CHALMERS
UNIVERSITY OF TECHNOLOGY

The integration of environmental factors in marine insurance underwriting for the tanker industry

Its impact on risk assessment and pricing

Fredrik Tidblad
Nikolaos Papikinos

DEPARTMENT OF MECHANICS AND MARITIME SCIENCES

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2024
www.chalmers.se

Master's thesis 2024

The integration of environmental factors in marine insurance underwriting for the tanker industry

Its impact on risk assessment and pricing

Fredrik Tidblad
Nikolaos Papikinos

CHALMERS
UNIVERSITY OF TECHNOLOGY

Department of Mechanics and Maritime Sciences
Division of Maritime Studies
Chalmers University of Technology
Gothenburg, Sweden 2024

The integration of environmental factors in marine insurance underwriting for the tanker industry
Its impact on risk assessment and pricing
Fredrik Tidblad and Nikolaos Papikinos

Supervisor: Abhinayan Basu Bal, University of Gothenburg

Examiner: Henrik Ringsberg, Chalmers University of Technology

Master's thesis 2024
Department of Mechanics and Maritime Science
Division of Maritime Studies
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +(46) 31 772 1000

Cover picture:
Oil tanker on a sea voyage transporting cargo with overlay graphics. Original picture retrieved from iStock and edited.

Gothenburg, Sweden 2024

Abstract
This thesis investigates the integration of environmental factors into marine insurance underwriting processes for the tanker industry together with an analysis of the potential impact on risk assessment and pricing. Through a comprehensive review of current literature and a methodological approach that includes qualitative analysis and case study research, it illustrates the importance of emissions and environmental regulatory framework in connection with risk assessment and insurance pricing. The overall outcome of this research shows that integration of environmental aspects enhances the accuracy of risk evaluations and helps insurers create sustainable business methods. The thesis concludes with a presentation of the findings and a discussion on the implications on insurers, the need for new risk assessment practices, relational contracts, and the advantage of a maritime industry ecosystem. The research underscores the significance of environmental considerations in the marine insurance sector and suggests pathways for embodying these factors more comprehensively in the future.

Keywords: Marine insurance, maritime industry ecosystem, environmental factors, tanker industry

Acknowledgements

Firstly, we would like to express our gratitude and give our sincerest thank you to our supervisor Abhinayan Basu Bal who have provided us with great guidance, expertise and support which has helped us tremendously in our process.

Secondly, we would like to thank Hans Filipsson at The Swedish Club for his valuable input and guidance in the planning phase of the thesis and his commitment to provide contacts for interviews. Lastly, we would like to thank all the interviewees who took time off their busy schedules to be a part of this study. This thesis could not have been done without you.

Table of contents

List of figures

List of tables

List of acronyms

AER – Annual Efficiency Ratio
cgDIST – Capacity Gross Ton Distance
CII – Carbon Intensity Indicator
CLC – Civil Liability Convention
CSR – Corporate Social Responsibility
DCS – Data Collection System
EEDI – Energy Efficiency Design Index
EEOI – Energy Efficiency Operational Index
EEXI – Energy Efficiency Existing Ship Index
EGD – European Green Deal
ESG – Environmental Social Governance
ETS – Emission Trading System
GHG – Greenhouse Gas
GT – Gross Tonnage
H&M – Hull & Machinery
IMO - The International Maritime Organization
LNG – Liquified Natural Gas
LPG – Liquified Petroleum Gas
MEPC – Marine Environmental Protection Committee
MIA - Marine Insurance Act
MRV – Monitoring, Reporting and Verifying
P&I – Protection & Indemnity
SECA – Sulphur Emission Control Areas
SEEMP – Ship Energy Efficiency Management Plan

1. Introduction

This novel research aims to present the integration of environmental factors into marine insurance underwriting practices for the tanker industry. The research addresses a contemporary and complex process for the marine insurance sector. The influence of environmental factors into marine insurance could lead to investments on new practices as awareness increase and stakeholders demand more sustainable practices. The overall aim is to address the contemporary need for environmental metrics and the understanding of integrating environmental factors into marine insurance underwriting, specifically for tankers. The choice to focus on the tanker industry is based on the industry sector's complex nature with both spot market and time charter contracts and the many different stakeholders. Charterers for instance, which have different controls of the vessel operation dependent on the type of charter contract. Moreover, stakeholders such as shipowners, regulators, port facilities and insurers make it a complex industry with emissions liabilities and demurrage as well as the notable risk of oil spills.

Following a discussion with a leading P&I insurer, the authors found lack of metrics for assessing ESG factors in relation to insurance risk assessment and pricing, therefore it would be highly beneficial for the industry and the academia for further research and development within this field.

1.1 Background

We live in the VUCA world, a world full of volatility, uncertainty, complexity, and ambiguity (Mack et al., 2016). The shipping industry is changing with new legislation, Sulphur Emission Control Areas (SECA), global CO2 reduction and EU Emission Trading System (ETS) to name a few. As most companies already have a Corporate Social Responsibility Framework (CSR), it is vital to work with ESG in order to remain competitive and to be prepared for new challenges (Monios & Wilmsmeier, 2020). The prominence of this framework has absorbed attention of stakeholders around the maritime sector and large investments have been applied within the subject of ESG (Nõmmela & Kaare, 2022).

Marine insurance policies have been created to spread the risk and help shipowners (Puscaciu & Ebiere, 2019), and environmental factors have great influence on industry's development (Lai & Xv, 2021). Thus, the connection of these two parameters could be beneficial for further research and connection between them. This thesis will address the necessity of a more holistic approach in the maritime insurance market, as the industry is highly volatile to environmental factors and changes which creates uncertainty among the stakeholders (Kavussanos et al., 2021).

Following the above, the difficulties in science and engineering of this topic are plenty. Reliable models that can predict outcomes, real time data in relation to environmental figures and underwriting strategies will be challenging to find and connect for optimum result. By adopting all the elements mentioned previously, this research envisages to help the maritime sector to improve insurance policies, decrease risk, improve sustainability in the tanker segment and promote the co-operation between industry stakeholders.

In the upcoming paragraphs, the environmental factors and marine insurance market are briefly discussed along with the tanker industry to provide context for framing the research questions.

1.1.1 Marine insurance market

The marine insurance market is an old and traditional way of covering liabilities of the shipping industry and is based on the Marine Insurance Act (MIA) of 1906 (Noussia, 2004). The development of marine insurance through the years has been very important for the maritime sector, it has achieved to cover a wide range of risks through multiple forms of insurance such as Hull & Machinery (H&M), Protection & Indemnity (P&I), Freight and Loss of Hire (Puscaciu & Ebiere, 2019). Known as a complex and unique structured system, the London and Lloyd's markets are the places where syndicates organize the insurance business, by calculating, assessing, and taking responsibility for each insurance policy. These can be divided into valued or unvalued, and voyage or time policies (Gurses, 2016). This model of decentralization, helps the syndicates to focus on specific insurance covers and facilitate the broad cover of a wide range of risks within this market (Gurses, 2016).

P&I clubs have a vital role in the marine insurance sector as 90% of the world's fleet in relation to tonnage is insured by mutual risk clubs (Bennett, 2001). Even though the establishment of direct connection between peril and result of accident could be challenge for shipowners, P&I clubs act as a trustee organization, working towards identification of insured and excluded perils, protecting and covering their members' liabilities (Manopo & Merkin QC, 2021). It can be considered that these clubs work as syndicates, where the members are solely shipowners and the premium is paid based on the gross tonnage (GT) of the vessels (Aase, 2007).

As the maritime sector is built up in the terms of strong cooperation among multiple stakeholders across the world, trust and mutuality are aspects with significant matter for the industry, therefore, the role of marine insurance through legislation and guidance is vital to avoid disasters such as the Torrey Canyon a Suezmax oil tanker that ran aground close to U.K. in 1967 with a major oil spill as consequence. The transportation through sea has always been the dominant factor of shipping goods and environmental awareness is constantly increasing, a common scheme is needed to protect and align shipowners. All the above witness the meaning of marine insurance and how much influence it may have in increasing the safety and security of transport of goods (Sperdokli, 2014).

1.1.2 Environmental factors

As the need of international trades has been increased the last few years and the maritime sector is responsible for almost 90% of global trades, the environmental pollution from vessels have a notable escalation, therefore, the are significant challenges in the industry (Guo et al., 2023). Emissions from vessels are responsible for both climate change and health problems for humans (Sofiev et al., 2018), oil spills and accidents can occur through vessel transportation, platform issues or pipelines (Feng et al., 2021). In addition, all previous factors have health, environmental and economic implications (Sartz et al., 2023).

Initiatives from industry's stakeholders to mitigate the overall impact have been implemented such as alternative fuels (Zetterdahl, 2016) or voyage optimization (Christodoulou & Cullinane, 2023). As the IMO provide guidelines for them and set the rules to achieve future targets (Shi et al., 2023) and the EU takes action towards GHG emission reduction (Chircop et al., 2018), it is crucial for all involved parties of the industry to take actions in order to reduce risk and promote the sustainability aspect of the shipping sector.

1.1.3 The tanker industry environmental factors

The history of crude oil transportation and the importance of it, starts in the middle of the 19th century. Since then, not only crude oil but derived products such as kerosene, paraffin,

lubricants, trade around the world as the demand arises and supply of these products facilitated by the tanker industry. Tankers are responsible for transportation of oil, liquified natural gas (LNG), liquified petroleum gas (LPG), ammonia, ethanol and divided into different categories subject to size, number of cargo tanks, tonnage and area of operation, some of which cannot cross Panama Canal or the Suez Canal (Tsakos, 2016).

Even though the significant efforts of regulators and shipowners who protect and promote safety awareness through their processes, the tanker industry remains a sensitive and volatile field of the maritime sector. This is due to the nature of cargo transportation and ecological risks. Aspects which not only influence the market but also the economies of areas in which they operate (Vidmar & Perkovič, 2018).

1.2 Objectives

This study expects to find environmental metrics that can be used in risk assessment and underwriting policy. It aims to address the contemporary need for environmental metrics and the understanding of integrating environmental factors into maritime insurance underwriting, specifically for tankers. The findings are expected to give important insight for both insurers and shipowners.
The authors want to highlight the possible usage of environmental performance in insurance practices, and hopefully this research can contribute to the evolution of insurance underwriting, by assisting the shift towards implementing ESG practices.

1.2.1 Research questions

The thesis will address the below stated research questions:

How can the marine insurance companies adapt their risk assessment to incorporate environmental factors of tanker vessels?

What data sources and metrics should marine insurers rely on to assess the environmental performance of insured entities?

How will the integration of environmental factors impact pricing of marine insurance policies?

1.3 Scope

The scope of this thesis is limited to the tanker industry due to its geographical and communicative ease. The leading P&I club of which the authors have been in contact with have connection with many shipowners within the tanker industry within the vicinity of Gothenburg, which was convenient for the scope of this thesis. Furthermore, as previously stated the choice of this specific sector was based on its complex nature with both different types of contracts and stakeholders.

The environmental factors addressed in this thesis are focusing mainly on ship emissions and the operations affecting these emissions. As the implementation of environmental factors into marine insurance underwriting is a contemporary subject, this thesis has collected secondary data from existing literature and primary data from relevant industry stakeholders.
Even though the thesis is limited to the tanker industry only, the methodology could be applied for other industries to find conclusions for other sectors.

1.4 Structure
Following this introductory section is the main body of the thesis, which include chapter 2 that presents the theory of the comprehensive literature review that was conducted, chapter 3 which addresses the methodology, chapter 4 which presents the findings, chapter 5 which discusses the findings and lastly chapter 6 with the conclusion of this research.

2. Theory
In this section, analysis of literature will be conducted to provide critical and necessary information for the relevant area of concern. The theory section comprises four fundamental pillars: emissions, marine insurance, risk assessment and the maritime ecosystem.

2.1 Emissions
The maritime industry contributes to around 2-3% of global CO2 emissions and this number is expected to grow by 50 – 250% based on an IMO study which was conducted in 2012 (Deane et al., 2019). Even though extensive discourse occurred for additional amendments, the shipping industry is highly traditional which makes it difficult for regulators to implement new rules and achieve goals for improved environmental procedures (Baumann, 2023). Ships not only pollute ecosystem with CO2 emissions but also with other varieties of pollutants which are responsible for climate change and health quality. Particulate matter, Sulphur oxides, nitrogen oxides are responsible for air-pollution and causation of diseases such as cancer, cardiovascular disease, and asthma (Sofiev et al., 2018). Emissions from exhaust contribute to acidification and eutrophication of marine waters and are primarily responsible for air pollution. Additionally, it can be transported over hundreds of kilometres in the atmosphere where it can reduce air quality (Karl et al., 2019).

Due to the significant impact of ship pollution towards humans, air and water, the implementation of Sulphur Emission Control Areas (SECA), areas where ships are obligated to use fuel with less than 0.1% Sulphur content and the implementation of new energy carriers such as LNG is used as mean to minimize the effect of particle emissions (Zetterdahl, 2016). Therefore, the adoption of emissions reduction measures and regulatory frameworks are essential contributors to emission reduction and to shift the maritime industry towards a better contribution against climate change.

The regulatory landscape of the maritime industry is extensive and comprehensive. A lot of effort has been put towards decarbonization of the shipping industry with high focus on the political and environmental aspects (Christodoulou & Cullinane, 2023). The maritime industry adopted MARPOL Annex VI as early as 1997, limiting the main air pollutants from ship exhaust gases and emissions from tanker cargo. This includes nitrous oxides (NOx), Sulphur oxides (SOx), particulate matter (PM), volatile organic compounds (VOC) from tankers and the intentional emissions of ozone depleting substances (ODS) (Chircop et al., 2018). With a growing concern within the IMO for the lack of progress and the possibility for national or regional initiatives, a new greenhouse gas study was agreed upon during the Marine Environmental Protection Committee (MEPC) meeting 56 in 2006. During the meeting, Norway proposed a CO2 levy to establish an international fund (Chircop et al., 2018). The conceptual framework of this international fund is based on allocation of CO2 taxes towards developing countries. This methodology is suggested to be carried out in correlation to import figures of each developing country while the remaining amount of money will be distributed to research and technological advancements for countries to enhance adaptive capacities towards climate change (Yubing Shi, 2017). Furthermore, during MEPC meeting 59 in 2009 it was agreed to publish the Guidelines for voluntary use of the Ship Energy Efficiency

Operational Indicator (EEOI). Moving forward the MEPC meeting 62 in 2011 decided to adopt the Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) which eventually entered into force in 2013. The EEDI is a measure that applies to new ships in the building stage to promote energy efficiency in the design stage, it does not include the operational aspects. The SEEMP is a management plan that considers the operational aspects of energy efficiency (Chircop et al., 2018). In line with the ongoing environmental policy changes, the EU decided to adopt a monitoring, reporting, and verifying system (MRV) which entered into force in 2015, with the first reporting period in 2018. The purpose of the MRV system is to gather reliable data of ships emissions. The MRV system requires all ships above 5000 gross tonnage (GT) with port calls within EU to report their emissions, which includes fuel consumption, distance sailed and transport work (Chircop et al., 2018). Following the decision of EU MRV the IMO decided to adopt the IMO Data Collection System (DCS) which entered into force in 2018. The IMO DCS requires all ships of 5000GT and above, with international voyages, to report total fuel consumption of each fuel type, distance travelled and hours underway. The data collected through the IMO DCS is anonymous and the individual ship data is not disclosed. It is also not as extensive as the EU MRV which makes the DCS usable for statistics and not detailed information for operational improvements (Deane et al., 2019). Furthermore, the European parliament's discussions to include shipping in the EU emission trading system (ETS) started as early as 2017, and it was eventually voted yes in 2020 to include shipping in ETS from 2024. The EU ETS sets a limit on the total amount of GHGs that can be emitted by the shipowners covered by the system, which could be expressed as emission allowance. If the cap is reached the shipowner is required to purchase additional allowance. If the cap is not reached, it is possible to sell the remaining allowance. The cap is reduced annually to ensure a reduction of GHG emissions (Christodoulou & Cullinane, 2023).

Moreover, the European Climate Law was adopted in 2021 with an initiative to implement the European Green Deal (EGD) with the target of reducing emissions by 55% by 2030. What is significant with the implementation of the EGD is that it makes climate neutrality not only a goal but a legally binding target (Heras, 2022). To reach the targeted reduction of emissions the EU Fit for 55 legislative framework was proposed, which provides legislative proposals to revise the EU 2030 climate and energy framework with the goal of implementing the EGD (Heras, 2022). The EU Fit for *55* framework includes EU ETS, a specific GHG intensity limit on the consumed energy of ships starting in 2025 and FuelEU Maritime (Christodoulou & Cullinane, 2022). The benefits of the European Climate Law is that it enhances the reliability and foreseeability of the EU's reduction strategies for the upcoming decades and grants the European Commission the authority to implement laws aimed at achieving climate neutrality (Heras, 2022). The FuelEU Maritime initiative aims to promote the decarbonization of the shipping sector when it enters into force in 2025. It will be realized by setting energy intensity limits of ships in a well-to-wake perspective to incentivize the usage of renewable energy sources or low-carbon fuel alternatives (Christodoulou & Cullinane, 2022). In 2022, IMO implemented updated measures for energy efficiency, the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII). The measure is a focusing on the transport work of existing ships and not the design of ships as the EEDI does (Bayraktar & Yuksel, 2023).

