LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY LUT

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DEVELOPING A PRODUCT-SERVICE SYSTEM BUSINESS MODEL FOR A CLEANTECH INNOVATION

Examiners: Professor Liisa-Maija Sainio

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ABSTRACT

Lappeenranta-Lahti University of Technology LUT
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Developing a Product-Service System business model for a cleantech innovation

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The conservation of the marine ecosystem is propelling the growth of the ballast water treatment system (BWTS) market. Therefore, BWTS manufacturers need to know which business model will lead to profitable participation in the market. The development of business model for a BWTS has hardly been studied at all. There is also a gap in the literature about the development of a Product-Service System (PSS) business model.

This thesis explores how to develop a PSS business model for a BWTS in the Finnish maritime industry's B2B market. The intention was therefore to develop a PSS business model for a BWTS. In addition, this study examines the terms of embedding product and service so that the solution creates value for the potential customer.

This qualitative case study was conducted by sending a questionnaire and interviewing potential customers of BWTS such as ports, port operators, and shipping companies. The data was complemented with a document review. The data was analyzed by qualitative content analysis with NVivo program. The results of this research indicate that the most suitable business model for a BWTS is the product-oriented PSS business model because potential customers need additional services to complement the product purchase. By using the product-oriented business model, value can be created by additional actions and flexibility in fulfilling customer requirements compared to traditional business model. The findings provide new insights into prior knowledge and indicate that companies in the maritime industry need servitized business models to be competitive.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
School of Business and Management
International Marketing Management -koulutusohjelma

Helena Rauhala

Product-Service System liiketoimintamallin kehittäminen cleantech-innovaatiolle

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Hakusanat: Liiketoimintamalli, Product-Service System, PSS, cleantech, painolastiveden käsittelyjärjestelmä, meriteollisuus, B2B

Meriekosysteemin suojelu edistää painolastiveden käsittelyjärjestelmien markkinoiden kasvua. Näin ollen painolastiveden käsittelyjärjestelmien valmistajien on tiedettävä, mikä liiketoimintamalli johtaa kannattavaan osallistumiseen markkinoilla. Akateemisessa kirjallisuudessa on tutkittu niukasti painolastiveden käsittelyjärjestelmän liiketoimintamallin kehittämistä sekä Product-Service System (PSS) liiketoimintamallin kehittämistä.

Tämä tutkimus tutkii, kuinka voidaan kehittää PSS-liiketoimintamalli painolastiveden käsittelyjärjestelmälle Suomen meriteollisuuden B2B-markkinoilla. Tutkimuksen tavoitteena oli siis kehittää PSS-liiketoimintamalli painolastiveden käsittelyjärjestelmälle. Lisäksi tässä tutkimuksessa tarkastellaan millainen tuote- ja palveluratkaisu luo arvoa potentiaalisille asiakkaille.

Tämä laadullinen tapaustutkimus toteutettiin lähettämällä kyselylomake ja haastattelemalla painolastiveden käsittelyjärjestelmän potentiaalisia asiakkaita, kuten satamia, satamaoperaattoreita ja varustamoita. Dataa täydennettiin asiakirjatarkastuksella. Tiedot analysoitiin laadullisella sisältöanalyysillä NVivo-ohjelman avulla. Tutkimuksen tulokset osoittavat, että painolastiveden käsittelyjärjestelmälle sopivin liiketoimintamalli on tuotekeskeinen PSS-liiketoimintamalli, sillä potentiaaliset asiakkaat tarvitsevat lisäpalveluita tuotehankinnan täydentämiseksi. Tuotekeskeistä liiketoimintamallia käyttämällä arvoa voidaan luoda lisäpalveluilla ja joustavuudella täyttää asiakkaiden vaatimukset perinteiseen liiketoimintamalliin verrattuna. Tulokset tarjoavat uusia oivalluksia aikaisempaan kirjallisuuteen ja osoittavat, että merenkulkualan yritykset tarvitsevat palvelukeskeisiä liiketoimintamalleja ollakseen kilpailukykyisiä.

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Cheers to new beginnings!

In Espoo, 5 August 2021,

Helena Rauhala

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LIST OF SYMBOLS AND ABBREVIATIONS

B2B	Business-to-business
B2C	Business-to-consumer
BM	Business model
BMI	Business model innovation
BWM	Ballast Water Management
BWMS	Ballast Water Management System
BWTS	Ballast Water Treatment System
CEO	Chief Executive Officer
COO	Chief Operating Officer
IMO	International Maritime Organization
PSS	Product-Service System
PS	Product-Service
USCG	United States Coast Guard

1 INTRODUCTION

The increasing awareness of the consequences associated with environmental problems is setting expectations on technological developments. Many hope that new clean technology innovations will solve the climate problem. Thus, clean technologies, in short cleantech, have become an interesting and important investment. Moreover, during recent years, the interest in cleantech has increased in the maritime industry due to the need to address many of the environmental impacts associated with maritime transportation and ships (Hermann & Wigger 2017). The focus is now on alternative solutions, such as ballast water treatment systems (BWTS) (Koukaki & Tei 2020). However, the biggest challenges of innovations are accelerating business models that take solutions to market (Sworder et al. 2017).

Business models have existed in business literature for several decades, and it has become a common term to use in practice and in the academic community. It is crucial for companies to design and implement a business model that determines how to create value for customers. (Teece 2010) Consequently, the importance of services in business models has increased in the B2B markets. A Product-Service System (PSS) business model allows companies to create new sources of added value and competitiveness to meet customer needs in an integrated and customized way by combining products and services. PSS is seen as an excellent way to enhance competitiveness and to foster sustainability simultaneously. (Tukker 2004) Although recent studies have highlighted a number of potential benefits of PSS, views on how companies can adopt PSS business models remain very limited (Reim et al. 2015).

Research on the business model in relation to companies developing cleantech solutions and innovations is especially interesting as these companies need to focus in particular on creating competitive business models to compete with traditional companies (Boons & Lüdeke-Freund 2013; Johnson & Suskewicz 2009). More research is needed on how cleantech innovations can be commercialized to the market using PSS business models. Moreover, business model development for a BWTS has barely been studied at all. Thus, there can be seen a clear research gap. Therefore, this thesis explores how to develop a PSS business model for a BWTS in the Finnish maritime industry's B2B market.

1.1 Literature review

This literature review discusses previous literature findings on business models and PSS business models. In addition, the literature on BWTS and maritime industry is described.

For over 50 years now, the term business model has been a topic of scientific discussion. Business models play a major role in management practices and in the competitiveness of a company. (Wirtz et al. 2016) To date, several studies have investigated business models (e.g., Osterwalder & Pigneur 2010; Zott et al. 2011; Teece 2010). Although the term has gained widespread use in the practice community, it lacks consensus. George and Bock (2011) found out in their systematic literature review that the academic literature is fragmented by inconsistent definitions and construct boundaries of business model. This view is supported by Zott et al. (2011) who found out that despite the overall surge in the literature on business models, scholars still do not agree on what is the exact definition.

The ultimate role of business model is to ensure that the technological core of the innovation creates and delivers value to the customer (Chesbrough & Rosenbloom 2002; Björkdahl 2009; Teece 2010). Companies employ business models to commercialize new ideas and technologies. An innovating company needs to find the right kind of business model, because a mediocre technology pursued within a great business model can be more valuable than a great technology exploited through a mediocre business model (Chesbrough 2010; Björkdahl 2009). Baden-

Fuller and Haefilger (2013) note that the choice of business model affects the way in which technology is monetized and the profitability for the relevant companies. However, the right business model is not obvious in the emerging industries, so the entrepreneurs/managers need to learn and adjust to succeed. Technological achievements fail commercially because little or no attention has been given to designing a business model to take them to market properly. (Teece 2010)

Over the past decades, there has been an increasing importance of services in the strategies and business models of manufacturing firms and other product companies in business-to-business markets (Cusumano et al. 2015; Brown et al. 2011). Businesses use services to differentiate themselves from competitors, develop and intensify customer relationships, increase customer satisfaction, induce customer switching costs, as well as build customer loyalty (Brown et al. 2011). In addition, services are more difficult to imitate than products, so they are a source of competitive advantage (Rothenberg 2007).

By integrating services into products this can be regarded as Product-Service Systems (PSS). PSS is a system of products, services, and supporting networks and infrastructure. It is a combination of tangible products and intangible services which can satisfy specific user’s needs. (Tukker 2004) According to Mont (2002) PSS is designed to be competitive, satisfy customer needs, and have a lower environmental impact than traditional business models. The three most widely accepted categories of PSS are: product-oriented, use-oriented, and result-oriented. The three types of PSS are different in terms of creating, delivering, and capturing value (Reim et al. 2015).

Barquet et al. (2011) explained that in traditional business models, the customer purchases a product, thus becoming responsible for monitoring its performance, providing assistance, and ensuring adequate disposal. On the contrary, in the PSS concept, the producer earns when customer uses a provided function. Thus, the ownership of the product is not necessarily transferred to the customer and the responsibility for maintaining the product during its life cycle and disposal remains with the producer. Additionally, Barquet et al. (2015) argued that PSS addresses the design of business models because value is not necessarily provided through the sale of the product, but by the functionality or result it can generate.

The concept of PSS has been openly discussed in the literature for over a decade. This PSS concept originated in Northern Europe in the late 1990s and the first publication on PSS was by Mark Goedkoop et al. (1999). By being commercially interesting and having environmental benefits, PSS is a subject of growing literature (Catulli et al. 2017). Landmark studies include works by Mont (2002), Tukker (2004), and Baines et al. (2007). Most of the studies in the PSS literature focus on case studies and examples of PSS offers. In addition, the prior literature has discussed the design of PSS, as well as their business and environmental benefits and drivers (Tukker 2015). Initial studies on PSS recognized that sustainability and environmental implications were fundamental, and the PSS concept was defined around these aims. Over the years, however, sustainability was treated more as an inherited result of PSS and the focus has shifted from embracing sustainability benefits to achieving economic benefits and customer satisfaction. (Baines et al. 2007; Reim et al. 2017) On the contrary, several studies have recognized that in certain cases, PSS has a negative impact on the environment through less cautious behaviour and rebound effects. Recently, however, the focus has shifted to achieving sustainable benefits by recognizing the need to work actively to realize the full sustainability potential of PSS. (Reim et al. 2017) Moreover, the drivers and barriers for companies to implement PSS have been covered widely (Tukker 2015). The potential benefits of PSS have been highlighted in prior studies, but the insights about how companies can adopt and implement PSS business models is still very limited (Reim et al. 2015). Literature on PSS design is generally focused on generation and identification phases of the design process. Few of the approaches analyzed contribute to concept development and evaluation phases. (Rondini et al. 2016) Richter et al. (2019) suggest that further research should therefore focus on developing a process model that can be used universally for the development of all

PSS types. In contrast to Richter et al. (2019) a study by Mont (2001) showed that it is very difficult to create general, widely applicable PSS.

Literature on PSS in the maritime industry has not been widely examined, but studies have been conducted on PSS in the maritime industry (e.g., Pagoropoulos et al. 2016; Pagoropoulos et al. 2017) and especially about implementing PSS in the Danish maritime industry (e.g., Andersen 2013; Neugebauer et al. 2013; Rivas-Herman 2015). Some of these research papers about Danish maritime industry and PSS were part of the PROTEUS project, which investigated PSS development as a way to increase competitiveness of Danish maritime companies (Mcaloone 2014).

In the maritime industry, PSS offerings provide an opportunity for both suppliers and customers to explore and ultimately implement servitized business models due to the long life cycle of the ships and the capital intensity of the industry (Pagoropoulos et al. 2017). In addition, the PSS offerings are already well-known in the maritime industry and institutional arrangements between shipbuilders, subcontractors, shipowners, and charterers have already been developed (Rivas-Hermann et al. 2015). On the contrary, Pagoropoulus et al. (2016) examined unsuccessful service offerings in the shipping industry and found that customer disregarded the servitized offerings because they were not considered as important sources of value. However, Andersen et al. (2013) found out that Danish maritime suppliers should pursue PSS-based strategies as PSS business models ensure a strong and sustainable competitive position as well as respect the complexities of the industry. Nevertheless, only a limited number of maritime companies are adopting PSS strategies due to a number of complex contextual factors, such as the affliction of organizational decline, the culture of the market, regulatory pressure, limited financial resources, inability to provide global support, and a lack of appropriate competencies and knowledge (Andersen et al. 2013).

There is an increasing common interest between academia and maritime industry about cleantech innovations. The focus of the ongoing discussions is on innovative solutions that aim to address multiple issues that can guarantee both economic and environmental benefits. Topics that are trending are: alternative fuels, green port policies, and new technologies that can reduce the environmental impact of shipping. In consequence, alternative solutions in the maritime industry such as ballast water treatment systems (BWTS), are being discussed. (Koukaki & Tei 2020) Therefore, this study is forward-looking for the maritime industry and adds value to the discussions.

BWTS is a growing market in the maritime industry. Research on BWTS has typically focused on the selection of the most suitable system or differences between BWTS technologies (e.g., Wang & Corbett 2021; Satir 2014). However, the literature on BWTS and business models is very limited, although the BWTS industry is significant for the actors in the maritime industry. It is important to understand which business model will lead to profitable participation in the BWTS market.

According to Rivas-Hermann et al. (2015) BWTS is fully compatible with the application of PSS. Furthermore, they purpose that port-based BWTS has the highest potential for eco-efficient value creation, and a possible PSS can be designed for such technology. Additionally, they found that different business models operate at different stages of the BWTS life cycle. Packages of products and services are especially welcomed by shipowners in the installation phase of BWTS. (Rivas-Hermann et al. 2015) However, it should be noted that Rivas-Hermann et al. (2015) study's empirical evidence was collected during February 2012-February 2013, which is before IMO's BWM Convention entered into force in September 2017. During 2012-2013, there was some knowledge about the up-coming convention, but the purchase and installation of ballast water systems was proceeding at a low rate and market growth was small (Rivas-Hermann et al. 2015).

