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Impact of IoT on Norwegian Seaport Logistics in the era of Industry 4.0 - a case study approach

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Abstract

This thesis explores the potential impact of IoT technology on seaport logistics within the industry 4.0 context. Through a descriptive case study, this research investigates the adoption of IoT in achieving competitive advantage for the seaport firms. Specifically, the study examines the current level of IoT integration at Cargo Port of Bergen, its vision for future IoT adoption, and the path to the desired implementation. Furthermore, the thesis assesses to what extend the IoT technology contributes to the seaport's competitive advantage. The research has been conducted within the framework of resource-based view for internal analysis, and the environmental models of competitive advantage for external analysis. The evaluation is conducted through the application of analytical tools such as SWOT, PESTEL, and VRIO. The findings of this study contribute to the existing knowledge on IoT adoption in the logistics industry and offer practical recommendations for the Norwegian seaports aiming to leverage IoT technologies to maintain their competitiveness.

Acknowledgement

We would like to express our gratitude to our lecturers for their significant guidance and support throughout our three-year study in Master of Business Administration in Strategy and Management, with specialization in Innovation at the Nord University. Our research would not have been possible without the contributions of the management at the Bergen seaport and corresponding companies, who provided us with insightful opinions, reflections, and projects that have helped us gain a deeper understanding of the research subject. We are also deeply grateful to our research supervisor, Sølvi Solvoll, who despite being in the USA for a research opportunity during our research in Norway, provided us with precious guidance and constructive feedback throughout the entire process. Lastly, we would like to extend our heartfelt thanks to our wives and daughters for their unwavering support and patience during this journey.

Sincerely,
Adrian Bamdadi and Vahid Abdollahi

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List of acronyms and abbreviations

Abbreviation	Description
3D	Three dimensions
5G	Fifth generation mobile network
AGV	Automated Guided Vehicles
AI	Artificial Intelligence
DGPS	Differential Global Positioning System
DSB	Direktoratet for samfunnssikkerhet og beredskap (Norwegian Directorate for Civil Protection)
EPI	Environmental Port Index
ERP	Enterprise Resource Planning
EU	The European Union
IAPH	International Association of Ports and Harbors
ICT	Information and Communication Technology
IoT	Internet of Things
MBA	Master of Business Administration
MSc	Master of Science
NCS	Norwegian Continental Shelf
NTNU	Norwegian University of Science and Technology
NTP	National Transport Plan
PESTEL	Political, Economic, Social, Technological, Environmental and Legal
QC	Quality control
SINTEF	Norwegian Institute for Applied Research, Technology, and Innovation
RBV	Resource Based View
SSB	Statistisk sentrlbyrå (Statistics Norway)
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TEU	Twenty-Foot Equivalent Unit
TØI	Transportøkonomisk institutt (Institute of Transport Economics)
UiO	University of Oslo
VRIO	Value, Rarity, Imitability, and Organization
WTO	World Trade Organization

1. Introduction

According to Bocheński, Palmowski and Studzieniecki (2021), seaports are important drivers of economic growth. Seaports are major economic hubs that offer a diverse variety of services. In Norway, due to the country's geographical conditions, with long coastal line in the west of the country, the seaports are an important part of the nation's economy, uniquely positioned as a gateway between Europe and intermodal transport system. According to the statistical reports issued by the Norwegian Coastal Administration, approximately eighty percent of total cargo import to Norway is conducted through the sea (Kystverket, 2023).

Looking into domestic goods transport in Norway, the Norwegian Center for Transport Research (in Norwegian: Transportøkonomisk Institutt, TØI) has logged the market share for various transportation modes since the second world war, as provided in the figure 01 (TØI-Report, 2021). The main trend captured by the figure is that road has quadrupled its market share compared to sea during the last five decades, i.e., an increase from twelve percent to fifty two percent. In contrast, the market share for the sea transportation has shrunk from sixty five percent to forty two percent.

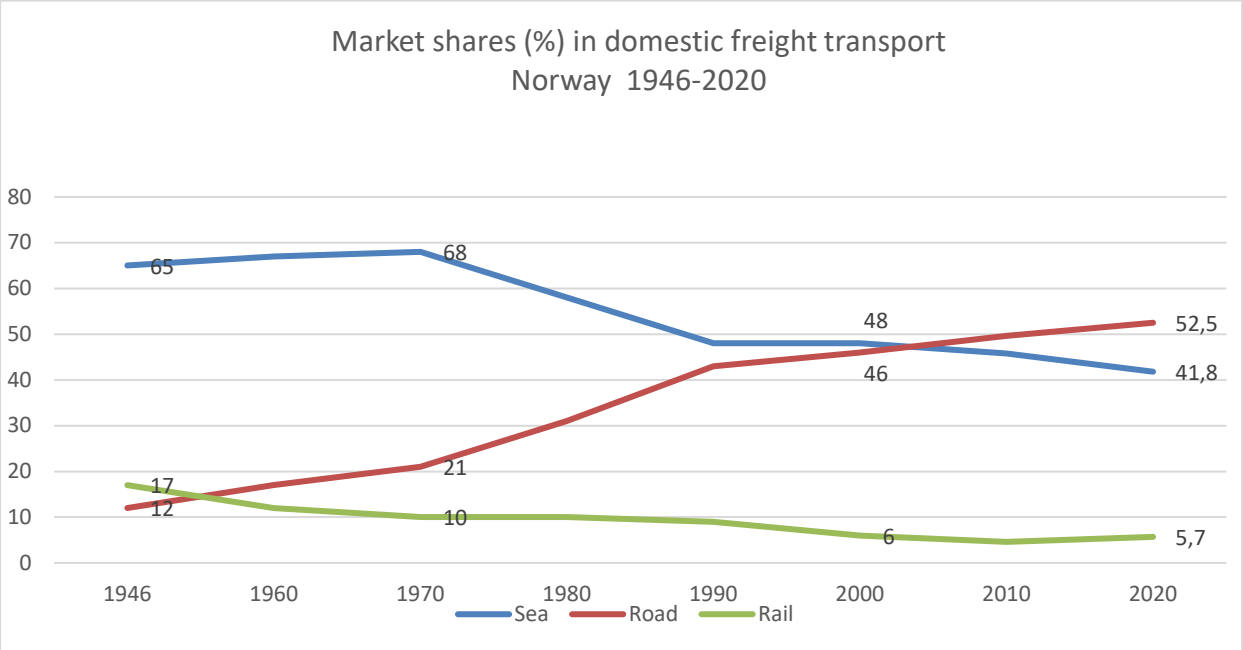

Figure 01 – Market share in domestic goods transport in Norway in the period 1946-2020 (TØI-Report, 2021)

When it comes to roads in Norway, they are generally narrow, costly to build, and difficult to maintain due to the country's topographical features, characterized by high mountains and cold climate (National Transport Plan, 2017). High traffic load on the road network increases the road's wear and tear, rises the probability of dangerous accidents on critical arteries, and most importantly, it leads to higher emission levels generated from transportation (National Transport Plan, 2017). According to the Norwegian statistics bureau (in Norwegian: Statistisk sentralbyrå, SSB), transport sector accounts for thirty percent of climate emissions in Norway (SSB, 2019). Figure 02 represents the emissions of climate gasses divided per mode of transport.

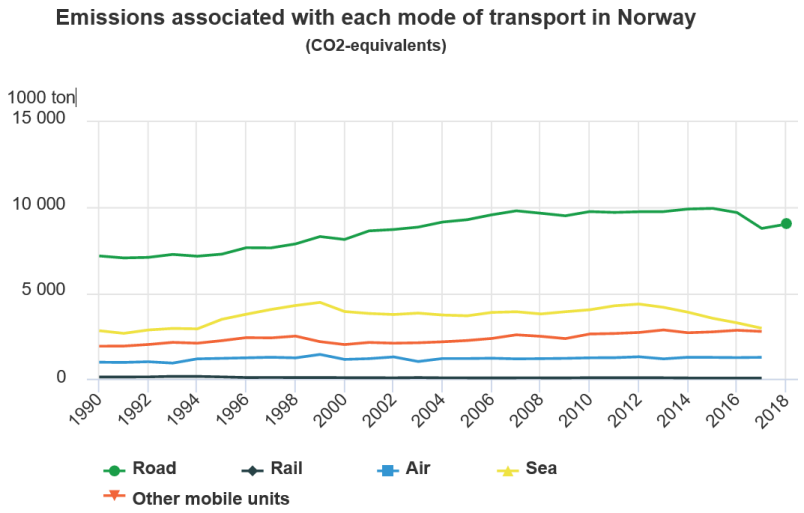

Figure 02: Emissions associated with each mode of transport in Norway (SSB, 2019)

To reduce emissions and increase road safety, Norway aims to shift more cargo to seaborne alternatives. The government has committed to this shift in a report to parliament, which will also decrease greenhouse gas emissions (Norway's Climate Action Plan, 2021). Despite the pledge, simply changing the transportation mode from roads to sea will not guarantee reduced emissions as the marine gasoil used in ships is more pollutant than diesel or gasoline used in trucks and cars (Corbett & Winebrake, 2008). In other words, it is not sufficient to simply shift cargo transportation from roads to sea without addressing the issue of emissions in the maritime industry. We, the authors of this thesis, find several potential ways to achieve the emissions reduction, namely through increased operational performance, by use of future carbon- free fuels, and by deployment of disruptive technological advancements. The sea logistics industry must adopt technologies that will gradually reduce emissions over time, with the ultimate goal of achieving zero-emission transportation.

To assess vulnerability across different transportation modes, it's important to consider factors beyond just emissions. The Norwegian Public Roads Administration conducted a national analysis and uncovered that road transport in Norway is the most susceptible to threats from climate change compared to other modes of transport (Petrovic, Humstad, & Dolva, 2019). The Norwegian Public Roads Administration is responsible for managing natural hazards on roads and ensuring that they remain open during severe winter conditions (Norwegian Public Roads Administration, 2019). Despite the efforts, according to Climate-in-Norway-2100 report published by the Norwegian Environment Agency (in Norwegian: Miljødirektoratet), the country, during the coming years, will further suffer from more precipitation, heavy rain, and shorter snow seasons as well as more frequent floods (Miljødirektoratet, 2017).

Thus, Norwegian seaports will play a crucial role in reducing emissions and promoting less vulnerable modes of transport, as well as enabling efficient seaport operations. It is expected from the seaports to adopt methods to ease the sea transport by utilizing the technological advancements and applying them in logistics operations. Efficient operations and the adoption of new technology are key factors for ensuring the success of seaports in the future (Pavlić Skender, Ribarić, & Jović, 2020). The emergence of the fourth industrial revolution, known as the industry 4.0, has introduced several disruptive technologies, among all, the Internet of Things (IoT) also have the potential to revolutionize logistics operations. As authors of this thesis, we are interested in exploring the impact of IoT on seaport logistics operations in the Cargo Port of Bergen. The seaport of Bergen is an ideal case study for this research due to its importance as a major seaport in Norway, and due to the fact that the seaport is moving its cargo division to a new location. Such a move presents an opportunity to implement IoT technology in seaport operations and potentially transform the seaport into a smart port, making it an ideal case study for understanding the potential impact of IoT on seaport logistics operations (Cho, Lee, & Kim, 2017).

1.1 Seaports

A seaport is a location on a coast containing one or more harbors where ships, ferries and boats can dock for transferring people and cargo to or from land (Dwarakish & Salim, 2015). Seaport locations are chosen based on sea conditions, navigable water, as well as optimizing the access to land where large populations live. As a matter of fact, the largest ports in the world are close to large metropolitan areas. The maritime sector encompasses variety of

services where the cargo and passenger transportation are the primary ones (Dwarakish & Salim, 2015). In addition, other services associated with sea transport can be offered at seaports. Among all, towing and tug assistance, emergency maintenance, berthing services, storage and handling of maritime cargo and customs clearance can be mentioned (Dwarakish & Salim, 2015). While customs clearance is mostly conducted by government authorities, infrastructure services are provided by seaport companies and cargo handling and terminal services, as well as tug assistance in most of the seaports are provided by private firms. Each of these various services has its own characteristics for efficient performance and will therefore require appropriate technology.

1.2 Value chain

To understand the way that IoT technology will impact the seaports and their operations, we need to rewind the seaborne freight value chain. There are many ways to freight the goods from one place to another. Planes are fast and trains are efficient, but water is by far the most economical mode of transport (Tarkowski, 2021). There is no need for roads or railways to be built, no intersections to stop at. Furthermore, once a ship starts its voyage, it requires little attention in terms of human interactions. This is mainly due to the fact that a container ship moves on a fixed speed through most of its voyage. The problem, until recently, was moving the cargo on and off the ships in the seaports, which often took significant time compared to the voyage itself. According to available sea distance calculators, a voyage from seaport of New York to Rotterdam might take fourteen days for a container ship (Shiptraffic, 2022), but full-scale loading and unloading might take another five days (Seaport of Rotterdam, 2022). This is equal to 36 percent of the voyage duration. Cutting this handling time at seaports, the fleet could have spent delivering more cargos. Early in the shipping history, seaport fees, dock workers and their equipment accounted for major portion of the freight cost (Tarkowski, 2021). By the time a product reached the shelves, its price would have to be risen significantly to make up for the transport costs. Nevertheless, everything changed by introducing containers.

By containerization, the seaports turn thousands of individual problems into just one, and that is how to handle one object, namely the so-called box, to allow entering and leaving the seaport to its destination, as efficient as possible. According to Coşar & Demir (2018), introduction of containerization offered enhanced efficiency to cargo handling and smoothed the connection between sea transport and intermodal transport. Intermodal Transportation

refers to movements of cargo between different kinds of transport modes. In other words, containers allowed for goods to be easily moved between ship, train, and truck. One of the most remarkable aspects of the containerization is that its standard became universal. World nations may not agree on a unique currency, power plug type, or which side of the road to drive on, but they globally agreed on the dimensions of the shipping container. To put this into context, a container which is loaded in China, will fit on the train that takes it to the dock at the seaport of Shanghai. The same container will fit on the ship that takes it to Europe. Likewise, it will fit on the truck that takes it to an inland destination in Norway. Figure 03 provides a general depiction of the intermodal transportation system and its interconnectedness.

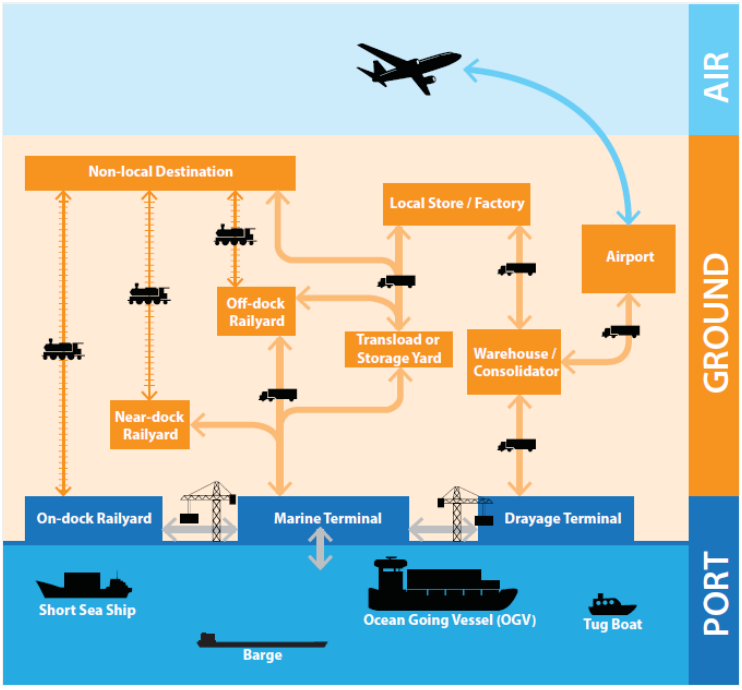

Figure 03 - Illustration of the intermodal transportation system.
Source: (United States Environmental Protection Agency, 2023)

Apart from the efficiency and implementation of industrial practices, there is a global trend that societies require higher recognition of sustainability, so that the existing businesses are strained to contribute to global sustainable development (Carpenter & Lozano, 2020). The United Nations has addressed seventeen goals for global sustainable development (United Nations, 2022). These can be seen in three main categories of social progress, economic development, as well as climate and environment (United Nations, 2022). To recognize

whether a commercial activity is sustainable, we may ask ourselves whether we can do it repeatedly forever without harming the environment and without overusing the next generations' resources. We shall also ask how much emission a certain business operation will generate. From the sustainability aspect, it is interesting to investigate how the logistics operations at seaports shall be restructured to form a sustainable business. IoT together with the other industry 4.0 technologies can bring benefits to the seaport value chain on their journey towards sustainable operations (Heikkilä, Saarni, & Saurama, 2022). In other words, studying IoT applications in seaport operations would uncover the measures a seaport must consider for achieving sustainable operations.

1.3 Value creation

Value creation is the process of generating value through the transformation of resources into products or services that meet the needs and expectations of customers (Porter, 1998). In the context of logistics operations, value creation is described as a multidimensional concept that involves the integration of various activities and processes, including transportation, warehousing, inventory management, information systems, and customer service (Lambert & Cooper, 2014). The value created through logistics operations can be measured in terms of cost savings, improved service quality, increased responsiveness to customer demands, and enhanced competitiveness in the market (Lambert & Cooper, 2014).

