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The container shipping industry's approach to comply with the Carbon Intensity Indicator regulations

Bachelor thesis for International Logistics Program

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CHALMERS UNIVERSITY OF TECHNOLOGY
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PREFACE

This bachelor thesis report marks the completion of our studies in the program of International Logistics at Chalmers University of Technology, corresponding to a total of 180 higher education credits and leading to a Bachelor of Science degree. The study presented herein accounts for 15 higher education credits and was conducted during the spring term of 2024.

Throughout this thesis, we delve into the container shipping industry's perception of the newly implemented Carbon Intensity Indicator regulations, utilizing the knowledge and skills acquired during our time at Chalmers.

We extend our appreciation to our mentor Christopher Thomassen and examiner Martin Larsson, for their guidance and support during the research process. Additionally, we would like to thank the company respondents who, by lending us their time and knowledge, made this study possible.

Hugo Bengtsson & Tora Wykman
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SAMMANDRAG

Sjöfarten spelar en viktig roll i den globala handeln och sticker ut från andra transportslag med sin höga kapacitet och relativt låga kostnad. Trots att utsläppen från internationell sjöfart är låga jämfört med andra transportslag står de för 3% av globala koldioxidutsläpp.

För att minska dessa utsläpp utvecklar FN-organet International Maritime Organization kontinuerligt nya regelverk för att leda branschen i en mer miljövänlig riktning. En av de senaste är Carbon Intensity Indicator, som rankar fartyg baserat på deras årliga koldioxidintensitet.

Denna studie syftar till att ta reda på hur containerrederier har anpassat sig efter regelverket samt vilka utmaningar och problem de stött på. Kontakt och intervjuer med representanter från rederier visar både likheter och skillnader, och tyder på att det finns flera sätt att anpassa sig på.

Studien presenterar operationella åtgärder såsom att minska fartygens hastighet som en vanligt förekommande strategi, vilket både minskar utsläpp och kostnader. Eftersom de flesta av dagens fartyg drivs av fossila bränslen står en övergång till alternativa bränslen högt på agendan, men det kommer med osäkerheter så som begränsad tillgång och höga kostnader.

Resultatet visar också att uträkningen som används för att fastställa fartygs ranking i vissa fall anses bristfällig, huvudsakligen på grund av dess teoretiska natur, vilket gör att den är möjlig att manipulera till viss del.

Nyckelord: Carbon Intensity Indicator, CII, IMO, MARPOL, Container shipping, Carbon dioxide, CO_2, Ship emissions

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ABSTRACT

Shipping plays a significant role in today's global trade and stands out from other transport modes with its high capacity and low cost. Even though the overall emissions from international shipping are low compared to other modes of transport, they account for 3% of global carbon dioxide emissions.

To mitigate this, the International Maritime Organization on behalf of the United Nations are constantly developing rules and regulations pushing the industry towards a more environmentally sustainable direction. One of the latest is the Carbon Intensity Indicator, which rates ships based on their annual carbon intensity.

This study was performed to investigate how companies in the container shipping industry have adapted to the regulations as well as what challenges and issues they have encountered. Contact and interviews with representatives from container shipping lines showed both similar and different strategies, suggesting that there are several ways to approach the rules.

The study presents operational adjustments such as reducing vessel speed to decrease emissions as a prevalent strategy to decrease both emissions and costs. As most ships today are running on fossil fuels, a transition to alternative fuels is high on the agenda but comes with uncertainties such as limited supply and high costs.

The research shows that the calculation used to determine a ship's rating is considered inadequate in some respects, mainly due to its theoretical nature, making it possible to manipulate in some instances.

Keywords: Carbon Intensity Indicator, CII, IMO, MARPOL, Container shipping, Carbon dioxide, CO_2, Ship emissions

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ACRONYMS AND TERMINOLOGY

AI	Artificial intelligence
CII	Carbon Intensity Indicator
CO_2	Carbon dioxide
DNV	Det Norske Veritas
GT	Gross-tonnage
GHG	Greenhouse gas
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
LNG	Liquified natural gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine diesel oil
MGO	Marine gas oil
SDG	Sustainable Development Goals
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development

1. INTRODUCTION

Since the majority of earth's surface is covered by water, it is not unexpected that sea transport plays a significant role in global transportation. Many countries are directly accessible by ships, and it is estimated that as much as 90 % of the world's transported cargo volume is at some point shipped by sea (Witthohn, 2023). Even if sea transport can be considered the most environmentally friendly mode of transport, because of the large amount of goods that can be carried on a maritime vessel, international shipping is responsible for a large share of global emissions. According to Statista (2023), international shipping accounted for 10 % of the worldwide transport sector's carbon dioxide (CO_2) emissions in 2022.

One organization responsible for regulating the environmental issues in the industry is the International Maritime Organization (IMO), which aims for international shipping to reach net-zero greenhouse gas (GHG) emissions by the year 2050 (IMO, n.d.-a). A new measure for ship owners as a tool to reach this goal is the mandatory action of calculating and reporting ships annual operational Carbon Intensity Indicator (CII). These requirements entered into force in January 2023, and are applicable to ships over 5000 gross-tonnage (GT). Based on a ship's annual operational CII, it will receive a rating, ranging between A – E, which will entail various implications for the ship. The CII regulations are to be reviewed by the IMO until January of 2026, which enables alterations and updates to follow (Baltic and International Maritime Council, 2023).

As these new regulations are linked to mitigating the environmental impact of the shipping industry, the strategies adopted by shipping lines could be vastly different from each other, since there are several ways of reducing a ship's emissions. Route- and speed optimization are valid ways of reducing emissions as well as cleaning the ship's hull to reduce drag (IMO, 2022). While running on low-carbon fuels is considered a highly effective approach to reduce emissions, a ship running on fossil fuels can improve its rating with the previously mentioned strategies.

