UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

The commercial effects of IMO's regulation of the global sulphur cap in 2020

A study on the procurement of deep-sea Ro-Ro at Volvo Cars

Master Thesis in Innovation and Industrial Management
Graduate School
2019-06-09

Authored by Erik Jansson & Jesper Saarinen

Supervised by Sven Lindmark

Abstract

The International Maritime Organization (IMO) has announced a new global sulphur content limit for fuels burnt on ships sailing in global waters. The implementation date for this regulation is on January the 1st, 2020 and entail a maximum sulphur content of 0.5%, in contrast to the current sulphur content limit in global waters of 3.5%. The regulation is expected to induce higher fuel costs for maritime transports on global waters and, thus higher rates for the users of these transports. While higher fuel costs are expected for using fuels with a sulphur content of 0.5%, there are other methods for a carrier to be compliant, which has other implications for the carrier and their customers. Swedish automotive manufacturer Volvo Car Corporation (VCC), being a consistent user of deep-sea Roll on-Roll off (Ro-Ro), can expect commercial implications as their suppliers of deep-sea Ro-Ro experience higher fuel costs. A central part of the relationship between ocean carriers and their customers is the Bunker Adjustment Factor (BAF), a tool used to adjust for fluctuating fuel prices. As fuel prices increase, hence the bunker surcharge, customers tend to put more emphasis on BAF to address transparency in regard to the extent a high surcharge is justified by the increased fuel costs.

The purpose of this study is therefore to analyze the commercial effects of IMO's regulation of the global sulphur content limit in 2020 on VCC procurement of deep-sea Ro-Ro, by investigating cost implications for suppliers of deep-sea Ro-Ro depending on compliance alternative, and consequently implications for VCC. The identified implications are considered in order to formulate recommendations for an adaptation of the currently used BAF model.

In order to obtain the full picture of the focal area, an extensive literature review was performed. In addition, data collection through interviews with people at VCC, their suppliers of Ro-Ro transports as well as with Marine Benchmark and document analysis and secondary analysis was performed.

Findings show that the predominant strategy applied by suppliers of deep-sea Ro-Ro are *compliant fuels*, claiming that the other option of installing a *scrubber* system to clean exhaust gases is not financially viable for the type of vessels used in deep-sea Ro-Ro, however this alternative were considered by a few of the suppliers. Furthermore, there are consensus that there will be repercussions on VCC for the increased fuel costs induced by this regulation, as carriers won't be able to carry these costs themselves.

Three fuel price scenarios based on future demand and availability for the fuels *HSFO*, *VLSFO*, and *ULSFO* were formulated. According to these scenarios, the fuel prices increase, regardless which scenario realized. The deep-sea Ro-Ro services utilized by VCC were investigated in terms of the supplier routes and vessels in the context of the fuel price scenarios to find cost implications. Using compliant fuels showed a fuel cost increase at 36%, 72% & 107%, while a scrubber investment would pay back in 0.3 - 2.1 years. Furthermore, recommended BAF adjustments are to adjust the bunker share on freight rate to 25% - 32%, while also including a figure for share of scrubbers and index prices for compliant fuels in the model.

Keywords: *Deep-Sea Ro-Ro Shipping, VCC, Procurement, IMO's Global Sulphur Content Limit, Sulphur Regulations, Marine Fuels, Bunker Adjustment Factor.*

Acknowledgements

First of all, we would like to thank our supervisor, Sven Lindmark, for guiding us through this master thesis to the best of his knowledge. Despite the subject of our thesis being far from your area of expertise, you managed to provide us with useful insights that helped us proceed in the project.

Further, we would like to thank the people at Volvo Cars for welcoming us and taking their time to participate in interviews and discussions. A special thank you to Martin Dahl, our supervisor at Volvo Cars, who was available whenever we needed guidance or contacts within the organization.

We also want to thank the representatives for the carriers of deep-sea Ro-Ro, who took their time to take part in our interviews, which provided us with vital data for this study. Your participation not only enabled the completion of this study, but also gave the opportunity to meet some of you in person and engage in fruitful discussions on the topic of the research and the challenges that your industry faces.

Finally, our sincere thanks to Börje Berneblad at Marine Benchmark, without whom the completion of this study would have been impossible. We appreciate you sharing your valuable insights on the maritime industry and providing us with the supplementary data crucial for fulfilling the purpose of this thesis.

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Abbreviations

BAF - Bunker Adjustment Factor

CAPEX - Capital Expenditures

CEU - Car Equivalent Unit

ECA - Emission Control Area

HFO - Heavy Fuel Oil

HSFO - High Sulphur Fuel Oil

IDP - Indirect Procurement

IMO - International Maritime Organization

LNG - Liquified Natural Gas

m/m - Mass by Mass

MDO - Marine Diesel Oil

MGO - Marine Gas Oil

OPEX - Operating Expenditures

PCC - Pure Car Carrier

PCTC - Pure Car & Truck Carrier

Ro-Con - Roll on Roll of Container

Ro-Ro - Roll on Roll Off

SECA - Sulphur Emission Control Area

SOx - Sulphur Oxide

ULSFO - Ultra Low Sulphur Fuel Oil

VCC - Volvo Car Corporation

VLSFO - Very Low Sulphur Fuel Oil

Definitions

Bunker - A word commonly used in the maritime industry for the ship fuel

Bunker Adjustment Factor (BAF) - A tool to adjust for fluctuations in ship fuel prices.

Car Equivalent Unit (CEU) - A measure of the cargo carrying capacity of a Ro-Ro vessel.

Carrier - The provider of the ocean transport service.

Deep Sea - The transportation of cargo on longer distances, mainly crossing an ocean by large vessels.

Exhaust Gas Cleaning System/Scrubber - A device used to remove certain particles or gasses from exhaust streams.

Freight - Refers to the actual transportation of cargo, in this case finished vehicles.

Freight rate - The actual rate, or price, paid to transport cargo from one location to another.

HSFO - High Sulphur Fuel Oil, a general term used to describe marine fuels with a sulphur content above 0.5%, including fuels types such as HFO, IFO380 or IFO180.

Indirect Procurement (IDP) - The purchasing of services or goods in order to run the day to day business. Hence, the service or good being purchased is not directly related to the product or service offering.

International Maritime Organization (IMO) - The United Nations Specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.

Mass by mass (m/m) - A ratio of the mass of a specific substance to the total mass.

Roll-on/Roll-off (Ro-Ro) - A vessel usually transporting vehicles, where the vehicles can easily roll on the vessel before departure and roll off the vessel at arrival.

Shipper - In this study “shippers” refers to the customers buying transport services from ocean carriers

Short Sea - The transportation of cargo in short distances along a coast, without crossing an ocean and usually operated by small vessels.

Slow steaming - The practice of operating transoceanic ships at a considerably lower speed than their maximum speed.

Surcharge - A fee added to the original price. Usually to cover up for uncertainties or risk.

ULSFO - Ultra Low Sulphur Fuels, a general term used to describe marine fuels with a sulphur content not exceeding 0.1%, including fuel types such as low sulphur MDO or MGO.

Vessel - During this study, the ships are sometimes referred to as vessels.

Vessel Operator - The provider of the ocean transport service.

VLSFO - Very Low Sulphur Fuels, a general term used to describe marine fuels with a sulphur content between 0.1% and 0.5%.

1. Introduction

The first chapter of the study, the introduction, is divided into three sections. First, the background intends to provide the reader with an introductory description of the context within which the study is focused, as well as a problematization of the issue at hand. The background is followed by a section regarding the purpose and research questions to the study. Lastly, the introduction is finalized with a section presenting the delimitations of the study, in order to clarify the scope of the study.

1.1. Background

Volvo Car Corporation (VCC) is a multinational company with a market presence in over 100 countries and on every continent (Volvo Cars, 2019), making them a frequent user of maritime transports for finished vehicle distribution, consequently inferring significant cost associated with these transports. This commercial aspect on maritime transports is amplified as the implementation date of a new regulation of the ship bunker approaches, which is expected to have severe cost implications for the shipping industry (Liang, 2017) and thereby also for shippers.

The regulation in focus is "IMO's sulphur 2020" - regulating the allowed sulphur content in ship fuel used in global waters (IMO, 2019a). This is one of several actions taken by the International Maritime Organization (IMO) in order to mitigate the rising emissions of SOx in the atmosphere from ships (Raza, Woxenius & Finnsgård, 2019): Under Annex VI of the MARPOL convention, the limits on sulphur content in ship fuel are established. The regulation of the global sulphur cap will be implemented on January 1st in 2020, lowering the previous sulphur content limit at maximum 3.5% m/m and that has been active since 2012, to 0.5% m/m, while even more stringent limits are already implemented since 2015 in the Emission Control Area (ECA) and Sulphur Emission Control Area (SECA), mostly located along coastlines and only allowing a sulphur content of 0.1% (IMO, 2016). This means that vessel operators are forced to use different type of fuels inside and outside the ECA/SECA with different sulphur content, and also, with different prices. A ship fuel with a lower sulphur content cost more to refine and are thus priced higher (Billing, Fitzgibbon & Shankar, 2018), inferring that the lowered sulphur content limit on the global sulphur cap from 3.5% to 0.5% will imply a higher fuel cost in 2020 for all carriers operating voyages in global waters.

The majority of all international traded goods are carried at sea, which covers 80% of the total volume of internationally traded goods (UNCTAD, 2018a) and puts maritime transport in a pivotal role in the global economy (Zis & Psaraftis, 2017). Therefore, with an increase in fuel costs in 2020 for carriers operating in global waters, ripple effects are expected into other industries that are users of such deep-sea transports (Wang, Chen, & Lai, 2011), which includes VCC and their transports of finished vehicles to various markets around the globe. The type of vessel used differ depending on the cargo being transported and the demand from the shipper (Stopford, 2009), evidently, in the case of VCCs distribution of finished vehicles on deep-sea routes, Ro-Ro type vessels are used (Beškovnik & Twrdy, 2011), such as Ro-Ro, Ro-Con, PCTC and PCC vessels, which are optimized for carrying cargo on wheels (Stopford, 2009). Consequently, any cost implications for VCC maritime transports of finished vehicle from the global sulphur cap in 2020, initially impacts its suppliers of deep-sea Ro-Ro services, indirectly affecting the customer.

However the impact may vary depending on how carriers choose to comply with the regulation, as there are several options of how to comply, which have been widely discussed in the literature (Schinas & Stefanakos, 2012; Panasiuk & Turkina, 2015; Zis, Panagiotis, Bell, Michael & Psaraftis, 2016; Abadie, Goicoechea & Galarraga, 2017). The most recurring options are; the previously discussed, change to low sulphur fuel; installing a scrubber system; or using a vessel that is propelled by LNG (Panasiuk & Turkina, 2015; Abadie et al., 2017), however the viability of LNG as a realistic compliance option has been disputed in a deep-sea context due to the underdeveloped infrastructure limiting global availability of LNG (Olaniyi, Atari & Prause, 2018). Every option infers different costs and risks, and while there is a great uncertainty to future oil prices, no option is the obvious choice (Barsamian, 2018). Therefore, depending on the compliance option suppliers of deep-sea Ro-Ro services chooses, the outcome of cost implications has the potential to differ considerably, both for the carrier and VCC - the shipper.

The carrier and shipper relationship are crucial (Kumar, Gorane & Kant, 2015), especially in regard to what extent and in what manner a potential cost increase can be and will be absorbed by the suppliers of deep-sea Ro-Ro services. This relationship with the Ro-Ro suppliers is managed by the purchasing function at VCC, being the interface between Ro-Ro shipping industry and VCC. There is no doubt that cost is an important factor for the procurement function of a large corporation such as VCC, managing and keeping down costs as much as possible is therefore essential (Maloni, Gligor & Lagoudis, 2016). Hence, the role of procurement is central in the aspect of managing the contracts and mechanisms that determines how and to what extent the cost implications induced by the new sulphur content limit in the Ro-Ro shipping sector will affect VCC. Increasing costs for carriers may be passed on to shippers by increasing freight rates or surcharges (Zis & Psaraftis, 2017), such as a bunker adjustment factor (Raza et al., 2019), which are used to transfer increased bunker costs to shippers. Historically, BAF disputes becomes a prominent obstacle in the dialogue between carrier and shipper as fuel prices increase drastically (Wang et al., 2011), and with the new sulphur content limits and an expected increase in bunker costs to follow, the current BAF mechanisms becomes a central focus between VCC and its suppliers of deep-sea Ro-Ro services.

1.1. Purpose & Research Questions

As described in the background, due to the pivotal role of maritime transports, increasing costs induced by IMO's new global sulphur content limit in 2020 can result in ripple effects and result in cost implications being passed on to shippers, such as VCC. Since the cost implications of the regulation are dependent on future fuel prices, which are uncertain, future freight rates becomes uncertain, hence resulting in an uncertainty for the buyers at VCC, not knowing what the future expenses of moving finished vehicles between continents using maritime transports. Also expressed in the background, is the fact that these cost implications on continental transports of finished vehicles at VCC must originate from suppliers of deep-sea Ro-Ro services, meaning that the choices of compliance that these suppliers make and the relationship between VCC and these suppliers are crucial in understanding what commercial effects IMO's regulation of the global sulphur cap may have. Thus, providing the basis for the purpose of this study:

The purpose of this study is to analyze the commercial effects of IMO's regulation of the global sulphur content limit in 2020 on VCC procurement of deep-sea Ro-Ro.

As evident by the purpose and its motivation, the commercial implications on VCC continental maritime transports of finished vehicles are passed on from the suppliers of deep-sea Ro-Ro services, meaning that in order to understand the effect on VCC, the cost implications of the regulation and the outcomes of supplier compliance options must be understood, thus leading to the first research question:

1. *How can VCC's suppliers of deep-sea Ro-Ro services be affected in terms of costs by IMO's regulation of the global sulphur content limit in 2020?*

With a deeper understanding of the industry of deep-sea Ro-Ro and how the chosen compliance options can affect these actors, the mechanisms used to transfer potential costs from suppliers of deep-sea Ro-Ro to VCC must be understood, in order to make sure that suppliers are properly compensated while a potential cost increase is justified. Since the regulation requires the switch different fuel with a lower sulphur content, a fuel cost increase can be expected. Therefore, the BAF mechanism that allows the transfer of increased bunker costs from suppliers to VCC must be understood in, which is the basis for the second research question:

2. *How can the current bunker adjustment factor used by VCC be adjusted to accommodate for the cost implications of IMO's regulation of the global sulphur content limit in 2020?*

In order to fulfill the purpose and answer these research questions, a case study was performed at Indirect Purchasing, at VCC in Torslanda, Göteborg, specifically with the section of procurement of Outbound Logistics.

1.2. Delimitations

This study is focused on the interface between the industry of deep-sea Ro-Ro shipping and the procurement of maritime continental transports of finished vehicles at VCC, involving two industries. However, the scope for the maritime industry is limited only to vessel operators within the industry deep-sea Ro-Ro, while the scope for the VCC, only regards the procurement function of outbound logistics at VCC. More specifically cost implications of the new regulations are studied. While there are many costs that could be affected by this regulation, only the cost implications related to fuel used to run ships and certain capital investments related to one of the compliance alternatives will be considered. Also, possible reaction from ocean carriers is not to comply with the new regulation. This is not a scenario considered during this study. Instead, compliance is assumed for all the cases being studied.

2. Methodology

This chapter explains the methodology of the study by first presenting an overview of the research and its process. Secondly, a section describing the research strategy, in terms of the scientific approach and the role of qualitative and quantitative data in the study follows. Thirdly, the case study design is explained under the research design section. This is followed by the fourth section, describing the methods used for data collection throughout the study, leading into a section regarding data analysis and the use of triangulation. Lastly, a discussion regarding the reliability and validity of the research is presented.

2.1. Overview of the Research and the Process

The study was conducted between January and May 2019, during which several activities with both theoretical and empirical basis was performed. The overarching process, the activities performed, the part of the research and the methods used for data collection and analysis are illustrated by Figure 1 and explained in this section below.

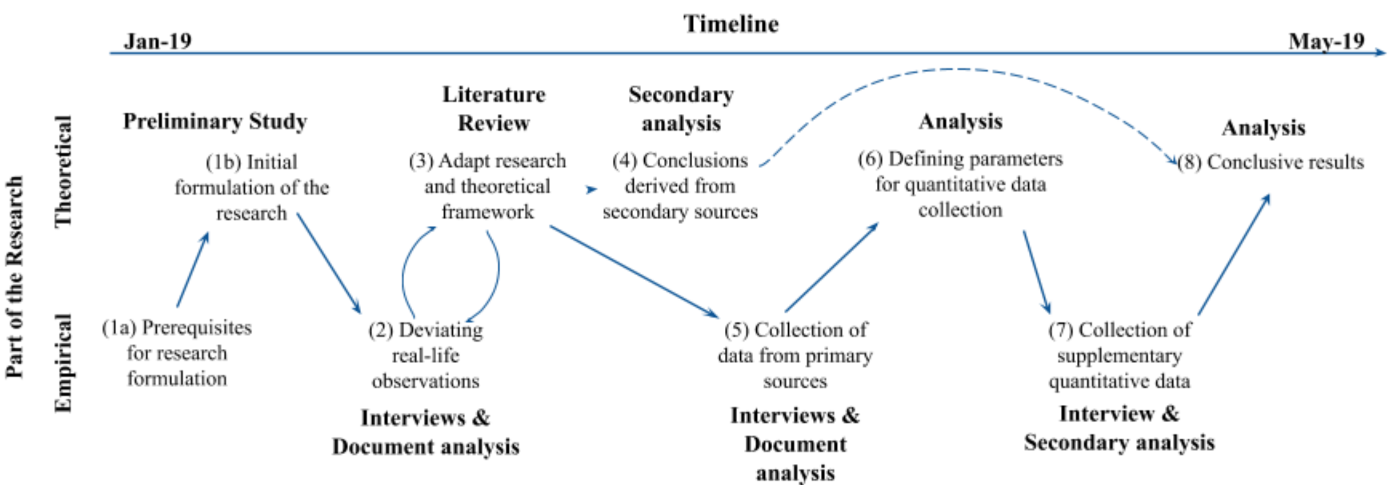

Figure 1: An overview of the research process throughout the study, inspired by an *abductive research process* by Kovács & Spens (2005, p.139)

The first part of the study, as we call prerequisites for research formulation (*1a*). Seeing that this study is a single case study problematized for Volvo, this meant establishing a first scope and direction of the study based on what we found from the initial problem at Volvo, what they need and can contribute with, and what we as researcher could provide. These prerequisites initiated a preliminary study, investigating what bodies of theory that are relevant to such a study and what is applicable, thus leading to an initial formulation for the research (*1b*). However, this only proved what needed to be further understand the issue specifically for procurement of deep-sea Ro-Ro at Volvo Cars.

This initiated the first step of data collection (*2*), where interviews with VCC buyers and content analyses of proprietary documents, conducted to understand current processes and relations with suppliers, and their perspectives on the sulphur regulations. An elaboration of these interviews and document analysis follows in the section regarding data collection. What was found here, decided the direction of the following activity; an adaptation of the research and the theoretical framework (*3*), which were conducted in iteration with each other. A theoretical foundation was developed by literature review, and also led the study in several directions.

One direction led to the secondary analysis of fuel price projections, used as the basis of the fuel price scenarios in this study (*4*), while the other led to the collection of data regarding suppliers of deep-sea Ro-Ro (*5*). This was carried out through interviews and document analysis. Based on the findings of the previous steps, an interview guide was formulated, which initiated interviews with suppliers to understand their perspective on IMO's regulation of the global sulphur content limit, and their services today, while also studying their official documents on sailing schedules and vessel fleet.

This led to the definition of parameters for quantitative data collection (*6*); which meant analyzing the result that that was found from suppliers regarding their vessels and services, creating the criteria for the what quantitative data that was needed. The collection of this data was obtained from two different sources; one part together with Marine Benchmark (*7*), in tandem with an interview; and the other part by using online GIS software as a tool to acquire spatial data. This data is considered as a set of *supplementary quantitative data* from secondary analysis and is explained as such in the section regarding data collection. This data was used to expand upon, and triangulate findings from suppliers of deep-sea Ro-Ro.

Lastly, the findings from interviews with VCC and its suppliers of deep-sea Ro-Ro, the document analysis of documents and the supplementary quantitative data are analyzed together with the result from secondary analysis of fuel price projections to generate conclusive results (*8*).

While the illustration of the process of the study in Figure 1 and its explanation in this section, provide aspects aimed at highlighting an overview of the process of the research, elements describing the research strategy may also be interpreted. Henceforth, an explanation of these elements and their place in the overarching strategy are appropriate, as explained in the following section.

2.2. Research Strategy

The research questions of this study require empirical research to be conducted on the cost implications of the new global sulphur content limit on carriers of deep-sea Ro-Ro services and in extension, on the indirect purchasing function at VCC, which is a very specific topic. However, the overarching topic of the implications of regulations for sulphur content limits on the maritime industry has and abundance of contemporary research, creating prerequisites in favor for descriptive or explanatory research, which seeks to expand on existing theory already discovered (Lee, Collier & Cullen, 2007). Although the topic for this study may benefit from existing bodies of theory, the specific nature of the topic limits the possibility to expand upon and applying existing theory. Consequently, the relationship between theory and research becomes affected, limiting what Bryman & Bell (2011) describes as the deduction of a hypothesis based on theoretical considerations and subjection to empirical scrutiny, also called *deductive theory* or a *purely deductive research process* (Kovács & Spens, 2005).

Furthermore, with the aim to gain a deeper understanding the commercial effects of specifically VCCs procurement of deep-sea Ro-Ro, the prerequisites for exploratory research are favorable, as existing theory might be difficult to apply in a normative sense. Basing research on inferences out of observation, known as inductive research (Bryman & Bell, 2011) or a purely inductive research process (Kovács & Spens, 2005), may thus seem more appropriate. However, as described by Bryman & Bell (2011), most deductive research implies parts of induction, just as most inductive research implies parts of deduction, implying a process of *iteration* between theory and empiricism, which is a key characteristic of the study. The theoretical and empirical perspectives were investigated in constant iteration, forming an understanding of the overarching concepts such as IMO's regulation of the global sulphur content limit in 2020, while empirically exploring the nature of procurement at VCC and the relationship with suppliers of deep-sea Ro-Ro, which can be described *as an abductive research process* (Kovács & Spens, 2005). This can be observed by the iteration between steps *2 & 3* illustrated in Figure 1 in the previous section. Further, the basis for the analytical framework and the direction of the study were adjusted in tandem with the iteration between theory and empiricism to accommodate for what was found.

Another aspect of the decision regarding research strategy is whether to have a quantitative or a qualitative approach. With the iterative, or abductive research process, as described for this study, the research strategy has characteristics that are in line with both quantitative and qualitative research. Bryman & Bell (2011) separates quantitative and qualitative research by the reasoning that quantitative research favors numbers while qualitative rather emphasize words, whereas in this study, numbers and the emphasis on words are both crucial. However, since the core part of the study is to understand the relationship between these two actors, procurement at VCC and its suppliers of deep-sea Ro-Ro, and consequently what cost implications that may arise due to the new global sulphur cap in this specific context, the qualitative approach has an epistemological orientation which are more aligned with the overall strategy and what drives the direction of the study in its abductive process. Specifically, this means that the qualitative aspect of the study is dominant in what theory is studied and how empirical data is collected. Furthermore, both research questions are more or less explorative, which are in line with the qualitative approach (Patel & Davidson, 2011), while the investigation of cost implications due to increased fuel prices implies a quantitative element in the study, which will be further discussed in the section regarding data collection.

2.3. Research Design

In order to fulfill the purpose of the study, a single case study design was used. Evidently, this was conducted with the section of procurement of outbound logistics at VCC, being a part of the IDP function. However, the context of this single case extends to actors outside IDP, meaning that several suppliers of deep-sea Ro-Ro shipping was included in the studied context. It is imperative to define the framework of how data will be collected and analyzed. This concerns the research design, which according to Bryman & Bell (2011), reflects the decisions regarding the importance of; expressing causality between variables; generalization; understanding behavior and meaning in the context of the specific case; and the temporal understanding of social phenomena. For this study, commercial implications of IMO's global sulphur cap in 2020 on the procurement of deep-sea Ro-Ro services at VCC and on the suppliers of these services are investigated, but most importantly, is understanding the meaning of this new regulation in the context of deep-sea Ro-Ro shipping and procurement at VCC, with emphasis on the causality between new regulations and costs, constituting conditions where a single case study design is most suitable. The type of case is best explained as a descriptive case, where the aim is to expand on themes already discovered in existing research (Bryman & Bell, 2011), in terms of investigating the impact of sulphur regulations on the maritime industry, which is the case for this study. Furthermore, in regard to level of analysis, which concerns the primary units of measurement and analysis (Bryman & Bell (2011), can be expressed for two different levels; organizational level and group level. On an organizational level, a supplier of deep-sea Ro-Ro represent the entire company and in line with the study design. However, VCC is not considered at a company level, but specifically the procurement function, meaning that a group level is more appropriate. Consequently, a different the level of analysis is used for procurement at VCC and the suppliers.

2.4. Data collection

During the study on possible cost implications of the regulation of new sulphur content limits in 2020 to the procurement of deep-sea Ro-Ro at VCC, qualitative and quantitative data was collected through both primary and secondary sources of data. The methods used for data collection were; literature review, interviews, document analysis and secondary analysis. The collection of data and analysis was iterative nature, as described in the research strategy, weaving back and forth between data and theory. The methods used for data collection are further explained in the following section.

2.4.1. Literature review

The literature review consisted of studying existing literature that helped the authors construct a basis of knowledge relevant to; deep-sea Ro-Ro shipping and maritime economics; marine fuels and fuels in regard to the sulphur content regulations, as well as modes of compliance; and lastly purchasing of maritime transports and BAF. The reviewing of literature was recurring in several stages of the study, often initiated as new information came to light from other sources. Electronic databases were exclusively used, and required the definition of relevant search parameters, which were, evidently, adjusted throughout the course of the study, not uncommon for interpretive research (Bryman & Bell, 2011). These search parameters were defined as the following keywords in different combinations: *IMO, 2020, regulation, sulphur, emission, global, shipping, deep-sea, Ro-Ro, costs, implications, maritime economics, bunker, fuel price projections, compliance, low-sulphur fuel, scrubber, purchasing, supplier relationship, information asymmetry and bunker adjustment*. Bryman & Bell (2011) mentions that variations in language and synonyms should be considered when searching in databases, therefore different conjugations, spelling and variations were used, e.g. *MARPOL Annex VI,* or *MARPOL Annex 6*, to refer to the regulation. As previously explained, additional literature was reviewed new information came to light, however this did not only initiate the authors to investigate bodies of theory that wasn't explored, but also in terms of formulating keywords. By using a snowball approach through the citations when discovering new literature, variations and wording of newly found concepts could be identified and included in the search parameters. Furthermore, snowballing was used as the dominant approach to find literature due to the flexible search parameters. While a systematic approach was utilized in the early stages of the study, unanticipated information of importance to the study emerged, as may occur in inductive research (Bryman & Bell, 2011), limiting the usefulness of the result of the initial systematic approach.

