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Leveraging ESG Investing with Digital Transformation to Enhance the Carbon Intensity Indicator

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Abstract

This thesis examines how Digital Transformation and Environmental, Social, and Governance investing can collectively address the limitations of the International Maritime Organisation’s Carbon Intensity Indicator, a key structure for assessing a ship's carbon emissions. While the CII aims to incentivise decarbonisation, its efficacy is constrained by data inaccuracies, operational inconsistencies, and fragmented stakeholder accountability.

This study examines how DT technologies, such as the Internet of Things and blockchain, can improve the transparency, reliability, and efficiency of both the CII framework and ESG investing. At the same time, it explores the role of ESG investing in promoting the adoption of these digital solutions within the shipping industry, while also influencing the governance of CII. Using a qualitative research methodology that includes thematic and comparative analysis, the thesis synthesises information from regulatory frameworks, case studies of leading shipping companies, and evaluations by ESG rating agencies.

Findings reveal that the interplay between DT and ESG investing can enhance stakeholder collaboration, balance the identified environmental and economic priorities, and create a cohesive and practical way for working towards decarbonising through CII. The research emphasises the need to move away from fragmented, traditional approaches, advocating for the integration of financial incentives and technology to usher in a new era of sustainability.

List of Abbreviations

CII	Carbon Intensity Indicator
CO2	Carbon Dioxide
CSR	Corporate Social Responsibility
DAO	Decentralised Autonomous Organisation
DLT	Distributed Ledger Technology
DT	Digital Transformation
DWT	Deadweight Tonnage
ESG	Environmental, Social, and Governance
ETB	Estimated Time of Berth
ETD	Estimated Time of Departure
EU	European Union
GHG	Greenhouse Gas
IMO	International Maritime Organisation
IoT	Internet of Things
LSEG	London Stock Exchange Group
MARPOL	International Convention for the Prevention of Pollution from Ships
MSCI	Morgan Stanley Capital International
Ro-Ro	Roll-on/Roll-off
SDG	Sustainable Development Goal
SEEMP	Ship Energy Efficiency Management Plan
UN	United Nations
VWT	Virtual Watch Tower

Table of Contents

1 Introduction

1.1 Background

In the world of global maritime trade, the journey toward sustainability poses significant challenges. As vessels enable 80% of global trade, the industry is a substantial contributor to greenhouse gas (GHG) emissions, where approximately 3% of the global total is contributed to the shipping industry.[1][2] Frameworks and societal expectations increasingly demand a shift toward environmentally responsible practices, prompting the maritime sector to pursue decarbonisation.[3]

The Carbon Intensity Indicator (CII) is a mechanism introduced by the International Maritime Organisation (IMO) to assess and rate the emissions performance of ships. The CII aims to encourage sustainable practices by rating vessels based on their carbon emissions relative to their cargo capacity and travel distance.[4] However, this system has significant limitations that hinder its effectiveness. The reliance on self-reported data,[5][6] the division of responsibility between shipowners and charterers,[7] and the lack of accountability,[8][9] highlights some of these weaknesses which are threatening its reliability and practical application.

Digital Transformation (DT) offers a powerful avenue to address these challenges. Through technologies like the Internet of Things (IoT) and blockchain, DT can enable real-time data collection, enhance transparency, and improve accountability within the maritime sector.[10][11][12] These tools have the potential to resolve some of the fundamental issues that undermine the

[1] UN Trade & Development. Launch of the Review of Maritime Transport 2023. (2023).

[2] Transport & Environment. Climate impact of shipping. (Accessed 2024).

[3] Girvin, S., Ulfbeck, V. Carbon-Free Shipping and Shipping Carbon: Contracts in Context. (1st edn, Hart Publishing 2024) 4-5.

[4] International Maritime Organization. Rules on ship carbon intensity and rating system enter into force. (2022).

[5] International Maritime Organization. Resolution MEPC.352(78) - 2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1). (2022).

[6] Masodzadeh, P., Ölçer, A., Ballini, F., Celis, J. G. Live carbon-tracking mechanism for ships, a methodology to mitigate uncertainties in the carbon intensity calculations. (ScienceDirect 2023).

[7] Basu Bal, A. Technology-mediated organisation of transport actors: laytime in perspective. (Journal of International Maritime Law 2024).

[8] International Maritime Organization. (n 4).

[9] Lee, S. Investigation of Factors Influencing Carbon Intensity Indicator (CII) Rating. (Cardiff Business School 2023).

[10] Yang, C., Lin, M. S. The impact of digitalization and digital logistics platform adoption on organizational performance in maritime logistics of Taiwan. (Taylor & Francis 2023).

[11] Ginters, E., Estrada, M., Angel, M. ICTE in Transportation and Logistics 2019. (1st edn, Springer 2020) 20-27.

[12] Haraldson, S. Digitalization of Sea transports – Enabling sustainable Multi-Modal transports. (Core 2015).

effectiveness of CII. However, DT's potential is often hindered by the maritime industry's reluctance to embrace these technologies.[13] This is where Environmental, Social, and Governance (ESG) investing becomes a critical factor. ESG guidelines have not only the potential to help address the shortcomings of CII by providing financial incentives and governance structure, but they can also act as a catalyst for overcoming the barriers in implementing DT.[14][15]

Conversely, DT can support ESG investing in much the same way it bolsters CII. The real-time data and enhanced transparency enabled by DT technologies has the potential to address the credibility issues that undermine ESG ratings, reducing the risk of greenwashing and improving the overall reliability of the guidelines.[16][17] This mutual reinforcement between DT and ESG investing creates a way to improve the effectiveness of both frameworks, while simultaneously transforming CII into a more credible and actionable tool.[18]

1.2 Purpose and Objectives

The purpose of this thesis is to critically examine the transformative potential of DT and ESG investing in addressing the challenges of sustainability within the maritime shipping industry. Specifically, it aims to explore how these two approaches can be leveraged to enhance the accuracy and efficacy of the IMO's CII. With this in mind, it is also essential to examine how DT and ESG investing can mutually reinforce each other, ensuring their combined relevance and impact in achieving the overarching objective of enhancing CII. Given the increasing demands and societal expectations for decarbonisation, the study underscores the necessity of aligning technological innovation with sustainable governance and financial practices.

[13] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. Digital transformation of maritime logistics: Exploring trends in the liner shipping segment. (ScienceDirect 2023).

[14] Tayan, B., Larcker, D., Watts, E., Pomorski, L. ESG Ratings: A Compass without Direction. (Harvard Law School Forum on Corporate Governance 2022).

[15] See chapter 4.1-4.1.4.1.

[16] Berg, F., Kölbel, J., Rigobón, R. Aggregate confusion: the divergence of ESG ratings. (Oxford Academic 2022).

[17] Avramov, D., Cheng, S., Lioui, A., Tarelli, A. Sustainable investing with ESG rating uncertainty. (Journal of Financial Economics 2022) 642-664.

[18] See chapter 4.3-4.3.2.

1.2.1 Research Questions

- In what ways can Environmental, Social, and Governance investing effectively drive the adoption and implementation of Digital Transformation within the shipping industry?
- How can the interplay between Digital Transformation and Environmental, Social, and Governance investing address the shortcomings of the Carbon Intensity Indicator to improve its accuracy and efficiency?

1.3 Methodology

1.3.1 Qualitative Approach

This study uses a qualitative approach to examine how DT, ESG investing, and CII compliance influence and shape one another. A qualitative methodology is well-suited for analysing the nuanced relationships between these approaches, as it allows for a detailed look at how DT and sustainable financial practices can be harmonised to achieve the objective.

Primary sources include frameworks such as the IMO's guidelines, case studies of leading shipping companies like COSCO, and insights from ESG rating agencies like Morgan Stanley Capital International (MSCI) and London Stock Exchange Group (LSEG). By examining these sources, the thesis aims to identify patterns and opportunities for how DT and ESG investing can bolster each other and enhance CII's effectiveness. This approach also facilitates an in-depth analysis of the operational and financial incentives driving stakeholders to adopt sustainable practices.

1.3.2 Comparative Analysis

A comparative analysis forms the core of this study, examining the standalone impact of the CII guidelines compared to an integrated approach that incorporates DT and ESG investing. This method highlights how DT tools, such as IoT and blockchain, can address CII's shortcomings in data accuracy, transparency, and accountability. Additionally, it evaluates how ESG-driven investments incentivise the adoption of these digital solutions and can directly support CII. Similarly, it compares the standalone effect of DT and ESG individually,

and the effect of their mutual reinforcement. The thesis will compare current practices with potential improvements, offering insights into the benefits of aligning technological advancements and financial incentives with sustainability goals.

1.3.3 Thematic Analysis

A thematic analysis is utilised to identify recurring themes in the adoption and implementation of DT, CII and ESG practices within the shipping industry. This approach involves analysing case studies, regulatory guidelines, and industry reports to uncover patterns in these approaches and assess how digital technologies and ESG frameworks can support compliance with CII. The analysis also identifies barriers to the integration of these approaches, such as organisational resistance to change, lack of standardisation in ESG ratings, and insufficient financial incentives. By systematically categorising these challenges, the study offers actionable recommendations to support the thesis.

1.3.4 Legal and Non-Legal Analysis

This thesis explores both legal and non-legal aspects of decarbonisation in the maritime sector, a scope that may initially seem unconventional for a legal study. However, this approach is essential since the legal issues discussed cannot be effectively analysed in isolation from their broader economic, technological, and governance contexts. Factors such as technological innovation, financial incentives, and organisational behaviour are integral to shaping the regulatory frameworks and compliance mechanisms within this field.

Incorporating non-legal perspectives does not diminish the thesis's legal focus; rather, it enhances the depth and relevance of the legal analysis. By considering the interactions between legal frameworks and practical realities, this research provides a more holistic understanding of the challenges and opportunities in implementing maritime decarbonisation regulations. These insights are further crucial for identifying how the legal frameworks, such as those developed by the IMO, can be refined or strengthened to address existing gaps and better support the maritime sector’s decarbonisation goals.

1.3.5 Limitations

Although this research seeks to provide valuable insights, it is subject to certain limitations. The reliance on secondary data, such as existing literature, may not fully capture the perspectives of key stakeholders involved in implementing DT and ESG practices. Future research could benefit from primary data collection, including interviews with industry professionals and regulators, to provide a more comprehensive understanding of these dynamics.

Additionally, although the paper consists of new perspectives, the rapidly evolving nature of DT and the maritime sector may result in a decrease of the study's relevance. As new technologies and regulations emerge, the findings of this research may require updating to reflect these advancements. However, despite these limitations, the study provides a solid foundation for understanding how DT and ESG investing can collectively address the sustainability challenges within the maritime sector.

1.4 Delimitations

The analysis will focus on the IMO's existing regulations, particularly the CII framework, and how the integration of DT and ESG investing could enhance these mechanisms. Continuously, the study specifically focuses on ships subject to the CII guidelines, with an emphasis on vessels of 5,000 gross tonnage and above, as these ships are required to undergo mandatory surveys and certification. The vessels considered include bulk carriers, gas carriers, tankers, containerships, general cargo ships, refrigerated cargo carriers, combination carriers, LNG carriers, Ro-Ro cargo ships, Ro-Ro passenger ships, and cruise passenger ships. [19]

To provide practical insights, a case study will be conducted on the shipping companies COSCO and Maersk. These organisations are prominent players in the maritime sector and operate under CII guidelines, making them ideal for examining the real-world application of this framework.[20] Additionally, a brief case study on ESG rating agencies, specifically MSCI

[19] International Maritime Organization. (n 4).

[20] Reiff, N. 10 Biggest Shipping Companies. (2024).

and LSEG, will further enrich the study by exploring how ESG metrics are applied in the shipping industry.

The study will also investigate the potential of DT technologies, specifically the IoT and Blockchain, to enhance transparency and facilitate real-time monitoring of emissions data. This research will not address the technical challenges associated with the implementation of CII. Instead, it will focus on the organisational barriers. By establishing these delimitations, the study aims to provide a detailed and thorough analysis on the chosen focus area, ultimately contributing to a deeper understanding of how these elements can interact, to promote sustainability in maritime operations.

1.5 Global Administrative Law

As globalisation has advanced, so too have international institutions that significantly influence the social, economic, and political aspects of nations. This evolution has given rise to the development of Global Governance and Global Administrative Law (GAL), frameworks designed to manage the transnational effects of global interactions. In practice, this often involves transnational administrative bodies that operate independently of national governments, raising concerns about accountability, fairness, transparency, and due process.[21]

ESG investing is a form of GAL and aligns closely with its foundational principles. GAL recognises a form of 'law' that is not solely based on state authority but on norms derived from legitimacy through public acceptance, participation, and accountability, which are principles that can also be seen in state-mandated law.[22] Similarly, as ESG investing lacks formal legal status, it derives its legitimacy from widespread recognition among investors, corporations, and the public, reflecting the way GAL functions within global governance.

Kingsbury's "social fact" conception of law proposes that GAL derives its authority from collective recognition and social practices rather than state mandates.[23] ESG investing reflects this principle by gaining authority through public support and corporate adherence to its

[21] Tripathi, R. Concept of Global Administrative Law: An Overview. (Sage 2011).

[22] Kingsbury, B. The Concept of 'Law' in Global Administrative Law. (European Journal of International Law 2009).

[23] Ibid.

standards, despite being a private initiative. Similar to GAL's flexibility, ESG standards are adaptive and influential, shaping corporate governance in ways traditional laws cannot, thus addressing a regulatory need in society.

Kingsbury further argues that GAL fulfils essential legal functions traditionally associated with national law, even without state-based mandates.[24] ESG investing has become a widely accepted standard of corporate accountability, mirroring these principles and reinforces GAL's legitimacy as a form of law. This also aligns with the view of law being seen as the "(...) expression of the general will".[25] However, it is important to note that without regulatory backing, ESG's influence remains dependent on public endorsement and could lose its impact if the public's opinion shifts. While ESG standards lack the force of "real law", they carry significant influence in practice, shaping global governance in ways similar to traditional legal structures. Consequently, ESG investing serves as a meaningful extension of GAL and a relevant analogy within this legal discussion, even though it is not 'law' in the conventional sense.

1.6 Structure

This thesis is organised into six chapters. Chapter 1 serves as the introduction, offering background context, defining the scope, posing research questions, and outlining the methodology and materials. Chapter 2 provides a descriptive foundation, detailing ESG investing, DT, and the CII. It explains their concepts, contexts, and relevance to the thesis. Chapter 3 highlights the limitations and challenges of ESG investing, DT, and CII, based on the groundwork established in Chapter 2. This chapter aims to identify the gaps that need to be addressed. Chapter 4.1 and 4.2 examines how ESG investing can support DT in the shipping sector and, in turn, how DT can enhance ESG investing. Chapter 4.3 discusses how the refined applications of ESG investing and DT, can contribute to the effective application of CII. Chapter 4.4 includes a table that provides specific stakeholders with clear guidance on their roles in strengthening the CII and effectively utilising DT and ESG frameworks. Finally, Chapter 5 concludes the thesis by summarising the findings.