Combining PSS and cleantech is appropriate for this study because PSS is closely linked to business model innovation and sustainability. PSS has received attention for being a suitable business model for sustainable innovations (Boons and Lüdeke-

Freund 2013). Overall, for clean technologies, innovative business models are relevant (Johnson & Suskewicz 2009). Moreover, services have been emphasized in the maritime industry (Rivas-Herman et al. 2015), so a PSS is an appropriate approach to this study. In addition, the full potential of a PSS in the maritime industry has not yet been realized (Rivas-Herman et al. 2015).

1.2 Research questions

This thesis aims to fill the gaps in the literature review and support existing literature by studying PSS business model development in the B2B market. The aim is to develop a PSS business model for a cleantech in the Finnish maritime industry's B2B market. Thus, main research question is:

RQ: How to develop a PSS business model for a cleantech innovation in B2B market?

As the main research question is broad, sub-questions are formed to support the main research question and to understand the phenomena behind the research question. All in all, three sub-questions are created:

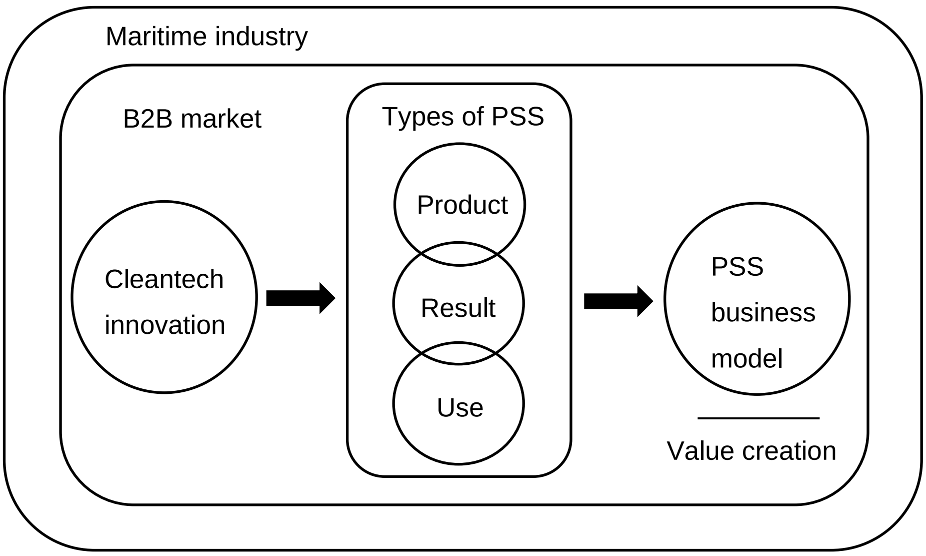
SQ1: How does the maritime industry affect the business model?
SQ2: How a PSS business model creates value for the B2B customer?
SQ3: What are the customer requirements for the cleantech product and services?

The first sub-question aims to understand how the maritime industry affects the business model development. To answer this question, maritime industry and ballast water treatment systems are examined. The second sub-question focuses on the relationship between the PSS business model and value creation to the customer. To answer this question, the PSS business model features that create value for the customer are examined. Lastly, the purpose of the third sub-question is to find out the customer requirements for the ballast water treatment system and for the related services. The aim is to figure out what are the most important features of the product and its related services.

1.3 Theoretical framework

The theoretical framework of this research is built around the studied phenomenon and research problem of the development of PSS business model for a cleantech innovation in maritime industry's B2B market. The theoretical framework is illustrated in figure 1 below and it consists of relevant concepts and theories used in this thesis, studied phenomenon, and linkage to the topic of the thesis.

Figure 1 Theoretical framework



The theoretical framework presents the relevant theories and concepts of this study: maritime industry, B2B market, cleantech, different PSS business model strategies (product-oriented, result-oriented, and use-oriented) and value that is created from the PSS business model.

1.4 Definitions

Ballast water treatment systems:

Ballast water treatment systems (BWTS) or ballast water management systems (BWMS) are new technologies that can clean ship's ballast water. BWTS is an equipment which mechanically, physically, chemically, or biologically processes ballast water to remove and inactive biological organisms such as zooplankton, algae, and bacteria. (Babicz 2015; Čampara Slišković et al. 2019) BWTS equipment can be operated at the uptake or discharge of ballast water, during the voyage, or at a combination of the events (Čampara et al. 2019).

Business model:

Scholars do not agree on the definition of business model, and the literature is young, dispersed, and developing according to the respective researchers' interests (Zott et al. 2011). Baden-Fuller and Haefilger (2013, 419) define business model as "*a system that solves the problem of identifying who is the customer, engaging with their needs, delivering satisfaction, and monetizing the value*." The ultimate role of a business model is to ensure that the technological core of the innovation creates and delivers value to the customer (Chesbrough & Rosenbloom 2002; Björkdahl 2009; Teece 2010).

Clean technology:

Clean technology, in short cleantech, refers to products, services, and processes of any sector that reduces or eliminates harmful environmental effects of production and consumption (Mäkinen & Laaksonen 2014; Alhola & Nissinen 2018). Cleantech concerns broad range of technology related to biofuels, wind power, green transportation methods, waste treatment, and recycling (Mäkinen & Laaksonen 2014). Cleantech provides superior performance at lower costs and at the same time it includes higher levels of recyclability as well as energy efficiency and reduces impact on natural resources (Jensen et al. 2020; Mäkinen & Laaksonen 2014).

Maritime industry:

The maritime industry consists of business activities related to ships, maritime technology, boats, maritime infrastructure, environmental technology, and maritime functions (The Finnish Maritime Society 2021). Moreover, it is connected to marine navigation, shipping, and marine engineering (Northeast Maritime Institute 2020).

Product-Service System:

Product-Service System (PSS) can be defined as consisting of "*tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs*" (Tukker 2004, 246). Another widely cited definition is provided by Mont (2002, 239): "*PSS is a system of products, services, supporting networks and infrastructure that is developed to be competitive, satisfy customer needs and be more sustainable than traditional business models*." The three most widely accepted categories of PSS are: product-oriented PSS, use-oriented PSS, and result-oriented PSS (Morelli 2006; Tukker 2004).

1.5 Delimitations

This thesis focuses on the development of a PSS business model for a cleantech innovation in Finnish maritime industry's B2B market. Although the research focuses on one field, BWTS, and one country's specific industry, Finland's maritime industry, it is still giving value globally. The PSS business model can be adopted all over the world for the commercialization of cleantech innovations. In addition, the conceptualization and categorization of PSS can be applied to other industries as well. Moreover, Finnish maritime companies have international partners, or the companies have foreign ownership (Karvonen et al. 2008), making the industry international, so the findings can be generalized to foreign maritime industries. The research focuses on the B2B market instead of the B2C market because the cleantech innovation's potential customers are in the B2B market. In addition, it is also a delimitation that the study's focus is on PSS business models instead of other business models. However, service-based business models are becoming more popular instead of product-based business model, so the topic is relevant. The delimitations of the industry, phenomena and concepts make the study more manageable and relevant.

1.6 Research methodology

The research was conducted by using qualitative research methodology. To cover the comprehensive views of potential customers on BWTS, different approaches were used to gain information. The potential customers are companies operating in the maritime industry's B2B markets, more specifically ports, port operators, shipping companies, and other service providers and companies in the waterways logistics field. The research process is presented in figure 2 below.

Figure 2 Research process

The data for the study was collected by a self-completed internet questionnaire to understand the general opinion of potential customers about BWTS. The questionnaire was distributed to respondents via e-mail to companies' top management to obtain their views and needs regarding BWTS and to gain knowledge about the strategical decision-making within the company. The answers were confidential, and individuals could not be identified. However, if the respondent provided their contact details, they could have been contacted for a follow-up interview. After the responses for the questionnaire were received, then follow-up interviews were conducted for the potential customers. Out of the people who gave their contact information, judgmental sampling strategy was used to select the interviewees. An individual semi-structured interview was used, and it was based on the main themes with key questions to be covered (Saunders et al. 2015). An interview is a good method as it allows a possibility to make additional observations and gives precise answers (Heikkilä 2014). This data collection method was used to gain an in-depth understanding of opinions about the topic. Thus, questions about maritime industry and how BWTS can create value were asked in detail.

A document review was also conducted so secondary sources included website and expert articles. After the questionnaire, interviews, and document review the collected data was analysed with a qualitative data analysis software, NVivo. The analysis followed Miles and Huberman’s (1994) framework to describe three main phases of data analysis: data reduction, data display, and conclusion drawing and verification, which were all used to analyse this research’s findings.

1.7 Structure of the study

The first chapter introduces the background of the study and presents the research questions and objectives. Chapters two and three form the theoretical part of the study by introducing all the relevant literature for this thesis. Chapter two describes the literature related to PSS business models, its theoretical development, and how existing theory will be utilized in this research. The third chapter discusses cleantech in the maritime industry. This section will introduce the reader to BWTS market, specifically in the Finnish maritime industry.

The fourth chapter discusses the chosen research methodology following with the chosen data collection and data analysis methods. In the fifth chapter the empirical findings of the research are discussed and analysed. Finally, in the sixth chapter conclusions are presented and the research questions are answered. Additionally, the theoretical contributions and managerial implications are discussed.

2 BUSINESS MODELS AND PRODUCT-SERVICE SYSTEM

Through business models, companies commercialize new ideas, technologies, and processes (Chesbrough 2010). The definition of business model (BM) varies greatly, however, it is widely agreed that a business model explains how a business creates, delivers, and captures value (Osterwalder & Pigneur 2010; Teece 2010). A business model describes the logic of the firm and how it operates as well as how it creates value for its stakeholders (Casadesus-Masanell & Ricart 2010). Furthermore, a business model is a conceptual tool that helps to capture, visualize, understand, communicate, and share the business logic (Osterwalder et al. 2005). All businesses use a particular business model, and it "*reflects management's hypothesis about what customers want, how they want it and what they will pay, and how an enterprise can organize to best meet customer needs and get paid doing so*" (Teece 2010, 172).

In addition to a diverse set of BM definitions, business models vary in components, theoretical basis, and approaches to classification (Shafer et al. 2005; George & Bock 2011; Baden-Fuller & Haefliger 2013). To better understand business models, one needs to look at their component parts and understand how they relate to one another. The study of elements or components to compound a BM framework is one of the research areas in BMs. (Osterwalder et al. 2005) However, there is still debate on the common components of the BM (Frankenberger et al. 2013). In a study by Shafer et al. (2005) they found out 12 definitions emerged from where one can find 42 different business model components: unique building blocks or elements. From there, they identified categories: strategic choices, creating value, capturing value, and the value network. Similarly, Guo et al. (2013) conceptualize BM as composed of three key elements: value propositions, value-creation systems, and value-capturing mechanisms. Osterwalder and Pigneur (2010) developed a well-known tool for business model generation which consists of nine building blocks: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. Casadesus-

Masanell and Ricart (2010) consider that BM is built based on the choices and consequences and thus, does not require specific components in it. Overall, the BM literature identifies that business models contain external and internal elements or components that are typically built around value proposition, value creation and revenue models.

A business model is never complete as the process of making strategic choices and testing business models should be ongoing and iterative (Shafer et al. 2005). Drivers such as globalization, competitors, regulation, and technological change, are changing the competitive environment and can quickly make a firm's existing BM less profitable (Casadesus-Masanell & Ricart 2010; Sosna et al. 2010). This has allowed fastest growing firms in this new environment to differentiate and innovate their business models (Casadesus-Masanell & Ricart 2010). Thus, continuous business model innovation is important to maintain success in the long term (Sosna et al. 2010).

Business model innovation (BMI) involves changing the way companies do business. According to Guo et al. (2013) BMI refers to the creation or reinvention of existing business models by proposing new value propositions, designing new value creation systems, and building original value capturing mechanisms. Bucherer et al. (2012) define business model innovation as a process that deliberately changes the core elements of a firm and its business logic. Foss and Saebi (2017, 201) define business model innovation as *"designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements."* Amit and Zott (2010) highlight that BMI relies on recombining the existing resources of a firm and its partners, and does not require significant investments in R&D.

Advances in technologies can facilitate new business models (Baden-Fuller & Haefliger 2013) which has driven interest on business model innovation (Casadesus-Masanell & Ricart 2010). The success of a firm is as much dependent on business model innovation as it is on technological innovation (Guo et al. 2013).

Because the value proposition of a business model is heavily influenced by the products and services offered and by the processes used, product or process innovations may lead to business model innovations (Bucherer et al. 2012). Servitization refers to the integration of service components into the firms' range of activities, and it often reflects a shift from selling products to selling integrated products and services that deliver value in use. Servitization can be argued to be an important driver of BMI. (Foss & Saebi 2017)

Traditionally many people have considered products separately from services. Services can be viewed as an activity done for others on a commercial basis with offerings where the value is provided in intangible forms and that are consumed at the same time they are produced. (Brax & Jonsson 2009; Goedkoop et al. 1999) Thus, a 'service-based' model refers to offering into services related to its products (Visnjic et al. 2016). On the other hand, a product is a tangible commodity manufactured to be sold to meet a user's need (Goedkoop et al. 1999). So, a 'product-based' business model implies that the firm develops and sells physical goods (Kindström & Kowalkowski 2014). So to say, service offerings are process-based where the core of offering is a process compered to goods that are sold as the outputs of a process (Brax & Jonsson 2009). During recent years 'servitization' of products and the 'productization' of services have emerged (Baines et al. 2007).

