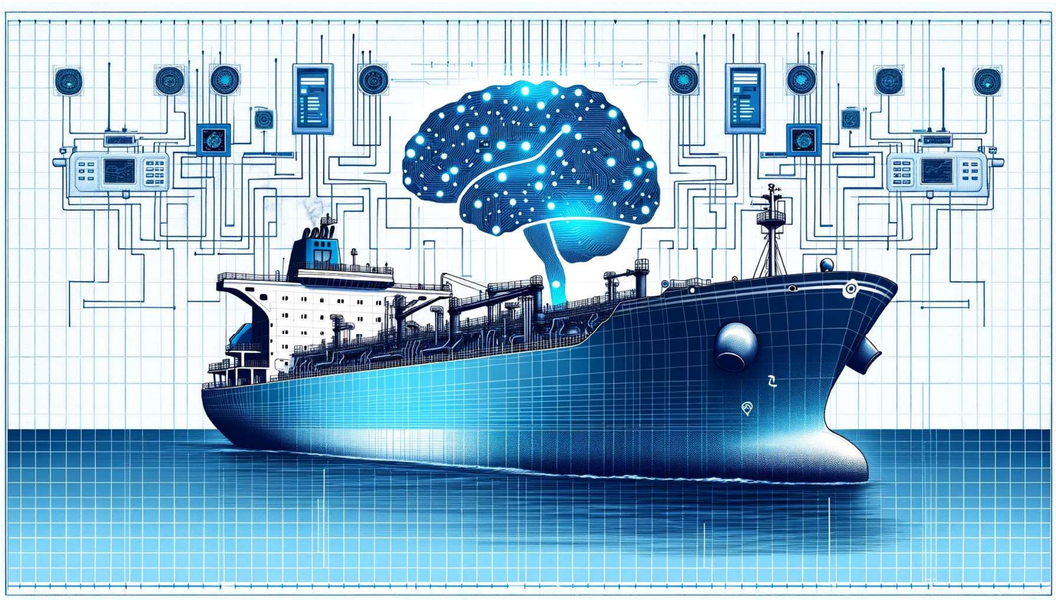

AI AI Captain

Leveraging Artificial Intelligence to Navigate Challenges in Tanker Shipping

Master's thesis in Management and Economics of Innovation

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Abstract

"AI AI Captain: Leveraging Artificial Intelligence to Navigate Challenges in Tanker Shipping" presents a comprehensive analysis of the transformative impact of AI on the tanker shipping industry. This research explores the operational and strategic challenges faced by the industry, positioning AI as a critical tool for overcoming these issues. It identifies and categorizes the key uncertainties in adopting AI, which include technological, organizational, commercial, and social aspects, thereby highlighting the complexity of stakeholder relationships and the inherent ambiguity in this sector. The study primarily utilizes focus group interviews with the case study company, Stena Bulk, and its principal customers, offering in-depth insights into the practical deployment and potential benefits of AI. This methodological approach sheds light on the multi-dimensional aspects of AI integration and its consequences for tanker shipping, underlining the sector's progressive shift towards embracing digital innovations.

Keywords: Artificial Intelligence, AI, Shipping, Innovation, Implementation, Barriers, Enablers, Opportunities.

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Andrea Wester & Jonathan Börjesson
Gothenburg, December 2023

List of Terminology

Below is the list of acronyms and shipping specific terminology that have been used throughout this thesis listed in alphabetical order:

Table 0.1: List of Terms

Term	Description
AIS	Automatic Identification System, a tracking system used on ships and by vessel traffic services
Assigned Capacity	Specific volume or tonnage a tanker is designed to carry
Autonomous Ships	Vessels operating independently using AI, sensors, and remote technologies for navigation and operations.
Bills of Lading	Legal documents issued by a carrier to acknowledge the receipt of goods for shipment
Brokers	Intermediaries who facilitate transactions between shipowners/operators and charterers
Bunker	Fuel used by ships, typically referring to heavy fuel oil or marine diesel
Bunker (team)	Specialists managing fuel procurement and supply for ships
Business Development	Strategies and activities aimed at identifying and pursuing growth opportunities, including market expansion, partnerships, service diversification, sustainability and transformation
CII	Carbon Intensity Indicator, a metric used to measure the carbon dioxide emissions per transport work of a ship
Charterer	The customer who, often through a broker, acquires transportation services from an operator

Chartering (team)	Professionals negotiating and managing the trading of the vessels for an operator
Charter Party	A legal agreement between a shipowner and a charterer specifying the terms and conditions for the voyage
Chartered Capacity	Specific volume or tonnage a tanker is designated to carry under a particular charter or voyage agreement
Claims Worksheet	Document detailing potential claims related to cargo discrepancies, damages, or charter party disputes, used for assessment and resolution
Demurrage	A charge incurred when a ship is detained beyond its agreed loading or unloading time, payable to the shipowner/operator by the charterer
DWT	Deadweight tons
FFA	Forward Freight Agreements, financial instruments used in shipping, allowing parties to hedge against or speculate on future changes in freight rates
Hull	The main body of a ship, including its frame, shell, and structure
HFO	Heavy Fuel Oil, a thick, low-grade type of fuel oil used in large vessels like tankers
Knot	A unit of speed equal to one nautical mile per hour
Laden	Refers to a ship that is carrying cargo, as opposed to being empty or in 'ballast' condition
Mass Flow Meters	Instruments used for accurately measuring the mass flow rate of a liquid, such as fuel oil, being transferred
Naval Architects	Engineers specializing in designing and constructing ships
Noon Reports	Daily updates provided by the ship's master
Operations	Group responsible for managing daily vessel activities and communicating with onboard crew
Parceling	Combining smaller quantities of cargo from different charterers into a single shipment on a tanker
RPM	Revolutions Per Minute, a measure of the rotational speed of a machine or engine
Shipping Operators	Companies or organizations responsible for the management and operation of tanker vessels

Spoofing	A deceptive practice involving the manipulation of a ship's electronic signals to disguise the ship's true location or identity
Statement of Facts	Official record documenting times and events during a ship's port call
Subs	Phrase indicating that a tentative agreement for chartering a tanker has been reached, but is subject to final approval or the fulfillment of specific conditions before it becomes a binding contract
Suezmax	A type of tanker with maximum dimensions to transit the Suez Canal fully laden, typically around 160,000 to 200,000 deadweight tons.
Tank-to-Wake	Refers to the measurement of greenhouse gas emissions from the point of fuel consumption (the ship's tank) to the point of emission release into the atmosphere (the wake)
TC-In	Time Charter-In, a chartering arrangement where an operator rents a vessel for a specified period, taking on the responsibility for providing fuel and paying port fees while the shipowner handles crew and maintenance
Technical Management	Oversight of vessel maintenance, repairs, and technical operations
Trading	The activity of buying or selling transporting goods
VLSFO	Very Low Sulfur Fuel Oil, a type of marine fuel oil with a low sulfur content
Well-to-Wake	This term encompasses the entire lifecycle of fuel emissions, from extraction (well) to final consumption (wake)

Contents

List of Acronyms **ix**

List of Figures **xvii**

List of Tables **xix**

1 Introduction **1**
1.1 Background . . . 1
1.1.1 Decarbonizing Shipping . . . 1
1.1.2 Conventional Industry . . . 2
1.1.3 Digitalization . . . 2
1.2 Aim . . . 3
1.3 Objectives . . . 3
1.3.1 Research Questions . . . 4

2 Previous Research **5**
2.1 Innovation and Artificial Intelligence . . . 5
2.2 Innovation within the maritime sector . . . 6

3 Theory **11**
3.1 Innovation from a theoretical perspective . . . 11
3.2 Theoretical framework . . . 13
3.3 Synthesizing uncertainties into a stakeholder framework . . . 13

4 Research Methodology **17**
4.1 Overview of case study methodology . . . 18
4.1.1 Overview of case study methodology . . . 18
4.1.2 Introduction to Stena Bulk . . . 19
4.2 Sampling . . . 20
4.2.1 Overview of purposive sampling . . . 20
4.2.2 Sampling for problem identification focus groups . . . 21
4.2.3 Sampling for subject matter expert focus groups . . . 21
4.3 Data Collection . . . 21
4.3.1 Focus groups . . . 22
4.4 Data Analysis . . . 25
4.4.1 Introduction to thematic analysis . . . 25
4.4.2 Thematic analysis to identify AI opportunities . . . 26

4.4.3 Subject matter expert input . . . 27
4.4.4 Data Stream Synthesis for Analysis . . . 29
4.5 Limitations . . . 29

5 Results **31**
5.1 Opportunities . . . 31
5.1.1 Document handling . . . 32
5.1.2 Digital Twins . . . 35
5.1.3 Market Prediction . . . 37
5.1.4 Uber for shipping . . . 39
5.1.5 Planning and Scheduling . . . 41
5.1.6 Fleet Analytics . . . 43
5.1.7 Knowledge Bank . . . 45
5.1.8 Cleaning Assistance . . . 48
5.1.9 Co-pilot . . . 50
5.1.10 Missed Invoices . . . 52
5.1.11 Bunker Analytics . . . 53
5.1.12 Predictive maintenance . . . 55
5.1.13 Safety . . . 58
5.1.14 Environmental footprint . . . 60
5.1.15 Navigating externals . . . 62
5.2 Barriers and enablers . . . 64
5.2.1 Barriers . . . 65
5.2.2 Dual roles: Barrier or enabler? . . . 70
5.2.3 Enablers . . . 73

6 Discussion **75**
6.1 Mapping of uncertainties . . . 75
6.1.1 Document handling . . . 75
6.1.2 Digital Twins . . . 76
6.1.3 Market Prediction . . . 78
6.1.4 Uber for shipping . . . 79
6.1.5 Planning and scheduling . . . 80
6.1.6 Fleet Analytics . . . 82
6.1.7 Knowledge Bank . . . 83
6.1.8 Cleaning Assistance . . . 84
6.1.9 Co-pilot . . . 86
6.1.10 Missed Invoices . . . 86
6.1.11 Bunker Analytics . . . 86
6.1.12 Predictive maintenance . . . 88
6.1.13 Safety . . . 89
6.1.14 Environmental Footprint . . . 90
6.1.15 Navigating externals . . . 91
6.1.16 Synthesis of Uncertainties . . . 93

7 Conclusion **95**

Bibliography **99**

A Containerization as an innovation process **I**

List of Figures

3.1 Distribution of uncertainties for the containerization process as they relate to stakeholder complexity and ambiguity 14
3.2 Integration of uncertainties into a relative measure of complexity and ambiguity 15

6.1 Mapping of stakeholder complexity and ambiguity 93
6.2 Grouping of opportunities from stakeholder framework 94

List of Tables

0.1 List of Terms ix

4.1 Research methodology overview 18
4.2 Opportunity identification focus groups (see Terminology List for an explanation of group roles and responsibilities) 24
4.3 Comprehensive list of parameters assessed by Subject Matter Experts 28

1

Introduction

1.1 Background

The shipping industry is a crucial part of the global economy, where approximately 90% of all internationally traded goods are transported by sea (WorldEconomicForum, 2018). The tanker shipping segment transports liquid commodities such as oil, natural gas, and chemicals. Vessels in this category range in size from 25 000 deadweight tons (dwt) to as much as 550 000 dwt (Strausscenter, 2008), imposing investments that can reach hundreds of millions of dollars (TradeWinds, 2023). The service is commercialized through either a spot market or contracts (COAs) (MarineInsight, 2023), emphasizing the significance of price, quality, and safety in every aspect, from vessel design to execution.

Thus, being a crucial component of global trade, the tanker shipping industry faces a myriad of challenges, ranging from environmental concerns to fierce competition. A brief summary of some of the most topical issues is presented in this section.

1.1.1 Decarbonizing Shipping

Tanker shipping significantly contributes to greenhouse gas (GHG) emissions by relying on "bunker fuel", a particularly carbon-intensive residue derived from fossil fuel refining, known as one of the most environmentally detrimental fuels worldwide(WorldEconomicForum, 2018). Despite its high carbon intensity and thus environmental impact, the low cost and widespread availability make it an appealing choice for the shipping industry. Largely due to this fuel consumption, the maritime sector is currently responsible for about 940 million tons of CO_2 emissions annually, which is approximately 2-3% of total global CO_2 emissions, and future projections indicate an increase of 50-250% due to increased energy demand (UNCTAD, 2022). Therefore, the imperative to decarbonize shipping and adopt sustainable practices has never been more urgent.

The International Maritime Organization (IMO) serves as the regulatory body in shipping, including overseeing the environmental effects. Currently, an aim is set to reduce 50% of the GHG emissions by 2050 compared to 2008 levels, with ultimate aspirations for complete phase-out (IMO, 2022). Achieving a 50% reduction would entail an estimated 85% decrease in CO_2 -equivalent emissions per ship, factoring in the expansion of the global fleet. To this end, various regulations have been put into place to support the sustainable transition.

However, given that the current trajectory falls short of the Paris Agreement standards (ICCT, 2021), other governmental entities and stakeholders, including the EU, banks, and customers, are also putting pressure on shipping to decarbonize by introducing additional regulations and requirements (SeaCargoCharter, 2020; DNV, 2021). Consequently, shipping companies are announcing emissions targets such as net zero operations by 2040 (StenaBulk, 2023).

1.1.2 Conventional Industry

The industry adheres to established norms that have persisted for decades (DNV, 2022a). This leads to traditional and conventional perspectives and behaviors, and an extreme cautiousness to change.

Nevertheless, it can be argued that the industry is characterized by a market that is volatile, uncertain, complex, and ambiguous (VUCA) (Lemoine & Bennett, 2014), due to the normality of shipping cycles, where multiple cycles of financial losses are offset by a year of profits (FreightWaves, 2021). Simultaneously, the previously mentioned sustainability concerns and regulatory landscape aiming to transform the industry are exacerbating this VUCA situation.

The vastness, complexity, and traditional mindset and culture of the shipping industry, within which tanker operations are situated, present challenges for companies striving to implement strategic change in order to maintain competitiveness.

Finding solutions that overcome the discussed barriers is key. Therefore, a viable solution should reduce consumption, increase safety and/or increase quality, whilst remaining flexible and not requiring any heavy investments in technology or dependencies on other actors.

1.1.3 Digitalization

In recent years, digital innovation has emerged as a potential solution to many of the industry's challenges. UNCTAD (2019) has for example identified that technologies such as artificial intelligence, blockchain, and the Internet of Things have the potential to revolutionize the way that tanker shipping operates. By leveraging these technologies, shipping companies may improve efficiency, reduce costs and emissions, and increase safety and quality without significant investments.

The integration of digital technologies utilizing artificial intelligence such as route and speed optimization, autonomous ships, and image recognition of hull conditions may potentially help the industry address environmental concerns while improving its operational efficiency. Safety may be enhanced by replacing the crew in unsafe activities when monitoring and controlling the ship, and instead doing this remotely. Furthermore, predictive maintenance by automatically monitoring the equipment onboard can address needs proactively, reducing the risk of failure and increasing the quality of the service. Lastly, smarter decisions regarding trading can be made by utilizing and optimizing real-time information and insights.

Nevertheless, substantial challenges remain. The implementation of autonomous ships or remote control mechanisms presents inherent complexities, and if not carefully managed, it could potentially undermine safety rather than enhance it. Moreover, the effectiveness of insights and decisions derived are contingent upon the quality of the input data. In the current prevailing conventional mindset, data sharing is not a common practice, and in some cases, data collection itself is not pursued (Wärtsilä, 2020).

Despite the potential benefits of digital innovation, the tanker industry has been slow to adopt these new technologies (DNV, 2022b). The conventional mindset can be hampering digitalization, as many players may be hesitant to embrace change, and the complexity of the industry makes implementing new technologies a daunting task. However, the conventional mindset can also act as a catalyst, as digitalization can bolster the competitive edge by reducing costs through lower consumption, enhancing safety, and improving operational quality without any investments that risk dependencies on infrastructure. These factors, as previously noted, hold high importance in the industry, which may accelerate support for the transformation.

By evaluating the potential for digital innovation and implementation within the tanker shipping industry, this thesis intends to contribute to a better understanding of how the industry can adapt to the challenges it faces and continue to thrive in an increasingly digital world.

1.2 Aim

The thesis aims to assess the opportunities for digital innovation within the tanker shipping industry. Specifically, the thesis will identify challenges and in turn opportunities in the tanker shipping value chain that can be alleviated by artificial intelligence.

Furthermore, the thesis will examine the barriers and enablers for implementing these solutions within the context of a tanker shipping operator, and provide a future perspective assessment.

1.3 Objectives

The objectives of the thesis are to:

- Identify key opportunities for tanker shipping operators and their customers,
- Assess potential artificial intelligence innovation opportunities,
- Examine barriers and enablers for the implementation of these opportunities.

1.3.1 Research Questions

The aim and objectives of the thesis impose the following research questions:

1. What are the key operational and strategic challenges faced by tanker shipping operators in the current industry landscape?
2. What opportunities exist for AI applications specific to the tanker shipping domain, considering the previously identified challenges?
3. What are the main barriers and facilitators for the adoption and implementation of AI solutions by tanker shipping operators?

2

Previous Research

In this chapter, we explore the role of AI in the innovation landscape, emphasizing its growing significance in reshaping business strategies and decision-making processes. Furthermore, previous innovation efforts within the maritime sector have been identified to understand the unique characteristics of innovation processes relating to shipping.

This exploration is crucial for the thesis focused on identifying innovation opportunities presented by AI in the shipping industry. By understanding the multi-faceted nature of innovation, particularly in the context of AI, the thesis aims to identify these opportunities effectively within the traditionally conservative maritime sector. This research provides a comprehensive background on which analysis of how AI can be integrated into the shipping industry to drive innovation can be performed, addressing both the technological advancements and the organizational changes necessary for successful implementation.

2.1 Innovation and Artificial Intelligence

Artificial Intelligence (AI) is a leading edge in computer science, combining sophisticated algorithms, machine learning, language understanding, and brain-like networks. Implementing AI means building systems that can do things usually needing human input, ranging from task automation to expert system problem solving (Hartmann et al., 2023). Concepts like "deep learning", and "rule-based learning" are key, showing AI's wide influence in different areas (Hartmann et al., 2023). AI is gaining prevalence because it not only creates demand for human skills complementing AI (Kumar, 2023) but also operates on its own, with machines learning and acting without people's direct guidance (Kankanhalli, 2020).

Lately, there's a growing connection between AI, business management, and strategy, moving from a tech-only view to considering its effects on companies and their strategies. Research papers and reports are exploring how AI affects decision-making, competitiveness, and strategic planning (Keding, 2020; Miller, 2023; Soni et al., 2020). Contributing to the strategic management perspective, Hartmann et al. (2023) propose a robust foundation for the assessment and implementation of AI. The authors are diligent in noting that AI is not a "silver bullet" and indicate that companies looking to benefit from the technological progress need to implement an integrated AI strategy that assesses the possibilities AI brings as well as which capabilities exist internally.

Hartmann et al. (2023) identify five common pitfalls for the implementation of AI, which overlap with several of the areas of uncertainty in radical technological development introduced by Hall & Martin (2005) (described in 3), further cementing their relevance within the domain of emerging technologies and AI. Hartmann et al. (2023) identifies *developing isolate use cases that do not create value for the business* as a key pitfall, highlighting the importance of understanding what the core objective of the firm is and if the proposed solution will contribute to this goal. Here we identify a clear uncertainty in both the organizational as well as the commercial dimension.

Difficulty in scaling use cases from pilot to production and *lacking internal resources and capabilities* are also proposed as a barrier to implementation by Hartmann et al. (2023), who argues that mismanagement of data and lack of experienced talent is a clear antagonist for a successful implementation. These pitfalls relate much more closely to technological and organizational uncertainties, where the viability of technology cannot be asserted before the company has understood how to manage its data resources and acquire the necessary capabilities.

Finally, *investment in AI infrastructure without a clear understanding of use cases* and *implementation of use cases without a maintenance strategy* are raised as barriers to the implementation of AI (Hartmann et al., 2023). Understanding the purpose of investments and aligning company resources to ensure these are maintained post-implementation strongly correlates to the minimization of organizational uncertainties.

2.2 Innovation within the maritime sector

In maritime transport, innovation is positioned as a pivotal force driving the sector forward. The shipping industry, traditionally perceived as conservative (Koukaki & Tei, 2020; Transportation Research Board & National Research Council, 1978), is currently at the cusp of a transformative era driven by technological advancements (Pruyn & van Hassel, 2022). This section delves into previous research on innovation in shipping, grouping barriers and facilitators for innovation processes into areas correlating with the uncertainties presented in section 3.1.

Technological uncertainties, along with their accompanying challenges and opportunities, are a commonly occurring theme in the literature on innovation within the maritime sector. Evidently, the type of innovation impacts to which degree uncertainties relating to the viability of the technology impact a successful implementation. As described by Transportation Research Board & National Research Council (1978), containerization in the US did not experience major challenges relating to technological advancements. As the U.S. Army Transportation Corps pioneered container transportation, once commercial companies recognized its benefits the widespread adoption of this method was not slowed by technological limitations.

This is clear from the numerous patents for containerized vessels submitted to the U.S. Patent Office within a notably short timeframe.

Contrarily, the development of autonomous ships and alternative fuels is defined by technological uncertainties. Overcoming technological challenges has been the overarching theme in the literature on autonomous technologies (Li & Yuen, 2022). For example, Chen et al. (2020) delve into small ship detection as traditional radar-based technology is not sufficient for safe autonomous operations and Utne et al. (2020) investigate how Bayesian Belief Networks, probabilistic models representing uncertain relationships using conditional probabilities, can be utilized to generate risk models. The maritime sector is and has been reliant on crude oil and natural gas for its fuel needs and a transition towards sustainable fuels is necessary (Foretich et al., 2021; Rony et al., 2023). This transition is a cross-sectoral challenge, however, the technological uncertainties the maritime industry faces are distinct from e.g. the vehicle industry. For example, the low mass and volumetric density of contemporary battery systems makes them unsuitable for deep sea shipping (Wang & Wright, 2021).

Notably, technological opportunities have been identified as an important enabler for digital transformation in the maritime industry. In a comprehensive review of digital transformation drivers and barriers, Tijan et al. (2021) noted that emerging technologies are impacting customer behavior and expectations, which Verhoef et al. (2021) contends stimulates maritime transportation companies to engage in digital transformation. The ability to capture value through the leveraging of large amounts of data is also presented by Tijan et al. (2021) as an important enabler for digital transformation.

Organizational uncertainties in the maritime sector have gained an increased prevalence in research. In a systematic review of maritime innovation, Koukaki & Tei (2020) proposes that there is evidence of swift development within the sector but a lack of organizational capabilities acts as a key barrier. This view contrasts the more common notion of the maritime sector as a traditional and conservative industry; rather than being opposed to innovation shipping operators are not capable of achieving their objectives.

Conservatism in the shipping industry is however a well-established barrier. Transportation Research Board & National Research Council (1978) highlights how achieving safety onboard is one of the key objectives of captains and traditionally management of maritime operators has chosen to promote internally, inheriting this risk-averse view into the executive suite. The significant capital investments required to build new vessels are also mentioned as a factor contributing to conservative management approaches (Transportation Research Board & National Research Council, 1978).

Tijan et al. (2021) also identifies several barriers relating to organizational uncertainties. Notably, both conservative management and lack of capabilities within the labor force are among the most cited barriers, indicating validity to the contradicting viewpoints raised in the previous paragraph. Tijan et al. (2021) also notes a lack of vision, strategy, and an absence of awareness of digital technologies act as important barriers to aligning innovation with the goals of an organization.

Operating in a highly variable market dynamic, the maritime industry faces significant commercial uncertainties. Chief among them stands the significant investment costs facing shipowners and operators (Stavroulakis & Papadimitriou, 2022). Stavroulakis & Papadimitriou (2022) identifies the high investment costs relating to shipbuilding as barriers towards innovation, 70% of which stems from material and labor costs, but notably also the impact of investments in infrastructure required to keep up with market changes.

