Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

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How Do Incumbent Firms Introduce Short Sea Autonomous Shipping and Cargo Operations into Their Offerings?

A Business Model Innovation Perspective on an Emerging Business Ecosystem for Digital Transformation in Maritime and Logistic Industries to Increase Social, Environmental and Economic Impacts

Master's thesis in the Executive Master in Technology Management (MTM)
Supervisor: Assoc. Prof. Tina Saebi, NHH
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Norwegian University of Science and Technology (NTNU) and Norwegian School of Economics (NHH)

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Preface

I am writing this preface when I am visiting my family in Eidangerfjorden. Through the windows, I can see the container terminal at Brevik. Yara Birkeland, an electrical-driven ship, will soon load and unload containers at the terminal. Initially, the ship will sail with the crew on board. In two years, the plan is for the ship to sail without the crew onboard. It will then be operated from an operation centre in Horten and eventually become autonomous. I am asking myself if we will see more small emission-free and autonomous ships sailing along the coasts, feeding terminals and larger ships with cargo. For a long time, the EU and Norwegian governments have wanted to replace road transport with rail and sea transport, but in Norway, this change has been slow. Will the promised effects of digital transformation—in this case, autonomous ships and cargo operations—be what makes the replacement of road transport with sea transport to happen?

This thesis completes a two-year part-time study programme for the Master of Technology Management degree from NTNU and NHH. When considering a topic for a master's thesis, I was looking for cases that could contribute to sustainability (International Maritime Organization, n.d.). The Yara Birkeland and ASKO Maritime projects and the prospected effects of a network of small, autonomous emission-free ships met this criterion.

In the master's programme, I have learned that innovation is more than a new idea or the development of technology—it must also be put into use. Going through the information about these and other similar projects and with great support from researchers at NTNU and my supervisor at NHH, I realised that little research had been conducted on the commercialisation of autonomous ships and cargo operations. By asking how firms introduce short sea autonomous shipping and cargo operations into their offerings, the challenges and opportunities of commercialising technology faced by incumbent firms behind the Yara Birkeland and ASKO Maritime projects will be explored. To make autonomous transportation effective, the complexity between the involved actors will increase compared to today. How does this affect the business models of incumbent firms in traditional industries?

Acknowledgements

First and foremost, I would like to thank my supervisor, Tina Saebi, who provided valuable and detailed feedback and helped me find a way through the many questions, topics and ideas this thesis started with. Your great competence and precise questions made me go through the topics again, which gave me a greater understanding of the research literature and what was relevant to the thesis. Your encouragement and optimism have made me believe that I would make it. In the end, I am solely responsible for this thesis, but in my mind, you have followed me all the way. Your support elevated my work significantly and your commitment surpassed anything I could have hoped for.

Second, I would like to thank the interviewees who participated in this study for giving their valuable time and insights. Their input has provided me with unique views on two exciting projects. I hope that the findings from this study will give them some insight in return.

I would also like to thank Erik Andreas Sæther and Øyvind Bjørgum at NTNU for their valuable contributions in finding a direction for this thesis. Thank you to my fellow students for the many discussions and work we had together. Thank you to all the lecturers in the master's programme and at the Institute for Manufacturing at the University of Cambridge.

Finally, I would like to thank my family for their support, understanding and patience.

Executive Summary

Short sea autonomous transport of goods is promised to increase social, environmental and economic impacts by replacing diesel-driven trailer transport with emission-free sea transport.

To gain insight into this emerging phenomenon, this thesis takes an exploratory approach with a single case study to investigate how incumbent firms introduce short sea autonomous shipping and cargo operations into their offerings in Norway. This thesis takes a business model innovation perspective of an emerging business ecosystem—digital transformation in maritime and logistic industries.

All three incumbent firms subject to the investigation have made efficiency innovations in their business models when digital transformation was introduced into their offerings. One finding suggests that the combination of institutional and commercial drivers gives incumbent firms in traditional industries the opportunity for efficiency innovation of their business model, while technological drivers give the firm the opportunity for market-creating business model innovation.

Another finding is that digital transformation increases the degree of complexity and dependencies among the involved actors. This is the main reason for observing an emerging business ecosystem among incumbent firms in traditional industries that have a value proposition for which one of the actors cannot deliver the value alone.

Uncertainties about two interrelated fungibilities—choice of interface standards between port facilities and ships and choice of digital logistic system—explain why an ecosystem is emerging and has not yet been fully established. These fungibilities cause uncertainties about the possibility of scaling up services to replace road transport with sea transport.

Extant research suggests that the key aspect of business models and business model innovation is complementary between activities underlying the mechanisms of a firm's value creation, delivery and capture. This thesis suggests that complementarity can also be a way to describe the interdependencies between firms' business models in an ecosystem by including a modified framework of value co-creation, co-delivery and co-capture at the network (meso) and societal (macro) levels. This expansion provides the possibility to make use of a modified ecosystem theory to describe how the innovation of firms' business models affects how they create, deliver and capture values together.

Keywords: business model, business model innovation, digital transformation, sustainability, business ecosystem, ecosystem, systems and complexity, incumbent firms, traditional industries, maritime industry, marine autonomous surface ships (MASS), logistics

Contents

1. Introduction

1.1 How Do Incumbent Firms Introduce Short Sea Autonomous Shipping and Cargo Operations into Their Offerings?

Short sea autonomous transport of goods is promised to increase social, environmental and economic impacts by replacing diesel-driven trailer transport with emission-free sea transport (Advanced, Efficient and Green Intermodal Systems (AEGIS), 2021). The focus of practitioners to achieve this transition has mainly been on the development of technical solutions (Green Shipping Programme, n.d.). However, innovation is more than the development of technology. It also involves the implementation of a significantly new or significantly improved product or process that has been made available to potential users or brought into use (Organisation for Economic Co-operation and Development (OECD)/Eurostat, 2018). Incumbent firms are currently introducing products and services for emission-free, short sea autonomous shipping and cargo operations in Norway. These are the Yara Birkeland project and the ASKO Maritime project. To gain insight into this emerging phenomenon, this thesis is centred on a qualitative study of the key incumbent firms taking the lead in these two projects. Specifically, how incumbent firms introduce short sea autonomous shipping and cargo operations into their offerings will be explored. The thesis combines two important theoretical lenses to explore this question: (i) business model innovation and digital transformation by large incumbent firms in traditional industries and (ii) the role of business models in the business ecosystem and how incumbent firms in traditional industries create, deliver and capture value together.

The first area of research is digital transformation, such as autonomous shipping and cargo operations. Digital transformation has promising prospects for business model innovations in traditional industrial sectors, such as transport (Velu et al., 2019). However, research about changes in the economics of competition due to digital transformation are mainly from the consumer sector (Velu et al., 2019). These are centred on internet-enabled platforms that facilitate the transaction, interaction and exchange of value between participants. Extant research has paid less attention to how digital transformation affects business models for large incumbent firms in traditional industries, such as international companies with long traditions in the maritime industry. Therefore, more research is required to understand how the introduction of digital transformation has affected the maritime and logistic industries' incumbent firms' propensity to alter their business models.

Digital transformation has the potential to disrupt the way values are created, delivered and captured, but not all companies are equally able to adapt their business model to capture value from new technology (Christensen et al., 2016). Previous studies have shown that many attempts at business model innovation fail (Christensen et al., 2016; Teece & Linden, 2017). For incumbents, it may be more convenient to innovate their business models in such a way that they are not in conflict with existing ones (Christensen et al., 2016). What opportunities and challenges are incumbent firms in traditional industries facing when their business models are being developed or innovated?

The second area of research in this thesis is based on the fact that short sea autonomous shipping and cargo operations are expected to have a large-scale effect. The prospect is to establish a network of small, flexible autonomous ships and cargo operations in ports, replacing road transport on a greater scale than the initial ambitions of the two above-mentioned projects (AEGIS, 2021). To achieve this promising opportunity, the involved firms need to deliver values—together—that each cannot deliver alone. Research about how incumbent firms in traditional industries take part in the emergence of an ecosystem and how this affects the innovation or development of their respective business models is underexplored (Foss & Saebi, 2018). How such networks improve joint value creation remains to be understood (Bankvall et al., 2017; Budler et al., 2021; Wirtz et al., 2016). Jacobides et al. (2018) have suggested a framework for how ecosystem members are tied together; however, further research is needed on coordination, collaboration and value creation, delivery and capture among actors from incumbent firms in traditional industries. What can be learned from the qualitative study of firms' challenges and opportunities in the two projects when the firms change (develop or innovate) and align their business models in an emerging business ecosystem? How do the firms create, deliver and capture value together?

1.2 Research Gaps

From the literature search on business models and business model innovation, this study identified two relevant research gaps. The first research gap concerns the effect of digital transformation on the business models of incumbent firms in traditional industries. The second research gap concerns how incumbents in an emerging business ecosystem create value together.

Business Model Innovation and Digital Transformation by Large Incumbent Firms in Traditional Industries

Research is necessary to understand how the introduction of digital transformation affects large incumbent firms' propensity to alter their business models. Four arguments explain why this is a research gap. First, business model innovation literature includes studies on business model innovation by incumbents in various industry contexts, including manufacturing, air transportation, newspapers and insurance; however, these studies do not include when firms introduce digital transformation (Agostini & Nosella, 2021; Kim & Min, 2015). Second, extant research literature describes that digital transformation has contributed to new business processes, new business models and new managerial models for digital enterprises (Teece & Linden, 2017). However, these experiences are mainly based on the literature on the consumer sector (Dasi et al., 2017) and not on business-to-business relationships in traditional industries. Third, while digital transformation has promising prospects for business model innovations in traditional industrial sectors, such as manufacturing, transport and oil and gas production, extant literature does not elaborate on how incumbent firms in traditional industries introduce digital transformation into their offerings (Velu et al., 2019). Finally, a current research trend is to study the business model innovation of small and medium enterprises on digitalisation, Industry 4.0 and open innovation (Fliser et al., 2021). However, this trend does not include business model innovation for large incumbent firms in traditional industries, such as international companies with long traditions in the maritime industry. Exploring how incumbent firms in traditional industries introduce digital transformation into their offerings will provide a better understanding of how this affects the development and innovation of their business models.

Related to the maritime and logistic industries, extant research describes that one of the main challenges for digital transformation in shipping is to design business models in which digitised information is effectively employed to strengthen the value chain (Aiello et al., 2020). There are expectations that autonomous ships will change the business models in the industry (Munim, 2019; World Maritime University, 2019); however, these studies do not describe *how* incumbent firms need to develop or innovate their existing business models. Research on the combination of the digitalisation of seaports and business model innovation with the aim of achieving sustainability is also underexplored (Del Giudice et al., 2021). The case study will provide a better understanding of how digital transformation affects the business models of incumbent firms in the maritime and logistics industries.

The Role of Business Models in Business Ecosystems and How Incumbent Firms in Traditional Industries Create, Deliver and Capture Value Together

The second research gap relevant to the study is how incumbent companies in an emerging business ecosystem create, deliver and capture value together to increase social, environmental and economic impact. Three arguments explain why this is a research gap. First, while extant research describes that next-generation competition is changing the way businesses compete, collaborate and operate (Teece & Linden, 2017), *how* incumbent firms in traditional industries take part in the emergence of an ecosystem and how this affects the innovation or development of their respective business models is underexplored (Foss & Saebi, 2018). A recent literature review was conducted on the business model concept in the context in which more than one actor is actively involved in the development and delivery of a joint offer (Jocevski et al., 2020); however, these studies do not involve incumbent firms in traditional industries. Second, while ecosystems are considered important to business model innovation because they make new business models viable and offer firms new arenas, structures and processes for business model experimentation (Fjeldstad & Snow, 2018), it remains to be understood how such networks improve joint value creation (Budler et al., 2021; Wirtz et al., 2016). Others argue that the network of interlinked business exchanges and interactions aimed at creating and developing value needs to be addressed and understood as a whole (Bankvall et al., 2017). Finally, a framework has been suggested for how ecosystem members are tied together by types of complementarities (Jacobides et al., 2018). Jacobides et al. recommend further research on coordination, collaboration and value creation and capture among the actors in business ecosystems. The framework is mainly based on insights from the consumer sector, which suggests the need for further research on incumbent firms in traditional industries. To summarise, additional research may give us a better understanding of the opportunities and challenges incumbent firms in traditional industries face during the emergence of a business ecosystem, how the actors' business models are complementary in an emerging business ecosystem and what values they create, deliver and capture together.

1.3 Research Questions

The context for the research questions involves key incumbent firms currently introducing products and services for emission-free, short sea autonomous shipping and cargo operations in Norway. Yara, ASKO, Wilhelmsen and Kongsberg Maritime are the key incumbent firms taking the lead in the digital transformation.

The *Yara Birkeland project* develops and offers emission-free, autonomous sea transport and efficient loading operations of containers at production facilities. Transporting containers by sea will commence at the beginning of 2022 (ShipInsight, 2021). The ship Yara Birkeland will transport fertilisers in containers from Yara's production facility in Herøya to the North Sea Terminal in Brevik (Yara, 2021). The *ASKO Maritime project* develops and offers emission-free, autonomous sea transport and efficient loading operations of trailers in ports. It offers its services to other subsidiaries of the corporation and to external customers who need to transport trailers across Oslofjord. The two ships and port operations are expected to be in service as of 2022. Massterly is the world's first company set up to operate autonomous surface vessels in the merchant fleet (Kongsberg Maritime, 2018). Massterly was established in 2018 as a joint venture by Wilhelmsen and Kongsberg Maritime. Several actors took part in developing technologies and providing services for the two projects.

RQ 1

1) How has the introduction of digital transformation affected the maritime and logistic industries' incumbent firms' propensities to alter their business models?
    a) What challenges and opportunities does each actor face in their digital transformation?
    b) How do incumbent firms in the maritime and logistics industries introduce digital transformation into their offerings?

RQ 2

2) How do incumbent firms in the maritime and logistics industries in an emerging business ecosystem create, deliver and capture value together?
    a) What challenges and opportunities are incumbent firms facing in the emergence of a business ecosystem?
    b) How are the actors' business models complementary to their emerging business ecosystem?

1.4 Outline of the Work

Relevant research literature about business models, business model innovation, sustainability, business ecosystems and what research problems these currently seek to solve have been reviewed; these have been seen in relation to the literature on digital transformation and incumbent firms in traditional industries. The findings of the relevant research gaps are summarised in Section 1.2. These are the basis for the research questions formulated in Section 1.3.

The purpose of Sections 2 and 3 is to establish the theoretical basis for the master's thesis. Section 2 argues why innovation is more than the development of technology and provides a summary of the opportunities for digital transformation in the consumer sector and potential opportunities for digital transformation in traditional industries. Section 2 also provides working definitions for business model and business model innovation. Section 3 provides frameworks that will be used to find answers to the two main research questions from the case study, such as the *three stages of a business model* (Christensen et al., 2016) and the framework for business ecosystems (Jacobides et al., 2018).

Section 4 describes why and how an exploratory investigation was chosen to answer the research questions. This section also describes the main steps of the research, literature review, criteria for selection and analysis method of the case study, including an evaluation of the research methods. The selected case consists of two projects that are currently being commercialised. Many of the actors are involved in both projects, which is the main reason why it is considered one case, and not two.

Section 5 presents the empirical findings of the case study, which are based on interviews and secondary sources.

Section 6 discusses the empirical findings in relation to the relevant research literature and the analysis method described in Section 4.

Finally, Section 7 concludes the research, describes implications the research may have for practitioners, authorities and researchers and suggests further work.

1.5 Contributions and Research Limitations

This study has the potential to contribute to the emerging literature on business model innovation in business ecosystems in relation to digital transformation by incumbent firms in traditional industries.

Contributions for Practitioners

Managers in maritime and other industries may struggle with how digital transformation affects their business models. The application of definitions and frameworks from the research literature and the choice of the methodology in this thesis may give practitioners insight into what challenges and opportunities incumbent firms face when altering their business models. This may provide insight into what should be priorities for digital transformation and which advantages characterise firms that take the lead in this transformation. The insight may also suggest how a practitioner should reframe what should be taken into consideration when evaluating how digital transformation can have social, environmental and economic impacts.

Digital transformation may lead to a change from a traditional value chain to a business ecosystem for the involved (incumbent) firms. The use of methodology and framework from the research literature described in this thesis may provide insights for practitioners about how a business ecosystem is emerging and working. The use of methodology and framework may be valuable for understanding how digital transformation affects the business models of the actors involved in the business ecosystem. The methodology and framework may also be valuable for understanding what challenges and opportunities firms face in their pursuit of large-scale effects from their investments. How digital platforms are emerging and their effects on the consumer market are known. This thesis provides insight into how digital platforms are emerging in traditional industries.

Contributions for Authorities and Public-private Partnerships

For authorities and public-private partnerships, the application of definitions and frameworks from the research literature and the choice of the methodology in this thesis may give insight into what challenges and opportunities an emerging ecosystem is facing to increase social, environmental and economic impacts. This may provide insights into what may be the hindrances for scaling up the services to replace road transport with sea transport.

Contributions to Research Literature

For researchers, the use of definitions and frameworks, research methods and the findings from the exploratory case study may further the theorising and empirical work on business models and business model innovation of incumbent firms in traditional industries when they introduce digital transformation.

An expansion of the business model and business model innovation constructs, by describing value creation, delivery and capture at meso and macro levels, provides the possibility to make use of a modified ecosystem theory to describe how innovation of the incumbent firms' business models affects how they create, deliver and capture values together. Section 4 describes how this can be done and may provide insight into how incumbent companies in traditional industries in an emerging business ecosystem create, deliver and capture value together to increase social, environmental and economic impact.

Research Limitations

Inquiries to relevant persons were made, but not everyone was able to respond on time, which resulted in the thesis relying more on secondary sources than the initial ambition did.

The study describes the changes that have been made to business models before and after the introduction of digital transformation. The study will not be able to describe the changes in the interdependencies of the architecture of how business model innovations affect other firms' business models. The study will not take into consideration the dynamic capabilities of an organisation to innovate its business models.

The study will use sustainability and corporate social responsibility as premises, but will *not* take into consideration the boundary between business model and business model innovation and firms' corporate social responsibility or the sustainable business model innovation process described by, for example, Bocken and Geradts (2020).

2. Innovation, Digital Transformation, Business Model and Business Model Innovation

One of the biggest barriers to technological innovation is how innovation is incorporated into existing business models or the development of new ones (see e.g. Chesbrough (2010), Fliser et al. (2021) and Teece (2010)). The commercialisation of technology is a necessary part of innovation, which is reflected in the practical definition of innovation presented in Section 2.1.

Digital transformation is most impactful when it leads to business model innovation (Velu et al., 2019). The choice of business model allows managers to capture the latent value of the technology (Chesbrough, 2010; Fliser et al., 2021; Foss & Saebi, 2018). This is described in Section 2.1, along with a summary of the opportunities for digital transformation in the consumer sector and potential opportunities for digital transformation in traditional industries.

To evaluate how a firm has altered its business model, it is necessary to define *business model* and *business model innovation*. The definitions should be practical for the case study and should seek to meet the much-needed dimensionalisation of business model and business model innovation constructs (Foss & Saebi, 2018). These are the premises for the choice of definitions of business model and business model innovation in Section 2.2.

Value creation, delivery and capture are essential elements in the definitions of business model and business model innovation. Definitions of these terms are given in the same section. These definitions also need to be practical in use for the case study.

2.1 Innovation and Digital Transformation

Innovation is More than the Development of Technology

This thesis will investigate how digital transformation affects the business models of incumbent firms in traditional industries. A case will be used in which technology for autonomous shipping and cargo operations in Norway is commercialised. The development of autonomous shipping and cargo operations has received much attention in Norway's maritime industry. But innovation is more than a new idea or the development of technology, organisations or systems—it must also be put into use or made available for others to use. This is reflected in the fourth revision of the Oslo Manual (OECD/Eurostat, 2018). The OECD/Eurostat adopted a practical approach to innovation, highlighting the necessity of its implementation. The OECD/Eurostat defines innovation as 'a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).' (OECD/Eurostat, 2018, p. 20).

The main problem is often not the invention of the technology itself but the commercialisation of it (Gans & Stern, 2003). Far more digital companies have failed to find a way to monetise their user bases than have succeeded. '[F]irms today must navigate a more complex innovation environment, build and maintain a richer set of alliances, and counter a wide range of competitors from both expected and unexpected quarters than ever before' (Teece & Linden, 2017, p. 4). The experiences of digital companies and the previously described research gaps make the case study interesting to investigate, with attention to how incumbent firms in traditional industries commercialise the introduction of digital technologies.

Digital Transformation in the Consumer Sector and Traditional Industry Sectors

Digital transformation has contributed to new business processes, new business models and new managerial models for digital enterprises (Teece & Linden, 2017). Digital transformation is most impactful when it leads to business model innovation (Velu et al., 2019). E-commerce, Uber, Airbnb and Spotify are well-known examples of digital transformation in the consumer sector. They represent the first significant wave of digital transformation, centred on internet-enabled platforms that facilitated transaction, interaction and exchange of value between participants (Velu et al., 2019). The platform companies that emerged in this wave captured significant value by monetising direct access to customers. They leveraged the benefits of network externalities, often acting as intermediaries in business ecosystems.

Digital technologies enable the separation of information from a physical form, which may separate content from the medium. It may also separate form and function (Hall & Pesenti, 2017). Digital transformation[1] can be defined as follows:

> [T]he use of digital technologies (….) and the data they produce to connect organizations, people, physical assets and processes to generate better business outcomes, including capitalizing on customer needs, realizing efficiencies and productivity growth, improving the effectiveness of decision making across the organization and enabling new business models. (Hao et al., 2020, p. 7)

In the manufacturing sector, digital transformation has the promising prospect of reducing production and transaction costs, resulting in decentralised collaborative organisations close to end users.

In the transport sector, car rental and car-sharing platforms have been developed, challenging the car rental industry. New players, such as Apple and Google, have entered the automobile industry. They challenge incumbents not only in the development of technologies, such as self-driven cars, but also in their business models (Velu et al., 2019).