2.4.2. Interviews

The predominant method for collecting qualitative data in this study are interviews. Interviews were conducted with representatives from VCC, their suppliers of ocean transports, as well as with two external actors for the case studied. These interviews are described in Table 1. Even though the process of interviewing, transcribing and analyzing interviews is very time consuming (Bryman & Bell, 2011), this is considered an appropriate method for data collection with iterative approach used in this study, enabling the analysis of interview results continuously. Furthermore, the interviews with VCC and their suppliers of deep-sea Ro-Ro were conducted in order to collect company specific data and to gather information on their two contrasting perspectives on the regulation of the global sulphur cap and its implications on costs, being the main driver for the data collection process and constituting the largest share of interviews. However, the interviews conducted with procurement at VCC were different in many aspects, compared to the ones conducted with the suppliers.

Seeing that VCC procurement is the main research object and the case company from which the basis of the study is built, a different interview process is expected and intended. A continuous dialogue was held with buyers aside from the interview occasions listed in Table 1, often regarding the progress of the study and its direction as unanticipated information is found that must be considered. The interviews held with the procurement manager of outbound logistics, which included a buyer of finished vehicle maritime transports at the first occasion, represent this type of dialogue, which was characterized by information rather being exchanged and general focus on the study scope and its progress. The first interview with the purpose of pure data collection was conducted at an early stage of the study with one of the buyers of deep-sea Ro-Ro at VCC. The reason for collecting data at this early stage was to align the process of finding literature with empirical findings, focusing on the problematization of the new sulphur content limits for procurement of maritime transports of finished vehicle at VCC. This required a flexible level of structure and the possibility to stay focused the topic, which according to Bryman & Bell (2011), can be achieved by using a semi-structured interview, offering a broad leeway for the respondent on how to reply, while still focusing on the subject at hand. While the same structure was used for the other semi-structured interviews with buyers at VCC, the interview questions were adjusted prior to the interview with *buyer 2*, to account for the information that emerged from the first interview. However, this set of questions was used for all of the semi-structured interviews at VCC, nevertheless. The findings from these interviews, together with theory, created the basis for the production of the *interview guide* (see **Appendix**), which were used in the interviews of suppliers of deep-sea Ro-Ro. A meeting was arranged to present a draft of the interview guide to all the buyers. This so called, group technique, can be used in interviewing as a way of helping individuals to work together to identify possible solutions (Bryman & Bell, 2011), which was an intention for this interview. During this meeting, the questions were systematically reviewed in order to make sure that no information is disclosed to suppliers that can affect future negotiations and the relationship, consequently, sanction the initiation of supplier interviews. After these supplier interviews, a final meeting was arranged with the same constellation of buyers in an unstructured group interview, with the purpose to inform the buyers of conclusions made from supplier interviews and discuss the resulting effects on the current BAF mechanism in place.

The interviews with suppliers of deep-sea Ro-Ro, as mentioned before, differed in many ways from the interviews conducted with VCC. Evidently, the main reason being the fact that the study is a single case study on procurement at VCC, of which the suppliers were informed. However, there are several specific aspects that characterized these interviews apart from the different relationships had. Firstly, an extensive interview guide was prepared for the supplier interviews. The questions were formulated with regard to the findings from the previous interviews with VCC and also in regard to what had been found theory and the discussion with an external actor to the study. The interview guide was designed for semi-structured interviews, with three overarching areas; questions regarding the views on compliance alternatives to the regulation; questions regarding the routes they operate that carries VCC cargo today; and questions regarding the strategies for the commercial repercussions on shipper. Providing a copy of the interview guide can help strengthen the dependability of research (Bryman & Bell, 2011), and can be found in the **Appendix**. Secondly, setting up the supplier interviews required an entirely different approach than for the interviews at VCC. The sample of suppliers to interview was provided by the buyers, with the only criteria that they must be existing suppliers of deep-sea Ro-Ro for VCC, which resulted in a sample of six suppliers (see Table 1), all which were sent an *excerpt of the interview guide* upon contact (see **Appendix**), which according to Patel & Davidson (2011) can result in well elaborated responses from the interviewees. Thirdly, there were several variations among these interviews that didn't exist in the VCC interviews, such as; respondents always being at different locations, resulting in a different interview context that sometimes had to be conducted through phone or video call; different roles of respondents and knowledge and thus a varying capability among respondents to provide ample responses; and consequently, severe variance in duration for the interviews. Lastly, significant for the supplier interviews are the fact that they were recorded and transcribed, having both authors present in the dialogue during the interview, allowing the interviewee to be examined more thoroughly, but most importantly, it allows the answers to be examined repeatedly (Bryman & Bell, 2011), after the interview is finished.

It should be noted that there are certain weaknesses related to the usage of interviews as a method for data collection during this study. Because the contracts between suppliers of deep-sea Ro-Ro shipping and VCC are based on negotiations, counterparts can't disclose all the information the authors require. For example, lack of transparency from the deep-sea Ro-Ro carriers is a topic being addressed by the content of this study, and there are no guarantees that these carriers were more transparent during the interviews as compared to their relationship with VCC. This is one of the reasons to why complementary data have been collected with the help of a third party, Marine Benchmark, a company that provides; "*customized analysis of maritime information through analysis of the world fleet and its vessel movements from global AIS-information (AIS-antennas from land & satellites) stored on an hourly basis since January 2009. Vessel movements and information of the world fleet are supplied by IHS Fairplay*" (Marine Benchmark, 2019). The first interview was held during the early stages of the study, focused on exploring how AIS-data could be used in the study to handle the problem of limited transparency for other methods of data collection. The second interview, conducted in the latest stages of the study, was also conducted in the form of a discussion (see Table 1). The aim of this meeting was to make sure that all aspects necessary for answering the research questions was covered by accessing quantitative data to complement the other findings, however, qualitative data emerged during these discussions which is considered to be of importance for the study.

Table 1: Description of all interviews conducted for the purpose of this study

Company	Role	Purpose	Duration	Method	Date
VCC (Shipper)	Procurement Manager & Buyer 1	Discussion	60 min	Unstructured	2019-01-28
Marine Benchmark	Maritime Analyst	Discussion	15 min	Unstructured	2019-02-02
VCC (Shipper)	Buyer 1	Data collection	30 min	Semi-structured	2019-02-08
VCC (Shipper)	Procurement Manager	Discussion	30 min	Unstructured	2019-02-15
VCC (Shipper)	Buyer 2	Data collection	45 min	Semi-structured	2019-02-19
VCC (Shipper)	Buyer 3	Data collection	50 min	Semi-structured	2019-02-21
VCC (Shipper)	Environmental Manager	Data collection	60 min	Semi-structured	2019-03-13
VCC (Shipper)	Buyer 1	Data collection	45 min	Semi-structured	2019-03-14
VCC (Shipper)	Procurement Manager & Buyer 1-3	Interview guide alignment	60 min	Semi-Structured	2019-04-10
Supplier (Carrier)	Business Developer & Strategist	Data collection	120 min	Semi-structured	2019-04-17
Supplier (Carrier)	CEO	Data collection	90 min	Semi-structured	2019-04-24
Supplier (Carrier)	Sales/KAM	Data collection	60 min	Semi-structured	2019-04-25
Supplier (Carrier)	Head of Sustainability	Data collection	150 min	Semi-structured	2019-04-26
Supplier (Carrier)	Sales/KAM	Data collection	40 min	Semi-structured	2019-04-26
Supplier (Carrier)	Sales/KAM	Data collection	50 min	Semi-structured	2019-04-29
VCC (Shipper)	Procurement Manager & Buyer 1-3	Discussion	45 min	Unstructured	2019-05-08
Marine Benchmark	Maritime Analyst	Discussion	180 min	Unstructured	2019-05-14

2.4.3. Document analysis

In addition to the collection of existing literature and conducting interviews, document analysis will work as a third source of data to the study. As Bryman & Bell (2011) recount, there exist a wide variety of document types. For this study, *public documents*, such as documents from the public organization IMO, as well as *official documents*, such as documents derived from organizational sources, e.g. VCC and their suppliers of ocean transport, will be of importance for the research. A distinction between these kinds of documents and the documents discussed in the literature study (reports etc.) has to be made. While the documents connected to the literature study is mainly produced on the request of a business research, public and official documents are rather "out there" ready to be analyzed (Bryman & Bell, 2011). When including documents such as the above described, Bryman & Bell (2011) stresses the importance of four features of the documents in order to assess their validity, these are; (1) *Authenticity*, meaning that the origin of the document should be unquestionable. This feature is fulfilled since the documents collected was received through direct contact with the originator of the document. (2) *Credibility*, meaning that the document should not consist of any errors or distortions. Much of the data collected from these documents has been able to be confirmed by a third party which implies that documents analyzed during the document analysis could be seen as credible, (3) *Representativeness*, meaning that it is important that the data should be typical of its kind, and if it is not, the extent to which the data is untypical should be known and assessed. Scanning through large amounts of corporate documents regarding Ro-Ro freight, the authors have been able to confirm the representativeness of the documents included in the document analysis. (4) Last, it is important that the document is *clear and comprehensible*. During this research project, VCC company documentation and official documents from VCCs suppliers of deep-sea Ro-Ro transport are examples of data that will fall under the category of document analysis.

2.4.4. Secondary analysis

As mentioned in the research strategy and previously in this section, quantitative as well as qualitative elements are a crucial part included in this study, specifically in order to investigate how cost implications appears for each respective alternative used for complying with IMO's regulation of the global sulphur content limit for carriers of deep-sea Ro-Ro. In order to investigate such implications, the future context in which the regulation has been implemented and the market for marine fuels has changed must first be forecasted. Furthermore, spatial figures on the trade routes used by the suppliers of VCC finished vehicles are required to understand the extent which a global regulation will affect these transports. Moreover, historical figures on Ro-Ro vessel activity on these routes are also needed in order to investigate how the vessels operated by suppliers of deep-sea Ro-Ro actually operate in this context, and thus what the implications would be, when this context changes. However, such measurements are impossible for the authors to collect as primary data, thus requiring the analysis of data collected by others, which Bryman & Bell (2011) refers to as secondary analysis. Therefore, the secondary analysis is used in this study for the larger portion of quantitative data collection, consisting of spatial data on trade routes, historical figures on vessel characteristics and current information on the scrubber prices. This set of data will be referred to in this report as the *supplementary quantitative data*. Furthermore, and most importantly, secondary analysis is used for the purpose of understanding the future market of marine fuels, which concern the fuel price scenarios.

2.4.4.1. Supplementary Quantitative Data

The collection of spatial data of trade lanes on fairway routes was conducted by measuring distances at relevant sea trading routes using a maritime GIS software as instrument. The routes measured were exclusively based on the routes that were found from qualitative data collection, namely the supplier interviews. Using more than one method to investigate a phenomenon can provide credibility to the study, which is a technique called triangulation (Bryman & Bell, 2011). The main purpose of this data is to complement the qualitative data; however, it also provides the possibility to cross-check findings from both qualitative and quantitative data and thus create a basis to assess collected data from a point of reference.

The supplementary quantitative data was collected in tandem with the final interview conducted with Marine Benchmark. The purpose of collecting this data can be expressed in two points. Firstly, to address the risk of collecting data from the suppliers interviews that are invalid, due to the reluctance to disclose information that they do not want procurement at VCC to possess. By accessing historical vessel information through AIS data, the information collected from suppliers can be cross-referenced and thus mitigating the risk of conducting analysis on incorrect measures. Secondly, to find complementary data on scrubber prices, which are otherwise inaccessible, and crucial to determine cost implications. All information is stored in Marine Benchmark's database and was customized to match the vessel characteristics found from supplier interviews. While this could be considered as primary data, since raw statistical data was accessed, the measurements and consolidation of this data was made by another party, making it difficult to apply any conventional practices of assessing primary quantitative data collection in this case. Therefore, the role of this data is in this study recognized as secondary data used in a secondary analysis.

2.4.4.2. Fuel Price Projections

The secondary analysis of fuel price projections was made by reviewing two separate studies which included forecasting of future fuel prices; CE Delft (2016) & EnSys Energy & Navigistics Consulting (2016), reviewed in the theoretical framework. While there are many speculations on future fuel prices, these two "fuel availability studies" were analyzed because they constituted the basis for the debate of two contrasting perspectives that led to the decision of the implementation date of IMO's regulation of the global sulphur limit in 2020. The secondary analysis meant reviewing the contrasting perspectives on future fuel prices and the potential contexts in which these prices would exist, providing fuel prices as input for the estimations of cost implications throughout the study.

2.5. Data analysis

In order to answer the first research question, the literature on cost drivers for vessel operators was analyzed. The data collected from the literature review were then used during the empirical data collection. Meaning literature review on cost drivers enabled the authors to know what cost areas to focus on during supplier interviews. More specifically, based on the literature on cost drivers, the authors obtained an understanding of what data, related to costs that would be important to collect in order to analyze what implications the new regulation might have for the shipping industry in terms of fuel costs. For example, certain ship characteristics highlighted as important in regard to ship costs was identified during the literature review, information that could be used during the interviews with the Ro-Ro carriers. In addition, the literature on the IMO global sulphur cap and possible alternatives for compliance provided an understanding for realistic methods of compliance, which could then be further investigated in regard to cost implications. By further reviewing previous research on the IMO global sulphur cap, especially regarding estimations on future fuel demand and fuel prices, the authors were able to formulate their own estimations of different scenarios and fuel prices for the future, which were later used to formulate cost implications. In addition, data gathered through supplier interviews and with a third part, a maritime analyst, regarding specific routes laid the foundation for the cost implications related to different demand and price scenarios. The combination of data from the literature review and empirical data resulted in possible cost implications in tangible numbers, which could then be used as a foundation to answer the second research question.

Regarding the second research question, literature review on the basic rationale behind a BAF model and the procurement function of a company in general, and VCC in particular, was gathered to obtain a profound understanding of the usage of a BAF model in general, and in particular how this model is used in the contractual agreements between VCC and their suppliers or Ro-Ro freights. This data worked as a basis for the formulation of interview questions used during the interviews conducted. The data collected during interviews with suppliers of Ro-Ro freight and representatives for VCC could then be used to map the separate views on the current and future BAF models respectively. The analysis conducted on the first research question, regarding possible cost implications for the shipping industry, made up the foundation for the second research question. During the analysis of the second research question, regarding how to construct a BAF model for VCC, the cost implications of the new regulation to the shipping industry as a whole was considered in regard to the current BAF models used at VCC. Further, the Ro-Ro carriers' and VCC's views on important aspects of an updated model customized for the new regulation were taken into consideration.

In order to strengthen the results of the study, avoiding misinterpretations of the findings, triangulation was applied, as described by Figure 2. According to Bryman & Bell (2011), triangulation is when more than one method or source of data is used to investigate a phenomenon. In the context of this study, qualitative as well as quantitative measures was used to investigate the same phenomena. During interviews with Ro-Ro carriers, data on fuel consumption was obtained, which was then confirmed by quantitative data on fuel consumption regarding specific ships obtained from Marine Benchmark. Further, data regarding specific routes was collected during carrier interviews. By investigating sailing schedules and service description for the respective carrier online, the authors could cross check (Bryman & Bell, 2011) that the information gathered through interviews were indeed correct. This methodology was also applicable regarding the BAF models currently used at VCC. From interviews with representatives from VCC, descriptions of BAF models used in ongoing contracts with Ro-Ro carriers was obtained. These descriptions of the current BAF models was later observed in VCC official documents, confirming the data collected.

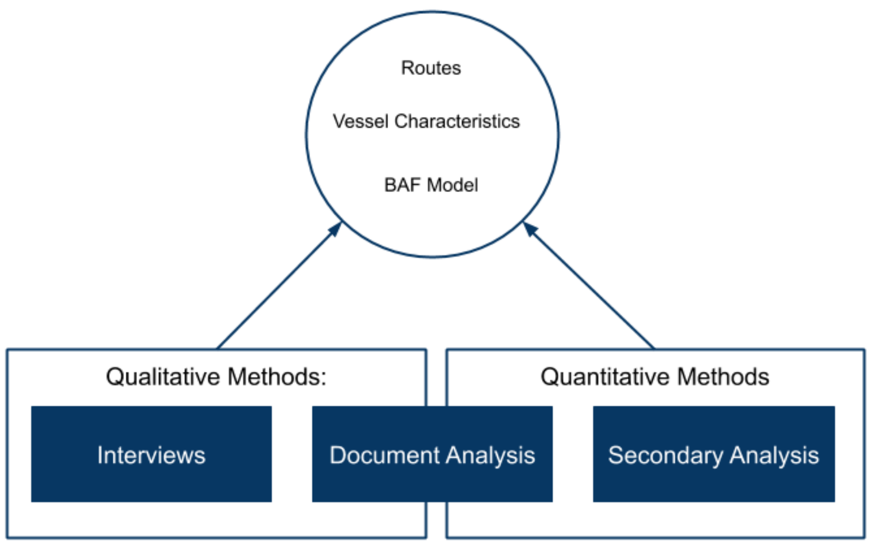

Figure 2: An illustration of the mixed methods used for triangulating findings

While the initial purpose of triangulation was to expand upon findings and provide information required that could not be obtained through interviews, cross-checking may, according to Bryman & Bell (2011), affect the credibility of findings and thus reliability and validity of the research.

2.6. Reliability and Validity

In this section the reliability and validity of the study are discussed. The discussion is based on Yin’s (2007) four concepts of reliability and validity. These are; (1) Construct validity (2) Internal validity, (3) External validity, and (4) Reliability.

The construct validity can be described as to test that the study, and the actions performed to test the topic of research, is actually testing what the research claim to be testing. For the purpose of this study, it is therefore of interest to investigate if the measures applied really refers to what implications the new regulation might have for the Ro-Ro sector of the maritime industry, and what elements of the current BAF model at VCC that need to be adjusted in regard to the context of the new regulation. As the first research question aim to investigate effects on the Ro-Ro sector, the interviews on the supplier side has exclusively been conducted with ocean Ro-Ro carriers, since it is logical to assume that they can provide data and insights specifically regarding Ro-Ro ocean transports. Furthermore, the second research question naturally delimits the investigation of BAF to only regard changes of elements currently within the model being used today, since the question is focused on an adaptation of the current model. Would the question intend to investigate how bunker adjustment mechanisms in general could be developed with regard to the new regulation, an entirely different approach and scope would be required.

The internal validity concerns the detection of a relationship between cause and effect regarding a certain claim. For the cause of internal validity during this study, it has been important not the least regarding the authors formulations of certain scenarios and price estimations. Therefore, the presented scenarios and price estimations have been thoroughly substantiated by literature and profound reports conducted within the field of the study, and more specifically the future demand and availability of ship fuel. Furthermore, in regard to the resulting cost implications of IMO’s global sulphur content limit on suppliers of deep-sea Ro-Ro, a significant part of the literature and case study was dedicated at identifying the drivers of costs, while also using quantitative data to cross-reference the drivers found.

The external validity concerns the degree to which the results can be generalized, meaning that the results reached during the study should be able to apply to other situations, outside the focal area of the study. On a general level, due to the specific research scope, it is unlikely that the result is generalizable beyond this context. However, there are aspects of the result that may be applicable in other contexts, such as the identified drivers and cost implications for other industries of maritime transports, while the extent of the cost implications may differ. Furthermore, other shippers of cargo using similar routes of deep-sea Ro-Ro are likely to be affected in the same manner as VCC.

Reliability means that the operations performed during the case study should be repeatable. While the specific scope of this study undermines the generalizability, it suggests that the same, or similar results would be reached, should a study within the same specific context be conducted. From the shipper perspective, in this case VCC, it can be inferred from the interviews that there is consensus within the organization regarding questions related to the new regulation. Implying that the same answers would be obtained from within the organization if another party would investigate the subject matter. A similar conclusion can be made regarding the findings from carrier interviews.

Furthermore, a portion of these findings were possible to cross-reference using quantitative methods, indicating that the same results are likely to be found, despite the method applied.

3. Theoretical Framework

This chapter provides the reader with a theoretical foundation in relation to the field of study. The term "theory" in this study refers to all secondary data collected through studying literature, not necessarily only general theory in an academic sense, but also industry specific reports and studies. Consequently, this theoretical framework will be applied to the forthcoming analysis where it is used to strengthen the finalizing results.

3.1. Relationship Between Research Questions and Theoretical framework

In the following chapter the theoretical framework will be presented in order to provide the reader with a theoretical foundation of the subject matter. As illustrated in Figure 3 below, theory in regard to the Ro-Ro sector of the maritime industry, the costs and pricing of ocean transports as well as the new sulphur regulation and the alternatives available in order to comply with it highlight the important aspects to consider when analyzing possible implications of the new regulation.

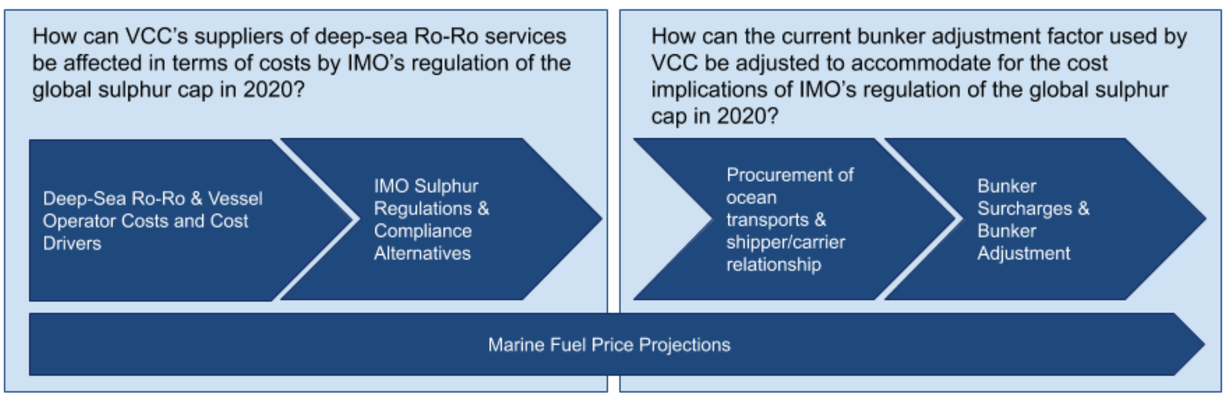

Figure 3: Illustration of the relationship between research questions and theoretical framework, highlighting each part of the theory and its connection to the respective research question.

The first part of the theoretical framework, illustrated by the left box in Figure 3, includes an overview of the Ro-Ro sector of the maritime industry as well as a description of the costs and drivers work to provide an initial understanding of the industry in regard to costs. Consequently, the following sections regarding the sulphur regulation in focus, the possible alternatives to comply with the regulation as well as projections of the relevant fuels are presented in order to give the reader insight into what consequences the new regulation can have for the Ro-Ro sector, which is vital in order to answer the first research question. Finally, as illustrated in the right box in Figure 3, the relationship between carriers and shippers is described leading to a central part of this relationship, bunker adjustment surcharge. These two sections should give the reader an understanding of how a shipper, VCC in this case, might be affected by the regulation. In addition, these two sections offer a valuable theoretical foundation in order to answer the second research question.

3.2. Deep-sea Ro-Ro shipping

Deep-sea shipping refers to transports carried out at sea for large volumes and between the continentals. Because of the high volumes being transported, the deep-sea shipping routes commonly goes between large industrial economies such as Europe, North America and Asia. However, because of the extensive global elements of the shipping industry, covering large parts of the world, the thousands of ports existing today are situated across a great number of regions worldwide (Stopford, 2009). Short-sea shipping refers to the transport carried out at sea within regions. The short-sea shipping often serves a function for transshipping goods that have arrived at larger regional ports by continental transports (Stopford, 2009), in other words, arrived by deep-sea shipping, which will be the focus of this study.

Ro-Ro vessel stands for roll-on roll-off vessel. It is fairly obvious from the name what characterize these kinds of vessels. Basically, it means that the cargo being shipped, usually some kind of vehicle, can easily roll on the ship before departure, and smoothly roll off the ship at arrival. These vessels exist in different shapes, often with several decks for vehicles to be stored on. Since cars are the most common cargo to transport by a ro-ro vessel, the capacity of the vessels is usually expressed in Car Equivalent Units, usually referred to as CEU (Shipping Guides Ltd, 2019). Ro-Ro vessels today has a capacity of up to 8000 CEU (Wallenius Wilhelmsen, 2019). Further, there are certain types of Ro-Ro vessels used by carriers; PCC, PCTC, Ro-Pax, and Ro-Con. The PCCs, Pure Car Carriers, are vessels that are built to exclusively fit the transport of cars. PCTCs, Pure Car & Truck Carriers, are similar to PCCs but are able to transport all sort of vehicles. Ro-Pax are vessels able to transport both vehicles and passengers. These types of vessels are rarely used for deep sea shipping, but rather for short sea voyages. Lastly, there are Ro-Con, which are a hybrid of a Ro-Ro and a container ship. They use the storage beneath deck to transport cars, while they have space on deck to transport containers as well (Kantharia, 2019, May 10).

The shipping industry is said to connect the world through its contribution to world trade, transporting goods all around the globe (World Shipping Council, 2014). This is not surprising considering the fact that more than 80% of world merchandise trade in terms of volume, is transported by sea. These volumes are estimated to grow at a compound annual growth rate of 3.2 % until 2022. In addition, over 50% of this trade is carried out using containers and liner shipping carriers. With the above in mind, it is not an overstatement to say that the maritime industry is essential in order for the world trade to function efficiently (UNCTAD, 2018b).

While being an extensively global industry, covering greater parts of the world, the shipping industry faces many challenges. Because of the large volumes of goods being transported, carriers invest heavily in larger and larger vessels, in order to expand the supply in terms of capacity. Expanding capacity to meet a higher demand puts the carriers in an exposed situation, should the demand drastically decrease. In fact, the global trade has seen a relatively weak growth since 2009, leaving many carriers with overcapacity. Further, the industry is characterized by heavy competition, and have been so for a long time, which in turn have resulted in low freight rates. Even though the prices are appreciated by shippers, they pose a great challenge for carriers as margins are low (UNCTAD, 2018b). Another challenge carrier has to face regards environmental regulations being stricter. Even though shipping is known to be a relatively environmentally friendly means of transport, organizations such as the IMO persistently presents new regulations in order to cut down emissions from ships. These regulations put pressure on carriers and results in increased costs which in turn affects the freight rates. An example of these increased costs is the global sulphur content limit in 2020, which calls for either changing to the new, more expensive, compliant fuels, or to invest in a scrubber system.

3.3. Vessel Operator Costs & Cost Drivers

Stopford (2009) explains some of the basic concepts needed to understand the costs for carriers, namely factors that determines carrier costs and the classification of these costs. Costs depend on the combination of these three factors; *the ship*, its characteristics, such as fuel consumption, ship condition and the required size of the crew operating it; *costs of bought in items*, which are beyond the ship owners control, such as crew wages, vessel repair costs, and most importantly bunker, which is a considerable expense for shipping lines (Notteboom & Vernimmen, 2009); and lastly, *how efficiently the owner manages the company*, which includes administration overheads and operational efficiency.