1.1 Aim of the study

The study aims to investigate what approaches container shipping lines have taken to comply with the CII regulations and to explore similarities as well as differences between their strategies, and their reasoning behind them. The report seeks to provide insight into the industry's response to the regulations and what they consider to be the main challenges and issues induced by the regulatory framework. Potential future approaches considered by the shipping lines will also be investigated.

1.2 Research questions

The report is based on three questions regarding the container shipping industry's perception of CII.

- How are container shipping lines adapting to comply with the CII regulations?
- What do container shipping lines consider to be the main challenges entailed by the CII regulations?
- Do container shipping lines see any flaws with the CII regulations?

1.3 Delimitations

Even though CII applies to all types of vessels, this report is solely looking into the container shipping segment. Only companies that have offices in Gothenburg, Sweden, have been contacted for interview requests. As CII revolves around reducing carbon intensity of shipping, only aspects regarding CO_2 emissions and no other type of pollution are considered when writing this report.

2. THEORY

This chapter presents information which is necessary for the reader to gain an understanding of the CII framework and why it was implemented. The first part of this chapter provides an insight to the environmental impact the shipping industry has in the form of CO_2 emissions. Furthermore, the organizations and conventions which are relevant for this report are introduced. How CII is structured and determined is then explained as well as ways of gaining an improved rating. Lastly, today's most prevalent fuels are presented followed by some promising alternative fuels.

2.1 Environmental impact of shipping

3% of global CO_2 emissions caused by humans are connected to the shipping industry, and these will most likely continue to increase if the right measures are not taken (Deng & Mi, 2023). Even if shipping is an efficient mode of transport with high loading capacity, the total amount of emissions reaches high numbers every year. One reason for this is that shipping is one of the world's most fossilized industries with over 97 % of the world fleet still running on fossil fuel. Several environmental regulations have emerged because of this, which tends to be challenging for shipping companies as it often raises the costs of an industry already characterized by low profit margins (Alger et al., 2021).

In 2007, container vessels generated 20 % of the international shipping industry's emissions, even though they made up for only 4 % of the world's fleet (Psaraftis & Kontovas, 2009). A literature review by Nunes et al. (2017), which evaluated 26 different reports about environmental pollution from ships, also shows that the container segment contributes to most emissions within the marine sector. The segment's high share of emissions is one reason why slow steaming is an important measure to take within the container shipping segment (Cariou, 2011). Slow steaming means sailing at a lower speed than the vessel's capable of, leading to a decrease in fuel consumption. Furthermore, Cariou shows that between 2008-2010 emissions from ships decreased by 11% due to slow steaming, without any new technology being adopted to the vessels.

Statistics shows that the demand for sea transport had been constantly growing for a decade when Covid-19 broke out, but after a short dip the numbers have continued to rise (United Nations Conference on Trade and Development [UNCTAD], 2023). If the demand continues to increase, the emissions are most likely to do the same (Kramel et al., 2021).

2.2 IMO and its conventions

IMO is an agency within the United Nations (UN) formed in 1958. The organization is responsible for overseeing and enhancing safety and security in the shipping industry, as well as developing environmental regulations, striving to prevent pollution from ships (IMO, n.d.-b). To deal with these subjects, IMO has implemented several conventions, of which three are mentioned as the most important on their website (IMO, n.d.-c). These are the International Convention for the Safety of Life at Sea (SOLAS), International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), and International Convention for the Prevention of Pollution from Ships (MARPOL).

MARPOL is aimed at protecting the marine environment by preventing pollution by ships, from both operational and accidental causes (IMO, n.d.-d). The MARPOL convention was adopted by IMO on the 2nd of November 1973. After several tanker accidents in 1976-1977, the Protocol of 1978 was adopted. Since the 1973 MARPOL Convention had not yet entered into force, the

1978 MARPOL Protocol absorbed the convention and they jointly entered into force on the 2nd of October 1983. MARPOL consists of a total of six annexes, each covering different regulations aimed at minimizing and preventing pollution from ships:

- Annex I Regulations for the Prevention of Pollution by Oil
- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV Prevention of Pollution by Sewage from Ships
- Annex V Prevention of Pollutions by Garbage from Ships
- Annex VI Prevention of Air Pollution from Ships

2.2.1 The IMO GHG Strategy

IMO is committed to support UN Sustainable Development Goal (SDG) 13 (IMO, n.d.-e), which is one of the 17 goals set out by the UN, together forming the core of the 2030 Agenda for Sustainable Development (UN, n.d.). The agenda was adopted by all member states of the UN in 2015, dedicated to facilitating a more sustainable future. The 17 goals included in the agenda cover topics such as reducing poverty and inequality, improving health and education, facilitating economic growth, preserving forests and oceans, and counteracting climate change. Goal 13 revolves around taking urgent action to combat climate change and its impacts, which is why the IMO have set their own goals for the maritime industry to contribute to the accomplishment of SDG 13.

One long-term goal of the IMO is to reach net-zero GHG emissions from international shipping by or around 2050 (IMO, n.d.-a), with net-zero referring to the balance between how much of GHG that is emitted and how much that is removed from the atmosphere. Compared to 2008, the reduction of GHG emissions from the maritime industry aims to reach at least 20% by 2030, and 70% by 2040 (IMO, n.d.-e). IMO also strives to reduce the carbon intensity, i.e., the CO_2 emissions per transport work by at least 40% by 2030, compared to 2008 (IMO n.d.-a).