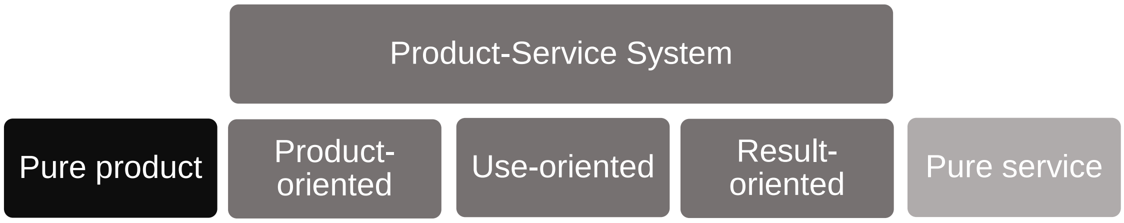
The choice of the relevant BM is crucial for the cusses of a firm as *"a better business model often will beat a better idea or technology*" (Chesbrough 2007, 12). Thus, success is as much dependent on business model innovation as it is on technology. Baden-Fuller and Haefliger (2013) noted that choice of business model influences the way in which technology is monetized and the profitability for the relevant firms. Extending traditional businesses into bundles of products and services (PS) has been a natural response for many firms. So to say, business models have evolved from product business models towards integrated Product-Service System (PSS) business models. There is a relationship between business model innovation and technical innovation (Chesbrough 2010). Because customers are provided with value through services rather than products (Barquet et al, 2013) and companies consider services as a source of added value (Rivas-Hermann et al. 2015) a PSS business model approach for this study is relevant.

Product-Service System is a special case of servitization which is described as *"a marketable set of products and services capable of jointly fulfilling a user's need"* (Goedkoop et al. 1999, 18). The traditional functionality of a product is extended by including additional services, this means that the emphasis is on the ´sale of the use' and not on the 'sale of the product'. Thus, the value is on the asset performance or utilization rather than ownership. This way, differentiation is achieved through the integration of product and services that provide value in use to the customer. (Baines et al. 2007) For decades, PSS business models have been predicted as one of the most effective tools to move society toward a resource-efficient, circular economy and to create a needed 'resource revolution' (Tukker 2015). Sustainability in PSS can be reached mainly through improved resource utilization or innovations that change operations as they are more beneficial for the environment. By producing fewer products and increasing durability and recyclability, the PSS is optimized to be eco-efficient. As the PSS focuses on the entire life cycle, it reduces the environmental impact. (Reim et al. 2017) It can be concluded that most Product-Service Systems are likely to lead to some environmental improvements, or at least no worse environmental performance (Tukker 2004). All in all, a PSS is competitive, satisfies customers and has a lower environmental impact than traditional business models (Mont 2002).

2.1 Three types of Product-Service System

There are three types of PSS that are common and widely accepted in the PSS literature. Tukker (2004) studied the various types of known PSSs and resulted in three main categories: product-oriented, use-oriented, and result-oriented. The three classifications are presented in figure 3 below. All three types of PSS solutions satisfy customer needs through a combination of products and services that are systemized to deliver the desired utility or function (Baines et al. 2007).

Figure 3 Categorization of PSS types, adopted from Tukker and Tischner (2005)



Product-oriented PSS: The product is sold in a traditional way, so ownership of the product is transferred to customers. Supporting services are included and provided to help ensure product performance over a given time period. (Catulli et al. 2017) Examples of such services include maintenance, repair, re-use, recycling, training, and consulting. The benefits include minimizing costs for a long-lasting, well-functioning product. (Baines et al. 2007) Additionally, a take-back agreement is available when the product reaches the end-of-life point (Azarenko et al. 2009).

Use-oriented PSS: Providing the use or availability of a product to the customer over a specified time period without transferring the ownership. The ownership rights related to the product are retained by the service provider (who may or may not have manufactured it). Examples include sharing/pooling, renting, and leasing. (Catulli et al. 2017) In this case, the company is motivated to develop a Product-Service System to maximize the use of the product needed to meet demand and to extend the life cycle of the product and materials used to manufacturer it (Baines et al. 2007).

Result-oriented PSS: The customer purchases a desired outcome or result instead of a product. The product required for service delivery is owned by the service provider (who may or may not have manufactured it). (Catulli et al. 2017) For example, selling laundered clothes instead of a washing machine (Baines et al. 2007).

2.2 Value creation

According to Osterwalder and Pigneur (2010, 14) *“business model describes the rationale of how an organization creates, delivers, and captures value.”* Value creation is the core of business models as companies tend to gain value by seizing new business opportunities, new markets, and new revenue streams. Value capture is a way to earn revenue (i.e., capture value) from providing a product, service or information to users and customers. (Bocken et al. 2014) The ability to create and capture continuous added value (often referred to as shareholder value) is often seen as the key measure of business success (Tukker 2004).

Value in PSS is created by taking over work tasks from customers and achieving the results more efficiently. This also results in improved customer relationship and their loyalty. (Reim et al. 2017) Also, the high level of contact and flow of information with the customer improves the relationship (Mont 2002). Customers benefit and gain value from a PSS because they receive greater diversity of choices in the market; maintenance and repair services; various payment schemes; and the prospect of different schemes of product use that suit them best in terms of ownership responsibilities (Mont 2002). PSS provides customers value through customization and higher quality. For the customer, PSS is considered to provide value by customization and higher quality. A flexible service component can also provide new combinations of products and services, better according to customer needs. (Baines et al. 2007) In addition, PSS often remove the administrative or monitoring tasks from the customer back to the manufacturer as the ownership stays under the producer for its entire life cycle. (Baines et al. 2007; Mont 2002) This is beneficial for the customers as they avoid risks, responsibilities, and costs that are traditionally associated with ownership (Baines et al. 2007). In addition, value is created through positive effects on the environment in terms of reduced material use and higher levels of resource utilization (Reim et al. 2017). Through PSSs, customers may more easily learn about environmental features of products and how they can contribute to minimizing the environmental impacts of consumption (Mont 2002). However, it should be noted that to capture value, the PSS should be designed so that the customers are willing to pay for the added value (Mont 2002).

The three types of PSS (product-oriented, use-oriented, and result-oriented) differ in the way that they create, deliver, and capture value. In their systematic literature review, Reim et al. (2015) combined the most significant differences of the PSS types (see table 1 below).

Table 1 Comparison of business model categories in terms of value creation, value delivery, and value capturing (Reim et al. 2015)

	Product-oriented	**Use-oriented**	**Result-oriented**
Value creation	Provider takes responsibility for the contracted services	Provider is responsible for the usability of the product or service	Provider is responsible for delivering results
Value delivery	Provider sells and services the product sale and service (e.g., maintenance or recycling)	Provider assures the usability of the physical product along with service	Provider delivers result
Value capture	Customer pays for physical product and for the performed services	Customer can make continuous payments over time (e.g., leasing)	Customer payments are based on outcome units; that is, they pay for the result

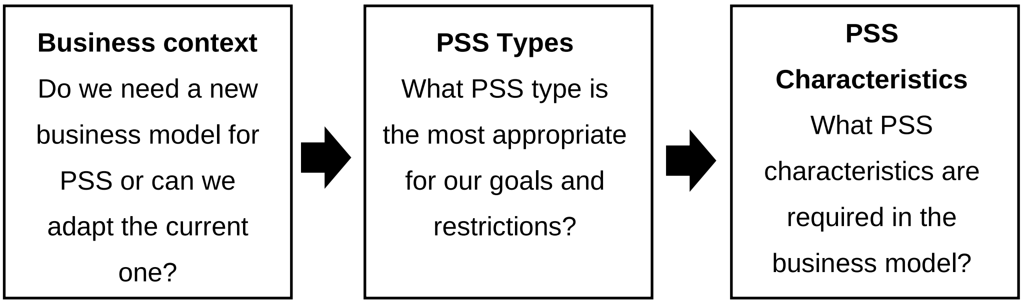
In the product-oriented PSS business model, the value is created for the buyer by reducing the amount of work they must do themselves. The focus on this category is mainly on selling a product with services. Whereas in the case of use-oriented PSS business model, the ownership is not transferred to the customer. Thus, the risks and responsibilities for the provider increase. Finally, in the in the result-oriented category of PSS business models, the ownership of the product stays with the provider, and the customer pays only for the supplier providing the agreed-upon result. (Reim et al. 2015)

2.3 Product-Service System business model design

Literature about developing and implementing a PSS business model is quite fragmented as there is no process model that can be used universally for the development of all PSS types. A recent study by Richter et al. (2019) described how the PSS models are very different, but similar in the aspect that they often use tools and methods that were originally developed for traditional product or service development. Likewise, Mont (2001) presented that it is difficult to create general, widely applicable PSSs because the systems have high levels of specialization. Specialization is dependent on product characteristics, organizational structure, chain actors and interrelations, network support, and infrastructure in place. PSS is also dependent on types of customers they are provided to either in the B2B or B2C market as customer groups vary in their purchasing behavior. (Mont 2001) Due to the findings in the literature, this study is going to follow some PSS development models and methodologies that match with the current situation of the cleantech innovation.

The focus of PSS design should be integrating business models, products, and services together throughout the lifecycle stages as well as creating innovative value (Vasantha et al. 2012). Barquet et al. (2013) developed a framework (Figure 4 below) to support companies interested in adopting PSS.

Figure 4 Framework to support the adoption of PSS (Barquet et al. 2013)



The first part, the business context, involves an analysis of the current business model in terms of PSS requirements, verifying the potential restrictions, which can be internal and external to the organization. There are two alternatives, either adapt the current business model or create a new one. The second part, the types of PSS, identifies the link between the business context and the PSS characteristics. It defines the main goals of the business model and allows for the selection of the most appropriate PSS characteristics. The third and last part, the PSS characteristics, embraces, for example, the definition of the customer relationships and partners that are required to develop and deliver the product–service offer. It is a description of the characteristics that should be incorporated by the new or adapted business model to create a specific type of PSS. (Barquet et al. 2013)

Similar, Mont (2001) purposes a step-by-step procedure to introduce and develop a PSS within a company. It is also composed of steps that examine the business's current situation, understating the customer's needs and choosing the right solution from different PSS characteristics.

1. An initial review should be done to identify practices and activities within the company, which can be used as a starting point for the PSS introduction. At the design phase of a product, a process for developing ideas for the PSS should be started. In addition, company should develop necessary expertise

and functions within the company as well as infrastructure and networks outside the company.

2. Then a marketing analysis examining customer's needs should be done. This way, a system can be developed that provides maximum satisfaction for them. This might also reveal ideas about possible value adding services or new functions to the producer.
3. Next, the company needs to choose the feasible PSS elements to introduce. These elements could be for example, training, service contracts, and second-hand market coverage. The company should choose the most efficient elements in terms of consumed resources and obtained results.
4. The implementation phase is after the elements are chosen. Products and services need to be developed and tested on a limited market so that correction and improvement can be made to the PSS or its elements.
5. Finally, new elements of the PSS in the company can be added to the selection continuously, according to criteria of economic, environmental, and social sustainability. (Mont 2001)

Gaiardelli et al. (2014) consider that a PSS business model encompasses four main elements: value proposition, the infrastructure and network, relationship capital, and sustainable aspect. The value proposition is also referred to as Product-Service (PS) offering and concerns the bundle of products and services offered, representing the benefit for which the customer is willing to pay. The infrastructure and network, such as the internal and external organisational structures, resources, and capabilities, determine how products and services can be produced and delivered to customers. The relationship capital that exists between the parties allows companies to target customers and distribution channels and determine how their products and services will be delivered; building strong relationships with the customers is also a major focus. This study focuses on the first element "value proposition", thus the PS offering.

PSS design requires the development of business model lead by the value proposition. A successful value proposition is dependent on the organizations ability to meet the interest of stakeholders and providing them benefits. According to da Costa Fernandes et al. (2019) different stakeholders need to be considered in the PSS business model design process. The identification of the stakeholders is important when designing the PSS value proposition. The PSS business model should involve different stakeholders and create, deliver, and capture value considering the coexistence of multiple stakeholders. (da Costa Fernandes et al. 2019)

A PSS business model can be implemented in many ways because different products and services can be combined in numerous ways to form unique systems and offerings that are hard to imitate. The suitable PSS should distinguish different levels of servitization and may include both traditional and green PS offerings. (Gaiardelli et al. 2014) Focusing on developing a sustainable PSS business model is also an option. Drivers for a sustainable PSS include legislation threat, client's wishes, feeling responsible, and image building (Goedkoop et al. 1999). However, offering sustainable PSS is inherently challenging. These challenges are related to for example, the design and sale of product-service combinations and aligning interest of all stakeholders. Consequently, many firms struggle to develop and deliver PSS effectively to contribute to the triple bottom line of environmental, economic, and social payoffs. (Reim et al. 2017)

Examples of chosen PS offerings for a B2B company are presented in table 2 below. All three categories differ in the degree of product emphasis, responsibilities, and ownership.