For seaports, value creation is particularly significant as seaports play a critical role in facilitating international trade and connecting producers and consumers across the globe. The value created through logistics operations at seaports can be measured in terms of cost savings, improved service quality, increased responsiveness to customer demands, and enhanced competitiveness in the market (Haezendonck, Coeck, & Alain, 2000). Among the involved parties who benefit the value created at seaports are shipping lines, freight forwarders, seaport authorities, terminal operators, cargo owners, and other stakeholders in the maritime supply chain (Garcia-Alonso, Garcia-Sanchez, & Prado-Roman, 2019).

Overall, value creation is a central element for understanding the importance of logistics operations at seaports, and the potential impact of IoT on enhancing the value created by these operations.

1.4 Competitive advantage

Sustainable competitive advantage is crucial for the survival and growth of any organization in today's highly competitive business world (Porter, 1998). It allows businesses to differentiate themselves from their competitors by offering unique products or services at lower costs, or with better quality. The logistics industry is no exception, and seaport operators are increasingly recognizing the need to adopt innovative technologies to enhance their operations and gain a competitive edge. In the context of seaports, competitive advantage can be described as the ability of a seaport to offer better services and infrastructure than its competitors (Ducruet & Notteboom, 2012). This can result into increased traffic, higher revenues, and better positioning in the global logistics industry. One way that seaports can gain competitive advantage is by adopting new technologies. According to a study by Al-Esmail & Radwan (2019), IoT can help seaports gain competitive advantage by enabling real-time tracking of shipments, optimizing resource allocation, and improving safety and security measures. Therefore, competitive advantage is a superior factor for the success of seaports, and IoT can be a powerful tool in helping them stay ahead of their competitors and create more value for their customers.

In this thesis, our focus is on the Internet of Things (IoT) and its impact on the seaport logistics at the Cargo Port of Bergen, with a particular emphasis on how IoT can help the seaport gain a sustainable competitive advantage. By examining the strategies and real-life examples of IoT adoption, we have provided insights into the potential benefits of this technology and help the seaport authorities make informed decisions.

1.5 The importance of the topic

Regarding the importance of topic for this master's thesis, we can mention the following four aspects:

- The role of seaports in the development of a nation
- National defense and emergency preparedness
- Society's critical infrastructure
- The role of seaports in sustainable development

1.5.1 The role of seaports in the development of a nation

In the 1990s, the formation of World Trade Organization (WTO) agreements led to the lifting of many international trade barriers. This allowed global manufacturers to disintegrate their

production systems and to relocate their productions to more cost-efficient locations, building geographically dispersed and flexibly organized supply chains. Greater freight costs can lead to lower activity levels at seaports and reduced access to technology, knowledge, and employment. Dwarakish & Salim (2015) estimated that a doubling of transportation costs can lead to a drop in national economic growth by half a percentage point, highlighting the importance of efficient seaport operations.

Through the utilization of regression analysis, it was determined that there exists a robust correlation between the gross national income of a specific city and both the total cargo trade and ship visits at its seaports (Özer, Şerif, & Kirca, 2021). The effectiveness of seaport operations holds notable importance in fostering economic growth, and the integration of IoT and other associated disruptive innovations has the potential to assume a pivotal role in this context. Consequently, the exploration of this subject justifies the need for additional research, making it an ideal choice for a master's dissertation project.

1.5.2 National defense and emergency preparedness

Seaports are not only influential for economic reasons, but also for national defense and emergency preparedness. Eriksen and Longva (2017) argue that seaports are essential for country's national security, as they are critical for ensuring the supply of essential goods, such as food, medicine, and aids in the time of crisis. The article further discusses various measures that can be implemented to enhance seaport security and response capacities, including the use of technology. It is therefore essential to ensure that seaports are equipped with the latest technologies to enhance their readiness and responsiveness during the crisis. Though, the authors admit the role of technology in seaport's emergency preparedness capabilities, they haven't touch upon the impact of disruptive technologies in upholding the intensity. We believe, investigating the state of IoT in seaport logistics can help identify ways to enhance seaport's resilience capabilities. For instance, the integration of IoT technology can play a significant role in enabling real-time monitoring and analysis of seaport operations, thereby empowering operators to swiftly identify and address potential security threats. Despite the Eriksen and Longva's support on the use of technology in seaport operations for national security purposes, seaports may also be vulnerable to various security threats, such as cyber-attacks (Eriksen & Longva, 2017). Overall, we summarize that the role of seaports in country's national defense and emergency preparedness is such fundamental that it warrants further research within the impact of IoT in seaport logistics.

1.5.3 Society's critical infrastructure

According to the definition provided by Norwegian Directorate for Civil Protection (In Norwegian: Direktoratet for samfunnssikkerhet og beredskap, DSB), the term critical infrastructure in the society refers to primary resources and aids that must be in place to maintain an activity or service which is vital for the people's basis needs. In this regard, security of supply, both with regards to food and energy, is determined as vital for society's functionality (DSB, 2016). Thus, seaports are considered a part of critical infrastructure for the society due to their contribution to supply security (DSB, 2016). During the COVID-19 pandemic outbreak in Norway, the government applied extensive restrictions to various activities in the society (NRK, 2023). However, the transportation of goods was recognized as a crucial sector that necessitated uninterrupted operations to ensure the continuous supply of essential items such as food and medicine. Consequently, it is of utmost importance to investigate the interplay between emerging technologies, their integration into seaport logistics, and how seaports can effectively fulfill their social mandate as critical infrastructure for society in the future.

1.5.4 The role of seaports in sustainable development

According to the International Association of Ports and Harbors' (IAPH) World Ports Sustainability Program, seaports are critical hubs that link global trade, local communities, and the environment (IAPH, 2021). The program identifies nineteen priority areas where seaports can contribute to promote sustainable development, including reducing greenhouse gas emissions, protecting marine biodiversity, and promoting circular economy principles (IAPH, 2021). The IoT is a key enabler of sustainable seaport operations, providing real-time data on environmental conditions, cargo movement, and supply chain visibility. By leveraging IoT technologies, seaports can optimize their operations, reduce costs, and enhance sustainability performance (IAPH, 2021). Hence, we can deduce that our research topic holds significant importance in the realm of global sustainable development.

1.6 Research gap

Numerous studies have examined how IoT technologies can enhance container terminal operations, leading to reduced waiting time, increased throughput, and optimized resource utilization. Furthermore, researchers have explored the application of IoT for real-time monitoring of cargo flows, showcasing its potential to enhance supply chain visibility and

reduce logistics costs. Despite Norway's rich seafaring history and prominence in renewable energy and sustainable transportation, limited research has been conducted on the utilization of IoT technologies in the Norwegian seaports. This gap is particularly noteworthy as it suggests unique opportunities for IoT-enabled seaport logistics in Norway. Therefore, our research aims to bridge this gap in the academic literature and contribute valuable insights, specifically in the realm of seaport logistics within the Norwegian context. By doing so, we not only address the unexplored application of theory in this context, but also make a novel contribution to the broader literature.

1.7 The authors' interest in the topic

We, the authors of this master's thesis, are graduates of MSc program in Logistics in Molde University College, in 2012. In our previous theses, we touched upon maritime industry and shipping. Specifically, one of us focused on route planning problems in maritime transportation, while the other one addressed the question of which structural changes were needed for a seaport to turn from a transportation node into a logistics center.

A decade ago, when we conducted our research in these fields, automation and digitalization were prominent concepts for seaports. However, as an instance, IoT and other industry 4.0 technologies were not yet feasible at that time. Today, we find ourselves in a new era of a multifaceted industrial revolution that is demanding the seaports further restructuring of their value chain in the shade of the new disruptive technologies. We believe this new era will revolutionize the way container ports operate, and this will have its marks on the way we live. Thus, we are enthusiastic to conduct our research within this topic.

2. Presentation of the research project

2.1 The problem statement

At the outset of this master's thesis, our objective was to examine the influence of IoT on value creation within EU seaport companies. Early on, our research supervisor emphasized the expansive nature of the study and advised us to focus and refine our scope in order to attain more specific and tangible results. Thus, in the early stages of our study, we recognized the need to delimit the boundaries of our research to a single country, and we ultimately selected Norway as our focal point. This was due to the fact that the country provides a unique opportunity for our research, characterized by its geographical location in the northern Europe, extensive coastal line in the west, low population, and high per capita income.

Norway's geographical location and its long coastal line with numerous large and smaller seaports uncovers the significance of seaborne trade for the country and this is a common ground for our research. In addition, low population and high per capita income substantiate the fact that country has its focus on export of few commodities, namely energy and seafood (Larsen & Skare, 2015), while importing all other products for the people's needs. Further, upon our initial screening of publicly available data from the Norwegian seaport industry, we observed significant variations among the seaports in terms of ownership and the nature of their logistics operations. To gain a comprehensive understanding of this diversity, we initiated communication by sending emails to the seaport companies. In these emails, we requested specific information and reached out to twenty ports in Norway, aiming to identify the seaports that align best with the objectives of our research. Based on the responses we received, as well as the initial screening we conducted by ourselves, we elaborated that some seaports are privately owned while others are owned by municipalities. For instance, Mongstad serves as a private seaport for Equinor, while the Norsea Group operates seven seaports situated along the coastal line. The private seaports are mainly established for a particular reason. Majority of these seaports serve the offshore oil and gas industry on the NCS. Another difference in the seaports across Norway is regarding the type of cargo handled. We understood that some seaports only handle dry bulk material, such as Farsund, while other seaports may only serve the fisheries or handle raw wood products, namely Lyngdal. Moreover, some ports may handle non-containerized or general cargo, specifically the seaport of Drammen which is specialized on importing cars to Norway. We uncovered also that some smaller seaports, such as Hammerfest, only function as landlord, as they open for clients to operate their own logistics. During this process, we shortlisted the remaining relevant seaports for our study. In our efforts to further narrow down the research topic, we decided to choose one single seaport as a case study. Lastly, we chose the seaport of Bergen due to several considerations that can be mentioned here.

Firstly, there are numerous numbers of seaports along the west cost of Norway, followed by the lengthy coastal line. Choosing one single seaport would allow us to sharpen the research into the lowest level of details and provide solid outcomes which might also be valid for other seaports with similar business operations. Therefore, as we had to choose one representative case, it would better be among the seaports located in the west cost of Norway.

Secondly, Bergen, being the second-largest city in Norway, is home to the country's second-largest seaport, which encompasses container terminal operations as well. (Bergen Havn,

2023). This makes the seaport of Bergen as an ideal case study for this research due to its importance as a major hub in the western Norway.

Lastly, since the seaport of Bergen plans to move its cargo division to a new location, it offers a unique opportunity to implement IoT technology in seaport operations and potentially transform the seaport into a smart port, making it an ideal case study for understanding the potential impact of IoT on seaport logistics.

2.2 Research questions

We identified our overall research question to be "what are the impacts of IoT technology on competitive advantage in seaports?". Subsequently, we conducted a case study on the Cargo Port of Bergen. To achieve this objective, four research questions were identified.

2.2.1 Question 1

What is the current state of IoT application at the Cargo Port of Bergen?

By asking this question, the utilization of IoT technology in the logistics operations at the Cargo Port of Bergen has been studied. The emphasis has been on investigating whether the IoT technology has been adopted, and if yes, to what extent. Moreover, we have captured the modifications that have taken place in seaport operations as a result of adopting the IoT technology.

Putting this information together provides us with the current state of IoT in the seaport of Bergen.

2.2.2 Question 2

What is the port's vision for the future state of IoT application at the Cargo Port of Bergen?

Regardless of whether the seaport company has utilized IoT to some extent or not, the management may have a clear vision on the desired role of this technology in their business operations. By asking the second research question, we have captured the desired future state of IoT in the seaport of Bergen. In this stage, we endeavor to find out how the Cargo Port of Bergen envision utilizing IoT advancements to optimize the logistics operations, create new value for stakeholders and strengthen the port's position in their market segment.

2.2.3 Question 3

What are the actions taken or considered, to bridge the gap between the current and desired state of IoT application at the seaport of Bergen?

To answer this research question, we have identified the specific projects and measures that the Cargo Port of Bergen has in the pipeline or needs to take in order to move from the current state of IoT adoption to the desired state that they have identified, based on the previous research question.

2.2.4 Question 4

To what extent does the implementation of IoT-based operations provide a competitive advantage for the Cargo Port of Bergen?

Building upon the answers to the previous research questions, as well as the data collected from interviews, literature review, and analysis tools such as SWOT, VRIO and PESTEL, we present an assessment on the potential benefits and drawbacks of implementing IoT solutions in the seaport's operations. This research question is crucial for support of the seaport's decision-making process and guiding its strategic initiatives, investment priorities, and collaboration opportunities.

2.3 Research boundaries

2.3.1 Geographical scope

This study is geographically limited to the Cargo Port of Bergen. Nevertheless, as projects in the seaport industry are often collaborative initiatives involving multiple seaports, we have only discussed those that are relevant to the seaport of Bergen.

2.3.2 Industry scope

While our study primarily centers on logistics operations at seaports, we acknowledge the substantial impact of the shipping industry on seaports and the reciprocal influence between them. In recognition of this interdependence, we have conducted interviews with two shipping companies as part of our research. Although the shipping industry does not serve as the primary focus of our project, we understand its significance and its role within the seaport sector.

2.3.3 Timeframe

Instead of examining the historical development of IoT, our focus in addressing the first research question was on the current state of IoT adoption within the logistics operations of the Cargo Port of Bergen.

2.3.4 Contribution to sustainable development

In the introduction chapter, we explored the growing interest among industry practitioners and politicians in Norway to shift more cargo transportation from roads to sea. The primary drivers for this transfer are sustainable development through emission reduction and increased safety on roads. One way to reduce emissions is by adopting carbon-free alternative fuels or improving the efficiency of existing businesses. However, this study does not delve into the technological aspects of emerging fuels like Hydrogen and Biofuels. Instead, our focus is towards exploring the impact of IoT technology in seaport logistics, specifically in terms of enhancing efficiency and promoting sustainability. In other words, we investigate how this improved efficiency can lead to a competitive advantage.

2.3.5 Technology-depth

The focus of this research, which is intended for an MBA program with a specialization in innovation, is not on the technical intricacies of IoT, sensor technology, or telecommunication technology. Instead, our aim is to conduct a critical assessment of how IoT drives competitive advantage in the logistics industry, leading to transformative changes, increased productivity, and reshaping of competitive advantage.

3. Literature review

3.1 Introduction

The Internet of Things (IoT) has been identified as a game-changer technology for various industries, and there is a growing interest in how this technology can be applied to logistics operations. Searching the literature, we observed researchers have shown great interest to the new industry 4.0 revolution and its contribution to the society. Hughes, Dwivedi, Rana, Williams, and Raghavan (2022) have presented a critical evaluation of the core technologies, impacting the next generation of manufacturers. Though, the impact of the industry 4.0 is not only limited to manufacturing of products. The seaports will also be affected, although they provide services instead of manufacturing.

Through an extensive literature review, Ben-Daya, Hassini, and Bahroum (2019) delve into the role of IoT and its implications for supply chain management. They carefully examine a total of hundred and five articles published between 2007 and 2016, thoroughly analyzing the key findings pertaining to IoT in logistics. This article serves as a valuable resource for gaining an overview of the benefits and challenges associated with the implementation of IoT in logistics. Such insights can effectively support our exploration of the potential impacts of IoT on the Cargo Port of Bergen's competitive advantage. However, the authors of this article acknowledge that the majority of studies in this area have primarily focused on conceptualizing the impact of IoT, with limited application of analytical models and empirical investigations. Consequently, our study aims to bridge this research gap by providing an empirical analysis of the impact of IoT on gaining a competitive advantage at the Cargo Port of Bergen. By addressing the research gap identified in the aforementioned article, our study will contribute significantly to the existing body of knowledge in this field.

Rejeb, Simske, Rejeb, Treiblmaier, and Zailani (2020) conducted a thorough review and bibliometric analysis to objectively underneath the knowledge development in IoT research within the context of supply chain and logistics. This analysis started with selection of eight hundred and seven journal articles published over two-decade period. The results revealed that IoT research has attracted significant attention from the logistics community. The paper concludes that even though academics and practitioners have already devoted huge attention to IoT in recent years, the integration of IoT in supply chain and logistics is still in its infancy. In this regard, by studying the concrete implementation of IoT in the seaport context, our research will provide valuable insights and contribute to advancing the understanding of how this technology can be effectively integrated into the seaport logistics.

Elaborating on the integration aspect of the technology application, Sanchez, Exposito, and Aguilar (2020), proposed an approach to analyze the integration challenges emerged from the industry 4.0. They utilized five integration levels, specifically connection, communication, coordination, cooperation, and collaboration. A traditional industry cannot be converted into industry 4.0 only by integrating the technologies in the lowest level, called connection. These should rather address the other integration aspects to allow the processes for self- configuring, self-managing, self-healing, and self-supervising (Sanchez, Exposito, & Aguilar, 2020). Therefore, we also intend to investigate the integration aspect of IoT technology within seaport logistics for our case study. We believe that the level of integration achieved in the

adoption of IoT can serve as a strong indicator of the potential for gaining a competitive advantage.