2.3 Carbon Intensity Indicator

CII, which is developed by the IMO, entered into force on the 1st of November 2022 and came into effect on 1st of January 2023, is a mandatory measure under MARPOL Annex V1 (IMO, n.d.-a). It is a rating system which impacts all cargo and passenger vessels of at least 5000 GT. The measure is developed in line with IMO's goal of reaching net-zero GHG emissions from ships by 2050.

The CII regulations revolve around the above-mentioned ship types having to calculate and report their annual operational carbon intensity indicator which will later determine the ship's rating. Ships receive ratings ranging between A-E, where A is the best and E is the worst.

The calculation shown below as equation (1), can be explained as the annual CO_2 emissions divided by the annual transport work which will provide the user with the ship's attained CII (IMO, 2021a). The ships attained CII is used to determine the ships rating.

(1)

$$\frac{CO_2 \text{ Emissions}}{\text{Deadweight} \cdot \text{Distance travelled}} = \text{Attained CII}$$

2.3.1 CII ratings

As described in the 28th regulation of MARPOL annex VI, ships can receive the rating A, B, C, D or E, where A corresponds to a major superior performance level (IMO, n.d.-f). B corresponds to a minor superior performance level, and C indicates a moderate performance level. The D and E rating corresponds to a minor inferior and an inferior performance level respectively. These ratings will have various implications on a ship's future operations. Ships that receive the rating A or B will gain the benefit of incentives from administrations, port authorities and other appropriate stakeholders. A ship which receives and maintains a rating of D for three consecutive years or E for one consecutive year are obligated to develop and submit a corrective action plan (IMO, n.d.-g). The plan shall include actions which will be taken to reach the required annual operational CII, as described in the 26th regulation of MARPOL annex VI. The value corresponding to the required annual operational CII is the equivalent of the rating level C. This suggests that the C rating is the lowest acceptable rating for a ship to maintain over longer periods of time.

2.3.2 Review period

From the time of implementation, the CII regulations are being reviewed, due to be completed by the IMO by the 1st of January of 2026 (IMO, n.d.-f). The review aims at analyzing and assessing the overall effectiveness of reducing carbon intensity from international shipping through these regulations. The IMO will also assess the need for reinforced or additional requirements regarding the corrective actions taken by ships rated D for three years or E for one year. Any need for enhancements of the enforcement mechanism, as well as the data collection system will be explored and revised if necessary.

2.3.3 Measures to comply

There are several different measures that shipping lines can take to comply with CII, both technical and operational. Bayraktar & Yuksel (2023) mention technical approaches such as reducing drag by keeping the hull and propeller clean and modifying the vessel design. Besides more regular cleaning of vessels, anti-fouling coatings can be used for a longer lasting effect. Switching to a different type of propeller can also result in higher energy efficiency and by that, result in a better CII rating. Transitioning from conventional engines and fossil fuels with lower carbon factors also has a positive impact on the rating.

When it comes to operational measures, route optimization and slow steaming are common approaches (Bayraktar & Yuksel, 2023). Adapting the route after for example weather forecasting can improve the energy efficiency, and slow steaming decreases the fuel consumption resulting in both lower environmental impact and decreased fuel cost. Cariou (2011) states that slow steaming is also connected to financial aspects, and if the fuel price is high, slow steaming can decrease the operational costs.

It is deemed by the UNCTAD (2023) that technology and digital solutions should be leveraged by the shipping industry to accelerate decarbonization. It is further claimed that technologies such as artificial intelligence (AI), internet of things and performance optimization platforms can provide great improvements to energy efficiency. The employment of digital tools is believed to be able to contribute to 15% of IMO's goal of reaching net-zero GHG emissions by 2050 (Det Norske Veritas [DNV], 2022).

2.4 Fuel types

Fuel cost makes up for a large portion of operating costs, often reaching up towards two thirds of shipping companies total expenses (UNCTAD, 2023). According to the Global Maritime Forum (2023), the three most common fuels today are Heavy Fuel Oil (HFO), marine gas oil (MGO), and marine diesel oil (MDO). García-Olivares et al. (2018) discusses different fuels that might be able to replace the current dominant fossil fuels in the marine industry. Even if many of them are considered better from a pure environmental perspective, problems arise when it comes to production of these fuels. For example, biofuel production requires availability of soil, thus becoming a rival to agriculture, and hydrogen requires extensive infrastructure that is yet not developed. The energy content in fossil fuels is also remarkably high compared to many alternatives.

Methanol stands out from other alternative fuels, with its low GHG emissions through its whole lifecycle, and is seen as a possible solution to decrease the environmental impact of shipping (Svanberg et al., 2018). The downside with methanol is its energy content, which is about 50 % lower than conventional fuel oils. This means that a vessel running on methanol needs to carry double the amount of fuel by weight to have the same energy on board as a vessel running on conventional fuels (Stojecvski et al., 2016, as cited in Svanberg et al., 2018). This is something that mainly affects vessels sailing on long routes, such as oceangoing container ships, while it may not be as problematic in short-sea shipping where bunkering can be performed more frequently.

Liquified natural gas (LNG) can also be an efficient fuel in regards of reducing CO_2 emissions (Balcombe et al., 2019). The availability of LNG is already in scale today, with networks facilitating bunkering (Shell, n.d.). By being cooled down to more than -160 degrees Celsius, LNG goes from gas to liquid, and the storage space required is up to 600 times lower than in gaseous form (Balcombe et al., 2019). However, just like methanol it requires more storage space than conventional fuels. A drawback with LNG is that it can result in leakage of methane when being combusted, and therefore contributing to global warming. Mitsui O.S.K. Lines (2021) highlights the requirements for installation of new engines, a large capital investment, and longer construction times for new vessels. LNG should be used as a transitional fuel rather than a long-term solution, since it is not believed to meet IMO’s target of GHG reduction in its current form (Solakivi et al., 2022).