For the oil and gas industry, digitalisation and automation promised to create and deliver significant value. Companies such as Equinor are developing unmanned platforms and digital twins[2] (Equinor,

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[1] Digitization as well as digitalization (some argue that these are two distinct concepts) may be considered to be different from digital transformation. Digitalization is the process of changing data into a digital form that can be easily read and processed by a computer (Oxford Learner's Dictionaries, n.d.; Oxford English Dictionary, n.d.). In the last few decades, digitization has mainly contributed to the efficiency of existing processes, such as reducing man-hours (Velu, 2021).

[2] A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making (IBM, n.d.)

2021). A newly established company, Cognite, is a digital platform provider for the oil, gas and energy industries. They 'turn industrial data into customer value by liberating it, contextualizing it, and making it actionable for users' (Cognite, 2021).

Kongsberg has several initiatives and takes part in joint research and development (R&D) projects, including developing ship control systems and navigation for MASS, digital information platforms (Kognifai and Vessel Insight) and delivering autonomous underwater vehicles (Kongsberg Maritime, n.d.a). In 2018, Massterly, the world's first autonomous shipping company, was established (Kongsberg Maritime, 2018). Alfa Laval, a traditional provider of heat transfer, centrifugal separation and fluid handling products and services, recently acquired the weather intelligence software company StormGeo (StormGeo, 2021). The Veracity Data Platform, established by Det Norske Veritas (Veracity, 2021), is also an example of developing a digital platform in the maritime industry.

Digital transformation in the shipping industry and logistics also includes the use of blockchain technology (Hargroves et al., 2021). Several initiatives are currently ongoing. For instance, the Port of Rotterdam, Europe's largest port, has set up BlockLab. BlockLab aims to replace the paper-based *bill of lading* system with a digital system available in real time to all necessary parties in the supply chain. This has the potential to significantly reduce transaction costs and time and to increase transparency and efficiency. Another example is the joint electronic ledger for global freight tracking developed by IBM and the Danish shipping container company Maersk in 2018. Information shared on the blockchain system includes custom releases, commercial invoices and cargo lists. Such information is shared with all parties immediately after it is produced. Roughly one million events are recorded in the system every day. A third example is the logistics company Shipchain SA, which developed a blockchain-based tracking system. The products are tracked from when they leave the manufacturer to when they arrive at the customer. The tracking system allows for automatic confirmation of delivery. All parties involved across the supply chain can automatically be paid when they have completed their part.

The above illustrates the many initiatives for digital transformation in traditional industries, but how do incumbent firms in traditional industries develop and innovate their business models? In this thesis, the case of how incumbent firms in the maritime and logistic industries introduce digital transformation into their offerings and create, deliver and capture value together will be examined.

2.2 Business Model and Business Model Innovation

To evaluate how a firm has altered its business model, it is necessary to define business model and business model innovation. Value creation, delivery and capture are essential elements in the definition of a business model, and working definitions of these are also presented in this section.

Definition of Business Model and Business Model Innovation

While the business model innovation literature addresses an important phenomenon, it lacks theoretical underpinning, and empirical enquiry is not cumulative (Foss & Saebi, 2017, 2018). Research on business model innovation and, in particular, business models has been extensive over the last two decades; however, it has been conducted in the absence of clear definitions of the central constructs (Foss & Saebi, 2017).

Teece's (2010) definition of a business model that is widely cited provides the basis for a much-needed dimensionalisation of the business model and business model innovation constructs (Foss & Saebi, 2018). Teece proposed that the business model and business model innovation constructs are about the architecture of a firm's value creation, delivery and capture mechanisms (Teece, 2010). An architecture is 'a mapping of the functional relations among those mechanisms and the underlying activities' (Foss & Saebi, 2018, p. 13).

In this thesis, the definition proposed by Teece was used. This definition describes the benefit the enterprise will deliver to customers, how it will organise to do so and how it will capture a portion of the value that it delivers. Teece (2010) argues that business models are necessary features of market economics. With customer choice, transaction costs, heterogeneity amongst consumers, heterogeneity amongst producers and heterogeneity amongst competition, firms may vary how the underlying activities are established and developed to achieve value creation, delivery and capture. This way of defining a business model is, therefore, more about 'how it is being done' than 'what is being done'. It is about the activity architecture controlled by a firm (Foss & Saebi, 2018).

> [A] business model is a system of interconnected and interdependent activities that determines the way the company does business with its customers, partners and vendors. In other words, a business model is a bundle of specific activities – an activity system – conducted to satisfy the perceived needs of the market, along with the specification of which parties (a company or its partners) conduct which activities, and how these activities are linked together. (Foss & Saebi, 2018, p. 13)

Foss & Saebi (2018) propose that, theoretically, the key aspect of business models is complementarity between activities underlying the mechanisms of a firm's value creation, delivery and capture. Business model innovation means novel changes in such complementary relations. They argue that their proposed understanding of business models and business model innovation may unify diverse contributions to the literature and may be productive when gaining new insight, but consensus on definitional and dimensionalisation issues is required. They argue that the notion of complementarity may result in much theorising and empirical work that further research can tap into, since it is related to traditional notions of, for example, management research on interdependence, synergy and systematicness. The notion also links to complex systems theories, innovation literature and modular versus architectural innovation.

Complementarity can be described as a managerial choice variable with varying strength (Foss & Saebi, 2018). For example, a firm may prefer many suppliers and arms-length relations, while others may prefer to cooperate intensely with a few suppliers. Complementarity may also differ in how a firm relates to its customers with respect to the type of relationship and intensity.

In this thesis, Foss and Saebi's (2017) definition and dimensions of the business model innovation construct are used. Business model innovation can be defined as 'designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements' (Foss & Saebi, 2017, p. 216).

Designed is included in the definition, since a business model innovation will require top-management action. By including nontriviality in the definition, minor changes to a business model avoided being considered an invention. Examples of trivialities may be supplier relations or product portfolios. Novelty is imposed to avoid including adoption/imitation of other incumbents' business models.

Value Creation, Delivery and Capture

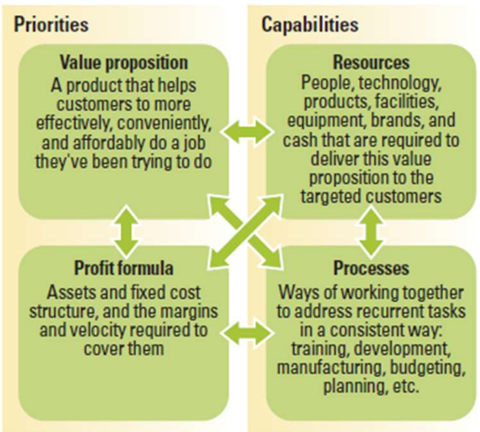
Value creation, delivery and capture are essential elements in the definitions of business model and business model innovation described above. They, too, need to be defined.

In this study, value creation is considered to include the value proposition described by Christensen et al. (2016). The value proposition is closely linked to the job to be done. This is a product (or a service) '… that helps customers to more effectively, conveniently and affordably do a job they've been trying to do' (Christensen et al., 2016, p. 22).

Christensen et al.'s (2016) business model is made up of four elements: a value proposition for customers, resources, processes and a profit formula (see Figure 1 below). They argued that this way of viewing a business model highlights the interdependencies among elements and illuminates what a business is capable and incapable of doing. Interdependencies are the integration required between individual elements of the business model. Each component of the model must be congruent with the others.

Figure 1

A business model is made up of four elements (Christensen et al., 2016)



Value delivery is considered herein to include the resources and processes described by the same authors. Resources are described as '[p]eople, technology, products, facilities, equipment, brands and cash that are required to deliver this value proposition to the targeted customers' (Christensen et al., 2016, p. 22). Processes are explained as '[w]ays of working together to address recurrent tasks in a consistent way: training, development, manufacturing, budgeting, planning, etc.' (Christensen et al., 2016, p. 22).

Value capture is considered to include a profit formula. The profit formula is described as '[a]ssets and fixed cost structure, and the margins and velocity required to cover them' (Christensen et al., 2016, p. 22).

Actors may also create value together. When a business model has a social or environmental impact, society will capture some of its value. These types of values will be further described when introducing the business ecosystem perspective in Section 3.2.

3. Incumbent Firms' Propensity to Alter Their Business Models and Business Ecosystems

Section 3.1 provides the context for the first research gap and the first research question (i.e. How has the introduction of digital transformation affected the propensity of maritime and logistic industries' incumbent firms' to alter their business models?). This is followed by the main drivers of change for business model innovation and a choice of framework describing the stages of a business model's journey. The change drivers and framework, in combination with the practical definitions from the previous section, will be used to answer the first research question.

Section 3.2 tackles the second research gap and the second research question (i.e. How do traditional industries develop a business ecosystem in which they create value to increase social, environmental and economic impact together?). Establishing a foundation for the analysis involves describing value co-creation, co-delivery and co-capture at the network (meso) and society (macro) levels. The framework and definitions will be used to detail the challenges and opportunities faced in an emerging business ecosystem. To overcome some of the challenges of analysing network-embedded business models, a framework of a business ecosystem based on modularity, the impact of different types of complementarities and the resulting fungibility is presented. This framework will be used in the case study to describe the interdependencies of firms' business models in emerging business ecosystems. This will be used to examine the main challenges and opportunities that incumbent firms in traditional industries face in the emergence of a business ecosystem.

3.1 Framework for Incumbent Firms Altering Their Business Models

This section introduces two main frameworks: the main change drivers for innovation (Johnson et al., 2008) and three stages of a business model's journey (i.e. whether the business model innovation is market-creating, market-sustaining or efficiency innovation) (Christensen et al., 2016). Categorisation of main change drivers for innovation (i.e. technological, institutional and commercial) involves a framework that can be used for relating the challenges and opportunities the incumbent is facing with the stage of the business model they have used to create innovation.

The Context of the First Research Gap and the First Research Question

The first research gap concerns how the introduction of digital transformation affects large incumbent firms' propensity to alter their business models (see Section 1.2). The research gap belongs to one of the main research streams of business model innovation: digital technologies and business model innovation (Agostini & Nosella, 2021). Most of the extant case studies target the media industry, information and communication technologies and new digital ventures (Agostini & Nosella, 2021). Extant literature on business model innovation in combination with industry and incumbents is mainly concerned with venture capital, business-to-consumer (B2C) markets, start-up companies, tour operators, and the fashion, telecom, car and music industries (see the summary of the literature review in Section 4.3). Scholars have called for more research on business model innovation when introducing digital technologies in traditional industries (Agostini & Nosella, 2021). This thesis will use a case study to address this call by asking how the introduction of digital transformation affects incumbents' propensity to alter their business models.

Research reviews have highlighted the usefulness of the business model construct in research on e-commerce, strategy and technology management, its use in different theories and the evolution of the business model itself (Fliser et al., 2021; Foss & Saebi, 2017); however, extant business model innovation literature does not explicitly address the issue of boundary conditions (Foss & Saebi, 2017). The first research gap involves an absence of information about the drivers, facilitators and hindrances of the innovation of business models (Foss & Saebi, 2017). We lack insight into under which circumstances business model innovation can give rise to a sustained competitive advantage. Boundary conditions may be critical because firms may differ with respect to the antecedents and consequences of business model innovation. Antecedents, moderators and outcomes of business model innovation may be dependent on whether the firms are, for example, entrepreneurial, incumbent, high tech, traditional, single industry or diversified. Therefore, studying incumbent firms in traditional industries, as we do in this thesis, may provide insight into the antecedents, moderators and outcomes of business model innovation. The thesis' focus on digital transformation and business model innovation by incumbent firms in traditional industries may thus provide examples of what contributes to changes in their value creation, delivery and capture.

One of the biggest barriers to technological innovation is how innovation is incorporated into an existing business model or its development (Chesbrough, 2010; Fliser et al., 2021; Teece, 2010). This research direction considers that business models bridge technology with the market (Velu, 2021). The choice of business model allows managers to capture the latent value of the technology (Chesbrough, 2010; Fliser et al., 2021; Foss & Saebi, 2018). One stream of research highlights the importance of aligning a business model with technological innovations and understanding it in that context (Fliser et al., 2021). Further studies on the opportunities that arise when new value is created through technological innovations are suggested (Fliser et al., 2021). This thesis will focus on the commercialisation of new technologies and how this may increase social, environmental and economic impacts. The exploratory approach in this thesis asks: What challenges and opportunities do incumbent firms in traditional industries experience when they develop their business models?

Has digital transformation resulted in incumbent firms' making market-creating innovations or efficiency innovations in their business models?

Main Change Drivers for Business Model Innovation.

What challenges and opportunities do incumbent firms consider when they introduce digital transformation into their offerings?

An analysis of the opportunities a firm considers and how it has developed or innovated its business model can be used to categorise its main change drivers. This categorisation can again be used to understand at which stage of the business model the firm has created innovation (i.e. market-creating, sustaining or efficiency innovation).

The main change drivers can be categorised as technological, institutional and commercial (Johnson et al., 2008). Technology drivers relate to new technologies that enable commercial opportunities, such as new business models or organisational forms that solve new customer needs (Elter & Saebi, 2020). Institutional drivers concern commercial constraints by governments or financial markets. These may be government regulations, legal and tax regulations, licences, General Data Protection Regulation, local laws and local tax regimes. For financial markets, it may be access to capital, investor preferences or the cost of capital. Commercial drivers are about new market opportunities and new customer needs; when new actors enter the market, competition in the market changes or diversifies through the inclusion of new capabilities. Commercial drivers can also involve efficiency through simplifications, scale effects, efficiency in processes, management and organisation.

Three Stages of a Business Model's Journey

Not all companies are equally able to adapt their business models to capture value from new technologies (Christensen et al., 2016). Executives in incumbent companies sometimes prefer to invest in their existing businesses because it seems less risky than trying to create entirely new businesses. The hard truth about business model innovation is that it is not the attributes of the innovator that principally drive success or failure. Rather, it is the nature of the innovation being attempted that drives the success or failure of business model innovation. Over the long term, Christensen et. al (2016) argues that the greatest innovation risk a company can make is to decide *not* to create new businesses that decouple the company's future from that of its current business units.

One way of evaluating how a firm has altered its business model is to categorise whether the business model innovation is market-creating, market-sustaining or efficiency innovation. The categorisation is based on a model of the business model's journey (Christensen et al., 2016). The model was developed to help incumbent firms understand and explain why most attempts to alter the course of existing business units fail. A business model's journey typically consists of three stages[3] (see Figure 2). An incumbent firm begins its journey with the creation of a new business unit

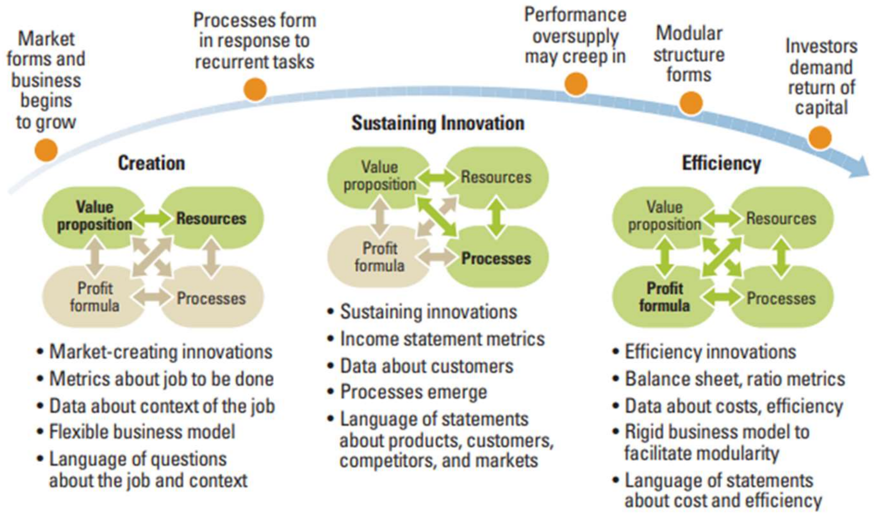
[3] Clayton Christensen later reformulated these stages. Christensen & Dillon (2020) use the categories: market-creating innovations, sustaining innovation and efficiency innovations.

and business model (market-creating innovation). The next stage is shifting to a growing business unit (market-sustaining innovation). The last stage is wringing efficiency from the business model (efficiency innovation). Each stage is conducive to a specific type of business model innovation, builds a particular set of interdependencies and is responsive to a particular set of performance metrics. Christensen et al. state that business models are designed not to change. The models become less flexible and more resistant to change as they develop over time. The reason is that interdependencies between the elements in the business model grow and harden over time. The better the business model performs at its assigned task, the more interdependent and less capable of change it becomes.

The reason for developing this model is that many attempts at business model innovation have failed (Christensen et al., 2016). Far too much energy is given to the last two stages—sustaining and efficiency innovation. By using the model, executives may better understand how business models develop over time. Managers can learn from past successes and failures, but the model provides an understanding of how new business models are created, how they evolve, the kinds of changes that are possible at various stages and what the changes mean for organisational renewal and growth. Executives need to understand the priorities associated with each business model stage. They should evaluate whether the business model innovation they are considering is consistent with the current priorities of their existing business models. Such analysis is important to the purpose of this thesis because it should lead to questions about where new organisational initiatives should be housed, how they should be measured and how the resources and processes at work within the company will either support or extinguish new initiatives.

Figure 2

The three stages of a business model's journey (Christensen et al., 2016); the first stage is also called market-creating innovation (Christensen & Dillon, 2020)



Christensen et al. (2016) argue that using the three stages of the journey may guide leaders to categorise innovation opportunities in terms of their fit with their existing business model's priorities. They recommend the following to leaders:

a. Determine how consistent the opportunity is with the priorities of the existing business model. The evaluation should be based on the stage of the business model's journey (market-creating, sustaining or efficiency innovation).
b. To achieve successful business model innovation, focus on creating new business models rather than changing existing ones.
c. Build a business creation engine. This can be done by spotting future growth gaps, running with potential disruptors of the business, starting new businesses by exploring the job to be done, resisting the urge to force new businesses to find a home in existing units and using mergers and acquisitions to create internal business model disruption and renewal.

The first stage, market-creating innovation, is when a small group of people is focused on developing a compelling value proposition (Christensen & Dillon, 2020). The group is fulfilling a significant unmet need and is focused on the job to be done. Those involved initiate questions about how the job can be done and focus on the connection between the value proposition and resources. Their attention to creating customers gives the business flexibility. Little attention is given to the processes and profit formula at this stage. When determining how consistent the opportunity is with the priorities of the existing business model, the evaluation at the market-creation innovation stage should consider the extent to which the opportunity meets the primary job to be done.

Not all companies starting on the business model journey will reach the second stage of market-sustaining innovation (Christensen & Dillon, 2020). This stage focuses on building a reliable, loyal base of customers. At this stage, the organisation is creating reliable and efficient processes to deliver products and services. The business unit focuses on the process of making good products better. The focus on identifying unmet needs and the flexibility of the business from the first stage gradually disappears. The authors describe that, at this stage, the voice of the customer gets louder, drowning out the voice of how the job should be done to some extent. When determining how consistent the opportunity is with the priorities of the existing business model in the sustaining innovation stage, the evaluation should consider to what extent the opportunity improves the existing job to be done, if it grows the current addressable market (or brings new customers into the existing market) or improves revenue growth, profitability or margins.

The third stage, efficiency innovation, is when a company tries to do more with less (Christensen & Dillon, 2020). This stage occurs when investments in product performance no longer generate additional profitability. The business unit prioritises activities to increase efficiency innovations, such as outsourcing, adding financial leverage, optimising processes and consolidating industries to gain economies of scale. Often, the business delivers more performance than the market can utilise, and customers may become unwilling to pay for it. Delivering more than the market can utilise or is willing to pay for may provide an opening for others to introduce disruptive innovations (Christensen et al., 2015). When determining how consistent the opportunity is with the priorities of the existing business model in the efficiency innovation stage, the evaluation should determine to what extent the opportunity enables lowering costs for existing customers, ensures capital is used more efficiently or results in outsourcing (or similar) for non-core elements of the model.

3.2 Framework of Business Ecosystems

How do incumbent firms in the maritime and logistics industries in an emerging business ecosystem create value together? To answer the second research question, a business ecosystem perspective will be introduced.

This method of reframing enables the observation of the actors taking part in creating, delivering and capturing value for the case study of short sea autonomous shipping and cargo operations in Norway. One of the prospects for short sea autonomous shipping and cargo operations is that they may be competitive with truck transportation. However, the goods will be transported from warehouse-to-warehouse, which often means that they will be transported both by sea and road. The incumbent actors being studied have footholds in both maritime and road transport. These industries are known to have traditional value chains, but they are from two traditional and distinct industries. The method of reframing makes it possible to include the main actors taking part in delivering the goods from warehouse-to-warehouse and not only port-to-port. Therefore, this study concerns autonomous shipping *and* cargo operations.

The Context of the Second Research Gap and the Second Research Question

Scholars have shown that digitalisation has led to both coopetition and competition (Caputo et al., 2021). Previous research has shown that digitalisation can facilitate synergies and knowledge sharing, even among actors in the same market. To be able to analyse this, a framework for value creation, delivery and capture within a micro-meso-macro system of competing goals will be introduced. These co-values will be linked to the challenges and opportunities that incumbent firms face when digital transformation is introduced into their business models. The findings from this study will be used as a basis to evaluate whether the emergence of a business ecosystem is observed.

Recent studies have focused on business models in relation to disruptive innovation, entrepreneurs and ecosystems (Snihur et al., 2018). What seems to be underexplored is the effects incumbent firms in traditional industries experience when taking part in emerging business ecosystems. One research gap in the extant literature is how multi-inventions, which digital transformation often implies, influence how incumbent firms compete and collaborate. Such insight should be from different industries and geographical settings and about how the firms create, deliver and capture value together (Garcia et al., 2019). This thesis will provide insight from the case study from Norway by asking how incumbent firms in the maritime and logistics industries in an emerging business ecosystem create, deliver and capture value together.