To summarize, the industry 4.0 has received tremendous attention from the industry and academia. However, what this revolution specifically means to the logistics sector, and, what the IoT technology means for seaport operations, has fairly remained unspoken. To better understand the role of the technology in shaping the industries, we provide a short review of the elaboration of industrial revolutions from one to four.

In summary, the logistics sector has witnessed significant attention in the context of Industry 4.0, both from industry practitioners and academic researchers. However, there has been relatively limited discussion on the specific implications of this revolution for the logistics sector, particularly in terms of the role of IoT technology in seaport operations.

In the upcoming subchapters, we delve into the historical progression from the first three industrial revolution, as well as the fourth, emphasizing its significance in shaping the logistics sector. Through this review, we aim to deepen our understanding of the corresponding technologies, including IoT. Additionally, we explore the concepts of Logistics 4.0 and Smart Ports, providing insights into their relevance and potential impact. Furthermore, we discuss the imperative nature of focusing on IoT and outline the theoretical framework and analysis tools that will guide our research.

3.2 The first three industrial revolutions

Industrial revolution is defined as the major changes or transition in manufacturing and industrial processes with new innovative technologies (Schwab, 2016). According to Perez (2002), the first industrial revolution started around 1771, by introducing wrought iron and machined cotton industry. The second industrial revolution happened around 1829 with introduction of steam engines and railway construction. The third industrial revolution took place around 1969 by introducing electronics, computers, and automation. Today, we are in the era of a fourth industrial revolution triggered by introduction of cyber-physical systems. Notably, the first two revolutions were, according to Bartodziej (2016), brought about by the mechanization and electrification of manufacturing processes, while the third stage is marked by a rise in informatization and automatization.

Figure 04 summarizes the four industrial revolutions along with the main innovations in each stage.

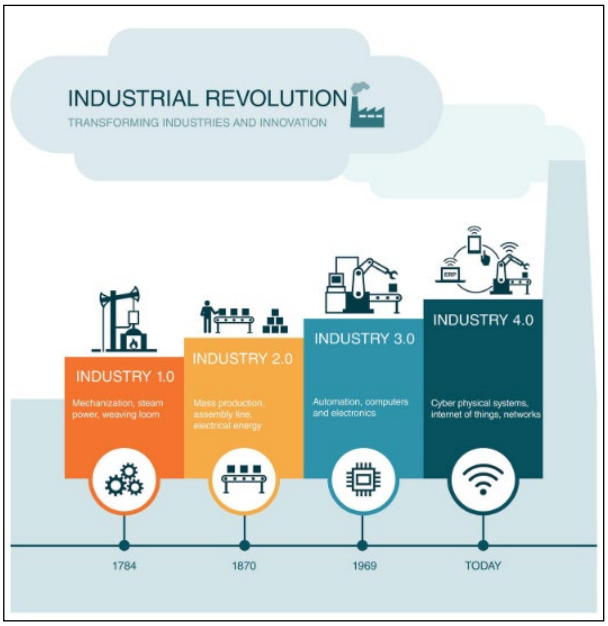

Figure 04: Summary of the industrial revolutions (Liu, Law & Law, 2022)

3.3 The industry 4.0

According to Schwab (2016), the industry 4.0 is a new phase in the industrial revolution that introduces intelligent networking of machines and processes with the help of information and communication technology, i.e., it connects the real world with the virtual digital world. In this era, computers, devices, and machines communicate with each other and make decisions without human involvements. Strømmen-Bakhtiar (2019) lists twelve potential disruptive technologies which come with the industry 4.0. In our research, the major focus will be on the Internet of Things. Nevertheless, there exists synergies between the IoT and two other technologies which will jointly provide benefits. These technologies are the big data and artificial intelligence. Therefore, we provide a brief description of these technologies as well in our thesis.

3.3.1 Internet of Things (IoT)

In general, no widely recognized explanation of the Internet of Things exists. All the definitions seem to suggest a shared recognition that the initial iteration of the Internet revolved around human-generated data, whereas the subsequent version focuses on data generated by things, which justifies why it is referred to as the internet for things. According to Sen (2018), Internet of Things (IoT) is a network of physical objects, devices, vehicles, buildings, or other items which are embedded with sensors and network connectivity, enabling

these objects to collect and exchange data among each other through the Internet. Placing sensors on everyday objects turning them into intelligent assets that can communicate is defined as IoT (Bhusan, Karim, Ijaz, Sharma, & Unhelkar, 2022). IoT is considered a pivotal technological trend and is expected to have a substantial impact on the future. This offers new opportunities to automate processes and improve the quality of life beyond what we are used to.

3.3.1.1 IoT in logistics

As it can be understood from the term, the IoT in logistics is comprised of all the physical objects within a logistics value chain which are connected to the internet, enabling them to capture and transfer the data from the logistics operations. These devices are not only the computers, but also can be trucks, forklifts, containers, entrance gates, and more (Ivankova, Mochalina, Goncharova, 2020).

Talking about the Internet of Things (IoT) in seaport logistics, the researchers identified the following benefits (Bouhlal, Aitabdelouahid, & Marzak, 2022):

- Real-time tracking and monitoring: IoT can be utilized to monitor vessels and containers in real-time. Furthermore, information about vessels and containers could be utilized to optimize container stacking at seaport terminals.
- Transition from manual to automated seaports/terminals: This transition enables a reduction in daily customer interactions, thereby increasing efficiency. The increased data exchange that IoT facilitates also allows for the optimization of the existing processes.

3.3.2 Big Data

The rapid growth of data generated and processed in all aspects of human activities has led to the emergence of a new global challenge, referred to as the information gap, stimulated the necessity for development of effective theories and practical methods for storing, processing, and analyzing this massive volume of data (Zgurovsky & Zaychenko, 2020). As stated by Shamsi, and Khojaye (2021), the concept of "big data" is a term used to describe the massive volume of information that exceeds the capacity of traditional data-processing methods and requires new technologies for effective management, analysis, and understanding.

3.3.3 Artificial Intelligence (AI)

Artificial Intelligence (AI) is a disruptive technology which encompasses the development of computer systems capable of carrying out tasks that would normally require human intelligence (Liu, Law & Law, 2022). As Liu, Law and Law mentioned (2022), AI is having a major impact on various industries and has the potential to change many aspects of our lives, but it also raises concerns such as job displacement and privacy that need to be addressed.

3.3.4 Technological interconnection

Figure 05 serves as a visual representation of the interconnectedness among these technologies, illustrating how they collectively contribute to improving overall performance. Adding IoT devices will help collecting and transferring the data to a data platform. The big data technology enables processing and interpreting the data captured from IoT devices. Afterwards, the artificial intelligence models assist the decision making on the interpreted data which helps to improve the overall performance.

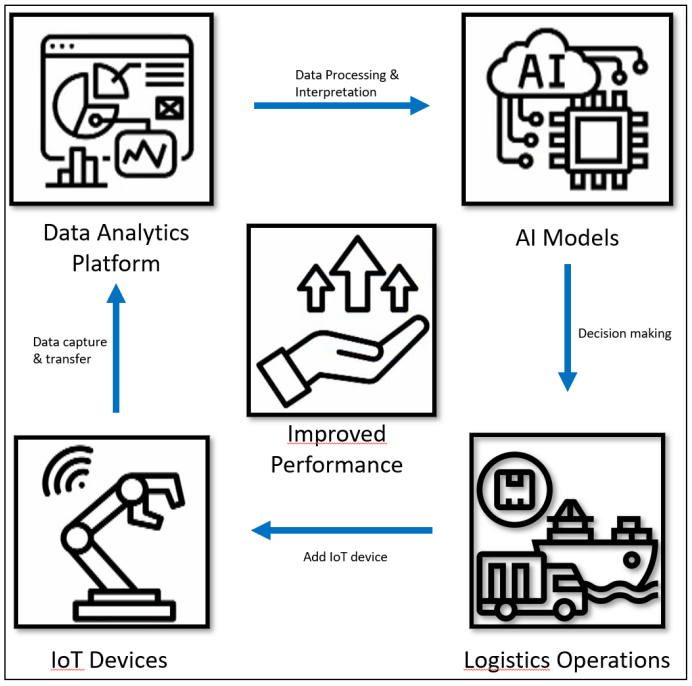

Figure 05 – Relationship between IoT and other industry 4.0 technologies

3.4 Logistics 4.0

The term Logistics 4.0 first appeared in 2011 as a response and support to Industry 4.0 (Wenzel & Spinler, 2017). Today, the terms Supply Chain 4.0, Procurement 4.0, Marketing 4.0, Distribution 4.0, Warehousing 4.0, etc., represent a broader initiative focused on integrating advanced technologies in the respective fields (Huang, Wang, & Duan, 2017).

Subsequently, Logistics 4.0 is a term that describes the integration of advanced technologies, such as IoT, artificial intelligence, and big data, into logistics operations (Winkelhaus & Grosse, 2020). This concept represents a significant shift in the way that logistics is conducted, with a focus on real-time data exchange, machine-to-machine communication, and collaboration across the entire supply chain (Winkelhaus & Grosse, 2020). In the context of seaport logistics, Logistics 4.0 presents numerous opportunities for improving the efficiency, reducing costs, and enhancing sustainability (Winkelhaus & Grosse, 2020). For example, the use of IoT sensors in containers and other logistics equipment can enable real-time monitoring of cargo movements, which can improve the accuracy of supply chain planning and reduce the risk of delays and disruptions. Moreover, the integration of IoT data with other sources of information, such as weather forecasts and traffic data, can enable more precise decision-making and optimization of logistics operations (Heiling, Stahlbock, & Voß, 2020). Overall, Logistics 4.0 represents a promising avenue for the application of IoT technology in seaport logistics and presents significant opportunities for improving the efficiency and sustainability in logistics operations.

3.5 Smart ports

According to Park (2022), the concept of smart ports has been defined in a multitude of ways, encompassing the attributes of automation, optimization of logistics, energy efficiency, environmental sustainability, and innovation through the integration of information technologies such as the Internet of Things (IoT), big data, and artificial intelligence.

As stated by Park (2022), smart port is more than merely automated seaports. Rather, the realization of seaport automation is achieved through the deployment of remotely controlled QC and AGV systems, which make use of DGPS, 3D mapping, sensors, IoT, and 5G communication technologies. Secure blockchain technology is employed to facilitate real-time information sharing with external organizations such as shipping companies and shippers, whilst AI solutions are utilized to optimize various aspects of seaport operations such as energy consumption, environmental impact, safety, and traffic flow (Park, 2022).

3.6 The urgency of focusing on IoT

It may be questioned why we believe that the significant growth of IoT technology in the industry will happen now. Sweden's Royal Institute of Technology (KTH) has established a framework for guiding idea development, which provides structure in development of an early-stage idea to innovation into the market. From this framework, we identified the

following key elements which can shed light on the IoT's timing question from different perspectives (Kunglia Tekniska Høgskolan Stockholm, 2023):

3.6.1 Technology readiness level

Before enumerating all the advantages that IoT can offer, it is important to acknowledge that the technology's development until recently has been a hindrance. What was once just a research paper suggesting the feasibility of attaching sensors to everything, is now becoming a reality. To elaborate on the technology readiness, we researched the sensor technology, network technology, battery technology and the cost of these components. The results show that advanced sensors are vastly commoditized. The network technology has enabled the high speed of data collection and transfer by emergence of 5G, while batteries provide more long-lasting power. Yet, the most prominent factor is that these technologies are nowadays available at a reasonable cost.

3.6.2 Investment readiness level

The amount of investment into the IoT technology would indicate how the markets see the role of this technology in shaping the future's industry. We believe that investors always have a critical eye on new emerging technologies prior to spending money on them. In general, investors seek for a technology that is both financially viable and commercially feasible. Thus, we consider the IoT investments in logistics sector as an indicator to prove right timing for the technology. Since the investments are not often a topic for academic literature, we had to search the reliable sources within the economics and business to find trustworthy information in this regard. According to Global Market Insights (Global Market Insights, 2023), which is a global market research company catering to corporations, universities and government agencies, there has been a constant increase in IoT investments, and this will increase by 25% from 2022 to 2028. IoT Analytics is another reputable source of market insights and business intelligence within the IoT Technology. This source forecasts the growth of 39% in 2025 compared to 2017 baseline (IoT Analytics, 2023).

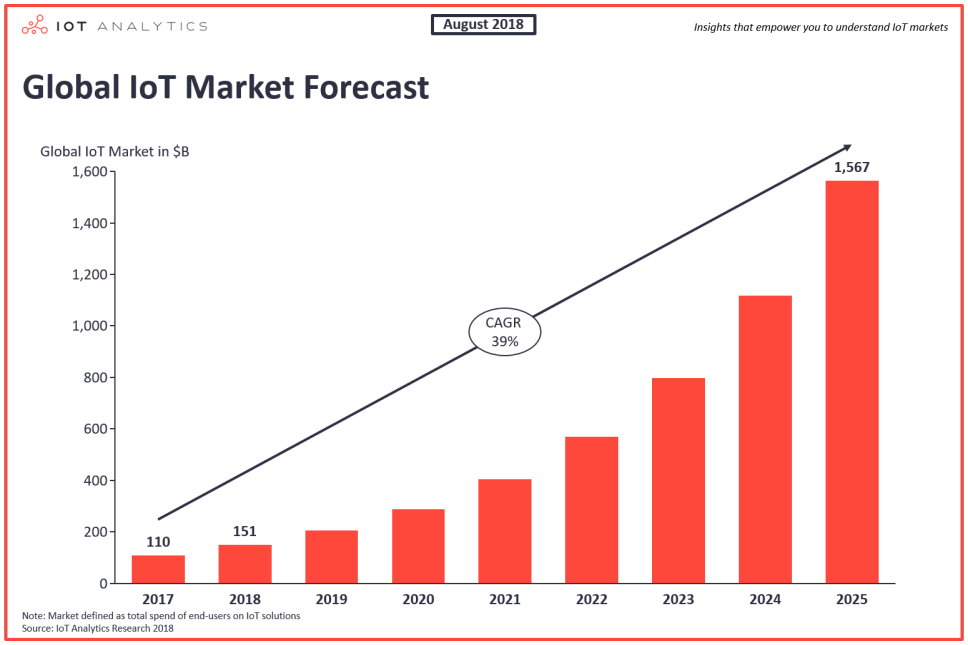

Figure 06 – Global IoT market forecast (IoT Analytics, 2023)

3.6.3 Customer readiness level

Customer readiness refers to how prepared the customer segment is to embrace the new technology and adopt it in the day-to-day business (Kunglia Tekniska Høgskolan Stockholm, 2023).To better understand the customer readiness, think of a scenario where a product is commercially available for purchase in a market, but the customer segment is still skeptical and unwilling to take it in use. To put this into context with an example, the first electric vehicle was introduced to the market in 1890s. However, only in the beginning of the 2000s private electric vehicles became a plausible choice for buyers. This course change wasn't due to unavailability of the product, but due to the increased recognition for the environmental damages caused by fossil fuel emissions. In the context of our research project, the target customer segment comprises seaport logistics companies. Consequently, IoT hardware manufacturers and software developers collaborate to meet the rising demand for integrated solutions in seaport operations.

To summarize, technical readiness level, investment readiness level, and customer readiness level are interrelated and influence each other in the adoption and implementation of IoT as a new technology. They complement each other and run in parallel when considering the success of innovation in a market. As for the case of IoT technology, we understand that due to recent progressions in all the three areas, the time has come for this technology to change the way seaport logistics operations operate.

3.7 Theory framework and analysis tools

In this subchapter, the theory framework and analysis tools utilized in this thesis are being discussed. According to Jay Barney (1991), since the 1960s, a single framework has been utilized to structure these research areas. This framework is provided in figure 07. This framework, depicted in figure 07, highlights that organizations achieve competitive advantage by employing strategies that leverage their internal strengths to capitalize on opportunities, while mitigating external threats and addressing internal weaknesses (Barney, 1991).

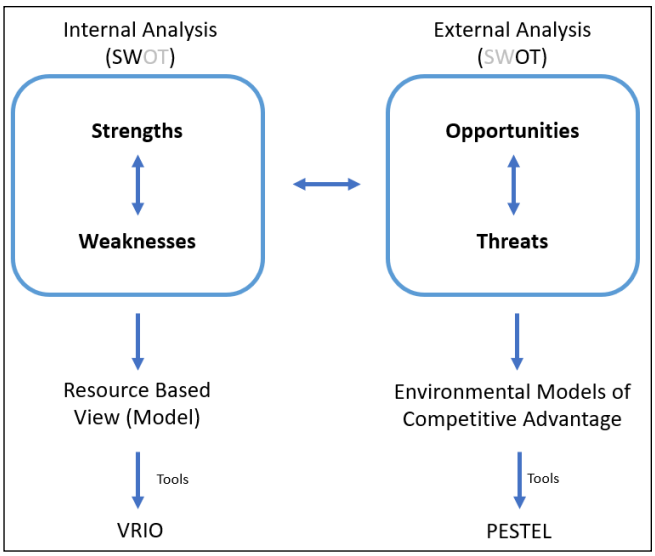

Figure 07 – The interplay of internal and external analysis within the theoretical framework

Considering both internal and external resources, the SWOT analysis as a decision-making tool, helps organizations identify their internal strengths and weaknesses, as well as external opportunities and threats arising from the environment in which they operate (Speth, 2015).