Tijan et al. (2021) notes high investment and implementation costs specifically relating to emerging technologies as a barrier towards innovation in the maritime industry. Furthermore, the uncertainty in the return on investments when allocating capital to digital transformation is also perceived as an inhibitor to innovation (Agrawal et al., 2019). This hesitancy to invest heavily in new technologies stems from the lack of clear and immediate benefits, combined with the rapid pace of technological evolution which may render current investments obsolete in a short period (McKinsey & Company, 2013).

Contrarily, commercial aspects have also been identified as enablers for emerging technologies. In particular, innovations that can help organizations reduce the cost of information sharing and transaction execution were noted by Iddris (2018) as robust drivers of digital transformation.

Closely linked to the high costs of shipbuilding is the variability in shipping rates, which increases the commercial uncertainties facing the maritime industry. In an industry report by McKinsey & Company (2013), shifting demand dynamics and a reliance on the price of crude oil not deteriorating are mentioned as commercial barriers facing shipowners looking to invest in a new generation of vessels.

As documented by Transportation Research Board & National Research Council (1978), the development and adoption of new technologies are highly dependent on interactions across a multitude of stakeholders, with barriers and enablers relating to a social dynamic emerging. One of the primary barriers to innovation was the misalignment of stakeholder objectives. In the early phases of containerization, for instance, the goals of the military, which initially adopted this method, were vastly different from those of the commercial shipping sector (Transportation Research Board & National Research Council, 1978). The military was focused on the secure and timely transportation of goods for strategic purposes, rather than on the economic efficiencies that were crucial to commercial shippers. This misalignment created a significant gap between the development of a technology and its practical application in a commercial context.

Another barrier came in the form of regulatory challenges. The absence of industry-specific guidelines often left companies uncertain about strategic decisions, particularly regarding what aspects of their operations to transform first (Transportation Research Board & National Research Council, 1978). Moreover, the differing regulations across countries posed a significant hurdle to the widespread adoption of new technologies or business models, complicating the path of innovation. The importance of regulatory intervention for technological development, specifically regarding sustainable innovations, is also raised by Börjesson et al. (2021). Governments and policy changes can decide the course of the industry and induce innovation processes from industry actors to comply with regulations.

Additionally, resistance from labor unions, especially in sectors like maritime shipping, represented a significant obstacle. As seen during the shift to containerization, unions were initially opposed to this change due to concerns over potential job losses (Transportation Research Board & National Research Council, 1978). In a more contemporary context, Brunila et al. (2021) also identifies labor unions as a likely antagonist towards the implementation of more autonomous systems in port operations.

Conversely, certain factors acted as enablers of innovation. Regulatory support and standardization, for instance, played a crucial role. The standardization of container sizes by governmental and regulatory bodies eventually facilitated the adoption of container shipping, aligning the method with broader industry needs (Transportation Research Board & National Research Council, 1978). However, this standardization also presented challenges, particularly for early adopters who had invested in different sizes of containers. Tijan et al. (2021) also identifies regulatory requirements as a commonly identified enabler of innovation, specifically policies aiming to achieve "green" transportation technology.

Furthermore, negotiations and compromises with resistant stakeholders, such as labor unions in the maritime sector, proved essential. By addressing the concerns of these groups and finding a middle ground, it was possible to advance innovations while balancing different interests (Transportation Research Board & National Research Council, 1978). Although these compromises sometimes meant limiting the potential benefits of the innovation, they were crucial in ensuring its broader acceptance and implementation.

3

Theory

This chapter introduces innovation from a theoretical perspective, including the traditional view of Schumpeter as well as more contemporary systematic frameworks. Subsequently, the identified frameworks for innovation management are applied to the context of this thesis.

3.1 Innovation from a theoretical perspective

The study of innovation has persistently engaged academics, industry leaders, and policymakers, progressing through diverse interpretations that have markedly influenced the administration of new ideas and technologies. This progression reflects a shift from Schumpeter's foundational view to a detailed, process-oriented understanding that acknowledges the complexities of today's innovation.

Joseph A. Schumpeter, a foundational figure in innovation theory, presented an economic development model emphasizing the entrepreneurial role and the concept of "creative destruction" (Schumpeter, 1942). His theory asserted that innovation results from recombining existing resources, which may lead to new products, methods, markets, supply sources, or organizational structures, with the entrepreneur as the pivotal agent of change (Schumpeter, 1934).

However, the 20^{th} century witnessed the evolution of Schumpeter's model into a more complex, systemic view of innovation. Research identified innovation as not just an individual insight or the product of a singular genius, but a complicated activity encompassing research and development (R&D), collaborative dynamics, and feedback loops between producers and consumers (Kline & Rosenberg, 1986; Lundvall, 1992)

The definition of innovation also expanded to include not only products and processes but also incremental and radical changes, as well as open and user-led innovation (von Hippel, 1988; Chesbrough, 2003). This reflects an acknowledgment that innovation can be either a modest improvement or a radical shift, and may originate from internal organizational processes or through external collaboration.

Contemporary discussions in innovation management strive to merge these diverse views. Current definitions recognize innovation as a multifaceted process that extends beyond the economic and technological to involve social and organizational dimensions (Tidd, 2009). Thus, innovation management entails a variety of practices and strategies that support the creation, evolution, and implementation of new and effective ideas.

The contemporary view of innovation as a complex and multi-dimensional process has gained traction, as evident in the increasingly prominent view of innovation from a systems perspective in academia and policy-making (Bergek et al., 2008). An *Innovation System* encompasses various actors, networks, and institutions that collectively contribute to the development, diffusion, and utilization of new technology, products, and processes (Bergek et al., 2008). Innovation Systems as an analytical construct can take many forms, such as national (Freeman, 1987), sectoral (Malerba, 2002), and technological (Bergek et al., 2008). However, the focus on actor and institution interaction to impact innovation patterns remains a constant theme.

Bergek et al. (2008) contends that Innovation Systems consist of inter-dependencies that foster synergies that each actor could not achieve in isolation. These elevated returns, achieved through systemic collaboration, are contrasted by the increased complexity of innovation projects comprising multiple actors. Hall & Martin (2005) view innovation and radical technological development as a knowledge quest that requires the reduction of four key uncertainties: *Technological uncertainty*, *Organisational uncertainty*, *Commercial uncertainty*, and *Social uncertainty*. Hall & Martin (2005) highlights that these uncertainties are greater when multiple actors are collaborating and interacting in the development and diffusion process.

To address the greater uncertainties in multidimensional innovation processes, Hall & Martin (2005) proposes an evaluation framework based on stakeholder theory. The authors define the concepts of *stakeholder complexity*, meaning increased complexity in the presence of many interacting stakeholders, and *stakeholder ambiguity*, which refers to when stakeholders have differing or hard-to-identify goals and interests. These concepts are according to Hall & Martin (2005) interrelated with the aforementioned uncertainties:

- **Technological uncertainty** pertains to the proven viability of technology, involving few stakeholders and clear, aligned goals.
- **Organizational uncertainty** examines how technology adoption aligns with a company's goals and capabilities, featuring complex stakeholder dynamics but clear objectives.
- **Commercial uncertainty** assesses the technology's economic value to industrial customers, entailing complex stakeholder interactions with defined expectations.
- **Social uncertainty** addresses the technology's potential disruptions affecting the public and government, characterized by complex and ambiguous stakeholder relationships.

3.2 Theoretical framework

In this section, the theoretical framework is presented. The purpose of a theoretical framework is to ground the research in previously established theory and act as the conduit for an integration of knowledge gathered from multiple sources (Grant & Osanloo, 2014).

The previously introduced sections 2.1 and 2.2, show that the work by Hall & Martin (2005) in identifying four main areas of uncertainty remains relevant to the topic of this thesis. Furthermore, Sections 2.1 and 2.2 have identified barriers and enablers to the innovation process, which will be expanded upon in Chapter 5. Utilizing this extensive set of barriers and enablers, a contextual-analysis approach will be applied to map relevant barriers and enablers for each opportunity identified in section 5 according to the four areas of uncertainty (Svensson, 2021).

With the key uncertainties identified for each opportunity, the stakeholder ambiguity and complexity dimensions will be synthesized according to Hall & Martin (2005). For example, opportunities where multiple barriers relating to social uncertainty have been identified will be considered both more ambiguous and complex from a stakeholder perspective. Contrarily, a problem where only technological challenges have been identified as according to Hall & Martin (2005) less complex and less ambiguous. Furthermore, enables that could reduce social, commercial, organizational, or technological uncertainty would result in lower ambiguity and complexity

As proposed by Hall & Martin (2005), when the degree of stakeholder complexity and ambiguity is low, uncertainty falls and the likelihood of success in the innovation process increases. Consequently, the mapping of complexity and ambiguity will stand as the baseline for a future perspective on which problems are suitable for the exploration of an actor in the shipping industry in the near future. However, the contextual-analysis performed in the mapping of uncertainties can potentially identify barriers so impactful the feasibility of the project drops significantly. Certain technological uncertainties are not complex nor ambiguous but lacking internal capabilities and commercial incentives will render the project obsolete. This extended analysis will be conducted in Chapter 7, based on the findings in Chapter 5.

An exemplification of the mapping of key barriers and enablers, how they relate to the four areas of uncertainties, and the resulting stakeholder complexity and ambiguity is conducted in appendix A, using the containerization process described by Transportation Research Board & National Research Council (1978).

3.3 Synthesizing uncertainties into a stakeholder framework

Hall & Martin (2005) propose a clear description of how the four areas of uncertainty relate to stakeholder complexity and ambiguity. Applying what is mentioned in

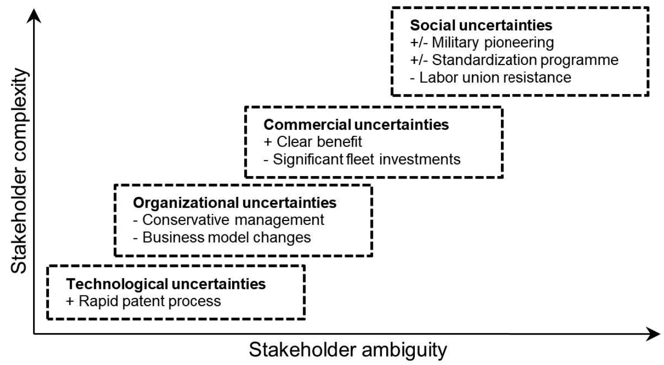

Figure 3.1: Distribution of uncertainties for the containerization process as they relate to stakeholder complexity and ambiguity

Chapter 2 and Chapter 5 the following version of Hall & Martin (2005) framework emerges:

- **Technological uncertainty** implies a low degree of complexity and ambiguity
- **Organizational uncertainty** entails moderate stakeholder complexity and moderate ambiguity
- **Commercial uncertainty** indicates a high degree of complexity and ambiguity ambiguity
- **Social uncertainty** indicates the highest degree of both complexity and ambiguity

Given the uncertainties relating to internal goal alignment within the maritime sector identified in the empirical study performed in this thesis, the stakeholder ambiguity relating to organizational uncertainties has been slightly increased compared to what Hall & Martin (2005) proposes. Furthermore, Hall & Martin (2005) views commercial uncertainties in the industrial context as a straightforward peer-to-peer process. Given the complex nature of tanker shipping, as identified in Chapter 5, where multiple commercial stakeholders (such as ports, towage operators, etc.) have to be considered in the day-to-day operations the commercial ambiguity and complexity have been considered materially higher.

Synthesizing Appendix A, the containerization process showed: low degrees of technological uncertainty, indications of impact from organizational and commercial uncertainties, and high degrees of social uncertainties. Considering only the technological, commercial, and organizational uncertainties, the containerization process could be argued to be somewhat complex but with low degrees of complexity. However, the notable social uncertainties suggest that the process was highly complex and ambiguous.

The eventual success of the containerization process, as detailed by Transportation

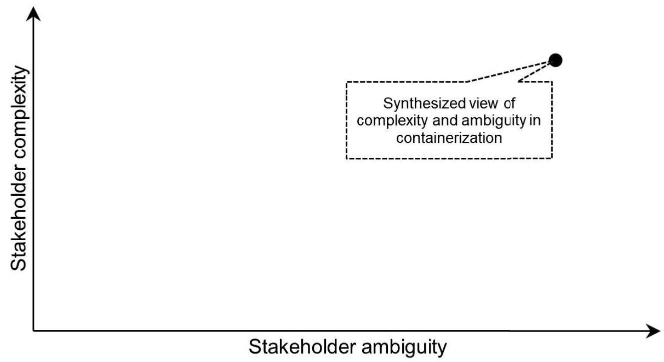

Figure 3.2: Integration of uncertainties into a relative measure of complexity and ambiguity

Research Board & National Research Council (1978), can be attributed to various interventions by the government, standardization authorities, and commercially driven strategies aimed at mitigating this complexity and ambiguity.

4

Research Methodology

To achieve a deep understanding of the challenges that face the tanker shipping industry, this thesis employed a comprehensive case study approach. The case subject was Stena Bulk, a key actor in the global tanker shipping space, who also provided access to their customers. Through the lens of the case study methodology, the research was divided into three distinct phases of data collection and analysis.

Firstly, focus group interviews were conducted with employees at Stena Bulk as well as their customers, from multiple functions and with differing levels of experience. This phase aimed to provide an in-depth context of the real-world challenges faced by actors in the tanker shipping industry, and which opportunities these challenges presented to an innovator.

The second phase aimed to leverage the knowledge of subject matter experts to assess the potential for AI to act as a solution to the opportunities presented in phase one. In this phase of the study, a focus group consisting of four subject matter experts was conducted to assess the potential of AI solutions for the opportunities identified in the initial phase. This discussion was split into three sessions over multiple days. The experts used a pre-developed framework to guide their discussions on AI potential, focusing on freedom of interaction and exploration of alternative solutions. The output generated consisted of an assessment of the technological potential and uncertainties relating to AI as the solution for the opportunities presented in phase one.

The third phase involved mapping the data gathered in the first and second phases to the framework relating to assessing emerging technology processes presented in Chapter 3. The objective was to understand which solutions would prove to be most beneficial for Stena Bulk to pursue internally, or in collaboration with other stakeholders.

An overview of the phases and subsequent research objectives pursued is presented in Table 4.1. This chapter continues with an overview of the case study methodology, followed by sections on sampling, data collection, and data analysis.

Phase	Research objective	Data collection/analysis
1.	Identify tanker shipping opportunities	Case subject and customer focus groups
2.	Assess AI solutions	Subject Matter Experts focus groups
3.	Map opportunities to innovation process framework	Thematic analysis of data gathered

Table 4.1: Research methodology overview

4.1 Overview of case study methodology

The case study methodology offers a comprehensive means of examining specific instances to gain a deeper understanding of complex phenomena within their natural settings (Yin, 2014). This methodology allows researchers to explore the unique attributes, dynamics, and interactions within a specific context, facilitating the extraction of valuable insights.

In this section, we will delve into the fundamental principles and key characteristics of the case study method and introduce the case study subject.

4.1.1 Overview of case study methodology

Yin (2014) defines a case study as "an empirical inquiry that

- investigates a contemporary phenomenon (the 'case') in depth and within its real-world context, especially when
- the boundaries between phenomenon and context may not be evidently clear."

In other words, a case study investigates real-world cases where specific contextual conditions are likely to impact the result of the research. As the aim of this thesis is to identify opportunities, barriers, and enablers for the implementation of AI solutions (the "phenomenon") in the tanker shipping industry (the "context") the case study methodology is deemed highly applicable.

Furthermore, Yin (2014) contends that the case study is suitable in a high-dimensional environment, where the variables and features of the inquiry will supersede the number of data points. Yin (2014) introduces a set of methodological characteristics, aimed at alleviating the challenges related to this aforementioned high-dimensional environment. Firstly, the case study methodology relies on "multiple sources of evidence" and "benefits from prior development of theoretical propositions to guide data collection and analysis" (Yin, 2014).

As the aim and context of this thesis is distinctly high-dimensional, the magnitude of variables that could influence the final result becomes unmanageable without imposing strict boundaries. Thus, this thesis aims to leverage the methodological characteristics of the case study to reduce the high-dimensional variable environment through a robust theoretical framework and multiple sources of data collection.

Having established the case study as a suitable methodological framework, it is necessary to *define* and *bound* the case study (Yin, 2014). After defining the case through distinct research questions in Section 1.3.1, the "tanker shipping operators" are presented as the case study topic.

Having bounded the case study to a limited set of tanker shipping operators, Yin (2014) proposes that access to key data is instrumental in the case study research, and subjects should be chosen accordingly. Thus, given the level of access provided, Stena Bulk and its key customers have been chosen as the sole representation of the tanker shipping industry in this thesis. Section 4.1.2 provides further insight into Stena Bulk as a company and as a case study subject.

4.1.2 Introduction to Stena Bulk

As a global operator, Stena Bulk has offices in five countries: Sweden, USA, Denmark, United Arab Emirates and Singapore. Stena Bulk has 95 shore-based employees, 300 onboard-based employees, and 64 vessels (Stena Bulk, nd). The company, which transports commodities for major oil and chemical companies, as well as independent trading houses, is divided into three different segments; dirty (crude oils), clean (vegetable oils and refined petroleum products), and Liquid Natural Gas. Trading both through contracts and on a global spot market, price, quality, and safety are of the highest importance in all aspects, ranging from vessel design to execution.

Stena Bulk has stated that its purpose is to help ensure that every economy and nation has access to the energy and resources it needs to survive, evolve, and thrive. To achieve this, the company has a vision to be customers' first choice for safe, dependable, innovative, and sustainable solutions that result in financial growth for the company and contribute to a better world for future generations (Stena Bulk, nd).

Thus, Stena Bulk has already begun its strategic realignment to provide energy to the world in a sustainable way, while still being financially profitable. Erik Hånell, President and CEO of Stena Bulk, has stated, “As a company, we strive to be a first mover by sending out positive messages that new advanced fuels, as well as technological energy efficiency advancements, are available today”.

To actively work towards achieving its targets and objectives, Stena Bulk focuses on implementing operational, behavioral, commercial, and technical measures. Subsequently, innovation and performance have been two of the key pillars within the company’s current strategy (Stena Bulk, nd).

As a subject for the case study focused on emerging technologies within the tanker shipping industry, Stena Bulk is a well-placed collaborator. Operating across multiple continents, in all the relevant market sections, Stena Bulk acts as a serviceable proxy for the industry as a whole. Furthermore, with an expressed strategic interest in emerging technology and innovation, there are relevant functions and personnel to interview, and relevant collaboration chains with key customers is being established.

4.2 Sampling

Sampling is a key aspect of focus group research, determining who participates and directly influencing the quality of collected insights. Employing well-defined criteria for participant selection is essential to ensure that the focus group discussions yield representative and valuable data.

In this section, we explore the over-arching methodology used to select participants for our focus groups, *purposive sampling*. Subsequently, we present the specific criteria used to select participants for the two phases of focus groups.

4.2.1 Overview of purposive sampling

Bell et al. (2022) describes purposive sampling as a strategic, non-stochastic, approach to selecting research participants who are relevant to the research question. The approach is suitable when a variety in the resulting sample is required. Furthermore, purposive sampling is explicitly mentioned as a common methodology in business research to "gain insight into a wide range of roles within an organization" (Bell et al., 2022).

Further delimitation can be done between *sequential* and *non-sequential* approaches, meaning participants are selected in an iterative process or a population is selected at the outset of the research respectively (Bell et al., 2022). In this thesis, a non-sequential purposive sampling was employed, as selecting participants with relevant experience is crucial for addressing the research questions and the criteria for who is to be considered relevant is of a static nature.

The non-sequential purposive sampling approach was employed when selecting participants for both the Phase 1 and Phase 2 focus groups. However, as there are differences in both the execution and purpose of the focus groups the type of purposive sampling differed. The specific approach that is selected for each type of focus group is described in Sections 4.2.2 and 4.2.3.

Worth noting is that a purposive sampling approach will impact the generalization of the findings (Bell et al., 2022), the implications of which are expanded upon in Section4.5.

4.2.2 Sampling for problem identification focus groups

As the aim of the problem identification focus groups was to identify real-world challenges the tanker shipping industry is facing and how these can become opportunities through the leveraging of AI, individuals from different functions and geographic business areas within Stena Bulk and its key customers were invited to participate in the focus groups. The participants were selected as "representatives" for their function and customer segments, as described in the *stratified* purposive sampling approach mentioned by Bell et al. (2022).

Specifically, participants from 6 functions, 5 geographies, and 2 customer companies (who are to be represented by 2 different functions) were invited. This sampling covers the larger areas of the tanker shipping operator value chain such as chartering and operations, but is also supplemented with input from functions such as naval architects to gain a holistic perspective when defining problems. The thesis does not aim to provide a geographically generalizable set of problems, but expanding the sampling of participants to include personnel from most of Stena Bulk's areas of operation was deemed non-superfluous as each business area faces its own set of idiosyncratic challenges proved to be relevant to the research questions.

Furthermore, participants from various organizational levels were invited to ensure a broader range of perspectives on potential issues. A detailed breakdown of the problem identification focus groups is presented in Table 4.2.

4.2.3 Sampling for subject matter expert focus groups

The subject matter expert focus group aims to provide an analysis of the technological potential and uncertainties related to the set of opportunities generated by previous focus groups, which requires less diversity in the background of the participants. Instead, ensuring that the participants had relevant experience and knowledge became paramount. This prompted the shift from a stratified sampling approach to a *snowball* approach. In the snowball methodology, researchers initially select a small sample of participants, who are subsequently requested to identify additional participants possessing the relevant experiences and characteristics relevant to the research questions. (Bell et al., 2022).

In this thesis, one researcher within the field of digital innovation was asked to identify colleagues with experience in the implementation of emerging technologies or artificial intelligence in general. The set of participants generated by the initial researchers formed the subject matter expert focus group.

4.3 Data Collection

To understand the challenges facing the tanker shipping industry, and to identify potential AI-driven solutions, two phases of *focus groups* was conducted. This section introduces the concept of focus groups and describes the execution of the two data collection phases in detail.

4.3.1 Focus groups

Morgan (1997) describes focus groups as a research technique in which data is gathered through group interactions on a topic defined by the researcher. The distinction between group interviews, focus groups, and other similar research methodologies is not well defined, however, one key distinction of the focus group is the emphasis on group interaction on a topic (Bell et al., 2022; Morgan, 1997).

The focus group interview is typically conducted in an unstructured manner, where the participants are given a higher degree of freedom to discuss relevant topics and issues compared to what is typically seen in interview settings (Bell et al., 2022). The unstructured setting combined with the group interaction also leads to interviewees sometimes being challenged on their statements, a dynamic not typically seen in researcher-led interviews, which arguably allows the researcher to gain more realistic accounts of the topic at hand (Morgan, 1997; Bell et al., 2022).

The focus group methodology also stands out as one of the more efficient approaches to qualitative data collection, the cost-benefit for one focus group is often viewed as substantially better than the equivalent number of interviews (Morgan, 1997; Bell et al., 2022). This rapid data collection does however impose certain issues in regards to the analysis of the data. As significant amounts of raw data can be generated in a short period of time, the researchers need to be prudent in deciding how many focus group sessions are necessary for answering the research questions, to avoid an unmanageable workload once the data analysis starts. The number of sessions to be conducted during this thesis is presented in Sections 4.3.1.1 and 4.3.1.2.

This set of traits has led to focus groups becoming a common methodology for researchers looking to define and assess problems (Hutt, 1979). As this thesis aimed to both define problems and identify opportunities, whilst remaining bound to the real-world challenges facing the actors currently operating in the tanker shipping industry, the focus group methodology stood out as an advantageous choice for data collection.