The classification of costs proposed by Stopford (2009), includes five categories; *Operating costs (OPEX),* costs associated with the day-to-day operations of the ship; *Periodic maintenance costs,* which are incurred for major repairs or modifications for which the ship is usually dry-docked; *Voyage costs,* which are the variable costs associated with a specific voyage e.g. fuel; *Capital costs (CAPEX),* which are costs associated with how the ship is financed; and *Cargo-handling costs*, includes expenses due to loading, stowing or discharging of cargo. This categorization of costs is not an accepted standard in the industry and is only mentioned for the benefit of understanding and discussing carrier costs. Figure 4 illustrates this classification of costs, for a hypothetical ten year old vessel in 2005 (Stopford, 2009).

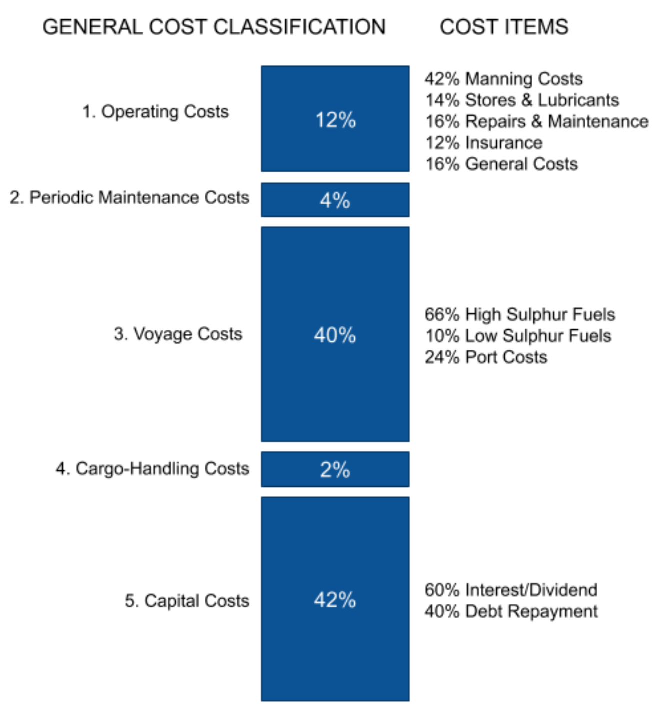

Figure 4: An illustration of the division of hypothetical costs for a ten year old vessel using the five categories of carrier costs inspired by Stopford (2009, p. 225).

As made apparent by Figure 4, both capital costs and voyage costs imply a majority share of the total costs for a carrier. While the share of costs different significantly between every case, it is not uncommon that they represent the larger share of a vessel. While, capital costs are mostly related to the activities of how the business is financed (Stopford, 2009), understanding the drivers behind voyage costs is imperative, since fuel costs are expected to increase by IMO's regulation of the global sulphur content limit in 2020.

3.3.1. Ship Characteristics

3.3.1.1 Age and Size

Carriers who invest in new larger vessels can benefit from higher economies of scale and fuel efficiency (Stopford, 2009; Notteboom & Vernimmen, 2009; UNCTAD, 2015), which relates to two important cost-central principles; the relationship between cost and vessel age; and the relationship between cost and vessel size (Stopford, 2009). Acquiring new vessels infers high capital costs, while reducing operating costs, voyage costs and maintenance costs as compared to older vessels, since newer vessels often require a smaller crew, require less maintenance, run more efficiently on the day to day operations and consume less fuel. However, older vessels are in general cheaper to run in terms of the total costs, since capital costs associated with owning an older vessel are significantly lower, resulting in the larger portion of costs being variable costs. These conditions is not as significant for all vessel types, Stopford (2009) describes that the economic advantages of new tanker ships was saturated in the 80s and 90s when the size of the new builds stopped growing, which has to this day extended the economic life of tanker vessels as compared to other ship types, indicating that the economic advantages of running newer vessels are on account of the larger size. Stopford (2009) compared the cost differentials between older and newer vessels and found that running newer vessels is a completely different business from that of running older vessels in terms of the cost structure. The savings on bunkering cheaper fuel and its impact on costs are potentially higher for a carrier who run older vessels, while carriers who run newer vessels may find greater savings by finding favorable financing. Hence, the age of the vessel affects how shipping companies can compete in terms of costs and what activities that are most essential for its business (e.g. bunkering or financing). Still, the age of the ship does not significantly affect the financial performance of a shipping company according to Bang, Kang, Martin & Woo (2012), meaning that there is not always a clear-cut choice for shipowners.

Furthermore, the relationship between cost and ship size determines the economies of scale for a vessel, often considered in terms of cost per CEU for Ro-Ro vessels (Stopford, 2009), meaning that owners of large vessels have a substantial cost advantage, provided that sufficient cargo volume can be found to utilize vessel capacity and that port facilities have the adequate infrastructure for the vessel size (Stopford, 2009; Cullinane & Khanna, 1999). This relationship is expressed by Stopford (2009) as C, the annual cost per CEU (or other measure of capacity unit) of a ship, where the sum of the five categories of costs; OC the operating costs per annum, PMC periodic maintenance costs per annum, voyage costs VC, cargo handling costs CHC and capital costs CC is divided by the CEU capacity for vessel m over a year t, which can be expressed as;

$$C_{tm} = \frac{OC_{tm} + PMC_{tm} + VC_{tm} + CHC_{tm} + CC_{tm}}{CEU_{tm}}$$

Scale benefits between using a smaller vessel with a capacity of 1400 CEU and a larger vessel with 8000 CEU is significant, total costs per unit of the larger vessel is only 39% compared to the smaller vessel (Stopford, 2009). However, there are constraints as to what extent the size of the vessel can provide economies of scale. The number of ports that can be entered are limited (Stopford, 2009), as some ports have been physically impossible to enter, or have inadequate infrastructure and productivity to handle a vessel of that size, also limiting the potential of loading extra backhaul cargo through additional port calls. Ports with inadequate capacity directly results in the diseconomies of scale for the larger vessels, as more time is spent in port (Cullinane & Khana, 1999). All though there have been significant advancements and automation in port operations (UNCTAD, 2015), increasing the number of ports that can be entered by larger vessels and reducing the diseconomies of scale. Furthermore, as the average size of vessels are increasing, there is an effect of oversupply of capacity and potentially diseconomies of scale as vessel capacity can't be utilized (UNCTAD, 2015).

3.3.1.2. Sailing speed and fuel consumption

It is common among carriers to apply the practice called *slow steaming,* which is a measure of reducing sailing speed (Raza, et al., 2019), to absorb overcapacity and mitigate effects of diseconomies of scale (UNCTAD, 2015), as it reduces fuel consumption and thus fuel costs (Notteboom & Cariou, 2013; Yin, Fan, Yang & Li, 2014). This relationship between vessel speed and fuel consumption follow a cubic relationship, meaning that the fuel consumption is proportional to the cube of the speed (Stopford, 2009; Yin et al., 2014; Zis, Angeloudis, Bell & Psaraftis, 2016; Raza et al., 2019). Small changes in vessel speed will then have a significant impact on the fuel consumption (Zis & Psaraftis, 2019) and operating at lower speeds leads to substantial savings in fuel consumption (Raza, et al., 2019) and consequently the fuel costs, although the magnitude of the savings on fuel costs are highly dependent on the price of the fuel. Furthermore, in investigating the service speed and fuel consumption for four different vessels sizes at different speeds, Notteboom & Vernimmen (2009) showed that an 8000 TEU container vessel reducing its speed from 26 knots to 20 knots lowers its fuel consumption by approximately 50%. Stopford (2009) also found a reduced fuel consumption of 50% for a Panamax bulk carrier lowering its speed from 16 knots to 13 knots. However, there are several other factors that affect this relationship, such as vessel age, machinery and propeller efficiency and hull and sea condition, meaning that the fuel consumption for vessels of the same size and speed can differ substantially (Stopford, 2009; Yin et al., 2014).

As previously mentioned, the practice known as "*slow steaming*", are commonly used as a response to overcapacity by reducing fuel consumption. However, as evident by the aforementioned discussion of the relationship between sailing speed and fuel consumption, the need to reduce fuel consumption is not solely due to mitigating diseconomies of scale, but a rather general measure that is efficient and easy to implement and used in order to reduce operational costs and external effects from vessel emissions (Finnsgård, Kalantari, Raza, Roso & Woxenius, 2018). There are extensive research on slow steaming as a measure to reduce fuel consumption, but also in regard to the economic viability and strategy from the carrier perspective (Finnsgård et al., 2018), emphasizing issues that debate the feasibility of slow steaming, e.g. that reducing sailing speed have negative implications for a carrier's ability to uphold its service schedule and maintaining its competitiveness in the Ro-Ro sector (Raza et al., 2019; Zis & Psaraftis, 2019). Therefore, it is imperative that carriers consider the potential repercussions of slow steaming on their current service schedule, in order not to neglect customers and diminish the service quality offered.

3.3.2. Service Schedule

The carrier decision concerning sailing speed are made with regard to the service schedule, and vice versa, as part of the liner service design (Notteboom & Vernimmen, 2009). This includes decisions regarding *service frequency*, *number of port calls*, *fleet size* and of course the route of the service offered, determining the *distance*, *transit time* and the *time spent at sea* and *in port* (Notteboom & Vernimmen, 2009; Stopford, 2009). Raza et al. (2019) emphasize that the sailing schedule requires compromising between different time requirements depending on the route or what type of ship is running, to deliver the expected service quality. Carriers of cargo with higher value may be less sensitive to costs arising due to higher sailing speeds and more conscious of time-related aspects, such as transit time, frequency or port turnaround time. Adjusting sailing speed or the number of port calls can be considered to find a balance which is appropriate for the service, with different cost implications. Even increasing fleet size can be used to decrease speed for the vessels used in the service and consequently the bunker consumption and its cost, while increasing capital costs (Stopford, 2009). This demonstrates how the costs structure can vary depending on how the service is designed.

In summary, it can be found that cost drivers for a carrier of deep-sea Ro-Ro are much connected with vessel characteristics and the service schedule, especially in regard to the fuel costs. Considering the uncertainty regarding what the price for fuel might be, the extent of the fuel costs is yet a mystery, one that has driven a lot of debate regarding IMO's regulations regarding the sulphur content limit and a public interest into what it is, why this is being introduced and how it will be enforced.

3.4. IMO regulations: Sulphur Cap

Deep sea vessels run mainly on heavy fuel oil, which is a residue of crude oil distillation. In turn, crude oil consists of sulphur which can be harmful for human beings as well as the environment when emissioned. In order to improve the air quality and protect the environment, the IMO has been regulating the sulphur emissions from ships in a progressive manner since 2005 (IMO, 2019a). The first global cap was set to a m/m of 4.5%, and further lowered to 3.5% in 2012, which is the global cap that applies today. However, in 2020 the global cap will decrease significantly, to a m/m of 0.5%, which equals to a decrease of almost 86%. Evidently, the earlier decreases in the global sulphur cap has not been as drastic as the one to be applied in January 2020.

3.4.1. Emission Control Areas

More than 90% of global trade is carried out at sea. The reasons to why most of the cargo is globally transported via the oceans are specifically the low cost and the relatively environmentally friendly aspect. Even though shipping is said to be one of the most sustainable modes of transport, emissions from vessels are still to be improved. IMO, the UN organization responsible for safety and environmental issues at sea (IMO, 2019b), has taken several actions to mitigate emissions by ships at sea. One of the most significant measures being the implementation of Emission Control Areas (North America) and Sulphur Emission Control Area (Europe), hereinafter referred to as ECA and SECA (see Figure 5). ECA and SECA are coastal areas where more stringent sulphur limits compared to global sea prevails, meaning that inside the SECA ships are not allowed to burn fuel exceeding a fixed sulphur limit that is significantly lower than on the global sea. Emission regulations applies to all fuels, equipment and devices used by ships, meaning that auxiliary engines, boilers and gas generators are also covered by these regulations (IMO, 2019a). In 2006, the Baltic Sea became the first SECA with a sulphur limit in the ship fuel of 1% m/m. One year later, in 2007, the North Sea and English Channel were also included, which together with the Baltic Sea constitutes the North Sea SECA. The fourth zone with regulations on sulphur emissions were North American and the US Caribbean coasts (Notteboom & Vernimmen, 2009), introducing the ECAs. Since 2015, the maximum permissible sulphur m/m in ECA and SECA is 0.1% (Fagerholt & Psaraftis, 2015). Since the global sulphur cap 2020 is set to a sulphur m/m of 0.5%, ECA and SECA will not be affected by the new regulation. Hence, the more a vessel operates in ECA and SECA today, the less consequences it will suffer as a result of the global sulphur cap. When entering an ECA or SECA, ships are obliged to only burn a compliant fuel, which means that the shift from a fuel with a higher sulphur content than 0.1% m/m has to be made prior to entrance. In addition, the documents describing the process of changing from one fuel to another need to be aboard all ships entering ECA and SECA (IMO, 2019a).

Figure 5: The world map highlighting the ECA's, SECA and DECA

In addition to the SECA zones presented by the IMO, The Chinese Ministry of Transport has also decided on areas by the coast of China, Taiwan and Hong Kong to have stricter sulphur emission regulations, often referred to as a Domestic Emission Control Area (DECA), highlighted in Figure 5. These regulations are similar to the ones stipulated by the IMO. The maximum m/m allowed for ships operating in the coastal ECA is 0.5% (Gard, 2019, February 5), while the maximum sulphur m/m within the inland ECAs is set to be 0.1% (Liu, Meng, Shang, Lv, Jin, Fu & He., 2018). There are discussions as to whether ECAs should be extended to cover additional coastal areas such as Australia, Japan, Singapore, the Mediterranean Sea and Mexico. However, initially the global cap implemented in January 2020 will apply in these areas (Abadie et al., 2017).

The aim of the implementation of SECA zones is to meliorate the health of people living in areas close to heavy ocean traffic, as well as protecting the environment from emissions. However, there are some obvious negative consequences for the shipping industry, increased fuel costs being the most significant. In order to run a vessel compliantly inside a SECA, the vessel must either run on a more expensive fuel or install a scrubber system. Both of which increase the total voyage cost (Bergqvist, Turesson & Weddmark, 2015).

3.4.2. Global Sulphur Content Limit

As aforementioned, historical data of global sulphur caps applied globally shows relatively small cuts in the m/m allowed in ship fuels on the deep sea. This is not the case with the new global sulphur content limit in 2020. The new regulation states that from January 1st 2020, the maximum sulphur m/m in the ship fuel is 0.5% for ships operating outside the Emission Control Areas, meaning that it will not be allowed to run a vessel on a fuel with a sulphur m/m exceeding 0.5% anywhere in the world. Lowering the limit from the earlier 3.5% m/m to 0.5% equals to a decrease of almost 86% (see Figure 6). The purpose of this decrease is to clean up the shipping industry by significantly reducing the maximum sulphur m/m allowed in the fuel of the ships. Human diseases such as respiratory symptoms and lung cancer, as well as environmental consequences such as acid rain will, according to the IMO, to a greater extent be avoided by introducing stricter regulations on the sulphur m/m in ship fuel. For example, the application of the new regulation can prevent premature death of about 570.000 people between 2020-2025 (IMO, 2019a).

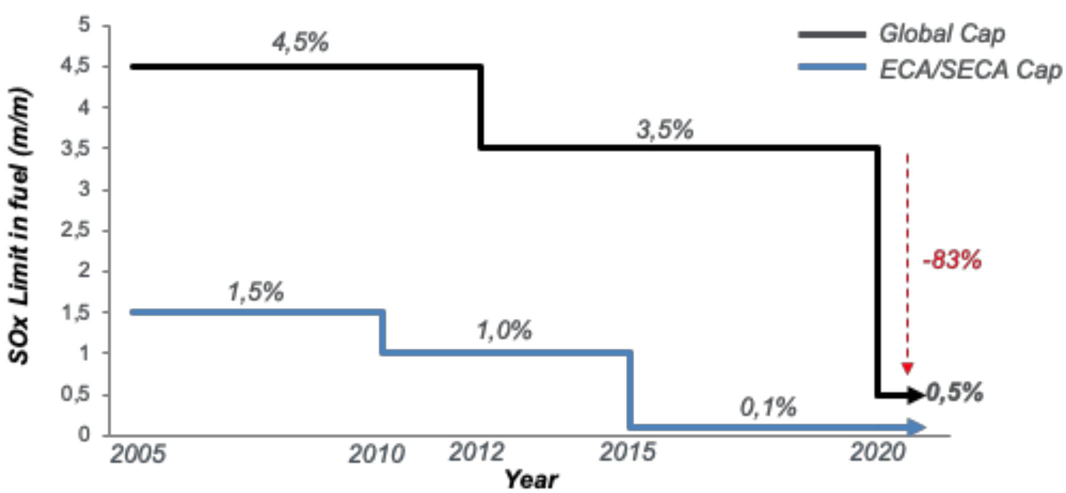

Figure 6: Illustration of the implementation dates of the sulphur content limit regulations through a timeline based on official data from IMO (Zis & Psaraftis, 2017)

An intense discussion regarding the Global Sulphur Cap 2020 regards the date on which the regulation should be put into force. Since the sulphur limit of 0.5% m/m will force vessels to run on a new fuel (or install a scrubber), the topic of discussion has mainly been connected to the future availability of the new fuel, especially for the first six months of the regulation. Particularly actors within the refining industry have expressed uncertainty as to when they will be able to fully meet the expected demand on fuels compliant with the new regulations (EnSys & Navigistics Consulting, 2016). Verleger (2018) presents an even more pessimistic perspective by asserting that setting the implementation date of the Global Sulphur Cap to 2020 can lead to an economic recession equal to the Great Recession in 2008. Verleger claims that the application of the Global Sulphur Cap as soon as January 1 2020 could result in an increase of gas oil prices with 100% and crude oil prices as high as 200$ per barrel, which in turn might result in a 5% decrease in global GDP in 2020 and as much as a 10% decrease by 2025. The main reason for these drastic consequences, according to Verleger (2018), is that the oil and refining industry lack incentives to put an extra effort to produce maritime fuel, since this fuel is the product with least value. In fact, the oil industry might rather have incentives to support the 2020 implementation date. The simple reason being that the demand for distillates will increase more than ever, combined with an uncertain supply, leading to a massive climb in prices (Verleger, 2018). Whereas many of the actors within the refining industry find it unlikely to supply the demand of compliant fuels as of January 1st, 2020, the IMO states that the capacity of the refining industry will be sufficiently developed to meet the expected demand (CE Delft, 2016 & IMO, 2019a). Hence, despite several attempts to delay the implementation of the regulation the date is settled to be January 1st, 2020.

This section has provided a description of the new regulation and what is means in terms of concrete sulphur content limits that ocean carriers need to abide to. As a logical transition, the following section is dedicated to the different alternatives that ocean carriers have in order to comply with the new regulation.

3.5. Compliance Alternatives

The upcoming regulation of global sulphur cap in 2020 will prohibit the use of high sulphur fuels oils (HSFO) used for most transports outside of ECAs and SECA today, which includes intermediate fuel oils such as IFO380. There are only a few alternatives that are seen as realistic in order to comply with IMO's regulation of the global sulphur content limit in 2020. One option is to run the vessels on a fuel which contains the allowed amount of sulphur, meaning a fuel with a sulphur content of no more than 0.5%, henceforth referred to as very low sulphur fuel (VLSFO). Another option is to install a scrubber system, making it possible to keep running the vessel on fuels containing more than 0.5% sulphur. A third option is to install an LNG system, enabling the vessels to run on liquified natural gas (Abadie et al., 2017). However, LNG lack the proper infrastructure in order to be counted as a viable means of compliance in less than a year (EnSys Energy & Navigistics Consulting, 2016), when the new regulation is set to be implemented. Hence, LNG is not a compliance alternative that will be further elaborated on in this study. When choosing which method to use in order to comply with the new regulation there are several aspects consider in the decision process. These aspects include fuel prices, size of the investment, the areas in which the vessel run, regulations applicable, number of days at sea, and the remaining lifetime of the vessel (Abadie et al., 2017). Below, the two most realistic alternatives of compliance are explained more into detail.

3.5.1. Compliant Fuels

IMO Global Sulphur Cap prohibits ships to burn fuel with a sulphur m/m exceeding 0.5%. As a consequence, carriers will have to choose a new method to run their vessels, a method compliant with the new regulation. One option to stay compliant is to burn a new fuel, most likely significantly more expensive than HSFO, with a sulphur content less than 0.5% (Cuijpers, Golombok, Van Avendonk, Boot, 2017). Panasiuk & Turkina (2015) refer to these new fuels as *low sulphur fuels*. A carrier that choose to run their vessels on a compliant fuel, can either do so by burning fuel with a sulphur m/m less than 0.1%, in order to being able to run their vessels all over the world without switching fuel. An alternative to this is to burn 0.1% fuel when inside ECA-zones, and otherwise run their vessels on a fuel with a sulphur m/m between 0.1% and 0.5%. Panasiuk & Turkina (2015) states that burning the low sulphur fuel will not call for any significant capital costs, since the vessels today are ready to run on this fuel without any major modifications, both when it comes to newbuilds and retrofits. However, without knowing the exact price of compliant fuels in 2020, Panasiuk & Turkina (2015) argues that it will certainly be higher than HSFO, which is the fuel burnt by the majority of the vessels sailing on the sea today. This implies that the operating costs of the ship will increase, should a carrier choose to comply with the new regulation by burning a low sulphur fuel. The reason being that the fuel costs will be higher compared to burning HSFO.

Regarding compliant fuels, a distinction has to be made. Because of ECA zones existing today, there are some coastal areas where a fuel with a sulphur content higher than 0.1% is not accepted. Therefore, there is already fuels available with a sulphur content lower than 0.1%, in this study referred to as ultra-low sulphur fuels (ULSFO). Looking at the price development for this kind of fuel, it is significantly more expensive than HSFO, as found by index prices (Bunkerworld, 2019). However, because of the new global cap in 2020, there is a need for a fuel with a sulphur limit between 0.1% and 0.5%. Starting in 2020, it is therefore most likely that there will exist two types of compliant fuels with different levels of sulphur m/m (Abadie et al., 2017). Further, Abadie et al. (2017) states that the fuel by which a ship is running is a very important factor to consider mainly because it is the largest cost item in the operational expenses (OPEX) of a vessel, which is why the price of the fuel is a very important factor when choosing what alternative to use in order to comply with the new regulation.

Whichever method the carriers chooses to apply in order to comply with the global sulphur content limit in 2020, they will have to face different challenges as well as advantages, depending of their choice of compliance. As a switch to a compliant fuel normally do not require the carrier to perform major modifications, capital costs will not change significantly as compared to, for example, installing a scrubber system. On the other hand, compliant fuels are expected to have a significantly higher price than HSFO, implying that the operational costs concerned with running on compliant fuels are higher than those connected to running the vessel with a scrubber. Another major drawback with compliant fuels is that the availability is uncertain. Which could result in a situation where the carrier is forced to run on the even more expensive ULSFO although sailing on global water where a 0.5% fuel would be sufficient. Finally, this method of compliance is suitable both on new ships and for retrofitting (Panasiuk & Turkina, 2015).

3.5.2. Scrubbers

Another SOx reduction measure in order to comply with the new regulation is to install a scrubber on the vessel. Either by retrofit or on newbuilds. The global sulphur cap 2020 states that vessels are not allowed to run on fuels with a sulphur m/m exceeding 0.5%. By installing a scrubber system, the carriers will be able to continue to run their vessels on HSFO, despite the sulphur content in HSFO is on average 2.7% (Mestl, Løvoll, Stensrud & Le Breton, 2013). The reason to this is that the scrubber system "cleans" the exhaust gas from sulphur oxides and particulates. Meaning that vessels can run on HSFO with a sulphur content way over the limit of 0.5% without practically any sulphur emissions. In newbuilds, a scrubber system can be installed in the vessel from the beginning. However, when retrofitting a ship, several parts such as the funnel structure, deck platforms and ladder, and exhaust gas pipes needs to be removed. In addition, every part of the scrubber system needs to be attached to the ship (Klimt Nielsen & Schack, 2012).

In comparison with running a vessel on a compliant fuel, the installation of a scrubber implies lower operational costs due to the cheaper fuel, but higher capital costs due to the relatively large investment and complex installation (Zis & Psaraftis, 2017). In addition, while a scrubber installment enable the carrier to continue to run their vessels on HSFO, the scrubber installation itself takes time and eventually increases the fuel consumption of the ship with approximately 2.5% while at the same time taking up cargo space which reduce total profit (Brynolf, Andersson & Fridell, 2014). There are mainly two types of scrubbers, wet and dry. Because of their relatively lower price and smaller size, wet scrubbers are the ones often used on ships. Three types of wet scrubbers are currently offered by manufacturers, these are open loop, closed loop, and a hybrid. The open loop scrubber only uses sea water and is relatively cheaper. However, it cannot be used in areas with stricter sulphur regulations, such as the Baltic Sea. The closed loop scrubber uses a mix of fresh water and caustic soda and is approximately 20% more expensive than an open loop scrubber. Finally, there are hybrid scrubbers which is a combination of an open and a closed loop scrubber (Panasiuk & Turkina, 2015).

Section 3.5 has elaborated on the different viable alternatives in order to comply with the new regulation. These alternatives imply the use of different fuels, which are expected to differ in terms of price. The next section will thus provide a theoretical foundation for the fuel price projections applied in this study in order to calculate on cost implications for the Ro-Ro sector as a result of the IMO global sulphur cap 2020.

3.6. Fuel Price Projections

Regardless which alternative is used to comply with the global sulphur cap in 2020, the cost of fuel is a considerable expense for a carrier (Notteboom & Vernimmen, 2009), thus making the future fuel price a determining factor in regard to the cost implications of the global sulphur cap for the shipping industry. However, there is high uncertainty regarding what the price for fuel will be, while the general expectation is that the fuel costs will increase, which has led to a number of estimations of what to expect (IBIA, 2017). These estimates varies between speculations of industry experts to extensive analyses of the refinery and shipping industry, that ranges from \$560/ton (IBIA, 2017) to \$1042/ton (EnSys Energy & Navigistics Consulting, 2016) for petroleum fuels compliant with the global sulphur cap in 2020, while estimates of the non-compliant HSFO can be found between \$200/ton (IBIA, 2017) and \$471/ton (EnSys Energy & Navigistics Consulting, 2016). The various price estimations are derived from different scenarios based on projections and assumptions regarding demand and supply, including considerations of e.g. uptake on scrubber systems, capacity expansion for the refinery sector, or to what extent actors will comply with the regulation.

Among the various estimations that has been made, there are two marine fuel availability studies, that through thorough analysis of refinery capacity and shipping industry demand, provided fuel price projections for different scenarios. CE Delft (2016) & EnSys Energy & Navigistics Consulting (2016) presented opposing fuel availability studies, while there was an ongoing debate of whether the regulation should be postponed, due to there being an insufficient supply of compliant fuels as to January 1st, 2020 (S&P Global Platts, 2018). In the light of the debate whether fuels would be sufficiently available, IMO commissioned the study by CE Delft (2016) as to inform them in the decision of the implementation date of the regulation. To provide additional insights and a 'second opinion', EnSys Energy & Navigistics Consulting (2016) conducted the supplemental fuel availability study, funded by associations from the energy and oil sector and shipping industry. The cases and fuel price projections found in the fuel availability study by CE Delft (2016) and the supplemental fuel availability study by EnSys Energy & Navigistics Consulting (2016) will be discussed in the following section.