Discussing the internal analysis, the Resource-Based View (RBV) serves as a theoretical framework for examining a firm's competitive advantage, which suggests that competitive advantage of a firm is solely derived from the exploitation of its tangible and intangible resources, as well as strategic capabilities (König & Caldwell, 2016). On the other hand, VRIO is an analysis tool used to evaluate firms' resources and capabilities, based on four criteria of value, rarity, inimitability, and organization (Knott, 2015). VRIO helps to determine whether the firm's resources and capabilities can be a source of competitive advantage or not. It is a practical application of the RBV theory. Therefore, VRIO analysis can be seen to operationalize the RBV framework and assess a firm's resources and capabilities in a more structured manner.

On the other side, the examination of external factors, by identifying the potential opportunities and threats, offers valuable insights into the broader business environment. Jay Barney (1991), states that the "Environmental Models of Competitive Advantage" refer to a set of theories or models that examine how the external environment of a firm can affect its competitive advantage. These models consider factors such as the industry structure, customer preferences, and technological changes, and how they influence a firm's ability to achieve and sustain a competitive advantage. One of the most well-known models in this category is the PESTEL analysis, which examines the broader political, economic, social, technological, environmental, and legal factors that can impact the firm's operations and competitive position (Grande, 2022). According to Grande (2022), external analysis focuses merely on how the enterprise should deal with the competitors and the community they operate in. This model helps firms identify potential opportunities and threats in their external environment and adjust their strategies accordingly.

The above-mentioned framework and analysis tools will be explored extensively in the chapter 6 with regards to adoption of IoT at the Cargo Port of Bergen.

4. Methodology

When it comes to research within the seaports business, the field of work can be categorized as strategic management of logistics and supply chain. We urged ourselves to investigate the degree to which logistics operations and its business model in a seaport have incorporated the IoT technology. We reviewed the strategies, ongoing projects, and evaluated the future outcome of this implementation on our case study. Every research must contain a satisfactory justification for the choice of design and method which is consistent and can shed light on the project's problem (The Norwegian National Research Ethics Committee, 2022). As the methodology will have an impact on the outcomes of our research, it is crucial to understand the advantages and disadvantages in our research project.

In this chapter, we discuss selection of research method, research design, and research strategy, along with our approach for data collection and analysis. Additionally, we provide the elaboration on ethical considerations, achieved contributions, and assessment of the quality and objectivity of the research project. Finally, we discuss the issue of confidentiality, provide our reflections on our role as researchers, and define our path from interviews to findings.

4.1 Research method of analysis

According to Johannessen, Christoffersen and Tufte (2020), the focus of methodology is on the manner to proceed, in order to assess whether our presumptions reflect the reality. Qualitative methodology can generate valuable and rich data, while it can be used alone or in conjunction with other research designs, depending on the nature of the research topic (D O'Gorman & MacIntosh, 2014). As stated by Sandelowski (2000), qualitative descriptive study is supported by the fundamental principles of observational research, without a previous commitment to any viewpoint of a certain phenomenon. When it comes to our research, we chose the qualitative approach. We believe that using the qualitative approach has been more fruitful compared to using a quantitative alternative. By employing a qualitative approach, we had the chance to highlight, in general, the description and knowledge of the sustainable competitiveness. Subsequently, we narrowed down this knowledge and conceptualized what exactly the sustainable competitiveness implied for the Cargo Port of Bergen in the future. Furthermore, it paved the way to identify what prerequisites will have direct impacts on the sustainable competitiveness in the setting of container ports.

4.2 Research design

Research design is a comprehensive strategy that outlines the decisions and considerations throughout the research process, and consists of three types, exploratory, descriptive, and causal (Johannessen, Christoffersen, & Tufte, 2020). Presenting a rich and comprehensive description of an entity of interest is referred to as a descriptive research design (D O'Gorman & MacIntosh, 2014). In the case of our research problem, the overall topic has widely been discussed by the society as well as academia, namely the impact of new disruptive industry 4.0 technologies on our lives. Since the objective of this study is to investigate and describe the way IoT will impact the overall value chain at a specific seaport, a descriptive research design has been used towards comprehensive investigation of sustainable competitiveness with regards to the seaport operations.

4.3 Research strategy

The case study approach is the most prevalent technique among academics for those who are focused on qualitative research within a descriptive design (Baškarada, 2014). According to Gerring (2004), the aim of descriptive case studies is to thoroughly examine the various

aspects of a phenomenon within its context, primarily with the goal of constructing theories. Adopting the case study method as the research strategy for our master's thesis project is primarily due to several reasons. The case study afforded us the opportunity to scrutinize the context of a particular seaport, along with the implementation and utilization of IoT within that context. By focusing on a singular seaport, we undertook a thorough examination of the effects of the technologies on the port's efficiency, operations, and competitiveness. Furthermore, the case study strategy offered us the versatility to analyze the deployment and usage of the IoT technology in the container port of Bergen from multiple viewpoints, including technological, organizational, and strategic.

4.4 Data collection

Both primary and secondary data have been valuable sources of information for our research. D O'Gorman and MacIntosh (2014) recognize that it is often advantageous to use a combination of both types of data in the research to provide a comprehensive and reliable analysis.

In the upcoming sub-chapters, we will provide a detailed description of the primary and secondary data sources used in this study. We began by gathering secondary data, before conducting interviews to collect the primary data. To present our data collection process in a chronological manner, we will begin by discussing our use of secondary data, followed by the collection of primary data.

4.4.1 Secondary data collection

Secondary data refers to data that is readily available and has been collected by someone else for a different purpose (D O'Gorman & MacIntosh, 2014). This can include data from sources such as reports published by government agencies, academic institutions, and private organizations. D O'Gorman and MacIntosh (2014) asserts the advantage of secondary data as it is often easily available and less costly to obtain than primary data. Secondary data can also provide a historical perspective and be used for comparison purposes. However, the researcher has less control over the quality and relevance of the data, and it may not fully address the specific research objectives and questions of the study.

Prior to conducting the interviews, we gathered reliable secondary data from various sources. Table 01 lists the secondary data sources used in this thesis.

Although we both have engineering backgrounds, we recognized the need to expand our knowledge of the emerging Industry 4.0 technologies, including IoT and other interconnected technologies. Through extensive reading of books and journal articles, we gained an understanding of the relationship between IoT, Big Data, and Artificial Intelligence. Furthermore, we familiarized ourselves with the role of Industry 4.0 in the seaport and shipping industry, as well as the key factors that contribute to seaport performance, productivity, and competitiveness. By delving into these topics, we were able to develop a clear understanding of the framework for data-driven decision making.

Subsequently, we conducted research on the Norwegian politicians' perspectives on sea transportation in Norway. Fortunately, in Norway, a significant amount of relevant information is publicly available. We accessed and reviewed official reports from the Norwegian government and the country's national transport plan. We also analyzed reports from other state and municipal institutions, such as the Norwegian coastal administration, the Norwegian environment agency, the ministry of transport, the Norwegian center for transport research, the Norwegian public roads administration, the Norwegian statistics bureau, and the Norwegian directorate for civil protection. Additionally, we visited the homepage of the Gemini center for Internet of Things, which serves to link and coordinate research and innovation within IoT at SINTEF, UiO, and NTNU.

At last, we assessed the United Nation's sustainable development goals through various reports, and how these relate to our research topic. In certain occasions, after conducting the interviews, we still recognized the need for more secondary data, and therefore, we revisited the same above-mentioned sources to capture the missing bricks.

Data Source Title	Type of Data	Publication Year	Publisher/Source
AEGIS project report (Advanced, Efficient and Green Intermodal Systems)	Project report	2023	AEGIS Homepage
Analysis at the nation level of vulnerability and adaptation measures in Norway	Analysis report	2019	Norwegian Public Roads Administration
Avinor homepage	Website	2023	Avinor
Basis for decision - Relocation of cargo port at Dokken to Ågotnes.	Presentation	2022	Bergen Municipality (Bergen Kommune)
Port of Bergen (Bergen Havn) homepage	Website	2023	Bergen Havn
Climate in Norway 2100	Report	2017	The Norwegian Environment Agency (Miljødirektoratet)

Data Source Title	Type of Data	Publication Year	Publisher/Source
Curriculum in ENT5010 Innovation Management.	Presentation	2022	Nord University
European Port cities in transition	Book	2020	Springer
Law – Amendments to the ports and waterways act (Lov om endringer I havne- og farvannsloven)	Regulation	2020	LOVDATA
Interviews: Learning the craft of qualitativ e research interviewing	Book	2015	Sage
Introduction to digital transformation and its impact on society	Book	2019	Informing science Press
Implementation notes – New port and waterways act (Iverksettingsrundskriv N-2/2020 - Ny havne- og farvannslov)	Report	2020	The Norwegian Ministry of Transport (samferdselsdepartementet)
National Transport Plan (Nasjonal transportplan)	Strategic plan	2017	The Norwegian Ministry of Transport (Samferdselsdepartementet)
The Norwegian Digital Port Infrastructure (Norsk Digital Havneinfrastruktur)	Project data	2023	Oslo Havn / Kartverket
Norway's Climate Action Plan for 2021-2030	Report	2021	The Norwegian parliament (Storting)
Norway's National Report for World Road Congress	Report	2019	Norwegian Public Roads Administration (Statens vegvesen)
Ocean Infinity SeaShuttle - Emission free container transport by sea. Rotterdam - Oslofjord	Project description	2022	Enova homepage
Promo video of the new port of Bergen	Video	2021	Bergen Havn
Regjeringens pressekonferanse 14.03.2020 ifm. nedstenging av Norge	News	2019	NRK (The Public Service Broadcaster in Norway)
Society's critical functions – What function must society always maintain? (Samfunnets kritiske funksjoner - Hvilken funksjonsevne må samfunnet opprettholde til enhver tid?)	Report	2016	Directorate for Civil Protection (Direktoratet for samfunnssikkerhet og beredskap, DSB)
Samskip's Ocean infinity project	Project description	2022	Samskip homepage
Statistics on the role of shipping in freight transport (Statistikk om skipsfartens rolle i godstransport)	Data in website	2023	The Norwegian Coastal Administration (Kystverket) homepage
Strategic roadmap - Port of Bergen 2021-2030	Report	2021	Bergen Havn

Data Source Title	Type of Data	Publication Year	Publisher/Source
Sustainable Development	Report	2022	United Nations homepage
The sustainability program	Report summary	2021	International Association of Ports and Harbors.
Means of transport in Norway 1946—2020 (Transportytelser i Norge 1946-2020)	Report	2021	The Norwegian Center for Transport Research (Transportøkonomisk institutt, TØI)
Various statistics and data about transport sector in Norway	Structured data	2019	The Norwegian Statistics Bureau (Statistisk sentralbyrå, SSB)

Table 01 – Overview over the reviewed secondary data used in this master's thesis.

4.4.2 Primary data collection

According to D O'Gorman and MacIntosh (2014), primary data refers to the data that is collected by us, the researchers, for a specific research project. This could be done through various methods such as surveys, experiments, interviews, and observations. For the case of our project, which is qualitative research with descriptive design, we chose interviews as the primary data collection method. We believe, by implementing interviews with various actors in the seaport logistics segment, the study's credibility has been preserved. We utilized semi-structured form of interview. Brinkmann and Kvale (2015) characterize semi-structured interviews as a form of qualitative research, wherein pre-planned open-ended questions are utilized. Such questions are further supplemented by additional questions that arise during the interview, because of the researcher's interaction with the respondents. Brinkmann and Kvale (2015) emphasize the significance of social interactions in semi-structured interviews, where the researcher shall demonstrate skills to establish a comfortable and non-threatening environment, to encourage the respondents to express their viewpoints openly and honestly, without hesitation. To achieve such an environment, we took several measures. We sent personalized emails to recipients with an introduction of ourselves, explanation about our research project, and suitable reasoning about why we need their contribution. In most cases, we received positive feedback, but there were a few cases where we did not receive any response. For the important ones, we sent reminder emails and explained how their contribution was crucial for our project. We expressed our genuine desire to talk to them and apologized for being persistent. Our approach has been effective, and we were eventually able to interview the nominated informants.

Before conducting the interviews, we provided the interviewees with an information letter outlining their data privacy rights. We also explained our policy on anonymity and informed them that they had the freedom to withdraw from the interview at any time, without providing a reason. To ensure that all parties provided their consent, we used a digital signing tool called DocuSign to obtain endorsed consent forms prior to the interview session.

Johannessen, Christoffersen, and Tufte (2020) suggest that researchers should determine the sample size, interviewees, and interview process before conducting interviews. We established a criterion that interviewees must be involved in seaport operations in some capacity and have knowledge of recent technological advancements. Initially, we identified three actors to interview, but as we progressed through the primary data collection phase, other relevant parties were recommended to us by the informants to provide a comprehensive picture of the situation. We conducted a total of seven interviews, each with a duration of sixty minutes. Table 02 lists the interviews and informants. The interviews were conducted from mid-January to mid-April 2023, using Microsoft Teams. We recorded the sessions using the record function in Microsoft Teams, and later transcribed the conversations for further use in our research project. Aside from one interview which was conducted in English, we used Norwegian language in other interviews, since it was more convenient for the interviewees.

As required by semi-structured form of interviews, our interviews involved open-ended questions that promoted conversation between the researchers and respondents and probing further with such questions helped us acquire the necessary information. Our interview guide consisted of seven questions, and we attended all interviews together, except for one interview session where one of us was unable to attend. The semi-structured interview allowed us to interact with the informants and explore the questions in depth. Through this approach, we were able to gain valuable insights into the current state and future potential of IoT in seaport operations, as perceived by those with firsthand experience. We ensured that we accurately captured the current state of IoT in the seaport of Bergen and sketched the desired state of seaport logistics based on the most precise information available at the time.

Item nr.	Company	Position	Detail description
1	Port of Bergen (Bergen Havn AS)	Marketing Manager	The person had logistics education and was the main person who guided us through various aspects.
2	GreigConnect	CEO	Supplier of ICT infrastructure to several ports in Norway, incl. port of Bergen.
3	North Sea Container Line AS	Chief Technical Officer (CTO)	One of the five shipping lines that freight containers to the port of Bergen.
4	The Norwegian mapping authority (Kartverket)	Department Director Kartverket Agder	This authority has been involved in the "Norwegian digital port structure" project which will also be used in the port of Bergen.
5	SINTEF Gemini Center of IoT	Senior researcher	This center acts as the bridge between the research and industry within the application of IoT.
6	Port of Oslo (Oslo Havn AS)	Department director FDVU	Related to the Norwegian digital port structure project which will also be used in the port of Bergen.
7	Ex-Tech	Head of Digital Transformation	Supplier of sensors which can be used in IoT devices and similar applications.

Table 02 – Overview over the interviews conducted for this master's thesis.

4.5 Data analysis

When researchers streamline and systematize the data material, they, first, organize the data by topic, and then, evaluate and interpret the data. This process is known as data analysis (Johannessen, Christoffersen, & Tufte, 2020). We had to reduce and refine the amount of data for our data analysis phase, as we had a considerable amount of text after the data collection. This reduction was based on the transcripts of the interviews. At this point, we got a broad sense of the entire body of data and picked out components that were pertinent to the problem. Focusing on what lies behind the statements that informants have said is a key component of interpretive reading (Johannessen, Christoffersen, & Tufte, 2020). Thus, reading the data material in an interpretive manner was necessary. By categorizing the data, we organized and condensed the data material. During the study process, we created several categories, such as the impact of IoT on logistics, maritime transportation, governmental policies, environmental aspects, technological aspects, and more.

4.5.1 Analysis - from data collection to findings

By gathering both primary and secondary data, we gained insights into the current state of IoT technology, the aspirations and goals of the seaport authorities regarding IoT adoption, and the specific projects driving the realization of their vision. Following the data collection, our analysis process began with the aim of deriving insightful findings. To facilitate our analysis, we employed three key assessment tools, namely SWOT (Strengths, Weaknesses, Opportunities, and Threats), VRIO (Value, Rarity, Imitability, and Organization), and PESTEL (Political, Economic, Sociocultural, Technological, Environmental, Legal). SWOT analysis enabled identification of internal and external factors influencing the port's adoption of IoT technologies. VRIO analysis provided a comprehensive evaluation of the port's resources and capabilities. The PESTEL analysis assessed six various factors impacting the IoT adoption. By conducting a comprehensive assessment, we enhanced our comprehension of the seaport's internal and external dynamics, enabling us to identify factors that can contribute to or impede the attainment of competitive advantage.