Important to note is that the open-ended nature of the focus group does put additional requirements on the moderator, the person conducting the focus group, as the participants have to be able to be given the freedom to discuss the topic whilst remaining within the boundaries of the research questions (Morgan, 1997). This thesis aimed to strike a balance between openness and topic adherence by using carefully designed interview materials and thoughtful moderator conduct. The focus groups were conducted through the introduction of the topic at hand (defining problems in phase one and assessing the AI potential of opportunities in phase two) and by proposing open-ended questions relating to this. The aim was then for the discussion to flow freely without the interjection of the moderator. However, when problems of adhering to the boundaries of the topic occurred or the discussion dried up quickly, handouts with examples of areas to discuss that had been prepared in advance were provided.

Furthermore, one of the key limitations of the focus group is the problem with different degrees of involvement in discussions from different participants (Bell et al., 2022). As the focus groups that were conducted in phase one involved participants from different hierarchical levels within the subject company, this issue was accentuated. To mitigate these issues, a certain degree of moderator involvement became necessary. As proposed by Morgan (1997), this limitation can sometimes be accepted as a trade-off for achieving greater variety in the participant sample, which is the view taken in this thesis.

There are additional considerations to make regarding the number of participants in each focus group as well as the number of sessions to be conducted, which are detailed in Sections 4.3.1.1 and 4.3.1.2

4.3.1.1 Opportunity Identification focus groups

The ideal number of participants in a focus group session is a contended topic (Bell et al., 2022), even differing opinions in defining the minimum number of participants can be observed (Morgan, 1997). Instead of focusing on a strict number of participants, Bell et al. (2022) suggest deciding the ideal number of participants depending on the desired group dynamics. Fewer participants are conducive to topics on which the participants are expected to provide a high degree of insight, whilst larger groups are preferred when multiple answers are considered better than in-depth discussions.

As phase one of the thesis aimed to unveil problems that involved a high degree of complexity, smaller groups of participants were preferred. However, to achieve a notable degree of width, highlighting the presence of diverse viewpoints and varying levels of consensus, certain sessions had to include more participants than others, due to them being viewed as knowledgeable on the topic discussed. Thus, the number of participants in each session ranged from 3 to 6. For additional insight into how the number of focus groups that were to be conducted was decided, see Section 4.2.2.

Provided in Table 4.2 is an outline of the focus groups that were conducted in relation to the identification of opportunities in the tanker shipping industry.

Function	Geography	Internal/ External	# of participants
Business development	Gothenburg	Internal	5
Operations	Gothenburg	Internal	4
Bunker	Gothenburg	Internal	3
Operations	Copenhagen	Internal	5
Chartering	Copenhagen	Internal	3
Mixed group	Dubai	Internal	4
Naval architects	Gothenburg	External	4
Technical management	Scotland	External	8
Business development	London	Customer 1	3
Business development	London	Customer 2	3

Table 4.2: Opportunity identification focus groups (see Terminology List for an explanation of group roles and responsibilities)

4.3.1.2 Subject Matter Expert focus groups

As the second phase of the study involved assessing the potential for AI as a solution to the set of opportunities proposed in the initial phase, the complexity and depth of discussion was considered high. As per Section 4.3.1.1, this is conducive to a smaller number of participants. Thus, the focus group in phase two involved 4 subject matter experts, who were given significant amounts of liberty to discuss the complexity of different opportunities and provide suitable recommendations. Given the complex nature of the topic and the large set of opportunities that were to be assessed, the focus group was split into 3 different sessions over multiple days. However, given that the participants and topic at hand did not change between sessions it will be referred to as a continuous session henceforth.

In this focus group session, the methodology with an initial subject introduction and supporting handouts, as proposed in Section 4.3.1, was used. However, as dynamic interaction between participants and the freedom to explore alternative solution paths was highly preferred, the involvement of the moderator was reduced even further. The participants had also been requested to develop a framework to assess the potential for AI as a solution beforehand. This framework served as the basis for discussion, and is further described in Section 4.4.3.

For insight into how the participants for the phase two focus group were selected, see Section 4.2.3.

4.4 Data Analysis

In this section, the approach to data analysis for this thesis is outlined. It begins with an introduction to thematic analysis, establishing the foundational framework for our analysis. This is followed by a detailed explanation of how thematic analysis was utilized in identifying AI-related opportunities from the focus group data. Subsequently, the methodology used by the subject matter experts to assess technological uncertainties associated with these opportunities is described. Lastly, the process of integrating these various data streams into a cohesive analysis framework, which is further elaborated in Chapter 3, is explained.

4.4.1 Introduction to thematic analysis

Thematic analysis is a widely used qualitative research method that offers flexibility and accessibility, particularly beneficial for those new to qualitative research. Unlike methods such as Grounded Theory or Discourse Analysis, thematic analysis does not require extensive theoretical or technical knowledge, making it a more accessible form of analysis (Braun & Clarke, 2006).

One of its key strengths is its theoretical freedom, allowing researchers to apply it within various theoretical frameworks. This versatility means that thematic analysis can be adapted to suit different research questions and objectives. It involves identifying, analyzing, and reporting patterns or themes within data, which enables a rich and detailed understanding of the data (Braun & Clarke, 2006). However, as noted by Braun & Clarke (2006) it's important to recognize that this process is not just a passive discovery of themes that 'emerge' from the data. Instead, it involves an active role where the researcher identifies patterns or themes, decides which are of interest, and reports them. This active involvement challenges the notion that themes simply 'reside' in the data waiting to be uncovered.

Thematic analysis can be approached in two main ways: inductive or theoretical (Braun & Clarke, 2006). Inductive thematic analysis is data-driven, meaning the themes identified are strongly linked to the data itself without trying to fit into a pre-existing coding frame or theoretical interest. In contrast, a theoretical thematic analysis is driven by the researcher's theoretical or analytic interests in the area. This approach tends to provide a more detailed analysis of certain aspects of the data, as opposed to a rich description of the data as a whole (Braun & Clarke, 2006).

As described by Braun & Clarke (2006), thematic analysis is a meticulous and structured approach to qualitative data analysis, beginning with a deep immersion in the data through activities like transcribing, reading, and re-reading. This familiarity helps in systematically coding interesting features across the dataset. The process then advances to organizing these codes into potential themes, each reflecting a patterned response within the data (Braun & Clarke, 2006). A crucial part of the analysis is reviewing these themes to ensure they accurately reflect the coded extracts and fit cohesively within the entire dataset. This step may involve the creation of a thematic map, providing a visual representation of the interconnections between themes. The analysis continues with defining and naming the themes, refining their specifics to accurately represent the data (Braun & Clarke, 2006). The final stage involves crafting a compelling narrative for the report, which includes finalizing the analysis of extracts and relating the findings to the original research question and literature Braun & Clarke (2006). Each stage in this process ensures a thorough and nuanced interpretation of the qualitative data.

4.4.2 Thematic analysis to identify AI opportunities

This thesis has employed thematic analysis to identify opportunities for applying AI in the shipping industry. This process was critical in synthesizing a vast amount of data collected from various sources, primarily focus groups and literature studies, into actionable insights.

The thematic analysis began by aggregating data from focus groups, which included both internal stakeholders and external customers with expertise in shipping. These discussions provided a wealth of raw data, offering insights into the challenges and opportunities facing the industry. Participants not only highlighted potential areas where AI could be leveraged but also discussed various barriers and facilitators to innovation within the shipping sector. (further described in Section 4.3).

To enrich and supplement the findings from these focus groups, a comprehensive literature study was conducted. This study played a pivotal role in further identifying barriers to innovation and facilitators that could aid in the integration of AI technologies in shipping processes (further described in Chapter 2).

The thematic analysis was structured to build upon this foundation of collected data. The primary aim was to distill the large volumes of qualitative data into a manageable number of themes that accurately represented the views and insights from the focus groups. This was essential to ensure that the synthesized opportunities and challenges were reflective of the industry's actual needs and perspectives.

The codification process was conducted in three distinct phases. In the first phase, a comprehensive set of issues and problems mentioned during the sessions was developed. This set of challenges was then clustered based on similarities in operational areas and proposed solutions, leading to the emergence of a set of higher-level opportunities. In the final phase, this new set of opportunities was further synthesized, focusing on the nature of the data that focus group participants deemed necessary to achieve the desired outcomes. This synthesis led to a further refinement of opportunities, emphasizing those that would derive their utility from the same data sources and target similar operational areas.

A key aspect of the thematic analysis was achieving data saturation. This meant that the process continued until no new themes or insights were emerging from the data, ensuring a comprehensive understanding of the topics discussed (Ando &

Young, 2014). This saturation was crucial in validating that the thematic analysis covered the breadth and depth of the issues and opportunities identified by the domain experts.

The analysis was conducted post the completion of all focus groups and the literature review. This timing ensured that the thematic analysis was grounded in a complete and diverse set of data, allowing for a more accurate and thorough synthesis of the information.

Through this thematic analysis, the thesis was able to convert a broad and complex array of data into a concise set of AI opportunities in shipping. This not only highlighted key areas for potential AI application but also identified significant barriers and facilitators, providing a clear roadmap for future innovation in the industry.

4.4.3 Subject matter expert input

The second phase of the study involved consultations with experts in digital innovation and AI. This stage focused on assessing how AI could tackle the challenges and opportunities identified earlier. Utilizing a framework developed by the subject matter experts, based on their previous work in the field of AI and innovation implementation and a cursory introduction to the difficulties typically seen in the shipping industry, the technological uncertainties relating to the identified opportunities were analyzed.

Initially, the process involved presenting the opportunities, considering the use case, business context, and technological impact. This helped in understanding the most impactful opportunities and the relative costs associated with addressing them.

Subsequently, the framework developed by the subject matter experts was employed to assess the technological uncertainties and potential. This included evaluating technological aspects such as data accessibility, variable magnitude range, and mapping structure, but also what impact the solution might have on the people in the organization. See Table 4.3 for a comprehensive list of parameters analyzed.

Area	**Parameter**	**Definition**
Data	Variable magnitude	How many different variables are needed?
	Data structure	How well structured is the data? Can you map it out?
	Data Volume	How much data is required to teach the algorithm?
	Volume status	Status of data volume today in relation to what is required to build and test an accurate solution?

Area	Parameter	Definition
	Availability	Do you have the data today?
	Sourcing	If not available, do you know where and how to get it?
	Willingness to share	If it's external data, how much will they be willing to share?
	Challenging to get	How challenging will it be to find it/get it?
	Streamlining	How challenging is it to get all the data needed into one place?
	Data quality	How is the quality of the data?
	Interpretability	Can a person read the data?
Organization	Current status	Is a person already doing it today but it's tedious and time-consuming?
	Solvability	Do you have access to a person that can map out a solution and what needs to be considered?
	Purpose	What is the purpose? To catch things we miss or to replace people? And if to replace, simple tasks or domain experts?
Problem scope	Scope	How well scoped is the problem?
	Output	What is the desired output?
	Nuance	How nuanced is it regarding interpretation or is it only time consuming?
Algorithms	Science status	How far advanced is the science?

Table 4.3: Comprehensive list of parameters assessed by Subject Matter Experts

Other areas discussed during the sessions were process digitalization, physical infrastructure, and existing platforms on the market. However, these related more specifically to the current state of Stena Bulk and whether an opportunity should be pursued in its current state, rather than if it's AI compatible or not.

The output of the discussion with the subject matter experts was a clear assessment of the technological potential and uncertainties related to each of the opportunities identified in phase one of the study.

4.4.4 Data Stream Synthesis for Analysis

The methodology applied in this research extends from the theoretical framework outlined in Chapter 3. This framework necessitates a comprehensive evaluation of various uncertainties: technological, commercial, organizational, and social. The initial phase of this study entailed correlating these uncertainties with the opportunities unearthed in the preliminary stage. Participants, who were domain experts in the maritime industry, contributed significantly to this analysis during phase one focus groups. They offered valuable insights into all categories of uncertainty, with the exception of technological aspects.

In the first phase, we also concentrated on identifying and compiling key barriers, facilitators, and risks associated with the opportunities found in maritime innovation. This was achieved through a combination of focus group discussions and an extensive literature review. The technological insights, however, were predominantly sourced from AI experts in the second phase.

Upon gathering all necessary inputs, we synthesized this diverse data to feed into the theoretical framework. This synthesis enabled a comprehensive analysis, aligning with the methodologies and outcomes detailed in Chapter 3.

During this stage of the study, triangulating data sources emerged as a key strategy. This involved comparing and assessing different viewpoints from focus group discussions and literature reviews. In this process, themes that were previously seen as definitive truths in certain data sources were re-examined from a more critical perspective. This critical review allowed for a more thorough understanding of the themes, providing an opportunity to challenge and rethink previous assumptions. The approach not only enhanced the robustness of the findings but also allowed for a more nuanced insight into the subject of the research.

4.5 Limitations

As the thesis was conducted in collaboration with Stena Bulk AB (Stena Bulk), and several of the interviews were sourced through their contact network, certain limitations emerge.

Firstly, there may be limitations in generalizability, as Stena Bulk and its key clients might face endogenous challenges not shared by others in their industry, or they might prioritize certain problems over others.

Secondly, beyond the intrinsic limitations of collaborating with a single entity, the thesis will be conducted using a qualitative methodology. This methodology implies several limitations relating to sample size, researcher bias, data quality, etc. Further limitations relating to the focus group approach to data collection are discussed in section 4.3.1.

Finally, the thesis aimed to provide an actionable future perspective assessment of potential innovations to Stena Bulk, which entailed limiting the set of potential digital solutions to evaluate. Speculations into the capabilities and potential of emerging technologies beyond the near future will not be attempted.

5
Results

5.1 Opportunities

The following section is based on the challenges faced by Stena Bulk, which have been transformed into opportunities for development. Therefore, the focus is not on the strengths of Stena Bulk, but rather on areas that allow for improvement. It is worth mentioning that significant enhancements have been made, and considerable work and effort have already been invested in data collection, storage, and utilization. However, some challenges still remain.

Stena Bulk, despite having access to a wealth of data covering various operational aspects, sometimes faces hurdles in efficiently managing and utilizing this information. The company is today to a high degree reliant on the experience and intuition of their employees, and the information has previously rather been stored in their heads than in systems. Consequently, there are challenges with inefficient storage, access, and retrieval processes. Nevertheless, progress has been made moving towards improved data storage and utilization as a supplement the human knowledge. However, this has resulted in multiple, uncoordinated platforms, leading to redundant reporting and a significant risk of data inconsistency. A notable issue is the limitation of sensor data to individual ships, limiting its broader utility over the fleet. Furthermore, the data storage, retrieval logging, and tracing was described as ad hoc, lacking a systematic and streamlined method. This overarching issue complicates the comparison and analysis of information, in addition to a deficiency in traceability and risking the loss of crucial data.

The manual nature of data extraction and utilization is another critical challenge. Navigating through diverse sources like email correspondence and voyage reports is time-consuming and error-prone, hindering the ability to derive insights from historical data effectively and sometimes leads to difficulties in accessing vital information. Hence, the current state of data management does not guarantee data quality, with manual corrections often needed to address inaccuracies. This lack of reliability in data quality impacts decision-making processes, as flawed data may lead to erroneous conclusions.

These data management-related challenges have resulted in an environment where a reluctance towards data-driven decision-making has emerged for some individuals. Despite the recognition of the need for data-driven decisions, which facilitate informed and objective choices, the existing challenges and limited resources hinder this realization, often leading to reliance on intuition or bias only that may be less effective. Furthermore, the lack of assigned capacity for data management exacerbates the challenge, diverting resources from fully capitalizing on data insights.

Traditionally, the shipping industry's focus was on the vessels one owned, but a shift is anticipated, with emphasis transitioning to individuals and the data they possess. This shift calls for an overhaul of the current data landscape, aiming for a more organized, reliable, and integrated system. Such a system would centralize all data, streamline processes, and ensure data quality, ultimately enhancing decision-making and operational efficiency.

This section outlines the specific opportunities Stena Bulk aims to address using artificial intelligence and enhanced data management. These opportunities were identified by a diverse group of study participants, from multiple business areas and geographies. The results are categorized into nine key areas. First, 'what' describes the nature of the opportunity. Second, 'why' explains the potential gains. Third, 'how' details the focus group's envisioned solutions. Fourth, 'where' considers the relevance of these opportunities for other actors. Fifth, 'when' assesses the urgency of pursuing these opportunities. Sixth, 'who' identifies the stakeholders needed for alignment. Seventh, 'information source' specifies the data sources for AI solutions. Eighth, 'core business' examines the relation of these opportunities to Stena's core activities. Finally, 'Focus groups' highlights the focus groups that identified these opportunities.

5.1.1 Document handling

I spend so much time either chasing documents or reviewing them. A dream would be to have everything in one place, that can connect documents, contracts and e-mails, and let me know if we comply or not, scans everything for me and automatically complete the manual reports I need to put together everyday.

Operations, Copenhagen

What? Presently, the prevalent use of physical documents necessitates stamps and signatures. The manual scrutiny of these documents for compliance is time-consuming and carries the risk of oversight. Moreover, making changes later or addressing issues such as missing stamps proves to be burdensome and time-intensive.

Furthermore, at present, each charterer follows their standard contract, with subsequent negotiations by Stena Bulk. The resulting charter party agreements and recaps are archived in email correspondences, adopting diverse formats like PDFs, Word documents, or scanned copies, occasionally presenting readability challenges and limiting analysis opportunities. The extensive length of these contracts makes the manual review inefficient, exacerbating the cumbersome process of comparing contracts and their respective clauses.

Consequently, in conjunction with lacking a structured feedback mechanism from the claims team regarding actual outcomes of clauses, suboptimal clauses can be included with disadvantageous outcomes, and some clauses can be overlooked. Moreover, the inefficiency in sharing legal advice from external sources across multiple offices increases the likelihood of repeated inquiries, resulting in additional costs. Additionally, the contracts require manual calculations of dates and consideration of specific calendar intricacies, adding to the manual effort in inputting this information.

Following the completion of a voyage, a manual analysis of related documents is necessary to evaluate the voyage's performance and identify potential claim opportunities. This manual process, currently reliant on a claims worksheet, introduces the risk of oversight, leading to potential financial losses. Internal sharing of this information in various formats further consumes operational time.

Additionally, the negotiation of claims could benefit from insights gained through past disputes, but this presently involves sifting through email correspondences. Moreover, the current manual process of comparing received invoices with charter party details to determine whether Stena Bulk or the charterer is responsible adds to the time-consuming and risk-prone nature, potentially incurring additional costs.

Why?

In the shipping industry, contracts pose a persistent challenge, primarily due to their cumbersome physical format. Stena Bulk faces challenges in efficiently incorporating clauses within charter parties, post-voyage analysis for identifying potential claims, and the completion of various documents in an optimal way, such as Statements of Facts. These hurdles expose the company to financial risks and vulnerabilities.

The envisioned outcome involves diminishing financial losses attributed to suboptimal clauses and analysis, bolstering risk management practices, and achieving heightened efficiency to enhance transparency while reducing time. As an example, ensuring that captains include pertinent information in the Statement of Facts (SOF) can result in demurrage savings of up to 200,000 USD annually for the Suezmax segment, as indicated by a recent study internally at Stena Bulk.

How? The value will be realized through the implementation of the "legal buddy", which includes automated creation of a knowledge bank, integration of dispute resolution information, establishment of a feedback mechanism, comprehensive research in email correspondence and contracts, comparative analysis, unbiased interpretation, and enhanced search capabilities. Subsequently to developing and implementing the "legal buddy" system, integrating it into the contract negotiation and analysis processes, and ensuring seamless adoption by relevant teams is crucial.

Where? The problem is most likely not unique to Stena Bulk, as it involves common issues in contractual language, disputes, and inefficiencies. The solution could potentially be applicable across the shipping industry but also other industries, and marketed to other companies facing similar challenges.

When? The urgency is implicit in the daily financial losses experienced by Stena Bulk. However, while acknowledging that changes may be unfeasible in a weak market, having the "legal buddy" during prosperous conditions as per today's market could lead to substantial long-term cost savings. However, building a solution today carries the risk of becoming obsolete if the industry moves from physical contracts to e.g., digital ones utilizing blockchain. Thus, it is important to introduce flexibility with the possibility to be adapted.

Who? Addressing this issue is more of an internal matter that Stena Bulk must resolve within the company, rather than collaborating with external parties to find a solution. Key stakeholders involved would likely include the chartering team, operations teams and claims teams.

Information source: To establish a comprehensive knowledge bank for the solution, access to historical charter parties (or other contracts desired to analyze like Terms of Sale), data on past disputes (including financial losses and historical negotiation details), email correspondence, and operational information stored in Orbit. Additionally, the inclusion of claims worksheets, Statements of Facts, and relevant intermediates is essential for a thorough analysis.

Core business? Implementing the "legal buddy" aligns with Stena Bulk's core business by potentially reducing financial losses, improving risk management, and enhancing efficiency.

Focus groups: Operations (Gothenburg and Copenhagen), chartering (Copenhagen), mix (Dubai)

5.1.2 Digital Twins

In shipping, we lack a systematically calculated baseline for consumption, we are relying on rough estimates which makes it impossible to define any savings or to optimize our operations.

Business Development, Gothenburg

What? Presently, ship comparisons and investment analyses rely on manually and arbitrarily calculated speed and consumption curves. These calculations involve rough estimations, such as assuming uniform consumption for each knot irrespective of weather conditions. Moreover, Stena Bulk currently adheres to a constant speed of 12 knots, which may not be optimal in specific weather conditions. Adjusting the speed, either slower or faster based on optimal engine RPM, could prove more efficient. Determining when to conduct hull cleanings is also arbitrarily assessed based on triggers, constituting manual processes.

Furthermore, investments and critical decisions hinge on these speed and consumption curves. Following an investment, attempts are made manually to identify the savings achieved by assessing the difference in average consumption throughout the year and comparing it with other ships. However, this approach overlooks various external factors that can impact the results.

Why? Given the global operations of Stena Bulk, accurately pinpointing and understanding the precise factors influencing consumption proves challenging. Variables such as weather, hull condition, trading patterns, speed, and crew behavior add layers of complexity. This lack of standardization makes it difficult to compare the performance of ships, hindering the accurate definition and evaluation of the impact of investments.

Furthermore, performance-improving technologies often undergo testing in ideal and isolated conditions, casting doubts on their real-world effectiveness. Digital twins offer a solution by establishing a baseline that excludes these multifaceted factors. This enables the identification of the true impact of investments and facilitates the calculation of their payback time, ensuring that potentially lacking investments are not rolled out fleet-wide due to inaccuracies in interpretation.

Additionally, digital twins enhance real-time vessel performance monitoring and provide actionable recommendations, reducing the need for manual data analysis. Thus, by implementing changes in behavior to optimize consumption, which is a significant cost for Stena Bulk and thus a primary focus area, becomes more feasible. For instance, suppliers of existing digital twins have claimed savings in consumption between 3-12 percentages from speed and route optimization, which is equal to about 1-2mt bunker fuel per day. With a cost of 700 USD per ton, and with a fleet size of 50 ships, about 13 million USD can be saved per year. Moreover, when contemplating adjustments, such as changes in constant speed to RPM, digital twins can serve as a valuable tool to demonstrate the advantages and persuade charterers. Therefore, digital twins present endless possibilities once a reliable baseline is established.

How?

By leveraging sensor data, information collected from real-world instruments and detectors installed on the ship, digital twins could provide a comprehensive insight into the actual consumption patterns of ships, eliminating the influence of various factors. This capability facilitates voyage simulation and performance predictions by manipulating isolated variables like speed or route, and further can enable real-world-like testing of emission devices.

Moreover, the technology allows for continuous monitoring of these alterations, simplifying the identification of reasons behind any efficiency gains. Building on this foundation, the optimization of various behaviors and decisions becomes achievable, such as identifying the optimal timing between hull cleanings, optimal trim states, and identifying best practice behaviors among crew members.