Table 2 Examples of PS offerings (Gaiardelli et al. 2014)

Product-oriented	Use-oriented	Result-oriented
Product installation, spare parts and consumables delivery, updates, remanufacturing, recycling, financial services, inspection and diagnosis, repair and maintenance, preventive maintenance, full maintenance contract, documentation	Leasing, short-term renting, long-term renting, sharing, pooling	Pay-per-use, outsourcing, functional based, pay-per-result

All three types of PSS solutions satisfy customer needs through a combination of products and services that are systemized to deliver the desired utility or function. PSS solution creation should be started with understanding customer's needs and how these needs can be fulfilled in the most economically beneficial and environmentally adapted way (Mont 2001). One key activity in providing PSS can be to take over responsibilities that customers previously handled. This could be done by providing a complete lifecycle solution to customers or by taking over operational activities from customers. (Reim et al. 2017) For example, a traditional manufacturer could build and sell a diesel engine, however, in a PSS, a network of firms or a firm could build the engine, install it in ship as well as monitor and maintain it throughout the ship's whole life cycle (Rivas-Hermann et al. 2015). The least problematic PSSs for companies to introduce product-oriented services and advice and consultancy (Tukker 2004). However, the results-oriented model is more sophisticated and represents the most popular interpretation of the features of a PSS (Baines et al. 2007). When implementing PSS, companies should also take into consideration contextual conditions that may favor or prevent the integration of PSS itself. Barriers for implementation could involve significant corporate, cultural, and regulatory barriers. (Ceschin 2013)

3 CLEANTECH IN THE MARITIME INDUSTRY

There is lack of conceptual consensus with the term relating to innovations that have a superior ecological performance as different authors use the words “clean(er) technology”, “eco-innovation”, and “environmental technologies” interchangeably (see Boons & Lüdeke-Freund 2013; Carrillo-Hermosilla et al. 2010). However, in this research study, cleantech and eco-innovation are used interchangeably.

Almost 80% of the cargo around the world is carried by ships. Growing cargo volumes have increased the demand for larger number of ships for transportation. (Lakshmi et al. 2021) Although sea transportation causes relatively less pollution compared with aviation and trucking transportation sectors, the shipping industry has faced significant environmental challenges for decades, that are generated in shipping operations like the heavy use of natural resources and disposal of shipping wastes. (Lai et al. 2011) Considering the increasing environmental impact of international shipping, the maritime industry has set in motion to encourage environmentally friendly shipping, for example by adopting environmental regulations to tackle environmental challenges. As a result, there is an increasing common interest between academia and maritime industry about environmental innovations. The focus is on innovative solutions that aim to address multiple issues that can guarantee both economic and environmental benefits, like ballast water treatment systems. (Koukaki & Tei 2020)

In the maritime industry, new cleantech solutions are needed for traditional shipping as well as offshore solutions. Cleantech focuses on reducing shipping emissions by adopting cleaner fuels and building a more effective infrastructure. In addition, maritime cleantech provides new market opportunities as it is increasingly connected to the offshore production of solar, wave and wind power. (Mäkinen & Laaksonen 2014) As a sector, ‘cleantech’ did not exist before the early 2000s. Yet by 2010 cleantech had become a recognisable technology sector. Cleantech is increasing importance as there is a growing need to prevent environmental pollution and mitigate climate change. (Caprotti 2012) Environmentally responsible shipping activities emphasize on reducing the toxic and gas emissions generated from shipping activities that pollute the natural environment. (Lai et al. 2011) However, the general assumption is that the maritime industry is conservative in terms of introducing new technologies or developing new market solutions (Koukaki & Tei 2020).

3.1 Ballast water management

Water is used as ballast to stabilize vessels at sea, making it is essential for the safe operating conditions throughout a voyage. This intake and discharge of water reduces hull stress, provides transverse stability, improves propulsion and manoeuvrability, and compensates for changes in different cargo wight levels as well as fuel and water consumption. (IMO 2019) Ballast water management occurs at both ports and on high seas. Thus, thousands of marine species could enter a ship's ballast tanks while pumping in ballast waters. Every country around the world is affected by the ballast water discharge as the transferred species may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions. (IMO 2019) Treatment and dispersal of ballast water are identified as one of the major procedures for the management of marine ecosystem (Lakshmi et al. 2021).

IMO initiated a discussion in 1991 to adopt international guidelines for ballast water management to prevent, reduce and put an end to the threat or negative impacts of ballast water discharge in the environment (IMO 2019). After 14 years of negotiations between IMO member states, the International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWM Convention) was eventually adopted by an IMO Diplomatic Conference in February 2004 (IMO 2019). The BWM Convention entered into force September 2017 whereby all ships in international trade are required to have a Ballast Water Management Plan and to manage their ballast water to meet the D-1 standard or D-2 standard for ballast water discharge by 8th September 2024 (IMO 2017; IMO 2019). As of May 2021, 86 countries representing approximately 91.12% of the world's merchant fleet tonnage have ratified the BWM Convention (IMO 2021). This control and management of ships' ballast water is one of the largest vector management initiatives in the world (Davidson et al. 2017).

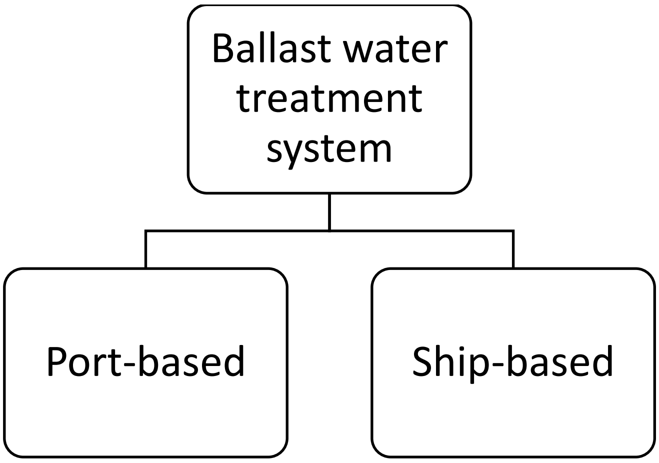
However, the United States is not a party of the IMO Convention. Equivalent to the BWM Convention, the United States Maritime Administration has developed its own ballast water management legislation under the dual authority of the US Coast Guard (USCG) and the Environmental Protection Agency called "Final Rule entitled Standards for Living Organisms in Ships' Ballast Water Discharged in US Waters." The USCG ballast water regulation became effective on June 2012 and requires all ships conducting ballast water operations in US territorial waters to comply with the US BWM regulations by installing a BWTS by 2021. (Čampara Frančić et al. 2019; Makkonen & Inkinen 2021)

Therefore, there are two influential regulatory regimes for BWTS technologies. BWMC set by IMO, is designed for ships involved in international trade and implemented by countries that have signed BWMC. While the one set by USCG's BWM obligates ships operating in the US waters. (Makkonen & Inkinen 2021) The major difference between the BWM Convention and USCG BWM is in the ballast water management system testing and verification requirements. As a result, the complexity and certain regulatory differences cause considerable concern amongst all stakeholders in the shipping industry, mainly shipowners and ship operators. (Čampara et al. 2019)

3.2 Ballast water treatment system

The technology of BWTS is still evolving and the number of manufacturers is constantly growing (Babicz 2015). The ballast water treatment system market consists of ballast water treatment-related manufacturing, technology, and service vendors which sell products and services to end users. The market is moderately competitive and consists of several players such as Wärtsilä Corporation (Finland), Alfa Laval AB (Sweden), and Damen Group (Netherlands). Due to increasing volume of international maritime trade and stricter regulations imposed by the IMO, the global ballast water treatment market size is expected to reach 8.9 billion U.S. dollars in 2027 (Statista 2021). It is widely recognized that there is no single system that is suitable for all ship types (Babicz 2015). The ballast water treatment system can be either ship-based or port based (see figure 5 below).

Figure 5 Ballast Water Treatment



Ship-based treatment involves the use of ballast water exchange or treatment of the ballast water on-board (Tsolaki & Diamadopoulos 2010). Shipboard treatment BWT technologies allow ships to manage and control ballast discharges by themselves. A marine sector technology manufacturer, Wärtsilä, has developed two BWT product series, Aquarius® UV & EC, which can be installed on-board (Wärtsilä 2021).

Port-based treatment involves transferring ballast water to an onshore treatment facility to clean the seawater of non-indigenous species. A visiting ship could exchange untreated ballast water for treated ballast seawater. (Tsolaki & Diamadopoulos 2010) Thus, vessels do not have to install a treatment unit on-board (Rivas-Hermann et al. 2015). The disadvantage of this method is that the construction of the treatment facility is costly (Tsolaki & Diamadopoulos 2010). According to Rivas-Hermann et al. (2015) port-based systems have the highest potential for eco-efficient value creation and a possible PSS can be designed for this kind of technology. Damen, a shipbuilding and engineering company, has developed a mobile ballast water treatment system, InvaSave, for port use (Damen 2021).

3.3 Potential customers of ballast water treatment system

The maritime industry is characterized by a highly complex market structure and a network of subsidiaries, suppliers, and customers (Hameri & Paatela 2005). The network which traditionally consist of relationships between shipbuilders, shipowners, and charterers who buy the transport use of a ship (Rivas-Hermann et al. 2015). As the BWTS can be either ship-based or port-based, it opens different business opportunities for different stakeholders of BWTS. The BWT regulation is meant to control and manage ship's ballast water but like every other market, the BWTS market also has numerous stakeholders: shipowners, BWTS-vendor, shipyards, laboratories for testing efficacy of BWTS, recognized organizations, and maritime administrations of coastal states. (Hasanspahić & Zec 2017) The stakeholders are present in different stages of the ballast water treatment system's business cycle. The business cycle revolves around three key stages: development, installation, and operation which provide several opportunities for maritime service companies. As the focus of this study is to develop a business model for the BWTS, the potential customers of the cleantech will be examined. The potential customers are shipping companies and service providers in ports.

Shipping companies

The shipping companies are a potential customer for a BWTS producer like mentioned before as the IMO regulation obligates ships to handle their ballast water. Shipping companies' business environment is complex as they need to comply regulations in their operations, face pressures of operating in a highly competitive international business, and customers' requests, with which shipping firms need to comply in the hope of continued business. (Lai et al. 2011) Shipping companies need to focus on different criteria while selecting the best solution of BWTS. Different ships have different criteria for their BWTS as the ships are unique in the way they operate. Issues that need to be considered when choosing the best BWTS are ship's size, age, type, ballast water capacity and ballast pump(s) capacity, and ballasting frequency. In addition, the ship's route, including water characteristics and the length of voyage, have an influence. (Bacher & Leino n.d.) However, for vessels with few ballast water discharges per year and for older vessels, fitting an on-board unit may not be economically efficient. Estimations for BWTS retrofit projects vary, but it should take around nine months. However, lack of capacity for stakeholder's classification societies, BWTS vendors, installation, docking, and design can all delay the retrofit process. (Bacher & Leino n.d.)

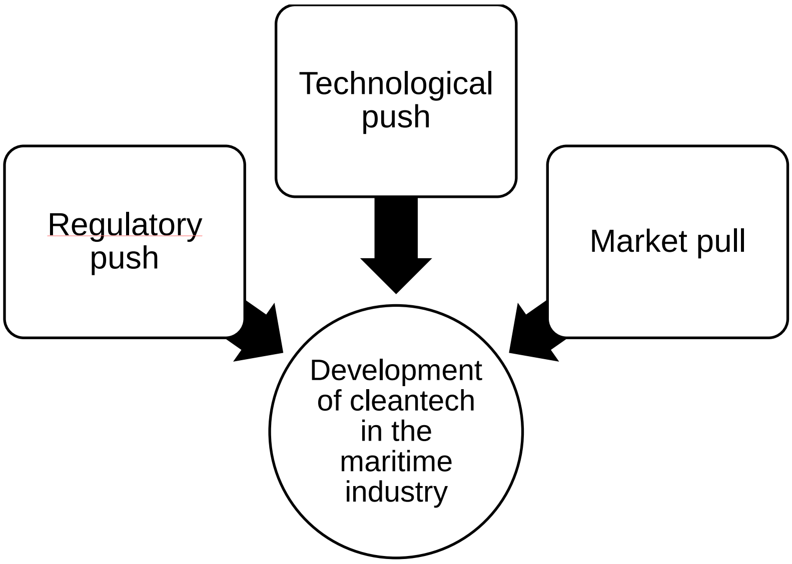
Service providers (Ports and port operators)

Other solution for the ballast water management is to transfer the ballast water to an onshore treatment facility. The use of a land based BWTS in ports has been considered as an option for BWT for more than a decade (King & Hagan 2013). This way the port-based treatment provides a business opportunity for service provides like ports and port operators. The service providers could provide BWTS as a solution for shipping companies so that the shipping companies would not need to invest in a BWTS. However, ports are sceptical if the BWTS would be logistically or economically feasible. So far, there have been very few attempts to test the feasibility of port-based BW treatment facilities (King & Hagan 2013) although port-based ballast water management services could save the costs of retrofitting. In addition, this can be a business opportunity to provide a ballast water treatment service when on-board systems are not appropriate or in the event of failure.

3.4 Drivers for cleantech in the maritime industry

There are several approaches to stimulating eco-innovation. Drivers for eco-innovation are changes in the external environment, such as the implementation of new regulations, the change in consumer preference or technological advantages (Hermann & Wigger 2017). Nevertheless, this study will focus on some of the key drivers which are vital for achieving eco-innovations and they will be regarded in the maritime industry and ballast water management. These drivers include technological push, market pull, and regulatory push (Hermann & Wigger 2017) which are presented in figure 6.

Figure 6 Drivers for cleantech in the maritime industry



Regulatory push

Regulatory frameworks are generally seen as one of the main drivers of environmental technology adoption (Montalvo 2008). The term regulatory push contains variety of policy instruments that work as market-based instruments: taxes and tradable permits, standards, negotiated agreements, and information-based instruments, i.e., the eco-label. (Hermann & Wigger 2017) Regulations stimulate firms to improve their existing processes, products, and services as well as develop new ones (Rennings & Rammer 2011).