4.6 Assessment of quality

Focusing on the following definitions allows for an evaluation of the quality in our research work:

4.6.1 Reliability

Reliability is about whether it is possible for other researchers to apply the same methods and to reach the same results (Johannessen, Christoffersen, & Tufte, 2020). According to Johannessen, Christoffersen, and Tufte (2020), it is possible to boost the reliability assessments of qualitative research by making the entire research process detailed and transparent. An open and transparent methodological approach provides insight into how the results have been created out of research work. Therefore, we believe that it has been crucial to concentrate on the details, explicitly which data was being collected, how it was collected and processed, and whether it was reliable. Informants who worked at the seaport and are in the management levels, as well as those working in terminal operator companies, the IT supplier, and the shipping companies were our primary sources of data. As a result, their own personal perceptions of reality were evaluated. To be able to focus on more details of the data, the use of recording was our main method which guaranteed the quality of the data. Moreover, when we had sketched the first version of our theses, we sent it again to a selection of the informants

and asked for validity of findings. By this approach, we believe, we upheld the quality of the research.

Despite the efforts to keep the methodological approach detailed and transparent, one factor that nevertheless affects the reliability is the informant's personal judgement. In other words, for a reader of this theses, to be able to come to the same conclusions as we did, they shall have access to the same informants. However, thinking about the required level of data privacy, we have not published the informant's personal information. This means that another researcher cannot contact the same persons if they want to reiterate the same results. Another concern that could impact the reliability of the results was that the informant's understanding with regards to the potentials of industry 4.0 might change throughout the time. This might lead to the fact that another researcher might achieve a different result interviewing the same person at a later stage.

4.6.2 Validity

Johannessen, Christoffersen, & Tufte (2020) distinguish between internal and external validity.

4.6.2.1 Internal validity

According to the definition, the internal validity indicates to which extend the research work and findings reflect the purpose of the study and represent the reality. In other words, the internal validity is about trustworthiness or credibility. Johannessen, Christoffersen, and Tufte (2020) explain that one way of strengthening the credibility of the research results is by returning the findings to the informants to confirm them. They claim that the informants are considered highly qualified to comment on the results of the research as they have been involved in the issue. However, this approach may also introduce some weaknesses as the informants are influenced by their affiliation and position in their respective organization. Another concern regarding the research's credibility could be the size of statistical population. Thinking of the low number of interviewees in our research, a concern could be that some voices might not be included in the selection of informants. This would be an unfortunate case as certain opinions might not be noted. Aside from the challenges we faced with regards to the credibility, one useful approach to improve the validity was to substantiate the empirical findings with the existing theory. In a broad sense, validity could be used to define the relationship between data and interpretation of the same data, i.e., validity considers the suitability of the measurement (Wellington & Hammond, 2020). To better enable the readers

of our study to determine whether the findings are applicable to their environment, we made every effort to provide a thorough and comprehensive reality.

According to the definition, the internal validity indicates to which extend the research work and findings reflect the purpose of the study and represent the reality. In other words, the internal validity is about trustworthiness or credibility. Johannessen, Christoffersen, and Tufte (2020) explain that one way of strengthening the credibility of the research results is by returning the findings to the informants to confirm them. They claim that the informants are considered highly qualified to comment on the results of the research as they have been involved in the issue. However, this approach may also introduce some weaknesses as the informants are influenced by their affiliation and position in the organization. Another concern regarding the research's credibility could be the size of statistical population. Thinking of the low number of interviewees in our research, a concern could be that some voices might not be included in the selection of informants. This would be an unfortunate case as certain opinions might not be noted. Aside from the challenges we faced with regards to the credibility, one useful approach to improve the validity was to substantiate the empirical findings with the existing theory. In a broad sense, validity could be used to define the relationship between data and interpretation of the same data, i.e., validity considers the suitability of the measurement (Wellington & Hammond, 2020). To better enable the readers of our study to determine whether the findings are applicable to their environment, we made every effort to provide a thorough and comprehensive reality.

4.6.2.2 External validity

The concept of external validity is often equated with transferability, which refers to the applicability of research findings beyond the specific context in which they were obtained, rather than the ability to generalize (Johannessen, Christoffersen, & Tufte, 2020). Transferability in qualitative research means whether one succeeds in creating descriptions, concepts, and interpretations that are applicable in other areas than what is being studied (Johannessen, Christoffersen, & Tufte, 2020). Considering our research topic for this thesis, we recognize that the degree of transferability to other contexts was limited. This is because we concentrated on a particular seaport in Norway, with a restricted number of participants and a specific geographic location. However, it is possible that the insights gained from this research will be valuable to other studies in the same field, particularly in terms of the changes

that seaports must make to remain competitive in the era of Industry 4.0. In summary, while the study had its own limitations and may not reflect the global picture, the results can still be used to predict the new shape of the seaport logistics sector at both the national and international levels.

4.7 Objectivity

In a research work, it is essential to highlight the extent to which the research results can be confirmed by other researchers (Johannessen, Christoffersen, & Tufte, 2020). In order the research results to be verifiable by other researchers, it is crucial to describe the decisions made throughout the research process (Johannessen, Christoffersen, & Tufte, 2020). This verifiability includes the objectivity criteria in qualitative research (Johannessen, Christoffersen, & Tufte, 2020). Verifiability of a research work shall be guaranteed by making both the weaknesses and strengths of the chosen method visible, so that the reader can chase the decisions and make sense out of them. In other words, other researchers can read our dissertation and based on the description of decisions, they should be able to draw the same conclusions. It is important to safeguard the objectivity of the study's conclusions so that they are not influenced by the author's own opinions (Johannessen, Christoffersen, & Tufte, 2020). As authors of this thesis, our cooperation throughout the entire research process has played a crucial role in increasing objectivity. By working together, we were able to bring different perspectives and ideas to the table, which allowed us to critically evaluate our findings and ensure that our conclusions were not based on personal biases.

4.8 Ethical considerations

According to Johannessen, Christoffersen, & Tufte (2020), ethic is about differentiating between right and wrong. The ethics indicate what we can, and we cannot do towards each other. Thagaard (2018) states that the ethical issues are especially prominent within the qualitative research methods. This is because the choices that the qualitative researchers undertake can potentially affect the persons who contribute to the research project. It is therefore more important in a qualitative work to emphasize on the ethical guidelines throughout various phases of the research work. The research ethics guidelines are embodied by the national research committees (Johannessen, Christoffersen, & Tufte, 2020). The guidelines can be grouped into three main categories of considerations, namely the informant’s right to self-determination and autonomy, the researcher’s duty to respect the informant’s privacy, and the

researcher's ethical responsibility to avoid causing any damage to other individuals (Johannessen, Christoffersen, & Tufte, 2020).

We, as researchers, were committed to uphold the ethical principles and adhere to legal guidelines throughout our research process. Our aim was to maintain a high level of awareness and ensure that our actions were governed by research ethical rules. Given the potential impact of the interview outcomes on the executive management of the seaport and their supplier network, it was essential for us to be mindful of ethical principles. Before participating in the interviews, we provided the interviewees with an overview of the project's purpose and the questions we intended to ask. We also made it clear that they were free to withdraw from the process at any time during or after the interview, without having to provide a reason. By being transparent and respectful of ethical considerations, we aimed to conduct our research with integrity and accountability.

4.8.1 The authors' reflections on own role as researchers

Our role as authors is principal, and we have strived to perform our duties diligently and professionally, as the research is influenced by our individual backgrounds and interests, which could lead to subjective opinions based on our previous education and professional experiences.

The Norwegian National Research Ethics Committees is an organization in Norway that has the responsibility to ensure that all research is conducted in accordance with recognized research ethical norms. The organization consists of four committees and commissions for medical and health research, social sciences and humanities, science, and technology, and for investigation and research misconduct. According to their website, all their committees are advisory, and anyone can seek advice (The Norwegian National Research Ethics Committees, 2022). Therefore, we visited their website and looked for the guidelines which were to be applied to the qualitative research. In a qualitative research project, the proximity of the researcher to the topic is a key prerequisite (The Norwegian National Research Ethics Committee, 2022).

Simultaneously, the researcher's reflexive attitude is necessary to be able to give an analytical interpretation to the empirical data (The Norwegian National Research Ethics Committee, 2022). Thus, there are clear expectations in the qualitative research that the researcher is aware of himself/herself and can critically assess and account for the ethical and scientific challenges of various research roles (The Norwegian National Research Ethics Committee, 2022). The

Norwegian National Research Committees defines "reflexivity" as a competence and a researcher's position. This refers to the researchers' ability to recognize the significance of their own role in various aspects of the research process, including interactions with research participants, empirical data, theoretical perspectives, and their own preconceived notions that they bring into the project. The Norwegian National Research Committees recommend that a well-crafted project description should include brief reflections on the researcher's own role and an explanation of how the researcher intends to address any pertinent issues related to their role during both the planning and implementation stages of the study.

In the case of our research project, we, the authors, recognized the significance of our own roles. Throughout the project, we endeavored to keep our positions as researchers front and center, where the rules of research ethics were among the core principals. We were conscious of our relationships with the organizations, as well as individuals whom we interviewed, allowed the empirical research to speak for itself and let the informants lead us through their knowledge with the least biased control from us. Therefore, we ensured that our own contribution as researchers did not harm the quality of the research. Furthermore, continuous guidance from our master's thesis supervisor was sought throughout the research process, to ensure that we remain on track.

4.9 Confidentiality

Interviewing the seaport management authorities could be challenging as they might not be willing to disclose the organization's plans to sustain their future competitiveness in the market. To overcome this challenge, we had to establish a mutual and trustworthy framework with interviewees where confidentiality and data privacy were of utmost importance. To maintain confidentiality, we utilized de-identification of the interviewee's data. However, we had to consider the trade-off between the degree of de-identification and the research's reliability, as the origins of the data were kept confidential. In our case, as we focused on a qualitative research based on a case-study, we prioritized the interviewee's trust in us, over the openness about sources of the data.

According to Johannessen, Christoffersen, and Tufte (2020), if the participants in the data collection can be recognized, consent registration in the Norwegian Center for Research Data is necessary according to the Personal Data Act. As earlier mentioned, we collected data by recording the interviews. To ensure that processing of personal data complies with the privacy laws, we sent a notification to the Norwegian Center for Research Data. Subsequently,

to guarantee that the informants were aware of their rights, we obtained consent from the informants prior to the interviews. In this manner, we secured that we met the requirements. Additionally, we ensured that the interviewees were provided with our contact details, education, career background, and informed about the use of their data upon completion of the study. We recognized the importance of protecting the interviewee's information and their right to control their own data, as they were free to withdraw from the research study at any time without any obligation to provide a reason.

4.10 The research model

Our research model aims to analyze the adoption of IoT technology in the Cargo Port of Bergen and its potential to provide the company with a competitive advantage. To achieve this, our investigation involved multiple steps. Firstly, we examined the current state of IoT utilization in the port operations. Secondly, we explored the firm's ambitions and goals for maximizing the benefits of IoT in their logistics operations, known as the desired state. Subsequently, we examined the plans and projects that would facilitate the transition from the current state to the desired state. Lastly, we assessed the measures, resources, and the business environment surrounding the organization to determine the extent to which these factors contribute to the firm's ability to gain a sustainable competitive advantage.

We employed a range of analytical tools, including SWOT analysis, VRIO analysis, and PESTEL analysis, which we categorized into internal and external factors influencing the implementation of IoT technology in the seaport. Our model focuses on identifying the strengths, weaknesses, opportunities, and threats that the seaport of Bergen faces in adopting IoT. Additionally, we evaluated the value, rarity, imitability, and organization of the port's resources to determine their potential for providing a competitive advantage. Furthermore, the PESTEL analysis allowed us to assess the political, economic, social, technological, environmental, and legal aspects of the organizational environment. By integrating these analytical tools and academic concepts, we offer a comprehensive and holistic analysis of the potential impact of IoT technology on the competitive position of the Cargo Port of Bergen. Figure 08 displays this research model.

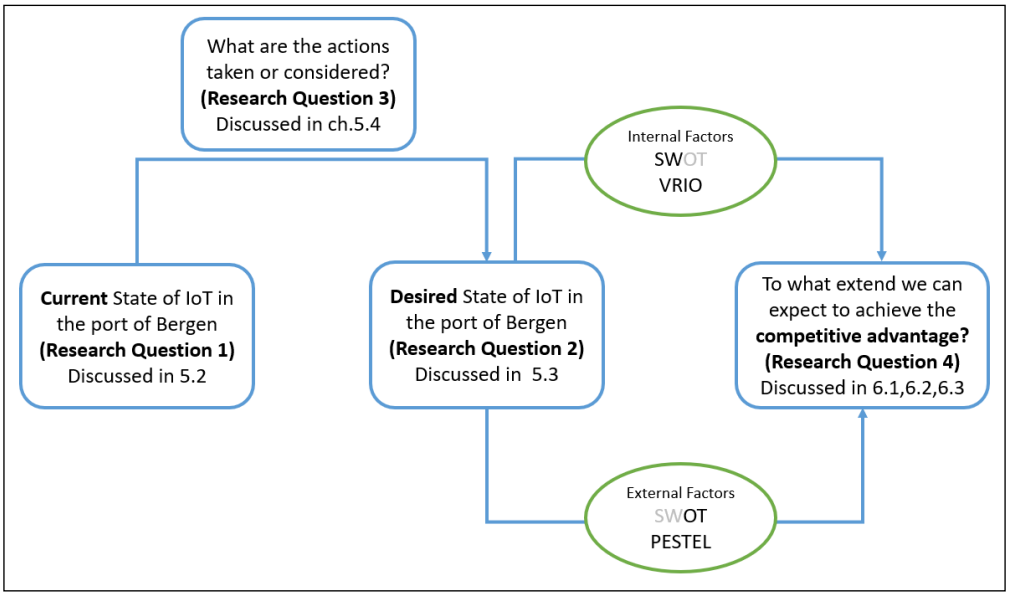

Figure 08: Flowchart for the research model

5. The seaport of Bergen and IoT

5.1 A snapshot of the port

In this chapter, we provided a brief introduction of the seaport of Bergen, its ownership structure, its financial results, and a concise description of how the quay operations are organized compared to other ports in Western and Eastern Norway. This information is provided here as it helps to understand the strategies the organization has chosen for their future growth.

Port of Bergen is co-owned by Bergen municipality as well as six other smaller municipalities around Bergen with ownership portions: Bergen (50%), Øygarden (20%), Alver (18%), Bjørnafjorden (5%), Askøy (5%), Austerheim (1%), and Fedje (1%) (Seaport of Bergen, 2023). Since 2020, the company has become a group consisting of three subsidiaries - Bergen Havn Ågotnes AS, Bergen Havn Utvikling AS, and the parent company, Bergen Havn AS (Seaport of Bergen, 2023). The financial results state that the company had 49 employees in 2021 with operational revenue of 137,1 MNOK and operational profit of 3,5 MNOK.

As a measure to reduce the pollutions from ships at quay, the seaport uses Environmental Port Index (EPI) which is developed inhouse. The implementation of this index allows for differentiated rates for quay service fees based on the ship's environmental profile and the pollution generated during its port stay. As a result, ships are provided with financial incentives to operate in a more environmentally friendly manner (Bergen Seaport, 2022).

The seaport of Bergen has outsourced loading, unloading, and terminal operations to two companies, Green Port Services AS, and West Port AS. The seaport serves five different shipping companies that freight containers to the port. Each shipping company is free to choose either of the two terminal operators for cargo handling at the quay. Additionally, the level of service required by the shipping companies varies. Some companies only utilize the seaport operators for physical cargo handling and direct other inquiries to the seaport authorities. While, others prefer to handle all services through the seaport operators and receive a cumulative invoice for various services.

Nevertheless, our study revealed that such a configuration is not universal among the seaports in Norway. For instance, the seaport of Stavanger has only one terminal operator, West Port AS, leading to a different situation. This can result in distinct pricing arrangements for the seaport services. Additionally, some ports in Norway prefer to conduct terminal operations in-house, rather than outsourcing them. Another important element is that all the visiting container ships in western Norway shall be equipped with onboard crane. This is because some of the ports alongside the coast do not have the crane at quayside. This also means that port authorities will be less involved in quay operations. In contrast, in Oslo fjord area, all ports have quay crane. This will also impact the way ports are organizing the services.

5.2 Current state of IoT in the Cargo Port of Bergen

The primary focus of our first research question is to examine the existing state of IoT implementation at the Cargo Port of Bergen. This chapter is dedicated to present our findings on the existing infrastructure and the extent of IoT adoption. This information is obtained through the interviews.

The seaport currently uses IT systems developed by a software company called Greig Connect. The current IT system consists of enterprise resource planning (ERP) which performs the resource planning, semi-automated invoicing, and terminal operative system. Greig Connect have supplied the same IT system to several other port companies in Norway. This potentially eases the universal logistics services across the Norwegian ports. When it comes to developing IT solutions between the shipping companies and the terminal, the two terminal operator firms work closely together to develop tailormade IT solutions towards the shipping companies. In addition, Greig Connect works towards both the Cargo Port of Bergen and the terminal operators to enhance the system functionality. The current systems enable

semi-autonomous operations which we will describe in next subchapter. However, as of today, no fully autonomous operations exist in the Port of Bergen.