3.6.1. CE Delft - Assessment of Fuel Oil Availability

In 2016, CE Delft, together with Stratas Advisors; UMAS; NMRI; Petromarket Research Group; and Shinichi Hanayama, was commissioned by IMO to assess the fuel oil availability in 2020, specifically whether fuels compliant with the global sulphur cap of 0.5% will be sufficiently available (CE Delft, 2016). Estimates for future demand for marine fuels, refinery supply capacity and the global refinery sector capability to produce compliant fuels were investigated to thoroughly assess fuel oil availability. The estimates for demand was achieved through three scenarios using the projections of IMO's third GHG study; a *base case* which considered growth in transport demand, fleet renewal, and an uptake for the use of scrubbers; an even higher growth in transport demand and fleet renewal for a *high case*, however a lower expected uptake on scrubbers, resulting in an increased demand for compliant fuels; and lastly a *low case*, which mirrors the high case. The cases reflect the demand for compliant fuels (fuels with a sulphur content lower than 0.50%), which means that the *high case* infers a higher than expected demand for compliant fuels, while the *low case* infers a lower than expected demand for compliant fuels.

Table 2: Fuel demand projections for three types of fuels expressed in million tons/year for the base case, high case and low case, from CE Delft (2016)

Sulphur content (%m/m)	<0.1%	0.1% - 0.5%	>0.5%
Base Case	39	233	36
High Case	48	290	14
Low Case	33	198	38

In determining whether fuel oil would be sufficiently available in 2020, CE Delft (2016) made fuel demand projections for the three cases, in regard to the demand for different levels of sulphur content in fuels. These demand projections can be found in Table 2. The projections show that an increased demand for petroleum fuels with a sulphur content of 0.1% - 0.5%, thus moving from the base case to the high case, result in increased demand for fuels with a sulphur content less than

0.1%, whilst the demand for fuels with a sulphur content above 0.5% decreases. As the description of the *high case* states a lower uptake on scrubbers, a decreased demand of fuel with a sulphur content higher than 0.5% is expected, since using this type of fuel only is allowed with scrubbers installed.

This projection of the future demand, consequently, indicate the share of the compliance alternatives chosen to comply with the global sulphur cap, for each of the different cases. Hence, estimates as to what extent carriers will go for either compliant fuels or scrubbers to comply can be found.

An analysis of the refinery sector, specifically regarding the capacity of refineries, led to projections of the supply of compliant fuels in 2020. CE Delft (2016) made the conclusion that the refinery sector will have the capability to supply sufficient quantities of marine fuels compliant to the global sulphur cap in 2020 for the three cases, mainly due to an increased capacity in the processes of desulphurization among refineries. Supply is estimated to exceed demand by 24% for the base case and 2% for the high case, however this estimate assume that some regions that lack refinery capacity will have access to large volumes of sweet crude, which is crude oil that has a natural low sulphur content (Wlazlowski, Hagströmer & Giulietti, 2011). Furthermore, delays of capacity expansion projects and unexpected downtime for refineries, changes in the global crude availability or emergence of new marine fuel blends could lead to a diverging result from that of the supply projection. Such diverging scenarios may be conceivable, yet it is unlikely that the supply of compliant fuels will be insufficient nevertheless (CE Delft, 2016).

In the assessment of marine fuel availability, CE Delft (2016) projected crude and refinery product prices. Historical records for the price of crude and marine fuels with various levels of sulphur content was used as input for the fuel projections (see historical figures 2010-2016 in Table 3). The aforementioned *base case* was assessed in regard to the supply and demand projections in order to model prices in 2020, which can be found in Table 2. However, since there are no historical records of prices for refinery products of fuel oil with a sulphur content of 0.5%, this projection is based on the assumption that such a fuel will be cheaper than MGO with a sulphur content of 0.1% and more expensive than fuel oil with a sulphur content of 1%, resulting in a 47$/ton price differential and thus creating a span for the price of fuel oil with a sulphur content of 0.5% (CE Delft, 2016).

Table 3: Refinery products and crude oil prices expressed in USD/ton, historical data and projections (CE Delft, 2016)

Fuel Type	2010	2012	2014	2016	2018	2020
MGO 0.1% m/m	672	997	896	452	552	616
Fuel Oil 0.5% m/m	N/A	N/A	N/A	N/A	N/A	595
Fuel Oil 1% m/m	625	918	809	390	497	569
Fuel Oil 3% m/m	521	741	616	252	377	466
Brent Crude (USD/bbl)	80	112	99	49	63	77

These fuel price projections are only made for the *base case*, however, as these prices are highly influenced by input costs (crude price), GDP, geopolitical risks and most importantly, demand and supply (CE Delft, 2016), fuel price projections for another scenario, such as the case of low demand or high demand would provide a different result.

3.6.2. EnSys Energy & Navigistics Consulting - Supplemental Marine Fuel Availability Study

In 2016, as a response to the report produced by CE Delft, EnSys Energy and Navigistics Consulting conducted a report focusing on the capacity of the refining industry to meet the expected demand of fuels compliant with the IMO Global Sulphur Cap 2020. The purpose of this report was to project the availability of compliant fuels, using projections of supply and demand which are described below (EnSys Energy & Navigistics Consulting, 2016) in order to evaluate the compliant fuel availability in 2020, and to provide additional insights to the report conducted by CE Delft. The conclusion from this report was, in contrast to the report conducted by CE Delft, that a relatively small amount of the vessels worldwide will run on scrubbers by the end of 2019. Meaning that the refining industry will not be able to sufficiently supply the demanded quantity of fuels compliant with IMO's global sulphur content limit in 2020, i.e. fuels with a sulphur content less than 0.5%.

Like CE Delft, the EnSys report aim to project the demand on compliant fuels when the new regulation comes into force, in January 2020. By projecting the future demand, EnSys investigates whether the refining industry will have sufficient capacity in order to supply the expected demand on compliant fuels. The reasoning and logic behind the demand and supply projections are explained below.

The demand analysis of the EnSys report, based on IMO´s third GHG study, is conducted by evaluating the future potential of the scrubber system. It is assumed that a greater potential of scrubbers will result in a higher demand, and in turn a lower demand of compliant fuels. Further, the projections of "base" demand of marine fuels are assessed, in order to finally project what volumes of HFO that will have to be "switched" to low sulphur compliant fuel.

EnSys created a survey for the members of the Exhaust Gas Cleaning System Association, focusing on the actual number of scrubber systems already installed, and the number of scrubber systems to be installed before the end of 2019. This survey showed that the adoption of scrubber systems in vessels by the end of 2019 will be fairly low. More specifically, the projected number of vessels to run with a scrubber system by 2020 equals to the use of 48 million tons of HFO. Further, EnSys project the amount of marine fuel consumption including a speed increase of the ships to be 342 million tons. Out of these 342 million tons of marine fuel, 205 million tons of HFO will have to be switched to 195 million tons of low sulphur fuel, which is illustrated in Table 4 below. EnSys further states that a greater increase in the speed of the ships could result in "*switch volume*" of up to 209 million tons of low sulphur fuel. In addition, EnSys projected the expected demand of HFO in 2020 if the new regulation would exist compared to if it would not. This projection shows that the expected demand on HFO, should the regulation be implemented, would decrease from 253 million tons per year to 48 million tons per year (see Table 4 below). In order to get an understanding of the needed capacity of the refining industry, EnSys applied a projection of the global demand for crude oil in 2020. This projection was based on the IEA outlook which projected a global demand for crude oil of 98.9 million barrels per day (mb/d).

Table 4: Expected fuel demand expressed in million tons/year without and with the IMO global sulphur content limit in 2020, and the switch in demand required going from the first scenario without the regulation to a scenario with the regulation, according to EnSys & Navigistics Consulting (2016).

Navigistics Scenario:	Without the 0.5% Limit	With the 0.5% Limit	Switch
HS HFO (3.5%)	253	48	205
Compliant Fuels (<0.1% & 0.1% - 0.5%)	88	283	195

The supply projections conducted by EnSys was based on their estimates for the capacity of the refining industry, including ongoing and finished expansion projects. Regarding the expansion projects, EnSys projected them to result in an addition of 5.6 mb/d of new distillation capacity, 3 mb/d of upgrading capacity, and 3.6 mb/d of desulphurization. Together with the base capacity in January 2016, EnSys projected a 2019 refining capacity of 101.7 mb/d.

Based on the demand and supply analyzes conducted by EnSys, the conclusion presented states that the refining industry will not possess sufficient capacity to supply the projected demand (195 million tons/year) on fuels compliant with the IMO global sulphur cap 2020. The reasoning behind this conclusion is that the current base capacity plus the future projects to be finished by the end of 2019 will not be enough to reach an adequate capacity. EnSys points out that hydrogen plant capacity would have to expand with another 35-50% as compared to the projects that are ongoing or scheduled today. While, according to EnSys this would be possible, there is still a need for an expansion of the sulphur plants with another 60-75% compared to the ongoing and scheduled projects today. Meaning that full compliance with the IMO Global Sulphur Cap is not possible by 2020, since the refining industry will not have the capacity to supply the expected demand on compliant fuels combined with other kind of oil related demands.

In addition to the supply and demand analysis by EnSys, they present two different scenarios regarding the degree of MDO versus heavy fuel in the future compliant fuel. Since the 0.1% sulphur fuel that have been available for a while have sometimes contained heavier fuels to some extent, EnSys find it unlikely that the new 0.5% sulphur fuel will be a 100% marine distillate, which is a lighter fuel. Hence, the two scenarios presented by EnSys is the High MDO and the Low MDO scenario. The High MDO scenario, assumes 90% MDO and 10% heavier fuel. The logic behind this situation is that, in the short term, the refining industry acts to the new regulation at an early stage by providing marine distillate that has been proven to be successful (0.1% ECA fuel). In the long term this scenario is explained by possible technical issues that limit the acceptance of heavier fuels. The Low MDO scenario assumes a higher degree of heavier fuels, more specifically 50% MDO and 50% heavier fuels. This is a scenario EnSys find more likely since heavier fuels are cheaper than distillates.

In an attempt to formulate projections of prices for IFO380 HS (0.5% - 3.5% fuels) and Diesel ULS (<0.1% S fuels), EnSys used 2015 average data for crude oil and product prices from Bloomberg and Clarkson Research Services as input data. The prices were presented for three different regions; US Gulf Coast, Northwest Europe, and Singapore. In Table 5 below, the global average of these regions is presented for IFO380 HS and Diesel ULS. In their report, EnSys Energy & Navigistics Consulting did not present a projection of a VLSFO price.

Table 5: Projected Fuel Prices as of 2020 in USD/tons (EnSys Energy & Navigistics Consulting, 2016)

	High MDO Low switch	High MDO Med Sw	High MDO High sw	Low MDO Low sw	Low MDO Med sw	Low MDO High sw
IFO380 HS (0.5%-3.5% fuels)	382.3	382.0	388.3	413.3	418.3	429.7
Diesel ULS (<0.1% fuels)	965	998	1035	934	962	1000

Until this point, the theoretical framework has been focused on providing a basis for answering the first research question. As of the next section, the focus shifts to the second research question starting off by describing the relationship between carrier and shipper, which is a vital aspect in the context of this study, particularly in regard to how VCC can adjust their BAF model in regard to the new regulation.

3.7. The Relationship between Carrier & Shipper

In large corporations the procurement function plays a vital role as keeping costs at a minimum is of great importance. Other vital aspects of the procurement function in today's business context are sustainability, lead time, flexibility and exposure to risk. With the above elements of procurement in mind, this function is clearly of strategic importance for large corporations. With the climate debate being one of the most intensively discussed topics in business today, responsible people at procurement functions are increasingly pressured to follow environmental as well as ethical guidelines. At the same time, they are often working towards a thrifty budget, causing dilemmas as to go with a cheaper, but ethically doubtful option, or vice versa. To make the procurement even more challenging, buyers also need to take into account applicable regulations and the opinions of stakeholders (Bhattacharjee, Kidd, Ghadge & Tiwari, 2019). Indeed, the procurement function of a corporation is as important as it is challenging. Hence, the relationship between the supplier and the buyer is essential for future success.

Being able to select the right supplier enables a corporation to reduce costs, gain competitive advantage, and satisfy customers by high quality, short lead times, and sustainability (Ghadimi, Azadnia, Heavey, Dolgui & Can, 2016). Almost exclusively, in any contractual agreement the supplier and the buyer´s dependence of each other is central (Ghadge, Dani, Ojha & Caldwell, 2017). The choice of supplier is a critical one for the procurement function, not the least because contracts are usually signed for several years at a time. Suppliers are usually chosen based on a thorough selection process during which important elements such as quality, punctuality, environmental impact, and ethical aspects. Kumar et al. (2015) points out several advantages for buyers of building a strong relationship with the suppliers. Some of which are reductions in costs and lead time, improvements in product design, service quality, and financial performance.

Within the industry of maritime shipping, the supplier and buyer-relation consist of the carrier (supplier) and the shipper (buyer). Because of the high competition of the shipping industry, carriers find it hard to differentiate in regard to their competitors. Hence, from the carrier's point of view long term relationships with shippers is vital in order to survive. Using the price as a way of differentiation is a short-term solution to high competition, since competitors can easily adjust their price to their competitors. However, a strong relationship between buyer and supplier includes intangible elements which makes it hard for competitors to duplicate, indicating relationship building to be a more long-term solution to the heavy competition ocean carriers are faced with (Maloni et al., 2016).

There is no doubt that cost is an important factor for the procurement function of large corporations. Cutting costs as much as possible is therefore of great importance in the carrier selection process for a procurement function. However, studies show that there are factors shippers' value higher than cost when considering which carrier to contract. Service factors such as reliability and safety are mentioned as more important (Maloni et al., 2016).

Another interesting aspect of the shipping industry to consider is the asymmetric information between the carrier and the shipper in regard to costs. Carriers possess more information regarding their cost breakdown, an important element during a contract negotiation. This also means that shippers in many cases do not know exactly what they are paying for, since a detailed breakdown of either the costs or the price is provided from the carriers, leading to an asymmetric information issue (Yang & Su, 2017).

While the relationship between carrier and shipper is a vital aspect of the second research question, the focal area is indeed the bunker adjustment factor. Hence, the next section will introduce general elements of this model, as well as crucial elements of the current BAF at VCC.

3.8. Bunker Surcharges & Bunker Adjustment

Since the fuel cost is a large proportion of the total costs for ocean carriers, the price for fuel is a critical aspect for the whole industry. At the same time fuel prices tend to fluctuate drastically from time to time, causing an element of uncertainty for the carriers. In order for carriers not to take on the full risk of fuel price fluctuations, a Bunker Adjustment Factor (BAF) is applied to the contractual agreement between carriers and shippers. Carriers use their own BAF-model to calculate the price which the shippers should pay for the fuel being consumed, which all follow the similar basic principles.

3.8.1. The Basic Principles of Bunker Adjustment

As demonstrated earlier, the bunker cost is a significant part of the total cost for a voyage. Hence, the cost for fuel will to a large extent affect the carriers, and consequently the shippers. Since the price for fuel is known to fluctuate heavily, a means to adjust their prices in regard to these fluctuations is essential for carriers (Menachof & Dicer, 2001). This means of adjustment is called the Bunker Adjustment Factor (BAF). The original idea of the Bunker fuel surcharge is to be a cost added to a base price, when fuel costs are higher than normal, i.e. cover for fluctuations in fuel prices. The base price is the contractual price for fuel agreed upon at the time of signing a contract for ocean transports. This base price usually reflects the current price level of fuels. A standard within the shipping industry is to apply a measurement period of three months. This means that an average fuel price is calculated quarterly. The average is then compared to the base price in order to see if any surcharge or deduction is necessary. Depending on what the actual price for fuel is, the BAF model accommodates for an adjustment of the agreed price between the carrier and the shipper. For example, should the actual price end up being higher than the base price during a three-month period, a BAF surcharge is added in order to compensate the carriers for what they have actually paid for their fuel (Cariou & Wolff, 2006).

3.8.2. The Elements in Existing Bunker Adjustment Models

On October 17th, 2008, the European Commission banned ocean carrier conferences. These conferences were gatherings with carriers from all around the world discussing topics such as freight rates, surcharges and common tariffs. For example, BAF models were developed jointly resulting in the shipping industry using the same BAF model globally. However, as a consequence of the prohibition of these conferences, every carrier has to formulate their own BAF model today (Wang et al., 2011). Therefore, there are several BAF models existing today, each belonging to a different carrier. In Table 6, the general elements of a BAF model are explained. In addition, a few BAF models from some of the largest ocean carriers worldwide are described.

Table 6: Elements identified in existing models for Bunker Adjustment

BAF Element	Description
Current Bunker Price	The current bunker price is a weighted average of available fuel prices gathered from the largest bunker ports in the world, usually obtained from S&P Global Platts or Bunkerworld.
Base Bunker Price	The base bunker price is the fuel price applied to the base bunker freight.
Change in Bunker Price	The difference between the current bunker price and the base bunker price is the change in bunker price.
Trade Factor	Reflect the average fuel consumption on any given trade route, including variables such as transit time, fuel efficiency, trade utilization and vessel speed. These variables are explained below.
Transit Time	The number of days from the vessel leaving the port of departure until it arrives at the port of destination.
Fuel Efficiency	The amount of bunker fuel used during the specific voyage.
Trade Utilization	An imbalance factor that express the ratio of head haul to back haul. The purpose is to take the differences in cargo into consideration. Meaning that carriers sometimes have to sail back a vessel with a large amount of empty space. This is the imbalance taken into consideration with
Vessel Speed	The speed at which a vessel is operating at sea.

3.8.2.1. Maersk Bunker Adjustment Factor

Maersk presented a new BAF model in January 1st, 2019, aimed at recovering the extra costs of complying with IMO's regulation of the global sulphur content limit in 2020 (A.P. Møller-Mærsk

A/S, 2018). The model is designed to separate volatile fuel costs from the basic ocean freight. This is done by using the current fuel price from the largest bunkering ports in the world and compare against a baseline price to calculate fuel price. This fuel price difference is multiplied with a trade factor including variables such as transit time, fuel efficiency, and trade imbalance, which should reflect the average fuel consumption on any given route (Ship & Bunker, 2018). The principle for calculating bunker consumption using Maersk BAF:

$$Fuel\ Price \times Trade\ Factor = BAF$$

A.P. Møller-Mærsk A/S (2018) explain that with only two variables and precalculated bunker surcharges on each trade lane, customers gain full predictability in planning their transports. While the *Fuel Price* can be verified by customers against index prices, the transparency of the *Trade Factor* is not as obvious, and calculated by the carrier as;

$$Fuel\ Efficiency \times Transit\ Time \times Trade\ Utilization = Trade\ Factor$$

Clear similarities can be found for BAF used for different maritime industries, while the larger container shipping liners such as Maersk and MSC (MSC, 2018) seems to be using the same two variable principle to calculate the bunker surcharge, which can also be observed for MOL's container shipping division.

3.8.2.2. MOL Bunker Adjustment Factor

A BAF model reviewed by Blom & Borisson (2008) and constructed by MOL, is used by multiplying the difference between the current bunker price and base bunker price with the average amount of fuel consumed per car. This factor is called Trade Sensitivity, similar to the Trade Factor used by Maersk, includes parameters such as Transit Time, Vessel Speed, Fuel Consumption and Trade Utilization, updated monthly.

$$(Current\ Bunker\ Price\ -\ Base\ Bunker\ Price) \times Trade\ Sensitivity = BAF$$

3.8.2.3. Chi & Dagar Bunker Adjustment Factor

In 2010, Yu Chi and Shailander Dagar developed an updated BAF formula that calculates the change in bunker cost per unit on behalf of Volvo Cars. By calculating the difference between actual and base bunker price, their model can calculate the monetary difference that needs to be adjusted by including the bunker consumed on a voyage, which is reached by multiplying bunker consumed per day with transit time in days (Chi & Dagar, 2010). The next step is to calculate the effective capacity, by simply multiplying vessel capacity with the utilization. In order to express the change in bunker cost per unit, Chi and Dagar divide the change in bunker cost with the effective capacity.

$$Change\ in\ Bunker\ Cost/Unit = Change\ in\ Bunker\ Cost/Effective\ Capacity$$

Investigating the above BAF models, it is evident that they are all very similar by their nature. However, some minor but interesting aspects separates them from each other. The Maersk and MOL models take trade imbalance into consideration. In order to adjust for backhauls where they are not able to utilize the full capacity of a vessel. Chi & Dagar's model do not consider this element, which could be explained by the fact that Chi and Dagar constructed their BAF model on the behalf of a shipper rather than a carrier. And to what extent the vessels capacity is utilized on the backhaul is not a concern of the shippers, while it is an important aspect to consider for ocean carriers. The BAF models of Maersk and MOL do not have any significant differences. Even though they have named the factor with which they multiply the bunker price difference, trade factor and trade sensitivity respectively, these factors basically include the same elements. Overall, these models share the same main purpose, which is to adjust for potentially fluctuating fuel prices.

3.8.3. The Contrasting Perspectives on Bunker Adjustment

The bunker adjustment factor has since its foundation been a central part of the contractual relationship between carriers and shippers. However, there is a difference of opinion between carriers and shippers regarding the BAF. While carriers state that BAF is necessary in order to adjust for the risk related to buying fuel and to cover for fuel costs, shippers contend that the risks associated with buying fuel that fluctuates in price is merely a part of the shipping industry that carriers should accept, or at least treat it in a more transparent way (Wang et al., 2011). Further, shippers states that BAF models are constructed in an opaque way, meaning that it is impossible to know the underlying mechanisms of the model. The reason to the shippers' desire for more transparency regarding the BAF model is mainly due to increased BAF surcharges. Leading shippers to believe that carriers utilize the model in order to add an extra, unjustified, amount to the final price and hence, using the BAF as a tool to generate revenue (Notteboom & Cariou, 2011). Another interesting aspect of BAF is highlighted by Wang et al. (2011), stating that BAF is working as a cushion for carriers protecting them from any negative effects of increased fuel costs. This statement is supported by the investigation of slow steaming among vessel operators. As found by Wang et al. (2011), vessel operators had not applied slow steaming to a large extent despite significant fuel cost increases between 2003 and 2008. Suggesting that carriers lack incentives to reduce their fuel consumption since they are merely passing on any fuel cost increase using the BAF (Wang et al. 2011). However, Raza et al. (2019) conducted a study which, among other things, highlight the fact that passing on the entire cost increase to the customers might harm the carrier. Not being cost efficient will result in carriers running the risk of losing customers to competitors, implying that carriers cannot rely entirely on the BAF to take care of any given fuel cost increase.

It should be noted that BAF is not necessarily used in all ocean transport agreements. There are two types of agreements commonly applied between the carriers and the shippers. Either the contractual agreement is based on a freight rate plus BAF, or it is solely based on an all-in freight rate. The main difference between these two types of contracts is that the all-in freight rate is not flexible in regard to fluctuating fuel prices, since the total freight rate is to be decided beforehand. Meaning that carriers have to estimate the fuel costs which should be part of the freight rate, often resulting in higher bunker shares. While this type of contract facilitates the budgeting for shippers, since they will know exactly how much they will pay for the whole contract, it also implies that they risk paying an excessive amount for fuel as a result of carriers over estimating future fuel costs (Wang et al., 2011).

3.9. The Summarized Framework

The foundation created by the theoretical framework in regard to the Ro-Ro sector of the maritime industry, the costs and pricing of ocean transports as well as the new sulphur regulation and the alternatives available in order to comply with it has highlighted the important aspects to consider when analyzing possible implications of the new regulation.

The first part of the theoretical framework, including an overview of the Ro-Ro sector of the maritime industry as well as a description of the costs and drivers worked to provide an initial understanding of the industry in regard to costs. Consequently, the following sections regarding the sulphur regulation in focus, the possible alternatives to comply with the regulation as well as projections of the relevant fuels were presented in order to give the reader insight into what consequences the new regulation can have for the Ro-Ro sector, which is vital in order to answer the first research question.

Finally, the relationship between carriers and shippers was described leading to a central part of this relationship, bunker adjustment surcharge. These two sections provided the reader with an understanding of how a shipper, VCC in this case, might be affected by the regulation. In addition, these two sections offered a valuable theoretical foundation in order to answer the second research question. In the next section, the findings from this study are presented as well as an analysis taking both the findings and the theoretical framework into consideration in order to answer the research questions of this study.

4. Findings & Analysis

This chapter presents both empirical findings as well as analyses, which is divided into three main sections, as presented by Figure 7.