[24] Ibid.

[25] Delperee, F. THE MEANING OF THE LAW. (UNDP Accessed 2024).

2 Core Concepts: CII, DT, and ESG Investing

2.1 Understanding the Carbon Intensity Indicator

2.1.1 Environmental Challenges in Shipping

Previous studies demonstrate that the shipping industry is a major contributor to climate change. GHG emissions and sulphur oxides from shipping and port activities drive global warming, leading to consequences such as rising sea levels and an increase in extreme weather events.[26] Approximately 3% of global emissions originate from the shipping industry,[27] amounting to 940 million tonnes of carbon dioxide (CO2) emissions annually. This represents 13% of the European Union's (EU) total greenhouse gas emissions, surpassing those of any individual EU member state. If considered a country, the shipping sector would rank sixth worldwide in emissions.[28] According to the IMO's fourth GHG study, emissions from global shipping were projected to increase by 90%–130% by 2050, if the anticipated growth in seaborne trade continued without any countermeasures.[29]

One of the first major initiatives to combat environmental issues was undertaken by the United Nations (UN) in 2015 with the introduction of the Sustainable Development Goals (SDGs) and the adoption of the Paris Agreement.[30] The UN's SDG aims to create significant impacts through objectives such as SDG 14, which calls for action to preserve marine life, and SDG 7, which promotes affordable and clean energy.[31] The Paris Agreement builds on the UN Framework Convention on Climate Change to rapidly reduce greenhouse gas emissions and improve countries' resilience to climate change. The primary objective of the Paris Agreement is to limit global temperature rise to 1.5-2 degrees Celsius.[32]

[26] Athanassiou, L. Damages, Recoveries and Remedies in Shipping. (1st edn, Taylor & Francis Group 2023) ch 12.

[27] Transport & Environment. (n 2)

[28] Braakman, A. Climate and Covid-19: Will the Shipping Industry Succeed in Charting the Right Course between Scylla and Charybdis? (Lawtext Publishing 2020).

[29] Athanassiou, L. (n 26) ch 12.

[30] Ibid 156.

[31] United Nations. The Sustainable Development Goals Report 2024. (2024).

[32] Athanassiou, L. (n 26) ch 12.

The IMO also plays a crucial role in addressing environmental challenges, notably through Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), which focuses on preventing air pollution.[33] In April 2018, the IMO adopted a strategy to reduce greenhouse gas emissions from ships, aligning with the Paris Agreement. This strategy aims for a 40% reduction in the carbon intensity of international shipping by 2030 and a 70% reduction by 2050, with an overarching goal of cutting GHG emissions by at least 50% by 2050 compared to 2008 levels.[34] Among the key measures introduced to achieve these targets is the CII, which is a framework central to advancing the IMO's emissions-reduction strategy.

2.1.2 The Carbon Intensity Indicator

The CII plays a crucial role in ensuring continuous improvement in a ship's carbon emissions. It achieves this by evaluating the vessel's annual operational CII and comparing it to the required annual CII. Based on this assessment, vessels are rated on a scale from A to E, with A indicating significantly superior performance and E representing poor performance.[35] This rating, which reflects the vessel's carbon intensity, is documented in a 'Statement of Compliance' and outlined further in the Ship Energy Efficiency Management Plan (SEEMP).[36] Shipowners must submit a corrective action plan if their ship is rated D for three consecutive years or receives an E rating for a single year, detailing how they will achieve a C rating or higher. To incentivise improvement, governments, port authorities, and other stakeholders are encouraged to offer benefits to ships rated A or B.[37]

Ships powered by low-carbon fuels tend to achieve better CII ratings than those relying on traditional fossil fuels. However, vessels can improve their ratings through various measures, including hull cleaning to reduce drag, optimising speed and routes, installing energy-efficient lighting, and utilising solar or wind power for auxiliary services.[38] The process for determining specific ratings and the key factors involved has been ratified in the comprehensive guidelines adopted by the Marine Environment Protection Committee

[33] International Maritime Organization. Climate action and clean air in shipping. (Accessed 2024).

[34] International Maritime Organization. 2018 Initial IMO Strategy. (2018).

[35] Ibid 159.

[36] International Maritime Organization. (n 4).

[37] Ibid.

[38] Ibid.

(MEPC). These guidelines provide a standardised method for evaluating vessel carbon efficiency, ensuring a consistent approach across the industry.[39]

2.1.2.1 Resolution MEPC.352(78) - (CII Guidelines, G1)

CII is defined as a metric quantifying the average CO2 emissions per transport of a ship. There are two primary types of CII: the demand-based CII, which is calculated using the actual or estimated mass or volume of cargo transported, and the supply-based CII, which uses the ship's capacity as a proxy for actual transport work.[40] The supply-based CII can be further categorised into the Annual Efficiency Ratio, which utilises Deadweight Tonnage (DWT), or Capacity Gross Ton Distance, which employs Gross Tonnage as a measure. Although the formula for calculating annual operation is stipulated, it is not directly relevant to this paper and will therefore not be detailed.[41]

The guidelines also promote the use of various trial indicators, such as the Energy Efficiency Performance Indicator, which evaluates energy efficiency relative to transport work, along with other metrics tailored specifically for certain vessels, such as passenger and Roll-on/Roll-off (Ro-Ro) ships.[42] To ensure effective implementation, Member States are encouraged to integrate these guidelines into their national laws and share this information with relevant stakeholders, including shipowners, operators, and seafarers. Additionally, the guidelines will be subject to regular reviews, accompanied by a comprehensive evaluation of various measures aimed at reducing carbon intensity in international shipping.[43]

2.1.2.2 Resolution MEPC.353(78) - (CII Guidelines, G2)

The guidelines are an essential framework for calculating reference lines associated with the operational CII of individual ships. They require the development of a unique reference line for each ship type stated under MARPOL Annex VI, regulation 28. These reference lines are derived from data that includes only comparable ships, ensuring accuracy and relevance.[44]

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[39] Ibid.

[40] International Maritime Organization. (n 5).

[41] Ibid.

[42] Ibid.

[43] Ibid.

[44] International Maritime Organization. Resolution MEPC.353(78) - 2022 Guidelines on the reference lines for use with Operational Carbon Intensity Indicators (CII Reference Lines Guidelines, G2). (2022).

Operational CII is defined as a curve reflecting the median operational carbon intensity performance of a specific group of ships based on their capacity. The reference line is calculated using data from 2019, selected due to limited data availability from earlier years. The guidelines provide formulas for establishing these reference lines and detailed parameters tailored to specific ship types.[45] These include bulk carriers, gas carriers, tankers, container ships, and Ro-Ro vessels, with each ship type assigned parameters that account for its distinct operational characteristics.[46]

2.1.2.3 Resolution MEPC.338(76) - (CII Guidelines, G3)

The annex to the resolution provides detailed guidelines for determining annual operational carbon intensity reduction factors from 2023 to 2030. These guidelines aim to achieve an average 40% reduction in CO2 emissions per unit of transport by 2030, compared to 2008 levels, on a global scale.[47] The methodology for calculating the operational carbon intensity involves dividing the total mass of CO2 emissions by the total transport for a given ship type. The achieved reduction in carbon intensity is calculated relative to specific reference years. If specific data on the annual transport of individual ships is unattainable, an approximation can be made using aggregated transport work data from reliable sources like the United Nations Conference on Trade and Development.[48]

According to the guidelines, the required annual operational CII for a ship is determined using a reference value from 2019, with specific reduction factors outlined for the years leading up to 2030. For instance, the reduction factors are set at 5% for 2023, 7% for 2024, 9% for 2025, and 11% for 2026. For the years 2027 to 2030, these factors will be further refined based on ongoing reviews. Furthermore, the guidelines stress the importance of continuous improvement in carbon intensity reduction, referencing the Initial IMO Strategy on Reduction of GHG Emissions from Ships. The equivalent carbon intensity reduction targets for 2030 are calculated based on historical data, indicating a necessary improvement

[45] Ibid.

[46] Ibid.

[47] International Maritime Organization. Resolution MEPC.338(76) - 2021 Guidelines on the operational carbon intensity reduction factors relative to reference lines (CII Reduction Factor Guidelines, G3). (2021).

[48] Ibid.

of at least 10% from the 2019 level when measured using aggregated demand-based metrics, and at least 21.5% using supply-based metrics.[49]

2.1.2.4 Resolution MEPC.354(78) - (CII Guidelines, G4)

Resolution MEPC.354(78) outlines the guidelines for operational carbon intensity ratings of ships, emphasising their role in ensuring uniform and effective implementation across the industry while allowing sufficient lead time for adaptation.[50] The resolution encourages national administrations to incorporate these guidelines into domestic legislation and urge member governments to share them with relevant stakeholders, including masters, seafarers, shipowners, and operators. Furthermore, the MEPC commits to reviewing the guidelines based on the implementation experience and additional data, aligning with the requirement in regulation 28.11 to complete a review of operational measures by January 1, 2026.[51]

The annex to the resolution provides comprehensive guidelines for assigning operational energy efficiency performance ratings to ships, applicable from 2023 to 2030. These guidelines outline a framework for evaluating a ship's annual operational carbon intensity performance, using a five-grade rating system (A, B, C, D, E, from best to worst) based on the attained annual operational CII. The ratings represent performance levels ranging from superior to inferior.[52] To determine ratings, the guidelines specify four boundaries for each year from 2023 to 2030: superior, lower, upper, and inferior boundaries. Under this system, approximately 30% of ships are expected to receive a rating of C, while the top-performing 15% and 20% are awarded A and B ratings, respectively. Conversely, the bottom-performing 20% and 15% receive D and E ratings, respectively.[53]

The guidelines provide a detailed methodology for calculating rating boundaries, employing statistical models based on historical data from the IMO Data Collection System. This process uses quantile regression to estimate the distribution of attained annual operational

[49] Ibid.

[50] International Maritime Organization. Resolution MEPC.354(78) - 2022 Guidelines on the operational carbon intensity rating of ships (CII Rating Guidelines, G4). (2022).

[51] Ibid.

[52] Ibid.

[53] Ibid.

CIIs, ensuring the boundaries for various ship types are defined consistently over time.[54] For example, it is stated that if the required CII for a bulk carrier is set at 10 gCO2/(dwt.nmile) for a specific year, the corresponding boundaries would be 8.6 gCO2/(dwt.nmile) for the superior boundary, 9.4 gCO2/(dwt.nmile) for the lower boundary, 10.6 gCO2/(dwt.nmile) for the upper boundary, and 11.8 gCO2/(dwt.nmile) for the inferior boundary. A ship achieving a CII of 9 gCO2/(dwt.nmile), would therefore be rated as B.[55]

2.1.2.5 Resolution MEPC.355(78) - (CII Guidelines, G5)

Resolution MEPC.355(78) provides guidelines for calculating correction factors and voyage adjustments related to the CII of ships, as stipulated by regulation 20 of MARPOL Annex VI. The guidelines stress the need for accurate reporting of both fuel oil consumption and distance travelled. All onboard fuel oil consumption must be recorded, regardless of the ship's operational state, and distances travelled must be documented in compliance with SOLAS regulations. In cases where a ship encounters ice or other scenarios specified in MARPOL Annex VI, certain fuel consumption can be excluded from annual CII index calculations. In such instances, the relevant data must be clearly documented in the ship's SEEMP monitoring plan and logbook.[56]

2.2 Digital Transformation within the Shipping Industry

2.2.1 Defining Digital Transformation

This thesis will focus on DT, a concept defined as a comprehensive shift impacting all levels of an organisation, driven by the adoption of digital technologies. DT encompasses a range of areas, including strategy, governance, leadership, culture, workforce, and technology.[57] In the maritime industry, DT signifies the integration of disruptive technologies to optimise traditional processes, with the overarching aim of improving efficiency, safety, and environmental sustainability.[58] As Osmundsen notes, DT is not confined to any single

[54] Ibid.

[55] Ibid.

[56] International Maritime Organization. Resolution MEPC.355(78) - 2022 interim Guidelines on correction factors and voyage adjustments for CII calculations (CII Guidelines, G5). (2022).

[57] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[58] Ginters, E., Estrada, M., Angel, M. (n 11) 20-27.

technological innovation. Instead, it represents a significant organisational transformation achieved through the combined integration of various technologies.[59]

Similarly, Goran asserts that DT encompasses more than just technological updates, it also requires alignment of strategic priorities and the integration of human factors, such as organisational culture, talent development, leadership, and mindset.[60] Complementing this perspective, Raza, Woxenius, Vural, and Lind describe DT as a strategic transformation in how shipping companies and their partners operate. This transformation is driven by digital technologies and relies on strong organisational abilities in the management, collaboration, and agile work methods.[61] Digital transformation was chosen for its broad scope, as it encompasses not only technological advancements but also the organisational changes that are integral to transformation. These aspects overlap with key elements of ESG investing, thus suggesting the potential for ESG principles to influence this concept.[62][63]

2.2.2 The Importance of Digital Transformation

Digital transformation holds significant potential to enhance the shipping industry by improving efficiency, reducing accidents at sea, cutting pollution and emissions, and minimising waiting times at ports. Through the automation and streamlining of outdated processes, DT initiatives can enable cost-effective and environmentally efficient maritime operations, boosting overall industry performance. A key challenge in the maritime sector is, for example, the involvement of multiple languages and institutions, which slows the pace of digitisation and standardisation. Notably, it is estimated that up to 50% of maritime transportation costs in the global container shipping sector stem from time spent on paperwork, which is a barrier that the integration of disruptive technologies can address.[64]

Historically, maritime operations have faced significant inefficiencies, such as vessels frequently waiting outside ports due to outdated contract terms. This inefficiency results in

[59] Osmundsen, K., Iden, J., Bygstad, B. Digital Transformation: drivers, success factors, and implications. (AIS eLibrary 2018).

[60] Goran, L., Laberge, R., Srinivasan, R. Culture for a digital age. (McKinsley 2017).

[61] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[62] See Chapter 2.3.1.

[63] See Chapter 4.1-4.1.4.1.