Maritime industry has the most regulations compared to other industries (Pitana & Handani 2020) and these environmental regulations and development of required technologies are rapidly changing the operating environment (Kilpi et al. 2021). Over the last century a regulatory system that covers all aspects of shipping business has evolved. Subject to regulation in one way or another are ship design, maintenance standards, crewing costs, employment conditions, operating systems, company overheads, taxation, oil pollution liability, environmental emissions, and cartels. (Stopford 2008) In addition, environment, emissions by ships, ballast water, and ship recycling have all received more attention over the past years. New environmental regulations put significant investment pressure on the maritime industry as well as forces maritime clusters to invest in cleantech development. (Mäkinen & Laaksonen 2014) Knowledge of maritime regulation is essential as regulation has an important part of the maritime industry and it has economic consequences. According to Andersen et al. (2013) the ongoing changes in international and national maritime legislation are in many cases the main strategic concern for maritime companies. The new regulations cause a change in business culture and new business routines in the companies working in the maritime industry. Consequently, changes have resulted in additional costs for shipowners or operators such as infrastructure and technologies, R&D and education, international networking, and national strategies (Mäkinen & Laaksonen 2014). These costs are included in the implementation costs to meet regulatory requirements. As a result, shipowners typically face the risk of a conflict of interest between consumers and their market share. (Pitana & Handani 2020) However, the regulatory changes lead to direct environmental benefits and such advances may eventually result in first-mover advantages in global competition in maritime cleantech (Mäkinen & Laaksonen 2014).

Like earlier mentioned, the BWM Convention is regarded as the first significant legislation adopted to control and eliminate environment and health issues from the transfer of invasive species. Additionally, USCG has its own BWM regulation for ships operating in the U.S. waters. These regulations include specific requirements that demand every vessel to treat its ballast water with appropriate treatment systems. Regulations have an influential impact on the BWTS market as it is dependent on international regulations, technical standards, and national implementation programmes (King et al. 2012).

Market pull

Market pull includes factors such as customer demand for greener products or production processes, a firm’s image linked to environmental protection, improved competition by the reduction of costs, and the creation of new markets (Hermann & Wigger 2017). Market-pull innovations are triggered by new or previously unknown needs (Bucherer et al. 2012) or pressures from customers and the larger public (Montalvo 2008).

The BWTS’ market demand on a global level has been established due to the BWM Convention. Additionally, there has been ongoing discussion within the maritime industry for solutions that reduce the impact of shipping on environment like BWTS (Koukaki & Tei 2020). Thus, maritime companies are influenced to invest in cleantech to satisfy customer demand as well as remain competitive in the market. Hence, market pull has had an impact on the growth of the BWTS market. However, the BWTS market size and timing are more dependent on international regulations, technical standards, and national implementation programmes (King et al. 2012). The demand for the BWTS has been already set as the BWM Convention was approved in 2004 and enforced in 2017, and as a result, new builds need to have BWTS installed, however existing vessels have time until 2024 for retrofitting BWTS (Makkonen & Inkinen 2021). Thus, the demand for BWTS will drastically increase when regulation’s deadline approaches in 2024.

There has been delay on the ratification of the BWM Convention by the IMO member nations because they wanted to delay the enforcement of the convention until they are sure that sufficient systems have been fully developed and supplied into the market. Consequently, the delay had a major set-back in affecting the demand of customers and growth of global market. BWTS Manufacturers, potential investors, and shipowners have been waiting for assurances from regulators before investing on the treatment systems. (King et al. 2012)

Technological push

Technological push concerns the supply side embedded knowledge that is in machines, human capital, and organizations. Technological push has two effects: it reduces manufacturing costs in the production processes, and it commercializes a greener product. This means improvements in product's quality and in the production process by cutting costs of material and energy. (Hermann & Wigger 2017) Technology-push innovations are triggered by the usage of new technologies and are driven mainly by R&D (Bucherer et al. 2012).

In the maritime industry, most companies adopt environmental technologies to reduce environmental impact as well as to meet up with strict environmental regulations and increasing pressure to adopt to eco-innovative practices. These developments towards stricter environmental regulations require the development and installation of new technologies. (Andersen et al. 2013) BWTS is a new technology and its developments' overall intention is to reduce environmental impacts by preventing the negative impacts of invasive species. The technology is an "end-of-pipe" solution since it deals with the symptoms but not the cause of the problems related to the use of ballast water. (Makkonen & Inkinen 2021) Like mentioned before, there was a delay in the ratification of the BWM Convention which caused the market to experience a slow development of ballast water treatment technologies (King et al. 2012).

4 RESEARCH DESIGN AND METHODS

This chapter consist of the research design and methodology. It begins with explaining the research design, after that it presents how the data was selected and collected. It also discusses the data analysis. Finally, a critical analysis of reliability and validity is presented.

4.1 Research Design

This research was conducted by using qualitative case study research method. Qualitative method was chosen because it studies participant's meanings and the relationship between them, using a variety of data collection techniques and analytical procedures, to develop a conceptual framework and theoretical contribution (Saunders et al. 2015, 168).

The primary data for this study was gathered through a questionnaire and interviews. By conducting a questionnaire, the researcher was able to gather findings from a larger sample which were then deepened through follow-up interviews to explain the findings from the questionnaire and gain more understanding. In this way of conducting research, the two data collection methods were complementary. Expanding the use of methods brings out broader perspectives and can increase the reliability of research (Hirsjärvi & Hurme 2015, 38). In addition, data was collected through a document review. The data collected from the questionnaire, interviews and document review were combined as the sample sizes from the questionnaire and interviews were small. The analysis of this research was done qualitatively.

This research has an inductive approach as it explores a topic and develops a theoretical explanation as the data is collected and analyzed (Saunders et al. 2016, 51). This was a suitable approach as it allows meanings to emerge from the data during data collection to identify patterns and relationships to build theory. In addition, existing theory can be used to formulate research question and concepts can be identified so that they can be explored in the research process. (Saunders et al. 2016, 52)

4.2 Data selection and collection

Empirical evidence was collected between March 2021 and June 2021 through a survey, in-depth interviews, and a document review. Data collection began with searching and collecting relevant existing literature from LUT university's library base, Scopus, and Google scholar to develop a good understating and insight into to the topic. The chosen literature included academic journals, high-quality articles, reports, and books. The chosen literature was critically evaluated. A literature review on PSS and business models was conducted to conceptually frame how PSS implementation are related and can be integrated.

A survey and interviews for potential customers were chosen for gathering primary data because developing knowledge of customer's processes helps customize functions and effectively integrate PSS into the customers' processes. In addition, customer involvement early in the design and development of the PSS offering, makes the development process more efficient and effective. (Reim et al. 2017)

Questionnaire

A self-developed questionnaire was sent to the potential customers and actors working in the Finnish maritime industry. Data collection was targeted for actors working in the maritime industry, more specifically in ports and shipping companies who could benefit from buying a BWTS. The companies were found by conducting a search on Google and the email addresses of potential respondents were found from the company web pages. All in all, the questionnaire was sent to 102 e-mail addresses.

The survey was sent electronically via e-mail, and it was accessible in an online survey tool Qualtrics. Qualtrics allows to design the questionnaire, capture, and automatically save data, as well as do analysis within the platform (Saunders et al. 2015, 442). The data was also downloaded as a data file for external analysis with NVivo which will be later discussed more. The e-mail sent contained information about the purpose of the study and instructions how to participate in the survey. The respondents were encouraged to respond and distribute the questionnaire to their networks.

The questionnaire was anonymous and confidential. The questionnaire is presented in appendix 1. The survey consisted of multiple-choice, open-ended, and Likert-scale set of questions. The questionnaire was designed to enable separation between different actors in the maritime industry such as shipping companies, port operators and ports. The questionnaire consists of subsets that were designed to understand different features about the company where the respondent works at, the current and future needs of the BWTS, ideas of potential usage ways of the innovation, and the importance of the different features of the innovation. The design of the questionnaire was carefully evaluated as it affects the response rate as well as reliability and validity of the data collected (Saunders et al. 2015, 439). The questions were carefully thought out and designed so that they are easy to understand. In addition, the questionnaire was designed to be short to maximize the number of responses. The questionnaire was tested to take around 5 minutes on a computer. Before sending the questionnaire, it was pilot tested so that there would be no problems in answering to the questionnaire and recording the data.

After the initial message, one reminder e-mail was sent one week before the deadline. The questionnaire was open for two weeks during 26.3.-9.4.2021 and 21 answers were received. The questionnaire was conducted both in Finnish and English to gain a higher response rate, however all the answers received were in Finnish.

Interviews

To gain more in-depth understating from the potential customers, interviews were also conducted. A semi-structured thematic interview fit the objectives of this study as the topic is broad and there are no unambiguous answers to the questions (Hirsjärvi & Hurme 2015, 47). In addition, this type of an interview was selected as it allowed the researcher to have a list of themes and key questions to be covered and their use could vary from interview to interview (Saunders et al. 2015, 391). Thus, an advantage of this interview type for this research was that it allowed flexibility for the interviewer to cover in-depth issues that require particular attention. The interviews were constructed through a pre-prepared interview guide and the interview questions aimed to cover all aspects of the research questions. The interview questions were mostly the same for all interviewees, however, the questions were adjusted based on whether the interviewee represented a port servicer provider or a shipping company and, on the fact, if they were planning to purchase or already had purchased a BWTS. The interview guide and questions are presented in appendix 2.

Most of the interviewees expressed their willingness to participate in the follow-up interviews in the survey that was sent previously. By sending out the survey beforehand, it allowed to prepare a list of potential interviewees and ensure a balance between different types of stakeholders and actors involved in the maritime industry. The intention was to select interviewees who had a significant role in the company, significant work experience in the maritime industry or who had technical knowledge relating to BWTS. Out of the people who gave their contact information, judgmental sampling strategy was used to select the interviewees. It is a non-probability sampling which seeks to select cases that will best answer to research questions and objectives (Saunders et al. 2015, 301). To select the interviewees, an expert assessment of to what degree the selected interviewees will provide comprehensive information for the case study. In addition, to gain more interviewees and identify members of the desired population, snowball sampling strategy was also used. With this technique, after contacting few cases, they were asked to identify further cases. (Saunders et al. 2015, 303) All in all, it was challenging to get interviewees for this research as there is only a limited amount of port service providers and shipping companies in Finland and the BWTS field is still quite new and narrow. The researcher consciously analyzed the results obtained throughout the process. The data collection was stopped when no new results emerged, and the data started to repeat itself.

Researcher carried out in-depth interviews with actors in the maritime industry. The interviewees consisted of 8 experts working for maritime industry and more specifically for ports, port operators, and shipping companies. To gain as much of insight as possible, the anonymity of the interviews was guaranteed, thus only the industry and title of the interviewee are presented in table 3 below. The table visualizes interviewee's role in the company, the business area of the company, the date of the interview, and the length of the interview. The date of the interview is the day the interview was conducted via Microsoft Teams meeting. The length of the interview was measured by the length of the recording as all interviews were carried online on Teams. So, the recorded time does not contain the introduction of the interview. The average length of the interviews was 27 minutes.

Table 3 Codes and details of case interview participants

Code	Position	Business area	Interview date	Interview length
Person A	Director of Operations Support	Port operator	29.4.2021	00:17:52
Person B	Technical Manager	Port and Port operator	29.4.2021	00:16:43
Person C	Executive Director	Waterway logistics	27.4.2021	00:40:52
Person D	Technical Manager	Shipping company	4.5.2021	00:24:22
Person E	Technical Superintendent	Shipping company	4.5.2021	00:34:42

Person F	Technical Superintendent	Shipping company	6.5.2021	00:29:48
Person G	Managing Director	Shipping company	11.5.2021	00:25:30
Person H	Port administrator	Port	11.5.2021	00:31:29

All interviewees are experienced experts in their field and their organizational position focuses on management. The 8 experts and their companies differ on many levels including company size, technical backgrounds, and global presence. However, they all share the network, key stakeholders, regulatory bodies, and they are potential customers for BWTS. The interviews are intended to provide a broad perspective about BWTS and maritime industry from the perspective of ports, port operators, and shipping companies. Interviewees seek to look at the issue more broadly from the perspective of both shipping companies and industrial companies, not just from the perspective of their own organization.

All interviews were conducted during May 2021 within three weeks and the duration of the interviews varied anywhere from 17 to 40 minutes. The variation of interview duration indicates that there are different levels to insight and opinions about the needs and wants regarding BWTS. In addition, some respondents had busy schedules. The interviews were conducted via Microsoft Teams as this way of interviewing proved to be cheaper in terms of time and was safe during the time of COVID-19. The interviews were recorded with the permission of the interviewee, and they were transcribed later, so that the researcher could take extra care in the validity of the research. The interviews were conducted in Finnish and later translated into English.

Document review

A document review was done to complement the interviews and survey. This document review differed from the literature review by having different kind of documentation and sources. Table 4 presents, the documents were different categories such as websites, magazines, and articles. Data was assessed by reading mainly articles and websites to exclude the ones that did not discuss BWTS or maritime industry.

Table 4 Document source and type used as source for empirical material

Document source	Document type
- Finnish and international magazines - Finnish and international maritime company webpages - BWTS suppliers' webpages (e.g., Alfa Laval, Wärtsilä)	- Newsletters, articles - Newsletters, articles - Product catalogue, commercial presentations

4.3 Data analysis

In the qualitative analysis, the empirical data was analysed by using coding and interpretation. To begin with the data analysis, the recorded audio from the interviews was transcribed into text by an external service to ensure high-quality transcribing. The content of the interviews, open-ended answers of the survey as well as previous publications were coded. The intention was to identify main themes and their relation to each other. To analyse the qualitative data of this study, NVivo software (version 12) was used.

Miles and Huberman (1994) develop a framework to describe three main phases of data analysis: data reduction, data display, and conclusion drawing and verification, which were all used to analyse this research's findings. It is important to note that as this research utilizes the findings of not just interviews and survey but also secondary sources, the data analysis has additional dimensions to it.