Extant research describes that next-generation competition places a premium on rapidly implementing (and continuously updating) novel business models and that the main characteristics of next-generation competition are dynamic competition, a semi-globalised world, multi-invention contexts, organisational capabilities and business ecosystems (Teece & Linden, 2017); however, these insights are mainly from the consumer sector. This thesis will use a case study to investigate the challenges and opportunities incumbent firms face in the emergence of a business ecosystem. The methodology was designed to look at how incumbent firms’ business models are complementary in the emerging business ecosystem.

Value Co-creation, Co-delivery and Co-capture

Extracting value from an innovation network may be complicated to understand or describe and may prove challenging when answering the second research question of how actors create value together. One reason for this is that value may be created at the micro and meso levels of the network, yet a major goal of value capture may be at the environmental and social (macro) levels (Garcia et al., 2019). Garcia et al. (2019) suggested that using open innovation to address societal challenges, such as pollution, requires an understanding of value creation and value capture within a micro-meso-macro systemic framework of competing goals.

Their suggestion is based on the fact that eco-innovation has primarily assumed a micro- (firm) and macro-level (ecosystem) perspective, while open innovation has primarily utilised a micro-and meso-level perspective. An eco-innovation can be defined as ‘an innovation that results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives’ (Garcia et al., 2019, p. 643).

The micro level, or individual level, is about firms, individual organisations and knowledge bodies (Garcia et al., 2019). Value creation at the micro level should result in knowledge acquisition, new customers, new products and financial benefits for the firm. At this level, value capture benefits the individual firm, irrespective of whether it also benefits the ecosystem.

The meso level, or network partnerships level, is about inter-organisational networks, co-partnering institutions or other intermediate structures (Garcia et al., 2019). Value co-creation at the meso level should generate knowledge sharing, expansion of networking contracts, licensing opportunities and new business models. Value co-capture at the meso level is concerned with how members of the network collaborate to achieve a desirable level of reward/monetisation to advance a common goal.

The macro level, or the eco-systemic level, is the societal level (Garcia et al., 2019). This level involves value co-creation for the benefit of the environment and society. The concept of environmental value co-capture at this level is more diffuse than at the two other levels. Value co-capture at this level involves not only the producers’ and consumers’ perspectives but also eco-systemic performance and impacts on society. Value co-capture includes societal/ecological value, such as unemployment reduction, air and water quality improvements and resource conservation. In other words, value capture at the macro level includes benefits to the environment that may not be measured economically.

Garcia et al.’s (2019) article did not include any description of co-delivery at the meso and macro levels. This thesis suggests that co-delivery at the meso level is about *how* organisations deliver value co-creation together. In other words, how they generate knowledge sharing, how they expand networking contracts, how they make use of licensing opportunities and how they create new business models—together. Further, it suggests that co-delivery at the macro level is about how society delivers value co-creation. This could, for example, be through R&D funding, changes in regulations, financial priorities by the government, etc.

Ecosystem Theory

One way of understanding a business ecosystem is '… as a structure [it] starts with a value proposition, which is delivered by the ecosystem whereby they need to deliver value together, which one of the actors could not deliver alone' (Urmetzer, 2021). Traditionally, business and business strategies have been concentrated within firms, but recent changes have resulted in more business being done through partnerships and ecosystems than through individual firms. Firms have traditionally competed, but more cooperation among firms has been observed today than previously. Firms have traditionally delivered products or services, but today's deliveries often involve complex solutions that combine products and services (Urmetzer, 2021).

However, a network-embedded business model is challenging to analyse because of the complexity between the actors and their respective business models (Bankvall et al., 2017). To overcome some of these challenges, the ecosystem theory suggested by Jacobides et al. (2018) will be used. The theory is derived from complexity theory, which is among the literature streams that have been suggested to overcome the many research gaps in the business model and business model innovation literature (Foss & Saebi, 2018).

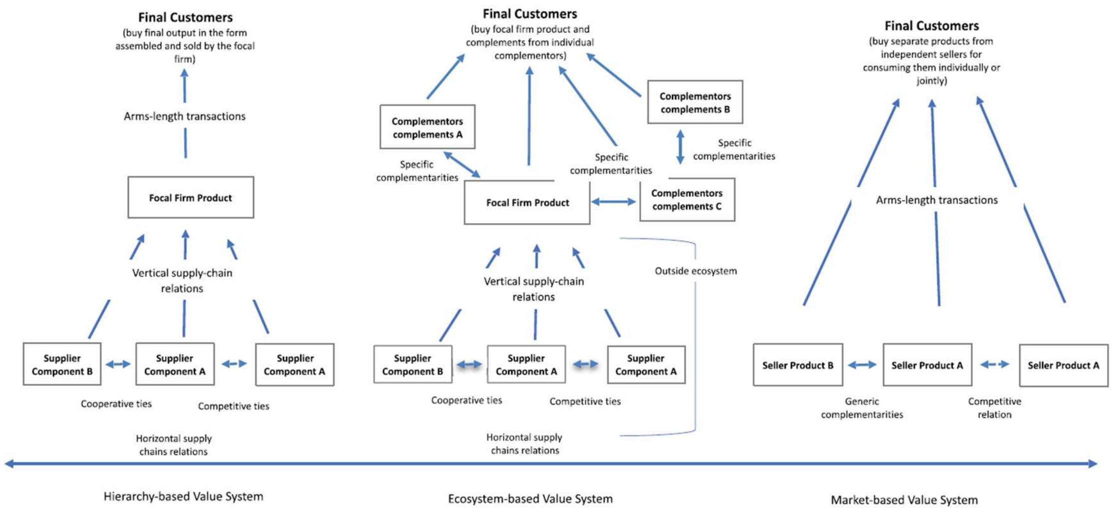
Ecosystem theory describes new structures of economic relationships (Jacobides et al., 2018). Jacobides et al. posit that an ecosystem is 'interacting organizations, enabled by modularity, not hierarchically managed, bound together by the nonredeployability of their collective investment elsewhere' (2018, p. 2255). The authors propose that the role of modularity, the impact of different types of complementarities and the resulting fungibility are elements that tie ecosystem members together in a web of interdependent yet autonomous activities.

Modularity.

Ecosystem theory suggests that a specific structure of relationships and alignment between actors is required for them to create value together. A distinctive feature is that an ecosystem provides a structure within which complementarities in production and consumption can be contained and coordinated without the need for vertical integration. An ecosystem has some degree of coordination without requiring hierarchical governance because of 'the ability to use some standards or base requirements that allow complementors to make their own decisions (in terms of design, prices, etc.), while still allowing for a complex interdependent product or service to be produced' (Jacobides et al., 2018, p. 2263). Modularity is meant by the authors to denote separability along a production (or production and consumption) chain and does not necessarily entail openness. What is distinctive for an ecosystem is that end customers choose from a set of complementors that are bound together through some interdependencies (see Figure 3). This could, for example, be that all complementors adhere to certain standards. Even the customers themselves must affiliate with one group or platform to be able to use its specific complements. What sets ecosystems apart from buyer-supplier relations is that in ecosystems, final customers can choose among the components that are supplied by each participant.

Figure 3

Different types of value systems; ecosystem-based value system is illustrated in the middle; from Jacobides et al. (2018)



Complementarities in Production and Consumption.

Learning how the actors create value together involves understanding how the actors' business models are complementary. Ecosystem theory argues that different types of complementariness in production and consumption shape ecosystem-based value systems. The theory suggests that the actors take part in an ecosystem when the combination of complementarities for production and consumption is unique or super modular. In other words, the actors take part in an ecosystem when the complementarities are nongeneric. Figure 4 describes the meanings of generic, unique and super modular complementarities. It also illustrates which combinations of complementarities in production and service shape ecosystems. The illustration is based on examples of different types of ecosystems, including producer-and platform-based ecosystems and multisided platforms.

Since ecosystem theory categorises types of complementarities in products and services, this thesis suggests relating these to complementarities in value creation and delivery (and, to some extent, capture mechanisms). These relationships are described in Table 1 and make it possible to align the type of complementarities with the findings from the first research question.

Figure 4

Types of complementarities and ecosystems (Jacobides et al., 2018)

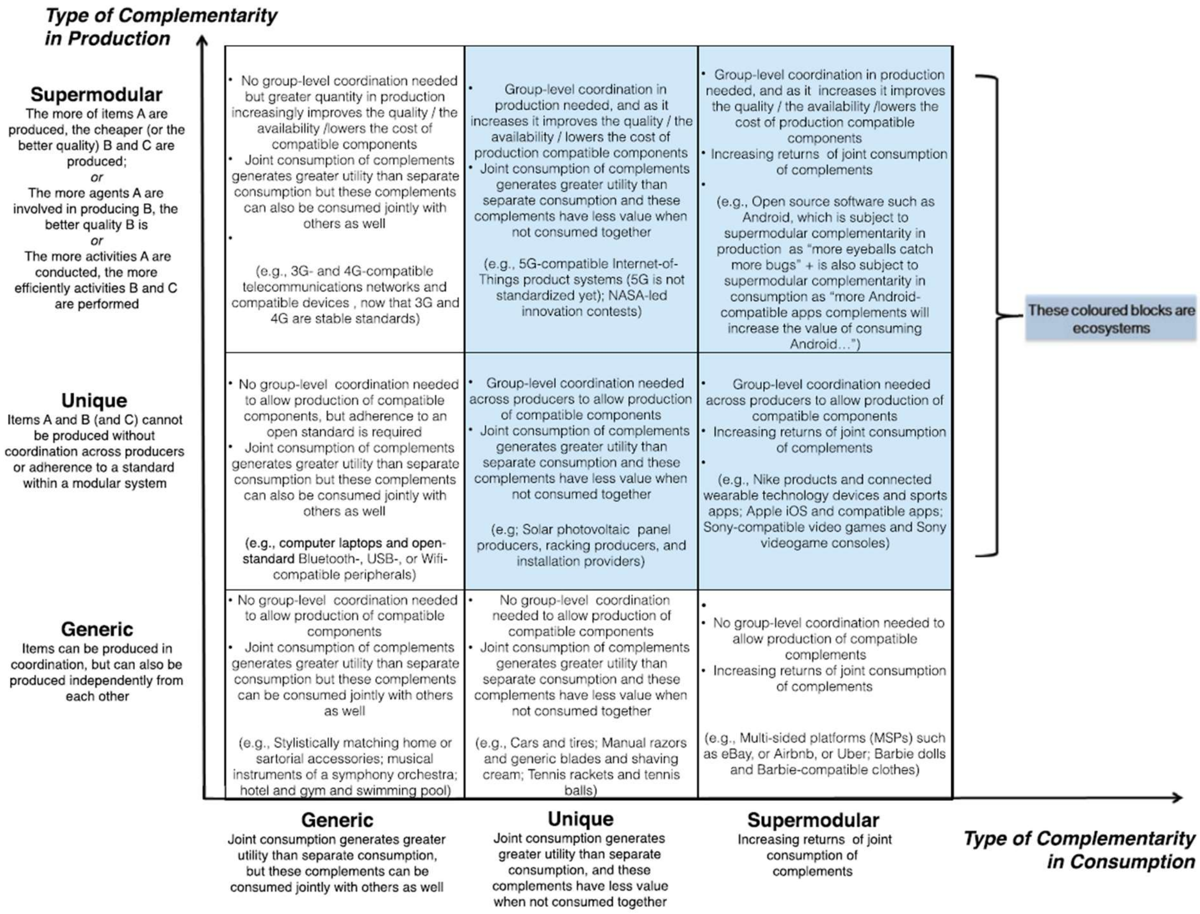


Table 1

Types of complementarities and ecosystems; type of complementary in production modified from Jacobides et al. (2018)

Type of complementarity in production/service				
Super modular[4] The more value delivery (product/service) from Firm A, the more value creation (product/service) from Firm B				
Unique[5] Firm A and Firm B cannot create (product/service) value without the coordination of value delivery between them or adherence to a standard within a modular system				
Generic[6] Firm A can create (product/service) value in coordination with value delivery from Firm B, but Firm A can also create (product/service) value independent of Firm B				
	Generic Joint consumption generates higher utility than separate consumption, but these complements can also be consumed jointly with others	*Unique* Joint consumption generates higher utility than separate consumption, and these complements have less value when not consumed together	*Super modular* Increasing returns result from the joint consumption of complements	***Type of complementarity in consumption***

Fungibility.

Because of these complementarities, connecting to an ecosystem involves some investment that is not fully fungible (Jacobides et al., 2018). Fungibility means that the investment or assets in place cannot be easily redeployed elsewhere without cost. New investments, adjustments to the membership and transaction rules of other ecosystems or coordination costs with other members' activities may be needed for an organisation to take part in the ecosystem. This means that fungibility is a fundamental structural feature that makes ecosystems strategically distinct from each

[4] Modified from Jacobides et al. (2018): The more of item A that is produced, the cheaper (or the better quality) B and C are produced. Or, the more agents of A that are involved in producing B, the better the quality of B is. Or, the more activities of A that are conducted, the more efficiently activities B and C are performed.
[5] Modified from Jacobides et al. (2018): Item A and B (and C) cannot be produced without coordination across producers or adherence to a standard within a modular system.
[6] Modified from Jacobides et al. (2018): Items can be produced in coordination but can also be produced independently from each other.

other. The degree to which a participant's effort is tied to one ecosystem and cannot be recoupled in any other setting determines the economic basis of its attachment to that ecosystem.

4. Methodology

This thesis is based on personal motivation to learn more about how the commercialisation of short sea autonomous ship transport is likely to replace road transportation and reduce greenhouse gas emissions. The research questions are about how incumbent firms introduce digital transformation into their offerings and how they, in an emerging business ecosystem, create value together. The two research questions and how to find answers to them were determined through the choice of methodology, which this section describes.

4.1 Purpose of the Thesis and the Choice of Methodology

This study asks *how* incumbent firms introduce digital transformation into their offerings and *how* they create value together. Answers to the question may give us a better understanding of the problem but will not necessarily lead to conclusions. The motivation, the way of formulating the research questions and the expected outcome of the work suggest an exploratory investigation method (Bell et al., 2019). The conditions and access to sources described below suggest the use of a qualitative study of a single case.

The commercial initiative of short sea autonomous shipping and cargo operation is the first and only one of its kind in Norway. There are no other direct comparative cases available. There are a few sources for exploratory investigation. The incumbent firms are few and different from each other, which makes it difficult to compare them. The investigation involved few actors but many variables. This suggests that the research design should be a case study. The actors have relationships with each other and have a common overarching goal of replacing road transport with emission-free sea transport. This qualifies for a single case study. Case studies are frequently used in social science research (Bell et al., 2019). The primary sources under such conditions are often interviews with stakeholders. News, research articles and reports from government or non-governmental organisations are often considered secondary sources.

4.2 Main Stages of the Exploratory Research Design Process

Researching and writing a thesis are iterative processes in which the goal is to present the content in a concise and well-structured manner. Well-presented articles or theses include concise content that explains why it is necessary to learn more (motivation/introduction), what the main research questions that will be answered are, the relevant theory that will be used, what approach will be taken to reach the answers (method), what objective empiric results have been found (findings), how these results can be understood in relation to the research questions (analysis) and what conclusion can be drawn from the research (conclusion). However, the work required to reach this goal is not necessarily straightforward. The study has been an iteration of the following stages: critical examination of existing literature research, review of ideas, concepts and theories that drive the research process, formulation of research questions, selection of samples, collection of data, analysis of data and dissemination of research and findings. Such a process for explorative research design is described by Bell et al. (2019).

4.3 Literature Review

Literature Review to Establish the Status of Research and Identify Research Gaps

The starting point for the literature review was to read the status of research on business models and business model innovation and the research gaps in the first comprehensive systematic review of the business model innovation literature by Foss and Saebi (2017). The authors followed up this study with their analysis of the research on business models and business model innovation (Foss & Saebi, 2018).

Bibliometric Review

The first step in the literature review was to search for recent bibliometric method reviews. Elsevier's Scopus, with access through NTNU for students, was used for the literature searches (Elsevier, n.d.).

The reason for this approach was that the research on business models and business model innovation has been extensive for the last two decades; however, it lacks theoretical underpinning and empirical enquiry and is not cumulative[7] (Foss & Saebi, 2018). The search consisted of bibliometric method reviews, research trends, groups of research directions, how these are distinguished from each other and growth of knowledge. This search provided direction and supported the work of identifying extant research gaps. It was also used to select articles that focused on trends and to consider whether they were relevant to the identified research gaps in this thesis. Bibliometric method reviews have gained importance in the literature and are used to map state-of-the-art scientific fields and disciplines (Zupic & Cater, 2015). The method quantifies and statistically evaluates the literature, identifying interconnections between publications.

In October 2020, a literature search was conducted for documents with 'business model innovation' and 'bibliometric' in the title, abstract or keywords. This resulted in 44 documents (see Table 2 for a summary). The list was reviewed and nine bibliometric reviews that might be relevant to business models and business model innovation for incumbent firms were identified.

The article of the most relevance was 'Business Model Innovation: Identifying Foundations and Trajectories' (Fliser et al., 2021). Another relevant article concerning the maritime industry was about digitalisation and new technologies for sustainable business models at the ship-port interface (Del Giudice et al., 2021). Six of the articles were bibliometric reviews of business models (Budler et al., 2021), of which three were business models in combination with digital/industry 4.0 (Agostini & Nosella, 2021; Caputo et al., 2021; Del Giudice et al., 2021) and two were business models for sustainability (Del Giudice et al., 2021; Preghenella & Battistella, 2021). One article was a systematic review of hybrid multisided platforms and was not considered relevant to the study.

[7] A search of Scopus for 'business model innovation' in the title, abstract or keywords between 2017 and 2021, within the field of 'all social sciences' and 'journals' returned more than 5000 documents in October 2021.

The results were used to describe the research gaps (see Section 1.2) and the background for business models and business model innovation (see Section 2.1).

Table 2

The literature search in Scopus; searches were limited to 'all social sciences' and 'journals' from 2017 and conducted in October 2021

Search words in title, abstract or keywords 'business model innovation' and …	*No. of hits*	*Topics and literature that may be relevant to the study*
'bibliometric'	44	Foundation and trajectories of business model innovation: (Budler et al., 2021; Fliser et al., 2021) Business model and digital/industry 4.0: (Agostini & Nosella, 2021; Caputo et al., 2021; Del Giudice et al., 2021) Business model for sustainability: (Del Giudice et al., 2021; Preghenella & Battistella, 2021) Open innovation: (Frankenberger et al., 2013) Digitalisation, new technologies, sustainability, ship-port: (Del Giudice et al., 2021)
'maritime' and 'digital'	12	(Aiello et al., 2020)
'industry' and 'incumbent'	31	Venture capital, B2C-market, start-up companies, tour operators, fashion industry, telecom, car, music industry Digital innovation and the boundaries of capabilities and organisation in a firm
'industry', 'incumbent' and 'sustainability'	12	Circular and sharing economy
'maritime' and 'open innovation'	4	Innovation in product and services in the shipping retrofit industry: (Rivas-Hermann et al., 2015)
'maritime', and 'ecosystem'	7	(Aiello et al., 2020)
'industry', 'incumbent', and 'performance' or 'outcome'	23	Small and medium enterprises' (SME) performance from business model innovation: (Latifi et al., 2021) Organisational redesign and business model innovation: (Latilla et al., 2021) Business model innovation drivers and outcomes in SMEs: (Gatautis et al., 2019) Enterprise resource planning in business model innovation: (Rodriguez et al., 2020)

Literature Search for Business Model and Business Model Innovation and Digital Transformation by Large, Incumbent Firms and the Maritime Industry

While the bibliometric searches provided the status of research trends, other types of searches were required to find relevant literature specific to the research gaps. Literature searches were performed using 'business model innovation' in combination with 'maritime', 'digital', 'industry' or 'incumbent' in the title, abstract or keywords. The searches were filtered by 'all social sciences'. Some of the documents concerned include venture capital, the B2C market, start-up companies, tour operators and the fashion, telecom, car and music industries. Other documents were about digital innovation and the boundary of capabilities, organisation in a firm or something similar. Others, such as those on the topic of dynamic capabilities and management or digital innovation, but without the boundary of business model innovation, were not considered relevant.

Literature Search for Business Model Innovation with a Focus on the Interface of Value Creation, Business Ecosystem and Sustainability

A similar literature search process was carried out for business model innovation and the interface of value creation, business ecosystem and sustainability. Literature searches were performed using 'business model innovation' in combination with 'incumbent', 'ecosystem', 'open innovation' or 'maritime' in the title, abstract or keywords.

Other Literature Searches

Other searches were also conducted in the iterative process of investigating possible research gaps. This included a search of the literature about the effect of business model innovation on performance.

Snowballing Process

The evaluation of the above searches showed that they were ineffective in identifying recent literature on the relevant subject. A snowball search process was therefore carried out. A snowballing process may be useful for complementing database searches and extending systematic literature studies; however, it may limit the transparency of the research because it is difficult for others to understand how the search process was conducted.

The starting point was recent bibliographic method reviews. For example, a selection of references related to value creation through business model innovation, one of the clusters by Fliser et al. (2012), was briefly reviewed. This cluster suggests that organisational learning, experimentation and understanding the business model are significant drivers of value creation through business model innovation. Another example is that a search of citations from the work of Gatautis et al. (2019) and Frankenberger et al. (2013) led to Jocevski et al. (2020), an article that had already been considered relevant. This gave us the impression that the search processes found the most relevant literature for the study. Relevant articles found from the snowballing process are listed in Table 3.