[64] Ginters, E., Estrada, M., Angel, M. (n 11) 20-27.

unnecessary fuel consumption and elevated emissions, which negatively impact both environmental sustainability and business revenue. Studies suggest that even small reductions in sailing distance could yield substantial annual savings in fuel costs and emissions. For instance, a 1% reduction in sailing distance for Baltic Sea traffic could save approximately €100 million per year.[65] To address these inefficiencies, the maritime industry is increasingly urged to adopt digital transformation.[66]

Research by Haroldson underscores the tangible benefits of digital transformation in enhancing maritime efficiency and sustainability. Digital information systems improve coordination in the sector's fragmented landscape. For example, earlier initiation of berth processes enabled by DT reduces the time between the Estimated Time of Departure (ETD) and the Estimated Time of Berth (ETB). Transparent sharing of real-time updates on ETB and ETD planning and agreements also fosters better collaboration among stakeholders. Moreover, DT facilitates environmentally friendly navigation through route optimisation and accurate ETB and ETD data, enabling more efficient management of berthing and cargo operations.[67]

Digital logistics platforms represent a key area where technology can drive significant improvements by enhancing transparency throughout the transportation process. These innovations optimise activities such as navigation, loading, and unloading of cargo, resulting in reduced energy consumption, faster delivery times, and increased profitability.[68]
Scholars argue that the long-term success of maritime regulation compliance may hinge on adopting adaptive, smart frameworks that leverage real-time data monitoring and performance-based standards to address current enforcement limitations. Such an approach not only strengthens maritime operations but also provides a model for effective regulatory systems across other industries. Additionally, evidence suggests that digital transformation not only supports sustained regulatory compliance but also addresses environmental impacts in areas not fully covered by existing regulations.[69]

[65] Haraldson, S. (n 12).

[66] Ibid.

[67] Ibid.

[68] Yang, C., Lin, M. S. (n 10).

[69] Olaniyi, E. O., Solarte-Vasquez, M. C., Inkinen, T. Smart regulations in maritime governance: Efficacy, gaps, and stakeholder perspectives. (ScienceDirect 2024).

2.2.2.1 Internet of Things

The Internet of Things can be identified as a specific technology that is foundational for this paper's thesis. IoT refers to a network of interconnected physical devices that communicate through wired or wireless connections, enabling the collection and sharing of data for various applications. In the maritime industry, IoT has significant potential for improving efficiency, particularly in managing complex transport and supply chain operations.[70] The full potential of IoT is realised when integrated with complementary technologies, creating a dynamic ecosystem where data is processed and analysed collaboratively. Additionally, satellite technologies and telematics, which transmit real-time data from devices to receivers, can enhance maritime navigation, safety, monitoring, communication, and environmental sustainability. By enabling real-time interactions between devices, applications, and people, IoT becomes a cornerstone for developing a collaborative and efficient maritime ecosystem.[71]

2.2.2.2 Blockchain

Blockchain technology is another critical aspect for this paper. As a form of distributed ledger technology (DLT), blockchain offers numerous advantages, including enabling proof of ownership and facilitating asset transfers between stakeholders without requiring third-party intermediaries. Traditional systems for recording and tracking transactions often rely on outdated technology with limited compatibility between systems, creating inefficiencies. For instance, many organisations still use centralised ledgers to record transaction data, which are not only prone to single points of failure but also depend on intermediaries for validation, resulting in potential delays.[72]

DLTs, like blockchain, improve these processes by providing an unchangeable time-stamped record of events, ensuring the authenticity and sequence of transactions. Furthermore, each participant maintains a complete copy of the transaction history, ensuring transparency and reducing the risk of fraud.[73] Blockchain also facilitates the use of "smart contracts", which are self-executing agreements governed by predefined rules and algorithms. These contracts are particularly well-suited for complex multi-party systems, such as maritime supply chains. For

[70] International Transport Forum. Information Sharing for Efficient Maritime Logistics. (2018).

[71] Ibid.

[72] Ibid.

[73] Ibid.

example, a smart contract could automatically trigger ownership transfer and payment once a shipment is confirmed as delivered, streamlining processes and reducing administrative overhead.[74]

2.3 ESG Investing in the Shipping Sector

2.3.1 Introduction to ESG

The global push for sustainability has led governments, citizens, and investment entities to place greater emphasis on environmental concerns. Investors are thus increasingly drawn to companies that adhere to sustainable practices, not only to promote environmental stewardship but also because these companies are seen as more financially viable in the long term. This shift is positive because, while regulators set the rules, investors are considered to play a pivotal role in ensuring these regulations are implemented effectively.[75] The European Union, for example, integrates private investment into its resource efficiency strategies, recognising its importance in achieving sustainable growth.[76] Similarly, the UN highlights the value of global partnerships in fulfilling the UN 2030 Agenda for SDGs and improving sustainable performance.[77]

ESG principles and ESG investing have gained significant prominence as a framework for examining and evaluating a company's sustainability impact. This approach assesses companies based on their performance in three key areas: environmental impact, social responsibility, and governance practices. Thus, with growing pressure from both investors and the public for sustainable practices, shipping companies are increasingly integrating ESG principles into their operations to become more sustainable and attract investment.[78] ESG ratings, which evaluate companies on these criteria, have also become essential tools for investors in determining where to allocate their funds.[79]

[74] Ibid.

[75] United Nations. (n 31).

[76] European Commission. Overview of sustainable finance. (Accessed 2024).

[77] United Nations. (n 31).

[78] Tsatsaronis, M., Syriopoulos, T., Karamperidis, S., Boura, G. Shipping-specific ESG rating and reporting framework. (Taylor & Francis 2024).

[79] Tayan, B., Larcker, D., Watts, E., Pomorski, L. (n 14).

The exact division of ESG differs, but the Environmental criteria (E) generally look at a company's energy consumption, waste generation, resource utilisation, and the resulting impact on ecosystems.[80] The Social criteria (S) addresses a company's labour standards, wages, and benefits, workplace and board diversity, racial justice, pay equity, human rights, talent management, community relations, privacy and data protection, health and safety, supply-chain management, and other issues related to human capital and social justice.[81] The Governance criteria (G) pertains to the governance of the "E" and "S" categories, including corporate board composition and structure, strategic sustainability oversight and compliance, executive compensation, political contributions, as well as bribery and corruption.[82]

2.3.2 ESG Rating Companies

ESG rating providers play a pivotal role in gathering data on companies, establishing ESG standards, and assigning grades to offer investors valuable insights into corporate sustainability efforts. The influence of these providers has grown significantly, with over 3,000 investors collectively managing $100 trillion in assets that have committed to integrating ESG ratings into their investment strategies.[83] There are many organisations that conduct such research and rating, with some of the largest being commercially private third-party companies.

According to a Harvard study, 88% of investment professionals currently incorporate third-party ESG ratings into their investment processes, underscoring the significant influence these firms have in shaping a sustainable future.[84] However, their impact is not without challenges, as highlighted by previous researchers, and these complexities will be explored further throughout this paper.[85][86][87] To exemplify how these third-party rating companies function and their relation to each other, two of the largest rating firms within the shipping

[80] Deckelbaum, A., Karp, b., Curran, D., Johnson, J., Lynch, L., Bergman, M., Weiss, P. Introduction to ESG. (Harvard Law School Forum on Corporate Governance 2020).

[81] Ibid.

[82] Ibid.

[83] Reynolds, F. COVID-19 accelerates ESG trends, global investors confirm. (PRI 2020).

[84] Tayan, B., Larcker, D., Watts, E., Pomorski, L. (n 14).

[85] Ibid.

[86] Berg, F., Kölbel, J., Rigobón, R. (n 16).

[87] Avramov, D., Cheng, S., Lioui, A., Tarelli, A. (n 17).

industry, MSCI and LSEG will be used as examples. These agencies are relevant due to their extensive client base and significant influence.[88]

2.3.2.1 Morgan Stanley Capital International

Morgan Stanley Capital International is an investment research firm that provides stock indexes, portfolio risk analysis, and performance analytics. In addition, MSCI provides ESG ratings and advisory services for over 8500 companies worldwide, supported by a team of more than 200 analysts.[89] In its ratings, the firm categorises the Environmental pillar into Climate Change, Natural Capital, Pollution and Waste, and Environmental Opportunities. Social ratings examine factors including Human capital, Product liability, Stakeholder Opposition and Social opportunities. In the Governance pillar, they look at corporate governance, which includes examining a company's board, their ownership accounting and pay. Further, they inspect the company's corporate behaviour, which includes the businesses ethics and transparency.[90]

Each of these subcomponents is evaluated and translated into a letter grade. Companies identified as "Leaders" (AAA and AA ratings) are recognised as industry frontrunners in effectively managing critical ESG risks and opportunities. Those rated as "Average" (A, BBB, BB) demonstrate moderate management of ESG factors compared to industry peers. Conversely, "Laggards" (B and CCC ratings) are deemed to have poor management of ESG risks and increased exposure to different types of risk. Importantly, different factors are stated to carry different values depending on the industry the company is in.[91]

2.3.2.2 London Stock Exchange Group

The London Stock Exchange Group is one of the world's largest providers of financial market data, with a team of 700 research analysts, calculating ESG scores for 15000 companies.[92] The Environmental criteria of ESG are categorised into resource use, emissions, and innovation. Their Social pillar assesses areas like workforce, human rights, community and

[88] Deloitte. ESG in the Shipping sector, The role of ESG in the evaluation of shipping companies. (2021) 14.

[89] MSCI. ESG Ratings. (Accessed 2024).

[90] Ibid.

[91] Ibid.

[92] LSEG. Environmental, social and governance scores from LSEG. (2023).

product responsibility. Their governance criteria focus on management actions, shareholder relations and their corporate social responsibility (CSR) strategy. Each category is assigned a score ranging from 0 to 100. Notably, while the weights of environmental and social categories vary by industry, governance remains consistently important across all industries due to its universal importance.[93]

Disclosure plays a central role in LSEG's scoring methodology. Thus, companies that fail to report immaterial data points are not significantly penalised, however, failing to disclose material data points will negatively impact their ESG scores. Additionally, LSEG incorporates an ESG Combined Score that is based on negative media stories. It achieves this by assessing the impact of significant controversies and integrating them into the standard ESG score to produce the overall Combined Score. For companies without such controversies, the ESG Combined Score aligns with the standard ESG Score.[94]

2.3.3 ESG Ratings and Compliance in Shipping

ESG considerations have become integral to the shipping industry, with approximately $14.5 billion in new funding being allocated to shipping organisations based on ESG indicators. Additionally, 63% of shipping companies have published at least one ESG report, reflecting their growing emphasis on sustainability.[95] Banks are also increasingly factoring ESG criteria into their investment decisions within the sector.[96] According to Clarkson, ESG is integrated in a substantial portion of the financing portfolios of institutions who offer shipping finance, amounting to approximately $281 billion as of October 2021.[97]

For shipping companies, maintaining a strong ESG rating is therefore essential to secure funding, particularly as the cost of capital represents nearly 50% of the expense of a new vessel.[98] Research also indicates that companies with higher ESG ratings tend to demonstrate

[93] Ibid.

[94] Ibid.

[95] This research was conducted on a random sample of shipping companies.

[96] Deloitte. (n 89) 28.

[97] Ibid 28.

[98] Tsatsaronis, M., Syriopoulos, T., Karamperidis, S., Boura, G. (n 79).

greater profitability over a 5–7-year period compared to those with lower ratings.[99] Conversely, a poorly executed ESG strategy is stated to result in disaster for small- and medium-sized domestic shipping companies, which often have limited access to investment funds.[100] To further illustrate the relationship between ESG ratings, rating agencies, regulations, and shipping companies, this thesis conducts a short case study on COSCO Shipping Holdings (COSCO), one of the largest players in the industry.[101] The exact same case study has also been performed on MAERSK, but as its result was analogous with COSCO, it was deemed unnecessary to present both studies.

2.3.3.1 LSEG's Rating

LSEG awarded COSCO an overall environmental score of 77, with specific scores of 93 for emissions, 88 for resource use, and 50 for innovation. In the social category, COSCO received an overall score of 74, which includes 37 for human rights, 85 for product responsibility, 73 for workforce, and 94 for community. Their governance score stands at 78, with sub-scores of 95 for management, 14 for shareholders, and 93 for CSR strategy. Combining these scores, COSCO achieved an overall ESG score of 75 out of 100, reflecting its performance across all ESG dimensions. Additionally, COSCO was ranked 10th among 208 companies in the freight and logistics services sector. However, details on the specific methodology used to calculate COSCO's rating remain unavailable.[102]

2.3.3.2 MSCI's Rating

MSCI does not provide detailed information on COSCO's ratings across all relevant subcategories. However, it highlights that while COSCO has set some decarbonisation target, it does not account for the "Implied Temperature Rise" metric, which is a forward-looking indicator that is used to assess a company's alignment with climate goals. COSCO's Temperature Rise is further determined to be at 2.3°C, which falls short of the ratings firm's global climate targets, as a rating of 2°C or below is considered compliant.[103]

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[99] Deloitte. (n 89) 31.

[100] Lee, J., Lee, J., Lee, C., Kim, Y. Identifying ESG trends of international container shipping companies using semantic network analysis and multiple case theory. (Sustainability 2023) 28.

[101] Reiff, N. (n 20).

[102] LSEG. COSCO SHIPPING Holdings Co Ltd ESG score. (Accessed 2023).

[103] MSCI. COSCO SHIPPING Holdings Co., Ltd. (Accessed 2024).

In terms of governance and environmental issues, COSCO is not involved in any major controversies. However, within the social category, the company is involved in moderate-to-severe controversies. Regarding alignment with the UN's SDGs, COSCO only meets the target for gender equality.[104] MSCI's evaluation also reveals that COSCO's corporate governance and behaviour are categorised as laggard. The company's performance in managing toxic emissions, waste, and health and safety is rated as average, while the only area where COSCO is considered a leader is in carbon emissions management. Overall, MSCI assigns COSCO a 'B' or "laggard" rating, indicating weak performance across environmental, social, and governance dimensions according to the set standards.[105]

2.3.3.3 COSCO and Framework Compliance

COSCO Shipping complies with the Monitoring, Reporting, and Verification regulations and the revised EU Emissions Trading System directives.[106] All their self-owned vessels have received CII ratings.[107] On June 25, 2023, COSCO SHIPPING announced the "Ship Carbon Intensity Indicator Digital Toolbox." This tool leverages artificial intelligence technology to monitor the energy usage of major commercial vessels worldwide. It will provide CII ratings and classifications, allowing users to gain insights into a ship's carbon intensity performance and overall CII status. The toolbox will also make recommendations for optimising CII ratings, with the aim to enhance sustainability in maritime operations.[108] Additionally, on March 28, 2019, COSCO SHIPPING LINES signed a low-sulphur fuel oil supply agreement with Double Rich Limited. Under this agreement, Double Rich Limited will supply fuel oil with a sulphur content not exceeding 0.5% m/m, aligning with the amended Annex VI of MARPOL.[109]

[104] Ibid.

[105] Ibid.

[106] Cosco Shipping Lines CO., LTD. Announcement about European Union Emissions Trading System (EU ETS) Surcharge. (2023).

[107] Cosco Shipping Lines CO., LTD. 2022 Sustainability Report. (2022).