At first the content of each case was thoroughly read and summarized to get the overall picture of the interviews. Then in the data reduction phase, began the process of selecting, simplifying, and transforming the data so that final conclusions can be drawn and authenticated (Miles & Huberman 1994). This phase included categorization and coding of the qualitative data to predetermined themes. This study's themes were based on the findings of previous literature and this study's theoretical framework, while maintaining the connection with research questions and objectives. All new emerging themes were added to the data analysis process. One main theme was the maritime industry, which contained BWTS market trends, competitors, and regulations. Another theme was potential customers, which included potential customer's budget, issues regarding BWTS, motives regarding BWTS, opinions about the BWTS ratification and schedule for the purchase of a BWTS. Last theme was value creation which contained needed additional services and product requirements of the BWTS.

The second phase of the Miles and Huberman Model (1994) is data display which is an organized assembly of information that permits conclusion drawing and action taking. Data display organizes data, helps to arrange concepts and the thoughts and it aims to make sense of the data that is collected. This process included thematic analyses to find the similarities and differences between the cases. Lastly, the third phase is conclusion drawing and verification, where the final conclusions are produced after completing data collection. Conclusions were built until the study reached the final stage. NVivo enabled the transparent and efficient data analysis through the entire process of coding data. To further support the transparency of this study, examples of coding are presented in appendix 3.

4.4 Reliability and validity

Eriksson and Kovalainen (2008) outline that research is based on the critical realist viewpoint that should be evaluated based on reliability and validity. Validity and reliability are often mentioned as the key criteria for a trustworthy study (Hirsjärvi & Hurme 2004). Reliability refers to replication and consistency (Sanders et al. 2015, 202) It is related to the establishment of a degree of consistency in research in the sense that another researcher can replicate the study and come up with similar findings (Eriksson & Kovalainen 2008). Validity is another classic evaluation criteria which refers to the extent to which conclusions drawn in research give an accurate description or explanation of what happened (Eriksson & Kovalainen 2008).

The reliability and validity of this study are based on well-planned methodology, which provide the opportunity to conduct the same research again. To improve transferability, a full description of the research questions, design, findings, and interpretations is provided throughout the whole process. To improve the issues relating to how well the research results can be generalized and how consistent the research is, a wide number of interviewed companies was chosen, including multiple companies from the same industry profile. In addition, it was essential to find the right interviewees from the organizations who have the relevant industry knowledge. However, the methodology is limited to the 21 answers received from the questionnaire and the eight interviews. Thus, it should be highlighted that this study uses experiences and opinions which might differ as time progresses and the interviews are biased to the specific opinions of the interviewees. More specifically, the bias may be more significant because the interviewees represent the views of their industries and so might be biased by their own profession. In addition, the coding and analysis of the interviews is exposed to bias because the process is based purely on the researcher’s interpretations. The evaluated thematic patterns are also based on the researcher’s conclusions.

5 FINDINGS

This chapter represents the empirical findings of the study. In order to better interpret the results, the data collected is further classified into themes based on the research questions and further into sub-themes based on the different topics inside the main theme. The purpose of this study was to develop a PSS business model based on the potential customers' needs and wants.

The data was collected from ports, shipping companies, port operators, and other marine companies working in the Finnish maritime industry by sending a questionnaire and then having in-depth interviews with them. The survey was open for two weeks and 21 answers were received. After receiving the answers for the questionnaire, eight interviews were held for the potential customers of the BWTS. Also, a document review was done to gain more understanding about the BWTS market and competitors.

The three data collection methods were combined in the qualitative analysis and the results are presented below. In the analysis, ports and port operators were combined as "port service providers". The findings of document review, questionnaire, and interviews are discussed simultaneously due to the complementarity research purpose.

5.1 Maritime industry

The maritime industry has high barrier of entry due to the high costs and intense competition. The industry has a complex network of multiple actors in different stages of the industry. The actors have many strong networks as well as partners inside and outside the port area. Ports and port operators usually have partners that provide support functions such as container and equipment repairment as well as cleaning and security. The shipping companies described themselves as more independent, but they had networks and partnerships with support functions related to loading and unloading the ship and fleet maintenance.

> *"The industry is small, and we know each other through events and newsletters by the (Finnish) Harbor Association. And, of course, we exchange quite a lot of information and consult each other, especially when it comes to, for example, the future equipment of the port, if there is something new under construction or something else."* (Person B, port and port operator)

> *"Partners and networks are one of the core issues of these port operations."* (Person H, port)

One of the key processes that require communication and cooperation with actors such as port, shipowner, and port operator, is when the ship arrives to the port. The arrival procedure needs to be smooth and fast for the ship as ships stay at the port the minimum time as possible. The overall description of a ship's arrival procedure was similar within the collected the data set. The process starts by informing in advance the time when the ship is going to arrive to the port. When the ship enters the port, it begins to prepare for unloading or loading which is then executed as agreed. Other activities might be refueling and inspection which are done either by port or port operator. Although the process can be complex, the data set indicated that it is possible for port service providers to add a BWTS service along the other port activities such as refueling.

The maritime industry in Finland was described as small and that different actors know each other from associations. Especially the ports and port operators had strong interaction within their own port and port operator associations and discussions. However, it was pointed out that there has been only little conversation about the BWTS and the opportunities it could provide for port service providers. The data indicated that the BWTS service could be handled during the ship's port time by a port service provider. However, there was no clear indicator which one of the port service providers it should be.

> *"It sounds like it is more related to the port facility's infrastructure related equipment (…) the port facility is the entity that then handles the services related to this vessel traffic for example waste management. This is also the case in other ports, at least in Finland. But, of course, it cannot be ruled out that the port operator will not be involved."* (Person A, port operator)

> *"I have been involved in discussions years ago about whether ports should be a BWT service provider, and this caused a reluctant reaction from ports."* (Person F, shipping company)

5.1.1 Ballast water treatment system market trends

IMO and USCG have put BWM into spotlight with strict standards. The demand for BWTS is accelerating as shipowners must meet the demands of the two significant regimes. This new and growing market benefits BWTS manufacturers such as Wärtsilä (MTV uutiset 2016). There is an expected spike in BWTS installations between 2022 and 2024, which will cause extended lead times at shipyards and that is something that shipowners must account for and plan accordingly when preparing for BWTS installations (Lloyd's list 2020).

The overall reception of the Finnish shipowners about the IMO's ratification has been doubtful and unpleasant especially due to the extra costs and urgency of the matter. The technology investment will be costly for the shipping companies, varying from approximately 0,5-1,5 million euros per ship. (MTV uutiset 2016)

Shipping companies mostly expressed their concerns relating the costs that are related with the BWTS. The overall costs of the installation of BWTS, are related to the ship's remaining lifetime and annual ballast volume. Additionally, the operational costs of the BWTS consists of costs of electricity, chemicals, and spare parts. (Bacher & Leino n.d.) The costs vary as the selection and installation of a BWTS is a very customized process. This process includes the design, installation, and commissioning. There are several stakeholders involved: shipowner, BWTS-vendor, classification society, contractors, design companies, and consultants. (Bacher & Leino n.d.)

Despite this apparent inertia from a shipowner's perspective, shipowners are very active in their networks and discussions. Currently the shipping companies are conducting on-going assessments of different technologies and service partnerships with BWTS suppliers. There is a strong support for the BWM, due to the harmful damage on the environment but IMO's requirements are seen as confusing and inconsistent.

> *"After all, it is a good that the ballast water is treated and I support that, but there should be some common sense in that treatment. For example, we operate in the Finnish and Swedish waters, which is the same water, but we still have to install it [BWTS]."* (Person E, shipowner)

5.1.2 Competitors

To develop a competitive business model, it is necessary to investigate the competitor's products and services in the BWTS. Due to the lucrative market opportunity, several new manufacturers have entered the BWMS market in the last 10 years (Jordan 2016). There are also some existing companies in the Finnish market like Wärtsilä that has already tested and sold their technology in the Baltic Sea (MTV uutiset 2016).

Shipping companies have responded to the looming 2024 deadline by doing research about the BWTS suppliers and by making orders and installations of the systems. The collected primary data indicated that shipping companies were either purchasing a BWTS from a supplier or developing their own BWTS. The BWTS manufacturer companies where purchases had been made already were from Alfa Laval, Optimarin, and Auramarine. There were different factors that impacted the purchases decisions such as price of the system and location of the manufacturer. It was pointed out that when buying from a nearby location, from Europe, the spare parts and maintenance are more easily accessed. Also, for person E's shipping company, it was vital to have a BWTS with a USCG type approval as the company was operating in the U.S. waters. At the time of purchase, Optimarin was one of the only manufacturers who had the type of approval.

> "*The [BWTS] equipment that have been installed for us; we have always had a training for them. We also receive help via phone calls. (…) The introduction and training are important, so that we know how to use that device properly. Those are the most important of all.*" (Person E, shipping company)

Norwegian Optimarin offers a help desk and a world-wide network of service partners to assist its BWTS customers when needed. Additionally, Optimarin offers spare parts, and it has created service part packages for every 2,5 year as part of the preventive maintenance of the system. (Optimarin 2021) Swedish Alfa Laval has designed a 360° Service Portfolio that covers the life cycle of the BWTS from start-up, maintenance, support, and improvements to monitoring services (Alfa Laval 2021). Finnish Auramarine is not currently providing any information about their BWTS. However, Auramarine provides installation, commissioning, maintenance, and repairs as in-service support for their maritime industry customers. (Auramarine 2020) It is also necessary to investigate the Finnish BWTS manufacturer Wärtsilä as it is operating in the BWTS market. Wärtsilä provides delivery and installation of the BWT system, as well as ongoing product lifecycle after sales and support. Their system's allows flexibility for application across the full range of ship types and sizes, for both the new build and retrofit markets. (Wärtsilä 2021)

5.1.3 The changing regulations shape the industry

The maritime industry is highly influenced by the changes in the legislation. Moreover, IMO's and USCG's BWM regulations play a crucial role in the BWTS market. The demand will only accelerate for BWTS as shipping companies have no choice but to comply with the regulations. The main reason for investing in BWTS is the pressure from the external authorities so that operations in international waters can be continued. IMO and USCG have both placed their own requirements for BWM. The requirements and the standards include discharge standard, shipboard testing, hold time and component and environmental testing (Jordan 2016).

The two different regulations cause confusion and uncertainty in the maritime industry. Shipping companies must decide if they want to follow the demands of one or both regimes. Like mentioned before, person E's shipping company based their BWTS purchase decision on the factor that Optimarin had USCG type approval which is necessary if operating in U.S. waters. The two regimes can place shipping companies in situations that they cannot operate in certain waters if they do not have the right type approval for BWTS (Bacher & Leino n.d.).

Person E also pointed out that they have also already bought BWTS to their ships, but they are only testing them because there are not required to use them now. Additionally, the data indicated that over the years IMO's regulations have changed and been delayed. In consequence, it has caused uncertainty amongst shipowners. Person E's shipping company is currently waiting for IMO's decisions whether the regulation will apply ice breakers.

> *"Now, it is on IMO's agenda to investigate should the ballast water treatment requirement apply to icebreakers. We are waiting for that*

decision and that is why we are not making any purchase decisions for BWTS right now." (Person E, shipping company)

Overall, many shipping companies have delayed their BWTS installation until closer to the compliance deadline as they have waited to see how the regulations are going to change. As a result, this situation will lead to the increasing demand for the BWTS during the 2022-2024. IMO's decisions will also impact the need for additional services and how shipowners need to indicate to the authorities how the systems have been used.

5.2 Potential customers' purchase plans

The potential customers of BWTS are shipping companies who are obligated by the BWM regulation to handle their ballast water. Furthermore, another potential customer group are port service providers as they can handle ship's ballast water as a service in ports. Thus, there are two options for managing ballast water, either by installing a BWTS on-board or using a port-based BWTS service.

The collected data indicated that ports and port operators are interested in becoming a BWTS service provider, but no decisions have been taken by companies at present. More specifically, ports were interested in adding BWT to their services than port operators. There has been no discussion in the Finnish maritime industry about BWT service, but that was not seen as an issue amongst the port service providers and shipping companies.

> "*We do not have conversation with others [ports] yet (…) I believe that this [IMO] regulation will force many to react pretty quickly soon. (...) Development takes place at a moderate pace usually in these port matters*." (Person H, port)

> *"I talk a lot with colleagues from other port operators about many things, but there has been no discussion about this [BWTS]. So, there would be no actual competition in the market."* (Person A, port operator)

The collected data indicates that shipping companies are the most determined buyers for BWTS as they are obligated to follow at least IMO's regulations, and they had more specific purchase plans for the BWTS. Port service providers had no opinions or decisions about budget or purchase schedules. Shipping companies' budgets for the BWTS purchase ranges between 100 000 - 400 000 euros per ship and the companies consider the whole life cycle costs in their purchase plans. The life cycle costs consider factors such as electricity, spare parts, and maintenance. If the shipping company had plans to purchase the BWTS, it was within a tight timetable of 1-2 years.

> *"I should make this purchase decision during this summer, because the first ship where it is now to be installed, has to be done early spring next year and all these [BWTS] suppliers, have said that the order takes a minimum of three months, but it is better if there is six months' time for the order."* (Person D, shipping company)

5.3 Towards a common understanding of potential customers' motives and issues

For the business model to be suitable for the potential customers, it is necessary to understand the motives and objectives that they have for BWM. The main motive for shipping companies to install a BWTS on-board was the IMO regulation because then the ship can travel anywhere if they have the BWTS installed. In addition, shipping companies are currently focusing on environmentally friendly shipping.

However, the installation of BWTS on-board is causing issues such as high costs, size of the system and the demanding schedule to install the system. In addition to the purchase and installation costs, system's use of electricity was seen as an additional cost. Moreover, the size of the system raised concerns as placing new equipment on existing vessels is challenging and expensive for the shipping companies. System's big size also makes the maintenance operations hard to reach.