3. METHODS

This chapter presents and explains the case study which was performed to conduct this research. The study is mainly based on qualitative data collected from interviews and personal communication via email with companies in the container shipping industry. Furthermore, the interview questions and the reasoning behind them are presented. The initial response from the companies is presented together with an overview of the respondents' work roles. Lastly, the process of the thematic analysis performed is described.

3.1 Research approach and method selection

Denscombe (2017), describes a case as something existing before the research is started, and that continues to exist afterwards. It is required for the subject studied to have clear boundaries and stand on an isolated foundation to enable it to be considered a case. One general aim of a case study is to reach beyond what is going on, by also investigate why it is going on, making it possible to gain deeper insight into a specific subject or phenomenon. Performing a case study allows the usage of both qualitative and quantitative data collection, as well as a combination of different research methods.

A case study was determined to be the best approach for this research, because of the nature of the subject studied. The CII regulations impact on the industry was of high relevance in time when the research was conducted. It was also assumed that the work with the regulations would continue to affect the shipping industry in the future.

3.2 Collection of data

The main data collection method for this study was research interviews together with personal communication via email. Research interviews are suitable to collect opinions from key persons in a specific field, as well as information that they possess based on their position (Denscombe, 2017). Denscombe further describes the three different kinds of interviews: structured, semi-structured, and unstructured. For this study, semi-structured interviews were chosen. This type of interview is based on a list of subjects for the interview with set questions, but also offers a flexibility for the interviewer to ask supplementary questions. It also allows for the respondent to develop their answers and opinions within the subject. In a semi-structured interview, the interviewer may change and develop their questions during the project based on new information received.

3.2.1 Literature overview

Beyond the qualitative data collected from direct contact with the companies, secondary data from peer-reviewed articles, books and organizational websites has been analyzed to provide a theoretical foundation for this study. The articles were retrieved from Scopus with the purpose of introducing the reader to the subject, as well as for the authors to gain deeper insight into the subject. The main goal was to find information about the overall environmental impact of ships and possible approaches to CII. When searching for articles, the keywords were Carbon Intensity Indicator, ship emissions, CO_2 emissions, container shipping, global shipping, and decarbonization of shipping. The results were sorted to show the highest cited literature first, and to not show results older than 15 years to be somewhat relevant in time. The initial search resulted in 68 hits which further referred to additional sources. Articles strictly treating the subject of other segments than container shipping, as well as research revolving around very specific technical adaptations that was tested out on vessels, were not further investigated. A total of eleven articles were considered to provide useful information for the theory chapter of

this research. To collect the information needed to provide an understanding of the CII regulations specifically, IMO's website and the 6th annex of MARPOL were considered the most valuable sources.

3.3 Selection of interviewed participants and interview questions

A total of seven companies were contacted and asked if they were willing to participate in an interview regarding their work with CII. All companies are either container shipping lines or members of logistics groups conducting business within maritime container shipping, and have offices in Gothenburg, Sweden. Out of these seven, three companies claimed not to have the required knowledge at their Swedish offices. In these three cases, the interview requests were forwarded to the same companies' headquarters located outside of Sweden. This resulted in contact with one of the companies, while the other two did not respond. The five companies that accepted the interview request, were emailed the following questions:

- How has the company primarily adapted to meet the requirements of the CII regulations?
- To what extent are you working with this in Sweden?
- What do you see as the biggest challenges regarding compliance with the CII regulations?
- What long-term strategies are you currently assessing, do you see other solutions besides what has been done so far?
- Are there any changes of the CII as a framework you would like to see in the future?

The questions were formed based on the study's research questions to gain understanding of how the companies have been needing to change their work in line with the regulations, as well as how they believed their approach could change in the future. What they saw as challenging with the rules was also considered an interesting aspect to get insight into. The question regarding the extent to which the companies work with CII in Sweden was asked to form a perception of the level of knowledge we could expect from the respondent and to further assess the information received.

According to Denscombe (2017), an ethical research approach is of great importance, regardless of the extent of a study. Together with the interview questions, a document made by Chalmers University of Technology regarding informed consent for participation in the project was attached. The document contained information about the study and its ethical rules, assuring that participation in the study could be cancelled at any time if desired by the respondent. It also guaranteed that answers to the interview questions would be presented anonymously without connection to specific persons or companies. The respondents were offered to sign it to give their approval of the upcoming interview being recorded.

Three of the five companies chose to directly answer the questions via email and encouraged follow-up questions. One of these three was unable to answer the questions but instead provided other valuable information about the complexity experienced with the CII. The two remaining companies who accepted to partake in an interview were asked if they wanted to participate via video meeting or through a physical meeting, resulting in one of each. These two interviews were recorded with the purpose of not losing any information provided. After the interviews were conducted, the recorded material was transcribed and sent to the respondent for approval before being presented in the result of this report. The companies' respondents all had different roles and are presented in the table below.

Table 1. An overview of the respondents' titles, company type and nature of the interview

	Role of respondent	Type of company	Interview type
Company A	Sustainability Manager	Container shipping line	E-mail
Company B	Operations Director	Container shipping line	Video meeting
Company C	Director and Partner	Container shipping line	E-mail
Company D	Chief Commercial Officer	Container shipping line	E-mail
Company E	Head of Sustainability	Logistics company	Physical meeting

Note. Table 4 provides information on the work roles of the respondents, what type of company they are employed at and how the interviews were conducted.

3.4 Thematic analysis

To process the information received from the companies, a thematic analysis was performed. The purpose of this was to analyze and find patterns across the set of qualitative data collected from the respondents who partook in this research. A thematic analysis emphasizes the process of coding the data in order to develop themes (Braun, 2022).

