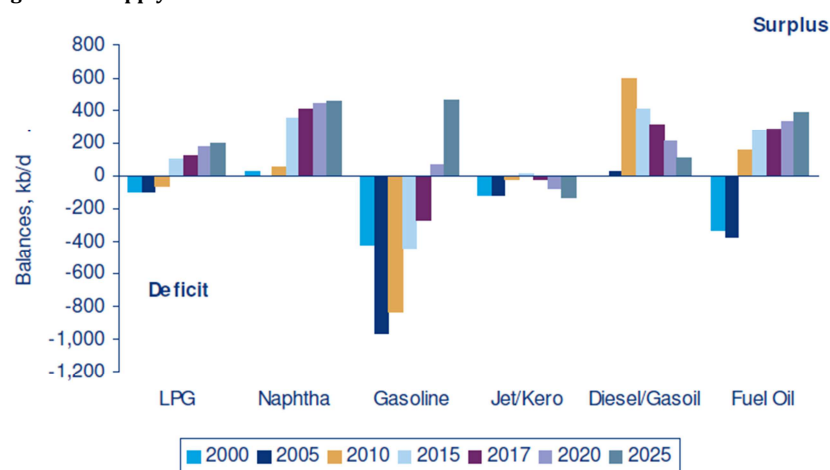
Annex H: Supply and demand balances

Figure H-1 Supply and demand balance for the Middle East



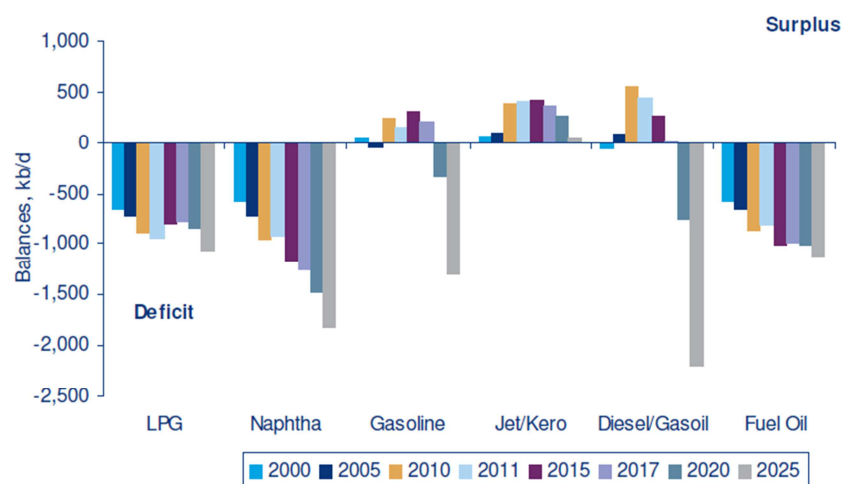
Source: (Wood-Mackenzie, 2012c)

Figure H-2 Supply and demand balance for North America



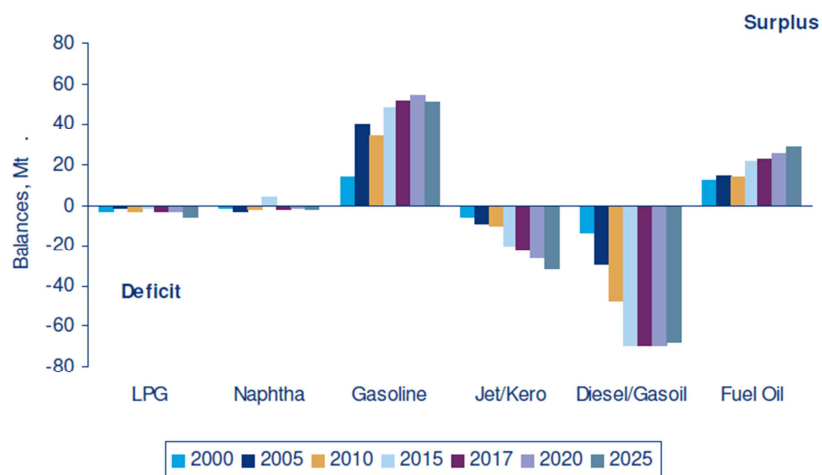
Source: (Wood-Mackenzie, 2011g)