Where?

The need for establishing accurate baselines, and the implementation of digital twins, is a cross-sectoral challenge that all major shipping operators and owners are likely to assess. Not only operators within the tanker shipping segment are addressing this challenge, but also container shippers and the like, further expanding the addressable market and potential collaborators.

When?

Establishing accurate prediction models through digital twins has been under investigation for multiple years, and it is difficult to assess when a major breakthrough is likely to happen. However, the magnitude of potential cost savings an operator can realize once this barrier has been overcome positions this challenge at the forefront of digitization efforts across shipping operators.

Who? The stakeholders essential for tackling this challenge are likely limited to shipping operators and owners, third-party analysis houses, and weather providers as wind, waves, and currents are crucial contributors. Owners are responsible for ensuring access to sensor data. Stena Bulk, as an owner and operator, can possess a model that incorporates both internally owned ships and those under time charter agreements. The third-party entities bring advanced analytics capabilities that are presently lacking in the sector.

Information source: Data is to be gathered from sensors installed on ships, noon reports, crew lists and weather providers. It is noteworthy that a significant challenge in weather predictions arises from the placement of sensors.

Core business? As Stena Bulk is striving for a more sustainable and economic fleet, the major performance improvements promised by digital twins are well aligned with Stena's core objectives. A more efficient fleet will allow for both less carbon emissions and cheaper operations.

Focus groups: All focus groups

5.1.3 Market Prediction

The charterers and brokers have too much power in terms of manipulating the market by knowing when and where there will be cargo. We don't have that much insight today. We can buy access to platforms with data, but we are not geared towards understanding all the data flowing around.

Chartering, Copenhagen

What? Stena Bulk faces a significant challenge in predicting and understanding market trends within the volatile shipping industry, hindering its ability to optimize fleet size, vessel positioning, and pricing strategies effectively. The industry exhibits minimal information sharing, as e.g., "*brokers keep their fixtures in a diary on their desk, rather than on a platform*", as stated by one of the customers. The information gap underscores the present dependence on human expertise, a critical factor in achieving somewhat accurate spot bidding. This reliance stems from individuals having navigated various phases of shipping cycles, drawing on their experiential knowledge. Nevertheless, manual efforts and occasional external consultant involvement are made to forecast the market. The absence of efficient data utilization and centralized information platforms hampers the comprehensive understanding of market conditions and dynamics. Consequently, charterers and brokers hold significant power.

Why? Solving these challenges is crucial as it directly impacts economic efficiency. Accurate market trend predictions and optimized fleet operations empower companies like Stena Bulk to make informed decisions and enhance strategic decision-making. Using a model of this nature enables the identification of market patterns and triggers for fluctuations. This allows for the consideration of multiple voyages ahead during trading, as opposed to focusing on just one. Consequently, adjustments can be made to the fleet size and positioning, enhancing preparedness for both downward and upward turns in the shipping cycle[1]. This proactive approach not only mitigates risks but also contributes to increased profitability.

How? Implementing a data-driven strategy involves deploying a comprehensive model to forecast market trends, analyze cargo supply and demand across different regions, using ship position lists, and consider global trends, geopolitics, and events like weather disruptions. The model should anticipate fleet growth, identify key disruptors influencing market fluctuations, and simulate various scenarios to predict trading patterns. While the model may not predict macro trends, it can offer actionable recommendations based on triggers, streamlining efforts and reducing information gaps with charterers and brokers.

Where? The challenge and benefit of market prediction extends beyond Stena Bulk to encompass the entire industry, including owners, operators, brokers, and charterers. Solutions developed for this issue could have broad applicability, benefiting other companies grappling with similar challenges. However, this would serve as a competitive advantage and, naturally, would not be shared within the industry but retained internally.

When? The urgency for adopting these solutions in the shipping industry stems from the critical importance of accurate market predictions, especially considering the volatile nature of shipping cycles. In a landscape where competitors are increasingly embracing such models, any delay in implementation by Stena Bulk could lead to severe consequences for its financial standing.

Who? A successful implementation of an internal model requires collaboration between Stena Bulk and their employee's experience of ship-

[1]Periodic fluctuations in demand and profitability within the shipping industry, with downward turns signifying reduced demand and profitability, often due to economic or supply factors, and upward turns indicating increased demand and profitability driven by economic growth and other factors, impacting the overall business climate in the industry.

ping markets, and an analytics team experienced in forecasting global markets, capable of considering the broader network that influences the market where Stena Bulk operates. Based on this, Stena Bulk can add the shipping layer on top of it.

Information source: Enhanced market predictions necessitate thorough data analysis, relying on historical data encompassing cargo supply and demand in various regions, ships' position lists, AIS data, and other relevant factors. Additionally, a global perspective is essential, considering geopolitical events, weather patterns, holidays, and seasonal variations —essentially all factors that can influence the market. Supply

Core business? Improving market prediction directly contributes to fulfilling Stena Bulk's KPIs, aligning with its core business objectives of operational efficiency and market competitiveness.

Focus groups: Chartering Copenhagen, Business development, and Dubai

5.1.4 Uber for shipping

From a sustainability perspective, imagine having an "Uber for ships" to improve triangulation with more laden and less repositioning of ships. So forgetting the most economic, but instead taking the closest cargo.

Customer 1, London

What? Currently, inefficiencies in commodity flows, such as empty vessel journeys to catch the best market or overlapping commodity routes e.g., moving an identical cargo from A to B and from B to A, though financially beneficial, occurs. This raises environmental concerns and emphasizes the need for sustainable practices. The industry's struggle with balancing economic incentives and reducing carbon emissions presents a unique challenge, especially when cost-effective solutions are sought. Compounding these issues is the lack of information sharing platforms, limiting the industry's ability to understand market dynamics comprehensively.

Why? The implementation of predictive models could have the potential to minimize idle ship periods, by allowing the optimization of a decision environment with higher dimensionality, which promotes more efficient vessel utilization, aligning with broader environmental sustainability goals by reducing emissions per nautical mile. However, while resolving existing inefficiencies in moving barrels temporarily may weaken Stena Bulk's market position, it potentially can contribute to long-term benefits by reducing the demand for ships, consequently shrinking the world fleet, thereby strengthening the market in the future. The expected outcome is a more efficient and environmentally responsible global shipping sector, aligning economic interests with the urgent need to reduce the industry's carbon footprint.

How? Addressing the decarbonization challenge could involve exploring solutions such as an "Uber for ships" which would optimize ship repositioning and speed to ensure more laden journeys, thereby enhancing efficiency and sustainability of the entire industry. This requires promoting industry-wide collaboration for information sharing and adopting standardized platforms for both operators, charterers, and brokers to collaborate on, that can enhance transparency and operational efficiency.

Where? The problem of decarbonization and market optimization in shipping has a global scope, affecting all players in the industry. It's not just an internal issue for individual companies but a universal challenge that affects the entire market. The market size for solutions addressing this issue is substantial, as it encompasses the entire global shipping industry. However, it is also limited, as it requires several stakeholders to change.

When? The urgency to implement this in the shipping industry is driven by the escalating importance of meeting decarbonization targets and the urgent need to reduce the shipping industry's significant carbon footprint. Delaying these initiatives risks falling behind in the global drive towards a greener, more sustainable future.

Who? This internalization poses a challenge where a collaborative effort is essential for optimizing ship utilization across the industry. The key stakeholders for a successful implementation include shipping operators like Stena Bulk, which could potentially benefit from improved operational efficiency and sustainability. Brokers and charterers are also crucial to get on board, which may pose a challenge as the brokers may become redundant, as a result of reduced information barriers in the interactions between charterers and their customers. Thus, maritime regulatory bodies and environmental organizations are also crucial, as they set and enforce decarbonization standards and sustainability practices.

Information source: The necessary dataset comprises available cargoes in different regions and the current positions of ships, similar to Uber. Operators can use this information to propose bids for specific cargoes, subject to approval by charterers. However, as mentioned, this process might render brokers less important.

Core business? In the short term, this may adversely impact the achievement of Stena Bulk's KPIs as the market could weaken. However, in the long term, it has the potential to align with its core business objectives of sustainability and operational efficiency.

Focus groups: Customers

5.1.5 Planning and Scheduling

A program helping you to decide which ship to do what to capture the optimal voyage and planning multiple voyages ahead, because it picks up market information and cargoes, dynamic speed to capture the best market, and so on. Essentially all the manual stuff that we do in chartering.

Mixed team, Dubai

What? Stena Bulk primarily struggles with the reliance on manual inputs, arbitrary speed and consumption curves, subjective considerations such as weather impact, and limited trading systems that do not encompass all potential scenarios. The current methods for ship position lists and tracking cargoes involve manual processes through Excel sheets, emails, and other communication tools, leading to inefficiencies. Furthermore, the current voyage management system lacks essential features like scenario storage[2]and organization-wide data sharing. Critical dates and information must be memorized by individuals, elevating the risk of oversight. Likewise, in the context of bunker planning, the process relies on the operations team to communicate when the ship is running low on bunker, initiating negotiations by the bunker team. This may result in suboptimal timings for negotiating the most favorable prices. This manual approach, coupled with the human mind's limitations in processing extensive information, can result in suboptimal scheduling and trading decisions such as parceling, and a failure to consider multiple voyages ahead.

Why? The current approach at Stena Bulk for voyage planning and bunker planning involves manual and limited data not available on demand. Instead, relevant teams are asked to produce the data on a case-by-case basis. This leads to suboptimal trading decisions, potentially missed earnings opportunities, increased costs, and potential de-

[2]The possibility to store key assumptions used to generate the output of voyage simulations.

lays. This inefficiency is further exacerbated when tracking cargoes, handling vast information, and considering various factors like port costs, bunker prices, and environmental regulations. An advanced scenario planning system holds the capacity to manage parameters beyond human processing capabilities, leading to enhanced accuracy, optimized trading and vessel utilization, and improved decision-making processes. Addressing this issue could result in maximized earnings, minimized fuel consumption, better resource utilization, and compliance with environmental regulations, thus significantly impacting the company's profitability and operational efficiency.

How? Implementing an advanced scenario planning system in Stena Bulk can enhance scheduling and trading operations by seamlessly tracking and allocating vessels across various offices. The system, featuring a user-friendly interface, offers universal access to all teams within the organization and ensures efficient management of historical data and future dates. Integration with other systems improves data quality and enables consideration of a broader range of data inputs, with features such as enhanced consumption accuracy through digital twins, analysis of historical weather conditions for precise calculations, and flexible speeds for emission control and earnings optimization considering the market. The system can suggest and optimize trading by efficiently matching cargoes automatically inserted with available ships, considers factors like bunker costs and traffic patterns, and conducts sensitivity analyses[3]for pricing strategies, and can compare different routes to identify the superior option. The model encompasses other important factors as well, such as FFAs, bunker hedges, and sanctions.

Where? The issues Stena Bulk faces are likely prevalent across the maritime shipping industry, suggesting a substantial market size.

When? Given the current inefficiencies and potential financial impacts, there is a high urgency for implementing these solutions. Immediate and long-term benefits are expected upon implementation.

Who? Key stakeholders in this initiative encompass various teams within Stena Bulk, notably chartering, operations, and bunker teams. Additionally, the engagement of external stakeholders, including providers of digital twins, brokers offering available cargoes, bunker

[3]A process of assessing how changes in key variables or parameters can impact the outcomes or results of a particular model, decision, or system, helping to understand the degree of sensitivity or vulnerability to variations in those variables.

suppliers for prices, and ports for costs, can be pivotal for data input.

Information source: The data needed for this system includes mainly cargo flows, and vessel movements, but also historical weather conditions, port costs and bunker prices etc. It also requires information from various communication channels in a standardized format and historical performance data to enable learning and prediction capabilities in the system.

Core business? This solution aligns with Stena Bulk's core business by optimizing trading decisions, maximizing earnings, reducing costs, and ensuring environmental compliance. It aims to enhance operational efficiency and customer satisfaction, directly impacting key performance indicators.

Focus groups: Mixed group (Dubai), Chartering (Copenhagen), Operations (Copenhagen), Business development (Gothenburg), Bunker (Gothenburg), Naval Architects (Gothenburg), Technical management (Scotland)

5.1.6 Fleet Analytics

Today we make decisions based on what we believe we know, not data-driven or fact-based. Can we somehow understand if the decisions we have made have been good or bad? What type of ship we should TC-in [Time Charter-in]? What type of ship that we should have in different situations?

Business Development, Gothenburg

What? Currently, crucial decisions related to the composition and positioning of the fleet, market risks, and the outcomes of made decisions are shaped by assumptions and experience rather than insights derived from comprehensive data analysis. The absence of robust data often forces decisions to be based on manual, arbitrary estimates and analyses, resulting in decisions that rely on perceived knowledge rather than verified facts. Additionally, crucial contributions are frequently disregarded. This tendency extends to situations where data is available, reflecting the broader challenge of some individual's reluctance towards data-driven decision-making at Stena Bulk. This reluctance stems from issues related to unstructured data storage, occasionally poor data quality, and the complexity of interpreting diverse formats.

Why? The expected value of increased utilization of data lies in unlocking valuable insights, leading to more informed decision-making, subsequently entailing increased profits, reduced costs or mitigated risks. Moreover, foundational data can substantiate decisions and provide confirmation regarding the rationale behind specific choices, and ensure that all valuable input has been considered. The magnitude of the problem is significant, impacting the efficiency of operations and trading and hindering the realization of the full potential of data-driven insights and decision-making.

How? To unlock additional value, Stena Bulk must initiate the effective utilization of historical data for more insightful decision-making. Potential solutions involve the implementation of systems that enhance the efficiency of gathering, storing, and analyzing data. However, with the existing data, patterns could be recognized, such as determining the optimal ship type or performance under varying conditions, identifying suitable ships for time charter in specific market conditions and durations, pinpointing optimal trading areas, sequencing cargo pickups, and assessing the risks associated with positions taken etc. By doing so, Stena Bulk can enhance estimations, calculations, and overall decision-making based on profound insights derived from data. Nevertheless, achieving this requires a cultural shift toward embracing data-driven decision-making.

Where? The overarching magnitude of the problem extends primarily internally at Stena Bulk, but similar challenges may be prevalent in the broader industry. Thus, the solution, once developed, could potentially be sold to other companies facing similar data-related challenges. Nevertheless, this could serve as a competitive edge for Stena Bulk and might not be available from external sources.

When? The urgency of timing is underscored by the current suboptimal utilization of data and the potential for missing crucial insights. The sooner data-driven decision-making is embraced, the sooner the company can benefit from improved efficiency and cost-effectiveness.

Who? Crucial stakeholders in this initiative encompass the relevant departments at Stena Bulk, specifically in fleet analytics are finance, management, and chartering. Additionally, the IT department plays a pivotal role in establishing robust data management practices.

Information source: The required data varies depending on the specific use case. However, for fleet analytics, essential data includes historical trading and market data, financial outcomes, consumption data, and ship-specific details.

Core business? Fulfilling Stena Bulk's KPIs would involve improving decision-making processes, reducing costs, and increasing profits. The solution is core to their business as it directly impacts operational efficiency and financial performance.

Focus groups: Chartering (Copenhagen), Business Development (Gothenburg), mix (Dubai)

5.1.7 Knowledge Bank

Every time we go on subs we are asking for the same documents which is frustrating. How can we not know this? I've asked for the same document ten different times from the same ship within two weeks.

Mixed team, Dubai

What? The challenge stem from the absence of a unified system compounding historical data spanning machinery, trading decisions, contract terms and ship operations, leading to the existence of multiple platforms, which is not only inconvenient but also prompts redundant reporting for the same parameters. This redundancy not only consumes valuable time through extensive manual reporting but also introduces the risk of inconsistencies. The lack of uniformity and cross-referencing in data input, even among sister vessels, results in significant disparities, complicating the comparison of information. The current state of data management lacks a guarantee of data quality, where e.g., verification of noon reports, sensor precision and the handling of physical and semi physical documents contribute to this.

This inefficiency extends to the time-consuming nature of both data analysis and documentation preparation. For instance, when a vessel is on subs, the dynamic documents need to be filled out since they are not accessible in a common system. This process is tedious and time-consuming for operations, captains, and technical management, exacerbated by time zone differences. The recurrent need to acquire these documents from the same vessel, sometimes as frequently as ten times within a two-week period, becomes a mundane aspect of work. Additionally, the crew faces urgency in completing tasks without prior notification of the intended transition to subs, adding to the inconvenience. Moreover, trading information is often stored in the minds of employees, posing a risk of information loss if they were to leave the organization. The lack of a systematic approach to log and trace data contributes to a deficiency in traceability, giving rise to risks and inefficiencies. This absence of traceability spans uncertainties such as cargo specifics to questions about decision-makers and their reasoning.

Why? The expected value encompasses achieving organized, reliable, and integrated data. Establishing a "One True Source" database for obtaining information not only reduces the risk of data loss if people leave but also facilitates seamless tracing of data and decisions. It enhances the ability to learn from data, promotes knowledge sharing, and ensures a unified foundation for decision-making across offices and vessels. Additionally, minimizing the time spent on subs is crucial, considering one of Stena Bulk's advantages lies in prompt completion. Automating processes or consolidating all information into a single platform capable of calculations and learning accelerates the completion of tasks, freeing up time for more critical activities. This approach eliminates inconvenient redundant reporting for the crew, operations, and technical management, thereby bolstering Stena Bulk's competitiveness. Early detection of mistakes and the implementation of automatic quality checks further contribute to time savings.

How? The envisioned solution revolves around transforming the existing data landscape through the consolidation and maintenance of all data in a unified and structured database —a "One True Source." This solution incorporates automatic quality checks, task streamlining, and the automation of repetitive processes, including document population. It also establishes interfaces with external sources to access relevant data. For example, the solution can house a comprehensive set of the approximately one hundred predefined questionnaires necessary during the "on subs" stage. It adapts and learns customer preferences, automates the population of crucial fields with stored or learned data from previous completions, and highlights gaps that demand the captain's attention. Subsequently, the captain and technical management have to ensure the regular updating of these fields e.g., on elements like crew lists, with daily validations ensuring accuracy.

Where? The magnitude of the problem extends beyond Stena Bulk, as other companies in the shipping industry likely face similar challenges. The solution, a centralized platform learning from historical input, could potentially be marketed to other companies in the industry, broadening its scope beyond internal use.

When? The critical nature of the situation is underscored by the labor-intensive process of manual data extraction, the potential for inconsistencies in reporting, and the risk of substantial data loss when an employee departs from the organization. Additionally, given the increasing significance of data, the pressing need to adeptly store and harness it becomes increasingly urgent.

Who? Crucial stakeholders encompass every department within Stena Bulk, with a specific emphasis on the management team considering the data governance. The effective functioning of the database is contingent on continuous maintenance after implementation. The mindset today is that "*it goes faster asking someone than searching for it*" according to Chartering in Copenhagen. Establishing clear guidelines outlining the necessary procedures and following these guidelines is imperative to ensure the database's meaningful integration and paramount for the success of the entire initiative.

Information source: The system should be able to integrate data from various sources, including email, Orbit, external systems, and more. Additionally, it must accommodate manual input, allowing, for instance, captains to contribute their data. Furthermore, external sources such as websites can be integrated for full coverage of information.

Core business? The proposed solution is in harmony with Stena Bulk's KPIs by targeting improvements in operational efficiency, decreased waiting times, and heightened data accuracy during document preparation. This endeavor is aligned with the commitment to maintaining a high-quality image, echoing the slogan, "oil should always travel in first class." Furthermore, the enhanced decision-making capabilities inherent in the solution are anticipated to bolster financial KPIs.

Focus groups: All focus groups

5.1.8 Cleaning Assistance

Can we clean the tanks faster while still complying with industry standards? So taking several aspects into consideration, such as the coating, the last three cargoes, the weather, where the vessel is going, this particular crew and if they have been good at cleaning before, and mainly, the market situation. Make it tailored to the ship and the situation and help the operator get a good grip if the time is realistic or not.

Operations, Copenhagen

What? The primary pain point is the lack of a systematic approach to tank cleaning planning. The frequency of cleaning relies on the cargo type, and currently, Stena Bulk undergoes cleaning approximately five to seven times annually per ship. The captain provides an update and a plan, complemented with pictures and comments. Subsequently, operations can analyze this information, providing a response with next steps and recommendations to ensure accurate time estimates. For instance, perhaps it's not advisable to use a high-temperature blast, such as 98 degrees, simply for the sake of increasing the speed for cleaning after specific cargoes, as this could potentially damage the coating over time. This resolution comes with the inherent risk of human errors, as this includes the potential for miscalculations in estimating the necessary time, resulting in more downtime than initially anticipated or not optimizing the cleaning based on the market.

However, in the case of supercargoes occurring about one time per ship and year, due to a lack of in-depth knowledge, they pay and rely on an external party, a human analyst who offers guidance and recommendations such as suggesting alternative approaches. Providing remote advice incurs a cost of approximately 2,000 to 3,000 USD per session, whereas an onboard visit entails an expense of around 15,000 USD. Based on these suggestions, the operator can advise the captain on adjustments, serving as a control mechanism to verify the reasonableness of the proposed time frame.

Why? The need to optimize tank cleaning procedures arises from concerns about time efficiency, bunker usage, and preservation of coating integrity, particularly for Stena Bulk's own ships. The expected value in solving this lies in improved operational efficiency, reduced costs, and enhanced vessel maintenance. Furthermore, the quicker the cleaning can be made the better, as any off hire entails losses from trading.

How? While the current reliance on human analysts exists, the proposed solution aims to automate and enhance this process, allowing for adaptability based on specific ship and situational factors. The value will be realized through the implementation of a system replacing the external human analysis, however still based on the captain's plan. The system can analyze multiple factors and provide tailored recommendations for optimizing the tank cleaning process, for instance coating condition, the last three cargoes, weather conditions, the vessel's destination, and this specific crew's historical performance in cleaning. It can systematically assess each aspect, ensuring alignment with the plan and suggesting ways to optimize time, and including recommendations for variables like water temperature. The system's adaptability will enable a tailored approach based on the ship and situation, assisting the operator in evaluating the realism of the expected time frame and determining if an extra two days are warranted, for instance.

Furthermore, if the system is connected with the market, and is aware of a cargo-free period for the next six days, a cautious approach may be recommended, but if it's only three days away, an accelerated cleaning strategy might be suggested. Additionally, the system could verify if the cleaning process adheres to industrial standards, comparing against established matrices. By analyzing historical trading data, it may also offer insights and can reveal trends to optimize the cleaning standard for enhanced efficiency. However, the challenge lies in finding ways to enhance efficiency without compromising quality.

Where? The overarching magnitude of the problem extends beyond internal operations, as efficient tank cleaning is a concern for the entire shipping industry. The solution, if successful, could potentially be marketed to other companies facing similar challenges, broadening its scope beyond Stena Bulk.

When? The timing urgency is driven by the ongoing challenges in tank cleaning efficiency. Presently, the situation is managed with the involvement of a third party. Nevertheless, the faster the implementation of this solution, the quicker it will yield immediate benefits in terms of improving operational efficiency and reducing costs.

Who? Key stakeholders include captains, operators, and for supercargoes, external human analysts involved in the tank cleaning decision-making process. Involving these stakeholders in the solution is crucial for successful implementation.

Information source: The dataset needed for this solution includes historical cleaning plans and adjustments, trading data, information on coating conditions, past cargoes, and crew performance metrics. Cleaning methods are crucial, such as water temperature etc. Additionally, market data for optimization is needed.

Core business? Fulfilling Stena Bulk's KPIs would involve improving operational efficiency, reducing bunker usage, and preserving coating. This, in turn, opens up opportunities to accommodate additional cargoes and adapt cleaning practices based on market conditions.