[108] COSCO SHIPPING. COSCO SHIPPING Green Digital Intelligence Ship Services Co., Ltd. held a news conference for launching smart sailing platform and the first batch of products. (2023).

[109] Ibid.

3 Challenges Facing CII, DT, and ESG Investing

3.1 Limitations with CII

3.1.1 Data Integrity and Stakeholder Coordination

The IMO highlights that shipping companies are responsible for both reporting accurate data and calculating their attained CII. Honest reporting is therefore essential for the system to function as intended. However, as ship operators recognise that their reported data directly impact their reputation, competitiveness, and tax obligations, some may be inclined to manipulate that data.[110] Hence, errors and inconsistencies in annual data reporting are often unavoidable due to manual reporting processes.[111] In practice, it has been noted that ship staff may alter data before submission to flag states,[112] in order to benefit in some way or another.[113] Additionally, flag states themselves have occasionally been suspected of playing questionable roles in data collection and verification.[114]

These issues can partly be attributed to the shipping industry's slow adoption of DT practices and to the structural imbalance within the CII framework, placing the responsibility of carbon emissions reporting on shipowners. While shipowners are held accountable for carbon emissions reporting, it is often the charterers who control emissions on a per-voyage basis.[115] This misalignment creates potential for charterers, depending on their agreements with the shipowners, to overlook emissions targets or manipulate data to avoid potential consequences.[116]

It is thus partly due to the design of the CII system that shipowners and charterers may be incentivised to prioritise individual benefits, such as maximising demurrage, over collective

[110] Masodzadeh, P., Ölçer, A., Ballini, F., Celis, J. G. (n 6).

[111] Masodzadeh, P., Ölcer, A., Ballini, F., Christodoulou, A. How to bridge the short-term measures to the market based measure? Proposal of a new hybrid MBM based on a new standard in ship operation. (ScienceDirect 2022).

[112] Masodzadeh, P., Ölcer, A., Ballini, F., Christodoulou, A. A review on barriers to and solutions for shipping decarbonization: what could be the best policy approach for shipping decarbonization? (ScienceDirect 2022).

[113] Faber, J., Nelissen, D., Smit, M., Behrends, B., Lee, S. The Fuel Efficiency of Maritime Transport. Potential for improvement and analysis of barriers. (ETDE-WEB 2012).

[114] Ibid.

[115] Basu Bal, A. (n 7).

[116] Faber, J., Nelissen, D., Smit, M., Behrends, B., Lee, S. (n 115).

goals like emissions reduction and sustainable practices.[117] This issue is particularly significant for time charterparties, where the CII requirements can lead to operational adjustments like slow steaming and rerouting to reduce emissions. While these measures reduce environmental impact, they can also cause delays in the supply chain, which is especially problematic for time charterers who pay based on the duration of their charter.[118]

Port waiting times further exacerbate these challenges. Prolonged idle time at ports, often caused by congestion or scheduling systems like "first-come, first-served", negatively impacts a vessel's CII rating and increases costs for time charterers. Thus, port management practices, as well as agreements between shipowners, charterers, and port authorities, can significantly influence a vessel's environmental performance.[119] Therefore, aligning and monitoring the actions of all stakeholders is essential to ensure that shipowners, charterers, and ports are equally motivated to work toward shared environmental objectives.

3.1.2 Lack of Accountability

Ships rated D for three consecutive years or E for a single year are required to submit a corrective action plan aimed at returning the ship's rating to a C grade. However, the framework lacks provisions specifying the consequences if such a plan is not implemented or if the target is not met, indicating a lack of accountability and enforcement.[120] Additionally, the framework provides no clear guidance on how stakeholders, such as port authorities, should respond when a ship with a D or E rating arrives, further highlighting the system's shortcomings.[121] The IMO has previously faced criticism for its lack of effective enforcement mechanisms.[122] This case highlights the challenges of enforcing contractual obligations related to environmental impact, as both the buyer and seller of the vessel appeared to disregard sustainability clauses entirely, undermining their intended purpose.[123]

[117] Basu Bal, A. (n 7).

[118] Girvin, S., Ulfbeck, V. (n 3) 42.

[119] Ibid 41.

[120] International Maritime Organization. (n 4).

[121] Lee, S. (n 9).

[122] Begum v Maran (UK) Ltd [2021] EWCA Civ 326.

[123] Girvin, S., Ulfbeck, V. (n 3) 7.

3.1.3 Lack of Incentives

The IMO encourages the rewarding of vessels that achieve A or B ratings, but the responsibility for implementing these incentives largely falls to individual governments and port authorities. Furthermore, the IMO provides no specific guidelines on how these benefits should be applied, leading to a lack of uniformity.[124] Without mandatory rewards or penalties tied to higher or lower ratings, companies may be less motivated to strive for an A grade. Instead, they might find it more beneficial to maintain a C rating, or even a D or E rating, without facing any significant consequences.[125][126] Some argue that IMO regulations already sufficiently address environmental and safety standards. As a result, without clear benefits, shipping companies have little motivation to invest additional resources, personnel, and costs into further sustainability initiatives.[127]

3.1.4 Sustainability vs. Profitability

Previous research highlights an inherent trade-off between economic benefits and environmental sustainability within the CII guidelines. Although models have been proposed to align CII compliance with economic performance, it is recognised that this balance may lead to a decline in environmental performance instead.[128] As some vessels work to meet the CII requirements, those already operating at higher CII levels may face hindrances that force them to compromise on environmental performance in order to maintain economic viability. Consequently, while the CII framework aims to promote sustainability, it may sometimes put companies in a position where they must choose between environmental responsibility and economic performance.[129]

This limit is further illustrated by the impact of vessel speed, which significantly affects the profitability of time charter agreements and is often included as a key clause in charterparties. Since speed adjustments directly affect a ship's emissions, shipowners often suggest altering vessel speed to comply with CII requirements. However, this will result in slower voyages,

[124] International Maritime Organization. (n 4).

[125] Lee, S. (n 9).

[126] See chapter 3.1.2.

[127] Girvin, S., Ulfbeck, V. (n 3) 31.

[128] Hua, R., Yin, J., Wang, S., Han, Y., Wang, X. Speed optimization for maximizing the ship's economic benefits considering the Carbon Intensity Indicator (CII). (ScienceDirect 2024).

[129] Ibid.

which in turn increases the duration needed to complete a journey. For time charterers, this extended time frame raises costs. Such factors can lead to disputes between parties, underscoring the challenge of balancing compliance with profitability.[130]

3.2 Barriers to DT Adoption in Shipping

Despite the significant advantages that digital technology offers the shipping industry, the sector remains slow in its adoption. The barriers to DT can be broadly categorised into three areas: organisational and governance, operational, and technological. Among these, organisational and governance challenges can be argued to be the most significant, particularly for larger shipping companies.[131] These challenges include limited external information sharing, uncoordinated internal departments, and deeply ingrained practices.[132] For example, established businesses often struggle to adopt DT due to the misguided belief that traditional methods, which have worked in the past, will continue to suffice in a digital world. However, as digital technologies reshape industries, continuing to rely on outdated practices may instead hinder companies from seizing new opportunities.[133]

As identified, the maritime sector's deeply rooted working culture also hinders the development of a digital mindset. Employees, accustomed to long-standing processes, are often resistant to change, even when they recognise the potential benefits of DT. This resistance has been attributed to various “legacy systems” where the fear of job loss or becoming irrelevant is the basis behind the hindrance. To overcome this, shipping companies must either attract a younger, digitally skilled workforce, or help their existing employees become more proficient with digital technologies. However, attracting and retaining digitally skilled personnel appears to be a challenge, and transitioning traditional employees to embrace new technologies is equally difficult.[134]

Additionally, silos within organisations further complicate DT. Different departments often operate independently, adhering to their own processes, with limited coordination. This

[130] Girvin, S., Ulfbeck, V. (n 3) 42.

[131] Ibid 42.

[132] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[133] Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., Buckley, N. Coming of age digitally. (MIT Sloan 2018).

[134] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

makes it harder to implement overarching changes across the whole company. This challenge extends beyond the organisation, as effectively implementing digital transformation involves collaboration between external companies as well. However, different stakeholders are often reluctant to share data and control, which makes information sharing across systems and companies challenging. This reluctance to exchange information externally is, therefore, also a significant barrier to the successful adoption of digital transformation.[135]

3.3 Diverging ESG Ratings and Regulatory Challenges

3.3.1 Discrepancies Among Raters

The research of Berg, Kölbel, and Rigobon examined major third-party ESG rating agencies such as KLD, Sustainalytics, Moody's ESG, S&P Global, LSEG, and MSCI. Their analysis focused on three dimensions: Scope (the attributes that rating providers aim to measure), Measurement (the methods used to evaluate these attributes), and Weighting (the importance given to each attribute). The study found that differences in measurement methods accounted for 56% of the variance among providers, differences in scope for 38%, and differences in weighting for 6%.[136] Avramov, Cheng, Lioui, and Tarelli also investigated ESG rating uncertainty across six major agencies, including LSEG, MSCI, Bloomberg, Morningstar, and RobecoSAM. They used the average standard deviation across these agencies as an indicator of the divergence in ESG ratings. Their findings confirmed significant variation among the providers, with an average rating correlation of 0.48 (where 1 represents perfect correlation and 0 represents no correlation).[137]

These studies highlight the considerable divergence in ESG rating systems, underscoring the need for further discussion on the issue. This is also contextualised in sections 2.3.2.1, 2.3.2.2, 2.3.3.1, and 2.3.3.2, where LSEG and MSCI assess different factors, employ distinct methodologies, and assign distinct grades to the same shipping companies. One fundamental cause of these inconsistencies is the lack of clear regulations and standards guiding rating providers. Without regulatory oversight, agencies are free to apply subjective methodologies

[135] Ibid.

[136] Berg, F., Kölbel, J., Rigobón, R. (n 16).

[137] Avramov, D., Cheng, S., Lioui, A., & Tarelli, A. (n 17).

without accountability.[138] For instance, MSCI operates without a clear regulatory body, rule-making process, enforcement mechanisms, or dispute resolution system. This lack of structure renders their processes unpredictable, inconsistent, and unreliable for consumers.[139]

3.3.2 ESG Ratings and Regulatory Gaps

The relationship between ESG ratings and relevant regulations is complex, which makes it challenging to precisely assess their correlation. This complexity arises partly because the environmental component of ESG ratings covers more than the legal aspects addressed by the CII regulations. Furthermore, the lack of comprehensive data on companies' adherence to all relevant guidelines, combined with the lack of transparency in ESG raters' evaluation methods, means that the necessary data for a definitive conclusion is unattainable. However, one way to evaluate this connection is by examining whether the factors considered by rating agencies are relevant to the maritime industry.

Previous research suggests that the general application of ESG evaluations is not specifically tailored to the shipping sector. Instead, they often draw on principles and frameworks from international organisations, such as the UN SDGs and the Global Reporting Initiative. While initiatives like the SDGs are indeed relevant to shipping, the ESG principles tend to be too broad, missing critical details specific to the industry.[140] Moreover, shipping companies that publish ESG reports have varying approaches and present different information, as there is no standardised template for the data required. As a result, the information provided often falls short of enabling accurate ratings in the maritime context. Thus, due to the broad scope of these ratings and the lack of specific, relevant data, they can be argued to not effectively address the unique goals of the shipping industry.[141]

[138] Tayan, B., Larcker, D., Watts, E., & Pomorski, L. (2022). (n 14).

[139] MSCI. (n 90).

[140] Tsatsaronis, M., Syriopoulos, T., Karamperidis, S., & Boura, G. (n 79).

[141] Ibid.

4 The Interplay Between the Core Concepts

4.1 How ESG Investing Facilitates DT Adoption

The shipping industry's slow adoption of digital transformation is hindered by several barriers, which ESG initiatives are argued to be capable of addressing. The organisational and governance issues include a persistent reliance on outdated practices, with companies maintaining the belief that traditional methods will continue to be the most effective. Furthermore, cultural resistance among employees hinders adaptation, coupled with difficulties in attracting younger, digitally proficient talent. Operational silos and a reluctance to share information with external stakeholders further obstruct the implementation of DT. Overcoming these barriers is essential for driving digital transformation within the shipping industry.[142]

4.1.1 The Concept of Digital Maturity

The success of an organisation's digital transformation is argued to depend on its level of digital maturity.[143] Previous research also indicates a positive correlation between higher digital maturity and improved organisational performance.[144] Digital maturity can further be categorised into digital intensity and transformation management intensity. Digital intensity encompasses an organisation’s technological capabilities and investments in transforming customer engagement, internal processes, and business models. Transformation management intensity, on the other hand, involves the vision, governance, and leadership necessary to drive and sustain digital transformation initiatives. Together, these dimensions determine how effectively companies can navigate and implement digital transformation.[145]

Building on this prior research, other scholars have also emphasised the critical role of customer-centricity and stakeholder collaboration as central elements of DT. Organisations often pursue DT to create value for themselves and their stakeholders, driven by external pressures such as demands for greater operational efficiency, cost reduction, and meeting

[142] See chapter 3.2.

[143] Cichosz, M. Wallenburg, C. Knemeyer, A. Digital transformation at logistics service providers: barriers, success factors and leading practices. (Emerald Insight 2020).

[144] Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, N. (n 135).

[145] Westerman, G., Bonnet, D., McAfee, A. The nine elements of digital transformation. (MIT Sloan 2014).

evolving customer expectations. Moreover, to remain competitive and prevent a return to outdated practices, ongoing investment in innovation and the cultivation of a forward-looking management perspective is essential. In this context, drivers of technology investment and partnerships that enhance information sharing, coordination, and collaboration are regarded as vital for successful DT.[146][147]

The premise is that ESG investing can serve as a powerful driver for enhancing both digital intensity and transformation management intensity. Regarding digital intensity, ESG investing can direct investor attention toward DT goals, prompting companies to allocate resources for the development of relevant technologies. This alignment not only attracts further investment but also shifts internal priorities toward accelerating the adoption of DT. This alignment will strengthen an organisation's technological capabilities and potentially lead to improved customer engagement and innovative business models.[148]

In addition, ESG investing holds distinct potential to influence transformation management intensity. By emphasising governance, leadership, and strategic vision in its metrics,[149] ESG frameworks can motivate companies to cultivate leadership capabilities, foster employee engagement, and establish governance structures essential for managing ongoing digital initiatives. These efforts help ensure the sustainability of DT, enabling organisations to continuously innovate while aligning operations with both digital and sustainability objectives. As such, ESG investing not only offers financial incentives for technological advancement but also nurtures the organisational leadership needed to drive and sustain long-term digital transformation. This interplay will be explored further in the following discussion.

4.1.2 Balancing Top-Down and Bottom-Up Approaches

In the shipping industry, ESG investing can play a pivotal role in driving DT by encouraging investors to prioritise companies with strong ESG ratings. This incentivises shipping

[146] Raza, Z., Woxenius, J., Vural, C. A., & Lind, M. (n 13).