Following is a visualized timeline for the policy and regulatory events addressed in this section.

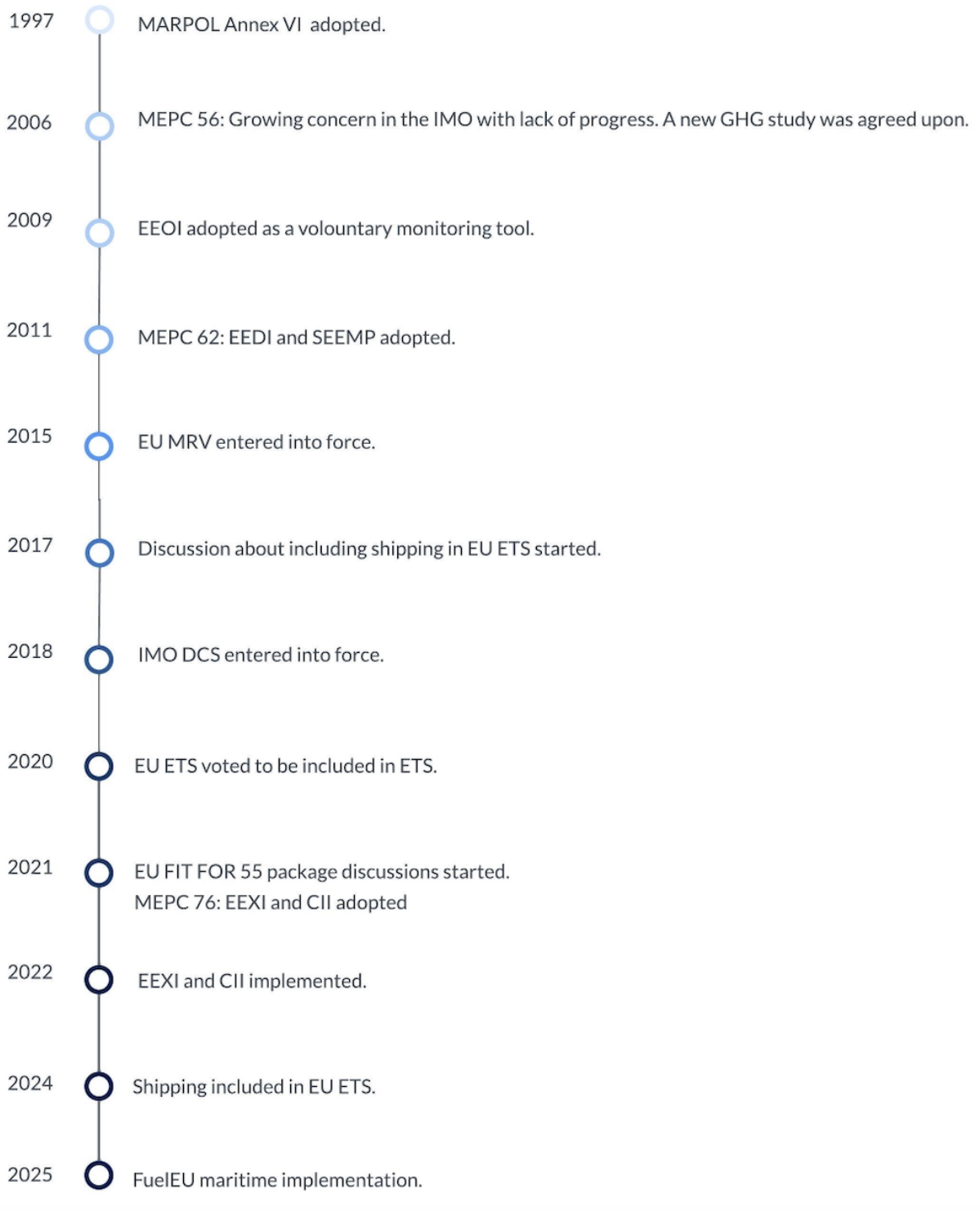


Figure 1. Policy and regulations timeline

2.1.2.1 EU emission trading scheme

The European Union following IMO initiatives for the decarbonization of the shipping sector, established the EU ETS. This endeavour acknowledged the EU as a strong driver for reaching the shipping sector's targets of 50% reduction of GHG emissions by 2050 in relation to 2008 levels (Fiorini & Gupta, 2021). Unlike other types of approaches for addressing the decarbonization issue, such as *command and control*, the emission trading scheme is a market-based measure mechanism which provides flexibility for industry stakeholders and allows them to arrange the increased cost of carbon pricing. It is a cap and trade system, where shipping

companies acquire their emissions allowances through auctioning based on previous years records, an annual cap of the total GHG emissions is applied and stakeholders can trade emissions through this system (Christodoulou & Cullinane, 2023).

The theoretical approach of the *emission trading scheme* mechanism is the systematic reduction of adverse side effects generated, because of economic processes (Baumol & Oates, 1971). For the implementation of an ETS in EU territory, regulators based their decision on two primary benefits of this mechanism. Setting a cap on total emissions aids the environmental effectiveness and keeps control of GHG emissions. Moreover, by reducing the total amount of emission annually, it encourages stakeholders to achieve the target of the industry's decarbonization. The second benefit is the creation of a price for emissions, as this will help industry to adjust their needs and balance the cost of reducing emissions (Koesler et al., 2015). However, as a mechanism which is new for the industry and has not proven effective yet, uncertainty arises across it. One of the reasons why it lacks predictability among participants is that emissions allowances are determined by the supply and demand. For an industry like the maritime industry where it is highly volatile and sensitive to global changes this is highly risky. In addition to this, the total allowances will be a critical factor on how the industry will absorb it on the grounds that if it is high, the price will be low and will discourage shipping companies to move towards sustainable practices and if it is low, big companies will have the advantage and adjust the price on their needs (Christodoulou & Cullinane, 2023).

The EU Monitoring, Reporting and Verification system (MRV) is being used for recording the CO2 emissions from vessels and it is being used as a tool for accurate emissions allowances. This will establish the flag states and shipping companies as the main regulated bodies (Lagouvardou & Psaraftis, 2022). The EU ETS started in January 2024 and includes all vessels above 5000 gross tonnages with no flag limitations which enter EU territory. At the current stage it refers only to CO2 emissions as methane and nitrous oxide emissions will be added in 2026. The ETS will cover 100% emissions which are generated in voyages between two EU ports, 50% of emissions between EU and non-EU ports and 100% of emissions at berths in EU ports (Syriopoulos et al., 2023). Therefore, the introduction of new legislation and clauses in relation to charter parties shall be implemented as charterers bear the price of bunkering and speed optimization while shipowners should be protecting their emission allowances and any additional chargers (Lagouvardou & Psaraftis, 2022).

A vital role for the viability and effectiveness of shipping companies is to understand the nature of this scheme and make the correct commercial decisions in both short and long aspects. For a long run perspective, the investment into sustainable practices is the most beneficial strategy for shipowners to minimize costs but for the short run perspective, a crucial aspect is how the appropriate hedging strategy will apply. The hedging strategy is relevant to the risk that the shipowners bear, buying extra emission allowances to prevent any upcoming price rises which will affect the profitability of upcoming voyages (Syriopoulos et al., 2023). In addition, if the cost for carbon reaches a level of 120 USD/ton it would influence the industry to invest on abatement operational technologies (Syriopoulos et al., 2023). Another uncertainty which arises regarding companies' strategic decisions is in relation to adding additional ports-of-calls to save emissions allowances and as a result a so called carbon leakage due to lack of a worldwide agreement, especially if the carbon price will be high (Lagouvardou & Psaraftis, 2022). However, a strategic decision like this, should not always be beneficial for shipowners as this would lead to increased emissions because of port activities and delay of voyage (Wu et al., 2024). Furthermore, the EU has formulated the Market Stability Reserve (MSR), which addresses a surplus of allowances to improve ETS resilience and adjust the supply of emission

allowances depending on supply and demand. Nonetheless, MSR's success is highly dependent on other policies in relation to sustainability abatement options which as a result lead to a unpredicted CO2 emission cap (Bruninx et al., 2020).

2.1.2.2 Carbon intensity indicator

The IMO, through the 76th session of the Marine Environmental Committee (MEPC 76), introduced the Carbon Intensity Indicator (CII) measure as an initiative to reach the decarbonization targets by 2030 and 2050 respectively. CII is the third part of the Ship Energy Efficiency Management Plan (SEEMP), a three-year action plan produced from IMO where ships shall keep onboard and includes a list of measures to improve vessel's efficiency and reduce carbon emissions for achieving the required targets (IMO, 2022a). CII measures a vessel's carbon emissions per unit of transport work. The vessel's performance of carbon emissions will be compared with IMO CII values with a span of one year's progress and will be rated based on it. The ratings are from A to E, where A is major superior, B is minor superior, C is moderate, D is minor inferior, and E is inferior. Further improvement actions will be demanded for vessels which are rated with a D for three consecutive years or an E for a single year. The IMO's CII values will decline as time progresses (Wang et al., 2021). If a vessel scores E for one year or D for three consecutive years, regulator bodies will apply economic restrictions for the vessel's performance to achieve CII model's aims. Moreover, the demands towards the shipowners will be increased in the case that a vessel improves its performance through CII standards. This performance will additionally affect the S&P (Sales and Purchase) market as better rating vessels will achieve a better sale price for their owners. Another important factor is the financial feasibility which will be achieved as financial institutions work closely with CII and ESG factors and this will determine the accessibility to financial funding (Hua et al., 2024).

The calculation of CII can occur either by estimating the actual mass or volume a vessel carries and this is to be referred to as demand-based CII, or by a proxy of the actual mass or volume a vessel carries on board which is referred to as supply-based CII. For proxy calculations where supply-based CII applies, DWT (Dead-Weight Tonnage) is used as capacity and is known as AER (Annual Efficiency Ratio), while using GT (Gross Tonnage) is called cgDIST (Capacity Gross ton Distance). Through CII, the carbon emissions are reported to the IMO DCS (Data Collection System) (IMO, 2022b)

The formula which operational CII of vessels is calculated divides the total mass of CO_2 emissions (M) by the total transport work (W) of a year. See figure 2 for the CII formula.

$$Attained\ CII_{ship} = M/W$$

Figure 2. CII formula (IMO, 2022b)

For M stands the total mass of CO_2 emissions in grams, j refers to type of fuel, FC_j the total fuel consumption in a year and C_{Fj} the conversion factor for fuel type.

$$M = FCj \times CFj$$

Figure 3. Total mass formula (IMO, 2022b)

The W stands the supply-based transport work where data information can be taken as proxy in case it is missing, C represents capacity where DWT is used as capacity measure for vessels like bulk, tankers, gas, general cargo, LNG, container. GT capacity measure is applicable for

vessels like passenger ships, ro-ro, vehicle carriers, ro-ro passengers. D_t is the total distance per nautical miles as reported in IMO DCS.

$$Ws = C \times Dt$$

Figure 4. Supply-based formula (IMO, 2022b)

The Energy Efficiency Operational Index (EEOI) is a recommended indicator to use, as opposed to CII which is mandatory. The EEOI is much like CII a tool to be used to assess a ships operational performance. When the EEOI is calculated the mass of CO_2 emitted per unit of transport work is obtained (IMO, 2009).

The formula of which EEOI is calculated divides the total mass of CO_2 emitted by the unit of cargo carried. There are obvious similarities between the CII and the EEOI, the difference is that EEOI calculates a ratio of CO_2 emitted per unit of transport work and not total amount of transport work.
In the below formulas *j* is the fuel type, *i* is the voyage number, FC_{ij} is the mass of fuel type consumed, m_{cargo} is the cargo carried in tonnes and *D* is the distance travelled in nautical miles (IMO, 2009).

$$\text{EEOI} = \frac{\sum_j FC_j \times C_{Fj}}{m_{\text{cargo}} \times D}$$

Figure 5. EEOI formula (IMO, 2009)

There is a formula provided by the IMO in the *Guidelines for voluntary use of the ship energy efficiency operational indicator (EEOI)* which considers the average EEOI for a number of voyages. This is much alike the EEOI formula, but the sum of each voyage's EEOI is incorporated in the formula. The average value does not give a simple average among a number of voyages, but an average of the actual calculated voyages (IMO, 2009).

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{\text{cargo},i} \times D_i)}$$

Figure 6. Average EEOI formula (IMO, 2009)

The unit of the calculated EEOI depends on the input of cargo into the formula. For a tanker ship, were tonnes of cargo carried is inserted the unit will be CO_2/tonnes•nautical miles, for a container ship were *twenty-foot equivalent unit* (TEU) is used the unit will be CO_2/TEU•nautical miles (IMO, 2009).

2.1.2.3 Ship energy efficiency index

The Energy Efficiency Design Index (EEDI) has been implemented by the IMO to control that new building ships are complying with minimum efficiency standards. It creates a cap of the allowed energy efficiency of new vessels based on the generated transport work. The index is expressed in terms of CO2 grams per ship capacity/mile with a time frame of 5 years where the amount of allowed emissions is decreasing (Francesco et al., 2022). The reason behind the systematic reduction of CO2 emissions every 5 years is based on the fact that this kind of measure will be sustainable and efficient only if it is implemented at a slow pace. See figure 7 for the EEDI formula.

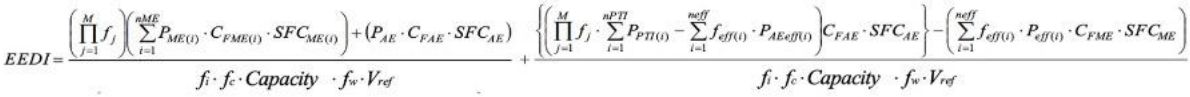


Figure 7. EEDI formula (IMO, 2022c)

The EEDI formula calculates the CO2 emission generated from main engines and adds the amount of CO2 generated from auxiliary engines while deducting the CO2 emissions due to innovative technology per transport work.

For the above formula's calculation, there are some parameters which are taken into consideration. C_F is the conversion factor between the measured fuel which is calculated in g and CO_2 emissions based on carbon content which is also measured in g. P_{ME} and P_{AE} stands for main and auxiliary engines. The Specific Fuel Consumption (SFC) is a measure of the engines fuel consumption in g/kWh, where it essentially indicates the engines fuel usage per produced power (IMO, 2022c).

For the purpose of achieving the target goals, requirements regarding engine and propulsion design have been raised. It is crucial for the success of the EEDI to investigate and apply the appropriate design of ship-engine-propeller matching (Ren et al., 2019).

The Energy Efficiency Existing Ship Index (EEXI) is as aforementioned a measure introduced by the IMO to enhance energy efficiency of ships in service. It is considered as an upgrade of EEDI with many similarities (Bayraktar & Yuksel, 2023). The EEXI involves a comprehensive and complex calculation that takes various parameters affecting the ships energy efficiency into consideration. See figure 8 for the EEXI calculation formula.

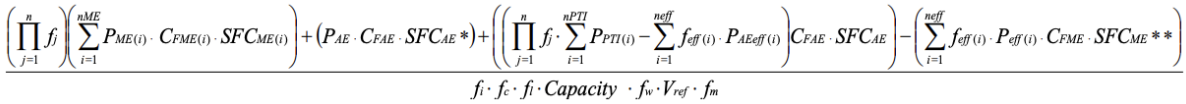


Figure 8. EEXI formula (IMO, 2021)

The calculation shows an index of the CO2 emissions from a ship per ton transported cargo per nautical mile. It takes into consideration the P_{ME} which is the main engine power, P_{AE} the auxiliary engine power, V_{ref} the reference speed of the ship based on approved speed curves, *SFC* the specific fuel consumption and lastly C_F which is a conversion factor between fuel consumption and CO2 emissions (IMO, 2021). The calculated value serves as a benchmark index to ensure that ships operate within the predefined energy efficiency frame (Bayraktar & Yuksel, 2023).

2.2 Marine insurance

In the below section the relevant aspects of marine insurance will be addressed.

2.2.1 Marine insurance contracts

A marine insurance contract is a contract where the insurer takes the responsibility of covering and indemnifying the insured against marine losses, which are caused by the marine adventure (Marine Insurance Act 1906, n.d.). The scope and conditions of this agreement depends on risk parameters and contract terms of insurance arrangement, which is caused by marine perils. According to the law of marine insurance, any marine activity can be insured against the risks (Gurses, 2016). Marine insurance contracts can be conducted for vessels, cargo, freight, or any other property against various perils which can occur during one voyage or time on time basis.

Moreover, specific insurance contracts can cover financial risks, loss of earnings, liabilities, and any other risks which may arise in relation with a voyage, such as war, pirates, detainments, fire, jettisons, even new kinds of risks such as cyber-attacks. For a contract to be valid, the assured must have an insurable interest in the insured property (Gurses, 2016). Even though there have been multiple explanations which tried to delve into the meaning of "insurable interest" and cover all types of connections, none of them has achieved a comprehensive definition of it. Nevertheless, insurable interest can be defined as the legal connection a person has with the assured entity and the ability this legal tie gives to the person for claiming compensation in case of claims during the insured period (Song, 2011).