Figure H-3 Supply and demand balance for Asia Pacific



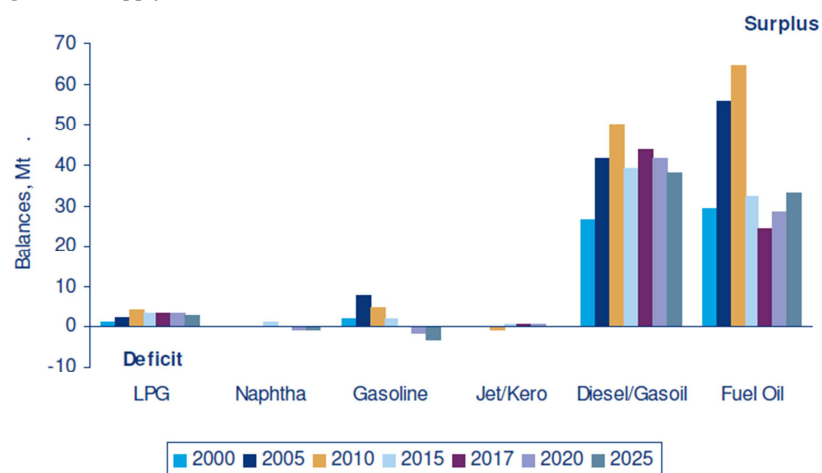
Source: (Wood-Mackenzie, 2012b)

Figure H-4 Supply and demand balance for Greater Europe



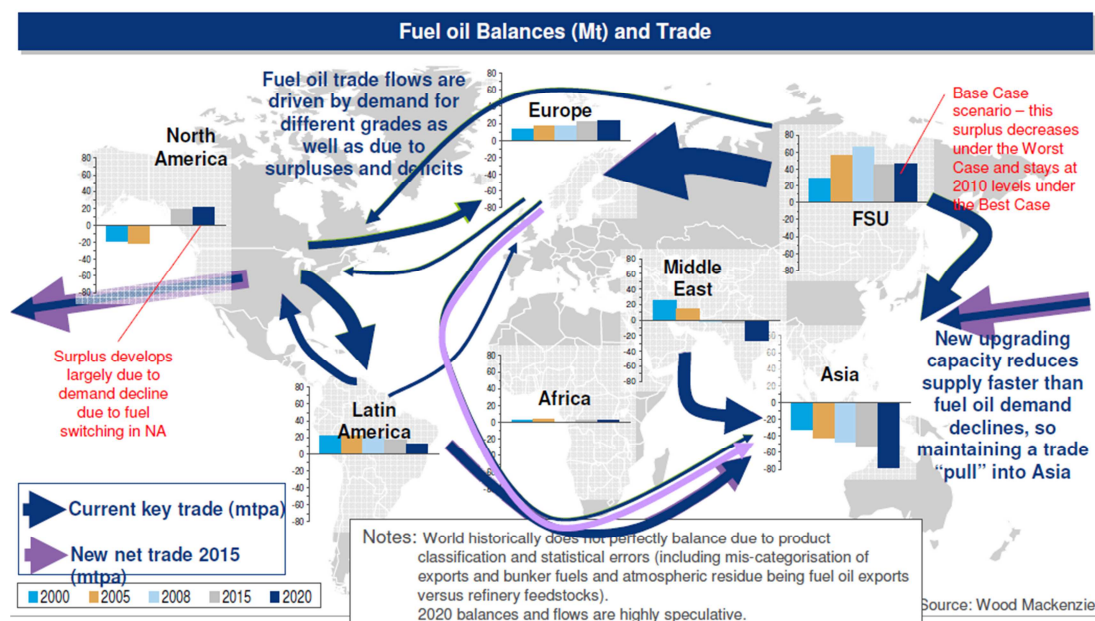
Source: (Wood-Mackenzie, 2011f)