Table 3

Example of the snowballing process

Snowballing process—the starting point	*Documents evaluated if relevant with the research gaps*
Value creation through business model innovation searched (Fliser et al., 2021)	Open innovation—Current research and research gaps: (Aiello et al., 2020; Jocevski et al., 2020; Saebi & Foss, 2015) Sustainable business model innovation—current research and research gaps: (Andreini et al., 2021; Bocken & Geradts, 2020) Case of open innovation to create sustainability in the maritime industry: (Garcia et al., 2019) Disruptive innovation from an entrepreneur's perspective in relation to an ecosystem and responses from incumbents: (Snihur et al., 2018) Business model and first-mover advantage: (Markides & Sosa, 2013)
Enterprise and network architectures (Budler et al., 2021)	Business model innovation and business ecosystem: (Bankvall et al., 2017; Fjeldstad & Snow, 2018)

Literature Review to Identify Secondary Sources

Secondary sources were used as findings in the case study. A search for secondary sources has been ongoing since the planning of this study. News article searches and searches through Google Scholar, Scopus, NTNU library for master's thesis and similar have been conducted. Secondary sources are data collected for purposes other than the study (Bell et al., 2019).

Amongst secondary sources that may be relevant to the study are World Maritime University (2019) and its expected use of autonomous ships in Norway and Kretschmann et al. (2017), Akbar et al. (2021) and Msakni et al. (2019) regarding the economic analysis of using unmanned autonomous ships for cargo transport. Other relevant secondary sources are the Norwegian government's policy for green shipping (The Norwegian Government, 2019), the Norwegian government's press release on their plan to establish a strategy for the R&D of green shipping and digitalisation (The Norwegian Government, 2021) and Menon Economics and Marintek's report on the maritime industry for the 21st century (Mellbye et al., 2016). A review of the future application of autonomous ships and their potential business models has been undertaken by Munim (2019).

4.4 The Case Study

This section presents the selection of the case, criteria for choosing companies and experts and how the interview guideline was prepared. The interview guideline is presented in Appendix 1.

The case study aims to describe the changes incumbent firms have made to their business models as a result of digital transformation. What have the incumbent firms in the maritime and logistic industries explored and how do they exploit the business opportunities autonomous shipping and cargo operations may provide? This is seen in relation to the potential opportunities that digital transformation may provide.

Selection of Case

The selected case consists of two projects that are currently being commercialised. Many of the actors are involved in both projects, which is the main reason why it is considered one case, and not two. Ventures and agreements have been established, companies have invested in new technologies and the companies have started to hire staff. This is a starting point for an exploratory investigation of how incumbents can innovate and align their existing business models when they commercialise digital technologies.

Public and governmental institutions are taking part in the realisation of these two projects. However, since the research questions concern how digital transformation is being commercialised, the focus is on commercial actors.

Several initiatives are currently ongoing to introduce autonomous transport on the sea; however, they are mainly R&D projects (AEGIS, 2021) or concepts that have not been commercialised (ZeaBuz, n.d.). An alternative method could have been to include these as a group of actors. However, it might have been more difficult to gain access to primary sources from these sources.

Criteria for Choosing Companies and Experts

The firms taking the lead in the digital transformation in the two projects currently commercialising short sea autonomous ship and cargo operations in Norway were selected—Yara, ASKO and Massterly. The three persons interviewed have or had a leading role in the two projects. Each of the interviews lasted for 1–1.5 hours and was carried out on Microsoft Teams or by phone. Information about the participants and interviews is listed in Table 4. Other persons and entities were also contacted in the search for interview subjects. Some of the persons were initially available for an interview, but the time for interviews was not settled.

Table 4

Information about the interviews

Project	*Position*	*Date of interview*	*Place and duration of interview*
Yara Birkeland	*Former Finance and Logistic Manager*	*December 14, 2021*	*Phone, approx. 1 hour*
ASKO Maritime	*Managing Director*	*November 26, 2021*	*Teams, 1 hour 18 min*
Both projects	*Vice President (VP) of Business Development*	*November 17, 2021*	*Phone, approx. 1 hour*

Interview Guideline and Conducting the Interviews

Data collection from primary sources is mainly based on interviews with experts. To structure the interviews, an interview guideline was prepared (see Appendix 1: Interview Guideline). Secondary sources, definitions and frameworks described in Section 3 were used to prepare the interview guide. The difference from secondary sources is that primary sources provide data for the purposes of the study (Bell et al., 2019).

The interviews were conducted using a funnel approach. This means that the interviewer begins with broad, open-ended questions about a topic. When needed, the interviewer narrows down to more closed-ended questions. The interviewer makes use of what has already been said or brings in a new topic, starting with broad, open-ended questions. The interview guide included a funnel approach for each of the main themes. Two of the interviews were recorded. The third interview was not recorded. Notes were taken and a summary of the interview was made shortly after the interview. The interviews were conducted in Norwegian, and the summaries were translated into English. The translated summaries from the interviews were submitted to two of the participants. They returned with comments and the summaries were corrected accordingly. A request was submitted to the third interviewer to ask for an email to which the summary could be submitted for review, but no response was received. Any quotes from the interviews used in Section 5 were freely translated from Norwegian.

4.5 Case Study Analysis

This section presents the methods for analysing the findings of the data collected from the case study. The structuring of the analysis from the case study will be based on the two research questions, definitions and frameworks described in Sections 2 and 3. Relevant results from the case study will be presented in Section 5 and discussed in Section 6.

Method for RQ 1

The sequence of analysis described below will be the basis for answering RQ 1 (i.e. How do incumbent firms in traditional industries introduce digital transformation into their offerings?).

The sequence begins by describing the business models of the case firms *before* the digital transformation. The business model will be categorised by what values are created, delivered and captured (see the working definitions provided in Section 2.2). The template in Table 5 below will be used to systematise the findings. The next step is to summarise what the case firms consider to be the opportunities and challenges for digital transformation. The opportunities and challenges will be categorised regarding the extent to which the firm considers them to describe value creation, value delivery and value capture. This step is followed by describing any changes in the business model *relative* to before the digital transformation was introduced in the firms' business models. This finding provides the basis for evaluating the extent to which the business model has been innovated. The working definition of business model innovation is used for this evaluation (i.e. to what extent the changes are designed, novel and non-trivial) (see Section 2.2).

The second to last step is the categorisation of the main change drivers of business model innovation. The main change drivers are commercial, institutional and technological (see Section 3.1). Finally, the extent to which the firms' business model innovations can be categorised as market-creating, sustaining or efficiency innovation is evaluated (see the description of the three stages of a business model's journey in Section 3.1).

Table 5

Structure for analysing the actors to answer RQ 1

Firm	*Categorisation*	*Business model **before** digital transformation*	*Challenges*	*Opportunities*	*Firm's business model innovation or development of new business model*	*Business model **after** digital transformation*	*Main change drivers for business model innovation*	*Stage of firm's business model journey*
Firm A	Value creation (proposition)							
	Value delivery—resources:							
	Value delivery—processes:							
	Value capture (profit formula):							
Firm B	…							
	…							
	…							

Method for RQ 2

A sequence of analyses and summaries of the results in two tables will provide answers to the second research question (i.e. how incumbent firms in an emerging ecosystem create value together). The starting point for the analysis is the actors' business models *after* they have been innovated.

The first step is to make use of the framework suggested by developing a summary of the opportunities and challenges faced by involved actors during the emergence of a business ecosystem (see Table 6). The opportunities and challenges will be categorised based on the level to which they belong (i.e. firm (micro), network (meso) or societal (macro) levels). This is followed by describing value creation and value capture within a micro-meso-macro systemic framework of competing goals, as suggested by Garcia et al. (2019) (see Section 3.2).

The next step is to describe the interdependencies of firms' business models in the emerging business ecosystem by use of the ecosystem theory, as suggested by Jacobides et al.'s (2018). The framework has been adjusted based on how the types of complementarities between the firms result in value creation and delivery (and, to some extent, capture mechanisms) (see Table in Section 3.2). Note that the framework will be used to describe the extent of interdependencies *after* firms have innovated their business models.

Table 6

Structure for analysing the actors to answer RQ 2 regarding opportunities and challenges

Firm	*Network level*	*Challenges*	*Opportunities*	*Value (co-) creation (value proposition)*	*Value (co-) delivery (resources and processes)*	*Value (co-) capture (profit formula)*
Firm A	Micro:					
	Meso:					
	Macro:					
Firm B	Micro:					
	Meso:					
	Macro:					

4.6 Evaluation of the Research Method

An evaluation of the research method serves the purpose of determining the extent to which the research may be considered reliable.

Criteria for Evaluation

The following four criteria can be used to evaluate the reliability of qualitative research (Bell et al., 2019):

- Credibility: The extent of credibility involves the degree of transparency. Triangulation of methods, data and persons may increase the credibility of the research.
- Transferability: Transferability concerns the extent to which information and analysis may be transferable to other contexts and circumstances.

- Dependability: Dependability involves the degree of transparency. The choice of methods and analysis may influence the degree of dependability.
- Confirmability: Confirmability involves the degree of subjectivity in the research. Supervision and triangulation may be some of the means to reduce the extent of subjectivity.

Discussion of Reliability

Using only one case, the way interviews are conducted and insufficient triangulation are considered the main factors negatively influencing the reliability of a qualitative research study.

To ensure credibility, the process for the literature searches was described and relevant findings were listed. This involved a literature search with a snowballing process, which was useful for complementing database searches and extending systematic literature studies. However, such a process limits the possibility of others repeating the searches and therefore reduces the extent of the transferability of the research.

To allow for transferability, the thesis is structured for the reader to understand what is distinctive from the case study. Only one case was included, which influences the extent of transferability the analysis may provide to other contexts and circumstances. One risk of using secondary data is that it may be based on biases that are unknown or difficult to identify.

To allow for dependability, the method for the case study analysis included the interview guideline. One of the main criticisms of qualitative research is that it may be difficult to replicate. The interviews and information from the primary sources are part of the research method, which is probably the most difficult to replicate. This may influence the research quality in the form of credibility, dependability and confirmability.

To allow for confirmability, the persons being interviewed were offered the opportunity to read through and comment on a summary of their interviews. The supervision of the work has reduced the extent of subjectivity. One weakness of the research process is the insufficient triangulation of primary sources. This may affect the quality of the information from primary sources by increasing the risk of subjectivity and, therefore, reducing the extent of confirmability. This study was conducted by only one person, which does not make it possible to conduct triangulation during the interviews by having two interviewers. Another method of triangulation could be to interview two people at the same time. However, the risk of gaining access to competent persons within the companies made it impractical to make use of this approach for improved reliability. Insisting on interviewing two people at the same time may hamper the chance of getting access to competent persons and was therefore not done.

Potential Conflict of Interest

The study was done in the authors' spare time and did not have any relationship to their full-time day job.

The author has a small number of shares of stock in two of the companies described in this case. The amount is small in number and in relation to the total number of shares of stock the author possesses. The shares for the two companies were bought more than a year before the study commenced. There has been no trade with these shares and no shares have been bought at the time of this study. The author is not employed and does not have any commitments or agreements with any of the companies involved in the case.

5. Findings from the Case Study

The findings will be structured using an initial introduction to the context of the case. The next section will describe relevant findings from the Yara Birkeland project, with attention to the incumbent firm Yara. This section will be followed by a description of relevant findings from the ASKO Maritime project, with attention to the incumbent firm ASKO. The last section will describe findings from the establishment of Massterly.

The findings presented in this section are based on primary and secondary sources and are considered relevant to the two research questions (i.e. How has the introduction of digital transformation affected the propensity of maritime and logistic industries' incumbent firms' to alter their business models? How do incumbent firms in the maritime and logistics industries in an emerging business ecosystem create, deliver and capture value together?).

5.1 Autonomous Short Sea Shipping in Norway—Incumbent Companies in the Context of the Case

The commercial initiatives for short sea autonomous shipping and cargo operations currently observed in Norway are mainly being implemented by incumbent companies. Two projects are currently developing technical and operative solutions for replacing road transport with emission-free, autonomous sea transport—the Yara Birkeland project and the ASKO Maritime project. They are the first movers in delivering such new products and services. The experience and expertise gained from the Yara project have also been used in the development of ASKO's project (Green Shipping Programme, 2020). Both projects were sponsored by the government (through the Enova Fund[8]). The case study will focus on the main firms taking part in these two projects. These are Yara—an international producer of fertiliser products and cargo owner, ASKO—a major Norwegian cargo owner and logistic company and Massterly—the world's first company set up to operate autonomous vessels to the merchant fleet.

Road transportation makes a significant contribution to greenhouse gas emissions (European Environmental Agency, 2021), but it is also unsustainable and places pressure on natural resources, such as land areas and ecosystems (United Nations, n.d.). The two projects are among the pilot projects initiated through the Green Shipping Programme (Green Shipping Programme, n.d.). The

[8] Enova SF is owned by the Ministry of Climate and Environment. It contributes to reducing greenhouse gas emissions, developing energy and climate technology and strengthening the security of supply.

programme is a public-private partnership. The Norwegian government wants to strengthen freight transport by sea (Norwegian Ministry of Transport, 2021). Over several years, this has been an aim of Norwegian governments and the EU, (European Commission, 2001, 2021). Transport emissions represent around 25% of the EU's total greenhouse gas emissions. The EU's aim of being the first climate-neutral continent by 2050 requires ambitious changes in transport (European Commission, 2020).

Ports are indispensable nodes of supply chains for maritime transport and involve many stakeholders (Del Giudice et al., 2021). Innovation in port operations has the potential to provide more efficient operations, complement existing infrastructure, extend connectivity and improve the environmental sustainability of port operations. Norway's National Transport Plan 2022–2033 intends to strengthen the grant scheme for efficient and environmentally friendly ports (Norwegian Ministry of Transport, 2021).

Innovation Norway states that digital transformation and green innovation go hand in hand (Innovasjon Norge, 2021). It provides examples of how digital technologies have developed new, environmentally sustainable solutions.

5.2 Yara and the Yara Birkeland Project

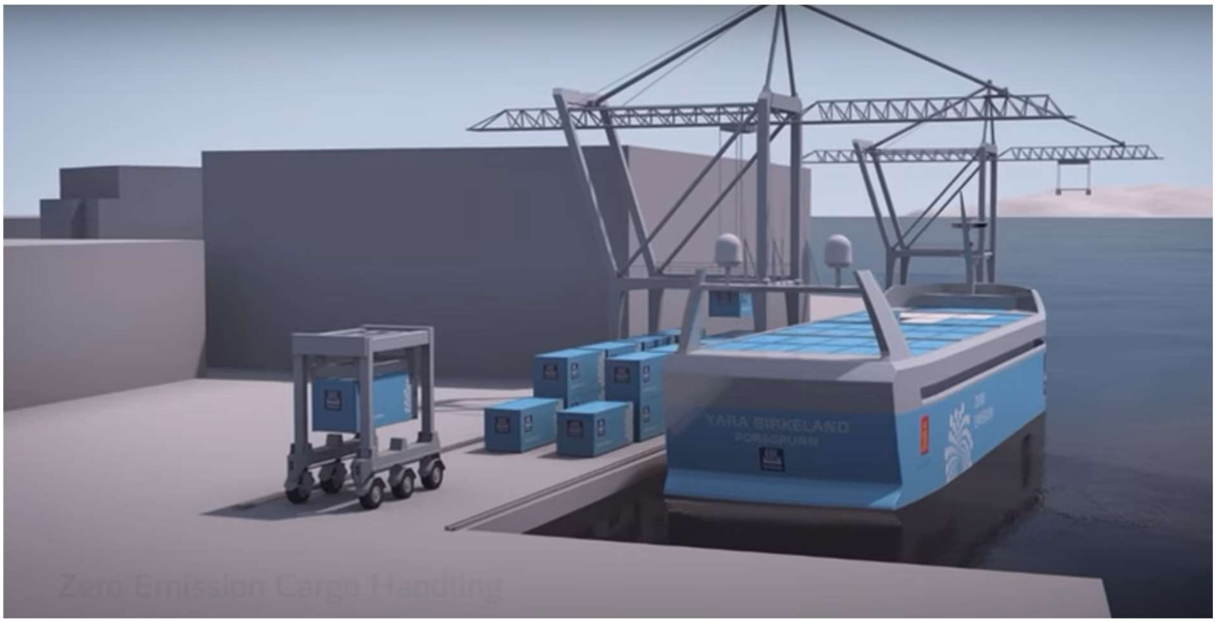
The Yara Birkeland project develops and offers emission-free, autonomous sea transport and efficient loading operations for containers at production facilities. Yara offers this service to its production facility (internal customer), but this service may also be offered to external customers in the future. Transporting containers by sea will commence at the beginning of 2022 (ShipInsight, 2021). The ship Yara Birkeland will transport fertilisers in containers from Yara's production facility in Herøya to the North Sea Terminal in Brevik[9] (Yara, 2021). The terminal has direct shipping lines to Belgium, the Netherlands, the United Kingdom and Sweden (Grenland Havn, n.d.). To reduce diesel-powered truck haulage by 40,000 journeys a year, Yara Birkeland will reduce nitric oxide (NOx) and carbon dioxide (CO_2) emissions, improve road safety, reduce road dust formation and reduce traffic noise in Porsgrunn (Yara, 2021).

Yara is among the world's leading fertiliser companies. Food shortages, limited farmland and air pollution are the main challenges that drive Yara's mission (Yara, n.d.b.). Natural gas, electricity and minerals are used to make competitive and effective fertiliser products (Yara, 2021). Herøya is one of two of Yara's largest production facilities. Approximately 50% of the production in Herøya is distributed overseas, mainly to Asia (Yara, n.d.). The other half is sold to Europe. Production requires large quantities of raw materials, which are shipped in bulk to the production facility. Some of the products (fertilisers) have been transported in containers by trucks to the ports of Brevik and Larvik. From these two ports, the containers have been shipped to Europe and the rest of the world by logistics service providers.

[9] Herøya and Brevik are both located within the municipality of Porsgrunn, Norway.

Figure 5

Yara Birkeland project (Yara International, 2018)



Yara ordered the building of the ship, Yara Birkeland, in 2018 (see Figure 5) (Yara, 2018). This was the same year it established Yara Birkeland AS, a subsidiary of the corporation. Yara previously partnered with Kongsberg to build the world's first autonomous zero-emission ship (Kongsberg, 2017). The idea was based on an earlier project, an ordinary feeder vessel for container freight between Yara's production facility in Herøya and the port terminals of Larvik and Brevik (Himle & Ulsnæs, 2018). The sole function of the ship is to transport the manufacturer's product to a port where it can be further shipped globally (World Maritime University, 2019). The ship is not meant to operate outside Norwegian territorial waters. The ambition was for the vessel to be a fully electric and autonomous container ship with zero emissions, replacing road transport using trucks. The ship is not designed to move products other than containers stacked in racks. It has the capacity for 120 containers (20-foot equivalent) and these will be loaded and unloaded with a gantry crane from the quay (Yara, 2021). Before ordering the vessel, other designs, such as a ship with roll-on and roll-off (RORO), were considered. According to the research participant interview with the former finance and logistics manager, 'The quay at Yara had a ramp for RORO, but the port of Larvik did not provide such a solution. This ruled out the RORO option.'

The initial plan was for the ship to be delivered in early 2020 and to gradually move from manned operations to fully autonomous operations by 2022 (Yara, 2018). The fitting of equipment and testing of the ship caused delays. The most recent plan is for the ship to be put into operation at the beginning of 2022 (Yara, 2021). The first two years will be a trial period with the aim of becoming certified as an autonomous, fully electric container vessel. In 2020, the container liners changed their schedule for port arrivals, resulting in the Yara Birkeland sailing only between Herøya and Brevik (Becker, 2020). This shortened the sailing distance between the ports by two-thirds compared with the original plan of sailing to Larvik.

In 2019, it was expected that Yara Birkeland would challenge traditional business models for the transport of goods (World Maritime University, 2019). Traditional business models for ship transport are based on traditional value chains and economies of scale. Building and operating Yara Birkeland were based on the idea of operating with a 'total transport system', which focused on a small scale and involved a new kind of flexibility (World Maritime University, 2019). The idea was that producers of goods would innovate or develop their business models to achieve more flexible production and transportation of their products. They expected that '[s]maller quantities transported with greater flexibility will replace the notion of economies of scale' (World Maritime University, 2019, p. 20). Producers of goods no longer want large ships sailing to a few large ports, but would prefer smaller ships that are associated with a flexible system involving calls to smaller ports and more direct routes, compared with the tradition of calls to a few, large ports. Autonomous ships are an enabling factor for developing this type of transport system. Innovating or developing a business model with a 'total transport system' means that an autonomous ship should not be considered as a conventional ship without a crew but as part of a totally new phenomenon. 'All the business models we are investigating are not comparable to conventional shipping', explained a representative of Yara (World Maritime University, 2019, p. 17). The expectation is that Yara Birkeland will be an economically viable alternative to truck transport, but other cases would also be relevant to the approach of a 'total transport system'. However, the report from World Maritime University does not describe what such other cases may be. In November 2020, Yara stated that its goal was to bring the ship Yara Birkeland into commercial operation (Yara, 2020). Different ownership models or partnerships were evaluated for operation and commercialisation. In November 2021, Yara (again) confirmed that Kongsberg Maritime will provide the technology and service for autonomous operation and Massterly will operate the ship (ShipInsight, 2021; Yara, 2021).

In addition to building and operating the autonomous ship, the initial plan of the Yara Birkeland project was to build a new quay in Herøya, install a new gantry crane and carriers and develop digital operations for moving and loading/unloading the containers (Stensvold, 2021). The estimation was that approximately 100 containers needed to be loaded with fertiliser products every day (Stensvold, 2018). Yara hired a leading digital services and software company to make a groundbreaking IT system for autonomous loading of the containers, transporting the containers to the quay and loading the containers on board the Yara Birkeland (Stensvold, 2021). 'The software provider Evry was tasked with a major challenge. No one has ever made a system like the one Yara ordered for their autonomous project in Herøya (Stensvold, 2018) (translation by the thesis author). The task was also to ensure that data about the containers were forwarded to the ports and container liners. Yara saw this development as an opportunity to develop the company Yara Birkeland AS a strategic partner in technology, transport and logistics (Stensvold, 2019). However, the introduction of automation and autonomous carriers and gantry cranes, in combination with a total change in the information technology (IT) and logistics systems for cargo handling, made it too complicated for Yara (Stensvold, 2020). This made the company realise that it had to implement the developments stepwise. In October 2021, Yara developed a digital logistics solution for the transport of the containers from its production facility via its new quay in Herøya to the port of Brevik (Stensvold, 2021). The solution is based on an existing system for the transport of containers with trucks. The company Yara Birkeland AS has so far *not* provided strategic partnerships in technology, transport or logistic (Stensvold, 2021). According to the research participant interview with Yara's former finance and logistics manager:

> Many have tried to change their business model from supplying products to delivering services. What often happens is that the largest and second largest company establishes a similar platform. Some manufacturers choose to establish a platform with a direct connection to their customers. However, to reduce the transaction costs, is it often necessary to establish a platform for several products and markets. For a producer to make use of several services, the result may often become very expensive. This can be illustrated by the consumer market. By paying for the entertainment services from Netflix, HBO, Disney+, etc., the total amount of entertainment will become expensive.