There are plenty of ways of placing insurance. Facultative insurance entails the specific terms and conditions, the potential assured collaborates with insurance brokers and seek risk acceptance into the market. It is a tailor-made approach; however, potential risks might apply later, in case no underwriter accepts these terms and the risk which might appear. Conversely, floating policies include pre aged rules for each occasion respectively. This is beneficial for the insurance process, on the grounds that if the underwriter accepts the initial terms of the contract, the underwriter remains liable for accepting coverage without following negotiations for future voyages. For shipowners with a large number of vessels, fleet policies are the most beneficial ones, consolidating coverage for the whole entity of the fleet, under one insurance contract. Variations under this agreement exist in relation to accidents and compensations as the valuation of vessels vary (Gurses, 2016).

The cornerstone principle in marine insurance contracts is the aspect of good faith, which ensures transparency, fairness, trust and a smooth and easy procedure of conducting a marine insurance contract. It is a crucial aspect to enhance the contractual stability between parties and compliance with legal obligations (Woloniecki, 2002).

2.2.2 Hull & Machinery insurance

One of the most common and important types of marine insurance, is the H&M which applies in any type of vessel and protects the physical entity, the machinery and equipment of perils which are caused during the voyage (Puscaciu & Ebiere, 2019). Usually, H&M insurance is separated from additional ones like third party liabilities, war risk, piracy, and freight. The H&M insurance covers the vessel's physical entity and usually is paid by the vessel's owners who add this additional cost to voyage freight or time-charter hires on vessel users. From the underwriters' perspective, it is crucial to consider a wide range of factors before accepting the risk and agreeing on the terms. One of the factors which is crucial for influencing the cost of the premium, is the vessel's flag but also age of vessel, management and political circumstances (Wood et al., 2002).

2.2.3 Protection & Indemnity insurance

Protection & Indemnity (P&I) insurance is a third-party liability insurance for shipowners and operators. P&I includes liabilities for loss or damage to cargo, damage to docks, claims for personal injury or loss of life, and environmental damage such as oil spills (The Swedish Club, 2024). Unlike Hull & Machinery (H&M) insurance, which covers the physical aspects of a vessel, P&I insurance is pointed towards the legal and liability aspects. P&I insurance is operated on a concept of mutuality, were members of a P&I club collectively insure against liabilities. A P&I club is operating as a non-profit organization in which members, most commonly shipowners or charterers, pay premium to spread the risk of liabilities connected to loss or expenses (Puscaciu & Ebiere, 2019)

P&I insurance has evolved significantly over the years. The system of mutual clubs' dates back to the beginning of the 18th century, but the types of risks and liabilities covered have expanded with changes in maritime law, international conventions as well as through lessons learned from accidents. One of the accidents that had a great impact on the development of P&I insurance was the Torrey Canyon oil spill in 1967, where a tanker ran aground with extensive oil spill consequently causing environmental damage. This accident provided insight in the lack of legal principles governing the compensation and liability for pollution damages (Marchand, 2017). Previously, the law for pollution caused by ships were inconsistent and lacked international standards. The victims faced challenges in obtaining compensation due to the requirement of proving the shipowner's fault. This incident incentivized the maritime sector to develop a new legal structure, introducing the 1969 Civil Liability Convention for Oil Pollution Damage (1969 CLC) and the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971 Fund Convention), marking a significant advancement in addressing liabilities incurred by oil spill damages (Marchand, 2017). Some years after the establishment of the 1969 CLC and 1971 Fund Convention, the maritime disasters of Amoco Cadiz in 1978 and Tanio in 1980, underscored the inadequacy of existing liability limits. These accidents led to the introduction of the 1984 protocols, subsequently updated in 1992 to provide broader coverage, a more comprehensive definition of pollution damage, and increased compensation. Further incidents, such as the Erika in 1999 and Presige in 2002, prompted continued revisions, culminating in the 2003 Supplementary Fund, enhancing the international compensation framework for oil pollution victims (Marchand, 2017).

Today, the rules governing P&I insurance are closely aligned with international maritime law, including conventions like the International Convention on Civil Liability for Oil Pollution Damage (CLC). Insurance contracts include specific clauses that address various forms of harm, ensuring that there is a direct connection between the potential harm a vessel might cause, and the coverage provided by the P&I club. For instance, a typical P&I insurance contract might include a pollution clause that specifies the extent of coverage and the conditions under which the insurer will pay for damages resulting from an oil spill or other types of environmental harm. This makes it clear to shipowners what their insurance covers and under what circumstances they can claim indemnity for their liabilities.

2.2.4 Underwriting policy

For the marine insurance market, the leading underwriter (L/U) has a vital role. The L/U is a person with deep knowledge and experience about a specific type of risk coverage. This person leads towards risk coverages and sets the tone for other insurers to follow and join a common shared risk. For other brokers the participation of the leading underwriter is a highly important matter as it provides stability and security. This relation between underwriters is provided through an insurance slip, a document which provides all details in relation with the insured risks (Gurses, 2016).

The underwriting policy creation is based on evaluation of risk factors and analysis of market conditions. By considering plenty of critical elements such as monetary value, risk probability, previous results, and demand/supply factors, an underwriting policy is constructed to create a tailor-made insurance premium. For assessing the level of risk , underwriting policy considers factors like vessel's age, client's loss record, area of navigation and the assured's employees experienced level (Oğuz, 2020).

2.2.5 Relational contracts

As the shipping industry is highly affected by globalization and newly adopted regulatory frameworks subject to environmental concerns, the implementation of relational contracts could be characterized as vital for the industry, in order to improve long-term relationships. Relational contracts do not aim for substitution the traditional contracts, instead it aims to oblige transaction's stakeholders to add value and enhance trust by collaboration towards common goals. Therefore, we can safely disclose that relational contracts are binding agreements, were two parties emphasise on collaboration, fostering communication and prioritizing flexibility and negotiation processes to solve emerging risks (Tvarnø et al., 2017).

Taking into consideration that ships' operation is a crucial emission factor and the responsible stakeholder of it could be either the owner or charterer, the alignment between all actors for the inclusion and distribution of responsibilities is needed. An example of this can be the new BIMCO clause *The EEXI Model Clause,* which oblige shipowners to proceed with vessel modifications in order to comply with EEXI standards, baring all costs for implementations and without any time lost. In case which shipowners are not capable to arrange on time, charterers do not have the right to terminate the charter party or reject any of the modifications such as reduced speed or time period (Athanassiou, 2024). Another example is the *CII Model Clause,* with both parties (owners and charterers) bearing responsibilities in time charter parties. Charterers operational optimization should be based on specific requirements and comply with charterparty attained CII based on fuel type and distance traveled without taking into consideration off-hire periods, something which might lead to reduced speed and changed routes. On the other hand, owners shall keep the vessel's energy efficiency and share data. Nonetheless, weather routing companies will have important role for routes optimization (Athanassiou, 2024). Lastly, it is worth mentioning the *ETSA Clause* by BIMCO. As costs will be increased via ETS implementation and by 2026 shipowners will have to pay full amount of emissions allowances, thus, methane and nitrous oxide emissions will have to be paid, the mentioned clause will act as protection for shipowners and transfer the additional cost (part or full subject to negotiations) to time charterer via a "pass-through" mechanism. In addition, the aforementioned clause can be used as a mean for re-routing and speed reduction, but this will be achieved only via negotiations (Baughen, 2023).

2.3 Risk assessment

Risk assessment is a process of risk management that provides an organized and defined method for assessing how goals and objectives might be impacted. It evaluates the possible outcomes and their likelihoods prior to deciding on the necessity of further action. Risk assessment seeks to address the following foundational considerations; What could potentially occur and for what reason (as part of risk identification)? What are the potential consequences? What is the likelihood that these events will happen in the future? Are there any elements that can lessen the impact of the risk or decrease the risk's chance of occurring? Is the risk level acceptable or permissible, or is it significant enough to warrant additional intervention? (Popov et al., 2016).

The risk assessment is commonly performed with the use of a risk matrix, which is a matrix were the risk severity or consequence is assessed together with the likelihood of the risk occurring. These two inputs provide the assessor with a risk score that can be evaluated for further actions. Within an organization, these different risk scores in the matrix can be put into different action types (Popov et al., 2016). One example is where the risk severity is assessed on a scale of 1-5 and the likelihood on the same scale, if the prior is assessed as a 3 and the latter as 5, it will be given a risk score of 3 times 5 equals 15. In this example the lowest risk

score is 1 and the highest 25. The organization can then decide for different action depending on the score, for example, 1-5: No actions, 6-10: Proceed with documentation and caution, 11-15: Mitigating actions needed and 16-25: Activity should not be proceeded with.
The benefits of risk assessment are not only the risk identification and assessment, but also the documentation of the possible risks and the continuous improvements that follows this monitoring process (Popov et al., 2016).

Below sub-paragraphs are aiming to analyse the processes of risk assessment of both marine insurance and finance sectors. The choice has been based on similarities in relation to the nature of their work processes. Both sectors are surrounded by strict regulatory framework, assisting shipping companies with financial and consultant procedures while aiming to accept risk as a mean to run their business.

2.3.1 Marine insurance risk assessment

Marine insurance companies have as a main target to protect and guide their customers in connection to risks during a marine voyage. As the demand for additional sea transportation has been increased during the last decades, the protection of it is crucial for all involved stakeholders (Ellili et al., 2023). Any misleads or careless initiatives could lead to severe consequences or even to marine catastrophe situation (Yang, 2020).

The marine insurance risk assessment is based onto vessels operations under risky circumstances and dangerous environments. Therefore, a critical factor for assessing the risk and prevent severe results is the accurate and comprehensive analysis of AIS data. This tool can help both insurers and ship owners to understand and locate potential risks along with historical records, meteorological data and previous claim reports (Adland et al., 2021). Especially for the tanker industry, the port of operation has important role in decision making as the infrastructure and facilities can influence the probability of event occurs. Additionally, one of the main reasons for accidents is the human factor as is highly linked to load/discharge operations (Ronza et al., 2003).

2.3.2 Finance and ESG

In 2004, the finance sector experienced a significant change with the introduction of the Environmental Social and Governance (ESG) framework. The framework emerged from the "Who Cares Wins" initiative, a collaborative effort under the guidance of the United Nations. It was a strategic move by financial institutions to better integrate ESG factors into their operations. This initiative was an extension of the principles set out in the Global Compact, which aimed to embed common principles in business practices by factoring in ESG considerations in investment assessments. This development marked a pivotal moment in the integration of sustainability into financial decision making (United Nations & Swiss Federal Department of Foreign Affairs, n.d.).

The ESG framework provides assistance to investors in assessing the financial performance of organizations based on their environmental, social, and governance abilities (United Nations & Swiss Federal Department of Foreign Affairs, n.d.). The environmental criteria focus on a company's environmental impact and sustainability. The key areas include energy use, waste, pollution, and natural resource conservation. The metrics used for assessing an investment is additionally the company's exposure to environmental risks and how it manages those risks. Companies with environmental and sustainable procedures can achieve better financial performance, which suggests a positive association between environmental responsibility and economic performance (Schaltegger & Wagner, 2011). The social criteria take into

consideration how a company manages relationships with its employees, suppliers, customers, and the communities where it operates. It includes aspects such as company culture and diversity. A study by Organizations with strong social responsibility experienced lower capital obstruction, indicating that socially responsible investment strategies could lead to better financial outcomes (Jo & Harjoto, 2012). The governance criteria focus on an organization's management, audits, internal controls, and shareholder rights. Investors may want to know that a company uses accurate and transparent accounting methods, and that stockholders are given an opportunity to vote on important issues. Organizations with strong governance practices linked to sustainability demonstrated a better operational performance compared to companies that does not (Eccles et al., 2014).

The ESG framework offers a holistic approach to assessing a company's long-term value, considering not just financial returns but also environmental, social, and governance impacts. This holistic approach is increasingly recognized as essential for sustainable investment and corporate success. The ESG framework has gotten a significant uptake in various industries, reflecting a shift in the global business environment. More and more companies are adopting ESG principles to align their operations with sustainable practices, driven by the growing awareness of climate change, social responsibility, and the need for transparent governance (de Souza Barbosa et al., 2023). The shipping industry, which is a vital sector in global trade and commerce, has also started integrating ESG criteria into its operations (Nõmmela & Kaare, 2022). In the shipping sector, ESG implementation involves adopting cleaner fuels, increasing energy efficiency, reducing greenhouse gas emissions, and ensuring responsible labour practices and governance (Lee et al., 2023). This shift is crucial given the industry's substantial environmental footprint and its role in international supply chains. The adoption of ESG criteria in the shipping industry is not just a response to regulatory pressures but also a strategic move to remain competitive and attractive to environmentally conscious investors and consumers. It highlights the sector's commitment to playing a part in achieving global sustainability goals (Nõmmela & Kaare, 2022).

2.4 Maritime ecosystem

Moving on to understand the connection between all different stakeholders and how the system operates, is critical to explain how value is created during the process of cooperation among them. It is safe to say that organizations with split incentives, working closely with each other and cooperate to achieve different goals without hierarchy in a modular way can create an ecosystem (Jacobides et al., 2018). The sustainability or not of an ecosystem relies on the balance between opposing forces. There are forces which act under one corporation and push economic activities and other entities which pull out economic activities into the broader market. Both management style and technological innovation can affect the effectiveness of an ecosystem (Holgersson et al., 2022). Therefore, complementarity and specialization are important elements of value creation inside an ecosystem in a way that the interdependence or not between organizations, and if cooperation or taking advantage of each other, will influence the viability of the ecosystem (Jacobides et al., 2018).

The marine industry is focusing on decarbonization and GHG emission goals, pushing towards multiple changes in order to accomplish them, with technological innovations and eco-friendly procedures monitor and lead the way for a blue economy in the shipping industry (Lai & Xv, 2021). As multiple stakeholders are involved in the maritime industry and the shipping chain, the introduction of new policies and tactics, might lead to unpredictable results as these new innovative solution could potentially characterized as disruptive ones (Gans, 2016).

Transition towards sustainability is a complex and challenging process for the marine sector as the infrastructure limitations, financial caution in the industry and long-term investments are the main barriers which slow down the innovation process (Spaniol & Rowland, 2022). There is limited discussion about industrial ecosystems in maritime studies, therefore, this field has to be promoted for understanding the industry (de Langen et al., 2020) and for the acknowledgement of maritime ecosystems dynamics.

As the maritime industry aim to achieve its goals and remain strong facing all these challenges, focus has been given towards blockchain technology for value-creation processes. The main idea behind this initiative is that it will simplify maritime activities via security and transparency without central authorities (Kumar et al., 2020). Additionally, as the maritime sector is an antiquated sector that relies on bureaucracy and old-fashion tactics, blockchain technology will help to resolve inefficiencies predominantly from time consuming processes, always with data security during the transaction which might involve more than 40 different stakeholders (Jovanovic et al., 2022). Maritime industry heavily relies on paper document procedures which lead to errors and time-consuming results. The blockchain technology will connect all involved actors, reduce costs, and enhance autonomy but also data transparency. For such an act to be successful, the widespread adoption is essential for every actor who is connected to these transactions and the understanding of roles and dynamics among them is the key for success (Jovanovic et al., 2022).

The main characteristic of an ecosystem is the interdependency among stakeholders where they generate and absorb value but on the same time, each one of them act by their own decision principles without any hierarchical control (Tsujimoto et al., 2018). Relational rents are crucial for the orchestration of ecosystems, followed by key stone players and lead companies. It is important for the feasibility of this kind of action that centripetal and centrifugal forces inside the ecosystem will keep balance between actors who are moving away due to competition. Therefore, orchestration and mediation will play significant role in a competitive environment which despite the fact that competition adds value to ecosystem, this shall act with transparency and trust (Tsytsyna & Valminen, 2023).

3. Methodology

In this chapter the methodology of this study will be explained which includes the research method, data collection, data analysis and the reliability of collected data. Moreover, the importance of ethical considerations of the conducted interviews are addressed.

3.1 Research method

This research has been conducted with the use of a mixed research method. A mixed method combines quantitative and qualitative approaches which in theory provides a more complete picture of the research topic by using the strengths of both quantitative and qualitative data (Hammond & Wellington, 2021).
The qualitative part of the research focused on professional experiences, beliefs, and expertise to understand the industry stakeholder's needs and considerations of what factors that could be considered when implementing environmental factors into marine insurance underwriting. In contrast to the qualitative approach, the quantitative part of the study emphasises the analysis of data in a numerical format, which can provide clear and comparable data (Hammond & Wellington, 2021).

In this thesis a case study methodology was used, giving the writers the opportunity of in-depth examination of the subject within its natural environment. To perform a case study research

effectively, a systematic approach involving the following steps should be conducted; defining research questions, selecting the case(s), determining data collection techniques, and analysing the data (Yin, 2018). The researcher should begin by clearly formulating and defining research questions that are contextually grounded in the literature and the selection of case(s). Data collection should be robust, employing multiple sources such as interviews, documents, and observations to ensure triangulation and richer insights (Yin, 2018). Finally, data analysis should be methodical, with a clear path from initial data gathering to the final case study report, in this case involving a thematic analysis with coding of the primary data. This structured process ensures reliability of the findings (Yin, 2018). The case study method is particularly preferable when addressing questions of "how" and "why" (Yin, 2018), which this thesis essentially does by investigating how the insurers can adapt to the contemporary need for environmental considerations. Another factor that Yin addresses is that a case study method is suitable for contemporary events which is aligned with this thesis (Yin, 2018). This study focuses on the adaption of environmental factors in marine insurance underwriting, which was derived from a thorough review of existing literature on environmental impacts and risk management within the industry. The initial framework, developed from secondary data sources, was later tested through the collection of primary data via interviews with key stakeholders in the industry. The interview data helped to validate the relevance and applicability of the possible criteria developed from the secondary data by directly reflecting the applicability and challenges faced in a practical setting.