Figure H-5 Supply and demand balance for the Former Soviet Union



Source: (Wood-Mackenzie, 2011e)

Figure H-6 Fuel oil trade flows



Source: (Wood-Mackenzie, 2011b)

Annex I: Bunkering ports

Singapore

On the Strait of Malacca, Singapore is located strategically on one of the busiest trading route in the world. Singapore is home to one of the largest ports (after Shanghai and Ningbo, both in China) in the world in terms of throughput of cargo and the largest when it comes to bunker fuels sales. In 2011 the cargo throughput was 531 million metric tons. Especially dry bulk cargo (containerships) and large volumes of petroleum products pass through this port. The bunker turnover was 43 million tons, steadily increasing from 25 million tons in 2005 (MPA, 2012). From this enormous amount of bunker fuel sold in 2011, more than 80% was heavy fuel oil, the rest being a combination of marine gasoil and marine diesel oil. The majority of bunker fuel sold in the port of Singapore is delivered by bunker tankers, meaning the supplies come from overseas, although this is not the only method of delivery.

Singapore is also one of the major refining centres. Of Singapore's gross domestic product (GDP) this industry accounts for around 5%. The top three refiners produce around 1.4 million barrels per day (mbpd), of which approximately 400.000 bpd is bunker fuel. These refineries are owned by Royal Dutch Shell (Pulau Bukom refinery with a capacity of 500.000 bpd), Exxon Mobil (Jurong Island refinery with a capacity of 605.000 bpd) and the Singapore Refining Company (capacity: 290.000 bpd) (SEDB, 2011). Singapore functions as the oil hub of Asia, with an important share in refining capacity, is home to a large trading market and has a strong logistical network. Because of the large amounts of bunker fuels passing through this port, it has becoming an important pricing centre for these products. Singapore's oil storage capacity is now about 24 million cubic metres, of which 13 million m³ is held by the aforementioned refiners and 11 million m³ by independent storage companies (Kolesnikov-Jessop, 2011; Tankterminals.com, 2012). Many oil companies have their regional headquarters in the port of Singapore, partly because of the oil refining and trading in, but also because of the many upstream activities: Singapore has an extensive rig building industry.

The bunker market is quite diverse as bunker fuels from all over the world are delivered in Singapore's port, with the majority originating in South America and Russia. Singapore is home to many bunker fuel traders, including the major refineries, but also several large and smaller independent traders (such as OW Bunker, Chemoil and Global Energy Trading). These refiners also function as important suppliers to the bunker fuel market and so do most of the independent traders. The traders and suppliers who only perform one of the two activities are mostly the smaller ones.

Rotterdam

Rotterdam is the largest port in Europe and functions as the main bunker hub in the region. Rotterdam has become such an important players due to the production of bunker fuels at its refineries, the depth of the harbour allowing the largest ships to enter the port and its strategic geographical location in North-West Europe. Rotterdam is both located along the busiest shipping lanes in Europe and on the export route from Russia and the Baltic countries, where most of the fuel oil is produced. For this reason bunker fuel can be delivered at a lower price in the ARA region than other major bunkering ports (Wilde, Kroon et al., 2007). As in Singapore, this area has established itself as an important pricing centre for bunker fuel.

Rotterdam had an cargo throughput of 434 million tons in 2011 (Port of Rotterdam, 2012) and a bunker fuel turnover of 12.2 million tons. The majority of the bunker fuel turnover was accountable to fuel oil, of which the bulk was produced in Russia. The depth of the waters in the port of Rotterdam allow Very Large Crude Carriers (VLCC's) and Ultra Large Crude Carriers (ULCC's) to load and discharge large amounts of wet bulk. This is another stimulus for the trade in fuel oil here. This is why more than 50% of the fuel oil is shipped to Singapore yearly (Wilde, Kroon et al., 2007). Until the recent tax changes in Russia, it was far more attractive for Russian oil companies to export oil products to Rotterdam instead of crude oil. While

the large carriers arrive with crudes, large volumes of Russian fuel oil are being transhipped in Rotterdam, filling the empty carriers. Rotterdam thus plays an important role in the export chain of Russian fuel oil (Wilde, Kroon et al., 2007).