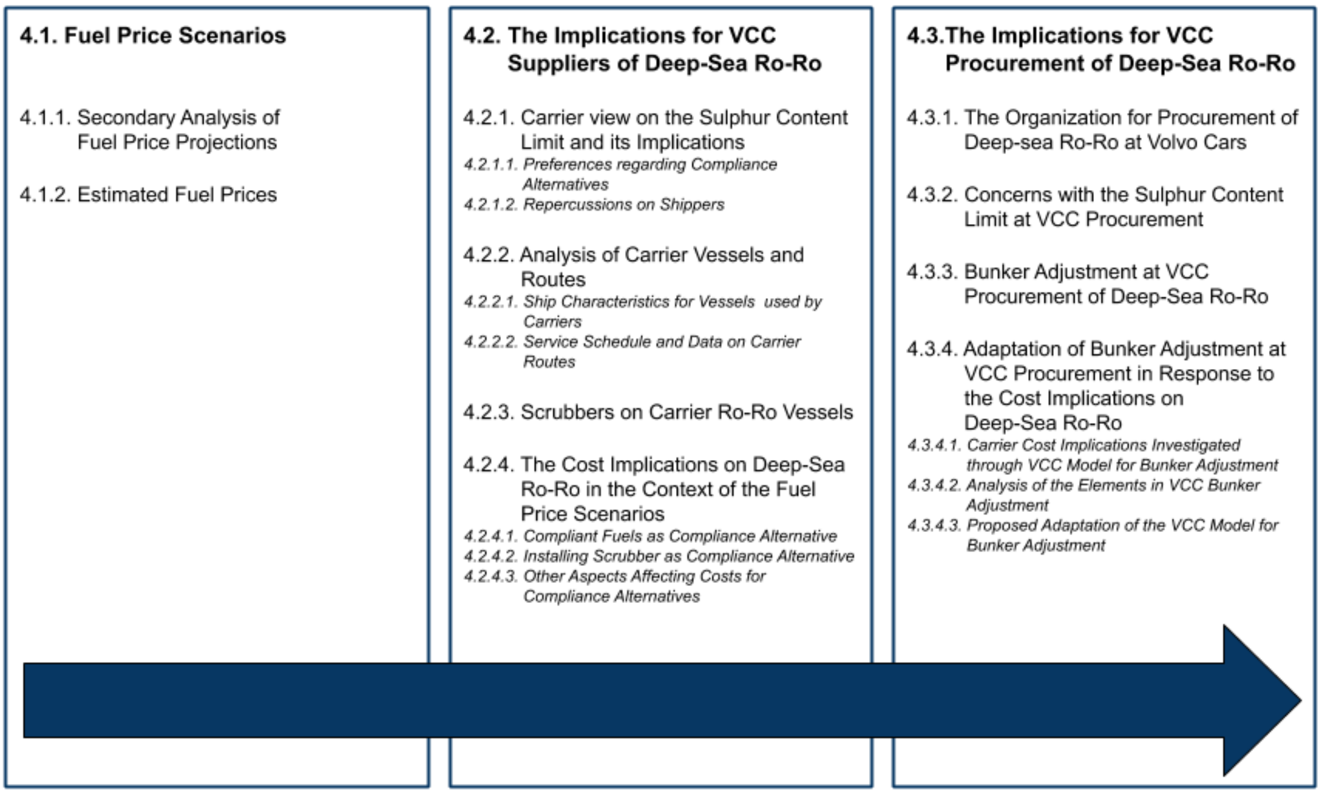

Figure 7: A disposition of the Findings & Analysis chapter in the report

Section 4.1, “Fuel Price Scenarios”, presents a secondary analysis which provides projected fuel prices used in the two other parts. Section 4.2, “The Implications for VCC Suppliers of Deep-Sea Ro-Ro”, contains empirical findings from suppliers of deep-sea Ro-Ro, as well as analyses providing basis to answer the first research question; *How can VCC’s suppliers of deep-sea Ro-Ro services be affected in terms of costs by IMO’s regulation of the global sulphur content limit in 2020?* Section 4.3, “The Implications for VCC Procurement of Deep-Sea Ro-Ro”, contains empirical findings from VCC procurement of deep-sea Ro-Ro, as well as analyses providing basis to answer the second research question; *How can the current bunker adjustment factor used by VCC be adjusted to accommodate for the cost implications of IMO’s regulation of the global sulphur content limit in 2020?*

4.1. Fuel Price Scenarios

This section focusses on the prices for fuel and where they are derived from. Firstly, the two main studies from which prices are gathered, CE Delft and EnSys Energy & Navigistics Consulting, are explained in order to provide a deeper understanding of the reasoning behind them. Consequently, all price scenarios from these studies are presented, which leads into the next part of this section *where the price scenarios formulated for this study are presented. The purpose of this section is to provide the reader with an understanding of the price scenarios used in this study, especially in regard to their role as the foundation for the cost implications being analyzed in the following section.*

4.1.1. Secondary Analysis of Fuel Price Projections

As previously discussed, a number of projections have been conducted by different researchers and experts to address the uncertainty regarding the future price of marine fuels. The fuel availability study by CE Delft (2016) & the supplemental fuel availability study by EnSys Energy & Navigistics Consulting (2016) have been investigated in detail for the purpose of analysis in this study, specifically in order to provide guidance in understanding what future fuel prices that are probable for these different cases. These cases and projection will be the basis for the three *Fuel Price Scenarios* used in this study that forms the environment in which the cost implications for the shipping industry is investigated.

A number of cases was presented by both studies, where CE Delft (2016) showed a low case, base case and high case, and the grading referring to the demand of petroleum fuels with a lower sulphur content than 0.5%. EnSys Energy & Navigistics Consulting (2016) initially presented seven different cases, with a base case assuming the postponement of the implementation date for the global sulphur cap. Since the proposal for postponing was overruled and the date for implementation fixed on January 1st, 2020 (IMO, 2019a), the EnSys base case have been disregarded for this analysis. However, in the cases where the implementation date was accepted, EnSys Energy & Navigistics Consulting (2016) used a similar approach as CE Delft (2016), grading cases based on the demand of low sulphur fuels when switching from HSFO is required, and thus resulting in the scenarios low switch, mid switch and high switch. However, the market penetration of VLSFO is also considered and to what extent the refinery industry will supply low sulphur distillate fuels such as MDO compared to VLSFO. This is expressed in two scenarios, low MDO and high MDO, resulting in the total of six different cases. The cases for CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) is summarized in Table 7.

Table 7: Cases from CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) considered for Fuel Price Scenarios

CE Delft (2016)	EnSys Energy & Navigistics Consulting (2016)	
	High MDO Cases	*Low MDO Cases*
Low Case	Low Switch - High MDO	Low Switch - Low MDO
Base Case	Mid Switch - High MDO	Mid Switch - Low MDO
High Case	High Switch - High MDO	High Switch - Low MDO

A key difference between the two studies is the assessment of refinery capacity, specifically in regard to the supply of VLSFO. EnSys Energy & Navigistics Consulting (2016) estimate a deficiency in regard to supply for every case, while CE Delft (2016) estimate supply to exceed demand for every case. This makes the comparison of absolute figures of demand between cases in the two studies to be misleading, if not considered in regard to the supply projections of the cases respectively. Therefore, the fuel price scenarios used in this study are graded by the demand in relation to its supply for the initial cases. This resulted in the structure of "*low case, mid case* and *high case*" for fuel price scenarios, where; the *low case* infers low demand of VLSFO as compared to the supply, thus supply exceeding demand; a *high case* where the demand of VLSFO is higher than its supply, resulting in supply deficiency; and lastly a *mid case*, which is a scenario between the *low case* and the *high case*. The *mid case* reflects a situation in the very middle between the figures in the *low case* and *high case*. Note that the description of these cases is the suggested classification of scenarios based on demand of VLSFO in relation to supply, in which the CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) cases can be considered.

By reviewing the cases by CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) presented in Table 7 in regard to demand in relation to supply, the theoretical cases can be used to represent the scenarios in the *low case, mid case* and *high case* structure. Since all cases developed by CE Delft (2016) estimate that supply will exceed demand, every case is viable to represent a *low case*. However, with the base case being the most probable (CE Delft, 2016), it has been chosen to represent the *low case* for the *Fuel Price Scenarios* of this study. Furthermore, the cases by EnSys Energy & Navigistics Consulting (2016) could potentially be used to represent a *high case*, since they present six cases, where all of the estimates of VLSFO demand exceeds supply. The case that most accurately represent a scenario where the supply of VLSFO is insufficient to satisfy demand, is the mid switch - low MDO case. This assessment was made in regard to; the case being a low MDO case, implying a 50% share of VLSFO in the total supply of compliant fuels; and a mid switch volume, implying that the volumes of HSFO that needs to be switched to compliant fuels will not increase or decrease due to changed fuel consumption, as the average vessel speeds is assumed to be the same as before the implementation date. Lastly, to represent the *mid case*, which reflects a situation where demand and supply are in somewhat of an equilibrium, the fuel prices are estimated by using the mean of the figures in the selected *low case* and *high case.* Table 8 summarizes the cases chosen to represent the *Fuel Price Scenarios* of this study.

Table 8: The cases and estimations used to represent the Fuel Price Scenarios

Low Case	*Mid Case*	*High Case*
Base Case *(CE Delft, 2016)*	Estimation based on Base Case *(CE Delft, 2016)* & Mid Switch - Low MDO *(EnSys Energy & Navigistics Consulting, 2016)*	Mid Switch - Low MDO *(EnSys Energy & Navigistics Consulting, 2016)*

With this set of cases chosen to represent three different outcomes regarding fuel availability in 2020, the fuel prices projected by CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) can be considered.

4.1.2. Estimated Fuel Prices

The fuels considered in these fuel price scenarios are exclusively petroleum fuels, which are classified by the sulphur content as; HSFO for fuels with a sulphur content between 0.5% - 3.5%; VLSFO for fuels with a sulphur content between 0.1%-0.5%; and ULSFO for fuels with a sulphur content less than 0.1% (IBIA, 2017). Note that the classifications are only made in regard to the sulphur content, meaning that e.g. distillate and residual fuels, can be classified as the same fuel in terms of pricing if the sulphur content are the same. Thus, the fuel price projections for fuels within the defined sulphur limits expressed by CE Delft (2016) and EnSys Energy & Navigistics Consulting (2016) were used as input for the *low case* and the *high case*, see Table 9. Specifically, fuel prices for Fuel oil (3.0%), Fuel oil (0.5%) and MGO (0.1%) from CE Delft (2016) were used to represent HSFO, VLSFO and ULSFO the *low case*. However, for EnSys Energy & Navigistics Consulting (2016), only fuel prices representing HSFO and ULSFO could be found for the *high case*, namely IFO380 HS (3.5%) and Diesel ULS (0.1%). Henceforth, in order to obtain the price for VLSFO in the event of a high case, estimations were made.

This estimate was found by assuming that the price of VLSFO is equivalent to that of mixing HSFO and ULSFO to achieve the sulphur content of 0.5%, using the prices of HSFO and ULSFO for the *high case*. The estimate was obtained through the following calculations, V representing the volume and S representing the sulphur content;

$$V_{HSFO} + V_{ULSFO} = V_{VLSFO}$$

$$\frac{S_{HSFO} + S_{ULSFO}}{V_{VLSFO}} = S_{VLSFO}$$

This resulted in a mix of 12% HSFO and 88% ULSFO, and consequently a VLSFO price estimated at \$898/ton. This price estimate is marked by [1] in Table 9.

As previously described, the *mid case* is found by using the mean of the figures from the *low case* and the *high case*. This applies for the fuel prices, which is illustrated in Table 9 by marking the estimated fuel prices for the *mid case* as [2].

Table 9: Estimated fuel prices for HSFO, VLSFO and ULSFO in 2020 for the low case, mid case and high case, expressed in \$/ton.

	Low Case	**Mid Case**	**High Case**
HSFO *(0.5% - 3.5%)*	466	442[2]	418
VLSFO *(0.1% - 0.5%)*	595	747[2]	898[1]
ULSFO *(<0.1%)*	616	789[2]	962

These *fuel price scenarios* provides projections of three potential futures; a *low case* based on the projections by CE Delft (2016), which assumes an overall increase in transport demand, fleet renewal and an uptake for scrubbers, also assuming that there is an excess supply of compliant fuels; a *high case* based on the projections by EnSys Energy & Navigistics Consulting (2016) that also projects an increase in transport demand, however with a lower estimate of the uptake of scrubbers, while the supply of compliant fuels are insufficient, consisting of 50% ULSFO and 50% VLSFO; and lastly, the *mid case* that assumes an increase in transport demand, however with an expected uptake on scrubbers to be lower than the *low case*, yet higher than the *high case*, while the supply of compliant fuels will be more or less sufficient if a portion of the demand of VLSFO is substituted by ULSFO. The high uptake on scrubbers in the *low case* creates a higher demand for HSFO, causing HSFO prices to be higher than in the other cases where the uptake of scrubbers is lower. The price differentials VLSFO - HSFO and ULSFO - HSFO are thus amplified in the *mid case* and *high case*, as HSFO prices decrease, while prices for the compliant fuels increase.

While forecasting future fuel prices is practically an educated guess, this set of cases enables the investigation of cost implications, which would be otherwise impossible. Hence, a context can be framed, which is made for the three separate cases in this study. However, in order to understand the extent of implications on VCC procurement of deep-sea Ro-Ro in the context of these fuel prices, the effects on the industry itself must first be understood.

4.2. The Implications for VCC Suppliers of Deep-Sea Ro-Ro

Section 4.2 focus on the shipping industry, in particular the deep-sea Ro-Ro sector, and what implications the IMO global sulphur cap 2020 might have on them. The first two parts of the section describes the Ro-Ro carriers' views in regard to preferences of compliance alternatives as well as an explanation of repercussions for shippers as a result of the new regulation, according to the Ro-Ro carriers. The section continues by presenting and analyzing data found in regard to the specific vessels and routes on which the interviewed carriers operate. Towards the end of this section, the presented data is used in order to investigate the potential cost implications on the deep-sea Ro-Ro carriers resulting from the two compliance alternatives; compliant fuels and the usage of scrubber systems, which in turn constitutes the foundation for answering the first research question; How can VCC's suppliers of deep-sea Ro-Ro services be affected in terms of costs by IMO's regulation of the global sulphur content limit in 2020?

4.2.1. Carrier view on the Sulphur Content Limit and its Implications

During this study, seven interviews were conducted with current suppliers of transport to VCC. Six of the interviews were with Ro-Ro carriers. In addition, one interview was conducted with a freight forwarder that VCC is currently using. Information gathered through the interviews regarding the carriers´ point of view on the global sulphur cap 2020 are presented below.

4.2.1.1. Preferences regarding Compliance Alternatives

An important aspect to consider regarding possible implications of the new regulation is how ocean carriers plan to be compliant with it, i.e. if they are planning to run their vessels on VLSFO, install scrubber systems, or apply another compliant method. From the interviews conducted during this study it is clear that using VLSFO is by far the most popular option. Out of the six Ro-Ro carriers that was interviewed, five stated that their plan is primarily to bunker VLSFO to be compliant. Two carriers added that they have invested in scrubbers to some extent and that they are discussing whether or not to increase the number of vessels with scrubbers installed. While the oil and refining industry has indicated that the supply of VLSFO as of January 1st, 2020 is uncertain, carriers seem to rely on the oil industry to be able to supply the demanded amount. Only one carrier expressed that they are awaiting the actual supply of VLSFO before taking a decision on how to comply. As of today, they have made some investments in scrubbers, and are discussing to invest more. However, they state that there is a lack of supply of scrubbers on the market at the moment. Further, this carrier explained that they will run their vessels on scrubbers if it is a sufficient alternative, meaning that the prices for the fuel are not unjustifiably high. From the interviews it can therefore be said that most carriers plan to run their vessels on VLSFO as a first alternative. However, installing scrubbers is an alternative being discussed, and some carriers has even begun to install scrubbers in order to mitigate the risk of supply insufficiency of VLSFO. This was confirmed by the interview held with a freight forwarder who interacts with many carriers. This freight forwarders picture of the initial period of the new regulation is that the majority, about 90%, will rely on VLSFO as a means to comply.

Among the carriers interviewed, there is a consensus that VLSFO seem to be the best alternative of compliance if it is available. The reason is mainly that the transition from running a vessel on HSFO to VLSFO is relatively smooth and does not infer any significant capital investments. Since costs are very important in this industry, this is a strong argument for VLSFO. However, there is also consensus regarding the uncertainty related to VLSFO. There are mainly two uncertainties. First, no one seem to be sure whether the fuel will be sufficiently available from January 1st, 2020, even though some of the carriers stated that they have secured a sufficient amount for themselves, they are not sure that VLSFO will be available for everyone. The second uncertainty regards the price. Not one of the carriers really knows how much VLSFO will cost during the initial period of the new regulation, and as a very cost dependent industry, this is a vital aspect to consider for actors within the carrier industry.

While it is agreed that VLSFO seem to be the best alternative to comply with the new regulation, the carriers interviewed acknowledge that the scrubber alternative also is a possible option. For example, one carrier states that this is the cleanest option. However, from the interviews it is clear that the large investment related to scrubber installments is an aspect that do not work in favor for this alternative. In addition, vessels that are to be run on scrubbers needs to be taken out of business for a time when the scrubber system is being installed. Another aspect of scrubbers mentioned by carriers is that there are regulatory uncertainties with this alternative. Some countries have already banned certain types of scrubbers, and if scrubbers are banned this large capital investment would be for nothing. Nevertheless, three out of the six carriers that was interviewed have installed scrubbers on a smaller amount of their fleet. The reason being to spread the risk and reduce costs if VLSFO were to be very expensive or insufficiently available when the new regulation applies. Further it is mentioned that which compliance alternative that is best depends on the ship type. Since different ships has different characteristics such as age and size, it is not possible to say that one single alternative is the best fit for all ships. However, retrofitting is a very complex process on Ro-Ro ships, which is why VLSFO is mentioned by most of the carriers as the best alternative for these kinds of vessels. Some of the carriers also believes that the price of HSFO will stay practically the same after the application of the new regulation, meaning that there are no significant fuel price uncertainties regarding the scrubber alternative.

4.2.1.2. Repercussions on Shippers

During the interviews with the carriers they were also asked to provide their view on how shippers (in this case VCC) will be affected by the new regulation. From these interviews it is clear that carriers believe that their industry is not capable of taking the potential increased costs of the new regulation, and hence they should take potential extra costs as a result of the new regulation.

Regarding how a potential increase in costs will be visible for shippers is not clear, but most of the carriers believe that the most appropriate way to handle this increase is to simply add the new fuel to existing BAF models. Meaning that the BAF itself will not change that much, but a new figure for the compliant fuel will be added. Also, the limit for bunker share on freight rate that VCC use in their BAF models today need to be adjusted, since the limits today will mean that carriers will not be compensated if the fuel prices increase. This is understandable considering the current share of bunker on carrier costs, which is around 37% on average for most of the carriers interviewed. However, this was disclosed as broad ranges of the bunker share for their services, meaning that this figure could be significantly higher or lower for a certain voyage, depending on the specific circumstances for said voyage.

One of the carriers further stated that it is not right to have a limit on the bunker share. Since fuel prices can fluctuate heavily the Bunker Share included in the BAF model should be more flexible. The majority of the carriers was clear on the point that any increase in price from their point of view is solely a result of increased costs, they will not use the BAF model to get paid excessively but rather to be fairly compensated.

Otherwise there are not any demands from the carriers that BAF models need to be adjusted heavily. The main change is that the price for the new fuel will be calculated for in BAF models after the application date of the new regulation. However, no carrier sees any strong incentives to change their current measurement periods of three months used in the BAF today. Even though a lower measurement period, e.g. one month would be better, it would imply to high administrations costs. Further a longer measurement period, e.g. six months would imply too large lags. One carrier suggested that a one month-period would be better for short term contracts. Apart from that, all of the carriers interviewed was satisfied with a three-month measurement period of fuel prices.

Furthermore, as there are heavy investments related to scrubber installment, such investments are certain to have implications for shippers, according to the carriers that have chosen to use this alternative to some extent. However, they cannot say at the moment when or how these investments will affect shippers. Some carriers also raised a concern that few companies are willing to pay for “green” investments, which makes scrubber investments hard to lay on the customers. Nevertheless, a scrubber investment is an alternative to comply that will have implications for the customers, which is likely affect shippers as other carrier investments do; through standard freight rates. If these freight rates will increase or if the scrubber investments can be carried by the carriers themselves by keeping their current rates, is likely to vary between carriers.

To summarize the interviews held with carriers, it can be stated that none of the carriers interviewed think that lead times will be affected by the global sulphur cap 2020. However, the shipping industry cannot stand for the potential increased costs. Instead, this is a cost that, according to carriers, the shippers will have to stand for. Meaning that the new regulation will have commercial implications for shippers, assuming that the price for the new compliant fuel will be higher than the price of HSFO. The extent of what these commercial implications will be, is evidently related to the fuel consumption, meaning that besides the price of fuel, the routes operated by these carriers and the characteristics of their vessels is important to consider in order to estimate the extent of the cost implications, and therefore requiring an analysis of their currently used routes and vessels.

4.2.2. Analysis of Carrier Vessels and Routes

In order to perform calculations on cost implications of the two compliance alternatives, data regarding specific routes and the characteristics of the vessels used on these routes were collected. This was done through several interviews with Volvo Cars´ Ro-Ro carriers and from sailing schedules presented on each carrier´s website. Data on vessel characteristics was further triangulated by using historical figures, based on the vessel type described by Ro-Ro carriers. This supplementary quantitative data was obtained by the help of Marine Benchmark and through their database, whom has stored AIS-data on vessels since 2009 to provide customized analysis of maritime data. The AIS data, meaning data obtained utilizing the automatic identification system, is collected through transponders installed on every vessel worldwide and provides spatial data on vessel position. Furthermore, supplementary quantitative data was also collected on the specific routes, using online maritime GIS software. Specifically, this data was used to measure distances between the port calls on routes. Lastly, data on scrubber pricing was also obtained with the help of Marine Benchmark.

4.2.2.1. Ship Characteristics for Vessels used by Carriers

It was found that the vessel characteristics of ships used on the routes varied in terms of size and age, not only between carriers but also in many cases between the vessels a carrier uses for the same service. Since all carriers are involved in deep sea Ro-Ro shipping of finished vehicles, the vessel types used on these routes were limited to PCTC, PCC, Ro-Ro and Ro-Con, however most frequently type used was the PCTC, with very similar ship characteristics. This resulted in a range of averages for the vessel age between 8-12 years for 91% of the routes, with a few exceptions including some brand-new vessels and some vessels situated towards the end of their lifecycle. Regarding the respective capacity of the vessels, it was found that the majority of the carrier's Ro-Ro-fleets could be found in a relatively narrowed scope of capacity, ranging from 6000 to 7500 CEU. Some carriers also operate vessels with either lesser or greater capacity, resulting in an overall average capacity for all the vessels accounted for of 6400 CEU, which is a capacity equal, or close to, the majority of the vessels included in the study.

By considering this ship type and range of capacity and age, supplementary quantitative data could be obtained for all vessels with the ship specifics: PCTC vessels, 8-12 years and 6000 - 7500 CEU. Only information on vessels operated by the carriers interviewed was obtained, which was a total of 186 vessels.

Another important aspect to take into consideration when calculating cost implications of the new regulation is the speed at which a vessel is sailing. Based on the interviews all carriers appear to operate at a speed, or close to a speed, which could be considered slow steaming. Some carriers stated that rather than slow steaming, they operate at an optimal speed in terms of both fuel consumption and transit time. However, this speed tends to be within the range or close to what could be considered slow steaming. It should be noted that the speed at which a vessel is running depends on many factors which is hard to anticipate, such as weather conditions. Hence, the data on speed provided by the carriers are averages. Calculating all the averages collected resulted in an average speed of 15.9 knots, a speed which is considered slow steaming. Coincidentally, the supplementary quantitative data showed an average steaming speed of 15.9 knots as well for the 186 vessels.

Further, in order to calculate the cost implications of the new regulation, the fuel consumption needs to be accounted for. As with the operating speed of a vessel, the fuel consumption depends on several factors such as weather conditions and at which speed the vessel is running. Hence, the data collected regarding the fuel consumption are ranges. Close to 90% (88%) of the vessels could be found within a fuel consumption range of 35-50 tons per day. A small share could only provide a broad range of their fuel consumption which is why their data was not included when calculating the average for all carriers. However, the average fuel consumption for the greater majority of the carriers was calculated to 42.5 tons per day. The fuel consumption found in the supplementary quantitative data was less dispersed between carriers than found in the interviews, while the resulting average differed by as little as 1.5%.

4.2.2.2. Service Schedule and Data on Carrier Routes

An interesting aspect found out during the interviews with the carriers is that the voyages for Ro-Ro´s on their trade lanes can differ significantly. In contrast to container freights, who run on predetermined schedules, the exact voyage for a Ro-Ro is not fixed to a rigid schedule. The number of port calls and where these ports are located, depends on the demand. Meaning that one voyages between e.g. Zeebrugge and Charleston, can look very different if compared to the next voyage for that service schedule.

In Table 10 below, data on the specific routes are presented for each route respectively. This includes port of departure and port of arrival, number of port calls and scheduled transit time, which was found through the interviews and official service schedules or a specific voyage on the carrier home page. The number of port calls and transit times often varies between voyages for carriers, which was expressed by the carriers themselves and in their schedules. The same service can vary between having nine port calls to having none, depending on the cargo on the specific voyage, consequently also affecting the transit time, which is the reason that many Ro-Ro carriers doesn't have rigid schedules, but rather a description of their service. A specific voyage could be found to represent two of the routes, resulting in a set number of port calls and transit time. For the other routes where no specific voyage could be found, the number of port calls was considered as if a voyage would be made with all port calls stated in the sailing schedule between port of origin and port of destination, also inferring the scheduled transit time for such a voyage. A sailing schedule were missing for two routes, where only a service description existed in its place, making it impossible to assume a specific transit time, however the number of port calls could be derived. Further, Table 10 shows the distance travelled inside ECA/SECA (D_{ECA}) and on global waters (D_G), an estimated transit time and the share spent inside and outside ECA/SECA for each route. The distance, expressed in nautical miles, were obtained by using online sea routing maps to find the sailing distance through fairway waters based on the assumed voyage derived from the service schedule on each route, meaning that port to port distances was investigated between each port call, divided in the distance travelled inside ECA/SECA and globally and share traveled in each one, respectively. Lastly, a transit time was estimated based on the total travel distance on route and the sailing speed of 15.9 knots, obtained from the ship characteristics of the considered type vessel. As seen in the Table 10, the service routes differ significantly in terms of number of port calls and transit time. The reason to the differences in transit times can to a great extent be explained by the fact that the trade lanes are different, and the number of port calls differs between the routes. The transit time between Charleston and Zeebrugge differs depending on the direction. This is because there are no port calls for the vessel between Charleston and Zeebrugge. However, a ship departing from Zeebrugge has three port calls before arriving to Charleston, which explains the difference in transit time on this route.

Table 10: Route specific data used in calculations

Service Route	Port calls (*N*)	Scheduled transit time (*days*)	D_{ECA}(*nm*)	D_G(*nm*)	Estimated transit time (*days*)	Share *inside* & *outside* ECA/SECA
Antwerp - Santos	8	30	1390	7218	23	16% / 84%
Antwerp - Setubal	1	6	437	1228	4	26% / 74%
Antwerp - Melbourne	9	44	648	15727	43	4% / 96%
Antwerp - Jebel Ali	7	27	648	6834	20	9% / 91%
Charleston - Zeebrugge	0	11-12	830	3767	12	18% / 82%
Zeebrugge - Toyohashi	5	40-47	1181	17255	48	6% / 94%
Zeebrugge - Charleston	3	14	2586	2390	13	52% / 48%
Zeebrugge - San Antonio	4	30	530	10526	29	5% / 95%

As found from carrier interviews, the voyages in industry of deep-sea Ro-Ro often vary, meaning that the route data are more representable as a voyage on these routes. However, in order to determine the extent of the commercial effects of IMOs regulation of the global sulphur content limit in 2020, they are considered as typical routes, on which the effects of using any of the two compliance alternatives are investigated. Nevertheless, since the commercial implications of compliance using low sulphur fuels is mostly tied to the fuel prices, while the cost implications of compliance by using scrubbers on account of significant capital investments, the prices of these investments for a carrier of deep-sea Ro-Ro must be considered, in order to compare the compliance alternatives.

4.2.3. Scrubbers on Carrier Ro-Ro Vessels

In order to find carrier cost implications for going with the scrubber as compliance alternative, information regarding the capital costs for a scrubber investment on an 8-12 year PCTC vessel with a capacity of 6400 CEU was obtained. These were scrubber prices, as part of the supplemental quantitative data. The prices for the equipment itself and the price for installing the scrubber on our type vessel is considered a capital cost, or CAPEX, for a carrier that makes the investment. Due to non-disclosure clauses, the exact figures on these prices cannot be disclosed, and are only presented in a manner which provides insight to how different scrubber types are priced in relation to each other. However, the exact prices were used calculating cost implications.

Prices were found on two different type of scrubber systems, *open loop scrubbers* and *hybrid scrubbers*, where the equipment cost for a hybrid system was ca 10% higher than for an open loop system. The equipment cost only varies between these two types of systems for the considered vessel type and size, however, the size of the system itself is dimensioned for the ship engine, meaning that a larger engine would require a larger system and consequently a higher price. But for this case, the engine power is considered the same for the type vessel.