In 2018, Yara made an agreement for the crane manufacturer Kalmar to deliver fully autonomous equipment, software and services for a unique, fully digitalised container-handling solution at Yara's facility in Herøya (Cargotec, 2018). Kalmar is owned by Cargotec, a leading provider of cargo and load handling solutions and has the goal of becoming the global leader in sustainable cargo flow (Cargotec, n.d.). Cargotec's business areas are Kalmar (in ports), Hiab (on roads) and MacGregor (at sea). The contract with Yara was for three electric, autonomous straddle carriers (AutoStrads) in addition to a rail-mounted gantry (RMG) crane (Stensvold, 2020). Cargotec considered this to be a groundbreaking project.

> The project involves several firsts for us, including the first fully automated RMG for vessel loading, unloading and container storage management. Furthermore, the Kalmar FastCharge AutoStrads will drive along the public roads in Porsgrunn Industrial Park, which are also used by normal road traffic. We are working closely with local authorities and other parties to ensure the safety of passengers and vehicles at all times. (Cargotec, 2018)

When Yara realised the complexity of making cargo operations autonomous (and seen in relation to developing IT solutions), the order of straddle carriers was cancelled (Stensvold, 2020). The gantry crane at the new quay was made to Yara's specifications, delivered by Kalmar in October 2021 and located at Yara's renewed quay (Stensvold, 2021). The gantry crane will initially be operated in a control room. The plan for gantry crane operations to become autonomous has been postponed (Stensvold, 2020). The crane manufacturer Kalmar gained experience from the project, which contributed to its work on developing autonomous cargo operations. For example, Cargotec announced in December 2021 that it had developed an experimental cloud-based logistics platform for autonomous container operations (Hafeez, 2021). The article states:

> [a]utonomous cargo handling can increase usage of short sea in last mile shipping which can reduce emissions and road traffic congestion. However, for commercial and logistical feasibility of autonomous operations, a connected digital solution is required where all stakeholders participate throughout the cargo lifecycle. (Hafeez, 2021, p. 1)

Of the other initiatives Yara recently pursued was the establishment of a new global unit, Yara Clean Ammonia, in 2020 (Yara, 2021). The purpose of the unit is to capture growth opportunities within carbon-free food solutions, shipping fuel and other clean ammonia applications. In August 2021, Yara announced the largest climate initiative in Norway (Yara, 2021). It established the company Hegra in partnership with Aker and Statkraft. The new company aims to electrify and decarbonise ammonia production in Herøya. This marks the beginning of developing a Norwegian value chain for green ammonia and hydrogen. Producing clean ammonia is a more environmentally friendly way to produce fertilisers than natural gas and is also a promising fuel for the maritime sector (Yara, n.d.a). Similar projects have been announced in the Netherlands and Australia (Yara, n.d.a). Of the other initiatives, Yara signed two memorandums of understanding in Japan (Yara, 2021). One of these is to collaborate on establishing clean ammonia supply chains in Japan. The other is to explore the establishment of a domestic clean ammonia distribution network and a bunkering business.

5.3 ASKO and the ASKO Maritime Project

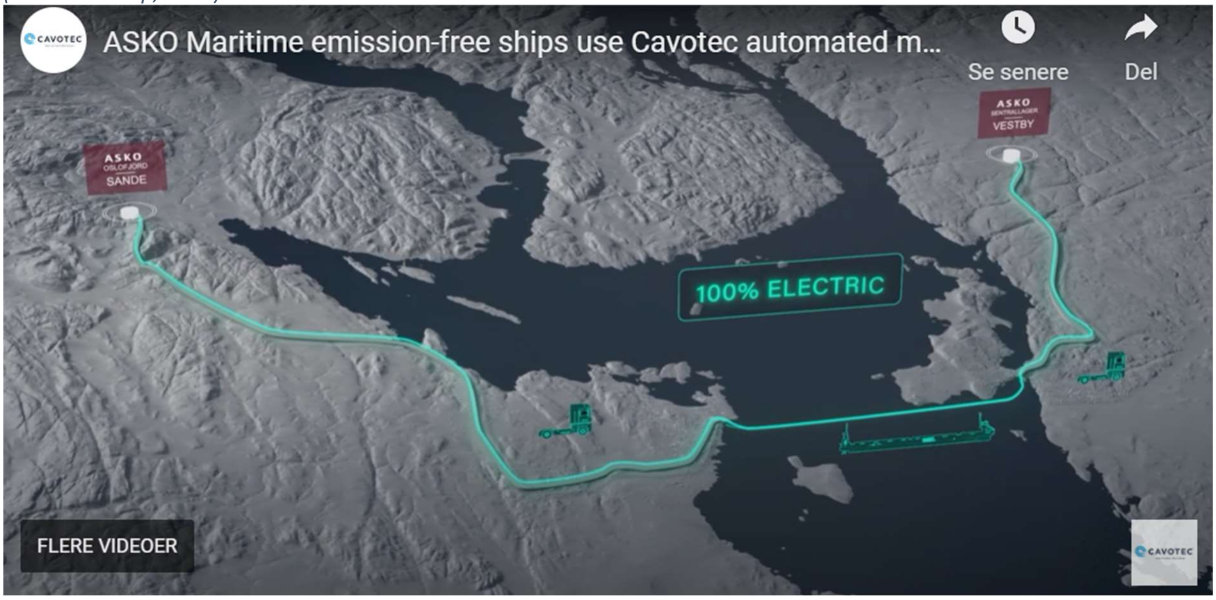
ASKO Norge AS is Norway's largest grocery wholesaler and part of NorgesGruppen (ASKO, n.d.a.). ASKO is one of NorgesGruppen's core business models. ASKO Norge AS owns approximately 20 companies. ASKO ensures effective distribution of products to the grocery, retail convenience goods and institutional catering sectors. It has extensive experience in making use of different transport modes to optimise logistical operations—on road, rail and sea—both domestically and internationally.

ASKO's ambition is to become sustainable and climate-neutral (ASKO, n.d.b.). It will achieve this by increasing efficiency in the use of energy, making use of renewable and sustainable energy and ensuring zero emissions during the transport of goods. This requires large investments in renewable energy and transport. The corporation wants to be at the forefront of the wholesale grocery market by developing environmentally sustainable solutions and improving efficiency when transporting goods. It accepts taking risks, and some of the investments may have lower returns compared to other types of corporate investments. One example of a previous project was when the transport of wholesale groceries was moved from trailers to trains between Trondheim and Bodø (ASKO, 2019). This was made possible because ASKO made a joint agreement with other actors who needed to transport goods on the same route. By using a train for transport, 13,000 trailers were removed from the road on this route, which reduced CO_2 emissions and the traffic load on the roads.

According to the research interview with ASKO Maritime's managing director, the ASKO Maritime project and the work of developing a solution for autonomous short sea shipping commenced in 2016. ASKO Maritime AS is a subsidiary of ASKO and was formally established in June 2020. In 2020, ASKO invested in two ships for the first time. The ASKO Maritime project develops and offers emission-free, autonomous sea transport and efficient loading operations of trailers in ports. It offers its services to other subsidiaries of the corporation and to external customers who need to transport trailers across the Oslofjord (see Figure 6). It has already made agreements with two external customers. The two ships and port operations are expected to be in service as of 2022.

Figure 6

The ASKO Maritime project provides efficient and emission-free distribution of wholesale groceries between warehouses (Cavotec Group, 2021)



'The corporation saw autonomous sea transport and automatic port operations as an opportunity to innovate its business model because it owns the entire value chain for transporting goods in addition to being the owner of the goods' (Managing Director, 2021). This makes it possible to consider all the costs and benefits of warehouse-to-warehouse. 'The investment in technical and systemic developments and operations (for autonomous ships and automatic port operations) will reduce the total costs for ASKO[10] because these services reduce the investment costs and operational costs for electric-driven trucks' (Managing Director, 2021). This makes the company different from a shipowner or a logistics company when considering its opportunities and challenges. This difference enables ASKO to see the total effect of their investments, risks and opportunities.

The current solution involves wholesale groceries being driven between two warehouses by diesel-powered trailers (Managing Director, 2021). The trailers use either the existing ferry or drive through a tunnel under the Oslofjord. The costs of transporting goods with trailers are expected to increase due to increased taxes on CO_2 emissions, increased road taxes and increased congestion. At the same

[10] Compared with electric-driven trailers and the use of the existing ferry

time, it is expected that the costs of emission-free trailers will be more expensive than those of traditional trailers. The introduction of electric-driven trucks (and their limited capacity and higher costs), in combination with a digital cargo chain management system and automatic loading and autonomous ships, are enabling technologies for the change in the way wholesale groceries are being transported. 'The additional costs of investing in and operating autonomous sea transport and ports are lower than the additional costs of investing in and operating additional electric-driven trucks' (Managing Director, 2021). By transporting the trailers only between the warehouse and the port, ASKO will need fewer electric-driven trucks and fewer man-hours than it does currently. This will result in less investment and operating costs for the road transport of trailers compared with not making use of autonomous ship transport.

'To achieve efficient and emission-free transport between warehouses, ASKO has taken the leading role among developers in digital transformation' (Managing Director, 2021). This means that they have taken the lead and invested in the development of electric-driven trailers between warehouse and port (other subsidiaries of ASKO), automatic, electric-driven harbour tractors and port operations and emission-free, autonomous ships (with the option of two more identical ships). The ships will initially have a crew on board. In the future, they will be operated from land. ASKO Maritime has chosen to load and unload trailers using a harbour tractor. This means that guidelines provided by the Norwegian Public Roads Administration already exist for ferry quay facilities and ramps.[11] The ports for car ferries in Norway already comply with these guidelines today.

'Service suppliers are considered partners in this project.' (Managing Director, 2021). Several technical solutions are being developed by different product and service providers, which also present challenges. 'Collaboration, trust and allowing time for the partners to establish their business models have been essential to coordinating the suppliers involved.' Managing Director, 2021). To maintain long-term value capture, it is important for ASKO Maritime that systems and technologies are not locked to one supplier. This will give ASKO Maritime flexibility in selecting other suppliers and other technical solutions in the future.

> For example, Kalmar (Cargotec) delivers two pilot electric-driven harbour tractors, while another company, Red Rock, fits the tractors with equipment for autonomous manoeuvres. The Red Rock[12] installation system on the Kalmar tractors may also be used on tractors from other manufacturers. (Managing Director, 2021)

Other cargo owners transporting goods, the transporting firms it uses, and its suppliers are key partners for ASKO Maritime (Managing Director, 2021). When more cargo owners make use of ASKO Maritime's service, positive impacts increase. 'For other cargo owners, the transportation needs may

[11] See Håndbok V431, V432 and V433 (Norwegian Public Roads Administration, n.d.)

[12] Red Rock is an engineering company in marine, offshore and IT development. It was recently acquired by Ocean Infinity, a marine robotics company (Ocean Infinity, 2021).

be complementary. For example, while one cargo owner has peaks in November and December, another cargo owner may have peaks in January and February' (Managing Director, 2021).

Integrating port operations and autonomous sea transport with road transport requires greater coordination and interdependencies between cargo owners, road transport providers, port operators and ship operators (Managing Director, 2021). ASKO Maritime will make use of an existing supply chain management system for the coordination and billing of transport operations between actors. This system is currently being modified to meet the needs of combining road and sea transport and using container cargo (other than groceries) on trolleys. This makes the other owners of the supply chain management system, TakeCargo, important partners.

Taking the lead and investing in this work also involve other risks and uncertainties (Managing Director, 2021). One uncertainty for the business model is what the regulations for the operation of autonomous ships will be and when these will be established, specifically how many operators will be required in the control centre for the operation of the ships (Managing Director, 2021). Sailing with a crew on board affects the economy of the project. The number of operators also affects the economy of the project. Both uncertainties—what the requirements will be and when they will be imposed—may increase operational costs and reduce ASKO's share of value capture. 'This uncertainty also limits ASKO's ability to plan how it can scale up the use of autonomous ships to other ports' (Managing Director, 2021). A contributor to reducing the uncertainties of introducing new services is that income is predictable. ASKO's transport needs between the two warehouses are predictable and high in volume. The costs of sea crossing are not significantly different from what ASKO pays for the existing ferry. Additionally, ASKO will receive income from at least two external customers with predictable transport needs.

Scaling up its service, for example, by sailing to other ports or between other ports, may be possible (Managing Director, 2021). However, uncertainties in what the regulations will be and when they will be established limit ASKO Maritime's planning for such a possibility. Warehouses along the Norwegian coast are often located in the vicinity of a small port. This means that warehouses are often located within the range of electric-driven trucks from ports. 'The most challenging part for ASKO Maritime to scale up their services is to explain to potential new customers that the gains will be higher than the costs when making use of autonomous ships and port operations' (Managing Director, 2021). This is again linked to external customers' willingness to invest in and change their systems and agreements with transport providers. In some situations, where the cargo will be delivered to another port, the port facilities must meet the necessary standards for autonomous ships. This will require additional costs and may demand time and resources to build port facilities for potential customers. This also challenges how the involved actors should change their business models and how the additional value will be shared in a fair way among the involved actors.

ASKO Maritime's business model of short sea autonomous ship transport and efficient port operations has a better likelihood of being scaled up if coordination and collaboration between large ports are improved (Managing Director, 2021). Collaboration with port authorities has a positive impact because it may increase the use of ASKO Maritime's services. For example, the ports of Moss and Horten are aligned with their specialities. The port of Horten has specialised in bulk cargo, while the port of Moss has specialised in containers. The services provided by ASKO Maritime and coordination between the ports provide synergies, resulting in fewer investment costs and less use of the port area. Local port authorities are also an important actor for ASKO Maritime because they permit the use of the ports. 'The pressure of land along the coast is high, and it is therefore necessary that port operations do not take hold of large land areas' (Managing Director, 2021). One challenge with ports in Norway is the alignment of a few large ports[13] (hubs for international trade) and their coordination with local infrastructure (road, rail and short sea shipping). One alternative could be to have a few international ports and a network of several smaller ports for trailers. Short sea shipping may transport goods between the few large ports and the many small local ports (Managing Director, 2021).

Another possibility for scaling up is to reduce the costs of transporting empty trailers (Managing Director, 2021). This is an example of how the traditional models of ownership of transport materials are a hindrance to increasing efficiency in transportation and reducing environmental impacts. For example, a pool of trailers may be rented out to transporters to increase positive impacts. This may again require other business models and coordination between the actors.

For society, ASKO Maritime's services may reduce the traffic load on roads and reduce the demand for investing in new land infrastructure (roads, tunnels, bridges) (Managing Director, 2021).

> Transporting cargo to local ports may also reduce the demand for local ferries. This again may reduce the need to increase the trailer capacity of ferries. For the government or local authorities, the costs of investing in port facilities may be lower than investing in road infrastructure or new ferries with increased trailer capacity. (Managing Director, 2021)

5.4 Massterly (Wilhelmsen and Kongsberg Maritime)

This section presents Massterly and the two firms behind it.

Massterly

Massterly is the world's first company set up to operate autonomous vessels in the merchant fleet (Kongsberg Maritime, 2018). Massterly was established in 2018 as a joint venture by Wilhelmsen and Kongsberg Maritime. Wilhelmsen is an international ship manager, ship agent and product and service supplier (Wilhelmsen, 2021). Kongsberg Maritime is an international product and service supplier in the maritime industry (Kongsberg Maritime, n.d.b.). The company will enable both Wilhelmsen and Kongsberg Maritime to take the next step in autonomous shipping by offering a complete value chain for autonomous vessels, from design and development to control systems, logistics services and vessel operations (Massterly, n.d.).

[13] Relatively large based on the Norwegian standard

The customer is the owner of the ship (VP of Business Development, 2021). Massterly's acquired competence and services in operating unmanned ships give it a comparative advantage over traditional ship management companies (VP of Business Development, 2021). Massterly expects that, traditionally, ship owners (which are not necessarily cargo owners) will make use of its services in the future. 'Shipping has a long tradition of effectivization and reducing the number of seafarers on board the ships. Unmanned and autonomous ships are a continuation of this effort' (VP of Business Development, 2021).

Massterly offers to make ships smarter, enabling ships to operate more autonomously, which reduces investment and operating costs (VP of Business Development, 2021).

> The investment costs will be reduced because the ships do not need to have accommodation for the seafarers and meet the requirements for personnel on board. These reductions in building costs outweigh the investment costs of new technology to make the ships autonomous. The operating costs will be reduced when ships can be operated from land and eventually become autonomous. (VP of Business Development, 2021)

Massterly has two customers: ASKO and Yara (VP of Business Development, 2021). Massterly will supply its ships with competent seafarers and will be responsible for the technical management of the ships. These two services are the same as those of a traditional ship manager, except that they will have a land-based operation centre for the ships, which will enable the ships to be unmanned. Massterly has supervised the building of ASKO's and Yara's ships. In practice, this has been done by hiring competent personnel from Wilhelmsen. Massterly will test the ships in operation during the first six months of 2022. This will give the company valuable insight into the use of new technologies for operating unmanned ships. The experiences Massterly gains will also be used by the authorities when they establish regulations for the remote operation of ships. One of Massterly's main uncertainties is the requirements for manning land-based operation centres. The manning level will have a direct consequence on the costs of operating the vessels.

'Massterly's core competence is its investment in the land-based operational (control) centre, which will enable the remote operation of ships' (VP of Business Development, 2021). Competent personnel for operating ships are supplied by Wilhelmsen Ship Management. Technologies for autonomous navigation and propulsion, including software and hardware for communication between the ships and the operation centre, are mainly supplied by Kongsberg Maritime. Kongsberg Maritime installs equipment and systems and provides regular services for maintenance and repair. Other product and service suppliers are also used with similar agreements. This means that the owners of Massterly are also its main product and service suppliers. Massterly's services depend on the quality of the technical solutions and competence (product and services) of its main suppliers. It is also dependent on others in that the ports are organised and provided with the technology and systems required for loading operations.

The value capture from cost reductions will be shared between Massterly, the ship owner (customer) and the product and service providers (VP of Business Development, 2021). The current income structure does not provide any significant upside for Massterly. 'When they have gained more experience, they will consider a more market-based income structure, which may change the distribution of risks and costs between Massterly and its customers' (VP of Business Development, 2021). New income models are also pending based on what regulations the authorities will impose.

The main opportunity with unmanned ships is that they will be more flexible to operate than manned ships and may replace road transport to some extent (VP of Business Development, 2021). The most significant reduction in carbon gas emissions will occur by replacing road transport with ship transport. This can be done by lowering the costs of ship transport as much as possible; alternatively, increasing the costs of road transport as much as possible.

> Requirements for ships to be emission-free increases sea transport costs and will only make a small contribution to the total reduction of greenhouse gas emissions. Increasing the costs of ship transport by requiring emission-free propulsion will increase the barrier to moving transport from road to sea. That is, requirements for ship transport to be emission-free are a hindrance when competing with road transport. (VP of Business Development, 2021)

Road transport has several competitive advantages compared to ship transport today (VP of Business Development, 2021). Transporting goods on trucks has low cost; the competence level for manning is low, access to labour is high, the trucks are standardised and produced in large quantities and trucks provide significant flexibility for shippers. Trucks also provide the possibility for greater frequency and reduce the time from production to delivery. Additionally, cargo has traditionally been damaged more often during loading for ship transport than for road transport.

'Technical solutions for efficient loading operations in small ports are the main hindrance for short sea shipping to be competitive with road transport' (VP of Business Development, 2021). The cargo will often be transported on road, loaded on a ship, unloaded at another port and finally transported on road to the end destination. This means that the cargo needs to be loaded twice to reach its destination.

> The experience is that the costs of these loadings amount to the same as shipping costs. This means that the port operations may become a bottleneck, thus delaying the transport, the costs of loading and unloading are high relative to the cost of sea transport and the operation has a greater risk of damaging the cargo. (VP of Business Development, 2021)

Unmanned and autonomous ships will be used for short sea shipping, but in the long run, they may also be used for deep sea shipping (VP of Business Development, 2021). For deep sea shipping, it is expected that it will take longer to establish international regulations than national regulations. A significant barrier to introducing autonomous ships for deep sea shipping is that the frequency of maintenance on board must be significantly reduced. The international ambition to reduce emissions from sea transport will require new technical solutions for propulsion, such as ammonia or hydrogen. This drive may also bring with it technologies that require less maintenance frequency. Shipping traditionally has three main costs: the investment cost of the ship, manning and fuel. The first two costs are drivers of increasing sailing speed. The last one (fuel) is a driver for reducing sailing speed. The optimal sailing speed is a cost-benefit balance among these three drivers. Unmanned ships mean that one of the drivers for increasing speed ceases, which implies that the optimal sailing speed can be reduced. New fuel types, such as ammonia or hydrogen, will cost more than traditional fuel, but by reducing sailing speed, the amount of fuel may be reduced. This may again result in lower fuel costs.