[147] Ginters, E., Estrada, M., Angel, M. (n 11) 20-27.

[148] Girvin, S., Ulfbeck, V. (n 3) 177-179.

[149] See chapter 2.3.1.

companies to adopt digital technologies to meet sustainability goals and attract investment.[150] This is also called a top-down approach, where the company leadership is influenced by external pressures from investors and ESG guidelines to implement DT across their operations. This approach offers several advantages, such as establishing a clear, unified goal across the organisation. This can help mitigate the issue of fragmented operations, by ensuring that all departments in the company are aligned towards a common objective.[151]

However, relying exclusively on a top-down approach will not ensure the successful implementation of DT. While strategic alignment within a company is essential, a purely top-down model may overlook the practical challenges faced by employees and end-users, potentially hindering the adoption and long-term sustainability of digital initiatives.[152] To overcome this, companies must integrate bottom-up strategies that encourage employee engagement and innovation across all levels. This is especially crucial in the shipping industry, where operational success relies on the expertise and active involvement of employees who directly interact with the technologies being implemented. [153]

As previously discussed by scholars, a bottom-up approach is crucial for implementing DT, and this is often achieved through a user-centric method.[154] However, this study proposes a shift in perspective, suggesting that companies should view their employees through the lens of the user-centric approach. In practice, this means involving employees at every stage of the digital transformation process, from development to implementation. By doing so, shipping companies can regularly assess the needs of the employees in their use of the technology, to then adapt the technological solutions accordingly. This approach not only improves the practical utility of digital solutions but also cultivates a culture of innovation, empowering employees to actively contribute to the company's sustainability objectives. The application of this idea in the context of ESG investing will be explored in sections 4.1.2.1 and 4.1.2.2.

[150] Girvin, S., Ulfbeck, V. (n 3) 177-179.

[151] Asana. Top-down-styrning vs bottom-up-styrning: vad är skillnaden? (2024).

[152] Bäcklund, K., Vigren, O., Carlsson, J. Implementing digital innovations: Overcoming organizational challenges. (ScienceDirect 2024).

[153] Kane, G. C., Palmer, D., Phillips, A. N. Achieving digital maturity. (MIT Sloan 2017).

[154] Bäcklund, K., Vigren, O., Carlsson, J. (n 154).

4.1.2.1 Overcoming Shipowner Resistance to DT

One of the identified hinders to DT in the shipping industry is the persistent reliance on outdated methods, with companies often resisting change. This reluctance, particularly at the leadership level, can be addressed through the top-down incentives created by ESG investing. As a result, company leaders are increasingly compelled to implement DT within their operations, recognising that DT is essential to maintain competitiveness and attract crucial investments. This aligns with existing research showing that stakeholder demands for increased visibility, cost efficiency, environmental responsibility, and reduced carbon emissions are driving owners to adopt DT. ESG standards reinforce these demands, pushing companies to modernise their practices in line with market expectations and sustainability objectives. These factors are thus crucial drivers of digital transformation within the shipping sector.[155][156]

4.1.2.2 Employee Engagement and Compliance

As mentioned in section 3.2, employee reluctance remains a significant barrier to the successful implementation of DT.[157] To overcome this challenge, it is, as previously mentioned, crucial to foster a culture that encourages employees to take ownership of technological projects, self-organise, and actively participate in the transformation process.[158] ESG initiatives can be instrumental in creating such an environment. ESG practices have been shown to enhance environmental awareness, transparency, and openness within organisations, which in turn helps build trust between employees and management. When employees are provided with clear, transparent information about the company's ethical practices and social responsibility, they are more likely to feel aligned with the organisation's values.[159]

This alignment can lead to increased job satisfaction, greater organisational commitment, and a stronger sense of purpose among employees. It also makes them more receptive to broader company goals, such as digital transformation. When employees understand the reasoning

[155] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[156] Girvin, S., Ulfbeck, V. (n 3) 177-179.

[157] Ibid 177-179.

[158] Bughin, J. Digital success requires a digital culture. (McKinsey & Company 2017).

[159] Zhang, T., Zhang, J., Tu, S. An Empirical Study on Corporate ESG Behavior and Employee Satisfaction: A Moderating Mediation Model. (MDPI 2024).

behind decisions, like adopting new technologies, and trust the leadership driving these decisions, they are more likely to support the transformation process. Furthermore, ESG practices foster a culture of accountability, where employees recognise that their contributions directly support the company's sustainability goals. This sense of responsibility enhances their commitment to the success of the technologies that are necessary to achieve those objectives. Additionally, it helps minimise the risk of mismanagement or ethical violations. This combination of trust and accountability motivates employees to not only understand the purpose behind digital transformation but to actively engage in supporting it.[160]

To enhance employee compliance and improve the likelihood of successful DT implementation, it is thus also crucial to educate employees on ESG principles. Providing training on sustainability, corporate governance, and ethical standards helps align the workforce with the company's values and fosters a deeper understanding of the connection between ESG and digital transformation. Employees with a stronger grasp of ESG concepts are more likely to be motivated by social responsibility and corporate ethics, increasing their engagement in the DT process. This approach also equips employees with the skills and knowledge necessary to actively contribute to the development and execution of both ESG strategies and DT initiatives.[161]

Adopting a bottom-up approach ensures that technological advancements are shaped by a shared commitment to improvement, rather than it being something that is imposed on employees. This approach also enables the existing workforce to upskill and adapt to new technologies, reducing the urgency to rely on younger employees for tech adoption. Instead, companies can harness the expertise and institutional knowledge of their current staff. Moreover, this approach alleviates fears of job loss, as employees perceive their roles as evolving rather than being replaced by new technologies.[162] ESG initiatives do thus fulfil a dual function of acting as an investment incentive while also facilitating the cultural transformation essential for successful digital transformation.

[160] Ibid.

[161] Ibid.

[162] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

4.1.3 Reluctance to External Cooperation

Previous research has shown that successful implementation of DT often depends on active collaboration with external stakeholders.[163] However, stakeholders in the shipping industry are reluctant to share operational and environmental data externally. This is partly due to a fear of being exploited by competitors and falling behind.[164] A practical example of this challenge is TradeLens, a platform developed by Maersk and IBM to enhance supply chain transparency through secure data sharing. Despite its promising potential, TradeLens was shut down in 2023 due to its inability to achieve the necessary level of commercial viability.[165] This failure can also be said to be attributed to external stakeholders' reluctance to share data on a competitor's platform.[166]

Scholars have argued that a platform like TradeLens could have succeeded if it had been governed by a centralised, neutral body to unify participants on a blockchain or other shared data platform, rather than relying on competitors to establish and manage it.[167] Stakeholders have even suggested that TradeLens might have succeeded if launched under the governance of neutral international institutions like the World Bank or the United Nations. These institutions could have provided a non-competitive and trustworthy framework for data sharing, fostering collaboration and mitigating concerns about competitive exploitation.[168]

The failure of TradeLens can be more accurately attributed to a lack of trust among industry stakeholders, who were concerned that Maersk might exploit the data for competitive advantage. Consequently, a platform overseen by a neutral third party rather than a competitor would likely achieve greater success, but not because it is state-owned or regulated, but because the third party is trusted.[169] Similarly, Cosco's "Ship Carbon Intensity Indicator Digital Toolbox" faces similar risks of limited adoption due to these trust issues.[170] Therefore, rather than focusing solely on state regulation, the critical factor for the success of

[163] Ichimura, Y., Dalaklis, D., Kidata, M., Christodoulou, A. Shipping in the era of digitalization: Mapping the future strategic plans of major maritime commercial actors. (ScienceDirect 2022).

[164] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[165] Maersk. A.P. Moller - Maersk and IBM to discontinue TradeLens, a blockchain-enabled global trade platform. (2022).

[166] Basu Bal, A. The generative carriage of goods. (Journal of International Maritime Law 2023).

[167] Raza, Z., Woxenius, J., Vural, C. A., Lind, M. (n 13).

[168] Basu Bal, A. (n 168).

[169] Ibid.

[170] See chapter 2.3.3.3.

such platforms lies in fostering an ecosystem founded on trust, transparency, and collaboration.[171]

Collaboration among stakeholders in initiatives like TradeLens is crucial for the successful development of the ecosystem itself. Such cooperation depends heavily on mutual trust and a willingness to share information. Building this collaboration requires stakeholders to recognise the ecosystem's value, to be incentivised to actively participate.[172] Further, to ensure that an ecosystem remains self-sustaining and beneficial to all participants, no single stakeholder should hold exclusive control. Instead, implementing shared governance and collective decision-making is critical. This approach helps maintain trust among participants while encouraging ongoing innovation throughout the ecosystem.[173]

For example, the Virtual Watch Tower (VWT) Project, launched in 2023, is a system-to-system solution designed to foster collaboration among global stakeholders to enhance supply chain visibility. The project aims to govern the supply chain, improve efficiency, and address ESG goals within the shipping industry. It emphasises coevolution, where all participants in the ecosystem share responsibility for its success, aligning both their economic and societal objectives.[174] In contrast to TradeLens, the VWT Project is organised around the concept of the public good, focusing on collective benefits rather than being perceived to focus on profit.[175]

Autio conceptualises this type of ecosystem orchestration as a network of independent participants working together to create a shared value. Unlike conventional supply chains governed by contractual agreements, ecosystems thrive on collaboration across four interconnected dimensions: technological, economic, institutional, and behavioural. These dimensions each play a vital role in the ecosystem's development, interacting dynamically to influence and shape the ecosystem as it evolves.[176]

[171] Basu Bal, A. (n 168).

[172] Ibid.

[173] Ibid.

[174] Virtual Watch Tower Network. VWT the Concept. (Accessed 2024).

[175] Basu Bal, A. (n 168).

[176] Autio, E. Orchestrating ecosystems: a multi-layered framework. (Taylor & Francis 2022).

The technological layer defines the platform's shared standards, influencing stakeholder roles and interactions. It evolves from establishing modular designs that encourage engagement in the initiation phase, to controlling bottlenecks in the mature phase. The economic layer governs incentives and financial structures, with strategies such as subsidies or rewards to attract participants initially, and later focusing on promoting network effects and monetising user bases. The institutional layer establishes governance rules and regulatory alignment, beginning with defining roles and contracts, followed by managing internal conflicts and ensuring compliance with external regulations as the ecosystem grows. Lastly, the behavioural layer shapes participant behaviours, driving early adoption through strategic urgency, fostering norms of cooperation, and reinforcing leadership to expand ecosystem dominance in the later stage.[177]

4.1.3.1 Technological Layer

Assuming the presumptions of this paper hold true, ESG investing has the potential to serve as a catalyst for digital transformation in the shipping sector. While this will not directly generate innovative technologies or design platforms that facilitate ecosystem connectivity,[178] it plays a crucial role behind the scenes. ESG investing helps establish the foundation for implementing the technological layer, particularly in the shipping industry.[179] By linking investment incentives to sustainability goals, such as reducing carbon emissions and improving transparency through DT, ESG investing pushes companies to adopt digital tools.

ESG is therefore a governing factor of the technological layer. This interpretation of the technological layer deviates from Autio's original perspective and may be argued to align more closely with other layers. However, this does in turn also highlight the interconnected nature of these layers.[180] It can further be argued that ESG plays a foundational role in preparing the conditions necessary for the technological ecosystem. As a result, ESG investing remains relevant to the technological layer by fostering the environment in which technological advancements can flourish.

[177] Ibid.

[178] Ibid.

[179] See chapter 4.1-4.1.4.1.

[180] Autio, E. (n 177).

4.1.3.2 Economical Layer

ESG investing directly creates economic incentives for companies to meet sustainability metrics.[181] If ESG investing, in line with this paper's thesis, incorporates a criterion that emphasises technology as part of sustainability metrics, these incentives become closely tied to how companies adopt and implement digital technologies. Companies that align with potential new DT metrics in ESG, such as improving data transparency, and integrating digital tools, will attract ESG-focused investments. In turn, these incentives motivate stakeholders to contribute data, resources, and innovation, achieving both technological advancements and sustainability goals.

4.1.3.3 Institutional Layer

It is clear that Environmental, Social, and Governance criteria alone cannot resolve conflicts or regulate internal rules within an ecosystem. This is particularly true as the ecosystem needs to evolve its regulations internally over time, allowing participants to interact independently and form a cohesive entity.[182] However, ESG investing introduces a governance framework that can lay the groundwork for the effective functioning of ecosystems. ESG criteria are integrated with general regulations and policies, and its ratings ensure adherence to global standards related to environmental sustainability, social responsibility, and corporate governance.[183] As a result, ESG investing has the potential to guide participants within the ecosystem, encouraging them to align with societal norms and incorporate these values into the ecosystem's operations. This, in turn, allows them to receive the incentives that Autio recognises as a crucial influence within the institutional layer.[184]

4.1.3.4 Behaviour Layer

ESG investing plays a pivotal role in shaping behaviour within the ecosystem by leveraging financial incentives to promote coopetition, a collaborative dynamic among competitors.[185] This cooperation then fosters a sense of shared responsibility among stakeholders, enabling them to hold each other accountable and work collectively toward the ecosystem's overall

[181] See chapter 2.3.1-2.3.2.

[182] Autio, E. (n 177).

[183] See chapter 2.3.1.

[184] Autio, E. (n 177).

[185] Girvin, S., Ulfbeck, V. (n 3) 26, 31, 177.

success, even while pursuing their individual interests. Beyond financial incentives, ESG principles create an ethical foundation that strengthens trust and engagement. As participants align with ESG-driven values, they are more likely to share data and resources, understanding that collaboration benefits their operations and supports broader environmental and social objectives. This ethical influence cultivates a culture of cooperation, where sharing becomes key to the ecosystem's growth, driving both digital transformation and sustainability.[186]

4.1.3.5 Fostering Value Creation with ESG Investing

The discussion above highlights how ESG investing can support and, in some cases, directly impact the development of a successful ecosystem layer. However, its greatest role may lie in creating value across all layers of an ecosystem. ESG investing can be seen as fulfilling an indirect governance role, establishing norms that influence participant behaviour and generate value through incentives and ethical values.[187] This helps ensure that platforms remain attractive to stakeholders, fostering innovation and cooperation rather than competition.

Furthermore, ESG investing acts as a catalyst for creating "transnational networks and coordination arrangements." These networks promote shared standards and practices without relying on binding decision-making authority, instead encouraging voluntary collaboration and mutual recognition for collective efforts. The unique feature of these transnational networks is that, when implemented successfully, their perceived value becomes so compelling that it surpasses potential challenges, such as concerns over data-sharing. As a result, this attracts more participants, who are motivated by the collective benefits these networks provide.[188]

ESG investing can therefore be a powerful driver of value creation with initiatives like the VWT, where shared objectives and mutual benefits are essential for long-term success. While ESG investing may not directly link to specific projects, it plays a vital role in orchestrating and shaping their evolution. By embedding sustainability, transparency, and governance principles into investment frameworks, ESG influences the direction and outcomes of these initiatives. Further it's also important to emphasise that this discussion focuses on how ESG

[186] See chapter 4.1.2.2.