This thesis applied an abductive approach, which is an approach that in fact is a combination between an inductive and a deductive method. An abductive approach involves incorporating a process of using the collected data to draw a conclusion and refining the conclusion with additional data (Hammond & Wellington, 2021). In this thesis the literature study provided insights on the case of how the insurer currently conduct their risk assessment and pricing procedures, this was later supplemented with the data gathered from the conducted interviews thus following an abductive approach.

Within this research a literature review and interviews were conducted in four separate areas, to give a comprehensive background to the current insurance policies and the pricing as well as the current environmental regulations and factors. See below conceptual framework.

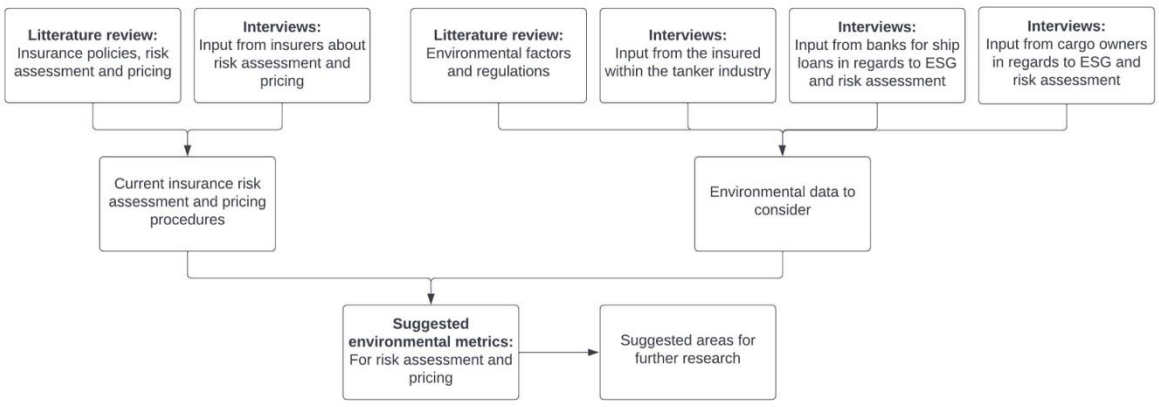


Figure 9. Conceptual framework

3.2 Data collection

In below section the data collection methods of the study are explained in detail.

3.2.1 Interviews

The primary method of data collection in this study is semi-structured interviews. Semi-structured interviews are used to gather qualitative data with a set of open-ended questions, allowing the interviewer to explore new areas that transpire during the interview process. This approach is beneficial for its flexible way of collecting data compared to structured interviews, and the ability to ask follow-up questions without constraints from the interview protocol (Hammond & Wellington, 2021). Moreover, a semi structured interview allows the interviewee to speak freely and go into depth within areas of interest (Denscombe, 2014).

The use of semi-structured interviews was chosen for this research due to its ability to collect detailed requested data while giving the interviewee a freedom to express other thoughts, ideas, and experiences. This ability is crucial for the study to gain qualitative data about the implementation of environmental factors in marine insurance.

As mentioned in the conceptual framework of the study, there are four different areas in which interviews will be carried out. The first with marine insurance providers to gain a comprehensive and in depth understanding of the underwriting process, secondly with shipping finance institutes to gather data on how the ESG risk is assessed, thirdly with a cargo owner and lastly with shipping companies within the tanker segment to gain their perspective in which environmental factors that could be implemented in the marine insurance contracts.

The interview schedules developed for this research were created with consideration to the concepts found in the literature review. The four distinct interview formats each included a mix of open-ended questions to encourage a broad conversation about the subject, along with more focused questions aimed at gathering precise data. The interviews' target groups were decided based on their expertise within the different areas of the maritime industry to provide a holistic view of the research topic. All the interviewees had fundamental experience of the policy and regulations mentioned in the theory section of this paper and they were able to provide data based on their experiences in the industry. Furthermore, the interviewees were selected based on the authors network with the finance institutes being a close contact to one of the authors, the insurer contact was provided by the industry supervisor of the thesis and the shipping company was approached at the Chalmers work-fair called Sjölog. Moving forward the interviewees were approached via an email with an introduction to the thesis and an interview preparation note with the questions for them to prepare.
All the interviewees gave their consent to record the interviews for transcription and analysis purposes without endangering the validity of the data. As soon as the transcriptions were completed the interview recordings were deleted. Furthermore, considerations to the ethical aspects have been an area of focus and no personal data or company sensitive data has been stored or published in this research.
Table 1 below shows the information about the different interviewees.

Table 1. Interviewee information

Type of company	Title of interviewee	Interview code	Number of interviews
Marine insurance company	Senior advisor / Director underwriting	MI	1
Financial institute	Junior relationships manager	FI	1

Shipowner	Sustainability controller	SO	1
Cargo owner	LNG cargo & shipping operations	CO	1

3.2.2 Literature review

The secondary data was collected through a literature review of peer-reviewed articles, legislative guidelines, rules and regulatory documents, books, and scientific journals. The literature search was mainly based on the databases of Chalmers library, Science direct, Google Scholar and Elsevier.

One of the authors attended a week's lectures in a shipping law course with focus in marine insurance at the University of Gothenburg to gain more knowledge of the topic before the literature review.

3.3 Data analysis

Choosing the right method to analyse collected interview data was crucial. Thematic analysis can be described as a method for qualitative data analysis that allows identification, analysis, and reporting of themes within the data (Greg Guest et al., 2012). A thematic analysis offers a deep insight into the interview data, making it particularly suitable when the researcher has limited prior knowledge of the subject matter (Hawkins, 2017), which is justified for the contemporary nature of this research topic. (Hawkins, 2017) emphasis the need for researchers to become intimately familiar with the data and to identify themes as they emerge, either through explicit statements or implied information. Given that the interviews were semi-structured, allowing participants to highlight what they deemed significant, thematic analysis was considered a suitable approach for analysing the interview data.

The careful selection of participants, who were expected to have considerable experience, revealed patterns in their responses. The semi-structured nature of the interviews and the use of open-ended questions led to responses within the same themes. Thematic analysis is instrumental in assessing the relevance, and importance of the ideas shared during the interviews (Hawkins, 2017).

The thematic analysis was performed to analyses the qualitative data gathered from the interviews. The analysis was made by finding common areas brought up during the interviews, creating codes for these words and furthermore creating themes to quantify the frequency of the different environmental factors that were addressed. After transcribing the interviews, the process involved becoming familiar with the data and selecting responses that were most relevant to the research topic, thereby streamlining the analysis by excluding repetitive or irrelevant information. Themes that met the study's criteria were marked in the dataset with various colours, each representing a different theme, making them easy to identify across the dataset and improving the efficiency of the analysis process. Subsequently, these themes were categorized into areas significant to the research topic. Following is the analysis visualized. The following visualized data analysis is simplified with summaries of the empirical themes, were the summarized ones ends with three dots. See appendix 1 for the full visualization of the conducted data analysis.

Figure 10: Summarized data analysis

3.4 Reliability and validity

The reliability of the research considers how reliable the method is. In quantitative research it is common to assess the reliability of the method by assessing if the same methodology could be applied on a different occasion and produce the same results. In qualitative research there are social aspects to consider and the authors engagement in the data collection can affect the possibility to reproduce the method with the same results (Denscombe, 2014). To counteract this dilemma, the authors have but great emphasis to provide a descriptive methodology and data analysis as (Denscombe, 2014) suggests. The aforementioned together with a opposition of the research process can benefit the reliability (Denscombe, 2014).

Furthermore, the validity of the collected data considers the correctness and if the data is appropriate for the research topic, more specific if it is relevant to the research questions (Denscombe, 2014). The validity of a study is important both in qualitative and quantitative studies. It is a way for the authors to present that their data is precise and suitable for the research topic. There is no good way of providing assurance of the validity of the collected data in a qualitative research, and (Denscombe, 2014) suggests actions to validate the data and to be transparent with the reader. The authors have considered these actions and have asked participants to validate their provided data by checking for accuracy.

3.5 Ethical considerations

The ethical considerations of this research have been an important matter for the authors. (Denscombe, 2014) states that there are four main aspects of research ethics; to protect the participants own interests, confirm that the participants are involved voluntarily with informed consent, to avoid deceit and maintain scientific integrity and to comply with the national legislation. Firstly, (Denscombe, 2014) states that the authors should ensure that the interview participants do not get negative effects from participating, which the authors made sure by letting the interviewees stay anonymous and not share any company or personally sensitive data.

Secondly, (Denscombe, 2014) states that the interviewees who took part in this research should participate by own choice and that it should be based on informed consent. The participants were invited to interview with the choice of not participating, and a Chalmers template for informed consent was presented to the interviewee before the interview. The letter of consent stated the ethical considerations of the study, that the stored data can be requested to be deleted at any time, the contact information to the authors and the Chalmers administration. Furthermore, (Denscombe, 2014) states that the authors should avoid deceit and misinformation in their contacts with the interviewees. Great focus has been made towards transparent and open communication with all participants. Lastly, (Denscombe, 2014) emphasis that the research should adhere to the national legislation. Thus, adhering to GDPR have been crucial and no personal data has been stored of the interview recordings or transcripts.

4. Findings

This chapter presents the findings from the thematic analysis conducted on the perspectives of key stakeholders in the tanker industry, namely cargo owners, insurers, financial institutions, and shipowners. The analysis aimed to identify common themes related to the integration of environmental factors in marine insurance underwriting, its impact on risk assessment, and pricing.

4.1 Findings divided by each stakeholder

In below section, the findings are presented divided into each stakeholder and presented based on themes that was found during the conducted analysis.

4.1.1 Cargo owners

Technological advancements and efficiency: The cargo owner stated that one of the environmental factors influencing their decision making is the fuel type. The decisions on fuel types are heavily influenced by market trends and regulations.

"Even if we are [using] the cleanest, I would say the cleanest form of fuel in the industry, which is the LNG, we have to make decision based on the markets because our ships has the ability to either burn LNG or dual fuel.".

LNG was highlighted as one of the preferred fuel types if the price of LNG is too high, they will have to prioritize cost over environment.

Regulatory compliance and uncertainty: A significant concern for cargo owners is regulatory compliance, particularly the uncertainty around new and existing regulations. In terms of the regulatory uncertainty, it was brought up that the cargo owner has no clear picture of the future regulations and that they have an increased burden due to the required reporting.

"...the process is in a very new stage and we don't have clear picture of the actual outcome of these regulations."

Another concern that was highlighted was the risk of older ships not being able to comply with new regulations and thus not being able to trade in certain areas such as the EU. Furthermore, existing, and upcoming regulations are of concern. The EU ETS and its cost implications are highlighted, with expectations that charterers will bear future emission costs. The cargo owner stated ideas to solve the uncertainty, one of which is data utilization. It was highlighted that through experience it has been seen that those who utilize the available data have a clear understanding of what to improve and were there are pitfalls that can be avoided. Lastly, during a discussion concerning new regulations it was addressed that the industry needs time to adapt to the new regulations.

"In addition, a number of sustainable fuels will be in the market and there is need for them, the ships obviously will be much more efficient, and the average age of the fleet will have been reduced considerably, I would say, because already the old ships cannot come over with new regulations. So, I believe that it's going to have a good impact.
However, the industry needs time. You cannot easily replace fuel with another fuel, with another form of energy, as the entire world has been built based on the fuels. And that is my view."

Sustainability strategy and investments: The cargo owner highlighted that regarding sustainability strategies, they focus on long-term relationships rather than short-term environmental assessments. In that sense, comprehensive environmental assessments are not conducted for the spot market.

"But also, we have what is called spot in LNG, which is a trip TC contract, but mainly when we are talking about partners, we are talking about long last relationships and LNG business because the industry is based on the long-term contracts buying and selling the cargo. So, the contracts try to be as back-to-back as possible.

So, long term relationship the first and foremost, the second is the assessment of the operations, how efficient is the counterparty by exchanging the data for the environmental regulations.".

One strategic decision that the cargo owner has taken is the implementation of engine power limitations which focuses on speed reduction of the vessels. The interviewed cargo owner has not yet implemented just-in-time sailing into their contracts.

Collaboration and industry standards: The analysis underscores the importance of collaboration. It was highlighted that alignment with counterparties is of great importance along with emphasizing the sharing of emission data. An idea for improvement that was suggested within the topic of collaboration is the implementation of a common platform for data collection so that all stakeholders collects and reports data in the same format. In addition to the collaboration, charter contracts are likely going to be updated and, in the future, include additional environmental clauses which are increasingly being added to time charter party (TCP) contracts.

"Yeah, I think that we will have a very clear-cut picture of what will be the process and what will be the possibilities of the counter parties. We will have evolution on the TCP clauses in regards to environmental regulations."

Risk management in environmental impact: The cargo owner discusses barriers and enablers to managing environmental impact, along with uncertainty and environmental risk.

"I would say barriers is [that] the shipping industry is a very capital-intensive industry, so including the inflation and the geopolitical situation with two ongoing wars, this is the barrier for accelerating the environmental plan. And enabler is, I would say the collective effort that all the countries have put on. Because everyone has understood the impact on the environment…"

Furthermore, it was highlighted that the cargo owner assesses how well the vessels are maintained, which standards they adhere to and how the performance is reported on maintenance records, vetting inspections, and certificates. This assessment is done to minimize the uncertainty and risk of collaborations and partnerships. Lastly, it was underscored that decisions on environmental risks are increasingly based on software analysis were environmental metrics such as CO2 emissions are used in an optimization engine which aids the decision maker. It was highlighted that the environmental metrics is not the main factor for the decision making. The cargo owner mainly looks at cost and what trades are profitable. They take into consideration the environmental factors in the aspect of the cost for compliance.

4.1.2 Insurers

Technological advancements and efficiency: The insurer emphasizes a significant interest in data utilization capabilities, such as AI for speeding up data usage, which can enhance operational efficiency and decision-making.

"Advancements on that side is going at freakish speed, with AI not the least. The level of data you can process today and how fast you can make use of it and how efficiently you can make use of it, is obviously something that we have to work with a lot moving forwards and already started".

There are concerns about the uncertainty of fuel choice and the lack of necessary infrastructure to support alternative energy carriers like LNG, which is seen as a short-term solution.

"I mean, there's so much infrastructure not invested in yet. So, you don't really know either which is the horse to bet on…"

Regulatory compliance and uncertainty: Insurers are aware of the fast pace at which the EU and other regulators are moving towards decarbonization. There is scepticism about relying

solely on CII ratings or the Poseidon Principles due to their limitations. In regards to a discussion with the interviewee's about the environmental factors effect on insurance premiums one of the participants brought up that there is not enough statistical data.

"*There are a lot of things happening right now, but I don't think anyone is really at the stage to say that you have statistical data to support that just because you have a good CII rating or just because you come up very well under the Poseidon principles."*

The insurer also discussed that insurance policies do not cover fines for non-compliance, only if these are related to accidents, which is a fundamental thing in regard to the topic of this thesis.

"we don't cover if you say fines or non-compliance…unless it's sort of refers to an accident where with as of result you end up sort of non-compliant"

Compliance with existing regulations and the possible introduction of new insurance products to address future regulatory changes are highlighted, reflecting on an adaptive strategy to regulatory dynamics. A potential solution for the usage of CII as an environmental metric was addressed, where CII could be calculated with other factors such as weather, speed optimization and vessel location.

"But today you can look at the, I mean coming back to the CII, maybe you find correlations there. You can look at weather factors, you can look at routing and speed and where the vessels are and you can do so much more with so much more data, a lot faster. And with that I think we're also moving towards becoming a bit more forward leaning in your assessment.

Sustainability strategy and investments: The strategy discussed during the interview involved ship owners' investment into new technology, alternative fuels, and their energy efficiency improvements.

"We have ship owning members looking to invest in new technology, alternative fuels, different means of how to operate more efficiently and that's something for us to monitor."

Insurers need to gain loss experience from new technologies and different means of efficient ship operations to fully be able to assess the risk. There is a realization that insurers cannot drive environmental change alone but can facilitate change by taking on higher risks to promote new technology even if the risk level is uncertain.

"...what's the risk quality like and is it a good risk or is it a bad risk? But then you can also turn it around that if we're going to facilitate a change in the industry, you also need access insurance even if we don't understand the risk fully and even if that poses a bigger risk for us because there's new technology, right. So, I think it's important for us as an insurer to not shy away also that if you invest in new technology that you know less, so you don't really know if it's going to be a good risk, whether it's going to produce a lot of claims. But I think it's important that we don't turn the back on our members…"

Within strategic factors, a fast transition phase is noted, with ESG factors becoming more prominent in insurers' considerations. There is a focus on ESG reporting and incorporating these into insurance frameworks to facilitate broader industry changes. But there is also an uncertainty expressed regarding future environmental factors to consider.