Further, the capital cost could vary heavily depending on the installation cost, which in its turn depends on the scrubber type, and if the scrubber system is being installed on a new vessel in construction or to retrofit an already finished vessel. Installing a scrubber system on a new vessel compared to retrofitting an older vessel differs by ca 40% for an open loop scrubber, and ca 60% for a hybrid scrubber. However, the installation cost could vary as much as 170% between installing an open loop system on a new build and to retrofit a hybrid system, resulting in a total capital cost differential of 180% between these alternatives. The installation costs when going for a retrofit option are not nearly as high for a bulk or tanker vessel with the same scrubber equipment, showing an installation cost differential between new build and retrofit that is half of that for a Ro-Ro or PCTC vessel, implying that retrofitting a PCTC vessel requires a larger capital investment than for other vessel types.

Furthermore, it was found that, besides from the capital cost, a scrubber investment induces additional operational costs, OPEX, in terms of slightly increased fuel consumption, however it was unclear to what extent. Therefore, the OPEX was calculated considering an increased fuel cost of 2.5%, based on the additional fuel consumption found by Abadie et al. (2017) & Klimt Nielsen & Schack (2012), which were used for calculating the cost implications of using scrubbers as compliance alternative on each route.

By assuming that the suppliers of deep-sea Ro-Ro use a vessel with the average ship characteristics found on their specific routes investigated, and additionally, in the event of equipping such a vessel with scrubber by using the assumptions described in this section, the potential cost implications of IMO's regulation of the global sulphur content limit in 2020 can be investigated by contrasting the two compliance alternatives in the context of the fuel price scenarios developed. The analysis of these cost effects is presented in the following section.

4.2.4. The Cost Implications on Deep-Sea Ro-Ro in the Context of the Fuel Price Scenarios

The route specific data, vessel characteristics of the type vessel used on these routes, and the costs of installing and running a scrubber on such a vessel were investigated in the context of the three fuels price scenarios, in order to estimate the cost implications of IMO's regulation of the global sulphur content limit in 2020. These scenarios are explained as: The "low case" scenario, illustrate a situation in which the demand for VLSFO is low. In turn, this means that the demand for HSFO is high, due to a high upkeep on scrubbers. The prices in each scenario logically follows these demands. The "mid case", which illustrate a scenario in between the most extreme cases in regard to the demand of VLSFO. Meaning that compared to the low case scenario, the prices for VLSFO and ULSFO are higher due to an increased demand. And consequently, the prices for HSFO is lower due to a decreased demand for this fuel. And lastly, the high case, which illustrate a situation where demand for VLSFO is high. Hence, the prices for VLSFO and ULSFO are as highest. And consequently, also the scenario with the lowest demand and price for HSFO.

4.2.4.1. Compliant Fuels as Compliance Alternative

A comparison was made to illustrate the difference between the fuel costs for carriers today and in 2020 for each of the cases, assuming they choose to run their vessels on compliant fuel. The price estimates presented in the section regarding fuel price scenarios, was used to calculate the fuel costs for a carrier running their vessels on VLSFO and ULSFO in 2020. The fuel costs for carriers today was calculated by using bunker prices collected from Ship and Bunker May 13th, 2019 (Ship & Bunker, 2019). The price used as input for the calculations are presented in Table 11.

Table 11: Fuel prices used as input, showing actual prices and estimates for HSFO, VLSFO and ULSFO.

	Today	Low Case	Mid Case	High Case
HSFO	410	466	442	418
VLSFO	N/A	595	747	898
ULSFO	592	616	789	962

Furthermore, using the average fuel consumption at 42.5 tons/day for each route, while considering the voyage transit time and the distance inside and outside ECA/SECA, a fuel consumption per voyage could be calculated for VLSFO and ULSFO respectively for each route, using the following principle:

$$Voyage\ Fuel\ Consumption_{Fuel\ Type} = Avg.Fuel\ Consumption/day \times Share\ outside/outside\ ECA/SECA$$

By multiplying the voyage fuel consumption for the fuel type with its respective fuel price, using the input prices for each of the cases, the fuel cost per fuel type were estimated for each route;

$$Fuel\ Cost_{Fuel\ Type} = Voyage\ Fuel\ Consumption_{Fuel\ Type} \times Fuel\ Price_{Fuel\ Type}$$

A fuel cost for each route for every scenario were thus obtained by the sum of VLSFO and ULSFO fuel cost;

$$Fuel\ Cost_{Total} = Fuel\ Cost_{VLSFO} + Fuel\ Cost_{ULSFO}$$

With the same principle, but using today's prices for HSFO and ULSFO, it was possible to formulate an estimated fuel cost increase for carriers running their vessels on VLSFO and ULSFO in 2020, as compared to what it would cost to run these vessels on these routes today. This was done for every route, comparing the calculated fuel costs from each case with the fuel cost today. These results are illustrated as the effect of the price of VLSFO by Figure 8.

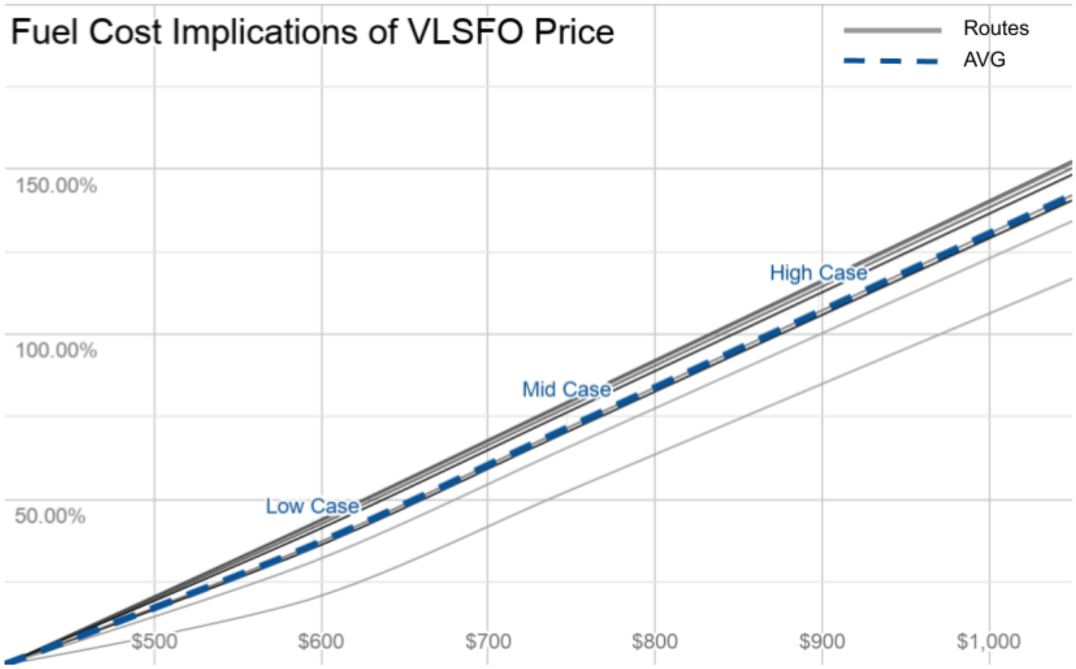

Figure 8: An illustration of the fuel cost increase depending on the price of VLSFO, in the case of switching from running vessels on HSFO to VLSFO.

The average percentual fuel cost increase for the eight routes investigated was calculated to 36%, 72% and 107% for each of the scenarios. Meaning that in the case of a scenario where the demand for VLSFO is low, those carriers who choose to run their vessels on VLSFO and ULSFO in 2020, will increase their fuel costs by 36% as compared to their fuel costs today, while if the demand would be slightly higher or very high, it would be on 72% or 107%. It should be noted that all the eight routes investigated deviates to some extent from the average, as illustrated by the gray lines. In other words, the extent to which a carrier will be affected depends on the specific route where the vessel operates. This is mainly explained by the fact that the more a vessel operates within an ECA zone today, the less affected it will be by the IMO global sulphur cap 2020. Since the limitations regarding sulphur emissions will stay the same for ECA zones in 2020, vessels will be able to run on the same fuel in these zones in 2020 as they are doing today. In other words, the new regulation will have the greatest impact on global waters, which is the area the new regulation concerns. While these effects are only estimated by assuming the use of low sulphur fuels as compliance alternative, other effects can be expected if scrubbers are installed.

4.2.4.2. Installing Scrubber as Compliance Alternative

The second aspect to be considered was the cost increase of installing and running a vessel with a scrubber system in 2020, as compared to the fuel costs for carriers running their vessels without a scrubber today. Investigating the implications of a scrubber investment required a more complex approach, since both the actual capital investment and installation of the scrubber system, which are fixed costs, as well as the operating costs for the scrubber system had to be accounted for.

The first step was to calculate the fuel costs for carriers running their vessels without a scrubber today. Meaning that they burn HSFO on global water and ULSFO in ECA zones. Hence, today's prices for HSFO and ULSFO was used in combination with the specific data for each route regarding how much time they spend in and outside ECA zones respectively in order to calculate their fuel costs today. The principle for this calculation is identical as the one carried out for estimating the fuel costs in 4.2.4.1.

Evidently, the fuel costs for using a scrubber was also calculated. Consequently, the estimated prices for HSFO in each fuel price scenario and the OPEX for running the scrubber system was used to calculate the fuel costs for carriers choosing to run their vessels with a scrubber system installed in 2020, following a similar principle as before. However, since using a scrubber allows vessels to sail inside ECA/SECA while burning HSFO, the share of the voyage spent in ECA/SECA could be excluded. Furthermore, the increased operating costs by 2.5% was also considered, resulting in the following calculation:

$$Fuel\ Cost_{HSFO} = Avg.Fuel\ Consumption/day \times 1.025 \times Fuel\ Price_{HSFO}$$

Comparing the fuel costs for carriers running their vessels without a scrubber system today, with the fuel costs for carriers running their vessels with a scrubber system in 2020, resulted in an average fuel cost increase of 8.6% and 3% for the low case and mid case respectively, while a fuel cost decrease of 2.6% was found for the high case. Note that these fuel cost changes only regard variable costs. The investment and the installing of a scrubber system also include a significant capital investment and installation cost that should be considered. Hence, the payback time of a scrubber investment was calculated.

During the calculations of payback time for a scrubber system, four different cases including two types of scrubbers was considered. These were (1) the investment and installment of an open loop scrubber on a new ship, (2) the investment and retrofit of an open loop scrubber on an old ship, (3) the investment and installment of a hybrid scrubber on a new ship, and (4) the investment and retrofit of a hybrid scrubber on an old ship. As explained in section 4.2.3, this infers different prices for installment and for the equipment itself, which were used to represent the capital cost required for using the scrubber alternative. The total cost of using the scrubber alternative is thus the sum of CAPEX and the fuel cost for each case, resulting in four different cost cases for scrubbers, in each fuel price scenario. Furthermore, in order to formulate the payback time in years, the differentials between the scrubber alternative and the compliant fuel alternative was calculated. This was done by investigating the difference in fuel costs for the scrubber alternative and the compliant fuel alternative for each route, using the following principle:

$$Fuel\ Cost_{Differential} = Fuel\ Cost_{Compliant\ Fuels} - Fuel\ Cost_{Scrubber}$$

This figure was calculated for each route and divided by the transit time on the respective route to obtain a measure for the fuel cost differential per day. The difference per day could be described as the amount, in terms of fuel costs, that a carrier will save by running their vessel with a scrubber as opposed to compliant fuels. Lastly, by dividing the total fixed costs (equipment + installment) for a scrubber with the fuel cost differential per day, the payback time in days was calculated, and expressed in years by dividing the number of days by 365.

$$Payback_{Scrubber\ Type} = \frac{CAPEX_{Scrubber\ type}}{Fuel\ Cost_{Differential}} \times \frac{1}{365}$$

Consequently, the payback time was calculated and expressed in years. This resulted in four payback times for each case, all of which are presented in Figure 9 below.

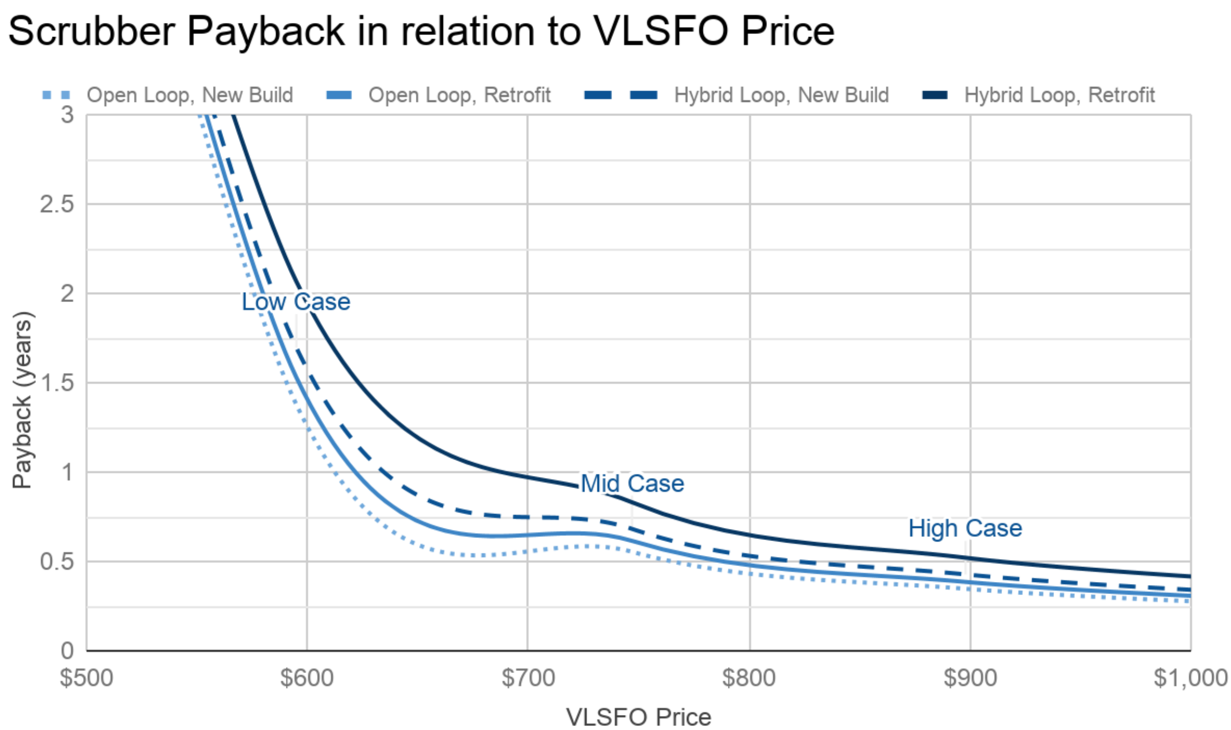

Figure 9: Illustration of the scrubber payback period in the context of the fuel price scenarios

In Figure 9, each line illustrates the payback time for a type of scrubber on either a new or old ship. For the open loop scrubber, we observe that the payback time ranges from 1.5 down to 0.3 years, depending on which case and if the ship is new or old. Regarding the hybrid scrubber, we can observe a payback time that ranges from 2.1 down to 0.4 years. Hence, a payback time for hybrid scrubbers that is slightly longer compared to the open loop scrubber, which is simply because the hybrid scrubber is the more expensive type of scrubber. Nevertheless, this means that regardless of which type of scrubber, the payback time for the scrubber system decreases the higher the demand, and consequently the price, on VLSFO. This is logical because in our estimates, the price on HSFO decrease as the price for VLSFO increase, resulting in an increased price difference between the type of fuels. And the larger the price difference, the more money a carrier will "save" each year by running their vessels with a scrubber system installed, hence shortening the payback time for the scrubber. As previously found, the compliant fuels alternative implied a significantly larger fuel cost implication compared to running the vessels with scrubber systems. Since the scrubber system alternative also calls for fixed costs regarding the actual investment and the installation cost, these also needs to be considered when evaluating this alternative. Our calculations of the payback times show that a carrier that installs a scrubber will after a maximum of 2.1 years, be able to enjoy significant cost advantages relative to their competitors that choose the compliant fuels alternative. This is because when the payback time is over, only the costs for fuel will differ between the two alternatives, where the price for HSFO is expected to be much lower than that of VLSFO and ULSFO. From our calculations regarding cost implications for the different compliance alternatives, including a consideration of the payback time, the scrubber system alternative appears to be the most cost-efficient alternative in the long term. However, there are additional aspects that needs to be considered which could potentially change the costs and payback time.

4.2.4.3. Other Aspects Affecting Costs for Compliance Alternatives

From the above calculations and analysis, we can observe many signs indicating that the scrubber technology should be the preferable method to comply the with IMO global sulphur cap. Depending on the demand and price for VLSFO, the payback time for a scrubber will be somewhere between 0.3 and 2.1 years. After this period, a carrier running their vessels with scrubber technology will be able to enjoy significant cost advantages in terms of fuel costs relative to their competitors who have chosen to run their vessels with compliant fuels. However, it should be noted that there are several additional factors that could be added to the analysis of the two compliance alternatives and hence, result in another outcome.

For example, from interviews with Ro-Ro carriers and during literature review, a common risk related to the scrubber technology is a regulatory risk. More specifically there are uncertainties whether or not scrubbers as they are designed today will be allowed on ships. In fact, some ports have already forbidden ships with scrubber technology to enter their harbor. Since scrubber systems implies large capital investments, there is a clear risk of making this investment since the technology can be obsolete, should authorities choose to ban them. Hence, a risk factor could be added to the calculations which would have resulted in another outcome possibly working in favor for the compliant fuels alternative. The reason to why the authors has chosen not to include the regulatory risk related to the scrubber technology is simply because the formulation of a viable risk factor calls for deep knowledge about the shipping industry and its regulatory environment. Simply adding an arbitrary risk factor would have made more harm than good to the outcome of the calculations and the analysis in terms of validity.

In addition, the OPEX used in the previous calculations could have included more aspects of operational costs such as caustic cost, sludge disposal charge, and cost of electric power for scrubber pumps. Adding such costs would have made the OPEX used for calculations more detailed, which in turn would have added validity to the results.

A third factor that would have made the results more reliable is the time for the installation of the scrubber system. This is a complex process which can take as long as three to four weeks, a long time in the shipping industry considering the ship can´t generate any revenues during this period. However, since the suppliers of deep-sea Ro-Ro would not disclose information regarding the revenues on the voyages, the potential loss of revenue during a scrubber installation couldn’t be considered. If this period would have been added to the calculations as a cost for the scrubber technology, it would have generated a result slightly more in favor for the compliant fuels alternative.

Furthermore, the energy content of marine fuels varies, highlighted by Aronietis, Sys, Van Hasel & Vanelslander (2016). It shows a higher fuel content for distillate fuels as compared to HSFO. This indicates that VLSFO has a higher energy content per ton than HSFO, meaning that the average fuel consumption used for calculations would require adjustment to consider the use of VLSFO. This would mitigate the cost implications for using compliant fuels and consequently, extend the payback period for scrubber investments.

It is likely that there are potential aspects not mentioned or considered that could affect the outcome of these calculations and thus the cost effects of each compliance alternative. Nevertheless, useful insights has been found regarding the potential cost effects on VCC's carriers of deep-sea Ro-Ro when IMO's new regulation of the global sulphur limit is implemented, which are crucial in order to investigate how the procurement of these transports will be affected at VCC and thus how the current process of bunker adjustment are affected.

4.3. The Implications for VCC Procurement of Deep-Sea Ro-Ro

The start of this section indicates the shift of the study focus, from the shipping industry and the suppliers of deep-sea Ro-Ro, toward procurement of these services at VCC, in the light of IMO's regulation of the global sulphur content limit. The first part describes the organization that purchases deep-sea Ro-Ro at VCC, followed by a second part where the empirical findings obtained through interviews with various actors at VCC and the concerns regarding the effects of the regulation is presented. The third part describes findings regarding the current process of bunker adjustment at VCC procurement of deep-sea Ro-Ro. Lastly, an analysis of VCC BAF is presented, using the results from the analysis of cost implications on carriers of deep-sea Ro-Ro as a foundation to answer the second research question; "How can the current bunker adjustment factor used by VCC be adjusted to accommodate for the cost implications of IMO's regulation of the global sulphur content limit in 2020?"; and consequently fulfill the purpose of the study.

4.3.1. The Organization for Procurement of Deep-Sea Ro-Ro at Volvo Cars

Volvo Car Corporation (VCC) is a multinational car manufacturer owned by Zhejiang Geely Holding. As of today, they are present on the global market and sold up to 642 000 cars in 2018, which signaled another sales record for the 5th year in a row. This global market is supplied by manufacturing facilities in Torslanda (Sweden), Ghent (Belgium), Chengdu (China), Daqing (China) and also by the most recent expansion in Charleston (US). Headquarters are located in Torslanda, together with manufacturing and other functions such as marketing, design center, product development and administrative tasks often related to the European market, but also runs the global lead for many functions in the company.

This study was performed in collaboration with one of the purchasing functions at VCC, Indirect Purchasing (IDP). IDP handles procurement of products and services which doesn't involve the parts to the car itself, e.g. machinery for the production, R&D equipment, facility management and construction or logistics. The section in focus for this study is the procurement of logistics services. These logistics services includes; the transportation of materials needed for production, handled by inbound logistics; the transportation of spare parts for after sales service, handled by global customer service (GCS); and the transportation of finished cars to VCCs car dealers and workshops across the globe, which is handled by outbound logistics. The different types of transports are illustrated by Figure 10.

Since the main focus of this study is on Ro-Ro ships, ocean freight in the outbound section of IDP is of greatest concern. The outbound section at IDP is responsible for the logistics of transports going out from VCC, such as finished cars being transported from Torslanda to retailers and end customers around the world. All finished vehicles transported by sea by uses Ro-Ro shipping almost exclusively, with a few exceptions for e.g. concept cars transported in container.

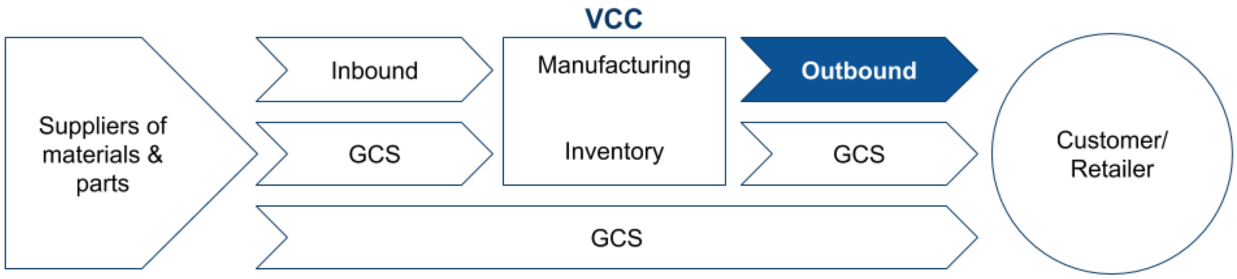

Figure 10: An illustration of purposes of transports in the VCC organization

As a buyer at IDP, you function as the interface between VCC and the supplying market of the commodity in focus, and with the task to procure the respective commodity at the lowest possible costs and in accordance with its specifications. This means that the buyer supports the internal stakeholders who formulate the specifications by processes such as sourcing, competitive tendering, negotiating and managing the supplier relationship, and consequently generate savings for VCC. In the case for the outbound section and procurement of sea freight, means that they interact with their respective stakeholders who want to ship cars to end customers and retailers, which are orders placed by the logistics function. In addition, the buyers have a tight relation with the suppliers of the ocean transports, the ocean carriers. In other words, the buyers interact on a general basis with their stakeholders at VCC as well as with different ocean carriers in order to negotiate contracts for the transport of cars. While the stakeholders' main objective is to make sure that end customers and retailers receive their orders, the buyers at VCC also need to ensure that VCC sign competitive contracts for transport, in other words the buyers objective is to sign contracts at the lowest possible cost without jeopardizing quality aspects such as delivery performance and sustainability.

4.3.2. Concerns with the Sulphur Content Limit at VCC Procurement

In this section, findings from interviews held with employees at the IDP department are presented. The focus was put on their views on the new regulations and the possible implications for Volvo Cars. These interviews were conducted with one purchasing manager, one strategic buyer, two senior buyers and one buyer.

As a heavy user of ocean transports, discussions regarding the Global Sulphur Cap 2020 has been prevalent at VCC and are getting more intense since the date of the implementation is getting closer. A common topic for all the interviews at VCC was the uncertainty surrounding the new regulation. All of the interview objects, to some extent, expressed that they are uncertain as to what consequences the regulation will have for VCC. The uncertainty is mainly derived from not knowing how the ocean carriers will act in order to comply. Which in turn makes it hard for VCC to predict how they will be affected. As aforementioned, one of the main objectives for a buyer, especially at a large corporation such as VCC, is to keep costs at a minimum. Therefore, concerns regarding if, and how, the costs will change due to the new regulation has been widely discussed at the IDP department at VCC.

As a consequence of the concerns related to the new regulation, VCC wants to be as prepared as possible for the upcoming negotiations with ocean carriers, where new prices for future ocean transports are to be set. During the interviews with employees at IDP they have expressed what they perceive to be a lack of transparency from the ocean carriers regarding the cost breakdown and pricing of their services. While indications point to the fact that costs will be affected by the new regulation, VCC as a buyer of ocean transports wants to be presented with a background and motivation to potential changes in future prices, in order to create an understanding to exactly what they pay for. With this in mind, the buyers feel that a deeper understanding of what implications the new regulations will have for the ocean carriers, in combination with what alternatives the carriers have in order to comply, will help them during future contract negotiations. The buyers explained that it is not about "winning" a negotiation in terms of signing a low price contract. Rather they want to ensure that carriers don't increase freight rates and claims that it is needed to comply with the new regulation, when it in fact has nothing to do with implications of the new regulation. Because of this, attention is put to the bunker adjustment factor, since this is the mechanism has the potential of offering some kind of transparency between the carrier and the shipper regarding the effect of fuel price changes on freight rates.

4.3.3. Bunker Adjustment at VCC Procurement of Deep-Sea Ro-Ro

As for most shippers that have long term contracts with Ro-Ro carriers today, VCC utilize bunker adjustment. With an expectancy that fuel prices will increase with the new regulation, but an uncertainty to what extent, VCC have strong incentives for using a model where the calculation of the bunker surcharges are known, since this can provide additional transparency to understand the carrier fuel costs, and consequently, help as to fairly compensate carriers for increased fuel prices without paying any kind of unjustified surcharge. However, all buyers expressed that the model being used today to determine BAF are limited in regard to IMOs global sulphur cap in 2020 and will require adjustment to accommodate for a drastic change in fuel prices, while it is uncertain as to what adjustments that are necessary and to what extent. While the goal is ambitious, the merits of a BAF is measured on its capability of reflecting the reality, while inferring the least amount of administrative work.