> *"Our oldest vessel was built in 1954, so it is already starting to be so old that it won't be jumping over waves for so long. How much we will invest in it, is a bit questionable."* (Person E, shipping company)

> *"One shipping company installed a BWT systems on-board and when they added up the price of the system, the cost the cost of installation, the fact that the ship was in the shipyard for a week during installation i.e. lost cargo, then the total cost was around 350-400 thousand euros. (..) A used ship that is 25-years-old costs about 3 million euros. So, this means that the cost of a BWT system is about 10% of the value of a used ship."* (Person C, waterways development organization)

Thus, for older ships the retrofit might not be an advisable solution. A port-based BWTS allows port service providers to service multiple ships with one treatment plant. This means that shipping companies do not have pay dry-docking installation costs and no off-charter losses. (Jallal 2020)

> *"I believe that there is potential for the service, because retrofitting the systems is expensive and the shipowners do not want to do it."* (Person A, port operator)

> *"It would be great, if we could arrive to the harbor and, if necessary, leave the ballast water and clean up the system, because it [BWTS] is an extremely expensive system to install on a ship."* (Person E, shipping company)

For port service providers this new business opportunity allows to stand out from the competition as there is competition for customers in the market. Most service providers saw the BWT service as an image boost and this better market position as some ships might not come to the port if the service is not offered.

> *"We are interested in being a BWT service provider because it allows us to differentiate ourselves from the competition."* (Person A, port operator)

The data indicated that the port service providers could offer the service for ships that have short and regular route because during these trips it is rarely necessary to adjust the amount of ballast water. In addition, shipping companies need the service if their own system is broken.

However, this will also raise issues for the shipping companies. As the BWT service would be handled when the ships are at the dock, the BW handling should not interfere with the unloading of goods. The collected data set demonstrated that the BW can be treated without interruptions at the port like refueling is done. However, it was mentioned that the service could potentially be harmful to cargo handling and make operating loss for the shipping companies. In addition, ship's departure cannot be delayed due to water pumping so the BWT service provider should consider the amount of ballast water that is required. In addition, shipping companies pointed out that it would be problematic for them that not all ports may not have that BWT service available. Thus, the ship would be dependent on port that offer a BWTS service.

> *"The problem for the ships is that when they go to a port that does not have the [BWTS] service. (…) I can say with a 100% certainty that this system will not be provided at every port."* (Person D, shipping company)

The shipping companies also pointed out that it might be difficult to sell a ship without that BWTS. Also, the costs of the service raised questions:

> *“Ports' arbitrariness to price that thing [BWTS service]. That would require legislation to make the port obliged to do so without delay and at agreed tariffs, like grey water (…) ports should be recommended or required for a no special fee system.* (Person G, shipping company)

5.4 Value creation from the business model

The purpose was to find out what kind of business model creates the most value for the customers. Value can be created to customers with products and services offered along the product life cycle. Additionally, it was investigated how much customer interaction is needed.

The ownership of the BWTS is important for the customer. It was found out that renting or leasing was rare for the maritime companies and usually the products used are fully owned by the companies. Potential customers are familiar with the idea of owning product and paying the whole amount at one. On reason for owning the product was that it is hard to sell a ship in the future that does not have a BWTS installed. Also, customers want to be responsible for the product after it has been bought.

The operation phase of BWTS provides some opportunities for the integration of product and services into packages as the data indicates that customers want service solutions along the product life cycle. Mostly potential customers wanted installation and maintenance along the product purchase or even just the installation as the customers believed that they could handle the maintenance in-house. Thus, technical support would be needed initially, but later on, they could handle it in-house. Being dependent on the supplier’s way of doing business was seen risky, so some wanted to have product-related operation conducted in-house. However, another viable service solution could be to handle all the life cycle activities such as product purchase, installation, maintenance, and disposal of the product.

It was found out that the port service providers want and need more of the additional services along the whole life cycle which included product purchase, installation, maintenance, and disposal of the product. On the contrary, shipping companies needed only the product purchase or product purchase and maintenance. However, both potential customer groups felt that technical support and spare parts are important throughout the whole product life cycle.

> *"We want to take care of them as much as possible ourselves. (...) The availability and continuity of spare parts is an important thing. But the maintenance of a [BWTS] is simple (…) it's a bit like a car. You change the filters and plugs, and that's it. The fact that we can get that same plug in another 20 years, that is important to us*." (Person E, shipping company)

> *"Additional services are needed, especially in the beginning. We don't know the system yet, so that is why we might need help with the maintenance during the product life cycle. I believe that we can take care of the basic maintenance as a port company, but some level of support should exist."* (Person H, port)

5.5 Customer requirements for the ballast water treatment system

Here the factors contributing to customer's requirements for the BWTS are presented. Potential customers need to take into different features and issues when selecting the most suitable BWTS because ships differ in size, age, type, ballast water capacity and ballast pump(s) capacity, and ballasting frequency (Bacher & Leino n.d.).

The gathered data indicates that the most important features for the potential customers are annual operating costs, availability of technical support, availability of spare parts, and price. Especially, the price of a system seemed to be a crucial factor in the system selection. The BWTS is considered as an additional cost, so the shipping companies want the price of the system to be as low as possible. Likewise, the system's use of electricity was considered as an important feature because that will impact the costs in the long run.

It was found out that the customers have requirements for the BWTS supplier. It is important for the potential customers that the supplier will be operating in the industry in the long run as additional services might be needed such as spare parts and technical support. Potential customers require that the availability of spare parts needs to be easy and fast throughout the whole product life cycle of BWTS. The supply of spare parts needs to be secured for a long time because BWTS is a mandatory device that must operate at all times. It was also indicated that references of the supplier were important. If the equipment has good references, then the purchasing decision will be easier.

> *"There are those BWTS suppliers who have grown suddenly but in 10 years they cannot be found anymore and in consequence we cannot get spare parts and maintenance anymore. The risk analysis of the supplier is essential, they have to be working with us for the next 20, 30, maybe 50 years."* (Person E, shipping company)

Potential customers also had requirements for the BWTS's size. The BWTS needs to be as small as possible because the ships have limited space where to install the system. Especially, when retrofitting old ships, the size of the system was regarded as an important feature. The size of the BWTS also raised concerns about how maintenance can access the system.

> *“All the other areas that do not carry cargo are small because the cargo is what brings the money. (…) Because of that, there is always a shortage of space.”* (Person D, shipping company)

Generally, ports, port operators, and shipping companies had similar answers when considering the importance of different features. However, the feature “mobility” had significant differences in answers of port service providers and shipping companies. Port service providers considered mobility as an important feature because they need to move it on the dock to the ships. Nevertheless, some port service providers were open for the idea that the BWTS could be installed on the dock.

> *“Thinking about our infrastructure, then it [BWTS] certainly needs to be mobile. Another thing that what I am thinking about is fixed stations, that are integrated into the dock, but those would need a rubber hose solution for the water. (…) Many ports do not have a single pier area, but the pier is made of sections, and that would probably require a mobile equipment*.” (Person B, port and port operator)

> *“I have done some researching, and at the moment there is a lot of installed [BWT] systems on the market for the shipping companies, so it is very interesting to study now whether there is a need for mobile [BWT] systems in ports.”* (Person A, port operator)

On the contrary, a common view amongst the shipping companies was that mobility is not an important feature as the BWTS will be installed on-board.

> *“Mobility doesn't matter. When the system is installed there, it will not be moved. (…) One thing that's challenging when it comes to retrofitting is the maintenance. You need to be able to move around the system so that it can be serviced. That also needs be considered and it is indeed challenging on these old ships.” (Person F, shipping company)*

However, one interviewee from a shipping company argued that:

> *"In our opinion, everything should be movable on-board. The world is changing and evolving, so these systems need to be easily replaceable. The unfortunate thing is that all systems are fixed. (…) But the more mobile and the more modular it [BWTS] is, the better."* (Person G, shipping company)

5.6 Summary of the findings

The maritime industry and the BWTS market are highly influenced by the changes of regulations. It was clear that one of the main reasons to invest in BWTS results from the pressure of the external authorities as the main reason for shipping companies to treat their ballast water is related to the IMO and USCG ratifications. Thus, it is important for ships to treat their ballast water to continue operations in the international waters. For port service providers, BWT service is seen a new business opportunity as well as a way to enhance their environmental image and stand out from the competitors.

It was found out that renting or leasing a BWTS was rare and usually the products used in the maritime companies are fully owned by the companies. BWTS are highly related to the technology purchased and additional services. Most of the data indicates that additional services are wanted throughout the product life cycle. However, some responders stated that they only need minimal services from the BWTS supplier such as training and availability of spare parts. Being dependent on the supplier's way of doing business was seen risky, so some wanted to have product-related operation conducted in-house. Nevertheless, the companies that had already purchased a BWTS seem to have additional services related to the product such as installation, maintenance, and telephone support.

Overall, potential customers had interest towards products which are easy to maintain and compact. The cost of the product life cycle has an impact on the purchasing decision. The most common concerns were higher costs, size of the system, and how the regulations can still change. In addition, there was a hurry for the shipping companies to start making purchase decisions.

6 DISCUSSION AND CONCLUSIONS

The following chapter summarizes this research and discusses the findings and conclusions of this study. Furthermore, it will indicate the theoretical contributions and discuss the practical implications for management. Finally, the limitations of this study will be assessed and suggestions for further studies will be provided.

The aim of this research was to develop a PSS business model for a BWTS. Literature review revealed that scholars have not yet arrived at a consensus on general guidelines of how to develop a PSS business model (Rondini et al.2016; Richeter et al. 2019). Surprisingly enough, many of the theories intercept because they adapt quite identical theoretical models and treat them as their own. Thus, within this work we applied theories as they fit. Additionally, the aim was to understand the customer requirements for the product and services and how the PSS business model creates value for the B2B customers. The main drivers for this research were the lack of academic research on this topic and the need to understand how to develop a business model for the BWTS. This topic is also current as the shipping companies in Finland are now planning on their BWTS purchases for the upcoming years. Thereby, the purpose of this study was to find answers to the following research questions:

SQ1: How does the maritime industry affect the business model?

The impact of maritime industry on the business model was identified from literature and research. The results of this study show, that the maritime industry has a regulative environment that shapes the businesses. BWTS market was induced by IMO's and USCG's environmental regulations (i.e., by regulatory pressures). The regulations and type approval's create uncertainty in the market that needs to be noted. The developed business model should be flexible and consider at least IMO's type approval as Finland is one of the countries that have signed the ratification. However, potential customers who need to buy the BWTS might also operate in the

U.S. waters and therefor need to follow the USCG ratification. The major difference between the BWM Convention and USCG BWM is in the ballast water management system testing and verification requirements. As a result, the complexity and certain regulatory differences cause considerable concern amongst all stakeholders in the shipping industry, mainly shipowners and ship operators. (Čampara et al. 2019)

The maritime industry is complex because of the high numbers of actors and networks operating in the environment. The IMO regulation ensures that shipping companies and other potential B2B customers need to buy a BWTS. Due to the market pull and growing high demand for the BWTS, there are several competing technologies and manufacturers operating in the market. To stand out from the competition, the developed business model must apply to customer needs and wants. The competitors' way of operating business in the BWTS market should be examined. The competitors offer the same product but with additional services, thus it is important to offer similar kinds of activities that the customers need. In the maritime industry, there are not many differences between the "traditional" and the "product-oriented" business models.

The BWTS market trends have grown over the years gradually. Mostly, the other competitors have developed BWTS that are installed on-board. However, there are other potential customers than just the shipping companies. Port service providers are potential customers of the BWTS, as they can offer the ballast water treatment to ships that arrive to the port. Especially, old vessels are under inspection that whether companies will invest and install BWTS on-board. The port service providers are showing interest in investing for a BWTS which can impact the business model as they are a different kind of customers with different needs.

SQ2: How a PSS business model creates value for the B2B customer?

Prior literature and this research's primary data gave insight on how the PSS business model creates value for the B2B customer. Over the years, business models have evolved from traditional business models towards integrated PSS business models. Business models that contain bundles of products and services has been way for companies to attract customers and stay competitive. Usually in the PSS business model, the responsibility to maintain the product along its life cycle and disposal remains with the producer. (Barquet et al. 2011) Customers benefit and gain value from a PSS because they receive greater diversity of choices in the market; maintenance and repair services; various payment schemes; and the prospect of different schemes of product use that suit them best in terms of ownership responsibilities (Mont 2002). PSS provides customers value through customization and higher quality. For the customer, PSS is considered to provide value by customization and higher quality. A flexible service component can also provide new combinations of products and services, better according to customer needs. (Baines et al. 2007)

This study's findings suggest that a PSS business model is suitable for the BWTS. This is because the high levels of competitiveness in the maritime industry increases pressure to find new ways to create offering and stay competitive. It is advisable for manufacturer firms to support their products through their lifecycles as many B2B firms may view services as a source of added value (Rivas-Hermann et al. 2015). In addition, the maritime industry is one in which PSS offerings are already well-known and institutional arrangements between shipbuilders, subcontractors, shipowners, and charterers are already developed (Rivas-Hermann et al. 2015) so the PSS business model is already familiar to the potential customers. PSS offerings provide an opportunity for both suppliers and customers to explore and ultimately implement the servitized business models due to the long-life cycle of the ships and the capital-intensity of the industry (Pagoropoulos et al. 2017).

It was found out that ownership of the BWTS is important for the potential customers as renting or leasing the product could potentially create unwanted challenges and risks. The operation phase of BWTS provides some opportunities for the integration of product and services into packages as the data indicates that customers want service solutions along the product life cycle. Thus, a traditional product-based or service-based business models are not enough in the maritime industry's B2B market, something in the middle is needed. The packages provided by the competitors also indicate that it would be hard to enter the market without the additional services.