"And new technology, ultimately, we will get more loss experience from it as well. I think there's going to be constant adaption and I think it's quite hard to predict where that leaves us 10 years from now, but no doubt is going to have, for every year that pass, [it] is going to have bigger and bigger impact in everything that we do."

Collaboration and Industry Standards: The insurer emphasised the importance of collaboration between insurers and their members to share experiences and learn from each other. Furthermore, a significant distinction was made to emphasise that ship owners as members are the ones who will set the course and point towards which direction the insurer will conduct its business.

"...one more point to be sort of kept in mind when it comes to our viewpoint is that we are a full mutual insurance provider. We are owned by the ship owners being our members and they are the ones also setting the course for us, what and how we should do conduct the business."

The main goal of the insurer to ensure global trade safety and assist when needed was highlighted.

"the core essence of why we're here really is for the membership and to ensure that the sort of global trade can continue and then transport safely cargo and to assist if and when something happens really and that that of course is always main priority, protect lives and livelihood out at sea but also to a very great extent sort of marine environment…"

They value the use of publicly available data, such as port state controls, class, and flag for them to evaluate risks levels.

"you can more clearly draw conclusions from that on sort of track record when it comes to how they run their vessels. When we look at risk at large, we make use of publicly available data. Of course, you have port state records, you have a class, you have flag."

There were issues addressed with monitoring of developments and correlating risks with available data, which is stated to be the key to maintaining synchronization with industry standards and practices.

"So I mean from our point of view at this stage it's very much about monitoring the developments and see if the risk correlations and how you can make use of the more data that you have available today.
And I think there's also perhaps a presumption that but that sort of good adherence and good compliance and mature thinking on, on decarbonization, there is a correlation towards quality and operations overall, but I don't think you statistically can say that you can add in some of these points and say for certain that this is going to be a risk that will have fewer claims on the loss record. So, it's a constant process at this stage and it's very premature, I would argue."

Furthermore, the geopolitical factors that affect the CII rating was discussed along with the interdependence between stakeholders and the slow enhancement of environmental risk factors.

Risk management in environmental impact: The insurers current risk assessment methodology includes both quantitative and qualitative assessments, with a focus on underwriting processes based on performance factors. Loss experience plays a significant role, and risk assessments typically happen in the first year rather than annually.

"..you will start by looking at those sort of quantitative factors, but you will also look very much towards sort of what is our loss experience for this segment. And how do these guys compare to our average experience in that field."

The risk assessments are not a yearly proceeding, for the renewal of a policy it is rather a performance-based assessment with reference to the previous year.

"…it is more based on performance because we have done our homework before, and we have a client where we will follow mainly on a performance basis, not asking for all these quality checks year by year"

There are multiple uncertainties concerning the emerging risks of new technologies and the challenge of assessing the quality of operations as previously addressed in this section. Additionally, barriers such as the lack of adequate marine insurance statistical data to assess environmental risks are prominent.

"Of course, we don't have statistical data to say what is a good and what is a bad risk. And from that, there will be no doubt emerging risk factors for us to take into account."

4.1.3 Finance

Technological advancements and efficiency: Financiers highlight that decision-making process is influenced by newly incorporated factors for the industry such as CII rating between A to E, CO2 tones that the vessel produces, and the ESG reporting in order to assess the vessels environmental performance. ESG report assessment have become increasingly important. These indicators can influence the industry's strategy for technological advancements and the relation between financial institutions and shipping companies.

"…approximately by September 2020, the ESG report for each credit facility, a new one or a monitoring of an existing exposure, it became as important as it is the actual credit approval."

This strategy could lead either to credit denial for ship owner's or an opportunity for investment into new technology with green loans.

Regulatory compliance and uncertainty: The interviewee highlights the regulatory uncertainty from newly admitted regulations. Bank reports have become more complex and difficult as CII indicator and CO2 tones have been implemented.

"Of course, the CII indicator and also the CO2 tones that a vessel produces through the years, our easy report has become more and more, let's say, difficult for us as employees, in order to finalize the assessment as well as in order to have a complete overview in order to present it within the other credit elements to our credit committee for the final approval."

IMO has target tough goals that create frustration to the industry and the EU ETS is on premature phase which is highlighted from the interviewee as a type of stock exchange. Therefore, unpredictable future and uncertainty dominates the regulatory landscapes.

"…the European ETS might be extended to all over the world, and at the moment it's like a stock exchange and you are buying rights, and you emit the CO2 to the environment."

Regarding existing and upcoming regulations, ballast water treatment has crucial role for the finance sector and is important for liquidity decisions.

"It's also very important that the vessel is ballast water fitted because if it's not ballast water fitted, we ask for more liquidity."

Another factor in connection to regulatory compliance is that European banks are obligated to report ESG fleet's performance.

Sustainability strategy and investments: Strong focus on sustainability and the influence of Environmental, Social, and Governance (ESG) to lending decisions is emphasised in this

theme. CII rating has a crucial role for credit decisions where it is highly emphasised that the deviation of previous CII scores can affect it, even though there are no recorded lending denials based on ESG assessment from this bank so far.

"It is very important to give credit to clients that have very let's say, improved CII indicators like minimum C But preferably A or B."

Amendments and follow up will be incorporated in case of bad ESG assessments. Another strategic decision of the finance sector is the expected price increase in case of non-compliance and discount will be addressed in case of compliance.

"I think that it will play a very critical role and in many cases it will lead to, let's say, increase in terms of pricing for the vessels if they don't comply with the current regulations and also will give let's say reduction to the ship owners and groups that are very keen to protect the environment and also trying to utilize their ESG for each vessel."

It is mentioned that due to new regulations, shipping routes might change, and creation of new maritime hubs will occur.

Collaboration and industry standards: The analysis states that collaboration across the maritime ecosystem is very important for data utilization and data collection platforms.

"…we also have access to some other platforms, such as Clarkson, Scope one in order to see the actual performance of the fleet and what's the outcome of the emissions to the environment."

The concept of creating ship pools is suspected to rise among ship owners in order to tackle environmental and regulatory challenges.

"…there might be 10-20 shipowners that place their vessels altogether as a pool because they want to utilize the best comparative advantage…"

Furthermore, it was also highlighted that there might be new clauses created which will be added to loan agreements to demand ESG improvements. Lastly, the interviewee stated that this financial institution only utilize data from shipowners.

Risk management in environmental impact: The analysis from the finance sector interview mentions barriers for the implementation of environmental factors to be the cost of improvement and the lack of a clear vision for the future stakeholder data requirements, pointing to uncertainty in environmental risk management.

"…the barrier here is the cost for sure, to my point of view because the small and mid-cap companies might not have that room to invest, so we might see some small and mid-cap shipowners to exit the market".

4.1.4 Shipowners

Technological advancements and efficiency: During the shipping company interview, it was stated that energy efficiency is a highly important aspect, therefore, the industry emphasise the need for adopting new technology with alternative energy carriers such as LNG, using dual-fuel internal combustion engines, battery packs and energy efficiency improvements like heat recovery systems.

"…we have this dual fuel with LNG and the diesel, making sure that we are available for all different kinds of fuels in the future. Also, we have a battery pack on board…"

It has been mentioned that this particular shipping company is investing into biofuels as energy carriers, aiming to achieve better CII rating. In addition, shipping company wants to enhance transition to alternative energy carriers, but the infrastructure, capacity and lack of availability is a concern.

Regulatory compliance and uncertainty: Shipowners must deal with great challenges as the new regulations are implemented in a fast pace despite the fact that technology cannot support the transition yet. CII calculations can be difficult to calculate, and it can even be unfair to some extent, subject to the factors that are taken into consideration for the calculations.

"But right now, CII doesn't take inconsideration if we are loaded or not. If we have cargo in our vessels, it only takes into consideration the emissions and the nautical miles."

"…one of our new vessels last year ended up outside France when it was a strike. So, we couldn't get to the port, and we had to lay outside for like 1 1/2 week or something and we went from an A to B [in rating] and that vessel that is so energy efficient couldn't catch up for the rest of the year. The strike was in March, so we had so many months left, but we couldn't get back on the A score due to a strike, this we can't affect, it's due to issues that aren't relevant for the vessel, but the vessel is getting penalized for it."

Another issue is the lack of the EEXI formula to facilitate calculations for diesel electric vessels. On the other hand, shipowners discuss the possibility of using the Energy Efficiency Operational Indicator (EEOI) as basis for calculating CII.

"…and that's a better way to use it [EEOI] because then we get points for having cargo and having short ballast voyages because that's the unnecessary."

"…so if we minimize our ballast legs, we get a good EEOI and then we can also get a good score. So that's a way to at least handle the tanker segment."

It was also stated that due to the FuelEU Maritime regulation and EU ETS, older vessels will not be able to operate anymore unless of major reconstructions. This leads to increased cost for compliance. At the end, it is stated that no clear solution has been agreed among regulators which makes the transition slow and creates uncertainty.

Sustainability strategy and investments: Important strategic decisions influence the sustainability strategy and investment appetite for the shipping company. Implementation of new technology, newbuilt vessels with focus on environmental factors and vessel design.

"…the environmental factors are highly prioritized when we're building vessels."

"…I also think that it will be a combination. You can't just count on the fuel type; you have to be more energy efficient. You have to have batteries; you have to have these energy conversions technologies and all of these other things as a complement."

Moreover, the need of a sustainable and environmentally friendly fleet by focusing on achieving low EEDI and meet regulatory criteria's can be determined as strategic factors which influence the sustainability and strategy investments.

Collaboration and industry standards: From the shipowner's perspective the need for enhanced collaboration among maritime ecosystem stakeholders and the increase of industry standards are highlighted.

"…we have this like we have 5 vessels in total in this company and four of them are on a time charter. So, for four of them, we aren't in charge of what type of fuel, what type of ports, what type of time schedule. We have no decision making in that those kinds of contexts."

Furthermore, the need for port availability for achieving various environmental goals was addressed together with the need for reduced waiting times considering the CII rating, which summarizes the aspects of collaboration between charterers, owners, ports, and regulators.

"…on a good year our vessel is moving about 50% of the year. The rest of the 50 is either at quay, getting cargo or discharging, or at anchorage waiting for available quay, and if we only have half of the year to be energy efficient that will get the nautical miles that the CII is based on, we are doomed to fail either way. So, for the CII and the tanker industry in these short voyages that we are doing, trading only into Europe. Of course, we can't get a high score if we haven't had these super energy efficient vessels like our new buildings"

As the CII score affects multiple stakeholders there is a problem with implementation of it on the grounds of synchronization between regulation and new technology. CII creates uncertainty regarding vessel operations, charter contracts and liquidity from finance sectors. Challenges exist in aligning with the fast-evolving regulations and upcoming new technologies, requiring cooperation within the industry.

Risk management in environmental impact: Regarding risk management, the shipowner considers plenty of uncertainties which affect their strategic decisions. Fuel type, lack of infrastructure regarding tanker operations and additional cost, influence the decision-making process. Shipowners also face barriers such as challenges of maintaining older vessels compliant with new regulatory frameworks. The risk management also assess crew safety, type of cargo, and minimize oil pollution.

4.2 Synthesis of findings

Based on the conducted analysis of interviews from key stakeholders, a holistic view of the integration of environmental factors into marine insurance underwriting, risk assessment, and pricing can be outlined.

Technological advancements and efficiency: Among all stakeholders there is a clear focus on adoption of new technologies and efficiency improvements. The adoption of alternative energy carriers such as LNG and biofuels is seen as a way going forward, though its implementation is hindered by infrastructural barriers and high costs. The data utilization, particularly through AI and software tools for environmental risk metrics, is also emphasised as a method to enhance the decision-making processes.

Regulatory compliance and uncertainty: There is a prevalent sense of regulatory uncertainty affecting all stakeholders that participated in this study. New and emerging regulations, such as the EU ETS and the CII are looked upon as significant challenges that increases the operational complexities. The stakeholders express a need for more clear regulatory frameworks to be able to plan and adapt their operational strategies.

Sustainability strategy and investments: The industry's stakeholders are investing towards new technology and sustainability practices as a long-term strategic plan to prioritize environmental targets and economic returns. The ESG framework has already been established in various companies among the industry ecosystem, reflecting on the industry's turn towards sustainability. Nonetheless, this shift into green future is challenged by high costs and

synchronization issues for stakeholders, which creates struggle to comply with regulation and implement technological advancements.

Collaboration and industry standards: The importance of cooperation in the industry ecosystem stakeholders has been highlighted by all the participants. Shared data platforms, information channels and united approach towards environmental standards and regulations are crucial aspects for tackling uncertainty and align with global sustainability targets.

Risk management in environmental impact: There are various risks which influence and determine the risk appetite of each company. Geopolitical factors, technological amendments, inflation, supply and demand of transportation, and regulations determine the risk assessment. For an accurate approach, stakeholders utilize data for assessing and risk mitigation as well as performance metrics. Despite these policies, barriers will still rise if lack of existing infrastructure and new technology emerge.

The integration of environmental considerations into the marine insurance sector is contemporary and influenced by external pressures such as regulatory changes and market conditions. Stakeholders are actively seeking ways to mitigate environmental impacts through technological innovation, strategic investments, and collaborative efforts. However, the pace of regulatory changes and the technological demands these changes impose considerable challenges which brings uncertainty.

The industry recognizes the need for clarity in regulations, better infrastructure for new technologies and enhanced collaborative frameworks to promote the industry ecosystem to standardize data collection and reporting. As the industry navigates these changes, the role of comprehensive risk management strategies becomes increasingly important, balancing cost, compliance, and environmental considerations in a rapidly evolving market.

5. Discussion

In the following sections the methodology and the findings will be discussed.

5.1 Methodology discussion

In this section the benefits and drawbacks of the method of choice will be discussed together with a currency, relevancy, authority, accuracy, and purpose test (CRAAP-test) being performed.

This study adopts a case study research approach to explore the integration of environmental factors into marine insurance underwriting within the tanker industry as previously mentioned. The authors put emphasis on the qualitative data, to better understand the industry ecosystem. The authors aimed to gain understanding and provide an in-depth and nuanced presentation of environmental risk assessments and their possible impact on policy pricing by employing a case study methodology. Case study research is known for its ability to delve deep into complex issues within industry contexts and it is a powerful tool for exploring cases where many variables are interconnected, just as an industry ecosystem is. The authors assess this to be well needed for the contemporary topic of this thesis. The method of choice is particularly good at providing a thorough understanding of the dynamics and processes, which was of essence to gain a holistic view of the industry. It allowed the authors to integrate various data sources such as interviews, observations, and documents, which enhances the conducted analysis. Furthermore, case studies can offer practical insights that are immediately applicable in similar industry scenarios, which could contribute to both theory and industry practices. However, this

approach as others has its limitations. It is known to be very time consuming and resource intensive, which in this case involved lengthy periods of data collection and analysis. The detailed nature of the investigation can also lead to challenges in generalizing findings to broader contexts, as the focus on a specific case or a limited number of cases might not reflect wider trends or varied conditions, which was of concern for the authors. Furthermore, the quality of a case study can be highly contingent upon the author's skills and objectivity, which made the authors raise concerns about consistency and transferability of the study. These aspects highlight the need for thorough preparations and critical consideration when using this methodology.

The primary method of data collection used in this study was semi-structured interviews with key stakeholders in the marine insurance sector, including an insurer, a representative from the finance sector, an employee at a shipowner and lastly a representative from a cargo owner. The interviews were designed to capture a broad range of insights and experiences from the different industry segments, thus, to provide a holistic view of the current practices and future trends in environmental risk assessment and the industrial ecosystem. With this said, it was of great importance to find relevant people to interview withing the different industry segments. With the above-mentioned interviews, the study conducted a thorough literature review as well, including both academic papers and policy frameworks. This review assisted in triangulating the interview data and ensuring the reliability and validity of the findings.

Data from the interviews and documents were analysed using a thematic analysis as previously stated. This method allowed for the identification of recurring themes and patterns, which were then critically examined in the context of existing literature on environmental risk management in insurance underwriting. An area of concern with this type of analysis is the transferability. Would a different set of authors be able to find the same findings and conclusion with the same method? The authors of this paper strongly believe that with this thoroughly explained methodology, the findings could likely be the same or at the very least similar.

5.1.1 CRAAP-test

To ensure the credibility and relevance of the data used in this study a brief CRAAP test was applied.

Currency: The author's made sure that the used data for this study was from recent and up to date policy documents and the latest reports on environmental impacts in marine insurance. This to ensure that recent sources of data were used where it was needed and applicable.

Relevance: The selected data sources and interview questions were chosen specifically to address the formulated research questions. The authors put great emphasise to focus on gathering data which connects to environmental factors in marine insurance, thus maintaining high relevance to the aim of the thesis.

Authority: The used data sources included published academic journals, books, regulations, and policy documents from reputable maritime and insurance organizations, as well as from known academic institutions to ensure that the information was authoritative and reliable.

Accuracy: To promote the accuracy of the findings, the authors checked the received information by cross-checking between multiple data sources, which included interview data and published reports, to check for consistency and accuracy.