The current model that are used at outbound purchasing, and thus the procurement of deep-sea Ro-Ro, is used by measuring deviations of quarterly averages of bunker prices from a base bunker price set at the time of tender. If a deviation is found, the BAF is calculated as percentage of which the freight rate should be adjusted, however, only the share of bunker costs of the freight rate are adjusted by the calculated BAF. The calculations use the following principle:

$$BAF\% = \frac{Average\ Bunker\ Price\ in\ Measurement\ Period\ -\ Base\ Bunker\ Rate}{Base\ Bunker\ Rate} \times Bunker\ Share\ on\ Freight\ Rate$$

Measuring quarterly deviations is the most commonly used process to account for fuel price variations in the shipping industry, which is no exception in this case. The average bunker price is measured in during the measurement period by VCC, the BAF is then calculated and communicated to the carrier for its approval in the adjustment period and lastly applied as a surcharge during an application period. This process is illustrated by Figure 11.

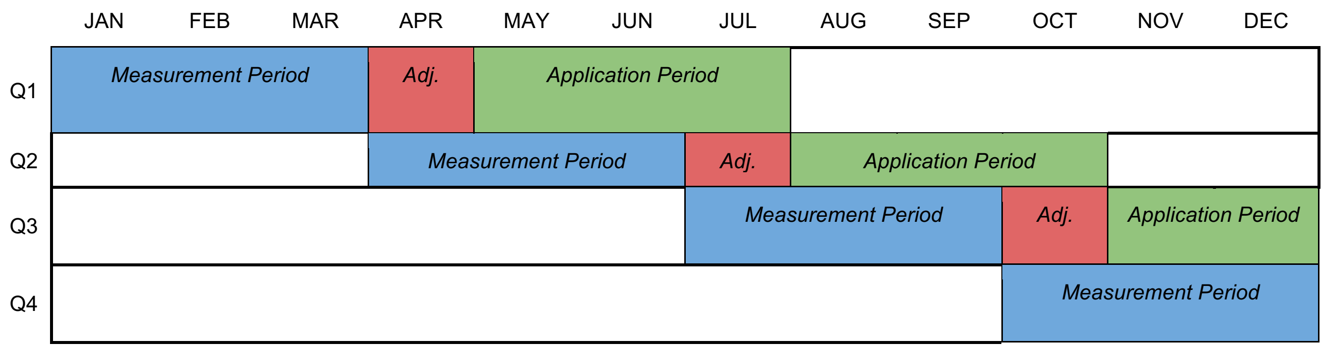

Figure 11: An illustration of the process of measurement, adjustment and application of BAF

As evident by the process described, the *Average Bunker Price in Measurement Period* is the average fuel price observed during the measurement period, which is done continuously throughout the contracted period. While the *Base Bunker Rate* is observed at the time of tender, which are to represent a bunker price that motivate the freight rates agreed upon when a contract is signed. Furthermore, since fuel price indexes differ between ports and sometimes also between the sites that publish these prices, the Rotterdam Fuel Price Index published by Bunkerworld are always used as the single source for fuel prices. This implies the observation of two price indexes; LSMGO, a fuel with a sulphur content 0.1%; and IFO380, a fuel with a sulphur content of 3.5%. Further, the share spent in ECA and SECA for each respective trade lane must be stated by the carrier, in order to include the aspect, the share each fuel type consumed in the calculations.

Most values are either measured or calculated by VCC, while the *Bunker as Share on the Freight Rate* require carrier input, which is provided at the beginning of a contract period. As compared to the "bunker share of costs" that was discussed in the findings from the carrier interviews, this variable refers to the bunker share of the freight rate, meaning that the carrier must disclose the share of bunker cost of the total cost, including profit on the route. Naturally, neither the profit nor the margin is distinguishable by the provided bunker share on freight rate, however it must be considered by the carrier to provide this figure. Furthermore, as the bunker costs and thus the bunker share depend on the bunker consumption, the carrier must also consider aspects regarding ship characteristics of the vessels and the service schedule for the route in order to appropriately assess such a figure for bunker share on freight rate, however specifics regarding these aspects are not transparent in the current model.

While there is no way for VCC to make sure that the figure for bunker share on freight rate reflects the actual situation, the BAF has a mechanism that limits the bunker share, and consequently, limits the share that are subjected to adjustment. Because of strong indications that fuel prices will increase in the future, VCC's carriers have been clear during meetings that these limits will have to be adjusted, since the limits today are not sufficient to compensate for what they will pay for the fuel when the new regulation has been applied. While VCC has every intention to fairly compensate the carriers for the increased cost of fuel, they do not want to pay an unjustified surcharge. The limit results in the following principle:

$$\mathit{Bunker\ Surcharge} \leq (\mathit{Base\ Freight\ Rate} + \mathit{Bunker\ Surcharge}) \times \mathit{Bunker\ Share\ on\ Freight\ Rate}$$

The aforementioned principle for BAF calculation and how all the variables described are used, can be explained by the following example for the Antwerp - Santos route, using fuel prices from

May 13th, 2019 as compared to the prices in the *low case* fuel price scenario, and lastly the arbitrary Bunker Share at 15%:

Table 12: Example of BAF calculation based on current BAF model at VCC

Example calculation using VCC BAF	***LSMGO***	***IFO380***
Share used	16%	84%
Base Price	592 USD	410 USD
Avg. Bunker Price in Measurement Period	616 USD	466 USD
Bunker Share on Freight Rate		15%

$$BAF = \left(\frac{616-592}{592} \times 0.16 + \frac{466-410}{410} \times 0{,}84\right) \times 0.15$$

$$BAF = 1.82\%$$

Hence, the bunker adjustment factor is calculated to 1.82%, meaning that rates are paid with an extra surcharge that amount to 1.82% of the base freight rate during the application period. Note that this is a hypothetical example. The bunker share on freight rate was assumed to be at 15%, after the fuel prices increased by 4% (592 to 616 USD) and 14% (410 to 466 USD), indicating that the bunker share must have been lower when the contract was signed and freight rates agreed, which was assumed for this example. If another example would be shown, where the base prices would have been higher and another increase would have been measured for the actual prices, an arbitrary choice of a 15% bunker share in freight rate would also infer that the freight rate that was agreed upon, must also be higher. This means that the ways for a carrier to respond in order to stay below a bunker share limit, when the fuel prices increase to a level that would cause bunker costs to exceed a said share, are either to absorb the cost increase that exceeds the limit themselves or increase fuel efficiency, or renegotiate and increase the freight rates to a point where the bunker cost represent such a share of the freight rate. Further, increasing the freight rates to stay below the limit could then either be achieved by increasing other costs or increasing the profit margin, which wouldn't have been needed if the bunker share on freight rate had not limit, meaning that the bunker share limit provides an incentive for VCC carriers to increase their freight rates. However, since freight rates cannot be adjusted once a contract is signed, the effects of price fluctuations are therefore contained for VCC during the contract period, while carriers runs the risk of not being compensated during this period and can only be adjusted in the negotiation for renewing said contract. Therefore, the negotiations for freight rates become crucial: Carriers must consider the risk of having lower rates and easily exceeding the bunker share limit and risk being uncompensated for increased bunker costs, while using higher rates with a high margin lowers this risk and provides leeway in case of drastic increases of bunker prices, but might lead to the loss of contract during tender. Since the negotiations is the only opportunity for a carrier to increase freight rates, it becomes imperative for VCC that the benefit of using their own BAF model with a bunker share limit justifies the rates that it entails, specifically meaning that the risk of paying for an unjustified amount must be balanced with the importance of using their own model and the ability to contain the effect of bunker price variations. Most importantly, both parties must consider these aspects from each other's perspective, if the risk is to be shared and a mutually beneficial relationship is desired.

4.3.4. Adaptation of Bunker Adjustment at VCC Procurement in Response to the Cost Implications on Deep-Sea Ro-Ro

This section presents the analysis of how the cost implications on suppliers of deep-sea Ro-Ro affect VCC procurement, more specifically, how the increased fuel costs appear for VCC through the BAF model currently used in the context of the fuel price scenarios. Additionally, the effects are further analyzed to provide the basis for how the VCC bunker adjustment model can be adapted to accommodate for the drastic fuel price changes, thus answering the second research question.

4.3.4.1. Carrier Cost Implications Investigated Through VCC Model for Bunker Adjustment

For the calculations of price implications as a result of the new regulation, three demand scenarios were formulated in order to estimate the price for fuel in the respective scenario. Comparing the fuel price paid by Ro-Ro carriers today with what they would pay for different types of fuel in each scenario resulted in a percentage change, as illustrated in the section 4.2.4. For the low case scenario, the average fuel cost increase for a carrier choosing to run their vessels on VLSFO on global water and ULSFO in ECA zones was 36%. The same fuel cost increases for the mid and high cases was calculated to 72% and 107% respectively. Meaning that regardless of which demand case that will be realized, significant cost increases are expected. In order to see what effects these prices for VLSFO and ULSFO would have for the BAF model currently used by VCC, the price on VLSFO and ULSFO from each scenario was applied as current prices to the formula. The price carriers pay for their fuel today, the HSFO price from the 13th of May, was applied as the base price to the formula. By doing this, the authors could investigate the reaction from VCC's current BAF model on the inspected routes, when fuel prices change from today's level to the expected price level in each demand case. In other words, what the BAF surcharge as a percentage would be. These effects are illustrated in Figure 12 below.

Looking at the dotted line, illustrating the average BAF surcharge as a percent in regard to the fuel price for all the routes inspected, we can see that already in the low case, with an estimated price for VLSFO of 595$ and an estimated price for ULSFO of 616$, the BAF is calculated to 10%. Following the dotted average line, we can observe a significant increase of the BAF as the prices goes up, resulting in a BAF of 22% for the mid case prices, and a BAF of 37% for the high case prices. Clearly, VCC's current BAF results in great surcharges when applying price estimations for VLSFO and ULSFO.

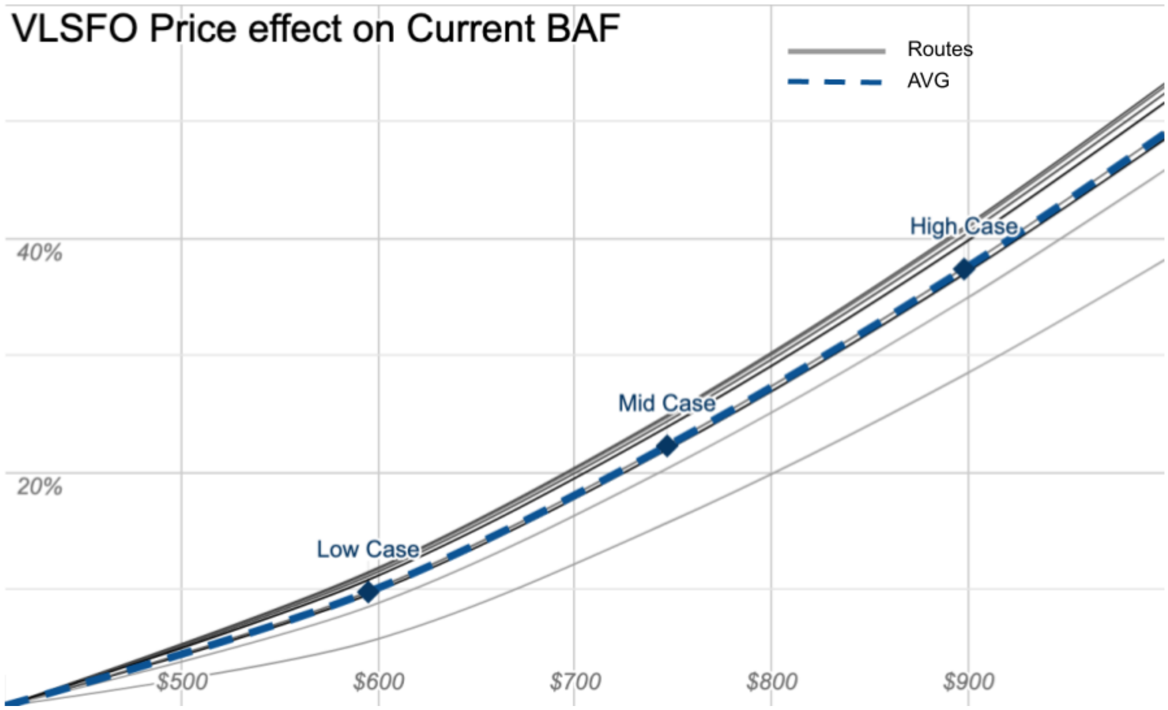

Figure 12: Illustration of VLSFO Price Effect on Current BAF for all sample routes and the average for these routes

The reason being the significant difference in price between current HSFO price and estimated price for VLSOF and ULSFO. For example, the prices from the mid case scenario indicates that a surcharge of more than ⅕ of the total freight rate would be added to the price as a consequence of the estimated fuel cost increase. Simply put, by applying the fuel prices for VLSFO and ULSFO estimated in this study, we can observe Panasiuk & Turkina's (2015) prediction of significant cost implications as a result of carriers choice to run their vessels on VLSFO and ULSFO as a means of compliance with the IMO global sulphur cap 2020. In turn, fuel cost implications will have a significant effect on the total costs for carriers, as bunker costs, according to Notteboom & Vernimmen (2009), account for a considerable expense for the shipping lines.

Inspecting each line in the graph individually, all of which illustrate the BAF in regard to price for all the routes investigated, an outlier can be observed. The bottom grey line consistently generates a significantly lower BAF, as compared to the other routes investigated. This is explained by the fact that the bottom grey line illustrates the Zeebrugge-Charleston route. Which is the route from our sample routes with the most time spent in ECA zones, more specifically 52% of the time of this route is spent in ECA zones. Which could be compared to the route from our sample with the second most time spent in ECA zones of 26%. This indicates that the more time a vessel spends in ECA zones today, the less affected in terms of fuel cost increases it will be by the new regulation. This is logical since the fuel burnt in ECA zones is already used today and is not expected to face the same price increase as compared to the price increase when switching from HSFO to VLSFO, which is the fuel that will be burnt on global water. From using our estimated fuel prices in the BAF currently used by VCC, two interesting takeaways was generated. Significant cost implications are to be expected as a result of the fuel switch from HSFO to VLSFO on global water, and as Stopford (2009) state, the route on which a vessel is operating will influence bunker consumption, and consequently to what extent it will be affected by the new regulation.

From interviews with Ro-Ro carriers, it can be stated that not one carrier that was interviewed intend to use scrubbers exclusively in order to comply with the new regulation. Investigating a situation where scrubbers are used as the only means of compliance was therefore disregarded. However, several carriers expressed that they have, or plan to, invest in scrubbers to some extent. Therefore, it is necessary to study the effects on carriers choosing a combination of compliant fuels and scrubbers to their fleet as a means of compliance with the new regulation, in order to understand how the BAF can be adjusted when also considering the use of scrubbers. Regarding scrubbers, it is important to highlight that this compliance alternative includes an OPEX as well as a CAPEX. The BAF however, cannot account for the CAPEX of a scrubber investment, which means that in addition to the effects on BAF and bunker share as a results of scrubbers, the investment and installation costs which account for a large part of expenses associated with a scrubber (Zis & Psaraftis, 2017), also needs to be considered for this alternative, although it has to be done separately from the BAF and bunker share analysis.

In order to consider the usage of scrubber systems as a means of compliance with the IMO global sulphur cap 2020, the effect of scrubbers on BAF was analyzed in terms of the extent to which scrubbers are used as a share on the total fleet. This is illustrated in Figure 13 below, where the X-axis show the number of scrubbers being used as a percentage of total amount of vessels, and the Y-axis show the resulting BAF of a given share of scrubbers. In addition, the three lines illustrate the low, mid, and high case respectively.

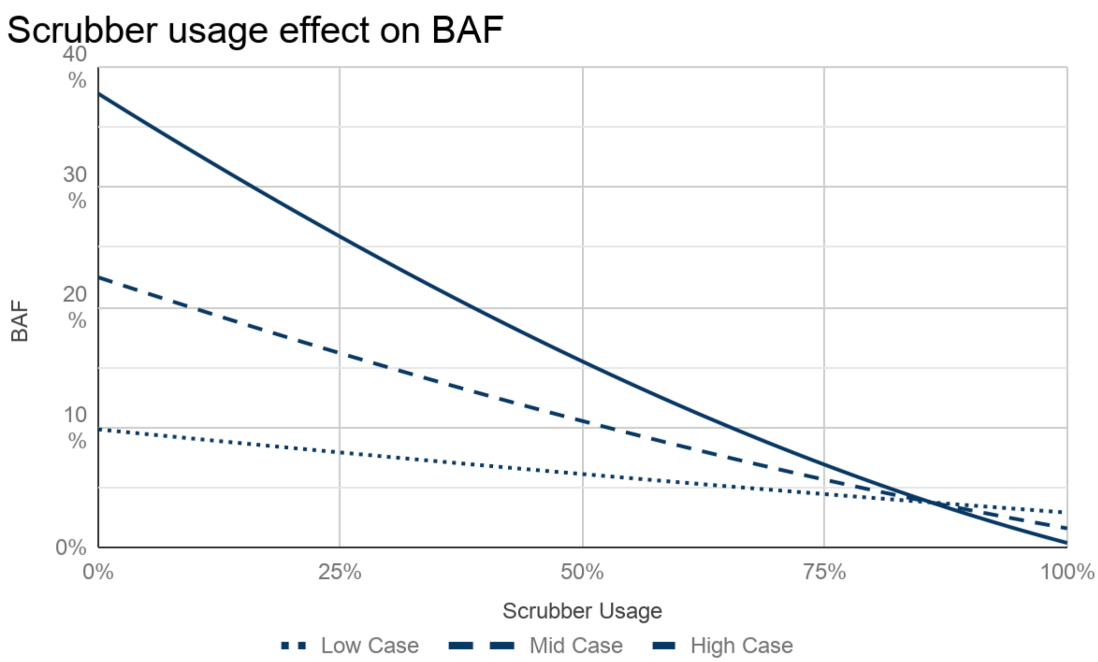

Figure 13: Illustration of the extent to which scrubber usage affect BAF for the three different price scenarios

From this figure, it is clear that the usage of scrubbers affects the outcome of BAF. As all cases indicates, the BAF decrease in conjunction with an increase of the number of scrubbers being used. For example, the line illustrating the mid case generates a BAF of roughly 15% when 25% of the fleet are equipped with scrubbers. While the BAF drops to 10% when 50% of the fleet is equipped with scrubbers. This is explained by the fact that regardless of which price scenario from our estimations, the difference between current HSFO price and our estimated HSFO price is significantly smaller as compared to the difference between our estimated price for VLSFO and ULSFO and the current price for HSFO, which implies that carriers using scrubbers to some extent in their fleet, cannot justify a bunker surcharge at the same level as a carrier exclusively using compliant fuels in order to run their vessels. This is in line with the fuel cost implications calculated in this study, where it was found that the difference in terms of fuel costs would be significantly larger for carriers running their vessels on compliant fuels as compared to carriers using scrubbers. In addition, our analysis of scrubber usage effect on BAF is also in line with Zis and Psaraftis (2017) statement that the use of scrubbers implies a lower operational cost as compared to compliant fuels. As aforementioned, the usage of a scrubber system also includes a relatively high capital cost regarding the investment itself and the installation of the scrubber system (Zis & Psaraftis, 2017). This means that while carriers using scrubbers to some extent might add a smaller bunker surcharge compared to carriers exclusively running their vessels on compliant fuels, they will also have to cover for expenditures not taken into considerations by the BAF model. As it was found during the interviews with Ro-Ro carriers, they intend to pass on the costs associated with scrubber investments to their customers, implying that additional surcharges are to be expected from carriers using scrubbers on their fleet to some extent.

Our analysis show that the IMO global sulphur cap 2020 will affect the outcome of BAF, mainly as a result of significant cost implications related to the available compliance alternatives. In order to formulate updates for a BAF model adjusted to accommodate for the new regulation, it is imperative to analyze the underlying elements of the bunker adjustment factor in general, to identify critical aspects of the model where change is needed.

4.3.4.2. Analysis of the Elements in VCC Bunker Adjustment

The current BAF at VCC share the same basic principle of the ones used by Maersk (2018), the MOL BAF reviewed by Blom & Borisson (2008) or the one presented by Chi & Dagar (2010), which are all used to calculate a surcharge that compensate carriers for excess fuel costs that are inferred by a price change in bunker. Consequently, they share many common elements.

As found in both theory and findings of the current model used by VCC, the *current bunker prices* are always considered, as to adjust for the price changes. However, there are different ways as to how this is expressed and various levels of transparency. For example, both the Maersk & MOL BAF express that the *actual fuel price* is considered and how this relates to a *baseline price*, which is also found in the VCC BAF, however expressed as the price change in percentage instead of using the price difference of a specific currency. The actual prices are not expressed by Chi & Dagar (2010) in their BAF, however both a base price and an actual price is required to calculate the base bunker cost and actual bunker cost. Yet, other elements are required for such a calculation, such as the fuel consumption on the voyage.

The *fuel consumption* is an aspect that is in one way or another included in all models, which in its turn is based on *ship characteristics* of the specific vessel used (Stopford, 2009; Yin et al., 2014) and the design of the *service* (Stopford, 2009), such as the size of the vessel, its sailing speed on voyage or transit time, as explained in the theoretical framework. These aspects are in most cases inaccessible by shippers and only known to the carriers, which in regard to its inclusion in

BAF calculations, results in BAF models never being fully transparent to both parties. These effects of information asymmetry are unavoidable, since carriers possess more information regarding their costs and what drives costs (Yang & Su, 2017).

Nevertheless, these aspects are crucial in all BAF calculations, which is why the VCC model requires the supplier input for a figure of the *bunker share on freight rate*. This differs from Maersk or MOL models, as the bunker surcharge is calculated by the carrier themselves and is instead included in a factor expressed as *trade factor* or *trade imbalance*. This is a fixed factor for each trade lane, which is a result of the carrier's evaluation of ship characteristics and route specifics, also considering trade imbalance to compensate for unutilized space on backhaul, resulting in that bunker consumed on the backhaul voyage is compensated by customers on the head haul voyage. No mechanisms for trade imbalance are present in either VCC or Chi & Dagar (2010) model for BAF, which can be explained by two reasons: Firstly, both models are developed either by or in collaboration with a shipper and not a carrier, implying that some variables that can be considered difficult to justify from a shipper perspective have been excluded. Secondly, none of the models are developed exclusively for container freight as for Maersk and MOL, where the service schedules are rigid and voyages must happen within the designated transit time despite the space utilization, often resulting in imbalances between import and exports, while in Ro-Ro the services are flexible and voyages adjusted to maximize space utilization. As a result, bunker surcharges are often more rigid for container than for Ro-Ro shipping.

In the attempt to bring transparency to bunker surcharges, many container shipping companies such as Maersk present fixed surcharges for different intervals of bunker prices for each trade lane that are pre calculated using their BAF model, which is only made possible due to the rigid nature of the services in that industry. This provides transparency to shippers in the regard of knowing what they will be charged, however not in regard to the figures used to calculate these charges. In contrast to this structure, the BAF currently used at VCC instead brings transparency in regard what share of fuel types that are consumed on the route, which is made clear to both shipper and carrier. While this doesn't provide any insight to the actual fuel consumption and its cost, it brings transparency to the extent that the price changes should affect a certain route. Further, since Ro-Ro service schedules are usually more flexible, VCCs BAF doesn't provide transparency in regard to the bunker surcharges that can be expected, however, the *bunker share on freight rate limit* restricts the bunker surcharge to a finite span (see expression below), meaning that it is possible for VCC and the carrier to estimate the resulting surcharge as soon as a base freight rates has been agreed upon.

4.3.4.3. Proposed Adaptation of the VCC model for Bunker Adjustment

Considering the limit for the bunker share on freight rate in the regard to the effects on the bunker surcharges for the increased fuel prices, where surcharges were observed up to almost +40% of the base freight rates with VCCs BAF, it is certain that suppliers will not be compensated for such an increase with the current limit. While it is an intuitive conclusion adjustment is necessary, it was also stressed by both VCC and the suppliers of deep-sea Ro-Ro that the limit needs to be changed. Therefore, the effects of the projected fuel prices specifically on the bunker share of freight rate was investigated. The estimated fuel prices were applied to the investigated routes in order to calculate what the average bunker share on freight rate would be for the low, mid and high case, respectively, as illustrated in Figure 14. Furthermore, as illustrated above in Figure 13, the use of scrubbers mitigates the impact on BAF, due to the lower price of HSFO, which is the fuel being burnt when have a scrubber system installed. Naturally, the costs of bunker also decrease for carriers using scrubbers and consequently, the bunker share on freight rate. Therefore, the use of scrubbers must also be considered when calculating this average bunker share on freight rate. An estimate of the share of suppliers using scrubbers was found based on the interviews with suppliers of deep-sea Ro-Ro, resulting in an average scrubber usage of 14%, while the remaining majority of 86% go for the compliant fuels. Among these 86%, the average time spent in ECA/SECA for the routes analyzed was found at 17%, and outside ECA/SECA at 83%. Therefore, the extent that each type of fuel was assumed to be used by VCC suppliers of deep-sea Ro-Ro on average was estimated to; HSFO usage at 14%; ULSFO usage at 15% (0.17 x 0.86); and VLSFO usage at 71% (0.83 x 0.86). The principle used to obtain the bunker share is reviewed in **Appendix**.

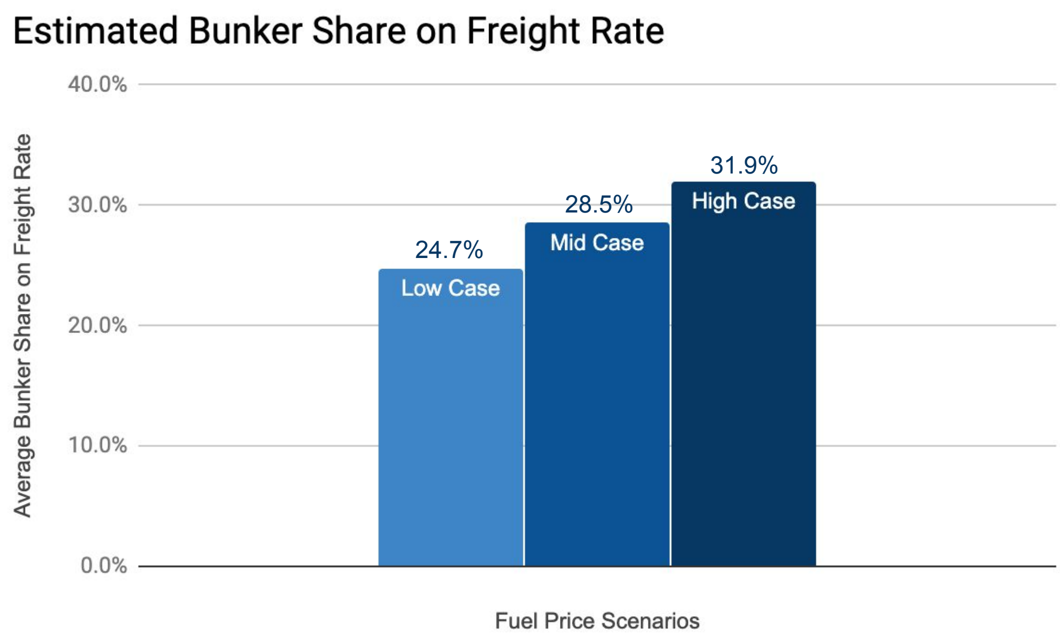

Figure 14: An illustration of an estimated bunker share on freight rate for each fuel price scenario, using route data averages from sample routes.