After the interviews and email conversations were completed, the answers from the companies were compiled into a document. This document was read through to get a broad perception of where the companies were standing in relation to the asked questions. The themes of interest were sorted out and later labeled as which measures the companies have taken regarding CII so far, what their future plans are, what challenges they are currently experiencing, and lastly, what flaws they consider the regulations to have.

The themes, together with the similarities and differences between the companies, were sorted and analyzed to build a result connected to the aim of the study and its research questions. Some information received by the data collection was not directly connected to the asked questions, but this was also analyzed to assess its potential relevance to the study.

4. RESULTS

The information gathered from the semi-structured interviews, as well as the information provided by the companies via email, is presented in this chapter. Firstly, how the work with CII has been approached so far is presented, followed by the companies' future plans and in regard to the regulations. Lastly, the main challenges as well as issues experienced by the companies are presented. The companies are referred to as Company A, B, C, D and E.

4.1 How CII has been approached

Company B claims to have started their work with CII before the regulations entered into force and describes that their short-term strategy mainly revolves around slow steaming. They state that because of this, several of their loops, which is the set schedule of predefined ports a ship visits during a voyage, have had to be altered. In some cases, additional ships needed to be added to a loop to maintain the same frequency and degree of utilization as before the regulations came into effect. In other cases, ports had to be removed from a loop to allow the company to continue to provide a weekly service to their customers. Company B describes the customer as a vital part of deciding whether additional vessels will be added, ports removed or if the loop will remain untouched, operating at a lower frequency. In some cases, customers accept service every ten days instead of once a week, which provides the company with more freedom when planning their network.

Similarly, Company D states that they also have decreased the speed of their vessels to be more energy efficient and reduce their emissions. They have also optimized their loops regarding which routes to sail and which ports to visit. Besides this, they work towards increased efficiency during port calls to reduce the time spent in port, and simultaneously decrease their emissions. Furthermore, they state that their main focus is to build new ships running on alternative fuels, such as LNG, as they have been doing for some time. They claim that this results in the largest possible reducing effect of carbon emissions. Today, they operate around 50 vessels running on alternative fuels.

Company C aims to take measures regarding ship building and new technology, stating that being innovative regarding ship design is a key focus of the company to decrease their GHG-emissions. They further explain that the company is looking to build ships running on alternative fuels such as methanol and bio-methanol. Besides these fuels, the company has already started to launch smaller fully electrified container vessels. Furthermore, Company C has, to assist in complying with the CII regulations, developed and launched a tool for their fleet using AI. This tool helps vessels to optimize their routes and keep track of their fuel consumption, resulting in improved fuel efficiency and ultimately reduced carbon emissions as well as costs, since less fuel is being consumed.

Similarly to Company B, Company E claims to have started its work with CII early, due to them being very forward in regard to sustainability issues. They further state that the company's early work has revolved around developing different tools to optimize the measuring of their vessels' CII. Apart from working to optimize CII measurements, Company E explains that their main focus lies upon modernizing their fleet. They strive to keep their rate of newbuilds high and at the same time phase out older vessels, stating that there is a distinct difference in terms of energy efficiency between a vessel built today and one that was built ten years ago. The company claims to have the highest rate of rejuvenation of their fleet compared to other shipping lines and have ordered 24 large container vessels that will run on methanol.

4.2 Future plans regarding CII

Company B's future plans mainly revolve around building new, more energy efficient ships that run on more environmentally friendly fuels than the conventional ones. The company has not decided on one single fuel to build their future fleet around but has instead begun to develop multi or dual fuel vessels. These vessels are planned to be equipped with the capability of being able to run on two or more different types of fuels. The company further explains that this is due to the uncertainties regarding which fuels will be the most prevalent in the future. Operating vessels that can switch between different types of fuels allows for the possibility of being more flexible and adjusting to the uncertain availability of these fuels.

Similarly, Company C claims that they too are committed to continuously improve their fleet of vessels to meet the requirements set by the CII regulations. They state that investments in developing new digital solutions, as well as innovations regarding shipbuilding which will help them reduce their carbon emissions, is their main priority today and in the foreseeable future. Furthermore, the company mentions that they possess their own shipyard, which they describe as a must to stay competitive in the current market. They further explain that failing in regard to this development would limit their ability to enter transports agreements with other companies in the future.

Company D also emphasizes the importance of improving their fleet to meet the possible future requirements of the CII regulations. They focus on developing a modern fleet in terms of innovative design as well as exploring different types of fuels. The company claims that they already have a very young fleet but are aware of ships in their possession which are closing in on 30 years old. Phasing out these older ships and replacing them with newer ones is one of the company's main priorities. Company D aims to double their number of vessels running on alternative fuels by 2028, totaling to around 100 ships. The same strategy is planned to be used by Company E. They state that they believe that the most important measure to be taken is to modernize the fleet, while at the same time phasing out older vessels. They also stress the importance of exploring more environmentally friendly fuels.

4.3 Challenges entailed by CII

The need to make good investments is seen as a challenge by company C, particularly upgrading to vessels running on alternative fuels. Today it is uncertain which fuel type that will be balanced in supply and demand and what is the right fuel to invest in, which was also expressed as a challenge by company B. To upgrade your fleet to a certain fuel, requires opportunities in both place and time to bunker the vessels. Company C also raises the question about price, in the end someone will need to pay the extra costs occurring from more expensive fuels, and this will most likely affect the end customers of the transports, which may not be of their highest interest. Just like Company C, Company D sees the cost as a challenge. To reach and maintain an acceptable CII rating comes with costs that need to be split between all actors in the transport chain.