Focus groups: Operations (Copenhagen), Business Development (Gothenburg)

5.1.9 Co-pilot

"We have an incredible amount of files and information in our systems and in our e-mails, so you can't find things. Imagine having a Chat GPT but for Stena Bulk that can help you find information, but also do things for you, such as analytic for board meetings, the monthly reports, sorting e-mails, data input and so on.

Operations, Gothenburg

You spend so much time reading and blending in people in e-mails, where you have duplicate conversations going around and sometimes people fall off. I wish to have if you click reply that all the systems would go "someone else is having the same discussion over here" or similar.

Operations, Copenhagen

What? A recurring theme across multiple focus groups centers on the critical importance of time, with operational schedules lacking the necessary time for flawless execution. Prioritization and allocation of sufficient time are deemed essential, leading to a focus on eliminating time-consuming tasks like report generation, manual data input, document retrieval, and navigating through emails and outdated information.

Another time-consuming aspect identified is internal information sharing, marked by redundant updates and challenges in reaching all stakeholders effectively. Another obstacle lies in the lack of clarity regarding who requires specific information and uncertainty about whether the information effectively reaches all relevant individuals. The process of including people in emails becomes time-consuming, leading to redundant conversations. Occasionally, individuals inadvertently miss information or are unintentionally excluded from discussions, where it's challenging tracking these occurrences. Simultaneously, there's a shared perception that individuals often lack essential information.

Stena Bulk's commitment to quality, encapsulated in the principle that "oil should always travel first class," extends across their entire business model. This commitment encompasses events to response times in chartering and operations. However, maintaining professionalism and alignment within the company towards customers and suppliers are demanding, particularly in email communications, where consistency, swift responses, and accurate information delivery are emphasized.

Why? The central issue here is the inefficiency in time management. The expected value lies in saving time, reducing redundancy, and ensuring accurate and accessible information for improved decision-making. Besides time savings, additional benefits such as improved communication where everyone who needs to be is included, and a consistent format towards externals can be achieved.

How? Automation plays a crucial role in eliminating the need for waiting for information production. The proposed solution entails the adoption of a co-pilot tool equipped with features such as automated data input and analysis, email sorting, to-do list creation, and file organization. This tool aims to automate tasks while ensuring information validation, organization, and efficient distribution to relevant individuals. It requires tracking readership, ensuring that the intended recipients have access, and potentially suggesting related email threads with similar discussions happening elsewhere. An added feature discussed is an internal "chat GPT". Additionally, incorporating chatbots and virtual assistants to handle customer inquiries and streamline communication processes and formats could serve as valuable supplementary features.

Where? The magnitude of the problem extends beyond Stena Bulk and the shipping industry, affecting any company in general. The proposed solution could potentially be marketed to other companies facing similar challenges in operations and information management.

When? The immediacy is underscored by the daily time constraints; however, as employees at Stena Bulk have not expressed time as a limiting factor in performing their daily tasks, the sense of urgency could be considered dimished.

Who? This pertains to every individual within the company, serving as a tool to facilitate their daily tasks.

Information source: The solution will need access to all the different systems, such as email, and a potential data warehouse containing information from VMS and Orbit.

Core business? A reduction in time spent on manual tasks, improved accuracy in data analysis, and enhanced communication efficiency will in general increase Stena Bulk's operational efficiency and increase profits. Improvements in response times, consistency in communication, and overall customer satisfaction is also aligned with Stena Bulk's guiding principles.

Focus groups: Chartering (Copenhagen), Operations (Copenhagen and Gothenburg), Business Development (Gothenburg), Bunker (Gothenburg), Technical Management (Scotland)

5.1.10 Missed Invoices

Lately we have had a few invoices that have been missed and thus delayed. It would be nice to have some sort of system that can help us monitor the status instead of chasing operations.

Bunker, Gothenburg

What? Lately, there have been challenges with invoices experiencing delays or oversight during the approval process, with about 2-3 invoices a month. The bunker team initially receives the invoice, which is then sent to operations for approval. Subsequently, operations input the invoice into their system and forward it to accounting to initiate the payment process via email instead of entering it directly into their system. However, if the invoice is not sent promptly due to bottlenecks in operations, the bunker team receives reminders. This prompts a follow-up process where they need to actively pursue operations for resolution. The main pain point is manual work, delays and oversight in the invoice approval process, and status visibility.

Why? Anticipated outcomes include an streamlined and seamless invoice approval process including timely approvals. By ensuring clarity in the invoice status with a transparent workflow for all stakeholders diminishes the necessity for manual interventions.

How? By implementing a centralized system that provides visibility into the status of invoices—whether they have been acknowledged, approved, or require follow-up. This streamlined approach would involve a unified system where they can easily access and manage information without the need for tracking through emails.

Where? Given its likely specificity to Stena Bulk's internal procedures, it's improbable that the market size for a solution of this nature would transcend their boundaries.

When? The current system is functional, albeit with cumbersome manual tasks. However, the focus is more on timely payments rather than urging others to pay. Consequently, urgency may be lower, as no complaints have surfaced regarding delayed processing, as its more related to inconvenience for the bunker team dealing with reminders.

Who? The emphasis was on bunker invoices, necessitating the inclusion of the bunker team, operations, and finance in any proposed solution.

Information source: Bunker invoices and payments are required.

Core business? This corresponds with the standards of excellence and professionalism by ensuring timely payment of invoices. However, it's important to note that this particular challenge is not directly tied to the core business activities.

Focus groups: Bunker (Gothenburg)

5.1.11 Bunker Analytics

A challenge is to determine the quality of the bunker and how good it is energy density wise. Maybe you can see a pattern among suppliers? But that also has the built in problem with measuring the volume in the industry which we have never really succeeded with.

Bunker, Gothenburg

What? The primary obstacles revolve around the accurate measurement and consensus on bunker volume. Currently, the industry resorts to weight-based measurements (in tons) due to difficulties in precisely gauging volume. While mass flow meters have been introduced, there remains an opportunity for enhancement, potentially through technological advancements. When the margin extends to approximately 2-3 percent or beyond, discussions will initiate. Given a fuel cost ranging from 500 to 900 USD and for instance a bunkering quantity of 1000 metric tons, the associated expense can reach up to 30,000 USD. Typically, this cost is evenly split, following a 50/50 distribution. The bunker team is currently identifying and remembering, without storing the knowledge anywhere, which suppliers have a history of engaging in deceptive practices related to the volume of bunker fuel.

This issue is further exacerbated in conjunction with another noteworthy challenge, which involves delineating the energy density and comprehending consumption trends. Variations in energy density among suppliers can lead to differences in consumption for a given distance. Consequently, this may result in Stena Bulk either overpaying or consistently choosing suboptimal suppliers. During negotiations, the bunker team considers these challenges based on their intuition and experience.

Why?

Inaccuracies can lead to inefficiencies, financial losses, and potential environmental impacts. Thus, a solution could lead to more precise financial transactions, better resource planning, and overall efficiency gains. Additionally, the accuracy of energy density estimates is crucial, particularly when considering the construction of digital twins. A preliminary examination of energy density reveals an average difference of 3 percent between HFO and VLSFO. Furthermore, within each fuel grade, the disparity could extend by an additional 3 percent. Although additional data is requisite to pinpoint supplier patterns accurately, the existing figures suggest the potential for substantial cost savings.

How?

Regarding volume, mass flow meters have been introduced but may require further enhancement where technological advancements could play a role. However, identifying patterns among supplier behaviors can provide a foundation in negotiations.

Furthermore, consumption patterns due to energy density can be identified and utilized. For instance, by exploring the energy efficiency of different products, attempting to discern patterns among suppliers regarding consumption trends over time, could then be considered in negotiations.

Where?

The problem extends across the shipping industry, especially the volume challenge. A solution could potentially be applicable and valuable to other companies in the shipping industry.

When? The identification of trends among suppliers stands to significantly enhance the cost-effectiveness of Stena Bulk, thus the timing is somewhat urgent.

Who? To conduct an analysis of this nature, bunker data and information from providers are essential. Therefore, the involvement of an external entity that possesses this data is of utmost importance.

Information source: Relying on external bunker data alone is sufficient for assessing energy density concerning suppliers, assuming accurate density measurements. However, for a more robust analysis, incorporating internal consumption data would further enhance the evaluation. Additionally, disputes and outcomes in relation to suppliers are needed.

Core business? Bunkers represent a significant expense for Stena Bulk, and any initiatives that can mitigate these costs align with their fundamental business objective of operating in a cost-effective manner.

Focus groups: Bunker (Gothenburg)

5.1.12 Predictive maintenance

How often do we do unnecessary maintenance just because we follow the manufacturer instructions? And sometimes despite following these recommendations we still get breakdowns. Can we somehow predict the maintenance with the help of sensors, vibrations and temperature monitoring and so on?

Naval Architect, Scotland

It's manual decisions regarding how the spare parts should be supplied to the ships. But we have an extreme amount of data in this, so why not instead optimize the financial aspect in relation to what we actually need?

Operations, Gothenburg

What? The primary pain point in the current scenario is the reliance on manual inspections and specific data-driven thresholds which triggers unnecessary maintenance activities. The scheduled inspections and maintenance procedures, guided by manufacturer recommendations, prove to be inefficient and occasionally inaccurate, resulting in unnecessary interventions and component replacements. Despite diligently following preventive measures, there is a paradoxical occurrence of both needless maintenance and unexpected breakdowns, leading to wasted time and resources. To mitigate downtime risks, vessels carry spare parts based on subjective judgments, lacking optimization and potentially causing financial inefficiencies.

Another prevalent challenge involves the effective management and tracking of spare parts, especially during crew transitions where the use of spare parts may go unreported. This poses the risk of being without crucial spare parts in the middle of the Atlantic, with locating them in the next port proving to be a formidable task, sometimes impossible due to delivery times.

Moreover, the absence of a systematic approach to maintenance planning, particularly without off-hire periods, results in ad hoc decision-making. This leads to last-minute rushes in paperwork preparation and increased costs, exacerbated by occasional unavailability of personnel to promptly address breakdowns, causing additional downtime and associated expenses. Furthermore, declaring the necessity for downtime due to maintenance is often met with skepticism and inquiries into its justification.

Why?

The shipping industry's need to optimize maintenance practices stems from the inefficiencies and high costs associated with current manual and reactive maintenance approaches. Thus, the goal is to shift towards a predictive maintenance model to anticipate equipment failures and optimize maintenance schedules accurately. By implementing a predictive and proactive maintenance strategy, Stena Bulk can significantly enhance operational efficiency, reduce downtime, and save costs. The expected result is a more streamlined and effective maintenance process that preempts failures, optimizes resource utilization and financial liquidity, and extends the lifespan of equipment.

How?

Realizing the value of a predictive maintenance system involves integrating advanced monitoring technologies with historical data analysis to anticipate equipment failures. For instance, by leveraging existing technologies and sensors, such as vibrations monitoring, temperature monitoring, and sound detection in conjunction with each other, Stena Bulk has the potential to predict failures in advance with interpretation of equipment behavior. Beyond this, potential solutions may encompass visualizing machinery through augmented reality and strategically placed cameras for real-time monitoring. Additionally, advanced data analytics can offer predictive insights, facilitating the tracking of spare parts and initiating orders when needed, entailing improved asset management and increased financial liquidity. Furthermore, the analysis can delve into the root causes of breakdowns, considering factors such as equipment issues or crew-related issues, while also factoring in individual experience, specific ship or equipment details, and demographic information.

Where?	The magnitude of this problem extends beyond a single company; it is a widespread challenge in the shipping industry. The market for predictive maintenance is significant, as many companies face similar inefficiencies. By developing a solution that effectively addresses these challenges, there's potential for broader application and commercialization, benefiting other companies in the industry and possibly in other sectors as well.
When?	The urgency of implementing predictive maintenance is moderately high, given the significant cost and time savings it offers, along with the potential to enhance safety and reliability. The sooner a solution is implemented, the quicker the benefits can be realized. However, the current maintenance challenges are not likely to increase significantly over the coming years.
Who?	Currently, onboard crews are responsible for maintenance activities, often guided by manufacturer recommendations and manual inspections. Key stakeholders in adopting a new solution include these maintenance teams, operational managers, and decision-makers at Stena Bulk who would need to approve and support the implementation.
Information source:	The dataset required includes historical maintenance records, sensor and visual data, operational logs, and manufacturer guidelines. Combining these with crew details will enable predictive analytics to identify patterns and predict failures.
Core business?	Implementing a predictive maintenance strategy aligns with Stena Bulk's objectives by enhancing operational efficiency, reducing maintenance costs, minimizing downtime, and potentially improving safety standards. It is a core aspect of their business, as maintenance is integral to the shipping industry's operations.
Focus groups:	Technical Management (Scotland), Naval Architects (Gothenburg), Customer

5.1.13 Safety

The purpose of our being is to manage the ships for Stena Bulk, and this we should do as safe and cost-effective as possible. This is our biggest challenge.

Technical Management, Scotland

What?

Presently, Stena Bulk faces various potentially dangerous challenges, spanning from crew members navigating confined spaces for investigations and maintenance, the looming threat of pirate attacks in high-risk regions, to the added risk of negatively impacting marine life, such as whales. Many activities are currently managed manually by the crew. To mitigate these risks, the technical management employs stringent safety measures, including rigorous training for the crew, well-defined procedures for both crew and operations, and the application of standard navigational tools and basic IT security measures.

However, given the dynamic nature of emerging threats, such as those involving spoofing or geopolitics, there is a growing concern that these measures may prove insufficient. Balancing the imperative of ensuring the highest levels of safety with the need for cost-effectiveness in shipping operations stands out as the primary challenge in this context.

Why?

At Stena Bulk, safety is a top priority, particularly in safeguarding both crew members engaging in high-risk activities and the overall safety of the vessels, including collision prevention. Environmental safety is further prioritized, with a commitment to preventing oil spills and safeguarding marine life beneath the water's surface. Despite encountering various daily challenges that pose potential dangers, Stena Bulk is dedicated to operating its ships with the dual objectives of maximizing safety and ensuring cost-effectiveness.

Elevating safety measures not only aligns with Stena Bulk's overarching goals but also contributes to the company's ongoing appeal as a reliable and attractive operator in the maritime industry.

How?

Integrating technologies such as augmented reality systems, designed to enhance visibility and detection for threat identification, or implementing systems capable of detecting disruptions in GPS signals to counteract spoofing, can significantly enhance safety measures. Moreover, leveraging cameras to replace crew members in hazardous spaces can also improve safety, but also to ensure compliance, such as monitoring crew members wearing appropriate safety gear like helmets. In the realm of incident prevention, sensors can be used to early detect potential dangers like fires, leaks, and gas hazards to proactively prevent them.

Furthermore, a comprehensive approach extends to assessing risks associated with shipping routes, cargo, and external variables like geopolitical events, helping to pinpoint potential security threats and anomalies. Lastly, the incorporation of advanced technologies enables the recommendation of alternative routes or adjusted speeds to minimize the impact on marine life.

Where? This is a global issue affecting the entire shipping industry. The solutions developed could benefit not only Stena Bulk but also other companies in the maritime sector.

When? Safety is a top priority at Stena Bulk, meaning that the sooner improvements can be made, the better. However, currently, they already conduct extremely secure operations due to thorough training provided by the technical management. Therefore, the situation is not urgent at the moment. Nevertheless, if there were to be a drastic increase in incidents with the increased uncertainty in geopolitics and cybersecurity, the urgency might become more pressing. But as of now, the situation is reasonably under control.

Who? Key stakeholders include Stena Bulk's technical management team, ship crew, IT security teams, and equipment manufacturers. Collaboration among these parties is essential for successful implementation.

Information source: The required information varies based on the specific use case. It may encompass real-time maritime traffic data, AIS data, onboard sensor data, information about marine life, and more. Access to global maritime databases and IT security threat intelligence is also crucial.

Core business? Implementing these solutions directly contributes to Stena Bulk's objectives, particularly those related to safety, operational efficiency, and environmental impact. These initiatives are core to their business as they align with their mission of being cost-effective, while showcasing a holistic commitment to safety and environmental responsibility in shipping operations.

Focus groups: Technical Management (Scotland), Naval Architects (Gothenburg)

5.1.14 Environmental footprint

Establishing the environmental footprint from these huge vessels from a lifecycle perspective in an intelligent way is one of our greatest challenges.

Naval Architects, Gothenburg

What? The primary pain point is the complexity in assessing the environmental footprint of vessels, especially during their birth (construction) and death (decommissioning) phases, and the difficulty in tracking every raw material, like steel and copper. Currently, Life Cycle Assessment (LCA)[4]is a manual and inconsistent process, lacking standardized methods. This inconsistency leads to disparate methodologies, hindering effective environmental management in the maritime industry and promoting the transition towards a system not based on theoretical measures of emissions. Consequently, interrogating suppliers for a clear assessment remains challenging due to the absence of standardized criteria, and the vast size of a vessel further complicates the determination of system boundaries.

Why? The need to solve the issue of accurately determining and managing the environmental footprint of vessels is driven by increasing environmental awareness and regulatory pressures. An accurate solution is vital for reducing the environmental impact of maritime activities, which is significant given the size and global reach of the shipping industry. By addressing this issue, a more sustainable maritime sector can be achieved, with reduced emissions and better resource utilization. The magnitude of this problem is considerable, as it affects global shipping, and the efficiency gains from a solution would be substantial, both environmentally and economically.

How? To realize the value of solving this problem, potential solutions might include developing standardized LCA methodologies and leveraging technology to automate and streamline the process. This could involve digital tools for data collection and analysis, and collaboration with suppliers for transparent emission data. For instance, an effective method to monitor all components of the vessel, and implementing a straightforward system for each supplier to input their emissions data could prove valuable in measuring the emissions from the entire lifecycle. However, the solution would need to be integrated into existing maritime operations and deployed across

[4] A systematic evaluation of the environmental impacts of a product, process, or service throughout its entire life cycle, from raw material extraction through production, use, and disposal, helping to gauge its environmental sustainability and identify areas for improvement in terms of resource use and environmental impact reduction.

the industry to ensure widespread adoption and effectiveness.

Where? The magnitude of this problem is vast, encompassing the entire global maritime sector. It's not just an internal issue but one that affects all shipping companies worldwide. The market size is significant, given the role of shipping in global trade. Additionally, it could be adjusted to fit other industries as well that is required to measure their environmental footprint from a life-cycle perspective.

When? The maritime industry is under growing pressure to demonstrate environmental responsibility, necessitating immediate attention to this issue. While the urgency is heightened due to the growing emphasis on environmental sustainability, there is not yet definitive regulatory pressure for precise environmental reporting throughout the life cycle, which somewhat diminishes the immediacy.

Who? Currently, this problem is faced by maritime companies globally, including ship owners, builders, and operators. Key stakeholders would include these companies, regulatory bodies, environmental groups, and technology providers. Collaboration among these groups is essential for developing and implementing effective solutions.

Information source: Necessary information includes detailed data on vessel construction materials, operational emissions, and end-of-life disposal processes. This data would need to come from a range of sources, including suppliers, regulatory bodies, and internal company records.

Core business? For a company like Stena Bulk, effectively managing the environmental footprint of vessels aligns with its core objectives centered around sustainability, efficiency, and compliance. By addressing this issue, Stena Bulk could improve its environmental performance, meet regulatory requirements more effectively, and potentially gain a competitive advantage in a market increasingly focused on sustainability. Nevertheless, it's crucial to emphasize that measuring the environmental footprint isn't central to their core operations, but instead more related to the work of naval architects, where Stena Bulk either buys or hires the "best performing ships". Thus, achieving savings, particularly in consumption, may be more in line with their objectives.

Focus groups: Naval architects (Gothenburg)

5.1.15 Navigating externals

We have so many new, unclear regulations, especially within sustainability. The national and regional regulations, discussions, and half-measures back and forth change very often, making it difficult to keep track. If we were to invest in systems to analyze this, there is a risk that they would need to be changed quite frequently. It's not feasible to build and invest in a deeply analytical tool, for example for CII, because by 2026, the regulations will probably look very different.

Business Development, Gothenburg

What?

The primary pain point is the lack of a standardized system for capturing external information about potential business partners and for monitoring regulatory changes. Due diligence is today made manually, which is time-consuming and bears the risk of oversight.

Furthermore, the shipping industry faces a substantial challenge in dealing with unclear and ambiguous sustainability regulations at both national and regional levels, with frequent changes and discussions surrounding them, creating complexity and difficulty in staying informed and compliant. Implementing comprehensive systems and tools for analysis is risky, as the regulatory landscape is likely to undergo substantial transformations. The complexity is heightened by the lack of consistency among various regulations and their adopted metrics. While some regulations assess emissions throughout the entire lifecycle (Well-to-Wake), others focus solely on Tank-to-Wake. Divergent perspectives on biofoul exacerbates this. Currently, this is managed through formal and informal channels, leading to sporadic and potentially outdated information. This approach requires people to be on top of updates, and lacks systematic risk assessment and fails to provide a clear, reliable picture of the business environment. Internally, the need is to transition from informal, ad hoc methods to a more structured, data-driven approach.

Why?

Stena Bulk encounters the complex task of navigating risk and compliance within a dynamic and uncertain regulatory environment, extending beyond conventional risk assessments. The imperative to address this challenge arises from the essential need to maintain reliability, mitigate risks, and adeptly respond to regulatory shifts. This includes the effective implementation of due diligence processes for external suppliers to minimize risks. A viable solution holds substantial value by ensuring uninterrupted operations, safeguarding resilience against potential disruptions, and enhancing the company's standing in terms of compliance and sustainability. The magnitude of this challenge is noteworthy, given the considerable costs associated with non-compliance or operational interruptions, and the potential consequences of unintentionally engaging with a supplier that violates sanctions. Rectifying this issue could lead to heightened efficiency, reduced exposure to risks, and a closer alignment with emerging sustainability regulations for Stena Bulk.

How? With a tool capable of screening external sources and leveraging this information internally for automated summaries and decision-making, value can be realized. The solution involves developing a systematic approach to gather and analyze information from external sources such as companies or regulatory bodies. Potential solutions might include leveraging technology for real-time data collection, advanced analytics for risk assessment and screenings, and tracking regulations, furnishing concise summaries of crucial elements. Due diligences can be made automatically, approving companies or rejecting them.

Furthermore, a system adept at monitoring a ship's activities could aid in determining compliance, offering recommendations to ensure adherence, and extending its application to cover sanctions and safety standards. By taking the current trading patterns into consideration, and in conjunction with scenario planning tools, an extensive analysis of the different regulations can be made. The complexities of the regulatory frameworks demands systems that are easily navigable and flexible, capable of swift responses to regulatory adjustments.

Where? The magnitude of this problem extends beyond Stena Bulk, as it is a common challenge faced by many companies in the shipping industry. There's a substantial market for solutions that standardize input from external parties and monitor regulatory changes. Other companies likely face similar issues, making this a broader industry challenge. Solutions developed could potentially be sold or licensed to other companies, indicating a significant market opportunity.

When? The urgency of timing is high due to the dynamic nature of the shipping industry and the fast-evolving regulatory landscape, especially concerning sustainability. Proactive measures are crucial to stay ahead of regulatory changes and manage risks effectively.

Who? At present, different departments within Stena Bulk address distinct challenges; the Sustainability department oversees sustainability regulations, while finance manages aspects like sanctions and conducts due diligence. However, for this solution to be effective, collaboration is essential. These departments must work in tandem with both operations and chartering, encompassing trading patterns and operations comprehensively to ensure a holistic approach.

Information source: Information sources required for this solution include real-time data feeds from regulatory bodies, industry news, and operational data from business partners. Reliable and up-to-date data is crucial for accurate risk assessment and regulatory compliance. Furthermore, for an assessment tool, internal operational and trading data is crucial.