Because of tightening refinery margins and increasingly strict environmental regulations, the Rotterdam refineries have been forced to invest in upgrading their facilities to decrease the production of heavy fuel oil. Partly for this reason the imports are large (around 400.000 bpd, (EPA, 2008)). The main refineries are the Pernis refinery (owned by Royal Dutch Shell) with a capacity of approximately 416.000 bpd, the BP refinery with the ability to produce 400.000 bpd, Q8 (owned by the Kuwait Petroleum Company) with a 80.000 bpd capacity and ExxonMobil's Botlek refinery with a capacity of around 200.000 bps. Total refining capacity is around 1.2 million barrels per day.

The bunker traders in the port of Rotterdam are – as in Singapore – both the refiners and the independents. Shell uses most of its Pernis refining capacity for their own clients, whereas the majority of BP's bunker output is bought by independent traders. These parties usually buy their bunkers on the local barge market or import volumes of bunker fuel before storing them in rented or owned storage tanks (some independent have their own storage tanks, e.g. Vitol/VTTI).

Rotterdam has several designated bunkering areas, of which Europoort and Botlek are the most important. The physical supply of bunker fuels is conducted in these areas by small bunkering barges. The fuel in these barges is loaded from large storage facilities (e.g. from Vopak).

Fujairah

In the recent years Fujairah has become the fastest growing bunkering port, and is currently second, behind Singapore. The Fujairah bunker market comprises three port areas, namely the port of Khor Fakkan, Fujairah and Kalba (EPA, 2008). Khor Fakkan is located in the north, Fujairah in the middle. But here, when we mention Fujairah, we mean the entire area. As opposed to some other important Arabian ports, Fujairah is located outside the Strait of Hormuz, the gateway to the Persian Gulf.⁵⁴ Fujairah is located near the Middle Eastern oil production (which accounts for around 20% of global oil production) and of all seaborne oil trade, 35% passes by Fujairah (EPA, 2012). For this reason the most important customers are not, as is the case with Singapore and Rotterdam, containerships, but large crude carriers (VLCC's and ULCC's), which often are anchored offshore waiting for cargo from the Persian Gulf. In 2011, approximately 24 million tons of bunker fuel was sold, double the volume sold in 2002 (EPA, 2008; Adawiah, 2012). Estimates range from 80% to 95% for the share of IFO 380 in this amount. The rest is IFO 180 and MGO. This is due to the high sulphur level in Arabian crudes, and the low availability of cutter stock for blending to IFO 180. MGO is mostly used for this purpose, but as a result the price differential between IFO380 and IFO 180 is relatively high.