[187] Autio, E. (n 177).

[188] Kingsbury, B., Krisch, N., Stewart, B. The Emergence of Global Administrative Law. (JSTOR. 2005).

investing affects individual companies and how they carry these established norms into the broader cooperative ecosystem. If the ecosystem itself were also evaluated based on ESG criteria, the impact of ESG investing could be even more significant.

4.1.4 Building and Sustaining Trust

Trust is widely recognised by scholars as a cornerstone of successful digital platforms and ecosystems. In straightforward transactional exchanges, where cooperation yields immediate benefits for all parties, individual and collective interests often align naturally. This dynamic underpins traditional trade, where mutual gain and the price mechanism effectively drive collaboration.[189] However, in scenarios focused on joint value creation, this alignment is less apparent.[190] The interdependence among stakeholders in such arrangements can give rise to dilemmas, with individual actors sometimes prioritising short-term personal gains over the collective's long-term success.[191]

The interdependence among stakeholders, combined with conflicting interests, often results in non-cooperation, where individual actors pursue immediate advantages at the expense of collective efforts.[192] A notable example of this dynamic is the case of the Southern Bluefin Tuna. Japan's decision to overfish for short-term economic gain undermined international conservation initiatives, threatening global tuna stocks and jeopardising the long-term sustainability of Japan's own fishing industry (Southern Bluefin Tuna Cases (New Zealand v. Japan; Australia v. Japan), Provisional Measures, 1999).

Such scenarios introduce significant uncertainty, particularly if some stakeholders participate in initiatives like the VWT, without a genuine commitment to its objectives. These participants may exploit the efforts of others, reaping the benefits of the initiative while contributing little themselves. This behaviour can demotivate more dedicated stakeholders,

[189] Bridoux, F., Stoelhorst, J. STAKEHOLDER GOVERNANCE: SOLVING THE COLLECTIVE ACTION PROBLEMS IN JOINT VALUE CREATION. (Academy of Management Review 2022) 216.

[190] Bridoux, F., Stoelhorst, J. Stakeholder relationships and social welfare: A behavioral theory of contributions to joint value creation. (Academy of Management Review 2016) 229–251.

[191] Bridoux, F., Stoelhorst, J. (n 190) 216.

[192] Ibid 216.

ultimately diminishing the initiative's overall value and effectiveness.[193][194] Moreover, some stakeholders may participate in initiatives like the VWT not out of a genuine desire to advance ESG objectives, but rather to create the appearance of alignment. By doing so, they aim to enhance their reputations, attract investments, or improve their ESG ratings, all without engaging in meaningful cooperation.

Trust, therefore, becomes central to resolving these dilemmas. Scholars argue that trust is not only a prerequisite for cooperation but also a dynamic mechanism that evolves over time. In collective action scenarios, stakeholders' willingness to cooperate often depends on their expectations that others will do the same. Initially, the "system trust" and confidence in the established rules and governance mechanisms of the organisation is argued to play a pivotal role. Further, in environments where stakeholders frequently join or leave, it is argued that a strong governance framework is needed to institutionalise trust, ensuring that shared norms and commitments are consistently upheld. Trust is not considered static but evolves in response to stakeholders' experiences and the effectiveness of governance structures. As trust increases, governance forms may shift to reflect deeper collaboration, and as trust diminishes, stricter rules may be required to maintain order.[195]

To establish the necessary framework and trust for a successful platform, scholars have emphasised the critical role of a neutral, non-profit entity acting as the orchestrator. This orchestrator would function as a fiduciary, committed to managing the platform's data and resources exclusively for the benefit of its stakeholders. By doing so, it ensures that both the platform and its software remain open, adaptable, and freely accessible for adoption, implementation, and updates. This participatory approach not only aligns the platform's operation with shared objectives but also reinforces trust and legitimacy within the ecosystem.[196]

Researcher Basu Bal[197] has proposed a governance model that combines a charity with a decentralised autonomous organisation (DAO) to foster trust and scalability within a shared

[193] Klein, G., Mahoney, T., McGahan, M., Pitelis, N. Organizational governance adaptation: Who is in, who is out, and who gets what. (Academy of Management Review 2019) 6–27.

[194] Bridoux, F., Stoelhorst, J. (n 190) 216.

[195] Ibid 216.

[196] Ibid 216.

[197] Basu Bal, A. (n 7).

digital ecosystem. This structure includes a user-funded charity, with the orchestrator acting as a trustee. These funds would serve as the foundation for an open-source platform designed explicitly for public benefit, ensuring accessibility and adaptability for all stakeholders. In parallel, a DAO based on blockchain technology would be established to enable decentralised, cost-efficient governance. The orchestrator would participate in the DAO using governance tokens, guiding software development in alignment with the ecosystem's vision. Developers who contribute their skills and expertise to the DAO would earn governance tokens in return. These tokens, tied to the platform's long-term success, could appreciate, providing incentives that align with the functionality and sustainability of the platform.[198]

A core element of this model is equity. The orchestrator, acting as a trustee, is tasked with maintaining a balanced and inclusive decision-making within the DAO. This emphasis on equity not only directs economic benefits but also establishes a guiding ethical principle within the legal framework, fostering sustainable and ethical practices in the digital ecosystem. Thus, equity functions as an ethical foundation, prioritising the fair distribution of value and the fulfilment of commitments among participants. Scholars often debate whether equity should focus on efficiency or fairness, but in this context, it plays a pivotal role in creating a just and collaborative ecosystem that is thought to align with both economic and societal objectives.[199]

4.1.4.1 Balancing Incentives and Trust

The charity-based governance model presents notable advantages, but it also introduces potential challenges. One primary concern is its reliance on stakeholder donations, which requires participants to contribute capital to a central entity without retaining direct control over how their funds are used. This lack of direct oversight may create uncertainty among stakeholders, potentially discouraging initial engagement, particularly from those hesitant to entrust resources to an unfamiliar entity. In practice, this could create an unnecessary hindrance to its implementation, potentially slowing the adoption of DT in the shipping industry. This concern mirrors the broader challenges currently faced in integrating new technologies into the sector. If the objective is to streamline DT adoption, introducing

[198] Ibid.

[199] Ibid.

additional financial requirements or intermediary structures could hinder rather than help the progress.

The assumption is drawn from Chapter 3.2, highlighting that simplicity is one of the keys to overcoming the challenges of DT implementation. A straightforward process is more likely to succeed by minimising perceived risks and reducing barriers to participation. That said, while ESG investing, as noted in Chapter 4.1.3.3, cannot resolve conflicts or directly regulate internal operations, its potential for value creation is undeniable.[200] ESG investing further promotes equity, both through its ethical influence,[201] and its integration of global regulations and policies.[202] Additionally, ESG ratings encourage investors to allocate resources to companies based on their ESG performance, fostering a more equitable distribution of investment aligned with their societal and environmental priorities.[203]

ESG investing is therefore argued to be able to bolster the charity model, by facilitating the creation of transnational networks and coordination arrangements that, as previously noted, bring inherent economic, ethical and reputational incentives. When viewed in the context of joining and contributing to the charity, these advantages could mitigate the potential hurdles surrounding the charity model, making it more appealing for stakeholders to contribute to the charity model. By aligning these incentives with the charity framework, ESG investing can effectively bridge the gap between perceived complexity and the value derived from participation. The global regulations and policies that ESG is built on will also be integrated into this model, providing a foundational structure for the ecosystem to be built on.

In practice, combining ESG investing with a charity-based governance model may present the most effective and balanced solution. ESG's ability to incentivise participation through financial rewards and reputational benefits could complement the potential drawbacks with the additional layers of a charity-based system. Simultaneously, the charity component would provide a mechanism for consistent governance and trust-building, ensuring equitable resource distribution and fostering collaboration. Together, these systems could complement

[200] See chapter 4.1.3.5.

[201] See chapter 4.1.2.2.

[202] See chapter 4.1.3.3.

[203] Girvin, S., Ulfbeck, V. (n 3) 177.

one another, leveraging the strengths of each theory, building a digital ecosystem with trust, transparency, and collaboration.[204]

4.2 Smart Solutions for Smarter ESG Ratings

Current ESG rating frameworks, as demonstrated by major firms like MSCI and LSEG, reveal a notable discrepancy in how they evaluate shipping companies. For instance, MSCI and LSEG can assign vastly different ratings to the same company, reflecting inconsistencies in their evaluation methodologies and criteria. Previous research also indicates that it also is a fundamental misalignment between ESG ratings and the actual needs of the maritime sector.[205] To resolve the discrepancies between ESG rating providers and better align ESG criteria with the maritime sector's specific needs, scholars have proposed a standardised ESG rating system tailored to shipping. This approach would incorporate key environmental and governance factors that are relevant to the unique challenges faced by the maritime industry, while addressing the current gaps in rating consistency and relevance.[206] Such proposals have also emphasised incorporation DT as a core criterion within a new standardised metric system.[207]

Digital technologies, such as the IoT and blockchain, are crucial for enabling real-time tracking, transparent reporting, and accurate measurement of environmental performance. By leveraging digital technologies as a criterion for achieving better ESG ratings, companies are more motivated to adopt these technologies. This would also allow rating firms to access more comprehensive, relevant, and up-to-date information on shipping companies' environmental performance, as this data could be made publicly available through platforms like VWT.[208][209][210] This transparency allows stakeholders, including investors and regulators,

[204] See chapter 4.1.3.

[205] See chapter 3.3.1-3.3.2.

[206] Tsatsaronis, M., Syriopoulos, T., Karamperidis, S., Boura, G. (n 79).

[207] Ibid.

[208] Haraldson, S. (n 12).

[209] Pu, S., Lam, J. S. L. Blockchain adoptions in the maritime industry: a conceptual framework. (Taylor & Francis 2020).

[210] Yli-Huumo, J., Ko, D., Choi, S., Park, S., Smolander, K. Where is current research on blockchain Technology? - A systematic review. (PLOS ONE 2016).

to fact-check ESG ratings against actual operational data, theoretically decreasing different ratings on the same shipping company.

This transparency would also enable rating firms to align their appraisals more closely with the actual operational data specific to the shipping industry, ensuring that ESG ratings reflect the true environmental and governance performance of maritime companies. As a result, DT can bridge the gap between ESG assessments and real-world performance, making ESG ratings more relevant and impactful. With greater accuracy and public accountability, ESG will gain more credibility, potentially having a more significant influence on the shipping industry's transition toward sustainability. This integration of DT into the ESG framework can help align private investment strategies with regulatory goals, ensuring that ESG investing plays a stronger role in driving environmental performance in shipping.[211]

4.2.1 Implementing Universal DT Criteria

A potential method for incorporating a universal DT criterion into ESG frameworks within the maritime industry, is a blended approach that combines international guidelines with localised implementation. This strategy aims to strike a balance between global standardisation and the flexibility required to address regional contexts. The IMO already employs a similar approach through its non-binding resolutions, which encourage voluntary collaboration between the port and shipping sectors to reduce greenhouse gas emissions.[212] Building on this model, the IMO could introduce similar non-binding guidelines for integrating DT criteria into ESG ratings. This approach would allow global ESG standards to be effectively aligned with the unique regulatory and operational needs of individual countries. It would also give rating agencies the flexibility to adjust their ESG practices and focus on the specific criteria most relevant to their assessments.[213]

Additionally, as outlined in Part I, Article 1 of the IMO Convention, the IMO's primary role is to foster cooperation among governments in regulating shipping practices. Its authority is centred on developing frameworks and encouraging voluntary compliance rather than enforcing direct regulations on private-sector entities. For example, while the IMO could

[211] Yang, C., Lin, M. S. (n 10).

[212] International Maritime Organization. 2023 IMO Strategy on Reduction of GHG Emissions from Ships. (2023).

[213] Varuhas, J., Stark, S. The Frontiers of Public Law. (1st edn, Hart Publishing 2019).

establish guidelines promoting the use of DT to enhance environmental and operational efficiency, its mandate does not extend to directly overseeing ESG rating agencies. In alignment with this, Article 2(b) of the IMO Convention authorises the IMO to recommend that member states consider integrating these innovations into their policies while leaving the actual implementation to individual countries or rating agencies. [214] Additionally, flexible guidelines can help reduce resistance that might emerge from overly rigid regulations, ensuring better alignment with the diverse economic and environmental priorities of different states.[215]

The non-binding guidelines in this dual approach would encourage voluntary compliance, making it attractive for countries and companies genuinely committed to sustainability to adopt these standards. The special application of this approach lies in the potential of ESG to foster a "Transnational Network and Coordination Arrangement", being a voluntary, collaborative framework where countries, rating agencies, and industry stakeholders can work together on shared DT and ESG standards, without the need for binding authority. By fostering informal cooperation, this network would create a consistent yet adaptable approach to DT integration in ESG, allowing industry players to coordinate on key issues like transparency, data sharing, and emissions tracking.[216]

Over time, as more stakeholders adopt these standards, the framework can gain momentum and evolve into an industry norm. Such a voluntary, cooperative network can incentivise participants to align with shared sustainability goals by granting positive recognition and potential market advantages for companies meeting these standards. Countries and rating agencies that embrace this approach will improve investor confidence, and strengthen their reputation in the global market, while also preserving internal priorities.[217] This dual approach provides a sustainable path forward, enabling widespread adoption of DT practices that enhance ESG transparency and accountability in shipping without imposing rigid, one-size-fits-all regulations.

[214] Ibid.

[215] Varuhas, J., Stark, S. (n 214).

[216] Kingsbury, B., Krisch, N., Stewart, B. (n 189).

[217] Ibid.

4.3 ESG Investing and DT Enhancing CII

In line with the previous discussion on how ESG investing, and DT can complement each other, the following sections will explore the practical application of these enhanced approaches and their potential impact on CII.

4.3.1 ESG Investing Strengthening CII Governance

The current structure of CII has been criticised for fostering an uncooperative dynamic between shipowners and charterers. This disconnect highlights the need for governance rules within their contractual agreements to clearly define decision-making roles related to CII, particularly in critical areas such as resource allocation, operational data management, and emissions tracking.[218] Establishing such clarity is crucial to resolving the misalignment between shipowners, who are responsible for reporting emissions, and charterers, who hold operational control over the activities that generate those emissions.