Core business? Implementing these solutions aligns with Stena Bulk's core business objectives by enhancing operational efficiency, risk management, and regulatory compliance. It directly contributes to their objective of becoming a sustainable shipping service provider, positioning them favorably in the decarbonization race and avoiding stranded assets. Such improvements are core to their business, impacting profitability, reputation, and long-term viability in a competitive and regulated industry.

Focus groups: Business Development (Gothenburg) and Bunker (Gothenburg)

5.2 Barriers and enablers

In this section, the barriers and enablers for implementing innovation in the maritime sector are explored through the lens of the conducted focus groups. The different factors brought up in the focus groups carry the capacity to function as barriers, enablers, or a combination of both, contingent upon the manner in which they are managed. Here, quotes from participants are used differently compared to the first section. Rather than serving as initial illustrative examples, they are directly integrated into the text to provide deeper insight into the findings.

Highlighted barriers encompass the impact of global trade with its ad hoc patterns and a fragmented fleet, conventional industry practices, the dominance of relationships in business while still lacking collaboration, the industry's struggle with underutilizing data, and the challenges of data sharing. Three factors—regulators, customer needs, and financial incentives—were identified as exhibiting dual roles, depending on their management. Finally, five enablers for successful implementation are outlined, with Stena Bulk having direct control over the first three, including incremental changes, alignment with core business, tailored industry-specific solutions, the impact of incidents or major global events, and the natural evolution of competition.

5.2.1 Barriers

Successfully introducing innovation requires overcoming some distinct and apparent barriers described below.

5.2.1.1 Global trading and a long lifespan of vessels

Stena Bulk operates globally, presenting a tremendous challenge. They experience highly ad hoc trading patterns, which means working with both developed and developing countries. While countries such as Sweden aims to streamline operations with electronic documents; some locations don't even have a computer. The contrasts are extreme, spanning from high to low. Consensus is crucial since Stena Bulk must cater to the customer's needs at the farthest end of the value chain. Stated by Operations in Gothenburg, "*internally, we can implement changes, but externally, we must align with the lowest common denominator*". One of the customers highlighted the industry's fragmentation with "*Rotterdam might be the most advanced port globally, but when you sail to a smaller one, you revert to using paper*". With 10,000 ports worldwide, each needing updates, the challenge of innovation implementation is immense. The persistence of outdated practices remains a concern, as there are always other ports or ships that haven't modernized. The involvement of numerous people and ports, without any huge players setting the tone, exponentially complicates the situation. Consequently, each company, terminal, or charterer has to have their own format.

It takes ten days to discharge in a small port in India because they are moving the equipment with camels. So talking about digitalization there they wouldn't understand.

Mixed team, Dubai

Adding to this obstacle is the extended lifespan of ships. Tanker ships are anticipated to be operational for a minimum of 20 years, resulting in vessels at various life stages trading under the same conditions. Implementing retrofits can be prohibitively expensive, such as upgrading a sensor package on a 15-year-old vessel, and might not align with the payback time, leading to a scenario where processes must function without the benefit of updated sensors as investments will not be made. This results in a considerable variation in capabilities and prerequisites across the fleet. As vessels vary considerably, and given the lengthy commercial lifespan of a ship, it's impractical to develop systems that only function on the most advanced models. Economic viability requires these systems to be compatible with ships that are more than 20 years old. This prompted the Operations team in Gothenburg to pose the question: "*How fast can you make changes like this?*" Given the lifespan, investments, and payback considerations, implementing modifications of this nature takes time. Consequently, the shipping industry operates in a world that evolves slowly while the external landscape changes rapidly, creating the need for these two parallel worlds to function in alignment.

5.2.1.2 Conventional industry

As noted in Chapter 2, the shipping industry is often described as a conservative and traditional industry, and characterized by its conservative practices and management, a sentiment which was echoed in the focus group interviews. Repeatedly highlighted in the focus group discussions, the reluctance to embrace change extends throughout the entire value chain, encompassing both suppliers and customers. This widespread conservatism in the sector can create a challenging environment for introducing and implementing innovative solutions, entailing sluggish transformations and prolonged timelines before any substantial actions are taken. While acknowledging the necessity of innovation to remain competitive and adhere to evolving regulatory and environmental standards, the maritime industry often finds it challenging to reconcile this with its preference for traditional practices. This tension is succinctly captured in a remark made during one of the focus group interviews: "*The challenge is that we [shipping] are so [expletive] conservative*".

Lack of trust in new systems, fear of fraud, and a risk-averse mindset contribute to the industry's resistance to change. Moreover, there exists an inclination to adhere to established norms to avoid the risks linked with early adoption of novel technologies or practices, as the perceived risks might outweigh the potential benefits. This risk/reward dynamic is prompting industry participants to opt for the security of conformity, and can, in part, be explained by the extensive lifespan of vessels, permeating the broader mindset within the industry.

One explanation for the maritime industry's entrenched reliance on traditional methods and hesitance to adopt new practices stems from a deep-rooted belief in the importance of experience. The Chartering team focus group shared their perspective on the issue: "*It is an old school industry and you can't just pick up a book and learn how to do this job - it is reliant on people's experience*". Another explanation was raised by the Operations team in Copenhagen, who contended that many actors had tried to disrupt the industry through digitization but legal barriers had acted as the conservative forces rather than the industry actors (regulatory implications on innovation are further discussed in Section 5.2.2.1).

Several focus groups mentioned conservative sentiment towards AI in particular. There's a legacy mindset that favors traditional methods and tools, rooted in a belief that if these methods worked for previous generations, they should suffice for the current one. This perspective is accompanied by a preference for simplicity and a resistance to complexity. AI, in particular, faces not only technical challenges in implementation but also mental barriers among those who are accustomed to older ways of working. There's a fear of the unfamiliar, concerns about job security, and a general nervousness about embracing new technologies.

On the other hand, the industry is witnessing an influx of younger professionals who bring new skills and are more open to technological innovations. These newcomers are more likely to adopt tools that simplify their work, although they still show reluctance towards anything perceived as overly complicated. The key to broader acceptance of technologies like AI lies not just in their functionality and the value they provide, but also in how they are presented and taught. It's crucial to focus on user-friendly interfaces and practical applications, helping users understand how to use these technologies rather than the complexities behind them.

As mentioned by one of the customers, "*this is much of a culture thing, if people start to learn and can see a benefit, they can overcome this conservatism*". However, this motivation to invest time and effort in bringing about change will not be apparent without immediate, tangible benefits, highlighted by the Chartering team in Copenhagen.

5.2.1.3 Relationship based industry with lack of collaboration

In the shipping industry, relationships play a pivotal role. The industry heavily relies on personal connections, echoed by the numerous conferences and events. Currently, they engage in socializing with clients and suppliers, fostering close relationships to secure business. Nevertheless, there's a tradition in the industry to be highly non-transparent. Many emphasize the importance of collaboration, but fewer actually engage in it. Hence the importance of interpersonal relationships, as much depends on personal chemistry—some are open to sharing information for reciprocal benefits. As stated in the business development focus group in Gothenburg, "*business transactions are conducted with those one favors; if you cannot connect with people, you cannot succeed in business*".

In regards to AI, this is a huge concern. Contemplating the scenario when everything is optimized to the maximum raises questions about the value of personal interactions: Do they desire such optimization, and at what cost? As the bunker team in Gothenburg phrased it; "*if this personal element diminishes, will it lead to the industry's decline in a sense?*". One can expect a resistance to embrace change as the stakeholders appreciate and value these personal relationships and surrounding activities, even though it may entail an increased workload in certain aspects.

However, despite the importance of relationships, typically, collaboration efforts are hindered by confidentiality measures and a lack of trust. The shipping industry is fragmented, with many stakeholders and the operations are highly short-term-oriented, primarily focused on the next deal. It is rare that they find themselves in situations that extend over a more prolonged period, demanding collaboration.

Nevertheless, this does not imply that positive sentiments toward collaboration were absent during the focus group interviews nor a lack of interest in collaboration opportunities. Instances of effective partnerships were highlighted, emphasizing how trust among participants served as a key facilitator and how Stena Bulk has actively participated in numerous joint ventures. Historically, these cooperative ventures have taken place vertically within the value chain, involving shipbuilders and ship owners or between owners and operators, as the primary objective of these collaborations was knowledge-sharing from Stena Bulk's side, in exchange to access of more ships. Moreover, the pool structure, where vessels operate collectively, reinforces the inclination for collaboration. The enabling factor here is the contractual agreements that mandate every participant to consider the collective interest, preventing any prioritization of individual owners. According to Operations in Copenhagen, having a contractual agreement in place is pivotal for successful collaboration, while the bunker team in Gothenburg emphasizes the importance of ensuring entities of comparable size and influence within the industry. Such partnerships could foster a more balanced and equitable competitive environment. Additionally, cross-sector initiatives have been launched to either exchange knowledge in specific projects or collectively influence regulators.

5.2.1.4 Data Sharing

Closely related to the conservatism observed in the industry in conjunction with the lack of collaboration is the perspective on data sharing and ownership. The uncertainty surrounding what constitutes commercially sensitive information poses a challenge. For instance, there is a clear barrier to understanding the true value of certain data, such as emission data, which makes firms reluctant to share it. Hence, caution is advised regarding the sharing of commercial decisions and strategies. Secrecy is pervasive; owners guard information closely, and are reluctant to share with others.

A direct outcome of this lack of collaboration raised by the Dubai team is the development of internal systems, where each ship agent tends to create proprietary software, but often, these systems are exclusive to them. In addition to multiple companies independently pursuing similar initiatives, selling such software is uncommon, despite significant development costs. Thus, the industry is marked by a trend of isolation, with companies maintaining closed, internal systems. However, relying solely on Stena Bulk's information for system development is limiting and narrow. These proprietary systems also introduce barriers in the form of vastly differing data storage processes, and there is currently no standardization in the naming and structuring of data.

Nevertheless, often, such information can be deduced through indirect methods, and when the information doesn't involve negotiation leverage, the industry demonstrates remarkable transparency. Access to broker databases, encompassing average market levels, historical fixing levels, world scales, and more, can be obtained by purchasing such data. Additionally, open reporting tools like MRV offer visibility into consumption data. Further more, as previously mentioned, the Operations team in Copenhagen contended that data sharing and collaboration occurs when there are clear contracts in place, which align the interest of the stakeholders.

5.2.1.5 Data Utilization

In the maritime sector, big data represents a significant yet underutilized resource, primarily due to outdated approaches in its management and analysis. "*Big data is the biggest lost opportunity in shipping because our approach is so old-fashioned*" as contended by the Dubai team focus group highlights the importance of both data utilization and the conservatives in the industry (as discussed in Section 5.2.1.2). This traditional approach to data handling in the maritime industry is hampering the sector's ability to harness the full potential of big data.

A consensus among the focus groups was that there is a vast amount of data generated through maritime operations, and if analyzed and utilized effectively, can lead to significant improvements in operational efficiency, safety, and environmental sustainability. Several focus groups contend that it is not paramount to collect more data, instead focus should shift towards understanding and managing the current data streams and ensure access to those who require it. However, due to the relatively modest size of Stena Bulk's fleet, it is highly probable that they will need to purchase external data. Two contrasting concerns were raised in this context. First, there's apprehension about whether computers will consider all factors as humans do. Second, there's worry about the risk of becoming indistinguishable from competitors, potentially diminishing the enjoyable and creative aspects of the job.

Inadequate data, insufficient interest in data, lacking structure, and overall poor quality. This industry has the least utilization of data insight in decision-making compared to any other sector I've worked in.

Business Development, Gothenburg

Moreover, the industry's reliance on legacy systems and resistance to change impede the adoption of more advanced, data-driven decision-making processes. This conservative attitude towards innovation and technology adoption results in missed opportunities. An example raised by the Dubai team focus group is the lack of utilization of noon reports. There are thousands of documents full of data that can be translated for real life usage, but the industry insist on utilizing standardized ratios (such as speed-consumption curves) because it is easier.

Even though additional data may not be deemed necessary, there are specific vital areas where data is presently not being collected. One of the primary barriers, raised by the Naval architect focus group, is the lack of accurate measurement principles, especially for thrust and torque. There's no definitive method to measure these accurately, which hinders precise assessments of a ship's performance. Additionally, the evaluation of a vessel's energy efficiency, factoring in fuel energy value and varying weather conditions like local wind, wave, and current, is complex. The data obtained, often based on the ship's speed through water, is frequently inaccurate.

Another obstacle is the difficulty in interpreting data from on-board connected measurements, such as vibrations and tensions. Alarm levels are typically set based on vaguely defined parameters or outsourced to suppliers for interpretation, which is necessary for maintenance. This process requires extensive and frequent measurements, all of which need to be managed onboard, as microsecond-level data should not be transmitted ashore. The Naval architect focus group identified that AI might act as an enabler in this context, shifting the industry consensus toward a more favorable view of data collection and utilization. However, they raised concerns over the costs and dangers associated with breakdowns, which would impose a very rigid performance benchmark.

5.2.2 Dual roles: Barrier or enabler?

The consensus within the focus groups pointed to three key factors that could support the effective implementation of innovations: regulations, customer demand, or financial incentives. Nevertheless, the discussion also highlighted that these very factors could potentially pose barriers, depending on how they are managed.

5.2.2.1 Regulatory influence

In the maritime sector, innovation is being significantly influenced by a dynamic interplay of factors, with regulatory bodies like the IMO becoming increasingly prominent as a force for change. The consensus among the focus groups was that regulators can serve as both barriers and enablers, depending on their actions.

The technical management in Scotland noted that the International Maritime Organization (IMO) is notably slow-moving, taking several years in enacting policies that facilitate global change. This slow pace can sometimes stifle innovation, as highlighted by the fact that the fastest regulatory change by the IMO took four years. The bunker team in Gothenburg echoed this sentiment, emphasizing that discussions on the same issue can persist for several years across various forums, resulting in minimal progress. They also highlighted the industry's occasional hindrance by the EU and IMO due to their perceived sluggishness, lack of sufficient influence, or global reach. The challenges of the diversity in legislation across different geographies creates a complex and uneven competitive environment, as operators must navigate varying legal requirements. This underscores the necessity to centralize regulations and establish global standardization across the entire industry.

Energy efficiency improvements are actively pursued, but global regulations and the absence of compensation pose significant obstacles to these initiatives.

Bunker team, Gothenburg

Despite this, it was contended that meaningful transformation in the conventional maritime sector is largely driven by regulatory policies. The necessity for regulations arises from the absence of voluntary changes, ensuring the establishment of a fair and level competitive playing field, as nothing is granted without a regulatory framework in place. This underlines the complex relationship between innovation, regulation, and the diverse stakeholders in the maritime industry.

Nevertheless, there are upcoming rules with uncertain implications for the industry, leading to ambiguity in how they will be applied. This inconsistency has led a significant portion of the industry to view these regulations as somewhat trivial, with an expectation that they may and should evolve, diminishing the seriousness with which they are currently regarded. However, the burden of complying with legislation for a more sustainable shipping environment often falls on operators and owners. There's a growing recognition that this responsibility should also extend upstream to the chartering entities, ensuring a more holistic approach to sustainability.

Many aspects are beyond our control, and whilst we can do everything possible, the responsibility should be shared collectively, not solely borne by shipowners.

Chartering, Copenhagen

On the technological front, new tools and processes for the accurate measurement of carbon emissions are pushing operators and shipowners toward innovation, as mentioned by the Dubai team: "*We are now slowly reaching a point where we have to digitalize things, especially now with more regulations and assessment tools for companies to be able to measure their carbon footprint*". These advancements are essential in reducing the negative environmental impact of maritime activities.

5.2.2.2 Customers and other players

According to Operations in Copenhagen, ship owners find themselves bound by decisions made by others. Therefore, if the drive for change comes from traders and charterers, it's even more advantageous than relying on regulators. This sentiment is echoed by the Chartering team in Copenhagen, asserting, "*The changes need to come from the clients; we are too small to push.*" They emphasize that for changes to occur, particularly those focused on sustainability, end users must be willing to bear the associated costs. Unfortunately, at present, there is a reluctance to accept any additional expenses. The Chartering team in Copenhagen adds, "*If they can choose 5 cents more for sustainability or 5 cents less for a non-sustainable option, they opt for the less expensive alternative.*" Operations in Gothenburg agreed and highlighted that the oil majors serve as primary obstacles, establishing standards according to their preferences. They noted, "*If we don't agree to their terms, they go elsewhere. If we don't deliver or act quickly enough, they don't want to collaborate with us.*" The Dubai team expressed a similar sentiment, stating, "*The trading and oil companies are the ones dictating change.*" Thus, If one or more of the oil majors were to demand a change, it would likely lead to a significant shift.

Cargo is king at the end of the day in the tanker shipping.

Mixed team, Dubai

The Dubai team also emphasized that if the world's largest ports or ship owners unite, they might have the influence to advocate for change. A customer raised a similar point, however, expressing doubt that the top 10 entities alone could compel the multitude of small owners in the industry's long tail. This long tail comprises 50 percentage of the industry, represented by small traders handling 1-2 cargoes per year or individuals owning just a couple of ships. Consequently, the industry's fragmentation, both in terms of fleet ownership and barrel trading, acts as a hindrance. The belief is that "*We can be as innovative as we want, but the small players will most likely hold it back*". A suggested solution is to acquire these smaller entities, consolidating the fleet to drive technological advancements. This discussion circles back to regulations, with skepticism about whether certain segments of this long tail would even adhere to legislation, as they may perceive the risk/reward ratio as justifying rule-breaking.

Technology cannot force change, the industry or the biggest players would have to want to
Customer, London

5.2.2.3 Financial incentives

Without an external catalyst for change, such as regulations or customer demand, incentives play a pivotal role. As emphasized by the business development focus group, "*either you have to be forced or benefit from it, otherwise people will just point at each other*". When referring to benefiting from it, the emphasis is on financial gains and business value, requiring financial sustainability and defensibility for profitability. The bunker team in Gothenburg exemplified this by stating, "*We can, for instance, embrace environmentally friendly practices today. It's not a substantial leap, given our knowledge and available measures. The primary obstacle is financial feasibility, as we would face significant costs.*"

It's important to acknowledge that shipping has evolved into a highly cost-efficient transportation method. However, this efficiency comes with a caveat: the low likelihood of disruption within the industry inadvertently places a greater responsibility on current actors to drive change. This sentiment was echoed across multiple focus group sessions, where it was argued that, like most industries, shipping operators are primarily driven by profit optimization. Operations in Copenhagen clarified that in shipping, every aspect is assigned a monetary value and efforts are directed towards minimizing costs. For instance, they highlighted, "*Reducing consumption is not primarily for emissions; we consider the cost. Of course, the two are interconnected, but the primary driver is cost.*" This does however highlight the point raised by the Operations team in Gothenburg, "*If there are commercial incentives, someone will pursue it*". From their point of view, innovation is not hampered by a lack of interest or capabilities, but rather by the current financial structures of the industry.

Moreover, Stena Bulk is subject to the vessel's activities under the voyage charterers, where efforts are made to optimize efficiency, such as adjusting speed to avoid arriving excessively early before laycan. Nevertheless, these measures are primarily cost-driven rather than environmentally motivated. The business development focus group in Gothenburg characterized the industry's business model as being structured around inefficiencies. Many industry practices, including the demurrage system (a fee charged for a vessel exceeding the agreed-upon time for port activities), are rooted in historical inefficiencies that may not align with modern sustainability objectives, often favoring short-term gains over long-term sustainability considerations. For instance, the financial benefits of claiming demurrage costs by arriving early in port may outweigh the savings in consumption, with emissions not being given due consideration.

The incentives to change are not there, and we lack the data to prove the value coming with a change.

Business development, Gothenburg

5.2.3 Enablers

Beyond the three enablers mentioned earlier, there are additional factors to consider. Some are within the control of Stena Bulk, while others are external forces.

5.2.3.1 Incremental changes

As emphasized in Section 5.2.1.2, transforming the shipping industry is a slow and gradual process. Operations in Copenhagen emphasized the necessity for time and patience for change, and the Naval Architects recommended embracing small, incremental changes over large, quick fixes, as the latter are seldom realized. Taking significant leaps poses risks, considering both competition and the substantial investments that may become locked in.

Think about it as a Ripple effect; initiate small changes and let the resulting impact guide the transformation

Technical Management, Scotland

5.2.3.2 Aligned with core business

As explained by Operations in Gothenburg, Stena Bulk's advantage lies in being quick and proactive in operations. There is much to gain compared to competitors if they focus on this, and it is not an impossible task; there is room for improvement. Additionally, they tailor their approach to meet customer needs, such as adjusting to specific coatings required for certain bio-products. "*Ultimately, it should benefit our business and our operations towards the customer*" they emphasized.

5.2.3.3 Tailor the solution to the industry

As highlighted in Section 5.2.1.2, the key to gaining broader acceptance lies in the user experience. Solutions should be tailored to the industry, minimizing the need for significant process changes. For instance, to address mental barriers, it's preferable to develop solutions that can be seamlessly integrated into events and conferences, aligning with current practices rather than causing disruptive transformations. The primary focus should be on supporting existing processes rather than disruptively transform them. Additionally, the technical management in Scotland emphasized the importance of presenting information in a way that relates to their operations, rather than just providing raw numbers.

5.2.3.4 Incidents or significant global events

It was noted that something impactful is required to change the industry and stir them from their current comfort zone. Operations in Gothenburg highlighted the paramount influence of COVID-19 on the shipping sector, impacting internal corporate culture and work methodologies, and the industry at large. Business Development in Gothenburg illustrated this further by stating, "*For instance, to implement electronic bills of lading, the industry would need a major accident or increased fraud to instill fear in actors, compelling them to change for enhanced security.*"

5.2.3.5 Evolving industry and competitors

As outlined by the technical management in Scotland, AI presents both challenges and opportunities, pushing the industry to evolve naturally, a trend seen in previous advancements "*from paper charts to ECDIS and TVs to iPhones*". The competitive landscape between Stena Bulk and its rivals will determine the industry's new norm, necessitating leadership to drive change and avoid falling behind. While there are risks in being an early adopter, there are also risks in not embracing innovation, highlighting the delicate balance and the need to keep pace with evolving competitors.

We exist in a dynamic world, requiring us to embrace adaptability and remain receptive to novel approaches

Operations, Copenhagen

6
Discussion

6.1 Mapping of uncertainties

In this section, each opportunity will be assessed by considering it through the lens of the uncertainties outlined in the Chapter 3 and the barriers and enablers identified in Chapter 5.

Here, we align the four areas of uncertainties, outlined in Section 3, with the findings detailed in Section 5. The evaluation of technological uncertainties is derived from the expert focus groups held during the second phase. Meanwhile, the remaining uncertainties—organizational, commercial, and social—originate from the data collected in the first phase's focus group sessions, involving Stena Bulk and its principal customers.

6.1.1 Document handling

This section introduces the uncertainties, and related barriers and enablers, for the implementation of a document handling system. The relative technological simplicity is highlighted as an enabler.

6.1.1.1 Technological

This could have been done 20 years ago.

Experts, Palo Alto

The issue is rather straightforward, requiring the AI to perform basic tasks such as comparing documents or summarizing different texts. It is a manageable number of variables and no extensive volume in training data is needed. The necessary data is already accessible internally, knowing where and how to retrieve it, in a sufficient amount for training. Although, organizing it into a cohesive structure poses a challenge.

Given that humans currently perform these tedious and time-consuming tasks, it presents an ideal use case for AI. The purpose is to enhance detection capabilities and streamline repetitive tasks, suitable for an AI. However, a potential hurdle is presented if a human struggles to interpret the scanned documents, as the AI will undoubtedly face the same challenge.

Considering many companies are already implementing similar processes in document handling, the suggestion is to identify a suitable existing solution and tailor it to specific requirements.