Wilh. Wilhelmsen

Wilh. Wilhelmsen Holding ASA was founded in 1861 and is a comprehensive global maritime group (Wilhelmsen, 2021). One of its four main business segments is providing ship management services. Wilhelmsen Ship Management is one of the world's largest third-party ship managers (Wilhelmsen, n.d.). The company delivers technical management for ship operations, crewing management to provide competent seafarers for ship operations and optimal operational expenditure (OPEX) management. The purpose of the latter is to deliver high vessel performance while maintaining OPEX. One of Wilh. Wilhelmsen Holding's subsidiary is RaaLabs, which offers services to ship managers. RaaLabs can access operational vessel data, digitalise onboard processes and empower the ship manager's crew (RaaLabs, 2021). This will increase ship managers' operational efficiency and reduce the environmental footprint of transported products.

Kongsberg Maritime

Kongsberg Maritime, a subsidiary of the Kongsberg Group, is a maritime technology and service provider (Kongsberg Maritime, n.d.b.). The Kongsberg Group is an international corporation delivering products and services to the maritime industry, defence, oil and gas, fisheries, aerospace and space industries (Kongsberg Group, n.d.a). It is mainly a product and service supplier that is increasingly focused on integrating these with services from the digitalisation of the industry. It has recently established Kongsberg Digital, a provider of next-generation software and digital solutions to customers within maritime, oil, gas and utility industries (Kongsberg Group, n.d.a.).

Kongsberg Maritime is responsible for all key enabling technologies, including the sensors and integration required for remote and autonomous operations, in addition to the electric drive, battery and propulsion control systems for the Yara Birkeland project (Kongsberg, 2017). Kongsberg Maritime will equip the two vessels for ASKO Maritime with the technology required for zero emissions and unmanned operations (Konsgberg Group, 2020).

Kongsberg Maritime's competitive advantage is that there is no other company manufacturer with more of the systems needed for autonomous ships than it has (Kongsberg Maritime, n.d.a). Its systems are designed to integrate with each other. Its systems deliver cost savings and enhance vessel safety, reliability and availability. Integration of its systems strengthens decision making, continuously optimises energy use and increases productivity. Kongsberg Maritime is involved in several development projects within autonomous shipping and holds contracts for the delivery of complete autonomous ship solutions (Kongsberg Maritime, n.d.a). Its main customers are shipping companies. Kongsberg Maritime has more than 20 years of experience in providing autonomous underwater vehicles and it makes use of technology and experiences from the defence industry. Its experience, portfolio of products and systems and how they are integrated with each other make it a provider of control systems for autonomous ships. It supplies marine technology and services for ship operations for navigation, communication, information management, machinery and propulsion, power, cranes, cargo operations, etc. It helps customers create the best integrated solutions for their vessels to achieve efficient, sustainable operations.

6. Discussion of the Findings from the Case Study

Section 6.1 investigates how incumbent firms introduce digital transformation into their offerings. This section will make use of the theory described in Sections 2 and 3 and the methodology designed in Section 4 to provide answers to the first research question. The analysis will concentrate on three actors: Yara, ASKO and Massterly. It will analyse the challenges and opportunities that each of these actors faces in the two projects: the Yara Birkeland project and the ASKO Maritime project. The analysis also includes observations of any changes in the companies' business models and whether they are innovations from an existing business model or if a new business model has been developed. This will lead to a discussion of the firm's main drivers for the changes it has made to its business models. This discussion forms the basis for evaluating the extent to which innovation of the actors' business models creates a new market (market-creating innovation) or increases efficiency in an existing market (efficiency innovation).

Section 6.2 describes the main challenges in digital transformation projects and discusses whether the actors are considered to be taking part in the emergence of a business ecosystem. The following is about what challenges and opportunities the actors involved in the two projects are facing and what co-values they create, deliver and capture together. The challenges, opportunities and co-values are grouped into three levels, which will provide a better understanding of what the firm (micro), the network (meso) and society (macro) are facing. Of particular interest are the meso level and the differences observed between the two projects regarding co-values.

Section 6.3 discusses the modularity, the impact of different types of complementarities and the resulting fungibility of the emerging business ecosystem(s). According to ecosystem theory, the elements tie ecosystem members together in a web of interdependent yet autonomous activities. This approach provides an understanding of how actors create value together by describing the types of complementarities. One observation is that the two projects seem to have different types of complementarities. This final section discusses whether uncertainties about the two interrelated fungibilities explain why the business ecosystem remains emerging, whether two separate ecosystems are developed or if the modularisation and extent of complementarities will eventually be aligned into one ecosystem.

6.1 Priority in Digital Transformation Projects

The technical developments for digital transformation are being developed in partnership with Yara's and ASKO's suppliers. This means that the main actors taking part in the digital transformation projects, in addition to Yara and ASKO, are ship managers (Massterly), ship product and service suppliers (Wilhelmsen, Kongsberg Maritime), a crane manufacturer (Kalmar/Cargotec), a harbour tractor manufacturer (Kalmar/Cargotec), automation developers (e.g., Red Rock), port authorities and operators, cargo transporters (truck drivers) and other cargo owners. These actors are dependent on each other to deliver the prospected value of increased efficiency, reduced road transport and reduced emissions. Yara and ASKO have taken the lead in coordinating development. Many of the actors are involved in both projects.

The priority in their digital transformation projects is to develop effective (digital) cargo supply chain management. The reason for this is based on the fact that the digital transformation projects have in common the ambition of developing autonomous ships, autonomous port operations and digital cargo supply chain management. The latter connects the cargo owner with cargo transporters, port operations and sea transport and is a necessary communication channel for the efficient transport of goods. It requires that information flows are aligned between the various actors and activities, resulting in an additional challenge related to technical developments; namely, that in addition to developing digital, automatic and autonomous systems for the components (transport order, ship, crane, harbour tractor, port facility, etc.), each of these components is dependent on receiving and providing information to the others. If one component is not sufficiently digitalised or the flow of information between the components is insufficient, this will impact how much efficiency is gained from the project. For example, if, when loading, information about the containers is not sufficiently provided to ship operators, it will impact ship operations and unloading operation efficiency. The cost (with respect to punctuality and quality) of using ships may be higher than the alternative. In short, without functional digital cargo supply chain management, the transaction costs between activities will be greater and the gains from investments will be less than expected. Based on the findings in section 5, digital cargo supply chain management is more important to have in place than autonomous crane operations, autonomous harbour tractors or autonomous ships. Both projects are currently developing all three elements; however, stepwise, where the initial ambition for port operations and sea transport will have a large degree of automation before they eventually become autonomous. The development of digital cargo supply chain management has been given priority in both projects.

6.2 Market-Creating Innovation or Efficiency Innovation of the Business Model

Yara and the Yara Birkeland Project

The Yara Birkeland project involves more than the development of an emission-free autonomous ship. It is also about the digitalisation of logistics, renewing a quay and cargo and crane operations.

Yara saw the Yara Birkeland project as an opportunity for market-creating innovation of a business model but has so far ended up with efficiency innovation (see Section 3.1) (Christensen & Dillon, 2020). So far, the drive for business model innovation has been to meet a new customer need for emission-free transport of fertilisers (commercial driver) in combination with the expectation that the costs for greenhouse gas emissions and road transport will increase (institutional driver). This has resulted in only small changes to Yara's business model of producing fertiliser products, see Table 7. The changes are based on top-management action (designed); they are novel, compared with other incumbents' business models in the same industry and they are non-trivial. In sum, the changes are a business model innovation (see the definition of business model innovation in Section 3.2). Its innovation of its business model has resulted in the sustainable transport of its products to the nearest port.

The ambitions of flexible production and transportation and a new business model (i.e. a market-creating innovation) were driven by the promising opportunities of new technologies, in this case, digital transformation and autonomous operations (technological driver). However, these ambitions have not yet been realised. One of Yara's opportunities, which was not realised, was to create a more flexible system for the production and transportation of its products. The second opportunity that was not realised was the development of a new business area to provide strategic partnerships in technology, transport and logistics. The ambition was to develop a total transport system to meet the needs of goods producers that want smaller ships, a more flexible system involving calls on smaller ports, more ports and more direct routes. The use of autonomous ships, as well as autonomous cargo handling, were enabling factors for developing this type of transport system. By offering its services to external customers and expanding to other quays, this could have been the start of creating a market with a value proposition where Yara Birkeland AS was at the core of forming a network of technology, transport and logistics. This new business area would be decoupled from Yara's core competence in producing fertilisers.

The reason the market-creating innovation was not realised was that groundbreaking development of IT systems for logistic operations and groundbreaking development of autonomous cargo handling, in combination with groundbreaking autonomous sea transport, became too complicated and resource intensive for Yara to pursue at the same time (Cargotec, 2018; Stensvold, 2020, 2021). Yara did not initially have a digital logistics system for cargo handling that it could improve; rather, it needed to develop one from the ground up. Yara's investments in developing autonomous crane operations probably provided more learning to the crane manufacturer than to Yara. Yara decided to prioritise the development of the ship and reduce the ambitions of the two other projects. This decision had the consequence that much of the competence Yara Birkeland AS needed to develop for its business model was not acquired. This limited Yara Birkeland AS's potential to build up the necessary competence for technical and logistic solutions, a network of suppliers and developers or a network of partners and customers needed for the job to be done.

By comparing the establishment of the company Yara Birkeland AS and the three related groundbreaking development projects with the new business unit Yara Clean Ammonia (in 2020), the latter is closest to Yara's core competence. Yara's core business is to produce competitive and effective fertiliser products. Transportation of its products is only a way to deliver this value. Clean ammonia projects are innovations at the heart of Yara's core product, producing fertilisers, which are probably also efficient innovations of its business model. Clean ammonia projects are a predictive way for an incumbent company in a traditional industry to innovate its business model.

Table 7

Yara and Yara Birkeland AS—business model before and after

Yara (Birkeland AS)

<table>
<tr><th>Categorisation</th><th>Business model before digital transformation</th><th>Challenges</th><th>Opportunities</th><th>Firm's business model innovation or development of new business model</th><th>Business model after digital transformation</th><th>Main change drivers for business model innovation</th><th>Stage of firm's business model journey</th></tr>
<tr><td>Value creation</td><td>Competitive and effective fertiliser products</td><td>Transportation of its products is not sufficiently sustainable (using diesel trucks and conventional ships)</td><td>Sustainable transportation of its products;
more flexible production and transportation of its products—connecting producer with consumer through transport logistics;
new business area by providing strategic partnerships in technology, transport and logistics</td><td>Emission-free transport of cargo in containers between the production facility and the nearest shipping port</td><td>Same as previous, and the emission-free transport of the cargo to the nearest shipping port</td><td rowspan="4">Emission-free transport of fertilisers is a new customer need (commercial driver) in combination with expectations that the costs for greenhouse gas emissions and road transport will increase (institutional driver)

The ambitions of the new business area and flexible production and transportation were driven by new technologies and the opportunities of digital transformation (technology driver); however, these ambitions have not yet been realised</td><td rowspan="4">Yara saw the opportunity of market-creating innovation, but ended up with efficiency innovation

Its attempts to innovate its business model and develop a new business model resulted in sustainable transporting of its products to the nearest port</td></tr>
<tr><td>Value delivery – resources:</td><td>Cargo transported in containers on trucks to the ports for shipping to Europe and Asia</td><td>Emissions and heavy cargo transport through a rural area

Manual operations and emissions from cargo operations at production facilities</td><td>Groundbreaking development for autonomous operations of cargo from the production facility to the destination, reducing emissions and road transport</td><td>Investment in a ship and a gantry crane</td><td>Emission-free, autonomous, short sea transport of containers to the nearest shipping port; same as previous, and emission-free gantry crane operated from a control room</td></tr>
<tr><td>Value delivery – processes:</td><td>Suppliers for transport trucks and ship logistics service providers; logistics of truck operations between the production facility and ports</td><td>Yara does not have the lead in the logistics for transporting its products to the consumer;
logistic operations for cargo transport are not digitalised and not aligned between local transport and shipping to the world</td><td>Groundbreaking developments of a new IT systems for autonomous loading of containers, transportation at the facility, loading on board the ship and communicating with logistics service providers</td><td>Digitalisation of cargo management at the production facility</td><td>Same as previous, and digital logistic solution for transport of the containers from its production facility via its new quay to the nearest port</td></tr>
<tr><td>Value capture:</td><td>Suppliers for transport of the goods</td><td>Uncertainties in regulations for autonomous ships—requirements to operators and when regulations will be established</td><td></td><td>Massterly as a new service provider for the operation of its ship</td><td>Same as previous</td></tr>
</table>

ASKO and the ASKO Maritime Project

The ASKO Maritime project develops and offers emission-free, autonomous sea transport and efficient loading operations of trailers in ports. These services are offered through ASKO Maritime AS. When comparing the business model before and after digital transformation, attention is paid to the distribution of goods between two warehouses and what autonomous ships and port operations introduce in the way of changes to value creation, delivery and capture. This study aims to describe the effect of digital transformation on ASKO's business model. The effects of the digital transformation are not only for ASKO Maritime AS but also for other subsidiaries of ASKO; thus, the effects for the corporation will be described, but not the effects of the transformation on any specific subsidiary of the corporation.

The main drive for digital transformation has been to meet the internal ambitions of sustainability, remain competitive and meet new demands in the existing market (commercial drivers). Emission-free transport provides NorgesGruppen's consumers with additional value. Another driver is the expectation that the costs for greenhouse gas emissions and road transport will increase (institutional driver). The ambitions of ASKO Maritime AS as a new business area were driven by new technologies and the opportunities for digital transformation (technology driver).

The changes ASKO has made so far are mainly efficiency innovations to its existing business model (the third stage of the business model's journey, as described by Christensen & Dillon (2020)), see Table 8. The reason for this is that the ASKO Maritime project is a continuation of improving efficiency in the logistics process. After technical developments, ASKO's business model involves the efficient *and* emission-free distribution of wholesale groceries between the two warehouses. The main difference after digital transformation is that the value creation it offers (and delivers) is emission-free transportation. The other difference is that ASKO Maritime will offer its services to external customers. The changes are based on top-management action (designed), they are novel, compared with other incumbents' business models in the same industry and they are non-trivial. In sum, the changes are a business model innovation. ASKO's business model innovation facilitates modularity. Because ASKO Maritime also provides services to external customers, it is possible to create a new market for sustainable transport by combining road and sea transport in the future. This means that the innovation of its business model may have the potential to replace road transport for its service to a large extent, potentially more than just between the ports of Moss and Horten.

One argument that ASKO Maritime represents a market-creating innovation is that it has taken another position in the value chain by being a service provider of port operations and sea transport. However, the innovation of its business model has been within the competencies of the transport logistics industry. In the development of its new services, ASKO has made use of its key resources, namely its extensive knowledge of logistics, long-term supplier relations and negotiation skills in negotiating agreements with suppliers. ASKO's skills in logistics distribution systems are an important backbone of NorgesGruppen. In addition, by comparing the innovations of ASKO Maritime with another one of its recent initiatives, the changes are not significantly different. In 2019, ASKO committed, in collaboration with others, to replacing trailers with trains. The most recent one invested ASKO in ships, while the first was committed to transporting a certain amount of goods via train. In sum, it leaves the impression that the changes ASKO has made thus far are more about innovating its existing business model and less about developing a new one.

Another argument for why business model innovation mainly achieves efficiency is that the changes in value delivery are primarily related to ASKO's use of service suppliers and modularity. ASKO has taken the lead in digital transformation by coordinating and aligning the technical developments of its suppliers. It has avoided being strongly committed to one technical solution or supplier. The choice of technology may result in lock-ins that limit ASKO's negotiation abilities, which again may influence how value capture is shared between ASKO and its suppliers. One example is the development of electric-driven automatic port tractors. ASKO coordinates the delivery of electrical-driven tractors by one manufacturer, while the automation system (for the parking of trailers) is fitted on these tractors by another supplier. ASKO's requirement for the technical solution is that the automation system can be fitted to a port tractor from another manufacturer. This design of modularity gives ASKO the possibility of replacing suppliers in the future and therefore limits the risk of being locked in. One exemption is its investment in ships. The ships and the equipment they are fitted with make them strongly committed to one manufacturer and service provider—Kongsberg Maritime. The investment and operation risks have been reduced by the government through Enova. To summarise, ASKO has established agreements with existing and new suppliers for the development of technical solutions. This makes it possible to facilitate modularity and continues ASKO's tradition of collaborating with suppliers and finding new ways to make logistics more efficient.

Table 8

ASKO and ASKO Maritime AS—business model before and after

ASKO Maritime AS

Categorisation	*Business model **before** digital transformation*	*Challenges*	*Opportunities*	*Firm's business model innovation or development of new business model*	*Business model **after** digital transformation*	*Main change drivers for business model innovation*	*Stage of firm's business model journey*
Value creation	ASKO: Efficient distribution of wholesale groceries between warehouses	How can we meet internal ambitions and consumers' expectations of sustainability and, at the same time, continue to be competitive?	Emission-free transport between warehouses	Establishing ASKO Maritime will allow ASKO to be a service supplier of emission-free port operations and short sea transport	ASKO: Efficient *and* emission-free distribution of wholesale groceries between warehouses ASKO Maritime: Emission-free, autonomous sea transport and efficient loading operations of trailers (containers on trolleys) in ports for internal and external customers	Emission-free transport of wholesale groceries is a new customer need and internal ambitions of sustainability and continue to be competitive (commercial driver), in combination with expectations that the costs for greenhouse gas emissions and road transport will increase (institutional driver) The ambitions of the new business area were driven by new technologies and the opportunities of digital transformation (technology driver)	Efficiency innovation is prioritised; reducing emissions has become a more significant parameter for efficiency Language is about costs and efficiency The business model is based on traditional logistics, except that it provides service and income from external customers Innovation facilitates modularity
Value delivery – resources:	Wholesale groceries are transported with diesel-driven trailers. The trailers used the ferry or tunnel to cross the Oslofjord Extensive knowledge of logistics, long-term supplier relations and negotiation skills for supplier agreements were required (e.g. to supply and maintain trailers)	Uncertainty in what will be technical solutions and the economy in emission-free transport of wholesale groceries	The advantage is that ASKO is a cargo owner *and* a logistic company	Increased knowledge in and network for digital transformation and emission-free transport solutions New suppliers	Same as previous, and: ASKO: Electrical-driven trailers between warehouses and ports ASKO Maritime: Automatic, electrical-driven harbour tractors and port operations; emission-free, autonomous ships		
Value delivery – processes:	Chain supply management system	Sea transport and port operations make the logistics of the distribution more complicated	Taking the lead role in the digital transformation	Modifications in the chain supply management system	Same as previous, and port and ship operations included in its logistic distribution system for internal and external customers and suppliers		
Value capture:	Financial value capture shared between the corporation and its suppliers	The costs of transport with trailers are expected to increase. Uncertainties in regulations for autonomous ships—requirements to operators and when regulations will be established	The innovation may reduce the total costs for ASKO compared to electric-driven trailers between the two warehouses; income from external customers	Income from external customers	Same as previous, and income from external customers; value capture depending on regulations for the operation of autonomous ships; value capture depending on the flexibility of suppliers		

Massterly

Massterly is the first mover in providing technical and operational services for autonomous ships to the merchant fleet.[14] The two companies behind it, Wilhelmsen and Kongsberg Maritime, have significant international positions in their respective markets within the maritime industry.

The way Massterly has adopted digital transformation into its offering has not triggered any market-creating innovation, but efficient innovation of the business model, when compared to the business model of Wilhelmsen Ship Management. Efficiency, in the form of a reduction in operating costs (for the ship owner and ship operator) and investment costs (for the ship owner), has been the driver of Massterly's business model. New technologies enable a reduction in investment and operational costs for ship owners (technology driver) and new capabilities of operating the ships from a land base diversify Massterly from other ship management companies (commercial driver).

Traditional business models are often rigid and facilitate modularity through the extensive use of product and service suppliers (Christensen et al., 2016). The acquired capabilities of (land-based) operation centres diversify Massterly from other ship management companies. The changes are based on top-management action (designed); they are novel, compared with other incumbents' business models in the same industry and they are non-trivial. In sum, the changes are a business model innovation.

The main change drivers for business model innovation are that the new technologies enable a reduction in investment and operational costs for ship owners (technology driver) and that this is a diversification from competitors through the development of new capabilities (commercial drivers).

Comparing the business models of Wilhelmsen Ship Management's and Massterly's ship management services provides the impression that the differences between these two are small, see Table 9. The value creation they both offer is the same: their main services are to supply competent crew and technical management for the operation of ships. The two most significant but obvious differences are in relation to how they deliver their value. The first difference is that Massterly provides competence in the remote operation of ships, in addition to providing competence for manning the ships. The second is that Massterly has a stronger relationship and commitment to one technical and service provider, namely one of its owners, Kongsberg Maritime. Massterly currently has another structure for capturing value than a traditional ship management company; however, this structure is expected to change when it gains more experience in the use of autonomous ships.

Massterly's main opportunity is that autonomous ships will reduce investment and operational costs compared to building and operating traditional ships. Being the first mover and improving its competence in building and operating ships from shore will have a comparative advantage over other ship management companies. It will be able to deliver the same services to ship owners but

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[14] To be more precise, it provides maritime autonomous surface ships for the merchant fleet, i.e. a ship which, to a varying degree, can operate independently of human interaction (Massterly, n.d.). Other companies already provide unmanned surface vehicles and unmanned underwater vehicles.

with reduced costs. The capture from this will be shared between Massterly, the shipowners (customers) and the product and service providers. This will ensure that Massterly and Wilhelmsen Ship Management continue to be competitive internationally for ship management services, and Kongsberg Maritime will continue to be competitive by providing products and services.

Massterly is dependent on what other actors organise and invest in technology to make port operations efficient. On the other hand, provided that short sea shipping will be competitive with road transport, Massterly has an opportunity to take part in a new ship management segment. When it comes to the opportunities of providing its services for deep sea shipping, it will depend on international regulations for autonomous shipping and the new ships having technology that enables low frequency of maintenance and high reliability of navigation and cargo control. In the meantime, Massterly might have opportunities to provide services for greater navigation reliability.