Purpose: The purpose of the data collection was clearly defined as thesis research with the objective to enhance the understanding of underwriting practices and the possibility to implement environmental factors into the practices.

It is the authors belief that by using a case study research method, integrating multiple data sources and a robust analytical framework by thematic analysis, this research provides valuable insights into how environmental factors are currently integrated in the underwriting process and suggests ways to enhance these practices for better risk management and policy pricing in the future.

5.2 Findings discussion

In the following section, the findings will be discussed with focus on the areas of greatest importance for the result.

Based on the worldwide approach towards sustainable practices followed by the IMO and EU's strict regulations, the integration of environmental factors in marine insurance underwriting policy is vitally important. This part is focusing on discussion among theory and interview findings while underscoring the complexity of the particular matter. Following are the highlighted and discussed main elements of the findings.

The initial aim of this thesis was to provide the marine insurance sector a clear solution based on formulas, metrics and KPI's where the environmental factors could be safely assessed to create an accurate connection with risk assessment processes and insurance premiums. This approach has been discovered to be premature. What could be argued for is the need of a maritime ecosystem to solve the problems presented in the findings. The stakeholders' perspectives show a strong consensus towards the integration of more comprehensive environmental considerations into their processes. This move is not only seen as a necessity for compliance but also as a possible strategic advantage. This shows that the stakeholders are willing to create new processes and it is important to emphasise the benefits of a maritime industry ecosystem to govern these processes for efficiently share valuable data and knowledge.

Furthermore, it is crucial and possibly a risk of liability for the insurer that there might be disputes moving forward, regarding which stakeholder is the polluter. In the case of a non-compliance or the cost of emission quota with regards to EU ETS of a tanker vessel that is time chartered, who is the polluter? For major oil spills, the shipowner is commonly the polluter. But for these types of emissions, it could be argued both that the shipowner and charterer are the polluters. Due to this, marine insurance contracts have become relational contracts. You cannot look at contracts individually anymore due to the complex nature of the industry. It is vital for the industry to understand the change of dynamics and nature of contracts in order to succeed with the new obligations, risk exposure and opportunities. Thus, the implementation of a polluter-pays principle in a maritime industry ecosystem with a digital platform with joint decision-making could be argued for. The challenge is that a new landscape of operations is evolving, and risks will be attaching differently in these types of operations. Therefore, BIMCO implemented a new clause to assess the liability of both shipowners and charterers towards emissions coverage. Based on the polluter-pays principle, charterers who are responsible for the vessel's operational status are requested to bear the costs of emissions in case of vessel's deviation of agreed CII scores and after shipowners "advanced warning", which essentially is a written warning from the shipowner to the charterer. In addition, the clause enhances

cooperation and transparency between actors which offers a way for them to prepare an action plan for meeting CII score. Perhaps the charterer could create a fund for this in the future. Even if this new clause has just been implemented, charterers could create a risk pooling practice of sharing financial risks and extra charges from emission allowances among a group of companies. Risk pool is a form of risk management, usually practiced by insurance and shipping companies to protect themselves from catastrophic events. In that way, charterers would be in a place where they prevent operational disruptions and severe financial charges in a completely new and uncertain environment such as EU ETS. Action like this could help the industry, if charterers act as united stakeholders who align a common risk mitigation plan, create compliance assurance, and promote a culture of cooperation and transparency.

The use of EEOI instead of CII could be argued to present a more accurate and comprehensive approach of assessing the environmental footprint in marine operations. Solely usage of CII for assessing the environmental performance leads to a lack of accurate calculation of the actual transport work of cargo carried, which leads to unfair ratings due to external factors such as port strikes and long waiting times. Nonetheless, EEOI is not perfect, there is still a need for a calculation that incorporates waiting times. The usage of CII, which is mandatory, and EEOI which is optional, could lead to additional benefits for a maritime ecosystem. The ecosystem design could be constructed so, that EEOI calculations are done, and all data is shared with the involved stakeholders in the ecosystem. This could also be a critical factor for maintaining a good CII rating, since owners or charterers might travel unnecessary distances in order to lower carbon ratio per distance. In an ecosystem where interconnection among all of them is the matter of the essence, the understanding and anticipating of needs is vital for the insurers. Overall, an active engagement among all ecosystem stakeholders where data transparency and shared information are essential, could facilitate the development of industry's standards benefiting each one of them.

Finally, after underscoring all different point of views and emphasizing the most critical aspect of the integration of environmental factors in marine insurance policies. The need of a robust and aligned maritime industry ecosystem where flexibility and trust between stakeholders along with an adoptable approach based on current environmental standards has been highlighted. As regulatory uncertainty, geopolitical considerations and cost fluctuations based on a volatile supply-demand are present, the need for enhancing technological advancements for environmental data analysis could be argued for.

As mentioned in the synthesis of findings it has shown to be a complex industry ecosystem involved in the processes of ship operations, the regulations and systems affecting it. In the below flowchart the maritime industry ecosystem is depicted. The dotted lines are connections that could be present in the future. What is crucial to understand is that all the different stakeholders revolve around the shipowner. The insurer which this thesis focus on is as connected to the ecosystem as the others are.

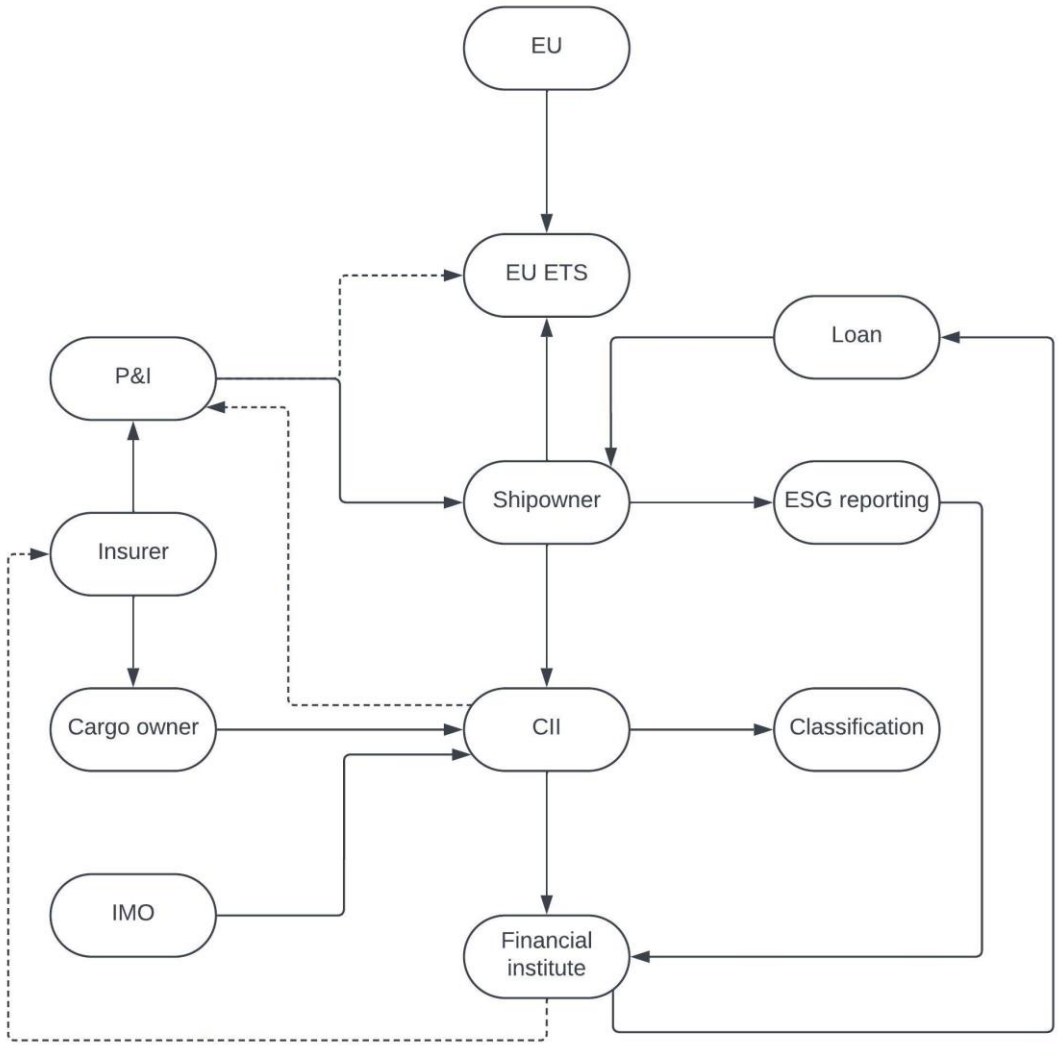


Figure 11. Industry ecosystem flowchart

To further explain the flowchart, the insurer provides both shipowners and cargo owners with insurance cover while the EU imposes the EU ETS on shipowners. Furthermore, the shipowner has CII ratings, imposed by the IMO of which classification societies need to verify and approve, the cargo owner or charterer affects the CII in which the shipowner might have limited control of. The financial institutions provide loan for shipowners while using ESG reporting and CII to assess the environmental performance that affects the loan. The possible link that the authors see is that with a maritime industry ecosystem the financial institutions and insurers could co-operate to exchange processes, data, and knowledge of risks. Moreover, the authors see a possible connection were CII and EU ETS could be incorporated into P&I insurance or separate insurances in the upcoming future.

It is worth mentioning the importance of fleet ESG reporting since it used as benchmark for assessing performance and promote investors interest. By using ESG performance, the marine insurers are allowed to assess risks, increase competitiveness, and work towards proactive measures. Furthermore, the need of ESG reporting under marine insurance sector is mandatory. In regard to financial institutions and insurers, these two different sectors exhibit similarities. Banks who specialize in shipping loans have already implemented ESG criteria into their operational frameworks. By adopting similar instruments, marine insurers can create tailor-

made processes of environmental risk management strategies. Notably, ESG performance assessments has not led to a denial so far for the finance sector, nonetheless, it has led to the creation of stricter rules and increased costs for shipowners who does not perform well. This is completely aligned with the marine insurance attitude to facilitate change rather than being a barrier for it.

6. Conclusion

In the following chapter, the conclusion of the thesis based on the research questions will be presented.

The outmost important conclusion of this thesis is the need of a maritime industry ecosystem with interdependency among stakeholders where they can generate and absorb value without hierarchical control of the system. The new BIMCO CII clause which push additional costs to charterers will change industry dynamics in many senses. With the contemporary need for relational contracts and the contractual decisions of who the polluter is, not only the shipowners will be considered as the polluter, thus, the insurers will have a more complex context at hand by needing to involve inputs from additional stakeholders in the risk assessment processes and decision-making. Together with the rapidly changing industry environment, opportunity arise for the stakeholders to co-operate in an industry ecosystem to find the best way moving forward.

Marine insurers can adapt their risk assessments by incorporating environmental factors related to tanker vessels. This can be done by creating processes similar to the financial institutions by developing models that include metrics for environmental performance. Insurers can integrate these factors into their existing risk assessment frameworks to evaluate the overall environmental risk profile of tanker operations more accurately. To assess the environmental performance of insured entities, marine insurers should rely on a combination of public data and data sources within an industry ecosystem created for this purpose. Metrics to consider might include the Energy Efficiency Operational Indicator (EEOI), Carbon Intensity Indicator (CII), and ESG assessments. These metrics allow insurers to quantitatively assess how well a shipping company or vessel performs relative to environmental standards.

It is premature to say how the integration of environmental factors into the underwriting process will influence the pricing of marine insurance policies, by looking at the financial intuitions the conclusion can be drawn that the price might be affected moving forward. Vessels and fleets that demonstrate better environmental performance could benefit from lower insurance premiums due to their reduced risk profile. Conversely, those with poor environmental records might face higher premiums. This pricing adjustment would serve as a financial incentive for ship operators to adopt greener technologies and practices. Over time, this could lead to a shift in the industry towards more sustainable operations, as the financial benefits of improved environmental performance become more pronounced. It is safe to say that insurers have the opportunity to bring in their collaborative experiences from their concept of mutuality with shipowners into taking the lead in forming a maritime industry ecosystem. Collaboratory platforms which include multiple actors like finance sector, cargo owners and ship owners could be hosted by insurers for facilitation of data transparency, sharing best practices and enhance innovation. Insurers could play a leading role in this project by building a foundation of trust and align all parties to environmental goals. The aspect of trust is crucial for the effectiveness of this initiative as will engaging stakeholders to work towards common targets.

6.1 Recommendations for further research

Given the conclusion of this study that there is a need for a maritime industry ecosystem, further research could be conducted into the implementation of such an ecosystem. Furthermore, it was previously stated that it is premature to find a definite solution for the environmental metrics to use and the pricing effects on this implementation. Thus, further research could be conducted within this area when more processes are implemented, and more available data are accessible.

References

Aase, K. K. (2007). Equilibrium in marine mutual insurance markets with convex operating costs. *Journal of Risk and Insurance*, *74*(1). https://search.ebscohost.com/login.aspx?direct=true&db=edsbig&AN=edsbig.A161845205&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Adland, R., Jia, H., Lode, T., & Skontorp, J. (2021). The value of meteorological data in marine risk assessment. *Reliability Engineering and System Safety*, *209*. Scopus®. https://doi.org/10.1016/j.ress.2021.107480

Athanassiou, L. I. (2024). Shipping Operators' Obligations and Liabilities Under the International and EU Emission Reduction Strategy. In *Damages, Recoveries and Remedies in Shipping Law* (pp. 155–173). Informa Law from Routledge.

Baughen, S. (2023). Full steam ahead – the EU's Emissions Trading Scheme captures international shipping from 1 January 2024. *Trafigura Pte Ltd v TKK Shipping Pte Ltd (The Thorco Lineage) [2023] EWHC 26 (Comm), [2023] Bus LR 890, [2023] 2 Lloyd's Rep 338*, *29*(2). https://www.lawtext.com/publication/the-journal-of-international-maritime-law/contents/volume-29/issue-2

Baumann, J. (2023). Shifting to Sustainable Shipping: Actors and Power Shifts in Shipping Emissions in the IMO. *Sustainability*, *15*(17). https://doi.org/10.3390/su151712742

Baumol, W. J., & Oates, W. E. (1971). The Use of Standards and Prices for Protection of the Environment. *The Swedish Journal of Economics*, *73*(1), 42–54. https://doi.org/10.2307/3439132

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*. https://doi.org/10.1016/j.oceaneng.2023.114295

Bennett, P. (2001). Mutual risk: P and I insurance clubs and maritime safety and environmental performance. *Marine Policy*, *25*(1), 13–21. Scopus®. https://doi.org/10.1016/S0308-597X(00)00029-4

Bruninx, K., Ovaere, M., & Delarue, E. (2020). The long-term impact of the market stability reserve on the EU emission trading system. *ENERGY ECONOMICS*, *89*. https://doi.org/10.1016/j.eneco.2020.104746

Chircop, A., Doelle, M., & Gauvin, R. (2018). *International Law and Policy Considerations for Shipping's Contribution to Climate Change Mitigation*. https://doi.org/10.2139/ssrn.3113274

Christodoulou, A., & Cullinane, K. (2022). Potential alternative fuel pathways for compliance with the 'FuelEU Maritime Initiative'. *Transportation Research Part D: Transport and Environment*, *112*, 103492–103492. https://doi.org/10.1016/J.TRD.2022.103492

Christodoulou, A., & Cullinane, K. (2023). The prospects for, and implications of, emissions trading in shipping. *Maritime Economics and Logistics*. https://doi.org/10.1057/s41278-023-00261-1

de Langen, P. W., Sornn-Friese, H., & Hallworth, J. (2020). The Role of Port Development Companies in Transitioning the Port Business Ecosystem; The Case of Port of Amsterdam's Circular Activities. *Sustainability*, *12*(11). https://doi.org/10.3390/su12114397

de Souza Barbosa, A., da Silva, M. C. B. C., da Silva, L. B., Morioka, S. N., & de Souza, V. F. (2023). Integration of Environmental, Social, and Governance (ESG) criteria: Their impacts on corporate sustainability performance. *Humanities and Social Sciences Communications*, *10*(1), 410–410. https://doi.org/10.1057/s41599-023-01919-0

Deane, F., Huggins, A., & Karim, M. S. (2019). Measuring, monitoring, reporting and verification of shipping emissions: Evaluating transparency and answerability. *Review of European Comparative & International Environmental Law*, *28*(3), 258–267. https://doi.org/10.1111/reel.12308

Denscombe, M. (2014). *The good research guide. [Electronic resource]: For small scale research projects.* (Fifth edition.). Open University Press; Chalmers Library E-book Collection. https://search.ebscohost.com/login.aspx?direct=true&db=cat07472a&AN=clec.DAWVLE29300840&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Eccles, G. R., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, *60*(11), 2835–2835.