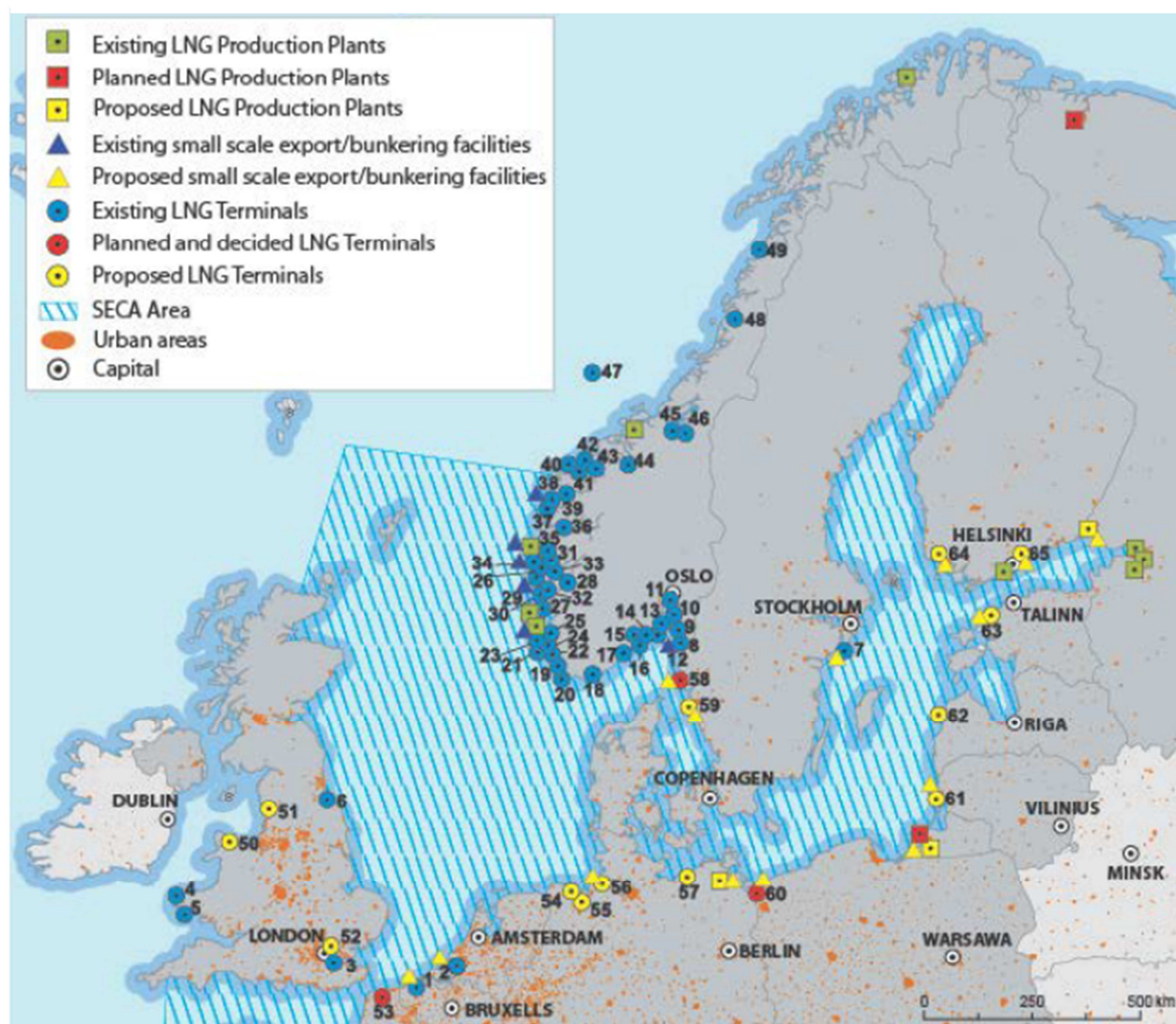
Fujairah is not known for its refining facilities. United Arab Emirates' refining capacity, however, is found near Adu Dhabi and Dubai, and further away the larger refineries around the Persian Gulf are located in Saudi Arabia, Bahrein, Kuwait and Iran. In 2011, the investment decision has been taken to build a 200.000 bpd refinery in Fujairah to be operational in 2016 (Carlisle, 2011). Supplementing Abu Dhabi's pipeline to Fujairah, this refinery can bypass the chokepoint Strait of Hormuz.

Bunkering takes place via bunker barges that load from storage tanks of tankers (i.e. off shore) and supply the passing carriers passing the Fujairah port. The storage capacity of the oil terminal is increasingly rapidly, reaching 6.5 million m³ this year and up to 8 million m³ in 2014. Vopak Horizon is the local market leader with a storage capacity of 2.1 million m³.

⁵⁴ This strait has been in the news early 2012, when Iran threatened to close this passage to Saudi-Arabian and Qatari oil and gas, as a response to global pressure on Iran following its plans for a nuclear programme, resulting in sanctions on Iranian oil. This drove up oil prices, and subsequently fuel oil prices (Hunter and Gienger, 2012).

Annex J: LNG infrastructure

Figure J-1 Existing and planned production plants and LNG terminals in the ECA 's



Source: (Bech, 2011)