6.1.1.2 Organizational

In the context of organizational uncertainties, whilst the industry is typically conservative, the nature of the document handling would eliminate tedious tasks, thereby facilitating organizational buy-in. Notably, this shift does not require a massive organizational change; rather, it introduces a new model for document handling as a tool for those already engaged in these tasks. However, the industry has historically struggled with poor data utilization, characterized by a lack of data storage and knowledge about effective data management. This situation is compounded by a degree of mistrust traditionally associated with new methods in the industry.

6.1.1.3 Commercial

Concerning commercial uncertainties related to document handling, certain key aspects will act as mitigators. Stena Bulk can achieve immediate financial gains by identifying favorable clauses in contracts, acting as an enabler of change. This highlights the critical legal aspect of the shipping industry, where enhancing contract data analysis is directly beneficial. However, much of the document handling does not impact the core business directly. This presents a paradox where improving document handling processes can lead to substantial benefits, but it is not a primary focus area.

6.1.1.4 Social

Social uncertainties relating to document handling involve the need to efficiently manage a mix of physical and digital documents, given the diverse preferences of clients and the requirements of different ports hailing from the global trading nature of the shipping industry. However, there is no reliance on third-party or external data sharing as the system is intended to operate only internally - thus reducing the impact from other stakeholders.

6.1.2 Digital Twins

This section introduces the technological, organizational, commercial, and social uncertanties related to developing Digital Twins. The fragmented nature of Stena's fleet stands as a key barriers, whilst the technological simplicity could act as an enabler.

6.1.2.1 Technological

This could also have been done 20 years ago.

Experts, Palo Alto

You could easily envision a company that could build you something like this in a couple of weeks. I don't envision this to be super hard.

Experts, Palo Alto

The experts affirmed that this is certainly an off-the-shelf product with a relatively rapid development process, which is aligned with reality as Stena Bulk has an ongoing project involving external suppliers.

They have high-quality and frequently collected data from sensors onboard some of the ships, and the primary challenge arises with ships lacking sensor data, relying on noon reports instead. The experts emphasized that this pertains more to fuel consumption concerning external factors, requiring less extensive data. These external factors, including weather, currents, crew, etc., can be straightforwardly mapped out. However, the difficulty lies in accurately determining which factor has the most significant impact on the ship, what to consider and how to measure some of them.

Interestingly, the main challenge identified with this opportunity doesn't stem from technological aspects but rather from the human factor and motivation, ensuring effective utilization.

6.1.2.2 Organizational

The integration of digital twin solutions presents organizational uncertainties. Key challenges include the need for a mindset shift, particularly among captains, to ensure the effective utilization of digital tools. The industry's historical reluctance to embrace big data exacerbates knowledge gaps in implementing data-intensive solutions and poses barriers to efficient data gathering. Although steps toward digital twins have been taken, they require incremental changes in operational practices, particularly for captains, emphasizing a gradual, proof-of-concept approach to facilitate transition.

6.1.2.3 Commercial

The commercial implication of the digital twin solution presents both challenges and opportunities. While improving analytics capabilities through digital twins can lead to monetary savings, notably in the reduction of fuel consumption, the financial benefits are not immediately apparent, slightly diminishing the potential impact of these enablers. Furthermore, the digital twin technology aligns closely with Stena Bulk's core business activities of optimizing its fleet operations. This alignment not only supports Stena Bulk's operational efficiency but also complements its sustainability targets.

6.1.2.4 Social

In implementing digital twin technologies, several social uncertainties and mitigators emerge. A fragmented fleet, where some ships are equipped with sensors while others rely on noon reports, creates disparities in data availability and quality. Time charter companies may be reluctant to share sensor data due to competitive concerns unless specific clauses protect their interests. However, as the industry gradually digitalizes, competitiveness increasingly depends on and accelerates the transition to new technologies like digital twins.

6.1.3 Market Prediction

This section introduces the uncertanties related to the implementation of a Market Prediction model at Stena. Most notably, the need for comprehensive interpretation and the multitude of variables need to be taken into consideration acts as a key barriers.

6.1.3.1 Technological

According to the experts, this issue revolves more around the supply and demand dynamics at ports, necessitating consideration of the commodities' current and desired positions. This nuanced problem involves substantial interpretation, extending beyond the capabilities of a mere mathematical model.

Addressing the global commodities market proves challenging due to the multitude of variables involved, prompting the suggestion to focus on specific commodities rather than attempting an all-encompassing approach. Despite this, it still requires managing a significant number of variables, which is difficult due to the uncertainties affecting the market. Additionally, in order to train the algorithm, an extensive dataset is required, much of which is external, posing a challenge for Stena Bulk as they lack control over and may not even be familiar with the acquisition methods for such data. Despite this, the company's market analysts can provide insights into crucial data points.

Various market prediction models already exist, with experts emphasizing one focused on oil and demand that is accessible at Stanford. This model can be customized to encompass shipping trading patterns. While the feasibility of AI is affirmed, collaboration with a larger entity is recommended, considering the scale of the problem and the need for access to pertinent data.

6.1.3.2 Organizational

The implementation of market prediction models utilizing AI would involve a high degree of organizational uncertainties and barriers. The industry's traditional approach, marked by skepticism towards data reliability, creates a substantial barrier. To integrate AI-driven market prediction models, a substantial shift in mindset is required across all chartering personnel. This change is not merely incremental but foundational. However, the integration of AI models can be executed in parallel with existing practices, providing a pathway for gradual adaptation and a transition towards more data-driven decision-making processes.

6.1.3.3 Commercial

Contrarily, there are significant enablers and mitigants of commercial uncertainties relating to the adoption of a data-driven market prediction methodology. These models can enhance decision making regarding trading patterns, fleet size, and positioning, thus realizing significant profits. For a shipping operator, trading activities are key. Tools that empower traders to make more accurate and confident decisions are well aligned with the core objective of the firm.

6.1.3.4 Social

Notably, significant social uncertainties and barriers also impact the ability to implement such solutions. Challenges include the need to understand diverse global trading patterns, the industry's preference for traditional, relationship-based business practices that may elude AI modeling, and a widespread reluctance to share essential external data. Moreover, the competitive landscape could in the future necessitate adopting AI-based prediction models, especially if rivals start using them, to maintain a competitive edge.

6.1.4 Uber for shipping

Uncertainties related to implementing an Uber for shipping system is presented in this section. The external nature of most relevant data was noted as a key barriers, as well as the clash with current business practises which potentially could reduce profits.

6.1.4.1 Technological

Creating a map of the data is relatively straightforward despite the diverse variables involved. However, the challenge lies in the fact that most of the data for this task is external and beyond Stena Bulk's control. The main hurdle is the reluctance of data sources to share information, and making this work would be nearly impossible without substantial collaboration.

Theoretically, an AI could address this issue, as Uber is doing for taxis, but it would necessitate extensive data sharing and collaboration efforts.

6.1.4.2 Organizational

The concept of an "Uber for shipping" introduces substantial organizational uncertainties in an industry deeply rooted in traditional practices. This innovative approach requires a radical shift from established industry norms, fundamentally altering the operational and strategic framework of the entire shipping industry. Such a change is not only massive in scope but also demands significant adjustments in the industry's structure and working methods, challenging the conventional barriers deeply embedded within the sector. This underscores the need for a comprehensive transformation, affecting all stakeholders and processes in the shipping industry.

6.1.4.3 Commercial

The concept of an "Uber for shipping" presents commercial uncertainties for companies like Stena Bulk. While this model might introduce efficiency and flexibility in shipping operations, it clashes with current business practices that favor shipping operators. For Stena Bulk, implementing such a model could potentially reduce profits as it diverges from their established business approach.

6.1.4.4 Social

There are multiple social uncertainties needed for the implementation of "Uber for shipping". One challenge is the requirement to integrate comprehensive global trading patterns into the model, necessitating a vast amount of external data. This presents a considerable obstacle as it involves gathering and processing complex and varied information from around the world.

Furthermore, the success of the platform is heavily dependent on customer demand and the willingness of major industry players to adopt this new system. Convincing these stakeholders, each with their own set of interests and reservations, to embrace a unified platform is a daunting task. This reliance on the collective action of various industry participants adds another layer of complexity to the innovation process.

Contrarily, the regulatory landscape could act as a key enabler of this innovation. Regulatory influence is acknowledged as a key driver of change in the shipping industry, and in the realm of environmental regulation, they often exhibit strong leadership and enforce stringent standards.

6.1.5 Planning and scheduling

This section introduces the barriers and enabler for implementing AI-driven Planning and Scheduling. Notably, it is possible to implement a system relying on internal data but to achieve optimal performance external stakeholders needs to be on-boarded.

6.1.5.1 Technological

This could also have been done 20 years ago.

Experts, Palo Alto

Certain aspects of this process can be addressed through straightforward digitalization, like handling ship handovers and providing a current situation overview. However, tasks such as speed recommendations based on market conditions and recommending optimal voyages may require AI capabilities. It was recommended approaching it as a probability model, framing it as a mathematical optimization problem. However, this approach would require nuanced interpretation and the addition of supplementary features.

The subject matter experts advised against Stena Bulk attempting full automation of decision-making processes. Instead, they suggested providing plans for human review, emphasizing that the goal should be to enhance the capabilities of intelligent individuals rather than replacing them.

While a significant amount of relevant data is already accessible, the absence of stored failed fixtures poses a challenge for the model's learning capabilities. It is feasible to outline the necessary data today, even though a moderate number of variables are required, given their understanding of the specific variables to be considered. However, structuring diverse data from various external sources into a unified format is a challenge. Although it's possible to build the model solely on Stena Bulk's internal data, incorporating external market information may enhance algorithm performance.

While tools for digitalization are available, those specifically tailored for optimization are more limited. However, as stated by the experts, it is feasible.

6.1.5.2 Organizational

The voyage planning and scheduling is heavily reliant on experiences gathered by the team at Stena Bulk, highlighting the "conventional industry" mindset, where organizational resistance is expected. A mistrust of data, or a belief that "we can do it better" is likely to hamper innovation toward a more integrated system, and data utilization is typically an area where a distinct lack of capabilities and interest is noted. A system that integrates voyage planning would indicate a major overhaul in organizational processes, not just in collecting the data to build the system, but also in how the software is later utilized. Difficulties in incrementally introducing the new models are likely to increase organizational resistance. These barriers can be somewhat mitigated by tailoring the solution to the industry and offering capabilities previously not possible. For example, by implementing a portable solution so that traders can access their data from their phones would likely induce a certain degree of goodwill from the organization.

6.1.5.3 Commercial

By optimizing voyage planning, there are however great financial incentives. This approach enables companies to realize immediate monetary gains by improving decision-making, considering several voyages ahead, and optimizing the current trading and fleet operations. This includes savings in time and ensuring that all possible options are evaluated and taken advantage of. Moreover, making informed trading decisions is crucial for the core business, as there is much to gain from tailoring their approach to meet the specific needs of their customers.

6.1.5.4 Social

The social uncertainties and barriers are mostly related to interactions and relationships with brokers. Currently, it would be difficult to synthesize the impact each trader's relationship with their brokers has on the business, as personal connections are likely to have an observable impact on the prices offered. Furthermore, brokers may need to be onboarded in new processes for a successful integration, which would likely include receiving data from them in a standardized format

6.1.6 Fleet Analytics

The technological, organizational, commercial, and social uncertainties related to the implementation of advanced Fleet Analytics, enhancing the modeling of fleet position, composition and trading decisions, is presented in this section. Notably, the conventionality of the industry and a reliance of human experience can act as a barrier towards the implementation.

6.1.6.1 Technological

The objective is to identify overlooked elements and detect patterns, which is something already done today. Trends are attempted to be identified through manual and conventional analysis efforts, making it a clear application for AI.

The scope of the issue and the specific aspects under investigation dictate the volume of data required, the necessary variables, and how nuanced the interpretation needs to be. Organizing and outlining the data can pose challenges, contingent on the intended objectives. However, it seems to be a straight-forward mathematical model, where much of the necessary data may be available internally, while some external data might be needed for a comprehensive analysis.

Therefore, AI is well-suited for this purpose, however given the large scale of issues that could be categorized under fleet analytics, such as determining the optimal vessel type in specific trading patterns or understanding the impact of decisions made, the scope of the issue needs to be well-defined before work on building models is initiated.

6.1.6.2 Organizational

Fleet analytics simplifies a certain degree of organizational uncertainty. The industry is conventionally driven, often relying on traditional methods over data-driven approaches, leading to skepticism about the reliability and utility of big data. Stena Bulk and the broader industry have a history of underutilizing big data, resulting in significant knowledge gaps and barriers to adopting new data-intensive solutions. However, there are certain events which could trigger a swifter implementation. For example, a major decision that ends up causing significant losses to Stena could trigger a shift in organizational mindset towards AI. Furthermore, the implementation of AI-based analytics is seen as a moderate change, primarily affecting the analytics team rather than the entire chartering team.

6.1.6.3 Commercial

Leveraging AI for fleet analytics can significantly improve decision-making and profitability. However, these insights alone are not enough; they must be accompanied by actionable changes to realize actual profits, thus moderating the potential for financial incentives to act as an enabler of change. Furthermore, the composition and position of the fleet are critical decisions impacting the core business. The evaluation of market risk, etc. are core capabilities for a shipping operator and leveraging AI could act as a supplement to improve these capabilities.

6.1.6.4 Social

There are a limited number of social uncertainties relating to the implementation of fleet analytics, as it at its core can be implemented internally without other stakeholders. However, while internal data can initiate analytics, incorporating external data significantly enhances performance, presenting a barrier to data acquisition and integration. Additionally, the fragmented nature of fleet data challenges the creation of comprehensive datasets, limiting AI's effectiveness. However, the competitive landscape could necessitate the adoption of AI in fleet management, as failure to do so might result in losing ground to competitors.

6.1.7 Knowledge Bank

This section introduces relevant barriers and enablers for establishing a Knowledge Bank at stena bulk, to reduce the lead-time for document retrieval. Technologically, the key barriers is the consolidation of information. Furthermore, barriers in the form of comprehensive organizational shifts and collaboration with external stakeholders are noted as relevant.

6.1.7.1 Technological

Capturing and storing diverse questionnaires, along with implementing autocomplete features, primarily entails addressing digitization challenges. Integrating certain aspects of AI involves remembering typical customer requests in various ports and providing autocompletion based on other reports.

The primary hurdle in this endeavor lies in consolidating all the information into a single repository due to the multitude of variables. While much of the required data is internal and scattered across different locations, some external data, such as questionnaires, is essential and can be shared willingly. Although not an extensive amount of data is needed to train the algorithms, more data contributes to better outcomes.

This task goes beyond a simple mathematical model, requiring a degree of interpretation, albeit not to a significant extent. Although this process is currently handled by individuals, it is time-consuming and tedious, making it an ideal application for AI.

The autocompletion of questionnaires and learning from previous completions is not highly advanced and has been successfully demonstrated. However, adapting this to the shipping industry would necessitate considerable customization.

6.1.7.2 Organizational

Implementing a "Knowledge Bank" in a conventional industry like shipping presents unique organizational uncertainties and barriers. The proposed system would involve significant changes for the organization and the possibility of making “incremental change” is diminished. However, the promise to reduce tedious tasks could render this barrier less impactful and help facilitate organizational buy-in.

6.1.7.3 Commercial

Implementing a knowledge bank would lead to enhanced service quality and reduced response times from the moment a ship goes on subs, thereby decreasing the likelihood of losing the charter. Even if the charter is lost, this approach minimizes unnecessary downtime. This serves as a direct financial benefit.

6.1.7.4 Social

Document preparation in relation to being “on subs” relies on input from external parties and thus implies certain social uncertainties. For example, to streamline a document preparation for a specific customer, a change in preferences and specifications for the information requested can prove to be a barrier. Additionally, given the diverse fleet and number of port calls a tanker operates in, there is going to be a highly diverse set of documents for the system to understand and save. Through the above, concerns regarding data sharing and the global nature of the shipping industry arise.

6.1.8 Cleaning Assistance

This section introduces the uncertainties identified in developing an AI driven systems for improved tank cleaning. Notably, the collaboration with external parties who own the relevant data is highlighted.

6.1.8.1 Technological

A third party is currently hired to assist in assessing when to clean the tanks, and for Stena the complexity lies in bridging this gap. Stena Bulk lacks insights into the parameters considered by the third party during their analysis of when to optimal point to clean tanks whilst remaining compliant with regulations. Building a tool without hiring an experienced individual would require a substantial amount of data to identify patterns, which may not be readily available, despite previous recommendations. The challenge persists if Stena has not encountered certain scenarios that could have been advised upon.

For expediting the process and considering it in relation to the market, basic mathematical models can be employed, utilizing internally available data. Subsequently, it's crucial to define the scope and the desired outcome—whether it's to replace external consultants or expedite simpler tasks.

If the necessary data is accessible, AI is a viable solution, contingent on mapping out the knowledge used to formulate advice. In cases of substantial financial impact, the suggestion is to hire an external expert with the required knowledge, if that aligns with the scope.

6.1.8.2 Organizational

In cleaning the tank, traditionally the captain and external consultants have acted as the source of knowledge and advisors. Introducing AI to supersede these decision-makers can cause friction within the organization, which traditionally has been considered conservative and reliant on people's experience. Furthermore, as noted previously, the shipping industry in general has shown both an inability and unwillingness to utilize big data. This elevates concerns if there is organizational alignment to introduce the necessary processes required to capture and utilize the data necessary for building a model to assist in cleaning the tanks. Organizational buy-in can be achieved if it becomes clear the model is there to support the captain's decision, an incremental change towards a more data-driven organization, however, the contrary applies as well. If it becomes clear the model aims to replace human interaction, organizational resistance is to be expected.

6.1.8.3 Commercial

There are financial incentives for automating and amplifying the decision-making, which would reduce commercial uncertainties related to the development of such a model. Faster cleaning will reduce downtime, leading to higher utilization of the fleet, which is aligned with Stena Bulk's core business. A more immediate, but less impactful, financial incentive is to avoid paying external consultants for evaluations.

6.1.8.4 Social

There are also stakeholder considerations that have implications on the degree of social uncertainty related to implementing a model to assist in tank cleaning. For example, there needs to be alignment with external regulators such as IMO, as the model needs to perform to the established benchmarks. The performance of the model is likely to be greatly improved through collaboration with other actors, such as external experts, however, this increases the need for external data sharing and trust between business partners - an area the shipping industry historically has trailed in.

6.1.9 Co-pilot

This section introduces the uncertainties related to developing a Co-pilot for internal use at Stena. There are few social or commercial barriers and enablers, as this is a quality-of-life tool intended for internal use. However, a certain degree of financial incentives are expected through the perceived financial gain realized by time saved in streamlining day-to-day operations.

6.1.9.1 Technological

This challenge isn't exclusive to shipping and has already been addressed and developed, indicating its potential feasibility. However, there is a remaining question about the accuracy of the solution, and if customization is required.

6.1.9.2 organizational

A co-pilot acting as a support tool for the organization is not expected to face organizational resistance, in the form of the traditional "conventional mindset" typically seen in the industry, as the tool is designed to reduce friction in day-to-day work. Work has already begun towards similar tools, making this a logical "next step" and incremental change which becomes easier for the organization to trust and adopt.

6.1.10 Missed Invoices

This section introduces barriers and enablers for a system to catch Missed Invoices. The proposed implementation of a centralized system for missed invoices will act as a supplement to current processes and reduce friction inside the organization. Furthermore, the tool is intended for internal use, with the potential outcome of better customer service. Thus, there are no perceived organizational, commercial, or social uncertainties. However, if the problem with missed invoices is not meditated, and Stena gains a reputation of a firm not always paying on time there could be consequences from customers, perhaps in reduced freight volume and a shift towards other operators. This would act as a strong enabler for the organization to adopt a shift in processes to ensure as few errors as possible in payment processing.

6.1.10.1 Technological

The primary issue here is organizing data in a structured manner rather than extracting insights from it. Consequently, the focus is more on digitalization rather than necessitating an AI solution.

6.1.11 Bunker Analytics

This section discusses the potential and challenges of integrating Bunker Analytics in Stena Bulk's operations for improved supplier selection and cost efficiency. It addresses the technical, organizational, commercial, and social aspects, highlighting AI's role in enhancing data-driven decisions while acknowledging resistance due to established industry practices and relationships.

6.1.11.1 Technological

The bunker volume challenge is primarily a technical issue, and AI may not resolve that. However, AI can identify patterns, such as consistent supplier discrepancies and correlations between fuel energy density and suppliers, offering a straightforward solution, but unfortunately, without nuance.

The required variables are limited, and they know where to obtain them. Nonetheless, some data, like cheating patterns, is internal, while some, such as energy density, involves an external measurement. Extracting data related to Stena Bulk is straightforward, but the challenge lies in additional data beyond Stena Bulk's bunkerings, which the model's performance would benefit from to increase the data volume.

Given that this task is tedious and time-consuming, it's an ideal candidate for AI.

6.1.11.2 Organizational

The bunker function of Stena Bulk is critical to its operations, and it wields a high degree of influence when selecting suppliers and ports to bunker in. This influence is supported by their extensive experience with whom to trade and not to trade with. A model that allows for more accurate prediction of reliable and fair partners would likely experience some backlash from the organization, where the "Conventional industry" mindset is highlighted. The organization is likely to trust its experience over a predictive model and no data has been stored historically further exasperating the issues of an organization which have historically been poor at utilizing data opportunities. However, the proposed system benefits from not requiring any shift in the organization once implemented, potentially acting as a supplement to the bunker team's domain expertise. This would reduce the resistance for the organization and act as an enabler for innovation.

6.1.11.3 Commercial

Bunker costs are one of the key cost drivers in the industry, and achieving only a few percentage points improvement in this area would yield significant cost-savings. This would act as a critical mitigator of commercial uncertainties, further strengthened by the core nature of the bunker team - to provide fuel to its vessels. Stena Bulk recognizes the bunker team, and its role in reducing costs, as critical to its operations which would allow for further incitements to invest into its performance.

6.1.11.4 Social

The key social uncertainty facing the implementation of a bunker analytics model is the reduced reliance on the relationships bunker staff has cultivated with its suppliers. These relationships are valued across firms, and there is an expressed preference to trade with someone who is deemed reliable rather neccesarily the cheapest. Furthermore, Stena Bulk's global operations encounter diverse levels of quality and transparency from bunker suppliers. It is observed that in certain regions, the misrepresentation of fuel quality and volume during the bunkering process is more common. This variation adds complexity to the task of developing an accurate model for managing these operations, tying into the previously mentioned importance of relationships with the bunker suppliers. There are however certain aspects that can act as mitigators for these uncertainties. For example, if multiple actors or regulators came together and increased the pressure on suppliers to be more transparent in their reporting of bunker quality, there would likely be a transition towards less deceptive practices. Stena could also potentially leverage its relationship with firms testing the quality of bunker fuel to receive external data, allowing for increased data volume to train its model on. Furthermore, a must-have for developing a bunker analytics model is access to data from the experts testing the fuel, as energy density data is not available internally at Stena. However, data sharing is thought to be difficult in the industry, as many view the value of their data as tough to assess.

6.1.12 Predictive maintenance

The uncertainties related to introducing AI-driven Predictive Maintenance is described in this section. The potential reliance on external data, and a general conservatism in the industry is noted as important barriers, whilst the proven technological feasibility in other industries can act as an enabler.

6.1.12.1 Technological

The concept of predictive maintenance has already been successfully implemented in various other industries. This necessitates an extensive array of variables and a substantial volume of historical data to facilitate learning and identify patterns. Given that it primarily involves data points from sensors, it is compatible with AI.

However, since the data onboard the ships may not have been internally stored at Stena, it might require a significant amount of external data beyond their control. A considerable portion of the data might be confined to the ships, posing a challenge in consolidating it into a unified repository due to the limited digitalization of the ships.

Moreover, gaining a nuanced understanding may be essential to comprehend how different pieces of equipment interact unless the goal is solely to detect patterns. Achieving nuanced interpretation might involve collaboration with suppliers.