To further address this issue, governance frameworks should include robust conflict resolution mechanisms capable of managing disputes arising from conflicting priorities.[219] For instance, shipowners may be incentivised to ensure accurate emissions reporting in alignment with ESG goals, while charterers may prioritise cost-efficiency, which can conflict with emissions reduction efforts.[220] By providing clear pathways for resolving such disputes, governance frameworks can reduce opportunistic behaviours and foster fair, transparent data-sharing practices. Additionally, for ESG and DT to effectively enhance CII compliance, governance rules must ensure a fair distribution of the value generated through collaborative efforts. This includes not only shipowners and charterers but also other stakeholders, such as ports.[221] Such an approach incentivises cooperation and reinforces stakeholder commitment to sustainability goals.

[218] Basu Bal, A. (n 7).

[219] Ibid.

[220] See chapter 3.1.1.

[221] Ibid.

4.3.1.1 ESG Investing and Collaborative CII Compliance

Establishing effective governance between charterers, ports, and shipowners under the CII guidelines requires contractual provisions that clearly define responsibilities, decision-making roles, and mechanisms for conflict resolution. This is arguably already covered, through industry organisations like BIMCO which have long worked to improve cooperation between these parties. For instance, the BIMCO CII operational clause for time charterparties introduces a structured framework to clarify obligations under the CII framework. Subclause (b) of the BIMCO clause explicitly emphasises that all parties must cooperate and act in good faith, encouraging the exchange of findings, best practices, and insights to enhance vessel energy efficiency. It also mandates the collection, reporting, and daily exchange of operational data to facilitate continuous monitoring, compliance and operational planning.[222] Good faith collaboration is further recognised as vital for achieving compliance and advancing shared sustainability goals.[223] However, the practical enforcement of such provisions remains uncertain.[224]

These CII clauses prioritise emissions reduction, emphasising societal interests over purely commercial concerns. This represents a notable shift from traditional contract law, which has historically prioritised the protection of private parties' contractual rights while largely overlooking public welfare considerations. This evolution is largely attributed to growing societal pressure, where failure to meet sustainability standards now poses significant reputational risks and substantial commercial liabilities for companies, compelling them to adopt a more balanced approach.[225] Despite this progress, the adoption of these new standards presents challenges, since measures like slow steaming and rerouting, while essential for emissions reduction, can cause delays across the logistics chain, leading to potential commercial losses. To encourage the integration of these provisions, it is therefore essential to balance the societal need, while creating value that outweigh the negative aspects that follow.[226][227]

[222] Bimco. CII OPERATIONS CLAUSE FOR TIME CHARTER PARTIES 2022. (2022).

[223] Girvin, S., Ulfbeck, V. (n 3) 6.

[224] Ibid 50.

[225] Ibid 4-5.

[226] Basu Bal, A. (n 7).

[227] See chapter 3.1.4.

Hence, ensuring contractual commitment to decarbonisation relies heavily on financial incentives. These incentives can be integrated into shipping contracts in various ways to encourage compliance. One approach is to address reputational and financial risks stemming from a counterpart's environmental shortcomings. For instance, poor environmental practices by a shipowner, shipper, or logistics provider can harm not only their reputation, but also that of their partners, reducing their ability to secure green financing or appeal to sustainability-focused clients.[228][229] To counteract this, contracts could include provisions allowing stakeholders who lose out on green financing opportunities due to a counterpart's environmental failures to claim damages for these losses. The enforceability of such claims, however, would depend on the terms specified in the agreement.[230]

Further, as discussed continuously throughout this paper, financial institutions also play an essential role in incentivising sustainability. Banks can promote the inclusion of environmental clauses by offering favourable financing terms to clients that align with IMO strategies and emissions goals. Conversely, non-compliance could lead to stricter financial conditions, such as higher interest rates. An example is DNB Bank ASA's $154 million sustainability-linked loan, which ties incentives to the Poseidon Principles and other sustainability benchmarks.[231] Banks and financial institutions also increasingly prioritise ESG-compliant investments, offering preferential lending rates and other benefits to shipowners, charterers, and ports with good ESG ratings. This approach creates tangible economic value for stakeholders, encouraging superior environmental performance. It also contrasts with the CII initiative, which lacks enforcement mechanisms and relies on states to reward high-rated ships.[232]

Additionally, as previously discussed, ESG-driven incentives can reinforce the concept of shared savings from DT efforts. This approach reduces the competitive tensions between stakeholders, as all parties benefit collectively from enhanced environmental practices.[233] On the other hand, companies with poor ESG ratings face significant challenges, including

[228] Girvin, S., Ulfbeck, V. (n 3) 26.

[229] See chapter 2.3.3.

[230] Girvin, S., Ulfbeck, V. (n 3) 31.

[231] Ibid 177.

[232] Hong, H., Kubik, J., Scheinkman, J. FINANCIAL CONSTRAINTS ON CORPORATE GOODNESS. (NBER WORKING PAPER SERIES 2012).

[233] See chapter 4.1.3.5-4.1.4.1.

difficulty attracting socially responsible investors, higher financing costs, and reduced competitiveness. This creates a negative feedback loop in which reduced investments lead to limited resources, leaving companies with fewer means to allocate toward sustainability initiatives. This lack of resources further hampers their ability to make progress on sustainability, ultimately diminishing their overall competitiveness in the market.[234] Compared to CII's corrective action plans, ESG investing offers clearer and more immediate consequences for non-compliance. This motivates charterers and ports to engage in sustainable clauses to avoid financial penalties or the risk of being pursued for damages due to lost financial opportunities by their contract partners.[235]

The distinction between sustainable and unsustainable practices is becoming increasingly pronounced, making it harder for states and organisations to justify prioritising cost-efficiency over pollution reduction when selecting vessels. Unlike CII, which may require stakeholders to choose between environmental and economic priorities,[236] ESG Investing inherently aligns these goals by integrating environmental focus with economic incentives.[237] ESG investing can further strengthens collaborative platforms such as the VWT,[238] providing essential infrastructure for collective data exchange, directly aligning with BIMCO clauses such as subclause (b), which stresses the need for reliable data reporting and sharing to maintain regulatory compliance. By integrating with VWT, stakeholders can monitor emissions, coordinate regulatory adherence, and optimise operational plans, all of which promote CII and sustainability standards. As a result, VWT supports ESG-driven incentives by providing transparency that can directly influence ESG ratings and, ultimately, financing decisions.

4.3.2 Enhancing CII Integrity with DT

As discussed in Chapter 3.1.1, significant challenges exist with the current data reporting practices under CII. Ship operators may manipulate emissions data to maintain favourable energy ratings, undermining the framework's legitimacy as a sustainability tool. This issue is

[234] Hong, H., Kubik, J., Scheinkman, J. (n 233).

[235] Girvin, S., Ulfbeck, V. (n 3) 31.

[236] See chapter 3.1.4.

[237] Girvin, S., Ulfbeck, V. (n 3) 22.

[238] See chapter 4.1.3.5-4.1.4.1.

further complicated by the fact that operational control over emissions may rest with charterers rather than shipowners. Even if charterers' alignment with sustainability improves, the risk of falsified data persists. To ensure the CII framework functions as intended, integrating DT is essential for achieving accurate, transparent reporting that minimises human intervention and potential inaccuracies. Technologies like IoT and blockchain provide practical solutions to these challenges. IoT enables real-time data tracking and automated reporting, allowing for continuous emissions monitoring and reducing the reliance on manual data entry, thereby limiting opportunities for manipulation.[239] Blockchain complements this by ensuring data integrity, creating a tamper-proof record of emissions data that can be transparently accessed by all relevant stakeholders.

In addition to improving data accuracy, DT enables enhanced collaboration within the CII framework. A DT-enabled platform like the VWT facilitates seamless data-sharing among stakeholders, enabling better coordination on emissions control, operational optimisation, and the pursuit of shared environmental goals. This fosters accountability among shipowners, charterers, and ports while reinforcing the reliability and consistency of CII metrics across all stages of shipping operations. Moreover, accurate and transparent data facilitated by DT, when combined with ESG investing, can drive industry-wide adherence to CII standards by directly linking accurate performance to economic incentives. Reliable CII ratings empower stakeholders to make informed decisions regarding investments and partnerships, especially as ESG investing becomes more trustworthy as well. Over time, the integration of DT into the maritime sector strengthens the connection between CII and ESG investing, supporting both economic competitiveness and environmental sustainability.[240]

4.4 Stakeholder Takeaways

This table provides actionable insights for each stakeholder, enabling them to understand their role in enhancing the CII and leveraging DT and ESG frameworks effectively. By aligning their strategies with these recommendations, stakeholders can contribute to a more sustainable and efficient maritime industry.

[239] See chapter 4.2.

[240] See chapter 4.2-4.3.1.1.

Stakeholders	**Takeaways - DT**	**Takeaways - ESG investing**
Shipowners	1. Embrace DT solutions, such as IoT and blockchain, to enhance emissions transparency. 2. Leverage technology to optimise fuel efficiency, lower costs, and reduce carbon emission. 3. Utilise collaborative digital platforms to capitalise on their benefits and ensure compliance with CII requirements.	1. Establish governance structures that work towards ESG standards. 2. Leverage ESG alignment to enhance reputation and attract environmentally conscious customers and investors. 3. Secure ESG-driven funding to modernise fleets with energy-efficient technologies and achieve higher CII ratings.
Charterers	1. Collaborate with other stakeholders to streamline DT adoption. 2. Share accurate data from shipping routes to align with regulatory CII requirements and attract partnership. 3. Leverage DT to optimise routes, reduce costs and minimise emissions.	1. Encourage charter party agreements that advocate for sustainable practices to lower emissions and reduce costs. 2. Leverage sustainability efforts to attract ESG investments. 3. Further highlight ESG-driven progress to foster stronger partnerships with shipowners and stakeholders.
Ports	1. Collaborate with other stakeholders to streamline DT adoption. 2. Adopt technologies to modernise and optimise port operations. 3. Prioritise reducing waiting times to lower costs and minimise carbon emissions.	1. Advocate for agreements that promote effective practices, fostering sustainability and reducing costs. 2. Offer ESG-aligned incentives for vessels demonstrating strong CII or ESG compliance. 3. Leverage sustainability efforts to attract ESG investments.

Technology Providers	1. Capitalise on opportunities in the shipping sector by developing DT solutions tailored to the industry's specific needs. 2. Prioritise tools that improve data transparency, emissions tracking, and operational efficiency. 3. Engage early to establish a presence in the maritime market, benefiting from the growing demand for regulatory compliance.	1. Align product development with ESG criteria to attract environmentally conscious stakeholders. 2. Position products as solutions to meet legal requirements, such as CII compliance, creating customer value. 3. Highlight the economic benefits of DT solutions to appeal to sustainability-focused investors and stakeholders.

5 Conclusion

The findings of this thesis reveal that the integration of DT and ESG investing can establish a unified approach that not only enhances the effectiveness of the CII but also drives meaningful progress in sustainability and decarbonisation within the maritime sector.

A central objective of this research was to explore how ESG investing can promote the adoption of digital transformation in the industry. The findings show that ESG investing can provide strong incentives by linking financial rewards to sustainability. This alignment drives the adoption of transformative technologies such as IoT and blockchain, which are essential for achieving sustainability goals while maintaining competitiveness. By embedding these priorities into corporate governance, ESG principles help overcome resistance to innovation and promote collaboration, transparency, and a unified commitment to progress.

This thesis also sought to examine how the integration of DT and ESG investing can help address the challenges faced by the CII. IoT technologies enable real-time emissions monitoring, ensuring the accurate and continuous collection of data, while blockchain enhances reliability by providing tamper-proof records of this data. Together, these technologies address critical limitations of the CII, such as its reliance on self-reported data and lack of transparency, thereby increasing its credibility and effectiveness. ESG investing further reinforces these advancements by supporting governance structures, fostering accountability among stakeholders, and facilitating fair distribution of the benefits arising from digitalisation.

Beyond tackling the specific challenges of the CII, this thesis could have broader applications. The alignment of these approaches could offer a model for industries navigating the intersection of technology, governance, and sustainability. The synergy between DT and ESG investing underscores that sustainability can be a driver of innovation, efficiency, and long-term value creation, rather than a trade-off with profitability. The maritime industry does thus have the potential to set a global example in tackling environmental challenges by aligning technological adoption with sustainable governance.

Continuously, while this study offers valuable insights into the interplay between ESG investing, DT, and the CII, it also has limitations that could be addressed in future work. One

notable shortcoming is the lack of primary data collection. Conducting interviews with key stakeholders, such as shipowners, ESG rating agencies, regulators, and technology providers, could have provided more practical perspectives, to better complement the theoretical analysis. Additionally, considering the perspectives of other stakeholders or initiatives that directly influence the impact of ESG investing could provide further necessary insights into its application. These insights would be particularly useful for identifying company-specific or situational challenges and opportunities in implementing ESG and DT frameworks. Exploring emerging technologies, such as artificial intelligence for predictive analytics, could also uncover new opportunities to enhance the accuracy and effectiveness of the CII.

Further, exploring the use of ESG-driven technologies in specific segments, such as small-to-medium enterprises or specialised vessels like LNG carriers, could reveal how these frameworks can address diverse needs. Longitudinal studies would also be particularly valuable, allowing researchers to track the long-term impacts of integrating ESG principles and DT tools on CII compliance, operational efficiency, and profitability. Such research could assess whether these approaches yield sustained benefits or face diminishing returns over time. By addressing these areas, future research can refine and build on the strategies presented in this study, paving the way for a more sustainable and economically resilient maritime industry.

6 Bibliography

Articles

- Autio, E. Orchestrating ecosystems: a multi-layered framework. (Taylor & Francis 2022). https://www.tandfonline.com/doi/full/10.1080/14479338.2021.1919120.
- Basu Bal, A. Technology-mediated organisation of transport actors: laytime in perspective. (Journal of International Maritime Law 2023). https://www.lawtext.com/publication/the-journal-of-international-maritime-law/contents/volume-29/issue-6.
- Basu Bal, A. The generative carriage of goods. (Journal of International Maritime Law 2023). https://gup.ub.gu.se/publication/329578.
- Braakman, A. Climate and Covid-19: Will the Shipping Industry Succeed in Charting the Right Course between Scylla and Charybdis? (Lawtext Publishing 2020). https://www.lawtext.com/publication/the-journal-of-international-maritime-law/contents/volume-26/issue-2.
- Bughin, J. Digital success requires a digital culture. (McKinsey & Company 2017). https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/the-strategy-and-corporate-finance-blog/digital-success-requires-a-digital-culture?fbclid=IwAR1GQhf81JoLOVbqK6bmEJZQpo4si9-N_gFTmcyUVA-kOvAdtBwDc9OtPb.
- Deckelbaum, A., Karp, b., Curran, D., Johnson, J., Lynch, L., Bergman, M., Weiss, P. Introduction to ESG. (Harvard Law School Forum on Corporate Governance 2020) https://corpgov.law.harvard.edu/2020/08/01/introduction-to-esg/.
- Goran, L., Laberge, R., Srinivasan, R. Culture for a digital age. (McKinsley 2017). https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/culture-for-a-digital-age#/.
- Haraldson, S. Digitalization of Sea transports – Enabling sustainable Multi-Modal transports. (Core 2015). https://core.ac.uk/download/pdf/301365815.pdf.
- Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., Buckley, N. Coming of age digitally. (MIT Sloan 2018). https://sloanreview.mit.edu/projects/coming-of-age-digitally/.
- Kingsbury, B. The Concept of 'Law' in Global Administrative Law. (European Journal of International Law 2019). https://doi.org/10.1093/ejil/chp005.