Company E is also planning on making a switch of fuels within their fleet, with several methanol ships currently on order. The challenge regarding this, according to the company, is that different shipping lines are pushing in different directions. Company E's respondent mentions that it will not be possible to achieve economy of scale if everyone chooses different paths regarding fuel types. The price of green fuels is also brought up as an issue, sometimes reaching up to four times higher than todays' conventional fuels. The supply of these fuels is also an aspect affecting the transition, due to low production combined with the high amounts of fuel required to reach enough capacity of the vessels. Just like other companies, Company E

mentions that the final cost will affect the whole transport chain, resulting in higher prices for the transport buyers. A concern about compliance of the rules is also brought up by Company E, raising the question if higher instances are sufficiently following up the numbers reported from the companies that are affected by the regulations.

4.4 The flaws of CII

Company B states that the CII measurements can be manipulated, since the formula used to calculate a ship's attained CII uses the vessel's capacity instead of the actual weight of the cargo being carried. In theory, this means that a company can deploy a larger vessel than necessary for a loop and increase the speed of the ship. By doing this, the vessel can maintain an equal or better rating than a ship sailing the same loop at a lower speed with no excess capacity. This is made possible since the denominator of equation (1) increases, resulting in a lower attained CII, which ultimately equals a better rating.

Another issue, highlighted by Company A, is that in some cases, a ship that is not moving can receive a worse rating than a ship that is sailing in circles. They further explain that this is because a ship always causes some emissions, regardless of if it is idle or sailing, which increases the numerator of equation (1). In the case of a ship standing still, the numerator of equation (1), i.e. the emissions, increases while the denominator, i.e. the transport work, remains the same, resulting in a higher attained CII and a worse rating. If the ship instead is moving, both the numerator and denominator of equation (1) increases, which could be beneficial in terms of the rating, even if the ship cause more emissions than the one standing still. Company A states that this could prove to be problematic in cases where ships sail in circles while waiting to berth at a port instead of anchoring, solely to maintain their rating instead of reducing their emissions.

One issue regarding slow steaming, expressed by Company B, is that it could decrease the emissions of an individual ship but increase a company's absolute emissions. This is due to what was earlier mentioned about the changes to a loop when slow steaming, that in some cases, additional vessels are required, leading to a higher number of vessels being used and therefore increase the total emissions caused by the shipping line.

5. DISCUSSION

The result gathered from the performed interviews as well as communication via email shows many similarities between the companies regarding actions taken to comply with the regulations. As the theory shows, slow steaming and switching to more sustainable fuels are of significant impact to reduce carbon emissions which the companies confirmed to be common approaches adopted in the industry.

Due to the benefits of reducing fuel consumption, and by that decreasing emissions, slow steaming has become a prevalent strategy adopted by some of the companies. It allows the companies to prolong the lifespan of their older vessels running on HFO, MDO or MGO. Therefore, these vessels can stay compliant to the CII regulations for a few more years without any additional investments, before being phased out. The accessibility of this strategy, together with the fact that it in many cases reduces operational costs (Cariou, 2011), makes it not very surprising that many have turned to adopting slow steaming as a strategy, at least in the short-term. However, in a long-term perspective, slow steaming does not seem to be the most optimal approach. It can be assumed that a shipping company would prefer to utilize the fleet not only in terms of its loading capacity, but also in terms of taking advantage of the speed that the vessels are capable of operating at.

The theoretical nature of the CII shows that it is not yet a perfect solution. As expressed by Company B, the fact that a company might need to operate more vessels to maintain the frequency of their services when slow steaming, could prove to be a concern. Operating more vessels will undoubtedly lead to increased investment costs, and the balance between efficiency and cost appears to be one of the toughest challenges today. To choose this path also means that the total emissions of a company could increase, which conflicts with the purpose of the regulations. It can therefore be assumed that CII in its current form looks better on paper than in practice. Since the regulations treat each vessel individually, it does not take a company's absolute emissions into consideration, which could possibly become a supplementary necessity to achieve the goal of net-zero emissions by 2050.

To assist with the compliance of the CII regulations, only one company mentioned using digital tools, AI in this case, which was a rather surprising discovery. As mentioned by DNV (2022), the implementation of digital tools could prove to account for around one sixth of the necessary reduction of GHG emissions to reach IMO's goal by 2050. Due to the technology accessible today and the rapid growth of digitalization worldwide, it was expected that more of the companies would discuss the implementation of digital tools as aids to comply with the CII regulations in the future.

Most of the technical solutions suggested by Bayraktar & Yuksel (2023), aiming to optimize a vessel's CII rating, were not mentioned by any of the companies. If these kinds of modifications are not planned to be implemented or if the companies decided not to disclose it is unknown. By comparing them to the more extensive approaches of slow steaming and the implementation of new fuels, they perhaps were considered to not make enough of a difference.

Even though several of the companies have started to develop and launch vessels running on alternative fuels, none of them claim to have made any definitive decision on which fuel to build their future fleet around. Based on the gathered information, the companies will most likely possess a fleet consisting of vessels running on various fuels, to avoid draining and

competing for the availability of certain types of fuel. This will most likely be the case until the supply of alternative fuels has become more reliable.

The consistent theme of concern regarding the increased costs expressed by the companies was not very surprising. Almost all the companies stated that the costs derived from the work performed to comply with the CII regulations will be challenging to deal with. As with any company trying to succeed, one of the goals is to reduce costs, to improve its profit margin. Since the profit margins of container lines are generally quite low (Alger et al., 2021), the concern they expressed, and the challenges they experienced regarding this, was expected. The large capital investments which are required to make progress towards the CII regulations as well as the IMO's net-zero goal could prove detrimental if not carefully thought out.