Regarding asset management, that is a straight-forward analysis based on previous breakdowns that can be found in the order history of new spare parts.

6.1.12.2 Organizational

As with many functions within Stena Bulk, the maintenance, and allocation of spare parts is inherently a subjective process based on internal expertise. Notably, an expressed distrust towards the data-driven recommendations supplied by the manufacturer has been identified. This highlights the conventionalism within the industry and the reliance on experience in decision-making. Implementing AI to make these decisions is likely to be faced with a high degree of organizational resistance, as a preference for own experience has been noted over most data-driven solutions. Furthermore, the lack of previous data utilization has likely resulted in a lack of capabilities and processes to capture the necessary data. However, this model does not require an immediate organizational pivot to implement and could instead be phased in through incremental change. This would allow the relevant personnel to learn to trust the system over a longer period of time, and implement it into day-to-day operations in a more natural manner. One of the key points to realize for the successful implementation of maintenance augmented by AI is to tailor the model so that the vessel crew understands the output, and how it was derived. They are not likely to trust "black box" solutions, without validating the output themselves.

6.1.12.3 Commercial

There are significant mitigators towards commercial uncertainties that can be realized through the implementation of a more accurate maintenance system. Ship downtime can be very costly, and where improvements can be expected. Furthermore, spare inventory could be reduced, increasing financial liquidity. Furthermore, fleet maintenance is a core aspect of a shipping operator's business - thus a system improving this process is well aligned with the core objectives of the firm. Contrarily, the fragmented nature of Stena's fleet, where not all ships have the same set or correct sensor, will act as a financial barrier due to the cost (both in labor and in parts) of retrofitting and upgrading the magnitude of sensors each ship needs to have. There will be a need for investments, and given the long lifespan of vessel there will be ships which are not worth investing in, hampering the ability to provide a comprehensive model.

6.1.12.4 Social

There are social uncertainties and external stakeholders that can impact the implementation of this type of system. Notably, data sharing with equipment manufacturers would allow for exponentially larger datasets and implicitly higher performance. Data sharing is typically difficult in the shipping industry, and thus far the Stena Bulk teams have not viewed manufacturer recommendations as perfect.

6.1.13 Safety

This section introduces the uncertainties related to implementing safety monitoring models based on AI. Notably, the technological barriers were deemed minimal as there are multiple solutions already on the market. instead organizational uncertainties and interaction with external stakeholder were noted as barriers.

6.1.13.1 Technological

Various solutions were discussed, some of which are already accessible in the market, albeit at a considerable cost. The focus doesn't necessarily have to be tailored exclusively to Stena Bulk, as long as the solution is applicable to the shipping industry.

6.1.13.2 Organizational

Organizational uncertainties relating to adopting AI-driven safety monitoring solutions involve a complex balance between opportunities and challenges. The conventional nature of the industry becomes less relevant, as safety has taken precedence. However, there's skepticism about replacing human judgment with technology, stemming from a belief in the superiority of human skills over equipment. Having previously not been engaged in data utilization concerning big data and AI, organizational concerns arise regarding the capability and willingness to implement AI and technology-based solutions, potentially hampering innovation in this field. This transition to AI is perceived as an incremental change, given that the industry is already moving towards increased reliance on technology when it concerns safety. This trend suggests a readiness among decision-makers and vessel crew to embrace AI advancements.

6.1.13.3 Commercial

Implementing safety monitoring solutions leveraging AI implies a certain degree of commercial uncertainties for Stena Bulk. First, there appears to be a lack of financial incentives to invest in these solutions, as they may prove costly without direct financial benefits. Despite this, Stena's commitment to being a reliable and safe operator is a core company value. Improving safety is expected to be well-received at all organizational levels, suggesting that despite the financial implications, there is likely to be strong support for such initiatives. This alignment with core values may drive the organization to overcome the commercial challenges associated with implementing safety monitoring solutions.

6.1.13.4 Social

The social uncertainties related to AI-based safety solutions in the shipping industry encompass several stakeholders and factors. Firstly, a fragmented fleet poses compatibility challenges, with older ships possibly not justifying the investment in new AI technologies. Effective safety measures require collaboration between ship manufacturers and equipment producers, emphasizing the critical role of data sharing, which can be complex. Market demands, including those from customers, can pressurize the industry towards enhanced safety. Lastly, the occurrence of more incidents, such as piracy or cybersecurity threats, can act as a catalyst for adopting advanced safety measures.

6.1.14 Environmental Footprint

This section discusses the uncertainties related to the implementation of Life Cycle Assessment, and an increased focus on Environmental Footprints, at Stena Bulk.

The availability and structure of data, as well as collaboration with other stakeholders stands as the notable barriers.

6.1.14.1 Technological

The primary issue here is organizing data in a structured manner rather than extracting insights from it. Consequently, the focus is more on digitalization rather than necessitating an AI solution.

If the scope would be to identify emissions savings potential, then perhaps that could be considered.

6.1.14.2 Organizational

Life Cycle Assessment is viewed as a difficult and non-standardized process. As there currently isn't a "best practice" established, typical barriers such as "conventionalism" and reliance on traditional methods are not expected to be present. There are however organizational barriers relating to a lack of data collection processes and capabilities seen in many big data projects.

6.1.14.3 Commercial

From a commercial point of view, the financial incentives are not aligned with the implementation of better LCA, as this is a cost-driver without any direct correlation with increased revenue. However, Stena Bulk has positioned itself as a champion for environmental progress within the industry, thus improved LCA is well aligned with the firm's core objectives.

6.1.14.4 Social

The largest barriers can be observed on the social dimension, where multiple stakeholders are required to participate. Firstly, the global scale of the industry would require a framework that works across regions. This can only be achieved through industry-wide collaboration or significant regulatory intervention. An accurate assessment process would likely also require a high degree of data sharing between different vertices of the industry, particularly engine and ship suppliers disclosing CO_2 emissions, which further highlights the magnitude of stakeholders involved.

6.1.15 Navigating externals

This section introduces the uncertanties in implementing a system for Navigating Externals, i.e. an improved due dilligence process. The key barriers exists in the form of the magnitude of variables needed to be taken into consideration, as well as the high degree of stakeholder interaction.

6.1.15.1 Technological

This task involves numerous variables, the majority of which are external and beyond Stena Bulk's control. Depending on the specified scope, these variables can be identified and limited, perhaps focusing only on certain regulators. However, the complexity increases with more sources to cover.

If the focus is on monitoring external partners by scanning the internet and summarizing or highlighting changes — essentially catching things that might be overlooked — then the task becomes relatively straightforward. However, challenges arise when interpretation is necessary to replace individuals with expertise. Similarly, analyzing the fleet in relation to changes introduces additional complexities.

While a human is currently handling this task, it is time-consuming and tedious, making it an ideal use case for AI.

6.1.15.2 Organizational

As seen in other opportunities, the performance of due diligence and regulations monitoring is perceived as a time-consuming process and model leveraging AI could assist in reducing this burden from Stena Bulk personnel. This implies less impact from the traditional "conventionality" seen in the industry and would imply a higher degree of internal adoption.

6.1.15.3 Commercial

The commercial implications of improved due diligence efforts are ambiguous. Introducing efficient models to track non-compliance with sanctions lists and environmental regulations can potentially save Stena Bulk significant amounts in fines. However, it's important to note that non-compliance has not been a material issue for the company to date, and the financial benefits realized from a more efficient regulation tracking process, while present, are not substantial. The overall financial impact of these improvements can be considered limited. Nevertheless, as a global shipping operator, Stena Bulk must be vigilant in understanding and adhering to the various sanctions and regulations critical to each region they operate in. Improving this aligns closely with the company's core business objectives. This enhancement in operational efficiency can contribute to a more streamlined, compliant, and effectively managed business.

6.1.15.4 Social

Navigating external factors implies a high degree of stakeholder interaction. A key aspect is the reliance on external data, which, fortunately, is largely publicly available. This accessibility of information reduces the need for extensive stakeholder interaction and making concessions to achieve internal goals, thereby potentially acting as an enabler for change. However, as there are a variety of differing regulations depending on their ships' locations worldwide, the prospect of aligning these regulations globally is not seen as an imminent possibility. Furthermore, these regulatory landscapes are prone to frequent changes. This complex regulatory interaction stands as the most notable barrier. Nevertheless, if the major players in the industry unite, there is a possibility to expedite this process, overcoming the challenges through collective effort. x

6.1.16 Synthesis of Uncertainties

Figure 6.1 illustrates the integration of uncertainties (characterized by barriers and enablers) into the framework of stakeholder complexity and ambiguity. This integration follows the methodology outlined in Chapter 3 and further detailed in Appendix A. In this approach, each uncertainty is evaluated for its level of stakeholder ambiguity or complexity. This evaluation also includes an analysis of the barriers and enablers associated with each uncertainty. An uncertainty is deemed less significant and potentially excluded from consideration if it is supported by several enablers, such as clear commercial incentives. Conversely, an uncertainty is considered more significant and impactful if it is hindered by multiple barriers, like the need for alignment among various stakeholders. Opportunities such as Uber for ships and addressing Environmental impact are proposed to be facing significant Stakeholder ambiguity and complexity, whilst opportunities such as Document handling and Fleet Analytics can mostly be completed internally at Stena.

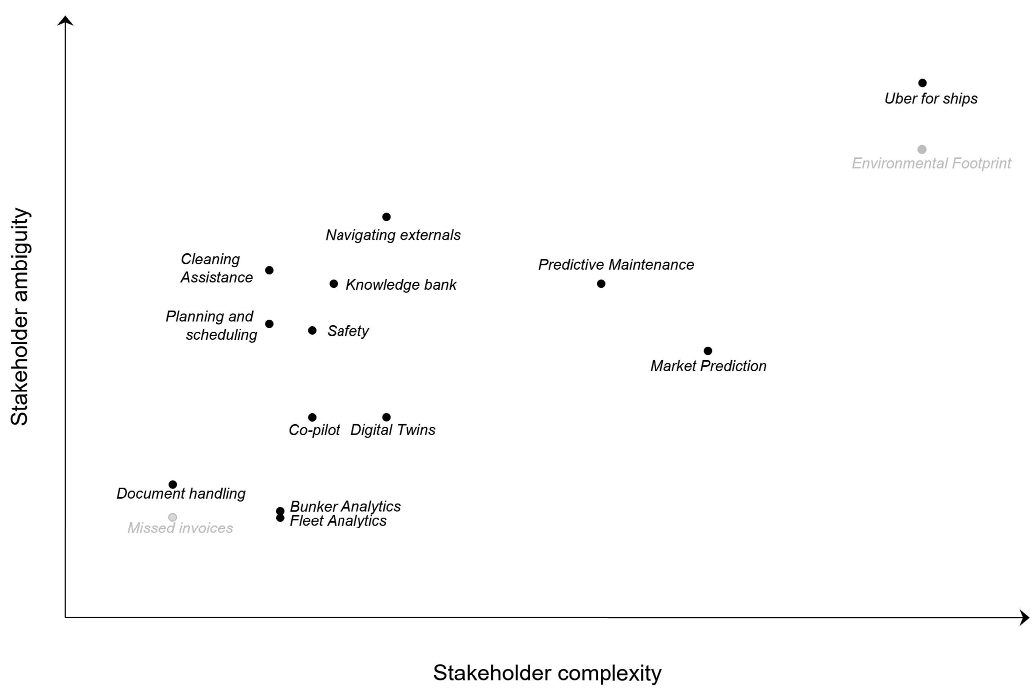

Figure 6.1: Mapping of stakeholder complexity and ambiguity

Furthermore, Figure 6.2 shows the opportunities group after themes identified in this chapter. Here the above trends are clarified further, where technologically simple

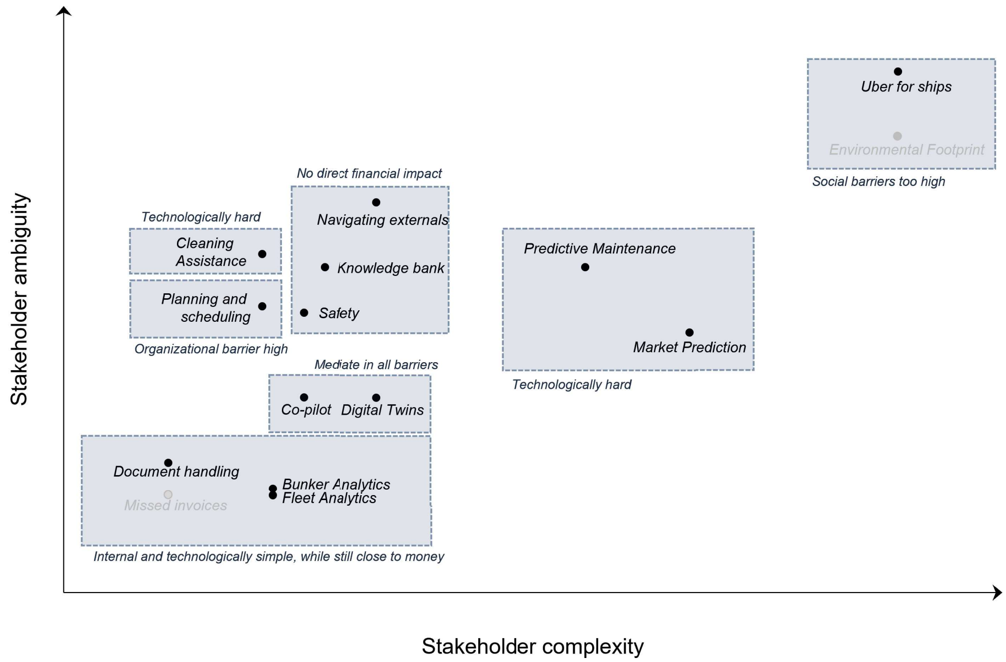

Figure 6.2: Grouping of opportunities from stakeholder framework

and commercially lucrative opportunities have been highlighted, as well as other categories such as technologically difficult opportunities such as Market Prediction and Predictive Maintenance. The implications of these categorizations are further discussed in Chapter 7.

7
Conclusion

In conclusion, the comprehensive analysis undertaken in this thesis illuminates how artificial intelligence can be leveraged to navigate contemporary opportunities presenting themselves in tanker shipping from various perspectives, revealing the intricate interplay of technological, organizational, commercial, and social uncertainties for a successful implementation.

The technological barrier is not substantial; as according to the experts, everything could have been accomplished 20 years ago. The primary concern, however, revolves around the existence and adequacy of data in terms of both volume and quality. Additionally, it hinges on whether Stena Bulk possesses the knowledge of necessary variables and the expertise required for nuanced interpretation if a sophisticated analysis is deemed essential. In essence, there are no significant technological impediments aside from the accessibility of data. Nevertheless, our observations indicate that data utilization within the organization poses a considerable challenge, and data sharing within the industry is not a common practice. Therefore, a recommendation is to commence comprehensive data storage, especially if the data proves essential for future solutions not considered currently.

As the experts further emphasized, which is in alignment with existing literature, the primary barrier is organizational. Many of the proposed solutions require changes to existing processes, making organizational buy-in crucial. Without this support, there is a risk of developing algorithms that may deviate because new processes are not followed. This challenge is particularly significant in the shipping industry due to its conventional mindset and limited experience with data storage, hence, convincing stakeholders may require extra effort. Therefore, prioritizing opportunities closely tied to financial outcomes becomes imperative to engage the organization effectively, considering this is the language spoken in the shipping industry. Additionally, it is also essential to focus on initiatives that enhance and support the core business, including catering to customer demands for a competitive advantage.

A strategic recommendation is to start with technically straightforward projects that utilize existing data and require minimal process changes. This approach allows for quick delivery and demonstrates tangible benefits. A potential initial project could be document handling, as it will eliminate tedious and time-consuming tasks for the organization, gaining their buy-in as they feel prioritized. By showcasing this immediate value, stakeholders can be persuaded to recognize the benefits and potentially reducing the organizational barrier for subsequent projects. This approach is effective because it addresses tasks perceived as mundane and aligns closely with financial objectives, with minimal distance between change and revenue generation.

Furthermore, it's crucial to effectively manage expectations within the organization to avoid unrealistic expectations of flawless performance from the solution right away. Take market prediction, for instance; if the expectation is for the solution to predict the market with 100 percent accuracy, success becomes unattainable, and organizational trust diminishes. However, recognizing the achievement of making 5 percent better decisions in the coming year, with subsequent improvements in the following years, can yield significant results. It is equally critical to identify the variables with the most significant impact on the market to track and follow them. This concept aligns with the idea of being an incremental change enabler.

Furthermore, connecting this to the industry context is pivotal. Winning over the organization involves conveying that the changes won't be disruptive but supportive, enhancing existing processes. The goal is to make what one is already doing better, leading to a transformation that seamlessly integrates without conscious awareness. As an illustration, having a planning and scheduling solution accessible on mobile devices can be beneficial. This enables users to carry the solution when meeting brokers face-to-face, recognizing the industry's emphasis on relationships. This strategic integration ensures that solutions not only support but enhance existing practices, paving the way for gradual transformation.

Another noteworthy conclusion emphasized by the experts is the purpose of not attempting to *"replace smart people but, instead, to make smart people even smarter"*. This sentiment aligns well with the shipping industry's conventional perspective, where computers are viewed as limited in their perspective versus the nuanced approach of human decision-making. This quote serves as a guiding principle in both the design of solutions and the decision of whether to develop them at all. In the realm of solution design, it directs the focus towards providing support in decision-making rather than automating decisions outright. However, as a guiding principle in determining the feasibility of development efforts; if the intention is to replace a highly intelligent individual, navigating the complexities of AI rules becomes particularly challenging, especially when lacking the necessary expertise, as evident in the case of cleaning assistance.

Finally, we strongly recommend starting with internal opportunities that do not necessitate external collaboration. The social uncertainty poses a significant, challenging-to-control barrier, particularly in a globally fragmented industry characterized by conservative practices. Avoiding the need to align with numerous stakeholders and reducing dependence on external data sharing would significantly enhance the potential for success. Overcoming social uncertainty likely requires regulatory measures, which may not be necessary for internal initiatives to thrive.

These conclusions not only contribute to our understanding of utilizing AI in shipping and its barriers, but it also opens avenues for further exploration and underscore the significance of continued research in this field.

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A

Containerization as an innovation process

As described in 2.2, Transportation Research Board & National Research Council (1978) describes the process in which maritime shipping of goods transitioned from break bulk shipping to widespread use of containers. This process was characterized by a high degree of social uncertainty. In particular, the involvement of governmental entities and resistance from labor unions increased both the number of stakeholders and caused misalignment in objectives. Transportation Research Board & National Research Council (1978) describes how the initial stages of the containerization phase were spearheaded by the U.S. Army Transportation Corp and U.S. Navy, in its mission to supply the front lines during WWII, the Korean War, and the Vietnam War. The Armed Forces did not utilize containers to increase loading efficiency or economic profit, instead, its goal was for the safe transit of precious cargo, temporary storage on arrival, and timely arrival of critical goods (Transportation Research Board & National Research Council, 1978). In this early phase, as the goal of the military differed from the commercial sector, no efforts were made to ensure the economic viability of the transportation method. The only commercial use seen during this stage was of the companies wishing to utilize the containers for their protective characteristics, i.e. the companies whose goals aligned with the Armed Forces.

The governmental involvement in the containerization did not stop at the Armed Forces. The American Standards Association established a modular series of nominal lengths for containers in 1959 (Transportation Research Board & National Research Council, 1978). This standardization acted as a significant enabler of the continued pursuit of an effective container trade as the length agreed upon had been aligned with the entire transportation industry (notably the 40' maximum length represented the largest size allowed on highways, and the 20' length in reality corresponded to two containers who coupled together represented 40') (Transportation Research Board & National Research Council, 1978). However, the standardization negatively impacted the early adopters of the technology, who had invested in differing sizes (Transportation Research Board & National Research Council, 1978). The multi-year standardization process likely deterred investment from many actors until the committee's decision, posing a significant barrier to innovation due to the long-term nature of vessel investments. In conclusion, the involvement of the government allowed for rapid diffusion of the innovation once a consensus was reached. However, during the initial stages, the goals pursued by governmental entities differed from what the commercial sector required and a standardization process that attempted to satisfy the demands of multiple sectors caused delays in the innovation process and increased the stakeholder ambiguity.

Similarly, the resistance from longshore labor unions contributed to a significant degree of social uncertainty. Historically, longshore labor was a major cost driver for shipping companies, and break-bulk storage required sizeable gangs to move cargo to and from trucks into the vessels (Transportation Research Board & National Research Council, 1978). This significant bottleneck in the supply chain, and rising labor costs, acted as the catalyst for commercial actors to pursue containerization which promised reduced loading times and longshore gang sizes (Transportation Research Board & National Research Council, 1978). It is evident that the motivations and goals of the labor unions drastically differed from the shipping operators. The unions' view was that containerization was going to cause significant loss of work, and several initial attempts at introducing container shipping failed because dockworkers refused to handle the containers (Transportation Research Board & National Research Council, 1978). Eventually, an agreement was made where the gang size was reduced from 21 to 17 persons and a fund was established to protect the longshore workers who were affected by loss of work. This agreement allowed for the pursuit of containerization to proceed, but at the cost of significantly less economic profit for the operators (and consequently fewer incentives), as the envisioned labor cost reduction was not achieved.

Barriers to innovation that relate to organizational uncertainties were also presented as critical in the containerization. Transportation Research Board & National Research Council (1978) contends that management in the maritime sector is traditionally risk-averse and conservative, an environment that stifles innovation. This conservative view is exemplified by Transportation Research Board & National Research Council (1978) in the mandated speed increase of oil tankers in the 1930's. The government required the subsidized Cimmarron class of tankers to be built with extra power in case they needed to be commandeered by the Navy. The management of the operators contested that the speeds enabled by the power increase were not economically feasible, resulting in the Navy funding the power increase. However, it was later revealed that the operators chose to utilize the additional power and operate their vessels at higher speeds. In the containerization case, few operators dared to oppose the conservative view and explore the benefits of containers, paving the way for the more risk-averse followers (Transportation Research Board & National Research Council, 1978).

As the container trade expanded, the business model of shipping operators changed, causing additional organizational friction and uncertainties. Previously the shipping operators had enjoyed a responsibility limited to the loading and offloading of the vessel, and the waterborne leg of the transport Transportation Research Board & National Research Council (1978). The new system required the shipping operators to assume a more hands-on approach toward the land segments of the trip. The operator now has to assume responsibility for containers and chassis which are geographically spread out and handled by trucking companies and customers alike (Transportation Research Board & National Research Council, 1978). Some shipping operators opted to mitigate this challenge by acquiring and integrating trucking companies (Transportation Research Board & National Research Council, 1978). Although this reduced the operational complexity, management, and governance of integrated companies likely posed other organizational challenges to these operators.

As asserted above, the commercial benefits of container trade were evident to most once the initial exploration phase had matured. Apart from not achieving full labor cost reduction, the reduced loading times proved to be lucrative for shipping operators and with a transparent harbor tariff system, the gains could be calculated before any investments were made (Transportation Research Board & National Research Council, 1978). Still, the long-term nature of vessel investments remained. With an expected economic life of more than 20 years, very little risk is assumed in shipbuilding Transportation Research Board & National Research Council (1978). Even if the profitability of container usage was apparent, a cautious and risk-averse fleet manager would still need to ensure that a more efficient, yet incompatible, transportation method was not introduced prematurely. This caution would be necessary to guarantee that the returns on investment in a container fleet are fully realized before making any transitions.

Technological uncertainties, as mentioned in section 2.2, did not pose major challenges to the transition from break bulk shipping. The U.S. Army Transportation Corps proved the technical viability of the shipping method, and several commercial actors were swift in developing vessels with integrated loading mechanisms for containers, such as cranes (Transportation Research Board & National Research Council, 1978).

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