Ellili, N., Nobanee, H., Dilshad, M. N., Alodat, A. Y., & Nuzhat, S. (2023). Mapping marine insurance: A bibliometric review: A taxonomical study using bibliometric visualization and systematic analysis. *Journal of Financial Services Marketing*. Scopus®. https://doi.org/10.1057/s41264-023-00232-w

Feng, Q., An, C. J., Cao, Y., Chen, Z., Owens, E., Taylor, E., Wang, Z., & Saad, E. A. (2021). An Analysis of Selected Oil Spill Case Studies on the Shorelines of Canada. *Journal of Environmental Informatics Letters*, *5*(1), 39–47. Scopus. https://doi.org/10.3808/jeil.202100052

Fiorini, M., & Gupta, N. (2021). *ICT Solutions and Digitalisation in Ports and Shipping*. Institution of Engineering and Technology (The IET).

https://search.ebscohost.com/login.aspx?direct=true&db=edsknv&AN=edsknv.kpICTSDPS3&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Francesco, B., Andrea, C., & E, M. M. (2022). 1.5.2 Present and Coming Regulations for Low-Carbon Shipping. In *Sustainable Energy Systems on Ships—Novel Technologies for Low Carbon Shipping*. Elsevier. https://search.ebscohost.com/login.aspx?direct=true&db=edsknv&AN=edsknv.kt01316AE4&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Gans, J. (2016). *The Disruption Dilemma* (1st ed.). MIT Press; Chalmers Library E-book Collection. https://search.ebscohost.com/login.aspx?direct=true&db=cat07472a&AN=clec.EBC4455141&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Greg Guest, Kathleen M. MacQueen, & Emily E. Namey. (2012). *Applied Thematic Analysis*. SAGE Publications, Inc; eBook Index. https://search.ebscohost.com/login.aspx?direct=true&db=edsebk&AN=3362032&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Guo, X., Li, J., & Huang, S. (2023). Study on Trade Effects of Green Maritime Transport Efficiency: An Empirical Test for China Based on Trade Decision Model. *Sustainability*, *15*(16). Gale In Context: Science. https://doi.org/10.3390/su151612327

Gurses, O. (2016). *Marine Insurance Law*. https://search.ebscohost.com/login.aspx?direct=true&db=edsbvb&AN=edsbvb.BV045040937&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Hammond, M., & Wellington, J. J. (2021). *Research methods: The key concepts.* (2nd edition.). Routledge. https://search.ebscohost.com/login.aspx?direct=true&db=cat07472a&AN=clec.ybp16706611&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Hawkins, J. M. (2017). Thematic analysis. In *The SAGE encyclopedia of communication research methods* (1–Vol. 4, pp. 1757–1760). Bibliotheksverbund Bayern. https://doi.org/10.4135/9781483381411

Heras, B. P. de las. (2022). The 'Fit for 55' Package: Towards a More Integrated Climate Framework in the EU. *Romanian Journal of European Affairs*, *22*(2), 63–78.

Holgersson, M., Baldwin, C. Y., Chesbrough, H., & M. Bogers, M. L. A. (2022). The Forces of Ecosystem Evolution. *California Management Review*, *64*(3), 5–23. Business Source Ultimate. https://doi.org/10.1177/00081256221086038

Hua, R., Yin, J., Wang, S., Han, Y., & Wang, X. (2024). Speed optimization for maximizing the ship's economic benefits considering the Carbon Intensity Indicator (CII). *Ocean Engineering*, *293*, N.PAG-N.PAG.

IMO. (2009). *GUIDELINES FOR VOLUNTARY USE OF THE SHIP ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)*. https://gmn.imo.org/wp-content/uploads/2017/05/Circ-684-EEOI-Guidelines.pdf

IMO. (2021). *2021 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY EXISTING SHIP INDEX (EEXI)*. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.333(76).pdf

IMO. (2022a). *2022 GUIDELINES FOR THE DEVELOPMENT OF A SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)*.

IMO. (2022b). *2022 GUIDELINES ON OPERATIONAL CARBON INTENSITY INDICATORS AND THE CALCULATION METHODS (CII GUIDELINES, G1)*. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.352(78).pdf

IMO. (2022c). *2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS*.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, *39*(8), 2255–2276. Scopus®. https://doi.org/10.1002/smj.2904

Jo, H., & Harjoto, M. (2012). The Causal Effect of Corporate Governance on Corporate Social Responsibility. *Journal of Business Ethics*, *106*(1), 53–72. https://doi.org/10.1007/s10551-011-1052-1

Jovanovic, M., Kostić, N., Sebastian, I. M., & Sedej, T. (2022). Managing a blockchain-based platform ecosystem for industry-wide adoption: The case of TradeLens. *Technological Forecasting and Social Change*, *184*, 121981. https://doi.org/10.1016/j.techfore.2022.121981

Jovanovic, M., Sjödin, D., & Parida, V. (2022). Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. *Technovation*, *118*, 102218. https://doi.org/10.1016/j.technovation.2020.102218

Karl, M., Jonson, J. E., Uppstu, A., Aulinger, A., Prank, M., Sofiev, M., Jalkanen, J.-P., Johansson, L., Quante, M., & Matthias, V. (2019). Effects of ship emissions on air quality in the Baltic Sea region simulated with three different chemistry transport models. *Atmospheric Chemistry and Physics*, *19*, 7019–7053. https://doi.org/10.5194/acp-19-7019-2019

Kavussanos, M. G., Tsouknidis, D. A., & Visvikis, I. D. (2021). *Freight Derivatives and Risk Management in Shipping; Second Edition*. www.routledge.com/Routledge-

Koesler, S., Achtnicht, M., & Köhler, J. (2015). Course set for a cap? A case study among ship operators on a maritime ETS. *Transport Policy*, *37*, 20–30.

Kumar, A., Liu, R., & Shan, Z. (2020). Is Blockchain a Silver Bullet for Supply Chain Management? Technical Challenges and Research Opportunities. *Decision Sciences*, *51*(1), 8–37. https://doi.org/10.1111/deci.12396

Lagouvardou, S., & Psaraftis, H. N. (2022). Implications of the EU Emissions Trading System (ETS) on European container routes: A carbon leakage case study. *Maritime Transport Research*, *3*. https://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S2666822X22000107&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Lai, Y., & Xv, S. (2021). Maritime service industry evaluation based on the combined empowerment method. *2021 International Conference on Education, Information Management and Service Science (EIMSS), Education, Information Management and Service Science (EIMSS), 2021 International Conference on, EIMSS*, 471–474. https://doi.org/10.1109/EIMSS53851.2021.00107

Lee, J., Lee, J., Lee, C., & Kim, Y. (2023). Identifying ESG Trends of International Container Shipping Companies Using Semantic Network Analysis and Multiple Case Theory. *Sustainability*, *15*(12), 9441–9441. https://doi.org/10.3390/su15129441

Mack, O., Khare, A., Kraemer, A., & Burgartz, T. (2016). *Managing in a VUCA World. [Electronic resource]* (O. Mack, A. Khare, A. Krämer, & T. Burgartz, Eds.). Springer International Publishing. https://search.ebscohost.com/login.aspx?direct=true&db=cat07472a&AN=clec.SPRINGERLINK9783319168890&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Manopo, B., & Merkin QC, R. (2021). A Critical Analysis of Causation Rules in Marine Insurance. *Bestuur*, *9*(2), 101–112. https://doi.org/10.20961/bestuur.v9i2.55165

Marchand, P. (2017). THE INTERNATIONAL LAW REGARDING SHIP-SOURCE POLLUTION LIABILITY AND COMPENSATION: EVOLUTION AND CURRENT CHALLENGES. *International Oil Spill Conference Proceedings*, *2017*(1), 193–210. https://doi.org/10.7901/2169-3358-2017.1.193

Marine Insurance Act 1906. (n.d.).

Monios, J., & Wilmsmeier, G. (2020). Deep adaptation to climate change in the maritime transport sector–a new paradigm for maritime economics? *Maritime Policy and Management*, *47*(7), 853–872. https://doi.org/10.1080/03088839.2020.1752947

Nõmmela, K., & Kaare, K. K. (2022). Maritime Policy Design Framework with ESG Performance Approach: Case of Estonia. *Economies*, *10*(4). https://doi.org/10.3390/economies10040088

Noussia, K.-P. (2004). *The 'principle of indemnity' in marine insurance contracts: A comparative study*. https://search.ebscohost.com/login.aspx?direct=true&db=ddu&AN=CA1D3F90A0390C32&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Oğuz, H. S. (2020). *Global marine insurance premiums and the maritime industry*.

Popov, G., Lyon, B. K., & Hollcroft, B. D. (2016). *Risk Assessment: A Practical Guide to Assessing Operational Risks.* (1st ed.). John Wiley & Sons, Incorporated; Chalmers Library E-book Collection.

https://search.ebscohost.com/login.aspx?direct=true&db=cat07472a&AN=clec.EBC4538959&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Puscaciu, V., & Ebiere, S. O. (2019). *Current Trends in Maritime Insurance*. https://search.ebscohost.com/login.aspx?direct=true&db=edsdoj&AN=edsdoj.7bf87edd82cb4210a1bbb5217cbb5e79&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Ren, H., Ding, Y., & Sui, C. (2019). Influence of EEDI (Energy efficiency design index) on ship-engine-propeller matching. *Journal of Marine Science and Engineering*, *7*(12). https://doi.org/10.3390/JMSE7120425

Ronza, A., Félez, S., Darbra, R. M., Carol, S., Vilchez, J., & Casal, J. (2003). Predicting the frequency of accidents in port areas by developing event trees from historical analysis. *Journal of Loss Prevention in the Process Industries*, *16*, 551–560. https://doi.org/10.1016/j.jlp.2003.08.010

Sartz, P. P., Hasan, M. I., & Aggarwal, S. (2023). Air quality impacts in the vicinity of a chemical herder mediated in-situ burn for Arctic oil spill response. *SCIENCE OF THE TOTAL ENVIRONMENT*, *892*, 163860. edswsc. https://doi.org/10.1016/j.scitotenv.2023.163860

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Business Strategy and the Environment*, *20*(4), 222–237. https://doi.org/10.1002/bse.682

Shi, Z., Endres, S., Rutgersson, A., Al-Hajjaji, S., Brynolf, S., Booge, D., Hassellov, I.-M., Kontovas, C., Kumar, R., Liu, H., Marandino, C., Matthias, V., Moldanova, J., Salo, K., Sebe,

M., Yi, W., Yang, M., & Zhang, C. (2023). Perspectives on shipping emissions and their impacts on the surface ocean and lower atmosphere: An environmental-social-economic dimension. *ELEMENTA-SCIENCE OF THE ANTHROPOCENE*, *11*(1), 00052. edswsc. https://doi.org/10.1525/elementa.2023.00052

Sofiev, M., Winebrake, J. J., Johansson, L., Carr, E. W., Prank, M., Soares, J., Vira, J., Kouznetsov, R., Jalkanen, J.-P., & Corbett, J. J. (2018). Cleaner fuels for ships provide public health benefits with climate tradeoffs. *Nature Communications*, *9*(1), 1–12. https://doi.org/10.1038/s41467-017-02774-9

Song, M. (2011). Insurable Interest in the Law of Marine Insurance. *Southampton Student Law Review*, *1*(2), 75–82.

Spaniol, M. J., & Rowland, N. J. (2022). Business ecosystems and the view from the future: The use of corporate foresight by stakeholders of the Ro-Ro shipping ecosystem in the Baltic Sea Region. *Technological Forecasting & Social Change*, *184*. ScienceDirect. https://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S0040162522004875&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Sperdokli, E. (2014). Marine Insurance for Oil Pollution. *Tort Trial & Insurance Practice Law Journal*, *49*(2), 611–644.

Syriopoulos, T., Roumpis, E., & Tsatsaronis, M. (2023). Hedging Strategies in Carbon Emission Price Dynamics: Implications for Shipping Markets. *Energies*, *16*(17). https://doi.org/10.3390/en16176396

The Swedish Club. (2024, February 14). *P&I Rules and Exceptions – Copyright The Swedish Club 2020*. https://rulesandexceptions.swedishclub.com/

Tsakos, N. (2016). *Tanker chartering.* (2016 ed.). Institute of chartered shipbrokers. https://search.ebscohost.com/login.aspx?direct=true&db=cat09075a&AN=clpc.oai.edge.chalmers.folio.ebsco.com.fs00001000.97d45bdc.1abf.47a7.a520.451b1f9a7472&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept—Towards coherent ecosystem design. *Technological Forecasting and Social Change*, *136*, 49–58. https://doi.org/10.1016/j.techfore.2017.06.032

Tsytsyna, E., & Valminen, T. (2023). How are actor dynamics balanced in ecosystems? An in-depth case study of an autonomous maritime transportation ecosystem. *REVIEW OF MANAGERIAL SCIENCE*. EDSWSS. https://doi.org/10.1007/s11846-023-00688-z

Tvarnø, C. D., Østergaard, K., & Schleimann, H. (2017). *Relational Maritime Contracts: A Cost and Risk Perspective*.

United Nations & Swiss Federal Department of Foreign Affairs. (n.d.). *Who cares wins: Connecting financial markets to a changing world*. https://www.unepfi.org/fileadmin/events/2004/stocks/who_cares_wins_global_compact_2004.pdf

Vidmar, P., & Perkovič, M. (2018). Safety assessment of crude oil tankers. *Safety Science*, *105*, 178–191.
Wang, S., Psaraftis, H. N., & Qi, J. (2021). Paradox of international maritime organization's carbon intensity indicator. *Communications in Transportation Research*, *1*, 100005–100005. https://doi.org/10.1016/j.commtr.2021.100005

Woloniecki, J. (2002). The Duty of Utmost Good Faith in Insurance Law: Where Is It in the 21st Century? *Defense Counsel Journal*, *69*(1), 63–63.

Wood, D. F., Barone, A. P., Murphy, P. R., & Wardlow, D. L. (2002). 12.4 Hull Insurance. In *International Logistics (2nd Edition)*. AMACOM. https://search.ebscohost.com/login.aspx?direct=true&db=edsknv&AN=edsknv.kt006HEJ22&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Wu, J., Liu, J., & Li, N. (2024). The evasion strategy options for competitive ocean carriers under the EU ETS. *Transportation Research Part E*, *183*. https://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S1366554524000292&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

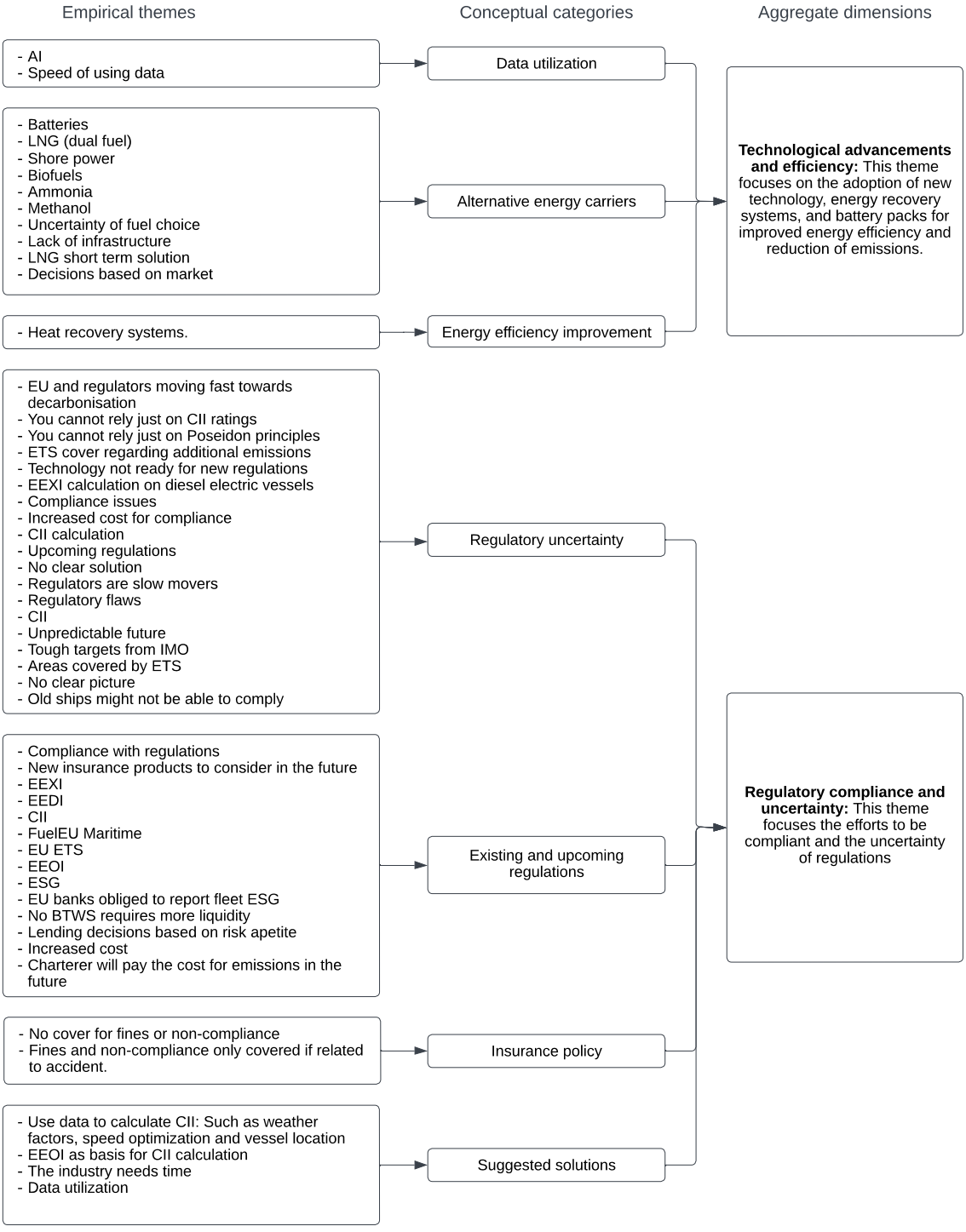
Yang, W. (2020). Influence of Time and Space Analysis of Marine Economy on Catastrophe Insurance Risk Assessment. *Journal of Coastal Research*, *115*(sp1), 583–586. Scopus®. https://doi.org/10.2112/JCR-SI115-156.1