Company E's concern about whether any third party was actively investigating the compliance with the CII regulations was a bit unexpected. Talking to the different companies as well as reading about the industry gave the impression that most work in the end boils down to minimizing costs. Therefore, the opinion that the rules should be stricter, or that the compliance should be further monitored, stood out. If this is something that the whole company stands by, or just the personal opinion of the respondent is hard to know. The fact that the respondent from Company E had the role as Head of Sustainability could point to both possibilities.

Operating bigger vessels than needed, which Company B mentions as a way of manipulating the CII measurements, does not seem like a believable solution. Even if this is possible due to the equation used, it goes against the goal of utilization on board that is needed to keep the costs down. Company A also describes the possibility for a vessel to receive a higher CII rating by constantly being on the move instead of lying at anchor while waiting to call a port. Neither this is a believable approach, since fuel costs already contribute to around two thirds of a shipping company's expenses (UNCTAD, 2023), most companies should want to conserve as much fuel as possible.

5.1 Method discussion

Even if information about adaptations made to comply with CII were available in most companies' sustainability reports, contact with people working in the industry was considered important to get a broader understanding of the regulations' effect on daily operations. This also created the possibility to get an explanation of how companies adapted to the rules, and why their choice of certain approaches had been made. The interviews also led to sidetracks, which opened for questions that were not considered when the research was started, resulting in a broader perspective on the subject.

To use interviews as a data collection method, Denscombe (2017) underlines the importance of access to potential interviewees. In this study, more extensive information was received from the two companies with which interviews were held, compared to the ones consisting of personal communication through email. The access to interviewees, in combination with two of the contacted companies not reaching back after the interview requests, led to a narrower result than expected. The process of finding respondents was protracted when being rejected after the initial contact with offices in Sweden. To early initiate contact with persons at the head offices might have increased the chances of having more companies involved in the study, leading to a more extensive result.

When it comes to reliability of qualitative research, it can rarely be determined by conducting the same research a second time (Denscombe, 2017). This is because the specific conditions

are hard to replicate in terms of social settings, as well as the close involvement of the initial researcher, resulting in a small chance of reaching the same conclusion twice. In the case of this specific study, the anonymity of the respondents makes the chance of connecting with the same company representatives low, which could prove for a low reliability. However, assuming that their responses are an overall company reflection rather than personal opinions, the chances for a similar result increase, and by that the reliability. This because the need to connect with the exact same respondent at each respective company to reach the same conclusion would diminish.

If the responses truly represent the viewpoints of the companies, then this also enhances the study's validity, since the primary aim was to examine companies within the industry. The validity further increases by the similar responses from the different companies, which also is in line with the theory on the subject. Due to not being able to get interviews with as many companies as first intended, and the number of respondents being rather low, the result cannot be considered representative enough for the whole industry. If more companies would have been able to participate in the research, it would have made it possible to further strengthen the validity of this study.

6. CONCLUSION

The study aimed to investigate container shipping lines current and possible future strategies to comply with the CII regulations. It also sought to find similarities as well as differences between companies' approaches and identify perceived challenges connected to the rules. The limited amount of available literature within the subject proved to be a threshold when conducting this research. However, performing the main part of the data collection through interviews and personal contact with companies provided valuable information about what the adaptations look like today and possibly will look like in the future.

Regarding how container shipping lines comply with the CII rules today, one of the main actions seems to be to slow steaming, which helps to decrease the fuel consumption as well as the CO_2 emissions and costs. However, this might be problematic if the service frequency does not live up to customer's expectations. If so, more vessels will be required to be operated, possibly resulting in an increase of emissions.

In the future, alternative fuels are of big importance to decrease the level of carbon emissions seen today. The main obstacle with these fuels is that the supply is not stable enough to cover all company's needs, and there are uncertainties surrounding which fuel to commit to. It is also clear that the greener fuels come with a higher price than the conventional ones and require large investment in new vessels compatible with the chosen fuel.

CII is experienced to come with some issues through its theoretical nature, by not considering all circumstances affecting a vessel's rating. If this is only a detail that can make the calculation look questionable on paper, or if it has a negative effect on the companies having to comply with the rules is hard to tell.

The study can conclude that there are several feasible measures to take to decrease the environmental impact of shipping and thereby comply with the CII regulations. Slow steaming and phasing out fossil fuels are two important aspects, but the question is if the industry is willing to deal with the sacrifices consisting of raised operating costs and investments required to modernize the fleet. Due to the CII regulations still being relatively newly implemented, companies in the industry are still trying to investigate which path is best to take. The research questions have been answered to a partially satisfactory level, but respondents from more companies as well as more interviews in general would have facilitated a more comprehensive conclusion.

6.1. Recommendations for further research

Due to this study strictly investigating the container shipping segment, with companies operating on similar conditions, it could be an idea to investigate and compare approaches between different segments in the industry. It would also be of value if similar research were to be made on more companies than was possible in this study.

Because of the conditions described earlier in this chapter it might be of interest to raise the questions of this study again in a couple of years. This would especially apply if the rules are to be changed after the planned revision of CII in 2026.

REFERENCES

Alger, J., Lister, J., & Dauvergne, P. (2021). Corporate governance and the environmental politics of shipping. In *Global Governance* (Vol. 27, Issue 1, pp. 144–166). Brill Academic Publishers. https://doi.org/10.1163/19426720-02701001

Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., & Staffell, I. (2019). How to decarbonise international shipping: Options for fuels, technologies and policies. In *Energy Conversion and Management* (Vol. 182, pp. 72–88). Elsevier Ltd. https://doi.org/10.1016/j.enconman.2018.12.080

Baltic and International Maritime Council (2023, July 10). *IMO initiates revision of the CII regulations.* https://www.bimco.org/insights-and-information/safety-security-environment/20230710-mepc-80-cii-regulations

Bayraktar, M., & Yuksel, O. (2023). A scenario-based assessment of the energy efficiency existing ship index (EEXI) and carbon intensity indicator (CII) regulations. *Ocean Engineering*, *278*, 114295. https://doi.org/10.1016/J.OCEANENG.2023.114295

Braun, V., & Clarke, V. (2022). *Thematic analysis: a practical guide.* SAGE.