5.2.1 Sensors and RFID tags

The cargo terminal currently utilizes Radio Frequency Identification (RFID) tags which are small electronic devices, contain a unique identification number and are attached to objects such as containers, and vehicles. This will help semi-automated operations. By the term, semi-automation, we indicate that the use of manual work is reduced, since the system can capture data through the electronic chip. However, the operation will still require labor work to scan the RFID tags.

5.2.2 Automated cargo handling systems

The ERP system assists the port authorities with resource planning and invoicing. However, the physical movement of cargo is not yet fully automated using IoT capable vehicles. However, this is the seaport of Bergen's ambitions upon establishing new port in Ågotnes. We will further elaborate on this move during this master's thesis.

5.2.3 Predictive analytics

As of today, the port authorities don't have a system to analyze the data about cargo movements to find patterns and factors to impact the logistics operations. We have been told by the IT supplier that they are working on development of such features to be launched in the mid-term when more automation is available at the seaports.

Overall, the Port of Bergen currently possesses some IT systems that can operate autonomously once the new seaport facility at Ågotnes is in place. However, this capability is restricted, and new investments and project initiatives are necessary to ensure proper implementation of IoT technology. As of today, the cargo operations involve human workforce.

5.3 Strategies at the seaport of Bergen (2021-2030)

Bergen is a city with strong maritime heritage. The city has long relied on its seaport for its economic sustenance, with trade, fishery, and petroleum activities being the key drivers. (Seaport of Bergen, 2023). The port, which is the second largest in Norway and a popular

cruise destination in Europe, is well positioned to drive seaport activities and cultivate new business opportunities in the region. (Seaport of Bergen, 2023).

Our second research question aims to explore the seaport's vision for the future state of IoT technology. To gain insights into this vision, it was important for us to review the strategies employed by the seaport of Bergen. Strategies serve as a guiding framework for achieving specific objectives and provide a high-level direction for an organization. They are long-term in nature and function as a roadmap towards success. The seaport authorities recognize that the strategy is the organization's compass which will guide further development of seaport operations in a way that it generates positive outcomes for customers, partners, owner municipalities and the society (Seaport of Bergen, 2023). By reviewing the strategies of the seaport of Bergen, we were able to grasp their intended direction. This assessment of the seaport's target destination enabled us to capture their ambitions for IoT adoption. Detailed information on the port's strategies and their potential impact on IoT implementation is discussed in the subchapters 5.3.1 to 5.3.4, and an overall assessment of these strategies is provided in 5.3.5.

5.3.1 Strong financial performance and profitability

It is said that the company aims to achieve this goal through professional and active operation and development (Seaport of Bergen, 2023). Among all measures to achieve this strategic goal, they point at developing new business areas as well as the right balance between commercial thinking and important social responsibility (Seaport of Bergen, 2023). As authors of this research dissertation and interviewers of Bergen seaport's management, we hold the belief that the organization comprehends the importance of maintaining a balance between profitability, which is essential to their existence, and fulfilling their social responsibility as crucial infrastructure for both the community and the nation.

5.3.1.1 Strategy discussion

The challenge of IoT adoption in relation to this strategy stems from the exclusion of Norwegian ports from the National Transport Plan (NTP). Norway's National Transport Plan is a parliamentary statement that presents the government's transport policy and describes which objectives and principles they set as a basis for the transport sector. Typically, and through the NTP, the Norwegian ministry of transport provides various tasks and projects to the Norwegian road administration (Statens Vegvesen), Avinor AS, the Norwegian railway

directorate (Jernbanedirektoratet), Bane NOR, and the Norwegian coastal administration (Kystverket). Accordingly, the grants are allocated to various sectors and their associated companies through the NTP. To put this into context, the roads that are built in Norway are initiated by the state, followed by the grants that are allocated through NTP. The same principle applies to ferries, railways, and airports. However, when it comes to ports, the task is not considered as a part of NTP. Instead, the seaport responsibility lies with the local municipalities. This may not seem tragic, but if we rewind the ports' revenue stream, it uncovers a serious challenge. We covered in chapter 1 that cargo handling in container ports is a business with tiny margins. Smaller ports along the Norwegian coast may not have a wide range of operations or income sources like larger ports do. As a result, they may not be able to offset any small losses in the goods segment with other profitable activities. This can make it challenging for them to maintain a positive overall balance sheet. Consequently, municipalities play a crucial role in supporting these ports by providing aid to ensure their continued operation. This is important because these ports are considered critical infrastructure for society.

Let us now draw a comparison between sea transport and air transport in Norway. According to information provided on Avinor's website, their primary role in society is to own, operate, and develop a national network of airports serving the civilian sector (Avinor, 2023). While major airports like Oslo, Bergen, and Stavanger generate positive profits, there are numerous smaller airports that operate at a financial loss. Avinor's social mission is to act as the central body that redistributes funds from the larger airports to support the smaller ones. This ensures overall air accessibility for all citizens, regardless of their location in the country. However, the situation regarding ports in Norway differs from Avinor's approach. Since the responsibility for the ports falls under the jurisdiction of municipalities, the ports in Norway are highly fragmented. This implies that they employ a range of systems, encompassing both IT systems and overall logistics infrastructure, to operate their services. Additionally, they use diverse pricing methods for their services and offer varying levels of quality.

Regarding the port of Bergen, the firm achieves positive financial results per annum. Though, container cargo does not constitute their major source of revenue. According to informants, they handle approximately forty thousand TEUs (Twenty-Foot Equivalent Unit) yearly, while Oslo handles three hundred thousand TEUs, and other smaller ports in the Oslo Fjord such as Drammen, Larvik, and Moss, handle practically sixty to seventy thousand TEUs. This comparison shows, despite the seaport of Bergen is the second largest seaport in Norway and

the largest in Western Norway, the cargo quantities are still far lower than the Norwegian ports in the east of Norway. This implies that the seaport of Bergen may not be able to adopt the most effective solutions due to volume of activity.

The seaport of Bergen's strong financial position can be attributed primarily to their cruise business, which is the largest among all Norwegian ports. Several informants have highlighted that the cruise sector represents the most lucrative activity for seaports in Norway.

5.3.2 An attractive emission-free port

The seaport authorities have ambitions to be an emission-free seaport by 2030. The organization aims to further develop the seaport of Bergen to be one of Europe's most innovative and sustainable seaports. To achieve this goal, port authorities are taking a collaborative approach across various municipalities in Vestland county.

As stated in the introduction, the politicians are motivated to set policies for transition of the goods traffic from road to sea due to environmental and safety considerations. However, we also addressed that if this goal is to be achieved, shipping is likely to become the primary and most significant source of pollution in the transportation sector, which will be a major concern. Rather, we must implement technologies that will gradually reduce emissions over time, with the goal of achieving zero-emission transportation. Therefore, we contend that the seaport of Bergen's zero-emission strategy is intersected with the emergence of new technologies.

5.3.2.1 Strategy discussion

One may argue that the implementation of IoT technology in ports is not directly connected to the green shift, which focuses on utilizing emission-free energy sources. While it is true that renewable energy is an important aspect of the green shift, it is also important to recognize that IoT technology can play a critical role in restructuring the operations for increased efficiency. There are two ways to reduce emissions in the transportation sector. Firstly, by adopting green technologies such as electric and hydrogen-powered vehicles. Secondly, by restructuring the way current operations are conducted to perform the same amount of work with less emissions. In this context, IoT technology can serve as a foundation for such restructuring.

As authors, we are of the opinion that seaport of Bergen's strategy to be an attractive emission-free port by 2030 is authentic and appropriate for the organization which has a significant social responsibility. This indicates, the target has been thoughtfully selected to align with the firm's commitment to fulfilling its societal obligations and making positive contributions to the community.

5.3.3 New cargo port at Ågotnes by 2027

The cargo dock in the seaport of Bergen is located at Dokken, which is a highly attractive city center location. As a result of urban development in central areas of Bergen, the municipality decided to relocate the cargo port to outside of the city center area. Therefore, port of Bergen invested in a property at Ågotnes in Øygarden municipality with plans for the development of a new cargo port facility (Bergen Seaport, 2022). The company anticipates a potential rise in cargo volumes if a proficient port, equipped with sufficient cargo handling and storage space is established, along with the establishment of adjacent logistics centers. Constructing a new cargo port could result in significant societal advantages, such as freeing up of valuable land nearby the city center and the fulfillment of a national objective to shift the transportation of goods from roads to sea (Bergen Seaport, 2022). However, according to the seaport authorities, it is demanding to create economic profitability for a new cargo port in the short and medium term. The company is therefore dependent on capital inflows from the municipalities to be able to carry out the investments required for the relocation.

5.3.3.1 Strategy discussion

We believe that the decision to relocate the cargo facilities and terminals is a genuine environmental-friendly strategic goal. Although, the decision is not solely taken by the seaport management and is the result of a resolution in Bergen city council. Further details regarding the relocation project will be covered in chapter 5.4.2. where we discuss the ongoing projects.

5.3.4 Double the cargo volume at quay, increase value creation linked to cargo

In general, increase of cargo handling at quay will result in higher revenues for the seaport of Bergen. Assuming the trade volume in Norway remains constant, higher cargo volume at quay can help achieve the national goal of transferring goods traffic from roads to sea. This will enable the seaport to regain the lost market share from the road transport segment. Moreover, the seaport of Bergen may also strive to capture a greater market share from its regional

competitors. Attain this strategic objective necessitates an action plan. In this regard, the construction of a new cargo port at Ågotnes can provide a contemporary and efficient transportation system that could make the Bergen seaport more attractive to shippers and carriers, compared to other alternatives. Among the measures to achieve this goal, the organization have pointed at proactive marketing efforts, enhanced collaboration with regional chambers of commerce, and supplement the cargo port operations at Ågotnes with public seaports in north and south, such as Mongstad and Samnøy (Seaport of Bergen, 2023).

5.3.4.1 Strategy discussion

The management team demonstrates astute understanding of the significance of increased volume as a primary driver for revenue growth, which in turn, strengthens their position in the region. They acknowledge that achieving higher volume requires capturing market share from other ports or road transport. Additionally, the organization acknowledges the value of their brand-new, modern seaport facility at Ågotnes as a key element for securing a sustainable competitive advantage. However, we argue that relying solely on the new facility is inadequate for attracting increased volume to the seaport of Bergen. We assert that establishing improved connectivity to smaller ports and private quays, like Mongstad, is essential. Numerous customers in the region may not possess the volume required for ships, but they have recurring shipping requirements to smaller destinations from Bergen.

5.3.5 Overall assessment of the seaport's vision with regards to IoT

In evaluating the seaport of Bergen's strategies and their relationship to the future adoption of IoT, it becomes evident that the targeted strategies align with the envisioned future state of IoT in seaport operations. The company has clearly identified its vision to be a modern, international, future-oriented, and sustainable seaport (Bergen Seaport, 2022). Considering the potential of IoT as a disruptive technology, it has the capability to positively contribute to this journey when appropriately adopted, implemented, and integrated. To our judgement, the Port of Bergen's strategies highlight the firm's recognition of IoT potentials as well as the organization's commitment to leverage it effectively in pursuit of their business goals.

5.4 Ongoing projects

During the interview process, it became apparent that several initiatives are being undertaken which contribute to bridge the gap between the current state and the desired state of IoT

adoption at the Port of Bergen. These measures encompass various ongoing projects within the seaport operations that lead to implementation of new technologies including IoT. Chapters 5.4.1 to 5.4.4. cover a summary of the pertinent projects.

5.4.1 Digital infrastructure in Norwegian seaports

In Norwegian, the project is named as “Norsk Digital Havneinfrastruktur”. It is a cooperation project among nine Norwegian seaports and the Norwegian mapping authority (Kartverket). The project has a homepage in which all the documents and work packages throughout the project are made publicly available. We have extracted a summary of the information and provided here as parts of current efforts in the Norwegian port logistics segment. In the project, the Norwegian mapping authority has been the project leader, while the Oslo seaport had the project owner role. In addition, a private Norwegian software company, Grieg Connect, has been involved as the system supplier. The project has been progressed in following main areas (Norsk Digital Havneinfrastruktur, 2023):

5.4.1.1 The future port

The project aims to improve the efficiency of seaport operations by developing and implementing digital infrastructure and IT systems. One of the key performance indicators for measuring the project's success is a reduction in berthing time at the quay. This is achieved through increased collaboration among all parties involved in vessel anchoring at the quay, enabled by greater transparency in the seaport systems. The project also seeks to simplify communication between vessels and the port. Potential project options include automatic connections to fresh water and electricity at the quay, as well as streamlined invoicing with minimal human intervention. Successful development of the project is reliant on collaboration with the ports, industry, and public sector as end-users.

5.4.1.2 National seaport database

This project builds on the knowledge acquired from two previous initiatives, namely "Port data 2020" by the Norwegian Mapping Authority and "Digitalization of harbor data" by the Norwegian Coastal Authorities conducted in 2020. The primary objective of the project is to establish standardization at the seaport through mapping the user needs. The project's central challenge is to develop a user-centered approach and a practical design for the standard. The digitalized seaport database, created through this project, is considered the basis for

developing digital tools. All seaport data will be stored in a national seaport database maintained by the Norwegian Mapping Authority.

5.4.1.3 Management of seaport data

It is the responsibility of each seaport to input and update data in the national seaport database, ensuring its quality and accuracy. Given that the digital tools in the seaport system rely on this data as input, timely updates are critical. The digital tools are then used for planning and communication with various stakeholders in the seaport logistics value chain.

In our efforts to find the answers for the third research question, we summarize that the Norwegian digital port infrastructure project is one of the right measures to bridge the gap from the current state to the future state of IoT adoptions.

5.4.2 Relocating the Cargo Port of Bergen

As we previously discussed, the cargo port in Bergen is currently situated in the city center area, and plans are underway by the Bergen city council to relocate the port facilities outside of the city. The seaport of Bergen (Bergen havn AS) is responsible for overseeing the operation of the cargo port and has taken the initiative to initiate a project for this relocation. This project is directly relevant to our thesis, particularly in addressing the third research question, as it involves the integration of IoT and Industry 4.0 technologies. In the following sections, we will provide an overview of the key highlights of this project and its implications for the adoption of new technologies.

Currently, activities at Dokken include container reloading from sea to road, freight transport on Ro-Ro ships, coastal freight of general cargo and bulk, as well as workshop and storage facilities. Figure 09 displays a view of the Dokken area in the Bergen city center.

Figure 09: View of the Dokken area in the Bergen city center (Visjon Dokken, 2023)

Alternative locations have been investigated and in 2016, Bergen city council approved Ågotnes as the location for the new cargo port and agreed on a gradual relocation with final establishment by 2027. This relocation will provide significant opportunities for the region's seaport business. The project is unique as it will result in the creation of a brand-new seaport for the city of Bergen, and stakeholders are taking a visionary approach to ensure that the new facility will meet regional needs for decades to come. To put the project into context, we will provide background on why it was initiated and the issues it aims to address for the Bergen municipality. We will then focus on the specific technologies that will be utilized in the establishment of the new cargo port at Ågotnes.

Among the sources we have studied, there is a report published by the seaport of Bergen which describes the challenges with the current location (Bergen Seaport, 2022):

- Current seaport facility at Dokken occupies attractive areas in city center.
- Port operations impose local air pollution and noise to the city center area.
- Inadequate/improper areas behind the quay affects the efficiency of the seaport operations.

The same report provides three objectives to be achieved through the seaport relocation (Bergen Seaport, 2022):

- The project will render the development of Dokken as a part of city center area.
- The project will contribute to reduced air pollution and noise in the area.
- The project will ensure efficient operation of cargo terminal.

The new cargo port at Ågotnes will be the Europe’s first zero-emissions seaport and will be a new hub for western Norway (Bergen Seaport, 2022). Development of self-propelled emission-free ships, a so-called electric autonomous feeder solution, which transports goods from Ågotnes hub to the entire region, aims to ensure reduction of goods transport on roads (Bergen Seaport, 2022).

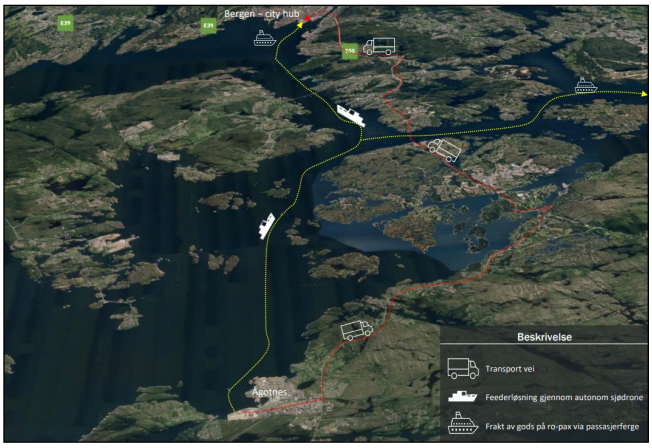

Figure 10: a view of the region, Bergen hub, Ågotnes, and the sea and road transport upon completion of the project (Bergen Seaport, 2022)

A fossil-free seaport requires good solutions for renewable and emission-free energy sources. It is planned for electric power charging stations as well as hydrogen refueling. The project sponsors and owners are clear about the fact that autonomous solutions are an important part of the new seaport facilities. The IoT technology will be utilized in the autonomous feeders. By the help of electric autonomous feeders, the seaport will be capable of emission-free transportation from the Ågotnes hub to other receipt terminals in the region.