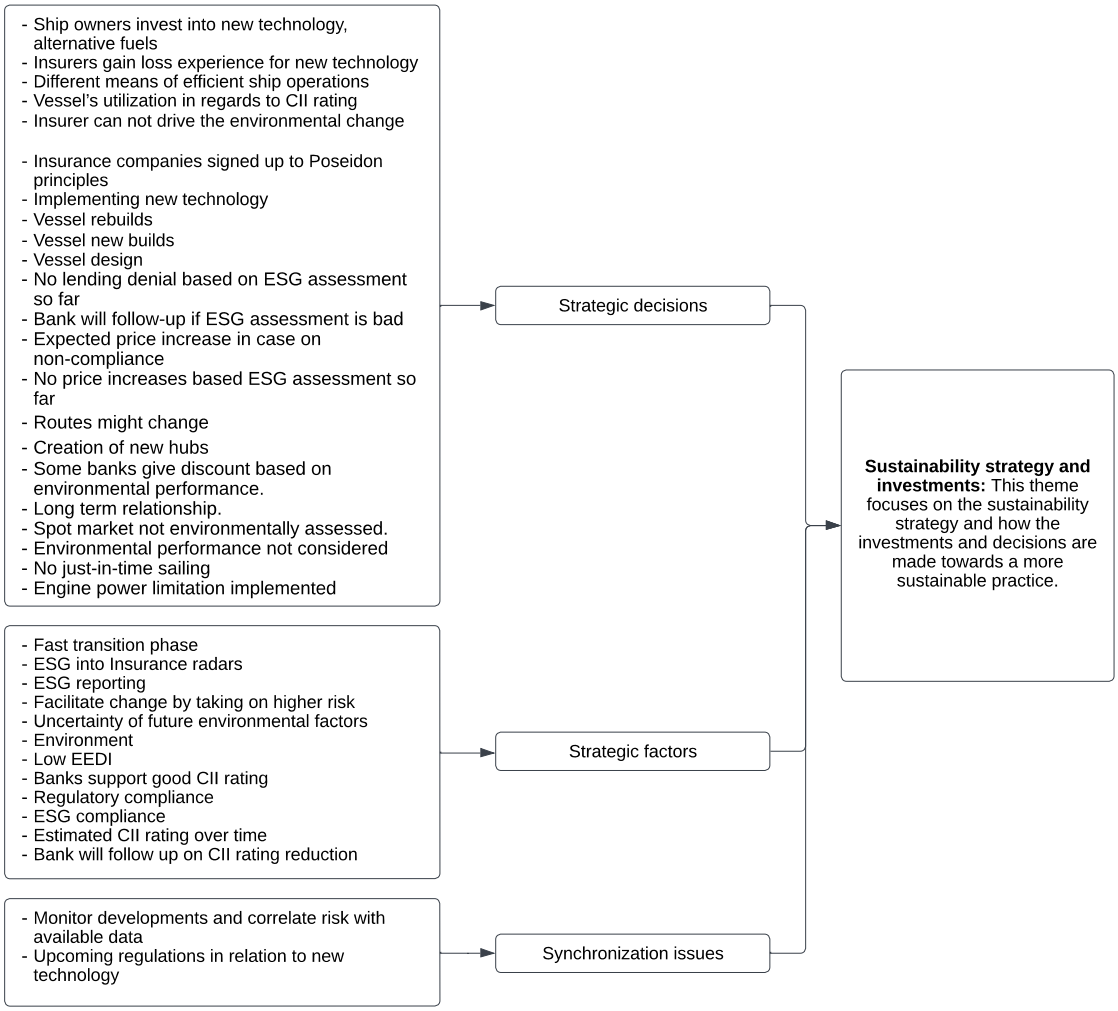
Yin, R. K. (2018). *Case study research and applications: Design and methods.* (Kuggen Lindholmen Method Yin; Sixth edition). SAGE; Chalmers Library Print Collection. https://search.ebscohost.com/login.aspx?direct=true&db=cat09075a&AN=clpc.oai.edge.chalmers.folio.ebsco.com.fs00001000.0ed34dcd.b0c3.40f1.9d2c.db270146c839&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

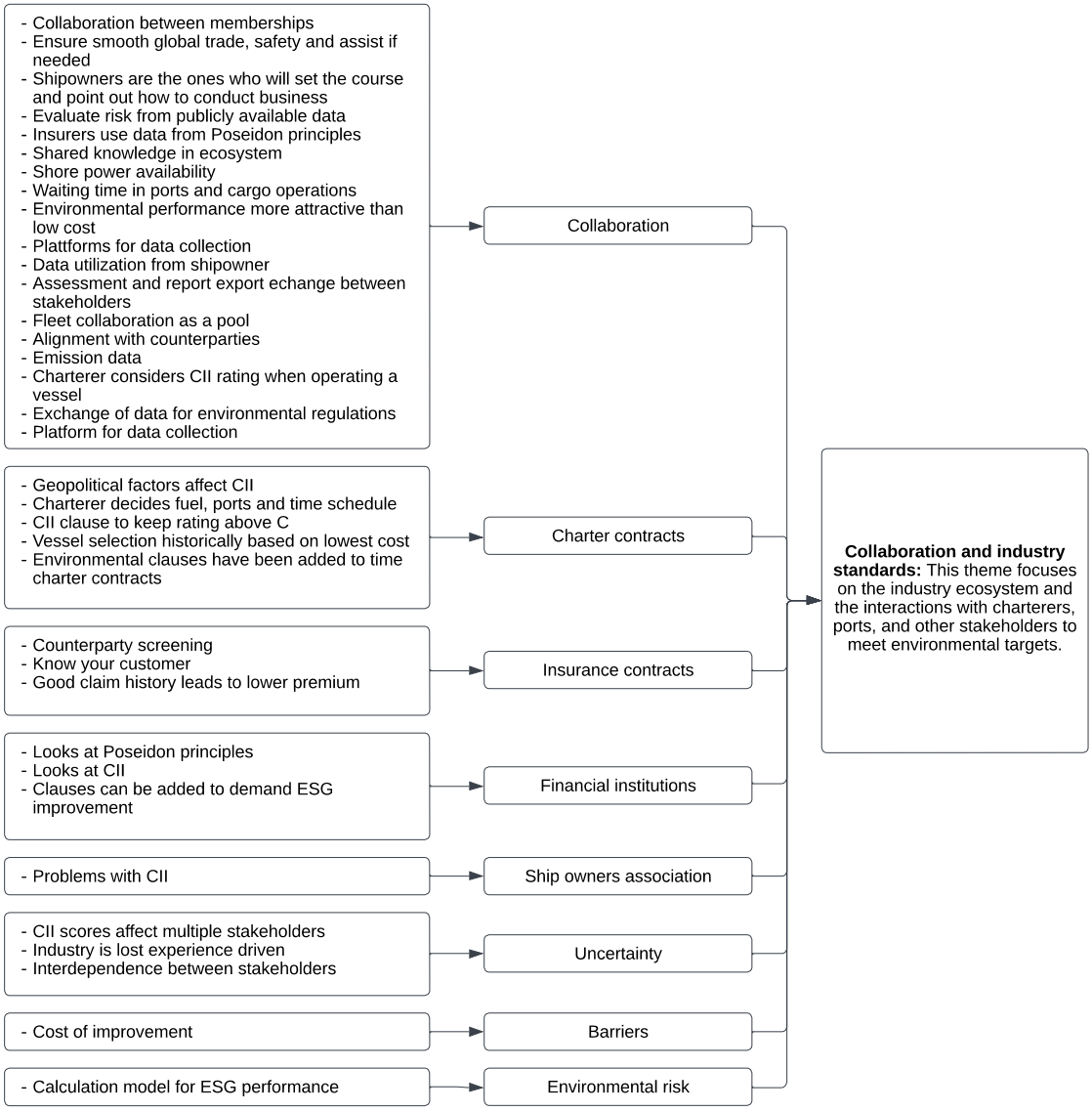
Yubing Shi. (2017). *Climate Change and International Shipping: The Regulatory Framework for the Reduction of Greenhouse Gas Emissions* (Issue volume 23). Brill | Nijhoff; eBook Index. https://search.ebscohost.com/login.aspx?direct=true&db=edsebk&AN=1940141&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

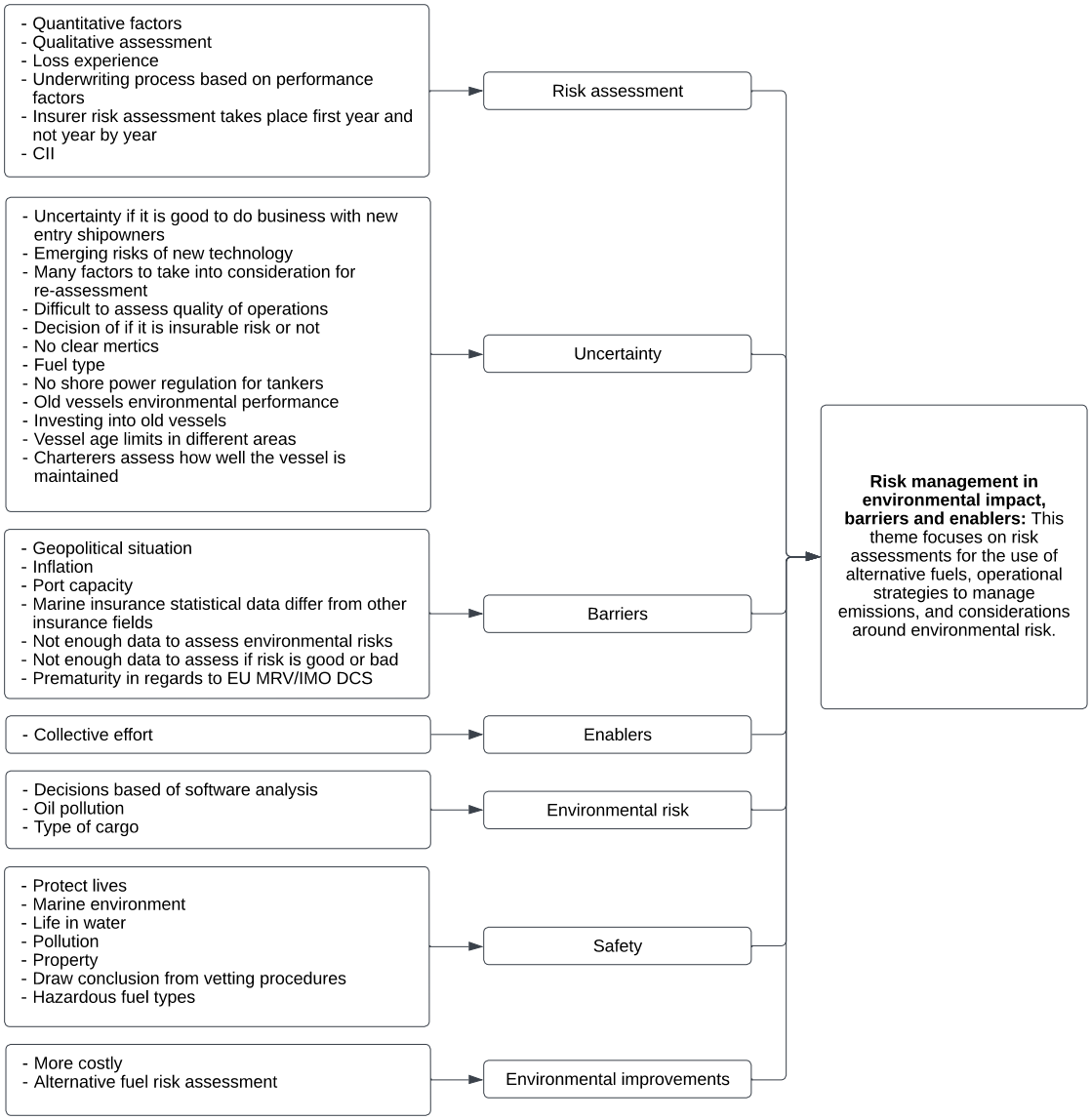
Zetterdahl, M. (2016). *Particle Emissions from Ships*. https://search.ebscohost.com/login.aspx?direct=true&db=ir01624a&AN=crp.64738eaa.81e7.43a0.8cce.b34571d7e9f9&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Appendix 1: Data analysis chart




- Ship owners invest into new technology, alternative fuels
- Insurers gain loss experience for new technology
- Different means of efficient ship operations
- Vessel's utilization in regards to CII rating
- Insurer can not drive the environmental change
- Insurance companies signed up to Poseidon principles
- Implementing new technology
- Vessel rebuilds
- Vessel new builds
- Vessel design
- No lending denial based on ESG assessment so far
- Bank will follow-up if ESG assessment is bad
- Expected price increase in case on non-compliance
- No price increases based ESG assessment so far
- Routes might change
- Creation of new hubs
- Some banks give discount based on environmental performance.
- Long term relationship.
- Spot market not environmentally assessed.
- Environmental performance not considered
- No just-in-time sailing
- Engine power limitation implemented
Strategic decisions
- Fast transition phase
- ESG into Insurance radars
- ESG reporting
- Facilitate change by taking on higher risk
- Uncertainty of future environmental factors
- Environment
- Low EEDI
- Banks support good CII rating
- Regulatory compliance
- ESG compliance
- Estimated CII rating over time
- Bank will follow up on CII rating reduction
Strategic factors
- Monitor developments and correlate risk with available data
- Upcoming regulations in relation to new technology
Synchronization issues
Sustainability strategy and investments: This theme focuses on the sustainability strategy and how the investments and decisions are made towards a more sustainable practice.


- Collaboration between memberships
- Ensure smooth global trade, safety and assist if needed
- Shipowners are the ones who will set the course and point out how to conduct business
- Evaluate risk from publicly available data
- Insurers use data from Poseidon principles
- Shared knowledge in ecosystem
- Shore power availability
- Waiting time in ports and cargo operations
- Environmental performance more attractive than low cost
- Plattforms for data collection
- Data utilization from shipowner
- Assessment and report export echange between stakeholders
- Fleet collaboration as a pool
- Alignment with counterparties
- Emission data
- Charterer considers CII rating when operating a vessel
- Exchange of data for environmental regulations
- Platform for data collection
Collaboration
- Geopolitical factors affect CII
- Charterer decides fuel, ports and time schedule
- CII clause to keep rating above C
- Vessel selection historically based on lowest cost
- Environmental clauses have been added to time charter contracts
Charter contracts
- Counterparty screening
- Know your customer
- Good claim history leads to lower premium
Insurance contracts
- Looks at Poseidon principles
- Looks at CII
- Clauses can be added to demand ESG improvement
Financial institutions
- Problems with CII
Ship owners association
- CII scores affect multiple stakeholders
- Industry is lost experience driven
- Interdependence between stakeholders
Uncertainty
- Cost of improvement
Barriers
- Calculation model for ESG performance
Environmental risk
Collaboration and industry standards: This theme focuses on the industry ecosystem and the interactions with charterers, ports, and other stakeholders to meet environmental targets.


- Quantitative factors
- Qualitative assessment
- Loss experience
- Underwriting process based on performance factors
- Insurer risk assessment takes place first year and not year by year
- CII
Risk assessment
- Uncertainty if it is good to do business with new entry shipowners
- Emerging risks of new technology
- Many factors to take into consideration for re-assessment
- Difficult to assess quality of operations
- Decision of if it is insurable risk or not
- No clear mertics
- Fuel type
- No shore power regulation for tankers
- Old vessels environmental performance
- Investing into old vessels
- Vessel age limits in different areas
- Charterers assess how well the vessel is maintained
Uncertainty
- Geopolitical situation
- Inflation
- Port capacity
- Marine insurance statistical data differ from other insurance fields
- Not enough data to assess environmental risks
- Not enough data to assess if risk is good or bad
- Prematurity in regards to EU MRV/IMO DCS
Barriers
- Collective effort
Enablers
- Decisions based of software analysis
- Oil pollution
- Type of cargo
Environmental risk
- Protect lives
- Marine environment
- Life in water
- Pollution
- Property
- Draw conclusion from vetting procedures
- Hazardous fuel types
Safety
- More costly
- Alternative fuel risk assessment
Environmental improvements
Risk management in environmental impact, barriers and enablers: This theme focuses on risk assessments for the use of alternative fuels, operational strategies to manage emissions, and considerations around environmental risk.

DEPARTMENT OF MECHANICS AND MARITIME SCIENCES
DIVISION OF MARITIME SCIENCE
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden

CHALMERS
UNIVERSITY OF TECHNOLOGY