Cariou, P. (2011). Is slow steaming a sustainable means of reducing CO2 emissions from container shipping? *Transportation Research Part D: Transport and Environment*, *16*(3), 260–264. https://doi.org/10.1016/j.trd.2010.12.005

Deng, S., & Mi, Z. (2023). A review on carbon emissions of global shipping. *Marine Development*, *1*(1). https://doi.org/10.1007/s44312-023-00001-2

Denscombe, M. (2017). *The Good Research Guide* (6th ed.) Open University Press.

Det Norske Veritas. (2022). *Maritime forecast to 2050. Energy Transition Outlook 2022.* https://www.dnv.com/publications/maritime-forecast-to-2050-2022-edition-235251/

García-Olivares, A., Solé, J., & Osychenko, O. (2018). Transportation in a 100% renewable energy system. *Energy Conversion and Management*, *158*, 266–285. https://doi.org/10.1016/j.enconman.2017.12.053

Global Maritime Forum. (2023, April). *The shipping industry's fuel choices on the path to net zero.* https://www.globalmaritimeforum.org/content/2023/04/the-shipping-industrys-fuel-choices-on-the-path-to-net-zero_final.pdf

International Maritime Organization. (2021a). *2021 Guidelines on operational carbon intensity indicators and the calculation methods (CII guidelines, G1).* https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.336(76).pdf

International Maritime Organization (2022, November 1). *Rules on ship carbon intensity and rating system enter into force.* https://www.imo.org/en/MediaCentre/PressBriefings/pages/CII-and-EEXI-entry-into-force.aspx

International Maritime Organization. (n.d.-a). *EEXI and CII - ship carbon intensity and rating system.* https://www.imo.org/en/MediaCentre/HotTopics/Pages/EEXI-CII-FAQ.aspx

International Maritime Organization. (n.d.-b). *Introduction to IMO.* https://www.imo.org/en/About/Pages/Default.aspx

International Maritime Organization. (n.d.-c). *List of IMO Conventions.* https://www.imo.org/en/about/Conventions/Pages/ListOfConventions.aspx

International Maritime Organization. (n.d.-d). *International Convention for the Prevention of Pollution from Ships (MARPOL).* https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx

International Maritime Organization. (n.d.-e). *2023 IMO Strategy on Reduction of GHG Emissions from Ships.* https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx

International Maritime Organization. (n.d.-f). *MARPOL, Annex VI, Regulation 28 – Operational Carbon Intensity.* http://dmr.regs4ships.com.eu1.proxy.openathens.net/docs/international/imo/marpol/ann_06/028.cfm

International Maritime Organization. (n.d.-g). *MARPOL, Annex VI, Regulation 26 – Ship Energy Efficiency Management Plan (SEEMP)* http://dmr.regs4ships.com.eu1.proxy.openathens.net/docs/international/imo/marpol/ann_06/026.cfm

Kramel, D., Muri, H., Kim, Y., Lonka, R., Nielsen, J. B., Ringvold, A. L., Bouman, E. A., Steen, S., & Strømman, A. H. (2021). Global Shipping Emissions from a Well-to-Wake Perspective: The MariTEAM Model. *Environmental Science and Technology*, *55*(22), 15040–15050. https://doi.org/10.1021/acs.est.1c03937

Mitsui O.S.K. Lines. (2021, June 7). *Current status and future prospects of LNG fuel for ships.* https://www.mol-service.com/blog/lng-as-ships-fuel

Nunes, R. A. O., Alvim-Ferraz, M. C. M., Martins, F. G., & Sousa, S. I. V. (2017). The activity-based methodology to assess ship emissions - A review. In *Environmental Pollution* (Vol. 231, pp. 87–103). Elsevier Ltd. https://doi.org/10.1016/j.envpol.2017.07.099

Psaraftis, H. N., & Kontovas, C. A. (2009). CO 2 Emission Statistics for the World Commercial Fleet. In *WMU Journal of Maritime Affairs* (Vol. 8, Issue 1). https://link.springer.com/article/10.1007/BF03195150

Shell. (n.d.). *LNG in shipping.* https://www.shell.com/what-we-do/oil-and-natural-gas/liquefied-natural-gas-lng/lng-in-shipping.html

Solakivi, T., Paimander, A., & Ojala, L. (2022). Cost competitiveness of alternative maritime fuels in the new regulatory framework. *Transportation Research Part D: Transport and Environment, 113*. https://doi.org/10.1016/j.trd.2022.103500

Statista, (2023, September 22). *Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2022, by sub sector.* https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/

Svanberg, M., Ellis, J., Lundgren, J., & Landälv, I. (2018). Renewable methanol as a fuel for the shipping industry. *Renewable and Sustainable Energy Reviews, 94*, 1217–1228. https://doi.org/10.1016/j.rser.2018.06.058

United Nations Conference on Trade and Development. (2023). *Review of maritime transport 2023.* https://unctad.org/system/files/official-document/rmt2023_en.pdf

United Nations, (n.d.). *The 17 Goals.* https://sdgs.un.org/goals

Witthohn, R. (2023). *International Shipping: The Role of Sea Transport in the Global Economy.* Springer. https://link.springer.com/book/10.1007/978-3-658-34273-9

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