As found in the figure, the extent for which the limit should be adjusted vary between 25% and 32%, depending on how one assesses the probability of each case. But, since the low and high cases illustrates two extreme situations, it is logical to assume that the demand and price for VLSFO should be somewhere in between. Looking at the mid case scenario can therefore give a hint of where to a new limit for bunker share freight rate should be put.

While adjusting the limit for the bunker share on freight rate is the most crucial adjustment of the BAF that must be made, in order to accommodate for the cost implications of IMO's regulation of the new global sulphur cap in 2020, other adjustments are also required for the model to be compatible with the new regulation.

The second, and possibly the clearest adjustment that need to be performed regards a new price index. Because the compliant fuel with a maximum sulphur m/m of 0.5% is a new fuel which will differ in price compared to the currently available HSFO and ULSFO, a figure based on a new price index for the compliant VLSFO must be included. The reason is simply because the bunker adjustment would not work if the BAF model were partly based on incorrect prices. This infer that a VLSFO price index must be measured during the measurement period and used in the calculations as one of the *Base Bunker Rates* and an *Average Bunker Price in Measurement Period*. Essentially, the VLSFO price index and its role in the BAF model will replace that of the HSFO, however, the price index for HSFO must still remain in the model to represent the fuel prices when using scrubbers, which will be discussed later. In summary, this adjustment entails that three different fuel rates must be considered for calculating BAF.

Thirdly, as by including VLSFO as another fuel rate, the *share of fuel* must also be considered for VLSFO, which is based on the share spent inside and outside ECA/SECA. Just as for the price index, the share of HSFO already exist to represent the share spent outside ECA in the current model. Therefore, the same figures that are currently used in some contracts or routes to describe the share of HSFO can also be used to represent the share of VLSFO instead, as long as the carrier doesn't drastically change the route and thus the share spent inside and outside ECA/SECA. Hence, the figure representing the share of HSFO must be instead represent the share of VLSFO.

Fourthly, the use of scrubbers must also be considered in the same manner as when the average bunker share on freight rate was calculated in Figure 14. Basically, this means that a figure representing the share of scrubbers must be used and indicating the share of HSFO consumed. This figure is most likely required to be provided by the carrier, as there is no way for VCC to find this information themselves. As previously mentioned, deep-sea Ro-Ro services are quite flexible, but also in terms of the vessels that are used, often resulting in that different vessels are used for the same route, making it quite difficult for carriers provide the exact share of vessels equipped with scrubbers on that route. While it would be optimal to use the share of vessels with scrubbers on route as figure, instead providing a figure for the share of scrubbers of the fleet they're operating could be sufficient while also desirable in terms of reducing the administrative work required for carriers.

The last adjustment required is the adaptation for calculating the new BAF, with regard to the proposed changes. Besides replacing the figures for HSFO with VLSFO, the most significant change for the calculations must be made to accommodate for the consideration of scrubber usage. The following principle is proposed:

$$BAF\% = ((BAF_{VLSFO} + BAF_{ULSFO}) \times (1 - Share\ of\ Scrubbers) + BAF_{HSFO}) \times Bunker\ Share\ on\ Freight\ Rate$$

Where; $Share\ of\ Scrubbers$ represent the share of vessels equipped with scrubbers in carrier fleet or used on route; BAF_{VLSFO}, BAF_{ULSFO} and BAF_{HSFO} an adjustment for each type of fuel, which are calculated respectively as:

$$BAF_{VLSFO} = \frac{Avg. VLSFO\ Price\ in\ Measurement\ Period\ -\ Base\ VLSFO\ Rate}{Base\ VLSFO\ Rate} \times Share\ of\ VLSFO$$

$$BAF_{ULSFO} = \frac{Avg. ULSFO\ Price\ in\ Measurement\ Period\ -\ Base\ ULSFO\ Rate}{Base\ ULSFO\ Rate} \times\ Share\ of\ ULSFO$$

$$BAF_{HSFO} = \frac{Avg. HSFO\ Price\ in\ Measurement\ Period\ -\ Base\ HSFO\ Rate}{Base\ HSFO\ Rate} \times\ Share\ of\ Scrubbers$$

When a BAF% has been obtained, the bunker surcharge is calculated using the same principle as the current BAF;

$$Bunker\ Surcharge\ =\ Freight\ Rate \times BAF\%$$

After which, the bunker surcharge is applied to the base rates and used throughout the application period.

While the most critical part of the adaptation of the BAF is the limit of the bunker share on freight rate, the suggested calculation provides means of considering the effects when a carrier is using either one of the compliance alternatives; VLSFO and ULSFO, or scrubber. This implies that the share of bunker cost is somewhat reduced on average, since scrubbers allows the use of the cheaper HSFO, and thus the potential of having a lower limit on the bunker share on freight rate than if only the first compliance alternative had been considered.

5. Discussion & Conclusions

In the finalizing section of this study, a discussion will be presented in regard to the results, implications and limitations of the study. The purpose being to clarify the relation between the results and the initial research problem before rounding off the study with our conclusions and suggestions for further research within the field of study.

5.1. Results

5.1.1. The Extent of IMO's Global Sulphur Content Limit Cost Implications for VCC Suppliers of Deep-Sea Ro-Ro...

There is one aspect regarding the IMO global sulphur cap which everyone involved can agree upon. This new sulphur regulation is surrounded by great uncertainty, especially related to fuel costs. An uncertainty that drives every company that might be affected to prepare as good as they can. During this study the authors have made estimations based on previous research on the topic in combination with additional indications and interviews held with involved actors from two perspectives, in order to present a picture of what implications the new regulation might have for carriers of Ro-Ro-vessels and their customers. And more specifically, to answer the first research question; *How can VCC's suppliers of deep-sea Ro-Ro services be affected in terms of costs by IMO's regulation of the global sulphur content limit in 2020?*

While the uncertainty is indeed high, there are certainly some clear signs of what the situation will look like during the initial period after the implementation of the new regulation. Collected data as well as previous studies on the topic strongly suggest that the majority of Ro-Ro carriers are relying on the refining industry being able to supply the demanded amount of VLSFO, meaning that the majority of Ro-Ro carriers will to a larger extent choose to run their vessels on VLSFO as a means of compliance when operating in global waters. Based on fuel price estimates conducted during this study, the application of compliant fuel as the main alternative to comply with the new regulation implies that Ro-Ro carriers will face significant fuel cost increases, which in turn will be passed on to shippers. One of the main uncertainties regarding the implementation of the new regulation is related to the price for the new fuel, VLSFO. While this study cannot answer to exactly what the price for the new fuel will be, the three price scenarios formulated in this study indicates that fuel costs related to global waters will face a significant increase regardless of which scenario that is realized. Because of strong indications of significant fuel cost increases, the importance of cost efficiency will be even more important in the future for Ro-Ro carriers. While their intention is to pass on these costs, shippers will certainly demand that costs are held at a minimum. Implying that carriers cannot simply pass on the costs increases without any effort to keep them as low as possible. A carrier that do not emphasize cost efficiency will indeed risk to lose important customers to competitors. Nevertheless, our study show that increased fuel costs seem inevitable. As there is already tension between carriers and shippers regarding surcharges, which shippers sometime perceive as unjustified, the transparency from carriers will be important. In fact, transparency might even work as a competitive advantage, where carriers who can justify their surcharges by transparency should be able to build on long term relationships with shippers.

In addition, the usage of scrubber systems calls for large capital investments, which most likely will be passed on to customers as well, even though how these costs will be passed on is not known as of today. From interviews with Ro-Ro carriers the authors learnt that some of them have, or plan to, invest in scrubbers to some extent. This seem to be a wise decision in order to spread the risk related to the uncertainty regarding the availability and price of VLSFO. At the same time, as previously mentioned in this study, the investment of scrubbers is also associated with risks, e.g. if they will even be allowed in the future. Meaning that before investing in scrubbers, Ro-Ro carriers should consider the many risks associated with these large investments. Regardless of the carriers' method of compliance, costs will increase. Large cost increases are a difficult challenge for any industry to handle, in worst case with severe consequences such as modal shifts or even bankruptcy. With this in mind, it is not improbable that the ocean transport industry will see several mergers or alliances as a strategic move from ocean carriers to handle the cost implications derived from the IMO global sulphur cap 2020.

5.1.2. ...and the Resulting Effects on VCC Procurement - BAF & Bunker Surcharges

Fuel costs account for a considerable part of the total cost for ocean carriers. At the same time indications show that the IMO global sulphur cap will imply significant increases in the costs for fuel. Because of this, much attention is put towards the mechanism intended to adjust for fluctuations in fuel price, the bunker adjustment factor. Accordingly, VCC's current BAF model was analyzed in order to answer the second research question; *How can the current bunker adjustment factor used by VCC be adjusted to accommodate for the cost implications of IMO's regulation of the global sulphur content limit in 2020?*

A perceived lack of transparency from the ocean carriers has driven VCC to use their own BAF when possible, in order to obtain as much insight as they can into what they actually pay for. This BAF model currently includes a cap for a maximum allowed bunker share. While this bunker cap can mitigate the transparency problem from VCC's perspective, it is not justified to keep the bunker cap at its current level, considering the expected increase in fuel costs. The findings and analyzes from this study show that keeping the bunker cap at its current level would result in ocean Ro-Ro carriers not getting fully compensated for the fuel they burn. Based on price estimations and sample routes it was found that the bunker share in 2020, depending on which price scenario being realized, will be somewhere between 24%-34%. While this indicates that the current bunker cap in VCC's BAF is too low, it also indicates that minor adjustment of the bunker cap should be sufficient. The adjustment of the current BAF model at VCC suggested in this study aim to accommodate for the uncertainties related to the new regulation. Updating the current BAF in accordance to the suggestions provided, should mitigate the perceived transparency problem while still considering the cost implications resulting in an increased bunker cap. Since lack of transparency, from VCC's perspective, and getting fairly compensated for fuel, from the Ro-Ro carriers perspective, have been identified as the two main issues regarding the new regulation, the suggested BAF adjustment in this study can work as a foundation for long term relationships between VCC and their Ro-Ro carriers.

While the suggested BAF adjustment consider scrubbers as well, it cannot take the CAPEX related to scrubber investments into account. Therefore, further discussions between VCC and their Ro-

Ro carriers are needed in order to clarify how carriers plan to get compensated for these investments.

5.2. Implications

The results from this study provide a more profound understanding of the IMO global sulphur cap 2020 and its possible implications. These insights should especially be interesting for Ro-Ro carriers and their customers, since the study is delimited to investigate the deep-sea Ro-Ro sector in regard to the new regulation. The results from the first research question is indeed more relevant for a broader audience, since the core focus of this question is cost implications for the Ro-Ro sector. These results can help different actors prepare for the implementation date of the new regulation, in terms of different alternatives to comply and what the implications of the different alternatives are.

The second research question on the other hand should be of greater interest to shippers, in particular VCC, because the focus regarding this research question was put on current BAF used at VCC outbound logistics. From the analysis and the following results, VCC can gain a better understanding of how their current BAF can be adjusted so that Ro-Ro carriers get fairly compensated for the fuel while VCC avoid paying unjustified surcharges related to the fuel. A crucial aspect of the procurement of outbound logistics is the negotiation regarding the contracts for these ocean transports. A deeper knowledge of the new regulation and its potential implications, combined with a BAF model adjusted for these implications, can help VCC manage these negotiations successfully. With the updated BAF model they will be able to present a model that is constructed to fairly compensate the Ro-Ro carriers for fuel while at the same time offer VCC transparency in regard to bunker costs, something that should be in the interest for both parties.

This study was delimited to focus on the procurement of outbound logistics regarding deep-sea Ro-Ro ships. While the results from this study first and foremost aim to answer the research questions which are delimited to the aforementioned focus areas, there are indeed other parties that might find this study helpful. Firstly, while the study is delimited to the outbound logistics of IDP at VCC, other teams such as inbound and global customer services could also obtain useful insights form these studies. Even though these teams are not involved in deep-sea Ro-Ro transports but rather with container ships, there are lots of similarities between these kinds of transports which implies that cost implications identified for the Ro-Ro sector might also apply to container ships. Making the findings and results from this study relevant to some extent also for ocean container freight.

While there has previously been extensive research related to sulphur regulations within the maritime industry, especially the IMO global sulphur cap 2020, the focus of previous research has rather been to look at the problem from the carrier's perspective. The research on maritime sulphur regulations from a shipper point of view is however limited, a gap that this research intends to fill. By problematizing the new regulations from the shipper point of view, and consequently providing solutions to the challenges identified, this study can shed light on issues with little or no prior research.

5.3. Limitations

As there are several uncertainties investigated in this study, several industries and a cast study conducted in the context of a company and its suppliers approaching the tender and negotiations of contracts, limitations are present in regard to the result and the methodology.

A crucial aspect of the IMO global sulphur cap 2020 is what the actual price will be for the new fuel, VLSFO. This is surrounded by great uncertainty since this is a fuel that do not exist as of today. In order to present fuel cost implications, the price for fuel is needed. Therefore, the authors conducted price estimates based on previous research within the field. Since estimates are by its nature no guarantee to be correct, the cost implications in this study should not be seen as an absolute truth regarding the actual fuel prices. However, three price scenarios were formulated in order to produce a range within which the actual price is more likely to be. Also, a number of sample routes was used to calculate cost implications as well as bunker share and the outcome of BAF. While these routes represent different types of routes, e.g. transatlantic, only Europe, different share in ECA etc., they are not representative for every route operated by a Ro-Ro vessel in the world. A greater sample, including more types of routes would have made the sample more representative. However, considering the availability of data related to Ro-Ro trade lanes, the sample was considered to be representative for the scope of this study. Talking about representativeness, it should also be mentioned that averages were used to present some of the findings. Meaning that these findings, and the subsequent results are more representative for some carriers than for others. Because the bunker consumption for a vessel depends on the specific ship characteristics and the weather condition under which the vessel is operating, the bunker consumption amount is unique for every vessel and route. Making it impossible to express a general bunker consumption for all ships running on a given route.

Another possible limitation of this study is that it was performed on the behalf of VCC. While the authors have been careful to analyze every aspect in an objective manner, discussions regarding a certain bias towards VCC is understandable. Also, as aforementioned, more aspects could have been considered for the calculations of the payback time for scrubbers. Important factors such as risk and time for installation could have changed the outcome of these calculations.

A final limitation concerns the data collected and used for the calculations and analysis of this study. As much of the data is confidential, the authors have not been able to disclose all the data on which calculations are based. While this might harm the traceability of the study, it was necessary in order to obtain the desired data.

5.4. Conclusions & Future Research

From the results of this study, it can be concluded that the IMO global sulphur cap 2020 will have implications regarding fuel costs for Ro-Ro carriers, which in turn will affect the shippers. Considering the realistic alternatives to comply with the new regulation, i.e. compliant fuels or scrubber systems, costs will increase. The compliant fuel alternative implies greater expenses for the actual fuel. The scrubber alternative enables Ro-Ro carriers to burn the same fuel as today but calls for significant investment and installation costs. Meaning that regardless of which alternative that is chosen in order to comply, a result from the new regulation will be higher costs. As carriers intend to pass on costs increases to some extent to shippers, e.g. VCC, the bunker adjustment factor will play a vital role in the transition phase to the new maritime sulphur standard. Hence, VCC's current BAF model was adjusted in order to facilitate negotiations with suppliers of deep-sea Ro-Ro transports, hopefully leading to long term relationships between ocean carriers and VCC. The results from this study have particularly contributed to insights in how to formulate a BAF model that can take several alternatives of compliance into consideration.

For future research, a recommendation would be to investigate how to provide transparency to CAPEX within the relationship between ocean carriers and shippers, such as the ones related to the large investments in scrubber systems. If a model for these capital costs could be made transparent as for fuel costs with BAF mechanisms, it could provide opportunities in further investigating cost implications on shippers for other research and potentially industry applications.

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Appendix

Appendix 1: Variations of keyword

Key Concept	Keywords and Variations
IMO's regulation of the global sulphur content limit in 2020	IMO, 2020, regulation, sulphur, emission, Marpol annex 6/VI, rule, legislation, sulphur cap, sulphur limit, sulphur content, global, compliance
Deep-sea Ro-Ro Shipping & Economics	Deep-sea, global, maritime transport, maritime industry, shipping lines, marine logistics, sea freight, carrier, Ro-Ro, vehicle transport, maritime economics, shipping costs
Fuel Price Projections	bunker, fuel oil, marine fuel, low-sulphur fuel, low-sulphur bunker, uncertainty, availability, very low sulphur fuel, low sulphur gasoil
Scrubber	abatement technology, exhaust gas cleaning system, abatement solutions
Procurement	purchasing, supplier relationship, supply chain
Costs Implications	commercial implications, costs, cost effects, commercial effects
Bunker Adjustment	bunker adjustment factor, bunker compensation, BAF, surcharge, bunker surcharge, bunker adjustment surcharge, bunker recovery charge, bunker emergency surcharge, fuel adjustment factor, FAF

Appendix 2: Interview Guide

Appendix 2.1. Full interview guide

Prologue

The grand opening. This section aims to get some general info about the carrier and some specific info of relevance to the study

- Can you describe your role at *company x*?
- Can you briefly describe your carrier services, what type of cargo are you shipping and what type of vessels are you running?
- The size of your fleet?
- What fuel(s) are you using to run your vessels today?
- Are you slow steaming your vessels today?

Part 1: Views on compliance alternatives

This section aims to investigate the carriers plans on compliance with the IMO Global Sulphur Cap 2020, i.e. what alternative are they going to apply in order to comply. Further we wish to understand the reasoning behind their choice of compliance alternative.

- How do you plan to comply with the global sulphur cap in 2020?
    - If plans are to use several alternatives to comply, to what extent are each alternative planned to be used?

- *Have you considered using compliant fuels (<0.5% SOx m/m)? / Why not?*
    - What benefits do you see by going with this alternative?
    - What type of fuel do you plan to use (VLSFO/MGO)?
    - What is your impression of the future availability of compliant fuels?
    - *Do you have any plans for how to act if there is a supply deficiency for VLSFO? What type of fuel will you use instead (Blend/MGO)?*

- *Have you considered using scrubbers? / Why not?*
    - What benefits do you see by going with this alternative?
    - Do you currently have any scrubbers installed or planned to install within the near future?
    - How can you justify the relatively large investment regarding the installation of a scrubber system? Do you have an estimation of the payback time of a scrubber system?
    - Are you installing scrubber systems to retrofit on vessels in service or on new vessels?
    - How are you planning to handle the period during the installation, when the vessel cannot be used, and the costs associated with this?
    - Have you considered the reduction of space for cargo, due to the installation of a scrubber system?
    - What are your thoughts regarding the increased energy consumption of having a scrubber system installed?
    - What is your impression of future price development of HFO?

- A possible benefit with the use of a scrubber system is that it can run on a higher speed with the same energy consumption as other fuels, is this something that you have considered?

- *Have you considered using LNG? / Why not?*
    - What benefits do you see by going with this alternative?
    - Do you currently have LNG fuel systems installed or planned to install within the near future?
    - What are your thoughts on the less developed infrastructure for LNG? Do you find this problematic?
    - How can you justify the relatively large investment regarding the installation of an LNG system? Do you have an estimation of the payback time of an LNG system?

- Have you considered other options that wasn't mentioned?
    - *Dual fuel systems?*

Part 2: Investigate specific route

Based on specific routes frequently used by VCC, this section aims to collect data on the measures, which drives the carrier ship costs that are most affected by the compliance alternatives. The goal is to use these input measures together with a theoretical benchmark to investigate the actual carrier cost impact of the compliance alternatives.

- What type of vessels are you currently running on this route?
    - Are these vessels equipped with scrubbers or run with LNG?
    - What is the age of these ships? Where are they in their lifecycle?
    - Vessel Size (tons)?
    - Vessel capacity (TEU/CEU)?
- If plans are to use several alternatives to comply, to what extent are each alternative planned to be used, for this specific route?
- Number of vessels at this route?
- Sailing schedule on this route?
- Number of days (from port of origin to destination)
- Number of stops
- Time at berth
- Do you have any data on the average speed of the vessel for this route?
- What is the fuel consumption per day (tons/day) for the average speed?
    - Is the sailing speed considered "slow steaming" for this vessel?

- Ship costs: Specifically, the bunker share on total cost or ship cost per trip?

Part 3: Commercial implications on shipper (BAF and investments)

This section aims to investigate certain elements regarding commercial implications. We want to get an understanding of the carriers' thoughts on a future development of BAF in regard to the new regulation and the uncertainty connected to fuel prices. In addition, we want to understand how carriers intend to *handle the costs associated with scrubber or LNG fuel system investment in terms of compensation from shipper, such as surcharges.*

- How do you think the new regulation will affect shippers? What effects do you think it will have for the shippers?

- Do you think that the investment associated with scrubber installment will affect your customers (shippers)?
    - In what way will this cost affect shippers? How do you justify this effect on the shippers?
    - Do you think that existing BAF-models needs to be adjusted, even though HFO is the primarily used fuel after a scrubber installment?

- Do you think that the investment associated with installing an LNG fuels system will affect your customers (shippers)?
    - In what way will this cost affect shippers? How do you justify this effect on the shippers?
- Do you currently have any adjustment/compensation-model or surcharge to accommodate for LNG price fluctuations?
    - Do you think that these models need to be adjusted?

- Do you think that existing BAF-models used in the industry will need adjustments to accommodate for a switch to VLSFO? How do you think this needs to be handled in regard to the uncertainty of the fuel price of VLSFO?

- Do you include a figure for fuel consumption when calculating BAF today?
    - If yes, is this figure of fuel consumption based on a vessel at slow steaming speed?

- Measurement period? How long is it in your current BAF?
    - What do you think is the optimal measurement period? Why?

Epilogue

The heartbreaking end. This section aims to investigate overarching issues which does not specifically belong in one of the aforementioned sections but will affect the areas which they investigate.

- Do you intend to keep the current lead times in 2020? How do you plan do that?

- What do you see as the greatest challenges for you as a carrier regarding the new regulation?

Appendix 2.2. Excerpt of interview guide (sent to suppliers upon contact)

Compliance with IMO's Global Sulphur Cap 2020, Interview Questions for: insert carrier name

These questions are part of a thesis work regarding IMO's Global Sulphur Cap in 2020 composed by Erik Jansson and Jesper Saarinen, students at the Innovation and Industrial Management Master's program at The School of Business, Economics and Law.

We will introduce with some general questions regarding the company's services, including;

- ➢ The size of your fleet?

- ➢ What fuel(s) are you using to run your vessels today?
- ➢ Are you slow steaming your vessels today?

We will ask some questions regarding how the compliance with the IMO Global Sulphur Cap 2020 will be achieved, i.e. what alternative(s) are going to be used in order to comply.

The following questions regard the specific route: ***insert route***

- ➢ What type of vessels are you currently running on this route?
    - ○ Are these vessels equipped with scrubbers or run with LNG?
    - ○ What is the age of these ships?
    - ○ Vessel Size (tons)?
    - ○ Vessel capacity (TEU/CEU)?
- ➢ If plans are to use several alternatives to comply, to what extent are each alternative planned to be used, for this specific route?
- ➢ Number of vessels at this route?
- ➢ Sailing schedule on this route?
- ➢ Number of days (from port of origin to destination)?
- ➢ Number of stops?
- ➢ Time at berth?
- ➢ Do you have any data on the average speed of the vessel for this route?
- ➢ What is the fuel consumption per day (tons/day) for the average speed?
- ➢ Ship costs: Specifically, the bunker share on total cost or ship cost per trip?

We will ask some questions regarding what commercial implications you expect, e.g. What are your thoughts on a future development of BAF in regard to the new regulation and the uncertainty connected to fuel prices? How do you think costs associated with scrubber or LNG fuel system investment will affect your customers? Specific questions are:

- ➢ Do you include a figure for fuel consumption when calculating BAF today?
- ➢ Measurement period? How long is it in your current BAF?

We will ask some questions regarding monitoring and enforcement of compliance, more specifically how you plan to show that you can ensure compliance with the Global Sulphur Cap 2020. This section includes questions such as:

- ➢ Do you think that existing mechanisms for enforcement, such as; port inspections (bunker delivery notes, ship log books or fuel samples); airborne monitoring; fixed stations monitoring; or carriage ban; will be sufficient to ensure a level playing field in the industry in regard to the sulphur regulations?
- ➢ How do you plan to guarantee compliance with the new regulation?

Appendix 3: Bunker Share on Freight Rate Estimations: Principle for calculation

The route specific data from 4.2.2.2 and vessel data reviewed in 4.2.2.1 was used as input for calculating the bunker share on freight rate estimations, specifically meaning that a bunker share on freight rate was estimated for each route.

Initially, a current freight rate was estimated for each route. This resulted in the following principle to estimate the freight rates/unit for each route, using today's fuel prices;

$$((Fuel\ Cost_{HSFO} + Fuel\ Cost_{ULSFO}) \times (\frac{1}{Bunker\ Share\ on\ Freight\ Rate})) \times Vessel\ Capacity = Freight\ Rate/unit$$

Where $Fuel\ Cost_{HSFO}$ and $Fuel\ Cost_{ULSFO}$ refers to the fuel cost/voyage for the share of HSFO and VLSFO, for a specific route. Lastly, $Vessel\ Capacity$is assumed at 6400 CEU as explained in 4.2.2.1.

By considering the estimated current freight rates as just explained, including a share of scrubber usage and the fuel prices in 2020 projected for each scenario, a bunker share on freight rate can thus be estimated for each fuel price scenario using the following principle

$$\frac{((Fuel\ Cost_{VLSFO} + Fuel\ Cost_{ULSFO}) \times (1 - Share_{Scrub}) + (Fuel\ Cost_{HSFO} \times Share_{Scrub}))/Vessel\ Capacity}{(((Fuel\ Cost_{VLSFO} + Fuel\ Cost_{ULSFO}) \times (1 - Share_{Scrub}) + (Fuel\ Cost_{HSFO} \times Share_{Scrub}))/Vessel\ Capacity)\ +\ Freight\ Rate/Unit \times 0.8)}$$

Each expression for fuel cost uses prices for VLSFO, ULSFO and HSFO from the fuel price scenarios, while the $Freight\ Rate/Unit$ was found using todays prices. This calculation assumes that all costs, but the fuel costs are unchanged by a new global sulphur cap, meaning that the only logical change in the freight rate are the fuel cost, which is expressed by the numerator. Further, this fuel cost can also be found as part of the denominator, together with the portion of $Freight\ Rate/Unit$ that doesn't include fuel costs, hence 80% of the $Freight\ Rate/Unit$. A simplification of this reasoning can be expressed as;

$$\frac{New\ Fuel\ Cost}{New\ Fuel\ Cost\ +\ Other\ Costs}$$

These estimated bunker shares on freight rate per route considered for each route were lastly expressed as an average for all routes, which led to the result illustrated in 4.3.4.3.