Table 9

Massterly—business model before and after

Firm Massterly[15]

Categorisation	*Business model **before** digital transformation*	*Challenges*	*Opportunities*	*Firm's business model innovation or development of new business model*	*Business model **after** digital transformation*	*Main change drivers for business model innovation*	*Stage of firm's business model journey*
Value creation	Deliver high vessel performance while optimal OPEX; supply competent crew for operation of the ships; technical management of the ship		Increase its market shares in the existing market; to a lesser extent, increased market by replacing road transport with sea transport		Same as previous	New technologies that enable a reduction in investment and operational costs for the ship owners (technology driver) Diversification from competitors by developing new capabilities (commercial driver)	Efficiency innovation is prioritised Language is about costs and efficiency The business model is based on a traditional business model in shipping The business model innovation is not significant; the traditional business model in shipping is rigid and facilitates modularity
Value delivery – resources:	Manning agency for operation of the ships; technical and operational competency for ship management	Uncertainties about the performance of technology for unmanned operations of the ships		Control centre for operation of the ships	Same as previous, and competency in the remote operation of ships		
Value delivery – processes:	Processes and systems for relation to customers and suppliers, manning and ship management				Stronger relation/commitment to one supplier of products and services for unmanned and autonomous ship operation		
Value capture:		Uncertainty about what the national and international regulations for unmanned operation will be	Reduce investment costs for customers; reduce operational costs for customers	Cost structure for operating the control centre; in the future, increase its share of value capture	The fee for its remote operating service is based on the costs of the operation centre		

[15]The firm Massterly was recently established as a joint venture. It had no original business model before. However, the business model may be considered to be derived from the established business model of a traditional ship management company (i.e. Wilhelmsen Ship Management, a subsidiary of Wilh. Wilhelmsen Holding ASA).

Similarities and Differences Between the Business Model Innovation of Yara and ASKO

What are the differences and similarities between the business model innovations of Yara and ASKO? Of similarity is that their business model innovations have been aimed at increasing the efficiency of transport. Their main drivers for business model innovation have been a combination of meeting new customer needs and remaining competitive (commercial drivers), the expectation that the costs for greenhouse gas emission and road transport will increase (institutional driver) and that digitalisation and the introduction of automation and autonomy was considered an opportunity for a new business area (technology driver). The main difference from the companies' previous business models is that the value they create will be emission-free transport of goods for a particular distance (i.e. from the east to the west side of the Oslofjord and from Herøya to Brevik). The main difference in value creation between the two companies is that ASKO offers its services to external customers. Yara may also offer its services to external customers, which means that this difference may not be significant in the long run.

The main differences between the business model innovations of Yara and ASKO are in how they innovate value delivery and capture. For value delivery, ASKO only needed to modify an existing digital logistics system commonly used for transporting wholesale groceries in Norway. Yara needed to develop a digital logistics system at its production facility. The difference in value capture is that Yara uses one supplier for developing the loading operations, while ASKO uses several suppliers and coordinates them for developing the port operations.

The reason for the main difference in value delivery is that ASKO was already a logistics provider. Its competence in logistics is one of NorgesGruppen's backbones. It already had a digital logistics system in place that only needed to be modified. In contrast, Yara is a cargo owner only and its core competence is not logistics. Development in three areas—logistic operations, autonomous cargo handling and autonomous sea transport—became too complicated and resource intensive for Yara to address at the same time. In contrast, ASKO has recent (and frequent) experiences collaborating with its suppliers for efficient transport, whether through trucks, trains or ships.

The above differences are also seen in relation to the extent of modularity, the use of service suppliers and how this influences how value capture is shared between the purchaser and supplier. Both projects transported a standard type of cargo: a container. Each company chose different loading and unloading systems. The ship Yara Birkeland is loaded using a harbour crane, while ASKO's ships are loaded using a standard ramp and harbour tractors. While Yara used one supplier to develop the loading operations, ASKO used several suppliers and coordinated them to develop the port operations. The consequence is that Yara becomes more dependent than ASKO on technology from one supplier, the crane manufacturer, while ASKO's modular design makes them less locked into technology from one supplier than Yara. This difference influences the negotiation powers between the purchaser and supplier, which again has consequences for which of them captures more of the value. This difference in modularity will be taken into consideration when investigating the complexity and interdependencies of the emerging business ecosystem.

Finally, Yara's and ASKO's projects have in common that they can be categorised as eco-innovations because replacing diesel-driven trailers with emission-free sea transport and cargo operations results in a reduction in environmental pollution (see definition by Garcia et al. (2019) in Section 3.3). In the next section, we make use of Garcia et al.'s (2019) approach for understanding value creation, delivery and capture within a micro-meso-macro systemic framework of competing goals.

6.3 Challenges and Opportunities in the Emergence of a Business Ecosystem

What opportunities and challenges are the projects facing? Is a business ecosystem emerging? How do the actors taking part in the two projects deliver value that they could not deliver alone? To answer these questions is the starting point of a previous discussion about the main challenges in the incumbent firms' digital transformation projects, given that the priority in both projects has been to develop effective (digital) cargo supply chain management (see Section 6.1 and 6.2). This provides a foundation for considering the extent to which and how the actors taking part in the two projects create, deliver and capture values at the micro, meso and macro levels.

Challenges, Opportunities and Co-values at the Meso Level

What challenges and opportunities are the Yara Birkeland project and the ASKO Maritime project facing? How can the values they co-create, co-deliver and co-capture (for simplicity, are these occasionally mentioned as co-values) be described? How can these co-values at the micro, meso and macro levels be distinguished from each other? Section 3.3 describes how the micro level concerns the firm. The meso level, or network partnership level, concerns inter-organisational networks, co-partnering institutions or other intermediate structures. This level involves the partners taking part in developing solutions and the actors taking part in the transport of containers. In other words, this level involves customers, complementors and suppliers. The third level, the macro level, is the societal level. At this level is value co-creation for the benefit of the environment and society.

Yara Birkeland AS and ASKO Maritime AS will be described at the micro level.[16] The micro level corresponds with what was previously described when answering the first research question (see Section 6.2). For a summary, see Table 10 and 11. The description at the macro level is similar for the projects. However, the research literature makes it difficult to understand the difference between value co-creation and co-capture at this level (see Section 2.3). One way to explain the co-values at the macro level is as follows: the opportunity for society is to reduce road transport and emissions. The value co-created by society is reduced emissions, reduced congestion on roads and reduced road incidents around the Oslofjord and in the municipality of Porsgrunn. The government has funded the projects (value co-delivery), which has reduced the risks of the projects. In return, society has reduced the demand for investment in road infrastructure (value co-capture).

Of particular interest are the meso level and the differences observed between the two projects. Table 10 and 11 highlights the main differences by using red text to differentiate between the two projects. The challenges at this level are either identical or similar between the two projects, but

[16] This is not precise; it could also be other entities of Yara and ASKO.

some of the opportunities and co-values are different. One challenge they have in common is that autonomous ship and cargo transport requires a greater degree of complexity and dependencies between actors than traditional transport using trailers. This is the main reason for observing an emerging business ecosystem with a value proposition in which one of the actors cannot deliver the value alone (refer to Urmetzer's (2021) definition in Section 3.2).

The most significant difference may explain why the total transaction costs in the ASKO Maritime project are considered lower than the transaction costs in the Yara Birkeland project. This difference is also related to the fact that autonomous ship and cargo transport require a greater degree of complexity and dependencies between the actors than does traditional transport using trailers. The difference between the two projects was observed in their development of a digital cargo supply chain management system. The Yara Birkeland project saw the challenge of increased complexity and dependencies as an opportunity to develop a flexible system for the production and transportation of its products; however, this was not enabled. While the Yara Birkeland project co-created a digital logistics solution for the transport of containers at the production facility, it was co-created in the ASKO Maritime project by including port and ship operations in a digital cargo chain management system already in use by transporters for wholesale grocery stores. ASKO (and its partners) only needed to make some adjustments to it. The difference is that, while the Yara Birkeland project delivers digital communication only for a transportation leg, another logistics system is used from the port of Brevik onwards. In the ASKO Maritime project, all the actors needed for transporting the containers from warehouse-to-warehouse (or door-to-door) are included in one system. The system used in the ASKO Maritime project serves as a digital platform for the actors taking part in the transport of the containers, which lowers the transaction costs compared to Yara's. These differences should be seen in relation to the fact that ASKO's core competence is cargo owners *and* logistics, while Yara's core competence is the production of cargo, where transportation is, to a large extent, provided by its suppliers.

Another significant difference between the two projects at the meso level is related to the design of modularity. In the next section, this difference is relevant when investigating the complexity and interdependencies of the emerging business ecosystem.

Table 10

Structure for analysing the actors to answer RQ 2 regarding opportunities and challenges and value creation, delivery and capture for the Yara Birkeland project; red text highlights the main differences at the meso level between the Yara Birkeland project and the ASKO Maritime project

	Network level	*Challenges*	*Opportunities*	*Value (co-) creation*	*Value (co-) delivery*	*Value (co-) capture*
	Micro – Yara Birkeland AS:	Transportation of its products is not sufficiently sustainable (by use of diesel trucks and conventional ships)	Emission-free transport between the production facility and shipping port; possibility for income from external customers	Same as previous, and emission-free transport of the cargo on sea to the nearest shipping port	Emission-free, autonomous, short sea transport of containers to the nearest shipping port; the emission-free gantry crane operated from a control room; renovated quay	Same as previous (cargo transport providers); value capture depending on regulations for operation of autonomous ships
Yara Birkeland project	Meso:	How to digitalise the transport products (ship, crane…) and systems and make them work together	Sharing of the risks and costs in developing new technologies between suppliers and Yara	Knowledge generated and shared between Yara, the crane manufacturer and the ship manager; expansion of networks; expansion of co-partnering; increased transport efficiency	Port facilities for autonomous ship; a new standard for crane operation of containers from autonomous ships	Yara has supplier agreements for ship management and port operations; coordination between the quay at the production facility and the port (Brevik)
		How to share the costs and value capture between Yara and its suppliers				
		A great degree of complexity and dependencies between the actors: cargo owner, port operators and ship operator	Flexible system for production and transportation of its products, however this was not enabled	Digital logistic solution for transport of the containers (at the production facility to the nearest port)	Digital communication at the production facility for cargo chain management and connected to (autonomous) ship operations and the port of Brevik	Transaction costs between production facility and ship management reduced
	Macro:	Emission and heavy cargo transport in a rural area	Reduced emissions and heavy cargo transport	Reduced emission, reduced congestion on roads and reduced road incidents in the rural area of Porsgrunn	Funding of the development project to reduce the risks	Reduced demand for investment in road infrastructure

Table 11

Structure for analysing the actors to answer RQ 2 regarding opportunities and challenges and value creation, delivery and capture for the ASKO Maritime project; red text highlights the main differences at the meso level between the Yara Birkeland project and the ASKO Maritime project

	Network level	*Challenges*	*Opportunities*	*Value (co-) creation*	*Value (co-) delivery*	*Value (co-) capture*
	Micro – ASKO Maritime AS:	How to meet internal ambitions and consumers' expectations of sustainability and at the same time continue to be competitive How to share the costs and value capture between the subsidiaries of the corporation	Emission-free transport between the warehouses; income from external customers; possibility of expanding services	Efficient *and* emission-free distribution of wholesale groceries between the warehouses Emission-free, autonomous sea transport and efficient loading operations of trailers (containers on trolleys) in ports for internal and external customers	Same as previous and electrical-driven trailers between warehouse and port Automatic, electrical-driven harbour tractors and port operations Emission-free, autonomous ships	Same as previous, and income from external customers; value capture depending on regulations for operation of autonomous ships; value capture pending flexibility in the use of suppliers
ASKO Maritime project	Meso:	How to digitalise the transport products (ships, harbour tractors…) and systems and make them work together How to share the costs and value capture between customers, ASKO Maritime, port owners/operators and suppliers	Sharing of the risks and costs in developing new technologies between suppliers and ASKO The transportation needs may be complementary in time For customers, the gains may be greater than the costs when making use of the autonomous ships and port operations	Knowledge generated and shared between the suppliers and ASKO; expansion of networks; expansion of co-partnering Increased transport efficiency	Port facilities for autonomous ship Already existing standards for the transport of containers and RO-RO ramp (port facility)	Customer agreements with ASKO Maritime ASKO Maritime has supplier agreements for ship management and port operations; coordination between the two ports (Moss and Horten)
		A great degree of complexity and dependencies between the actors: cargo owner, transport provider, port operators, ship operators	Modify an already existing digital cargo chain management system	Digital cargo chain management system used for wholesale grocery transporters (digital platform)	Internal and external customers and cargo transport suppliers connected to cargo chain management, (automatic) port operations and (autonomous) ship operations	Low transaction costs for the actors by using the digital cargo chain management system
	Macro:	How to reduce road transport and emissions	Reduce road transport and emissions	Reduced emissions, reduced congestion on roads and reduced road incidents around the Oslofjord	Funding of the development project to reduce the risks	Reduced demand for investment in road infrastructure

6.4 Modularity, the Impact of Complementarities and the Resulting Fungibility in the Emergence of a Business Ecosystem

One challenge identified in the previous section is that digital transformation requires a greater degree of complexity and dependency between actors than traditional transport using trailers. The two projects have this challenge in common. How can complexity and interdependency be described? Have the firms' business model innovations contributed to any differences in the degree of complexity and interdependency? Discussing these questions will help us better understand how the actors create value together. However, the complexity between actors and their respective business models makes it challenging to analyse them (Bankvall et al., 2017). To overcome some of these challenges, the ecosystem theory suggested by Jacobides et al. (2018) will be used, but with modifications (see Section 3.3). The authors of the ecosystem theory propose that the role of modularity, the impact of different types of complementarities and the resulting fungibility are elements that tie ecosystem members together in a web of interdependent yet autonomous activities.

This section will start by describing the structure of complementarities the actors have in production and consumption after the innovation of the business models. Ecosystem theory suggests that a specific structure of relationships and alignment between actors is required for them to create value together. This section continues the discussion by analysing whether there are any differences between the two projects. Findings from the above are used to summarise the extent to which digital transformation by incumbent firms in the traditional industries of maritime and logistics may increase social, environmental and economic impacts.

Structure of Relationship and Alignment for the Two Projects After the Innovation of the Business Model

A distinctive feature of ecosystem theory is that an ecosystem provides a structure within which complementarities in production or consumption can be contained and coordinated without the need for vertical integration. Although the types of complementarities in production were the same for the two projects, they may differ in the type of complementarities in consumption. For simplicity, only the main actors who take part when transporting the containers will be discussed.

The Yara Birkeland project involves the cargo owner (Yara), port operator in Herøya (Yara), ship operator of the ship Yara Birkeland (Massterly) and port operator at Brevik (North Sea Terminal). Yara's digital logistics solution provides information about container operations from the production facility to the (autonomous) ship and operators at the port of Brevik. The previous section describes co-values they create, deliver and capture together. This indicates that complementarity in *production* (and service) among the actors is unique. However, complementarity in *production* can be categorised as super modular. In Section 3.3, super modular complementarity in production is defined as the more value delivery (product/service) from Firm A, the more value creation (product/service) from Firm B. In contrast, unique complementarity in production is defined such that Firm A and Firm B cannot create (product/service) value without the coordination of value delivery between them or adherence to a standard within a modular system. The argument for the category super modular is that increased automatic (or autonomous) container loading operations at the production facility will result in increased efficiency of the transportation of containers for Yara. Similarly, the more that Massterly operates the ship autonomously, the more efficient the transportation of the containers will be for Yara.

Combining Yara's digital logistics system with automatic loading operations and (autonomous) ship operations generates greater combined utility than if any of these operations are done separately. This indicates a unique type of complementarity in *consumption* for the *Yara Birkeland project*. Unique complementarity in consumption is defined as joint consumption generating higher utility than separate consumption, and these complements have less value when not consumed together. By combining these two types of complementarities, super modular in production and unique in consumption, it is considered an ecosystem, in accordance with Jacobides et. al (2018). This is illustrated in Figure 7. Jacobides et al. (2018) described an ecosystem as having some degree of coordination without requiring hierarchical governance because of 'the ability to use some standards or base requirements that allow complementors to make their own decisions (in terms of design, prices, etc.), while still allowing for a complex interdependent product or service to be produced' (Jacobides et al., 2018, p. 2263).

In the *ASKO Maritime project*, a few more actors are involved than in the Yara Birkeland project. The cargo owner may be ASKO or an external customer (e.g. NOAH), and the transport provider may be ASKO or a transport provider for an external customer. Massterly is also the operator of the two ships in this project. The port operators are at the ports of Moss and Horten. A modified software system, TakeCargo, the cargo chain management system, is the digital logistics solution for transporting containers from door-to-door. The argument that the type of complementarity in *production* is super modular is identical to the Yara Birkeland project. If there are any differences between the two projects, then they are the type of complementarity in *consumption*. Super modular complementarity in consumption is defined as increasing returns resulting from the joint consumption of complements. The argument is that TakeCargo, the cargo chain management system and the modularity of the technologies being developed provide a greater set of options for the use of complementarities than the Yara Birkeland project provides. It is cargo chain management (that serves as a digital platform), the way modularity has been designed, ASKO Maritime providing services to external customers and that the service is for the entire transport chain that gives the actors in the ASKO Maritime project the possibility of increasing returns from the joint consumption of complements. One example of modularity is the combination of Kalmar's electrical harbour tractors with Red Rock's sensors for automation. This type of modularity provides possibilities for other complementarities to take part in the system. For example, another producer of harbour tractors may provide products in the ecosystem. In contrast, the cargo crane and the automation delivered to Yara are from only one provider (Kalmar), which provides fewer options for the use of complementarities in the Yara Birkeland project than in the ASKO Maritime project. In addition, the ASKO Maritime project provides complementary services for the entire transport service chain, not just part of it. This suggests that the ASKO Maritime project has super modular complementarity in *consumption* (see Figure 8).

Figure 7

Type of complementarity—Yara Birkeland project

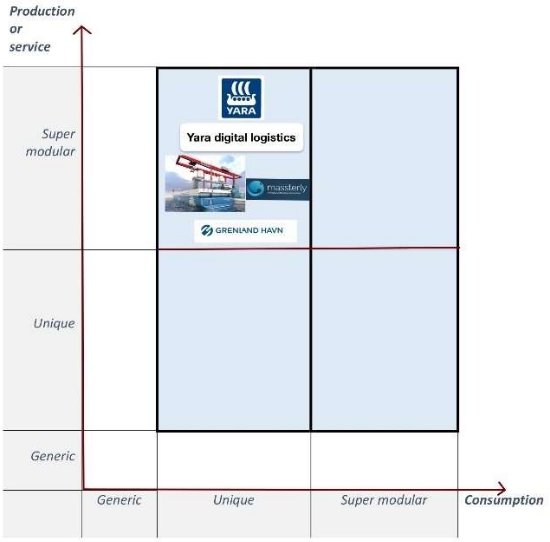
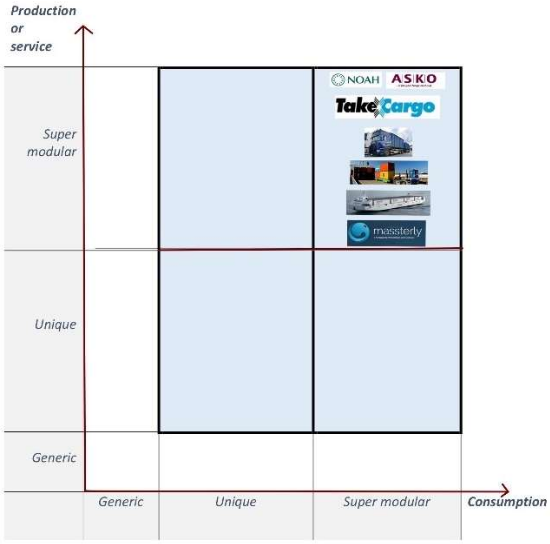


Figure 8

Type of complementarity—ASKO Maritime project



Uncertainties About Two Interrelated Fungibilities, Choice of Interface Standards Between Port Facilities and Ships and Choice of Digital Logistic System

The findings regarding the difference in the type of complementarities in consumption between the Yara Birkeland project and the ASKO Maritime project raise a question. The findings suggest that the two projects have differences in the type of complementarities of consumption due to customer groups (only internal or internal and external), the way the projects have designed the cargo chain management system, the way modularity has been designed and whether the services are for the entire transport chain or only part of it. Does this mean that one emerging business ecosystem is observed, or are two business ecosystems emerging?