- Pu, S., Lam, J. S. L. Blockchain adoptions in the maritime industry: a conceptual framework. (Taylor & Francis 2020). https://doi.org/10.1080/03088839.2020.1825855.
- Reiff, N. 10 Biggest Shipping Companies. (Investopedia 2024). https://www.investopedia.com/10-biggest-shipping-companies-5077534.
- Reynolds, F. COVID-19 accelerates ESG trends, global investors confirm. (PRI 2020). https://www.unpri.org/pri-blog/covid-19-accelerates-esg-trends-global-investors-confirm/6372.article.
- Tayan, B., Larcker, D., Watts, E., Pomorski, L. ESG Ratings: A Compass without Direction. (Harvard Law School Forum on Corporate Governance 2022) https://corpgov.law.harvard.edu/2022/08/24/esg-ratings-a-compass-without-direction/.
- Tsatsaronis, M., Syriopoulos, T., Karamperidis, S., Boura, G. Shipping-specific ESG rating and reporting framework. (Taylor & Francis 2024). https://doi-org.ezproxy.ub.gu.se/10.1080/03088839.2024.2342730.
- Westerman, G., Bonnet, D., McAfee, A. The nine elements of digital transformation. (MIT Sloan 2014). https://sloanreview.mit.edu/article/the-nine-elements-of-digital-transformation/.
- Zhang, T., Zhang, J., Tu, S. An Empirical Study on Corporate ESG Behavior and Employee Satisfaction: A Moderating Mediation Model. (MDPI 2024). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11047324/.
- Yang, C., Lin, M. S. The impact of digitalization and digital logistics platform adoption on organizational performance in maritime logistics of Taiwan. (Taylor & Francis 2023). https://doi.org/10.1080/03088839.2023.2234911.
- Yli-Huumo, J., Ko, D., Choi, S., Park, S., Smolander, K. Where is current research on blockchain Technology? - A systematic review. (PLOS ONE 2016). https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0163477&type=printable.

Books

- Athanassiou, L. Damages, Recoveries and Remedies in Shipping Law. (1st edn, Taylor & Francis Group 2023).
- Ginters, E., Estrada, M., Angel, M. ICTE in Transportation and Logistics 2019. (1st edn, Springer 2020).

- Girvin, S., Ulfbeck, V. Carbon-Free Shipping and Shipping Carbon: Contracts in Context. (1st edn, Hart Publishing 2024).
- Varuhas, J., Stark, S. The Frontiers of Public Law. (1st edn, Hart Publishing 2019).

Guidelines and Conventions

- International Maritime Organization. Resolution MEPC.352(78) - 2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1). (2022). https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.352(78).pdf.
- International Maritime Organization. Resolution MEPC.353(78) - 2022 Guidelines on the reference lines for use with Operational Carbon Intensity Indicators (CII Reference Lines Guidelines, G2). (2022). https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.353(78).pdf.
- International Maritime Organization. Resolution MEPC.338(76) - 2021 Guidelines on the operational carbon intensity reduction factors relative to reference lines (CII Reduction Factor Guidelines, G3). (2021). https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.338(76).pdf.
- International Maritime Organization. Resolution MEPC.354(78) - 2022 Guidelines on the operational carbon intensity rating of ships (CII Rating Guidelines, G4). (2022). https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.354(78).pdf.
- International Maritime Organization. Resolution MEPC.355(78) - 2022 interim Guidelines on correction factors and voyage adjustments for CII calculations (CII Guidelines, G5). (2022). https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.355(78).pdf.
- University of Oslo. Convention on the International Maritime Organization (IMO). (Accessed 2024). https://www.jus.uio.no/english/services/library/treaties/14/14-01/imo_consolidated.html.

Papers

- Avramov, D., Cheng, S., Lioui, A., Tarelli, A. Sustainable investing with ESG rating uncertainty. (Journal of Financial Economics 2022). https://doi.org/10.1016/j.jfineco.2021.09.009.
- Berg, F., Kölbel, J., Rigobón, R. Aggregate confusion: the divergence of ESG ratings. (Oxford Academic 2022). https://doi.org/10.1093/rof/rfac033.
- Bridoux, F., Stoelhorst, J. Stakeholder relationships and social welfare: A behavioral theory of contributions to joint value creation. (Academy of Management Review 2016). https://www.researchgate.net/publication/277931021_Stakeholder_Relationships_and_Social_Welfare_A_Behavioral_Theory_of_Contributions_to_Joint_Value_Creation.
- Bridoux, F., Stoelhorst, J. STAKEHOLDER GOVERNANCE: SOLVING THE COLLECTIVE ACTION PROBLEMS IN JOINT VALUE CREATION. (Academy of Management Review 2022). https://www.researchgate.net/publication/343595298_STAKEHOLDER_GOVERNANCE_SOLVING_THE_COLLECTIVE_ACTION_PROBLEMS_IN_JOINT_VALUE_CREATION.
- Bäcklund, K., Vigren, O., Carlsson, J. Implementing digital innovations: Overcoming organizational challenges. (ScienceDirect 2024). https://kth.diva-portal.org/smash/get/diva2:1853726/FULLTEXT01.pdf.
- Cichosz, M. Wallenburg, C. Knemeyer, A. Digital transformation at logistics service providers: barriers, success factors and leading practices. (Emerald Insight 2022). https://www.emerald.com/insight/content/doi/10.1108/IJLM-08-2019-0229/full/html.
- Faber, J., Nelissen, D., Smit, M., Behrends, B., Lee, S. The Fuel Efficiency of Maritime Transport. Potential for improvement and analysis of barriers. (ETDE-WEB 2012). https://www.osti.gov/etdeweb/biblio/22122349.
- Hong, H., Kubik, J., Scheinkman, J. FINANCIAL CONSTRAINTS ON CORPORATE GOODNESS. (NBER WORKING PAPER SERIES 2012). https://www.nber.org/system/files/working_papers/w18476/w18476.pdf.
- Hua, R., Yin, J., Wang, S., Han, Y., Wang, X. Speed optimization for maximizing the ship's economic benefits considering the Carbon Intensity Indicator (CII). (ScienceDirect 2024). https://doi.org/10.1016/j.oceaneng.2024.116712.
- Ichimura, Y., Dalaklis, D., Kidata, M., Christodoulou, A. Shipping in the era of digitalization: Mapping the future strategic plans of major maritime commercial

actors. (ScienceDirect 2022). https://www.sciencedirect.com/science/article/pii/S2666954422000023.

- Kingsbury, B., Krisch, N., Stewart, B. The Emergence of Global Administrative Law. (JSTOR 2005). https://www.jstor.org/stable/27592106?seq=1.
- Klein, G., Mahoney, T., McGahan, M., Pitelis, N. Organizational governance adaptation: Who is in, who is out, and who gets what. (Academy of Management Review 2019). https://www.researchgate.net/publication/319402727_Organizational_Governance_Adaptation_Who_Is_In_Who_Is_Out_and_Who_Gets_What.
- Lee, S. Investigation of Factors Influencing Carbon Intensity Indicator (CII) Rating. (Cardiff Business School 2023). https://sustainableworldports.org/wp-content/uploads/Investigation-of-Factors-Influencing-Carbon-Intensity-Indicator-CII-RatingYeosuGwangyang-Port-Authority.pdf.
- Lee, J., Lee, J., Lee, C., Kim, Y. Identifying ESG trends of international container shipping companies using semantic network analysis and multiple case theory. (Sustainability 2023). https://doi.org/10.3390/su15129441.
- Masodzadeh, P., Ölçer, A., Ballini, F., Celis, J. G. Live carbon-tracking mechanism for ships, a methodology to mitigate uncertainties in the carbon intensity calculations. (ScienceDirect 2023). https://www.sciencedirect.com/science/article/pii/S2590198223002518#s0005.
- Masodzadeh, P., Ölcer, A., Ballini, F., Christodoulou, A. A review on barriers to and solutions for shipping decarbonization: what could be the best policy approach for shipping decarbonization? (ScienceDirect 2022). https://www.sciencedirect.com/science/article/pii/S0025326X22006907?casa_token=aWEPjhNAz3IAAAAA:nLFQhaP_VBVHPPa3O9CMEKGRYFYvT54JbmQzEK50hH9Tt1pjTdcHzP3AVQP1_c61aCHYtt4wGg.
- Masodzadeh, P., Ölcer, A., Ballini, F., Christodoulou, A. How to bridge the short-term measures to the market based measure? Proposal of a new hybrid MBM based on a new standard in ship operation. (ScienceDirect 2022). https://www.sciencedirect.com/science/article/pii/S0967070X22000257?casa_token=vDMprTHmEG8AAAAA:vhtoEhJF6ZGO1_pZOo66mzvcNpXYSoeTte8Lg2sJVu5AtVdBBTPPUP-zu-QoIO3Iys_nLlNcew.

- Olaniyi, E. O., Solarte-Vasquez, M. C., Inkinen, T. Smart regulations in maritime governance: Efficacy, gaps, and stakeholder perspectives. (ScienceDirect 2024). https://www.sciencedirect.com/science/article/pii/S0025326X24003187#s0135.
- Osmundsen, K., Iden, J., Bygstad, B. Digital Transformation: drivers, success factors, and implications. (AIS eLibrary 2018). https://aisel.aisnet.org/mcis2018/37/.
- Raza, Z., Woxenius, J., Vural, C. A., Lind, M. Digital transformation of maritime logistics: Exploring trends in the liner shipping segment. (ScienceDirect 2023). https://www.sciencedirect.com/science/article/pii/S016636152200207X#bib43.
- Tripathi, R. Concept of Global Administrative Law: An Overview. (Sage 2011). https://www.jstor.org/stable/45073012.

Other

- Begum v Maran (UK) Ltd [2021] EWCA Civ 326.
- Bimco. CII OPERATIONS CLAUSE FOR TIME CHARTER PARTIES 2022. (2022). https://www.bimco.org/contracts-and-clauses/bimco-clauses/current/cii-operations-clause-2022.
- COSCO SHIPPING. COSCO SHIPPING Green Digital Intelligence Ship Services Co., Ltd. held a news conference for launching smart sailing platform and the first batch of products. (2023). https://hk.coscoshipping.com/en/xwzx/xwfb/art/2023/art_1527102058.html.
- Cosco Shipping Lines CO., LTD. 2022 Sustainability Report. (2022). https://lines.coscoshipping.com/lines_resource/pdf/quality2022en.pdf.
- Cosco Shipping Lines CO., LTD. Announcement about European Union Emissions Trading System (EU ETS) Surcharge. (2023). https://lines.coscoshipping.com/home/News/detail/1700269414767298524050000000000000231.
- Deloitte. ESG in the Shipping sector, The role of ESG in the evaluation of shipping companies. (2021). https://www2.deloitte.com/content/dam/Deloitte/gr/Documents/consumer-business/gr_esg_in_the_shipping_sector_noexp.pdf.
- Delperee, F. THE MEANING OF THE LAW. (RADA FOR EUROPE Accessed 2024). https://www.undp.org/sites/g/files/zskgke326/files/migration/ua/paper-meaning-of-law-EN.pdf.

- European Commission. Overview of sustainable finance. (Accessed 2024). https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en.
- International Maritime Organization. 2018 Initial IMO Strategy. (2018). https://www.imo.org/en/OurWork/Environment/Pages/Vision-and-level-of-ambition-of-the-Initial-IMO-Strategy.aspx.
- International Maritime Organization. Rules on ship carbon intensity and rating system enter into force. (2022). https://www.imo.org/en/MediaCentre/PressBriefings/Pages/CII-and-EEXI-entry-into-force.aspx.
- International Maritime Organization. 2023 IMO Strategy on Reduction of GHG Emissions from Ships. (2023). https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx.
- International Maritime Organization. (Accessed 2024). https://www.imo.org/en/OurWork/Environment/Pages/Decarbonization%20and%20Clean%20air%20in%20shipping.aspx.
- International Transport Forum. Information Sharing for Efficient Maritime Logistics. (OECD 2018). www.itf-oecd.org/sites/default/files/docs/information-sharing-maritime-logistics.pdf.
- Kane, G. C., Palmer, D., Phillips, A. N. Achieving digital maturity. (MIT Sloan 2017). https://sadil.ws/bitstream/handle/123456789/1453/DUP_Achieving-digital-maturity.pdf?sequence=1&isAllowed=y.
- LSEG. COSCO SHIPPING Holdings Co Ltd ESG score. (Accessed 2023). https://www.lseg.com/en/data-analytics/sustainable-finance/esg-scores?esg=COSCO+SHIPPING+Holdings+Co+Ltd.
- LSEG. Environmental, social and governance scores from LSEG. (2023). https://www.lseg.com/content/dam/data-analytics/en_us/documents/methodology/lseg-esg-scores-methodology.pdf?esg=Super+Retail+Group+Ltd.
- Maersk. A.P. Moller - Maersk and IBM to discontinue TradeLens, a blockchain-enabled global trade platform. (2022). https://www.maersk.com/news/articles/2022/11/29/maersk-and-ibm-to-discontinue-tradelens.

- MSCI. COSCO SHIPPING Holdings Co., Ltd. (Accessed 2024). https://www.msci.com/our-solutions/esg-investing/esg-ratings-climate-search-tool/issuer/cosco-shipping-holdings-co-ltd/IID000000002149331.
- MSCI. ESG Ratings. (Accessed 2024). https://www.msci.com/our-solutions/esg-investing/esg-ratings.
- Team Asana. Top-down-styrning vs bottom-up-styrning: vad är skillnaden? (2024). https://asana.com/sv/resources/top-down-approach.
- Transport & Environment. Climate impact of shipping. (Accessed 2024). https://www.transportenvironment.org/topics/ships/climate-impact-shipping.
- United Nations. The Sustainable Development Goals Report 2024. (2024). https://unstats.un.org/sdgs/report/2024/.
- UN Trade & Development. Launch of the Review of Maritime Transport 2023. (2023). https://unctad.org/meeting/launch-review-maritime-transport-2023.
- Virtual Watch Tower Network. VWT the Concept. (Accessed 2024). https://virtualwatchtower.org/#vwttheconcept.