Figure 11: Screenshot from animation film to illustrate how the cargo port at Ågotnes will look like (Ågotnes - Bergen Havn, 2021)

Overall, we believe this project is the main pillar of IoT adoption in the future operations of Bergen port. Upon completion of the project, Port of Bergen will have both emission-free and autonomous vehicles and vessels.

5.4.3 Sea transport system as a future alternative to road transport

We discussed earlier that sea transport is a more environmental-friendly and energy-efficient alternative compared to road.

The AEGIS is an acronym for Advanced, Efficient, and Green Intermodal Systems, and represents a research project, aiming to create a more environmental-friendly transportation system throughout Europe, including the development of eco-friendly ports in European cities. The project's focus is on achieving full automation from ships to ports, with the ultimate goal of creating an advanced, efficient, and green intermodal system. In the project, three main case studies will be followed. Figure 12 summarized the cases.

Figure 12: Summary of AEGIS's three cases (AEGIS project, 2023)

Sea transportation has traditionally involved moving large volumes of goods with high loading and unloading costs. Typically, cross-continent container ships carry substantial amounts of goods, which are then divided into smaller shipments and distributed locally using trucks. To make seaborne transport more competitive for smaller volumes and smaller ports, new technology must be developed. AEGIS aims to create a new seaborne transportation system by combining large container ships in Europe's main shipping lines with smaller autonomous feeder boats. This will reduce emissions generated by road transport and increase flexibility in serving smaller quays alongside fjords. AEGIS will also explore ways to connect cargo ships directly to inland waterways in Northern Europe using a LOLO (Lift-On/Lift-Off) container-based freight solution. By utilizing cutting-edge technology and fewer terminals near the main waterway, overall efficiency is expected to increase. The last leg of the transportation route will feature a flexible system, with small, unmanned vessels that are autonomous and electric, ensuring that cargo reaches its destination (AEGIS project, 2023).

Figure 13: Screenshot from animation video made for AEGIS project (AEGIS project, 2023)

Figure 14: Short Sea terminals – Transport from large ports in Europe such as Rotterdam to smaller destinations alongside the populated coastal areas in Norway and Sweden (AEGIS project, 2023)

The researchers behind this project aim to demonstrate the feasibility of autonomous ships and automated ports, and how they can bring flexibility, efficiency, and a greener future to the residents of these cities. This 3-years project was initiated in June 2020, with 7.5 million Euros from the EU's research initiative Horizon 2020 research and innovation program (AEGIS project, 2023). SINTEF Ocean leads the project and 40% of the total research funds is allocated to Norway. Through the AEGIS project, researchers, seaport authorities, technology suppliers and shipping companies from four countries of Norway, Sweden,

Denmark, and Germany will elaborate the autonomous transport chain of the future. From Norway, seaport of Trondheim, SINTEF, one container shipping company along the Norwegian coast, NorthSea Container Line (NCL), and one seaport logistics system supplier, Greig Connect are involved. Although our master's thesis focuses on the seaport of Bergen, we discovered a considering number of synergies between this project and the plans for Bergen's new seaport with autonomous feeder boats and emission free seaport operations.
Overall, upon completion of this project, the outcome will be feasible seaborne goods transport in smaller batches and by autonomous vessels. This involves extensive use of IoT technology and will benefit the port of Bergen among other involved ports across Europe.

5.4.4 Zero-emission container transport at sea

The Sea Shuttle' project is a pilot initiative for zero-emission container transport between Rotterdam and Oslo. Samskip and Ocean Infinity are two companies that in June 2022 secured funds through ENOVA innovation award for two emission-free vessels to connect Norway and the Netherlands by 2025 (Samskip, 2022). Although the project is primarily focused on the Oslo region in Norway, we included it in our dissertation because similar ships with the same design will be available for the seaport of Bergen for consideration after successful operations in Oslo.
These vessels will run on hydrogen as their primary fuel. The hydrogen will be stored in pressurized tanks shaped into containers. The re-fueling will be by exchanging the hydrogen containers with new ones during berthing at ports (ENOVA, 2022). The company accounts for energy efficiency in design with lower speed as well as special hull and propulsion system that are suited for lower speeds than usual. As of today, the hydrogen as maritime fuel costs more than traditional fossil fuels. However, it is meant that lower energy consumption will compensate for high hydrogen cost. In the future and when the hydrogen is vastly available for maritime transportation, the cost picture will be more economical than today. Among the technological innovations we can mention design of the ship with very low energy needs per one nautical mile, introduction of fuel cells, safe re-fueling through container exchange. This project will also leverage IoT technology, enabling autonomous and semi-autonomous operations for tasks such as exchanging hydrogen containers, loading, and unloading cargo containers at the quay, and controlling general ship stability and motion.

6. Analysis and assessment

In the subchapter 3.7, we discussed the framework and various tools that emphasize the significance of internal and external resources. In our endeavor to address the fourth research question, we conducted a comprehensive analysis of the diverse factors influencing the seaport. These analyses are described in 6.1 to 6.3. Overall, the analyses revealed that the seaport of Bergen possesses significant potentials for establishing a robust and sustainable competitive advantage.

6.1 SWOT analysis of the strategies

The SWOT analysis technique enables us to identify both internal factors, such as strengths and weaknesses, as well as external factors, namely, the opportunities and threats. We highly recommend that the seaport of Bergen carefully review and consider acting on the results gained from the following SWOT analysis:

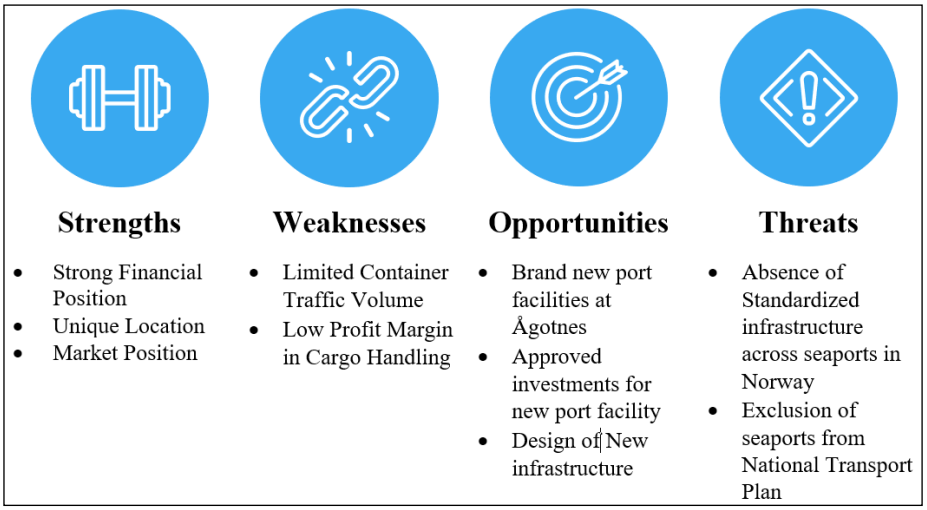

Figure 15 – SWOT Analysis of the strategies with regards to adoption of IoT

6.1.1 Strength

The seaport of Bergen's strong financial position and unique location in western Norway make it well-suited for investments in IT infrastructure and IoT devices. Companies that plan to adopt IoT technology in their business should have a strong financial foundation and market position to support such investments. The seaport of Bergen possesses both qualities, which we identify as strengths. Furthermore, the port of Bergen’s market position as the second largest port in Norway and the first largest port in west coast of the country provides the firm with a market position that cannot be easily challenged in the future.

6.1.2 Weakness

Despite being the second largest seaport in Norway, seaport of Bergen does not have the highest container traffic, compared to other ports in the eastern part of Norway. Likewise, the revenue generated from cargo handling operations only ranks their fourth significant revenue source. These factors suggest that the seaport of Bergen may not be able to fully benefit from the adoption of IoT technology. To justify the optimization of cargo handling and transition towards full autonomous operations, the seaport must have a significant volume of cargo traffic and be operating close to their nominal maximum capacity. In the introduction chapter, we discussed how seaport efficiency is measured by the number of containers handled in a year. If the flow of incoming containers is constrained, efficiency may not be an accurate reflection of the port's operations due to underutilization.

6.1.3 Opportunity

We contend that the relocation of seaport facilities to Ågotnes represents the most promising opportunity for the seaport of Bergen at present. Obtaining approvals and investments for a new seaport in a European city is exceedingly rare, and we did not find a similar case during our research. When considering adjustments necessary to integrate new technologies, a new seaport facility offers significant advantages over modifying an existing port. The infrastructure can be designed from scratch, allowing for every aspect to be planned for maximum efficiency. It is important to note that relocating operations will not entail simply moving existing equipment to the new location. Rather, the seaport authorities must create an infrastructure that can meet the operations demand for the next century. If the seaport management takes full advantage of this unique opportunity, we believe that no other seaport will be able to compete with the brand-new seaport of Bergen in the foreseeable future.

6.1.4 Threat

The absence of a standardized service structure among the various ports in western Norway is a significant threat, not only for the seaport of Bergen, but also for other ports in the region. Shipping companies demand a standardized and universal structure to simplify their operations and reduce overall costs. To address this, an establishment of a new national authority for ports can be proposed, similar to the well-known "Avinor" for the civil aviation industry in Norway, which could be named as "Havinor". We will further elaborate on this idea in chapter 7 when we discuss our recommendations.

6.1.5 Summary of the SWOT analysis

The port's strong financial position and unique location are identified as strengths, providing a solid foundation for investing in IT infrastructure and IoT devices. These parameters position the seaport favorably for adopting IoT technology and gaining a competitive edge. However, a weakness is identified in the port's limited container traffic compared to other ports in the eastern part of the country, indicating a potential constraint in fully benefiting from the IoT adoption. To address this, the port needs to focus on increasing its container traffic to maximize the benefits of IoT technology. The relocation of seaport facilities to Ågotnes presents a significant opportunity for the port, since a brand-new infrastructure is planned to be designed and optimized for efficiency, setting it apart from competitors. This relocation can also bring more cargo from road transport segment to the Port of Bergen as well as securing more frequent container ship visits to port of Bergen. This unique opportunity, if fully capitalized on, can position the port as a leader in the industry. The threat, namely, the absence of a standardized service structure among ports in western Norway, potentially hinders the efficiency and increases the costs for shipping companies. To mitigate this threat, the establishment of a national authority for ports and integration of seaport operations into the National Transport Plan shall be considered. This would streamline operations, improve standardization, and provide necessary support to unprofitable ports, ultimately benefiting the seaport of Bergen and the shipping industry. By leveraging its strengths, addressing weaknesses, capitalizing on opportunities, and mitigating threats, the port can enhance its competitive advantage and solidify its position in the market.

6.2 A Resource-Based View of competitive advantage at the seaport of Bergen

The seaport of Bergen should verify which internal factors provide them with lasting competitive advantage, with regards to the future competition in the market. Recognizing these sources can help management to correctly capitalize on the organization’s strengths, and to further develop capabilities which the company require for gaining the competitive advantage. The first step in this analysis is to evaluate company’s resources. Resource based view investigates the enterprise as a bundle of resources and acknowledges that companies have dissimilar resource sets (Barney & Wright, 1998).

The seaport 's strategic advantage is a result of several resources, including government support, substantial investments, well-planned operations, and information technology, as well as their strategic location. By effectively utilizing information technology in crucial areas, for example to cope with the constrained land area, the Cargo Port of Bergen can increase its shipping capacity and ensure long-term sustainability.

6.2.1 VRIO analysis of the strategies with regards to adoption of IoT

Through implementation of the IoT-aligned strategies and planned initiatives, the seaport of Bergen will have the potential to significantly enhance its financial performance and secure a formidable competitive advantage. Here, we have provided the results of VRIO analysis of the seaport resources:

Geographical location: As mentioned earlier, the seaport of Bergen is the largest seaport in the west coast of Norway and is owned by Bergen and six other neighboring municipalities. Such position both from the ownership perspective and geographical location provides a unique opportunity for the organization, which is valuable, rare, and inimitable.

Regarding the imitability, one may argue, if the competitors are aware of a capability, they may also attempt to imitate it. Although competitors may be able to observe and understand the privileged resource or capability, they cannot replicate it due to various reasons such as their resource constraints or the capability being unique, rare, or socially complex. Jay Barney (1991) uses the term “imperfectly imitable” to indicate the fact that competitors may wish to replicate a capability, but they cannot perfectly replicate it.

Strong financial performance and profitability: This is a valuable and rare resource, but it may not be inimitable as other seaports can also achieve strong financial performance and profitability. However, the company seems to have organized this resource effectively, making it a sustained competitive advantage. Recent research shows a greater difference in profitability between companies who are active within a single industry, compared to the ones with businesses in different sectors (Grande, 2022). Since the seaport of Bergen, in addition to cargo traffic, has other services and income streams, the company is considered as more resilient towards future challenges from competitors.

An attractive emission-free port: This resource is valuable as more and more companies are seeking sustainable solutions, but it may not be rare as other ports may also have similar initiatives. It may be inimitable as it requires a significant investment in technology and

infrastructure. The company seems to have organized this resource effectively, making it a sustained competitive advantage. Talking about the emission-free port, we discussed in chapter 5 the relationship between this strategy and the adoption of IoT in the port operations. Thus, here, we only focus on the VRIO analysis of this strategy.

Constructing a new cargo port at Ågotnes by 2027: This is a valuable and rare resource as not many ports have the resources to construct a new cargo port. It may be inimitable as it requires significant resources and expertise, but it may not be organized as the project is still in the planning phase. Although access to capital is an important factor for such a seaport relocation, we do not consider the monetary resources as competitive advantage since such resources are not difficult to copy or replace (Madsen, 2006). However, utilizing these resources is considered as a gateway to provide the enterprise with competitive advantage.

Double the cargo volume handled at the quay and increase value creation linked to cargo: This is a valuable and rare resource as not many ports in the region can consider doubling their cargo volume. It may be inimitable as it requires significant resources and expertise, but it may not be organized as the project is still in the planning phase.

To provide a better overview, we organized the results of VRIO analysis in a tabular form. The table 03 shows this overview.

Resource of Capability	Valuable	Rare	Inimitable	Organization	Impact on Competitive Advantage
Geographical location	✓	✓	✓	✓	Sustainable competitive advantage
Ownership Structure	✓	✓	✗	✓	Unused competitive advantage
Financial Profitability	✓	✗	✗	✓	Competitive parity
Emission-Free Port	✓	✗	✗	✓	Competitive parity
New Seaport at Ågotnes	✓	✓	✓	✓	Sustainable competitive advantage
Double Cargo Volume	✓	✓	✓	✗	Unused competitive advantage

Table 03 – VRIO Analysis of strategies at the seaport of Bergen

The VRIO analysis reveals that port of Bergen possesses internal resources that contribute to its sustained competitive advantage. These resources provide the port with a unique edge over its competitors and enable it to succeed in the market. However, the plans for a new cargo port and increasing cargo volume may pose challenges in terms of organization and resource allocation, potentially affecting the port's ability to maintain its competitive advantage. To ensure the inimitability of these initiatives, it is crucial for the company to prioritize further organization and resource management. By streamlining operations, optimizing processes, and allocating resources effectively, the port may enhance its competitive advantage, ensuring long-term sustainability and profitability. This strategic focus on internal resources will enable the port to continue its success in the market and stay ahead of the competition.

6.3 PESTEL analysis with regards to adoption of IoT

Through the application of the PESTEL analysis, external factors that could impact the Cargo Port of Bergen's ability to achieve sustainable competitive advantage have been evaluated.

6.3.1 Political

Earlier in this thesis, we discussed that the Norwegian policy makers are motivated to set policies for transition of the goods traffic from road to sea due to environmental and safety considerations. This single factor is key to favor the port of Bergen’s position compared to road transportation. However, it cannot ensure the port of Bergen’s competitive advantage since other neighboring ports have similar privilege compared to road segment. Additionally, the port of Bergen being owned by Bergen and six other municipalities can leverage strong political advantage as these municipalities commit to provide their support making the port of Bergen a unique industry actor in the maritime segment in Norway. The government's commitment to promoting trade and investment could be beneficial for the port of Bergen. Conversely, any unfavorable changes in government regulations or policies could negatively impact the company's operations. We suggest the port authorities to be aware of their political advantage to drive their success.

6.3.2 Economic

Considering seaport of Bergen as a brick in Norway’s national economy, the company can be influenced by external economic factors such as GDP growth rate, inflation rate, interest rates, exchange rates, unemployment rate in the country, and the industry trends. One important

factor to consider is the overall economic performance of Norway. The growth rate of the country's GDP, as well as interest rates can have significant impacts on the port's operations. For example, a slowdown in the economy could result in a decrease in the demand for goods, leading to a decline in cargo traffic as well as revenues for the port. Additionally, fluctuations in exchange rates can affect the prices of logistics services for customers. Another important economic factor to consider is industry trends, such as changes in customer demand for specific types of cargo, new technologies that could disrupt traditional shipping methods, and shifting trade patterns and agreements that could impact the port's ability to attract and retain business.