Uncertainties in choice of interface standards between port facilities and ships and choice of digital logistic system explain why the business ecosystem is emerging. These two interrelated fungibilities may also explain why the question is raised as to whether one or two business ecosystems are emerging. More importantly, these fungibilities cause uncertainties about the possibility of scaling up services to replace road transport with sea transport. The arguments are as follows. One of the main challenges ASKO describes for scaling up activities is to explain to external customers (i.e. cargo owners) that the total costs of using its services will be lower than the alternative. This is again linked to the challenges for external customers to be willing to invest in and change their systems and agreements with transport providers. This also challenges how the involved actors should change their business models and how the additional values they will gain should be shared in a fair way among the involved parties. This is seen in relation to the traditional business models used by incumbent actors in the transport industries. In particular, the separation between ship and road transport and their traditional business models is a hindrance for combining road and sea transport and reducing the total costs for transportation, emissions and traffic load on the roads. Fungibility was previously explained to be that the investment or assets in place cannot be easily redeployed elsewhere without cost. New investments, adjustments to the membership and transaction rules of other ecosystems or coordination costs with other members' activities may be needed for new customers to take part in the ecosystem. One of the fungibilities observed relates to uncertainty about which standards the interface between port facilities and ships should be. The design of the ship Yara Birkeland requires harbour cranes, while the design of the ships of ASKO Maritime requires ramps and harbour trucks[17]. This uncertainty is expressed as one of the main challenges described in the findings from the case study (see Section 5) when Yara, ASKO and Massterly innovated their business models; they are dependent on a network of ports with the necessary facilities for automatic loading and discharging. For the system to be scaled up, the ports must align and invest in the same system. It is possible to have both loading operation systems (i.e. crane and tractor); however, this may either increase the fungibility (one port invests in both systems) or limit the possibility of flexibility in the use of the transport systems (some ports invest in cranes, other in harbour tractors). This creates an additional challenge for ports to coordinate and may increase the complexity of the ecosystem. The other interrelated fungibility relates to the use of a logistics system as a digital platform for the ecosystem. Currently, two different logistics systems are being used: Yara's internal system and TakeCargo. Both serve as platforms linking the system of suppliers and complementors. This study previously described that the priority in Yara's and ASKO's digital transformation projects is to develop effective (digital) cargo supply chain management. For the emergence of a business ecosystem, there is the question of whether organisations need to develop one common platform or whether they can have separate platforms. Yara's internal system provides a limited possibility of scaling up the use of sea transport beyond the Grenland district. TakeCargo has been developed for the transport of wholesale groceries in Norway. The system has a larger potential for scaling up the use of sea transport (in combination with road transport) in Norway. This study initially mentioned that several digital transformation initiatives are currently going on in the shipping and logistics industries (e.g. Port of Rotterdam's BlockLab and IBM's and Maersk's electronic ledger for global freight tracking). This included that Cargotec, the company providing the crane to Yara and the harbour tractors to ASKO, recently announced that it had developed an experimental cloud-based logistics platform for autonomous container operations. Red Rock was recently acquired by Ocean Infinity, a marine robotics company (Ocean Infinity, 2021). This leaves the question of who will take the lead in developing a logistics platform for autonomous container transport. Will this be Yara's internal logistic system, TakeCargo's or another, such as an international crane manufacturer or large container freighters? Uncertainties about the two interrelated fungibilities—choice of interface standards between port facilities and ships and choice of digital logistic system—explain why an ecosystem is emerging and has not yet been fully established. A question remains whether the continuation will be that two separate ecosystems are being developed or if the modularisation,

[17] Similar differences may be found for charging of the ships, mooring arrangements, etc.

extent of complementarities and the choices about the two interrelated fungibilities will eventually be combined into one.

7. Conclusion and Implications

This thesis asks how incumbent firms introduce short sea autonomous shipping and cargo operations into their offerings. It has taken a business model innovation perspective on an emerging business ecosystem. An exploratory investigation method was applied with a single case study. The case study investigated two projects: the Yara Birkeland project and the ASKO Maritime project. These digital transformation projects have in common the ambition of developing autonomous ships, autonomous port operations and digital cargo supply chain management. The latter connects the cargo owner with the cargo transporters, port operations and sea transport and has been given priority in both projects. The development of the digital transformation is currently ongoing and the services from the two projects will be introduced in 2022.

7.1 Efficiency Innovation of Business Models when Companies Introduced Digital Transformation into Their Offerings

Have the incumbent firms investigated in this qualitative study, Yara Birkeland AS, ASKO Maritime AS and Massterly, made a market-creating innovation or an efficiency innovation in their business models when they introduced digital transformation into their offerings? The finding is that all three companies have made efficient innovations in their business models. Yara, ASKO and Massterly's main drivers for business model innovation are to remain competitive and meet new demands in their existing markets. This finding is an example of incumbent companies sometimes preferring to invest in their existing businesses because it seems less risky than trying to create entirely new businesses (Christensen et al., 2016).

However, two of the examples have shades of detail worth noticing. Observations from the two examples suggest that autonomous systems are enabling technologies for digital transformation in maritime and logistic industries to increase social, environmental and economic impacts with the potential of creating a new market for incumbent firms in traditional industries. This observation corresponds with the prospect that digital transformation has promising prospects for business model innovations in traditional industrial sectors such as transport (Velu et al., 2019). The firms' antecedents, abilities or resources, and choice of modularity may be some of the factors limiting a market-creating innovation of a business model to happen. In the first example, the Yara Birkeland project had the ambition of a market-creating innovation, but learned that the ambitions did not correspond with its antecedents and the number of resources needed to create a new market. The reason was that the groundbreaking development of IT systems for logistic operations and the groundbreaking development of autonomous cargo handling, in combination with groundbreaking autonomous sea transport, became too complicated and resource intensive for Yara to pursue at the same time. The main driver for the efficiency innovation of Yara's business model was to meet a new customer need for emission-free transport of fertilisers (commercial driver) in combination with the expectation that the costs for greenhouse gas emissions and road transport will increase (institutional driver). In the other example, the ASKO Maritime project was ASKO's main driver for business model innovation, also commercial and institutional, by delivering emission-free transport of wholesale groceries and meeting the expectation that the costs for greenhouse gas emissions and road transport will increase. These drivers were not intended to create a new market but to ensure the company remained competitive and met new demands in the existing market. ASKO Maritime's ambition for a new business area was, like Yara, driven by the promising opportunities of digital transformation and autonomous operations (technological driver). The modification of a digital logistics system and the choice of modularity, in combination with ASKO Maritime AS providing services to external customers, may provide the possibility for the firm to create a new market in the future.

7.2 The Emergence of a Business Ecosystem

One of the main challenges at the network (meso) level for the digital transformation projects of introducing autonomous shipping and cargo operations is that the degree of complexity and dependencies between the actors taking part in the transportation of containers becomes greater than with traditional transport using trailers. This challenge is the main reason for observing an emerging business ecosystem with a value proposition in which one of the actors cannot deliver value alone (Urmetzer, 2021).

Among value co-creation at the meso (network) level in the Yara Birkeland project and the ASKO Maritime project is increased transport efficiency. Value co-creation at the society (macro) level in the two projects is reduced emissions, reduced congestion on roads and reduced road incidents in the rural area of Porsgrunn and around the Oslofjord.

The total transaction costs at the meso (network) level in the ASKO Maritime project are considered lower than in the Yara Birkeland project. In the Yara Birkeland project, the system is only for one transportation leg; another logistics system is used from the port of Brevik onwards. In the ASKO Maritime project, all the actors needed for transporting the containers from warehouse-to-warehouse (or door-to-door) are included in one system. The system used in the ASKO Maritime project serves as a digital platform for the actors taking part in the transport of the containers.

The authors of the ecosystem theory propose that the role of modularity, the impact of different types of complementarities and the resulting fungibility are elements that tie ecosystem members together in a web of interdependent yet autonomous activities (Jacobides et al., 2018). Although the types of complementarities in *production* are the same for the two projects, they differ in terms of the type of complementarity in *consumption*. The findings suggest that these differences in the type of complementarities of consumption are due to customer groups, the way the projects have designed the cargo chain management system, the way modularity has been designed and whether the services are for the entire transport chain. It is the cargo chain management (that serves as a digital platform), the way modularity has been designed, ASKO Maritime providing services to external customers and the fact that the service is for the entire transport chain that gives the actors in the ASKO Maritime project the possibility of increasing returns from the joint consumption of complements.

Uncertainties about two interrelated fungibilities—choice of interface standards between port facilities and ships and choice of digital logistic system—explain why an ecosystem is emerging that has not yet been fully established. These fungibilities cause uncertainties about the possibility of scaling up services to replace road transport with sea transport. Uncertainties include whether potential customers will consider that the total cost of using the services will be lower than the alternative, whether customers will be willing to invest and change their systems, and which standards and systems should be invested in to meet the demands required for using Yara Birkeland's and ASKO Maritime's services.

7.3 Implications for Practitioners and Research

For Practitioners

1) Digital transformation, by separating information from its physical form, is promised to be most impactful when it leads to business model innovation. However, digital transformation may be extensive and may require coordination across disciplines and with more firms than initially expected. In the two projects this study has investigated regarding incumbent firms in traditional maritime and logistic industries, the firms have given priority to establishing/developing a digital system connecting the chain of operations with the actors taking part in delivering and using the services. Automation and autonomy will be developed in the long run.
2) To make digital transformation happen, someone needs to take the lead. In the two projects, the firm with extensive knowledge of logistics had the advantage of being the lead, compared to only being cargo owners. The main advantages were that it already had a digital logistics system in place (which only needed to be modified) and competences in modularisation when new solutions were developed.
3) To understand how digital transformation may increase social, environmental and economic impacts, this study suggests a reframing of two dimensions. This way of reframing should be reflected when considering possibilities for altering business models. One dimension may be reframed by considering the entire chain of supply and complementarities. In the qualitative study, the transport of containers was reframed from port-to-port to door-to-door. Considering the entire value chain for transporting goods makes it possible to consider all the costs and benefits of door-to-door. This is what has previously been seen in the consumer sector: digital transformations have centred on internet-enabled platforms that facilitate the transaction, interaction and exchange of value between participants (Velu et al., 2019). The other dimension to be reframed involves considering which values are created, delivered and captured at the firm (micro), network (meso) and society (macro) levels.
4) Digital transformation may create additional complexity and interconnectedness among the involved actors. This may lead to a change from a traditional value chain to a business ecosystem for incumbent firms. Modularity, the impact of different types of complementarities and the

resulting fungibility may be a way to understand how a business system is emerging and working. In the qualitative study, two differences in the ecosystem were observed: whether the logistics supply chain system served as a digital platform and the extent of modularity. Fungibilities cause uncertainties about the possibility of scaling up services and developing the business ecosystem. One uncertainty may be whether potential customers will consider the total cost of using the services compared to the alternative. Another uncertainty may be whether potential customers will be willing to invest and change their systems to meet the demands required for using the product and services created, delivered and captured among the actors in the business ecosystem. A third uncertainty is which standards and systems should be chosen.

5) The observations from the qualitative study indicate that several actors are working to establish digital platforms. Choice of digital platform influences the development of business ecosystems and whether they will become one or several. This may again have consequences for the extent to which the ecosystems are scaled up.

For Authorities and Public-private Partnerships with Aims to Increase Social, Environmental and Economic Impacts from Transportation

One main challenge in introducing autonomous shipping and cargo operations is that the degree of complexity and dependencies between the actors increases. This is the main reason for observing an emerging business ecosystem with a value proposition in which one of the actors cannot deliver the value alone.

One finding from the qualitative case study is that uncertainties about two interrelated fungibilities, choice of interface standards between port facilities and ships and choice of digital logistic system—explain why an ecosystem is emerging and has not yet been fully established. The fungibilities cause uncertainties about the possibility of scaling up services to replace road transport with sea transport. This finding suggests that authorities and public-private partnerships should investigate possibilities for how to reduce these two fungibilities. Such investigation could involve considering whether key elements of the interface between port facilities and ships should be standardised to increase the extent of modularisation and if a digital logistic platform should be considered as technical infrastructure and harmonised nationally, within the EU or internationally. Modularisation of port-ship interfaces, harmonisation and technical standards for a logistic platform may reduce fungibility and increase the possibility of scaling up services when several players take part in developing logistic platforms for autonomous and sustainable transport by combining different transport modes.

For Researchers

The first research gap identified in this thesis concerns how the introduction of digital transformation affects the propensity of large incumbent firms' to alter their business models. The use of definitions and frameworks, the research method and the findings from the exploratory case study may be used for further theorising and empirical work on business models and business model innovation of incumbent firms in traditional industries when they introduce digital transformation. The argument for this is that the way of structuring changes to firms' business model in this thesis was by use of

Teece's (2010) definition of a business model. What opportunities and challenges incumbent firms faced in their digital transformation was structured based on to what extent the firms altered their value creation, value delivery and value capture. This use of complementarities between the underlying activities has been suggested to provide the basis for a much-needed dimensionalisation of the business model and business model innovation constructs (Foss & Saebi, 2018). Another argument is that the categorisation of the main change drivers for business model innovation (technological, institutional and commercial) by Johnson et al. (2008) was useful when analysing whether digital transformation provided market-creating innovation, sustaining innovation or efficiency innovation of the incumbent firms' business model (refer to the three stages of a business model's journey by Christensen et al. (2016)). Understanding the challenges and opportunities and how the incumbent firms changed their method of value creation, delivery and capture provides insight into why some firms end up with efficiency innovation and what potential they have for market-creating innovation.

The second research gap relevant to the study was how incumbent companies in traditional industries in an emerging business ecosystem create, deliver and capture value together to increase social, environmental and economic impact. Foss and Saebi (2018) suggested that, theoretically, the key aspect of business models is complementarity between activities underlying the mechanisms of a firm's value creation, delivery and capture. They suggested that business model innovation is a novel change in such complementary relations. This thesis suggests that complementarity can also be a way to describe the interdependencies between firms' business models in an ecosystem by including value (co-)creation, (co-)delivery and (co-)capture at the macro and meso levels (modified from Garcia et al. (2019)). This expansion provides the possibility to make use of a modified ecosystem theory (Jacobides et al., 2018) to describe how innovation of the firms' business models affects how they create, deliver and capture value together. The reason for this suggestion is that the categorisation suggested by Garcia et al. (2019) provides an understanding of which challenges and opportunities the involved actors are facing when altering value co-creation, value co-delivery and value co-capture within a micro-meso-macro framework of competing goals. This (modified) framework is a way to link how firms innovate their business models and how the firms' business models complement each other in a business ecosystem. This was made possible by altering Jacobides et al.'s (2018) definition of complementarity in production. The method and the use of the ecosystem theory by Jacobides et al. (2018) provided insight into the differences in modularity, impact of complementarity and resulting fungibility between the two projects in the case study. One finding from the case study suggests that digital transformation may create additional complexity and interconnectedness between the incumbent firms taking part in creating, delivering and capturing value together. Another finding suggests that understanding fungibilities provides insight into what limits the possibility of scaling up the products and services by the complementors in an emerging business ecosystem.

7.4 Suggestions for Further Research

The firms being investigated are currently developing technology and systems for digital transformation, which means that the findings from this thesis are a description of their status today. One suggestion for further research is a longitudinal qualitative study that collects data and information about business model innovation when incumbent firms gain more experience in digital transformation and from their services. Their experiences may provide more insight into how incumbent firms alter their business models and how the business ecosystem(s) is emerging than what this study achieved. Longitudinal studies have been identified as a research gap for digital technologies and business model innovation (Agostini & Nosella, 2021).

This thesis briefly described initiatives that may develop into platforms in one or several ecosystems. A suggestion is to investigate the development of theses platforms from a business ecosystem perspective.

Entrepreneurs are also taking part in digital transformation by introducing autonomous ship operations and cargo operations. Suggestions for further research include conducting a qualitative study about how entrepreneurs develop their business models and discussing these findings with the results of this thesis.

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List of Figures and Tables

Appendix 1: Interview Guideline

Below are the interview guidelines for interviewing key persons relevant to the case study.

The guideline has the purpose of structuring the topics and supporting a funnel approach during the interview. The questions are therefore structured by topics, main questions and follow-up questions. The principle is to ask broad and open questions. Only when necessary, will questions down the funnel for each of the topics be asked. The topics and questions are structured by the two research questions (RQ 1 and RQ 2) (see Section 1.3).

This means that the questions listed in Table 12 might not necessarily be covered. They may also be replaced with others depending on the responses received. The sequence of the topics is listed in Table 12. However, the sequence might change depending on the responses received. The extent of the questions will also be adjusted if the time available for the interview is limited.

The main questions for the interviews are as follows:
How are incumbent firms commercialising technologies that will provide autonomous shipping and cargo operations?

1) Establishing rapport

Establish rapport between the interviewee and the interviewer. This includes describing the following conditions for the interview:

- The interviews are being conducted voluntarily.
- No person will be identified in the master’s thesis; only the person's role/function will be referred to.
- The names of the companies will not be used in the thesis; however, the companies might be easily identified by any reader, since few companies are taking part in short sea shipping in the Oslofjord area.
- The interviewer will receive a summary from the interview, which he/she can read and revert to without any objection. The main purpose of the summary is to confirm that the information has been received correctly.

2) **Understand the person’s involvement in the commercialisation of the firm’s innovations**

Understand the person's involvement in the commercialisation of the innovations.

For RQ 1:

3) **Understand what is being/has been innovated**

   Understand what is being innovated or has been innovated. The purpose is to understand the underlying activities of the business model.

4) **Understand the business model *before* they commercialise the innovation**

   Understand the business model before they introduced the innovation. This establishes the baseline for analysing the extent of business model innovation. One risk during the interview is that the person may not understand why it is important to spend time on this. Another risk is that the answers may be too extensive, requiring too much time for the interviews.

5) **Understand the opportunities and challenges they considered before/when commercialising the innovations**

   Understand the opportunities and challenges the firm evaluated with the introduction of new technology, systems and organisation. This establishes the prospected potential the firm is eyeing, limitations and forms the basis of what they believe they will be able to create, deliver and capture.

6) **Understand the business model *after* they commercialise the innovation**

   Understand the business model after/when they commercialise the innovation. This time, the answers may be more structured and detailed regarding what they consider to be their business model. Understanding their previous business model and the opportunities and challenges they considered provides a better basis for talking about their existing business model.

7) Planning for more

   Understand how they will proceed and further develop their commercialisation. I might not get much information about this.

For RQ 2:

8) **Key partners**

   Understand who are the other most important actors taking part to achieve autonomous shipping and cargo operations.

9) Dependencies and directions

   Understand the dependencies between key actors and the direction of these dependencies.

10) **Value co-creation**

   Understand what value they create together. This is for both the meso and macro levels.

11) Value co-delivery

   Understand how they deliver value together. This is for the meso and macro levels. Since this involves the commercialisation of products/services, I will not pay much attention to governmental or similar contributions in the form of funding, e.g., typically Enova funding.

12) **Value co-capture**

Understand how they capture value together. This is for the meso and macro levels. Of particular interest is whether they consider the capture to be fair among key actors.

13) **Opportunities and challenges**

Understand what they consider to be the main opportunities and challenges when they create, deliver and capture value together.

14) **Planning for more**

Learn if there are any plans for further developments. Of particular interest is learning what is considered necessary for further development to reach the full potential of autonomous shipping and cargo operations.

15) **Conclusion of the interview**

Summarise the interview and explain the way forward.

Table 12

Question—How are incumbent firms commercialising technologies that will provide autonomous shipping and cargo operations?

How are incumbent firms commercialising technologies that will provide autonomous shipping and cargo operations?		
1) Rapport	Establish rapport	
2) Involvement	How have you been involved in the innovation project(s)?	
Main topics RQ 1	**Main questions, RQ 1**	**Follow-up questions, RQ 1**
3) Business model now (i.e. after innovation)	What is your firm's business model now (*after* you have commercialised the innovations)?	
	Value creation What products and services do you offer?	What do your customers need of products/services from you?
		What products do you create?
		What services do you create?
		Who are your customers?
		What products/services do you offer to new types of customers?
		What products/services do you offer to your existing customers?
	Value delivery How do you deliver your products and services?	How do you deliver your products and services?
		What new resources have you acquired?
		What new knowledge have you acquired?
		What new partners have you established?

		What new suppliers have you established?
		What new ways of meeting your customers have you established?
	Value capture What do you get in return?	Who pays for your products and services?
		Who do you pay for products and services?
		What other benefits/value do you gain from delivering your products and services?
4) The firm's innovations	Please explain what your firm has innovated that contributes to autonomous shipping and cargo operations.	
		Technical solutions
		Resources (people, facilities, equipment, brands, investments)
		Processes (training, development, manufacturing, budget, planning)
		Organisation
		Systems
5) Business model before innovation	What was your firm's business model *before* you commercialised the innovations?	
	Value creation What products and services did you offer?	What did your customers previously need in the way of products/services from you?
		What products/services did you previously offer before your innovations?
		What type of customers did you have?
	Value delivery How did you deliver your products and services?	How did you deliver your products and services?
		What resources did you use?
		What competencies did you have?
		What partners did you have?
		What suppliers did you have?
		How have you met your customers?
	Value capture What did you get in return?	Who paid for your products and services?
		Who did you pay for products and services?
		What other benefits/value did you gain from delivering your products and services?
	Do you still offer this business model after your innovation?	
6) Opportunities and challenges	What did you consider to be the opportunities for commercialising the innovations?	
	What did you consider to be the challenges for commercialising the innovations?	
7) Planning for more	Do you plan to offer new products/services?	
	Do you plan other ways of delivering your existing or new products/services?	

	Do you plan other ways to increase your value capture?	
	What needs to be developed for the firm to reach the full potential of your innovations?	
Main topics RQ 2	**Main questions, RQ 2**	**Follow-up questions, RQ 2**
8) Key partners	Who are the key actors for delivering autonomous shipping and cargo operations?	What do each of the partners deliver in the way of products and services?
9) Dependencies and directions	On whom are you dependent for delivering products/services?	What products and services are other actors delivering to you?
		Are you dependent on what this actor is delivering?
		Could you get the products/services from someone else?
		Will you be able to deliver more products/services if the other actor is delivering more?
	On whom are you dependent that you deliver products/services to?	What products and services do you deliver to other actors?
		Are other actors dependent on the delivery of your products/services?
		Could they get it from someone else?
10) Value co-creation	From the perspective of you and the other key actors, what products and services do you create *together*?	Which customers are critical for the commercialisation to happen?
		Who are your end customers (type)?
		What do you create of value for society?
11) Value co-delivery	How do you and the other key actors deliver products and services to the end customers *together*?	How do you collaborate?
		What systems do you have (*together*)?
		What standards do you use that are common for you?
12) Value co-capture	What do you (*together*) get in return?	Who benefits most from this return?
		Is the share of return fair among you?
		Do any others benefit from your innovation?
		How does it benefit society?
13) Opportunities and challenges	What opportunities do you feel the innovations can provide?	What are the opportunities that you, together with the other key partners, face in delivering autonomous shipping and cargo operations?
	What are the main challenges you and the other key actors are facing (*together*)?	Which of the challenges are most critical?
		Do you deliver the potential together or are there any hindrances limiting it?
		What are the main hindrances?
14) Planning for more	Do you, in collaboration with other actors, plan for more?	
	Are any of the other actors planning for more?	
	What needs to be developed to reach the full potential of autonomous shipping and cargo operations?	
15) Conclusion	Summary of the interview and way forward	

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