6.3.3 Social

Regarding the social aspects, we covered the seaport's social responsibility being a part of country's critical infrastructure. We consider this parameter as the overarching framework for the port. This indicates, the reason for the port to exist is not always the profit. For example, the port is an important part of emergency preparedness at the time of war. Aside from this important fact, other social factors such as demographic changes, and cultural or lifestyle changes can impact the port. To put this into context with an example, consider that cruise ship vacations miss their popularity over the future years. This can impact the port of Bergen since their most significant source of income is from cruise ships visits. In such a situation, it doesn't help if the port authorities operate with the best IoT-based services in their facility.

6.3.4 Technological

We discussed that lack of uniform infrastructure across the Norwegian ports is an external factor that could potentially hinder the implementation of IoT and other disruptive technologies in the port of Bergen, since these technologies require standardization and volume. Furthermore, the technological advancements in the industry can also have an impact on the competitiveness of the port of Bergen. For example, the emergence of autonomous shipping could potentially reduce the need for human labor and increase efficiency in the transportation of goods, leading to a shift in the demand for ports that are equipped to handle these types of vessels. Additionally, advancements in renewable energy technologies can also affect the port's competitiveness, as an increasing number of shipping companies are looking to reduce their carbon footprint and adopt more sustainable practices. Talking about the technological aspects, it is important to thoroughly review and assess the technology readiness level as well as customer readiness level for maturity prior to any investments.

6.3.5 Environmental

As we are aware, climate changes urge the need for green shift which is about reduction of greenhouse gasses in the atmosphere. The current container ships visiting the seaport of Bergen are not environmental-friendly as they are powered by diesel engines. Therefore, electrification (Power from shore) and digitalization shall play a key role in the innovation initiatives to ensure the ship berths at the seaport of Bergen can be carried out with zero emissions. Aside from what measures the seaport of Bergen considers taking, new maritime regulations shall also be followed. In 2018, the organization announced its initial strategy to reduce total annual greenhouse gas emissions from international shipping by at least 50 % by 2050 (Kongsberg Maritime, 2022). Based on the market setup in cargo shipping and the horizon for global commodity demand, the seaport of Bergen shall consider capitalizing on their know-how with regards to seaport and terminal business and increase the efforts for innovation in the IoT technology. This enables the company to stay competitive with lower environmental footprint.

6.3.6 Legal

In terms of legal considerations, the Norwegian seaports, including the seaport of Bergen, are subjects to national policies that impact their operations. These policies are outlined in the Norwegian legislation concerning seaports and waterways. The 'Havne og Farvannsloven' act related to ports and waterways in Norway was updated and became effective from January 1st, 2021. The objective of the new law is to promote sea transport and facilitate efficient, safe, and environmentally friendly seaport operations, and use of waterways, while also ensuring a competitive industry. Additionally, the act aims to safeguard national defense and preparedness objectives (LOVDATA, 2020). The previous legislation governing ports and waterways in Norway limited municipalities, who own the seaports, in their ability to derive profits from seaport companies and use them for purposes beyond seaport operations. Under the previous act, municipalities were not permitted to finance hospitals, schools, or other welfare services using the profits from seaport operations, as the management of all capital in seaport operations was strictly regulated. The new act. changes this, allowing for the distribution of funds from seaport operations to municipalities, provided that sufficient funds are set aside for daily operations, maintenance, and investments related to services for ships, goods, and passenger traffic at the ports (Bergen Seaport, 2022). The ministry of transport issued a circular note (in Norwegian: 'rundskriv') to accompany the new Ports and Waterways Act, numbered N-2/2020, on January 9th, 2020.

The circular note stipulates that under the new act, the level of investment and extent of seaport operations will be determined by the owner, i.e., the municipality (Ministry of Transport, 2020). Despite the changes in allowances in the new Ports and Waterways act, the responsibility for operating ports still lies with the municipalities and ports are not included in the National Transport Plan. This ownership structure has led to fragmented seaport facilities, variations in types of services among ports, and differences in quality and pricing.

6.3.7 Summary of PESTEL analysis

The Cargo Port of Bergen's competitive advantage is influenced by external factors listed in Table 04.

		
Political	**Economic**	**Social**
• Political agreement to favor seaborne transport. • Political leverage by ownership structure	• Country's National Economy • GDP Growth rate • Inflation Rate • Interest Rate	• Port as Critical Infrastructure • Port's role in Emergency Preparedness Plan
		
Technological	**Environmental**	**Legal**
• Uniform IT Infrastructure • Technological Advancements in Logistics Industry • Emission-free Energy Technologies	• Reduction of Environmental Footprint • New Maritime Regulations •	• Norwegian Seaports and Waterways Act • Norwegian National Transport Plan • Port Ownership by Municipalities

Table 04 – PESTEL Analysis of external factors for the seaport of Bergen

To ensure survival and competitiveness, the port must prioritize transitioning to a greener and more sustainable approach. This involves focusing on electrification and digitalization to reduce emissions and meet regulations. Embracing these advancements can lead to a net-zero emissions edge and meeting reduction targets. Additionally, Norwegian legislation allows for funds from seaport operations to improve infrastructure and services, enhancing the port's competitive advantage. However, the fragmented ownership structure of seaports in Norway poses challenges for implementing IoT technologies. Standardization and collaboration among ports are crucial to overcome this, achieving economies of scale and cost efficiency for collective competitive advantage and long-term success in the market.

7. Discussions and conclusions

Within this master thesis, we have delved into the overall question of "what are the impacts of IoT technology on competitive advantage in seaports?" Furthermore, by conducting a comprehensive analysis of the Cargo Port of Bergen as a case study, we have effectively addressed both the overarching research question and its accompanying four sub-questions. In the following chapter, we present our in-depth responses to the research questions, accompanied by valuable practical recommendations derived from the findings. Subsequently, we elaborate on the achieved contributions of this study and explore potential avenues for further research in this field.

7.1 Addressing the research questions

7.1.1 Addressing the research question 1

In order to address the first research question, “What is the current state of IoT application at the Cargo Port of Bergen?”, it has been identified that the seaport utilizes various IT systems from Greig Connect, including an ERP system for resource planning and invoicing, as well as a terminal operative system. The two terminal operator companies collaborate on IT solutions for shipping companies, and the IT vendor works closely with the seaport and its operators. This current setup allows for semi-automated operations, particularly in the areas of resource planning and invoicing. However, it is important to note that the ultimate goal of IoT, which involves autonomous machine-to-machine communication, is not yet realized. While the potential for autonomous operations exists with the introduction of new facilities, it is apparent that additional investments and projects are necessary to facilitate the implementation of IoT technology.

7.1.2 Addressing the research question 2

In relation to the second research question, “What is the port's vision for the future state of IoT application at the Cargo Port of Bergen?”, we have observed that the seaport's envisioned future state of IoT aligns closely with the strategies outlined earlier, indicating a strong coherence between these strategies and the objectives of IoT implementation. To further elaborate on the point, it can be said that the port's vision for the future state of IoT adoption involves leveraging the benefits of this disruptive technology to enhance operational efficiency, optimize resource utilization, and improve customer service. The seaport's strategies clearly reflect this vision, showcasing its commitment to embracing and implementing IoT in a comprehensive and strategic manner. This alignment between seaport strategies and IoT objectives underscores the seaport's dedication to ensuring future competitiveness and sustainability through the effective utilization of this disruptive technology.

7.1.3 Addressing the research question 3

Upon addressing the third research question, “What are the actions taken or considered, to bridge the gap between the current and desired state of IoT application at the seaport of Bergen?”, it became evident that there are various initiatives and steps being taken or considered to bridge the gap between the current and desired state of IoT implementation at the Cargo Port of Bergen.

These initiatives encompass various measures undertaken by the seaport of Bergen, including ongoing projects such as the relocation of the cargo port and the development of autonomous, emission-free sea transport. Furthermore, the seaport has fostered collaborations with key industry stakeholders, including technology providers, academia, and government agencies, to foster innovation and explore avenues for enhancing IoT capabilities. For instance, partnerships have been forged with leading technology firms to conduct pilot tests of IoT-enabled systems and solutions for cargo handling and logistics. Additionally, the seaport actively engages in research and development endeavors focused on advancing IoT and related technologies in the maritime sector, namely the Horizon 2020 project. These efforts demonstrate the seaport of Bergen's steadfast commitment to embracing the potential of IoT and other disruptive technologies, poised to drive growth, sustainability, and competitiveness in the future.

7.1.4 Addressing the research question 4

When it comes to the final research question, “To what extent does the implementation of IoT-based operations provide a competitive advantage for the Cargo Port of Bergen?”, the answer is affirmative, indicating a high degree of competitiveness. By conducting a thorough analysis of multiple factors impacting the seaport, it becomes clear that the Cargo Port of Bergen has the capacity to establish a formidable competitive advantage. The seaport possesses a strategic advantage derived from various resources, including government support, substantial investments, well-planned operations, information technology, and a strategic location. While the seaport's internal resources contribute to its sustained competitive advantage, the plans for a new cargo port and increased cargo volume pose challenges in terms of organization and resource allocation. To maintain its competitive edge, the company must prioritize further organization and resource management, streamlining operations, optimizing processes, and allocating resources effectively. Additionally, to ensure the survival of cargo handling operations, the port should prioritize a greener and more sustainable approach, focusing on electrification, digitalization, and compliance with maritime regulations. Embracing these advancements would enable the seaport to achieve net-zero emissions, meet emission reduction targets, and gain a competitive edge. Furthermore, the Norwegian legislation allowing the distribution of funds from seaport operations to municipalities presents an opportunity for infrastructure improvement and efficient service provision. However, the fragmented ownership structure of seaports in Norway poses challenges for implementing IoT technologies, emphasizing the need for standardization and collaboration among seaports. By establishing common protocols and fostering cooperation, the seaports can strengthen their collective competitive advantage and ensure long-term success in the dynamic market.

7.2 Recommendations

7.2.1 Collaboration with focus on integration

Based on our assessments, the Cargo Port of Bergen shows promise for semi-autonomous operations with the adoption of IoT technology, thanks to the presence of several compatible systems. However, to achieve fully autonomous operations, additional investments and project initiatives are required. Once IoT is implemented, emphasis should be placed on seamless integration to maximize the benefits derived from it. Here, we refer to five levels of integration which we discussed in the literature review, connection, communication,

coordination, cooperation, and collaboration (Sanchez, Exposito, & Aguilar, 2020). As provided by researchers, there is a typical pitfall of integrating the systems in the lowest level, namely connection. However, the true potential of IoT adoption lies in achieving the highest level of integration, which can be achieved through collaboration. This level of integration provides the processes for self- configuring, self-managing, self-healing, and self-supervising (Sanchez, Exposito, & Aguilar, 2020).

Aside from the integration aspect, in order to achieve a sustainable competitive advantage, the Cargo Port of Bergen should collaborate with various stakeholders such as IT suppliers, terminal operators, shipping companies, and other seaports in the region to develop solutions that enhance their logistics operations and business models. We have discussed that collaboration among firms will not only provide them with a universal system but also help in reducing the costs of implementation for each party involved.

7.2.2 Havinor

In our perspective as authors, we propose the establishment of a state-owned company akin to Avinor AS, as a potential solution. This new entity, which we refer to as "Havinor AS," would facilitate effective collaboration and coordination among seaports in Norway, fostering sustainable development and industry growth. By centralizing the management of all seaports under Havinor, resources could be redistributed more efficiently from larger to smaller ports. Furthermore, integrating seaport operations into the National Transport Plan would enable the provision of national grants to financially strained seaports, ensuring the implementation of standardized IT systems throughout the country. Such measures would not only benefit the shipping industry but also address concerns of cargo carriers.

7.2.3 Co-opetition

In case a Havinor concept is not possible to achieve, the seaports across the Norwegian coastal line must collaborate with each other in one way or another, aiming for establishment of a homogeneous infrastructure along the coast. Although this will not provide a competitive advantage for one seaport against the others, it will provide an equal common ground for all the seaports to grow in efficiency and productivity. It is also important to note that collaboration does not mean the absence of competition. In fact, collaboration and competition can coexist, and in some cases, they may even reinforce each other (Terpend & Krause, 2015). One way that collaboration and competition can coexist is through the concept of co-opetition.

Co-opetition refers to a situation where firms collaborate with their competitors to achieve mutual benefits while still competing in the same marketplace (Brandenburger & Nalebuff, 1996). The same phenomenon can be applied in the seaport environments. By examining the interplay of competition and cooperation among seaports in terms of geographical location, service level, and shipping distance, the implementation of a cooperative strategy can have a substantial positive impact on the profitability of the port group (Wang & Sun, 2016).

7.2.4 Academia and industry collaboration

When it comes to collaboration between academia and the seaport industry, in general, it is crucial in the context of adopting IoT technology in the cargo port industry. Academic research can provide valuable insights into the potential benefits and challenges of implementing IoT solutions in the seaport industry, as well as innovative ideas for how to optimize their use. On the other hand, the seaport industry can provide real-world data and practical feedback on the effectiveness and feasibility of IoT solutions. By working together, academia and the seaport industry can accelerate the development and implementation of IoT solutions, leading to more efficient and sustainable seaport operations. In addition, collaboration can also create opportunities for knowledge transfer and skill development for students and professionals in both academia and the seaport industry. As authors, we believe that SINTEF, the Norwegian research organization specializing in contract research, plays a crucial role in this context.

7.2.5 IoT adoption as a day-to-day move

As the researchers of this thesis, we dedicated six months to exploring various aspects of IoT. It is worth noting that the adoption of IoT in the logistics industry has not yet reached the extensive scale discussed in academic research. In Chapter 3.6, we conducted an examination of the technology readiness level, specifically focusing on battery, broadband, and sensor technologies. Our evaluation led us to the conclusion that the current timing is favorable for IoT implementation. However, despite significant advancements, projections indicate that the full potential of IoT adoption is still five to ten years away. Therefore, managers contemplating early adoption should exercise caution, considering both the potential benefits and risks involved.

The future of IoT technology presents both opportunities and challenges, requiring logistics managers and stakeholders to be prepared and plan for leveraging data to enhance their performance metrics. In other words, the race to adopt IoT is about maintaining consistency

rather than rushing into implementation. Seaports should avoid hasty full-scale early adoption and instead opt for a gradual and steady approach. The focus should be on developing robust systems and infrastructures that may not be fully autonomous initially but are designed with futureproofing in mind. This approach ensures that seaports can accommodate future expansion and advancements without the risk of becoming outdated.

7.3 Achieved contributions

This thesis has made significant contributions in multiple areas. Firstly, it adds to the understanding of the potential impact of IoT technology on seaport logistics. Through a comprehensive analysis, the research provides valuable insights into the advantages and challenges of adopting IoT in seaports. This contribution enhances the existing body of knowledge by deepening our understanding of how IoT can enhance competitiveness in seaport logistics. The insights gained from this research are relevant and beneficial to seaport managers, logistics experts, policymakers, and other stakeholders involved in the industry.

Secondly, the thesis offers practical recommendations for seaports to maximize the benefits of IoT technology. These recommendations provide actionable steps for seaport operators to effectively integrate IoT into their operations, leading to improved operational efficiency and increased collective revenue. By following these recommendations, seaports can leverage IoT technology to optimize processes, enhance resource utilization, and streamline operations, ultimately improving their overall performance and competitiveness in the market.

Further, the findings of this study have the capacity to provide guidance for the integration of IoT technology in seaports, leading to improved operational efficiency and collective revenue growth. This is particularly significant for Norway's seaport logistics industry, given the country's extensive maritime sector and reliance on efficient and dependable seaport operations.

7.4 Further research

While this research has shed light on the current utilization and adoption of IoT technology in the Cargo Port of Bergen, there are still ample opportunities for further exploration and analysis. One potential avenue for future research involves conducting a more comprehensive analysis of the economic, social, and environmental impacts of IoT technology on both the seaport and the surrounding community. This would provide a deeper understanding of the broader implications of IoT implementation in the port's operations.

Moreover, further research could be conducted to assess the potential for IoT technology to be utilized in other seaports across Norway. Examining the role of a state-owned company in facilitating the adoption and integration of IoT across all seaports in the country would provide valuable insights into how a collaborative approach can be harnessed to drive technological advancements and efficiency improvements on a national scale.

In addition, there is a scope for investigating how the collaboration between academia and the seaport industry can be further strengthened to foster innovation and sustainable development in the seaport sector. Exploring strategies and initiatives that promote closer collaboration, knowledge sharing, and joint research projects would contribute to the continuous advancement of IoT and other technologies in seaport operations.

Lastly, it is crucial to explore new and emerging technologies beyond IoT that have the potential to contribute to sustainability and competitive advantage in the cargo port industry. By pursuing these avenues for further research, the knowledge and understanding of IoT technology and its implications in seaport operations can be advanced, paving the way for continuous improvement, innovation, and sustainable development in the field.

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