To offer the BWTS in the form of PSS, this means that close customer relationships need to be managed. The service provider needs to have regular information sharing with the customers which also creates value for the customer. The primary data gathered indicated that potential customers gain added value from additional services. Potential customers want and need services along the product life cycle as it is important for them that the BWTS supplier is in the business for the upcoming decades. By offering services along the life cycle, the customers gain added value. The additional services can be e.g., training, support (hotline, maintenance team), and consulting. This way the PSS will also prolong the product's lifetime.

SQ3: What are the customer requirements for the cleantech product and services?

To find out about the customer requirements for the BWTS and additional services, a questionnaire and interviews were conducted for the potential customers. The BWTS has two types of potential customer groups: port service providers and shipping companies. The shipping companies are the typical customer for the BWTS, however, port service providers can be also regarded as a potential customer as they can provide BWT at ports to old ships that have regular and short routes. Ships that travel long distances internationally need a BWTS that is installed on-board. Thus, the requirements for the BWTYS are strongly related to the companies' objectives and challenges concerning the BWT processes.

This study revealed that the shipping companies and port service providers have similar requirements for the BWTS as a product. Both customer groups were concerned about the costs and size of the product. As this is a new investment for the customers, they need the costs to be low as possible. The size was regarded as an important product feature as it needs to be compact as possible. This way it fits to the ships, and it is easily manageable at the ports. The mobility feature of BWTS was the only feature that had differences in opinions. The shipping companies do not need the BWTS to be mobile as it is installed on-board. On the other hand, port service providers saw the mobility of BWTS important as they might need to move the BWTS on the dock.

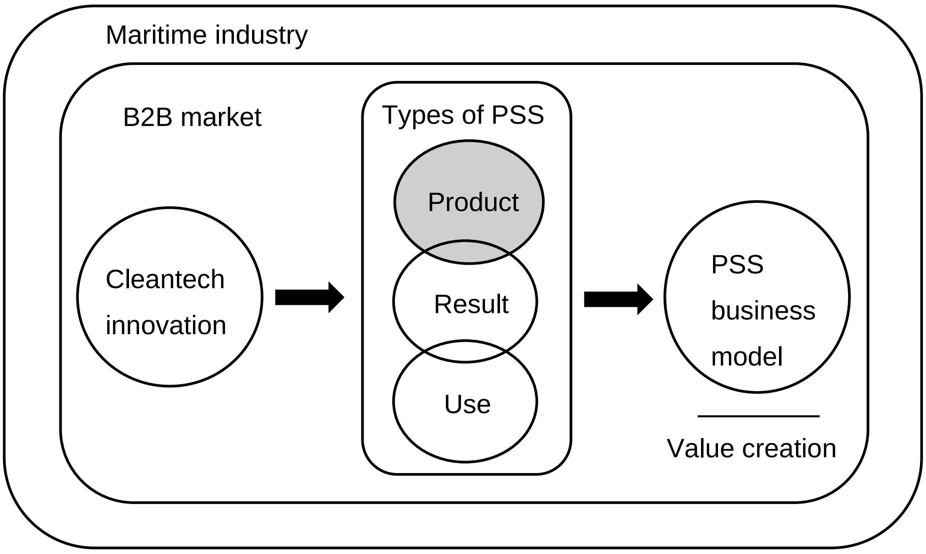
Through the study it was found out that there are customer requirements for specific services along the product purchase. As the BWTS is a new technology for the potential customers, product related services are needed. For most, the basic installation-based and training services are needed at least in the beginning but later they can take care of it by themselves. The companies wanted to conduct maintenance in-house because they do not want to be too dependent on the BWTS supplier and that is seen as additional costs. The potential customers also view that the maintenance of the BWTS easy. In this sense, training services are needed for the customers that choose to conduct maintenance in-house. However, some companies needed maintenance services. This in return increases the need for 24h maintenance services that are rapidly available for the customers. In addition, the availability of spare parts was an important feature when deciding where to purchase the BWTS from.

RQ: How to develop a PSS business model for a cleantech product?

To develop the most suitable PSS business model for the BWTS, a combination of different guidelines and procedures by Mont (2001), Barquet et al. (2013) and Gaiardelli et al. (2014) were followed. Additionally, the insight gained from the theoretical part and empirical findings were used. It was necessary to find out how the maritime industry affects the business model, how the PSS business model creates value to its customers and what are the customer requirements for the

BWTS and related services. The process of the PSS business model development is presented in figure 7 which indicates the process of developing the most suitable PSS business model for the cleantech innovation in the maritime industry's B2B market.

Figure 7 Revised model of the theoretical framework



First, an initial review was conducted to identify the possible practises and activities within the company that can be used as a starting point for the PSS introduction. This was the process for developing ideas for the PSS. Second, a marketing analysis was done to understand customer requirements. This was done by sending a questionnaire and conducting interviews for potential customers. This way, the developed PSS business model creates value for the customers and reveals new possible services or other functions that the supplier can provide. Also, customer involvement early in the design and development of the PSS offering, makes the development process more efficient and effective (Reim et al. 2017). It was necessary to understand more about the maritime industry and how competitors are currently operating so a literature review and document review were conducted. Lastly, the most feasible PSS elements were chosen that also create the most value for the potential customers. The developed business model for the BWTS is a product-oriented PSS business model.

In this case, the product-oriented PSS business model is mostly based on the service offerings along the product purchase. It is necessary to offer some extra value with services to the customers to gain the interest of customers. This type of a business model is familiar for the customers and other actors in the maritime industry as there are not many differences between a “traditional” and a “product-oriented” business models as additional services are almost always provided. Additionally, the product-oriented business model is typical in the BWTS market. Competitors in the BWTS market are offering a wide range of additional services for their customers.

The advantage of this model is that it uses the traditional business model's cash flow, so the whole amount is paid at once. The customer is responsible for the product after it has been bought and has to choose what actions are needed so the suppliers does not own the product. Therefore, all the stakeholders are keen with this approach. The value created for the customer is through the product and additional services.

By using the product-oriented business model, value can be created by additional actions and flexibility in fulfilling customer requirements compared to traditional business model. The BWTS is a new technology thus customers do not have knowledge about the usage of the system. So, when the customer buys the product and due to the lack of knowledge of the usage of the machine, the customer must buy additional services such as installation and maintenance at least for the start. This creates the BWTS an opportunity to sell and offer service agreements to assure functionality and durability for the customer. In the product-oriented PSS business model, the value is created for the buyer by reducing the amount of work they must do themselves. (Reim et al. 2015)

The recommended additional services for a BWTS are based on the combination of Gaiardelli et al. (2014) PS offerings for a B2B company and the findings of the research findings of what customers need. The suggested additional services are:

- installation
- training
- maintenance / technical support
- spare parts
- disposal

Most of the potential customers required additional services at the beginning of the product life cycle. Customers were not familiar with the BWTS technology and therefore they need services such as installation and training. These offerings will be managed and supported at least in the beginning of the product life cycle or even through the whole product life cycle. This is beneficial for the BWTS supplier because product-oriented services such as advice and consultancy are the least problematic services for companies to introduce (Tukker 2004). Most of the customers also showed interest for services during the whole product life cycle of the BWTS. They required maintenance, technical support, and spare parts when needed. Nevertheless, additional services such as maintenance programme ensures the machine utilisation over a given period of time. By prolonging the product's lifetime, this will be also regarded as resource efficiency. The disposal of the product is something that can be also offered for the customers. At the end of the product life cycle the BWTS supplier could take care of the product disposal which as a result creates value for the customer.

It should be noted that a business model is never complete as the process of making strategic choices and testing business models should be ongoing (Shafer et al. 2005), thus the process should not end with the choice of the most suitable business model.

6.1 Theoretical contributions

This research contributes to literature by addressing to the gap in the literature about how to develop a PSS business model for a cleantech innovation. More specifically, it brings insight to a less academically researched topic regarding a business model development for a BWTS. Additionally, there is increasing interest between academia and maritime industry about cleantech innovation such as BWTS (Koukaki & Tei 2020) making this study forward-looking and adding value for the on-going discussion.

Prior literature seems to lack consensus on how to develop a PSS business model (Rondini et al. 2016) and there is a need for process model for PSS development (Richter et al. 2019) as understanding the phases that are included in the PSS business model development are crucial. Although it is difficult to generate a widely applicable PSSs (Mont 2001), this study and its findings can be used as a guideline for PSS development.

The results of this thesis support the fact that a PSS business model can be applied in the maritime industry (e.g., Andersen 2013; Neugebauer et al. 2013; Rivas-Herman 2015). The results also bring more evidence and strengthens the outcome of Rivas-Hermann et al. (2015) that PSS is a relevant business model for a BWTS.

This study increases understanding on the ways companies in the maritime industry want value from business models. Moreover, results offer valuable insight about what customers want from the bundle of product and services in relation to BWTS. Solutions of products and services create added value to customers in the installation phase of BWTS (Rivas-Hermann et al. 2015). On the contrary, Pagoropoulus et al. (2016) examined from the shipping industry that customers disregarded the servitized offerings because they were not perceived as important sources of value.

6.2 Managerial implications

The research findings revealed several managerial implications that can be considered. This research aims to provide practical guidelines and suggestions for companies to examine and utilize, especially in the maritime industry.

This research is beneficial for managers in manufacturing companies who are responsible for PSS business model development. The development process of a PSS business model is challenging and complex, so this thesis can be used as a guiding tool. This way managers can make better decisions in the ongoing development process. Managers need to choose the most suitable PSS type (product-oriented, use-oriented, and result-oriented) that fits the businesses objectives and creates value for their customers.

In particular, the findings are beneficial for operational managers working at BWTS supplier company as well as for other actors in the maritime industry. The BWTS market is a growing market in the maritime industry, so it is important for the BWTS suppliers to know which business model will lead to economic profit for the company and create value for the customers. Prior research has typically focused on the technology of BWTS, so current knowledge about business model development for the cleantech innovation is needed.

In addition, managers can take inspiration from this thesis regarding what product related services can be provided to customers throughout the product lifecycle. Especially, the customers of a BWTS supplier have somewhat similar requirements for service-based offering of the BWTS. Thus, this study can be used as a guideline for the process of adding new services: customer's current needs should be identified, and it is important to involve the customer in the idea development process which can bring out new ideas and also make sure that the company continues on with ideas with strong potential as well as weak ideas are eliminated.

Overall, this thesis can generate discussion for the port service providers about adding a BWTS to their services. So far there has been little or no discussion about the topic in Finland, but it is advisable now to start the conversation and idea development process as the deadline for retrofitting ships is coming to an end in 2024. BWTS service would be beneficial for shipping companies that do not want to retrofit their old ships.

6.3 Limitations and future research

There are several limitations that need to be considered when analyzing the results and findings of this research. The empirical analysis was based on data set of different companies in the maritime industry that are potential customers of a BWTS. The primary data was based on a questionnaire that received 21 answers and eight interviews. The analysis is hindered by a low number of respondents and interviewees as the sample size is small compared to the total number of companies operating in the maritime industry. It was the intention of the author to acquire data from a bigger sample size as general conclusions are hard to make on the current basis. It cannot be stated to represent the truth for all companies in general. Thus, further research could include a larger sample. Additionally, the companies in the sample were operating in different business areas (shipping company, port, and port authority) so the level of involvement and knowledge about BWTS could have impact the responses. Further studies could be considered within a single shipping company or port service providers category as this could give more insight to a unified sample and easier data interpretation.

In addition, this study was part of a university research project related to a general investigation about ballast water treatment systems. This study was conducted in a university environment and there is no specific case company that the business model was developed for. Therefore, the environment where the study was conducted may have influenced the analysis and results of the study. Thus, further research can be applied to BWTS manufacturing companies.

The present study has certain limitations regarding the PSS literature that should be considered when interpreting the results. The PSS literature is lacking consensus on the approach on different theories and generalization of what is the best approach for PSS business model development. Therefore, for future research, other approach of PSS business model development could rise from this research.

Lastly, this thesis develops a PSS business model with a limited process. The process starts by choosing a suitable PSS business model and elements to be added in it. The process ends with a particular PSS business model (product-oriented) for the BWTS. However, the process stopped before the PSS business model is implemented and therefore it does not include any conclusions on how successful the PSS business model was. Future research is needed to evaluate whether the PSS business model and implementation is right for the BWTS or not.

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APPENDICES

Appendix 1: Questionnaire (translated)

Thank you for agreeing to take part in this questionnaire about ballast water treatment system (BWTS). Obtaining responses is vital to make the necessary changes in the development of our research.

The answers will be treated confidentially, and the individual respondents will not be identifiable from the material. However, if you tell us the name of your company, we can take into account the needs of your company. If you can be contacted for an interview concerning development of ballast water treatment system, please leave your name and contact information.

It will take a maximum of 5 minutes to complete this survey. Please answer all questions.

1. Company name (Optional)

2. Your name and job title (Optional)

3. Your contact details (Phone number and e-mail) (Optional)

4. Where is the company headquarters located?

5. What is your line of business?
    a. Port authority
    b. Port operator
    c. Shipping company
    d. Haulage company
    e. Shipper
    f. Other (Please specify)

6. In what waters does your company operate?
    a. Only in Finnish inland waters
    b. Only in international waters
    c. In Finnish inland waters and international waters
    d. Other (Please specify)

7. Do you operate in Lake Saimaa?
    a. Yes
    b. No
    c. Not sure

8. Do you have a BWTS in use?
    a. Yes
    b. No

c. Not sure

9. Do you have purchase plans for the BWTS?
    a. Yes
    b. No
    c. Not sure

10. When are you going to purchase the BWTS?
    a. Within 1 year
    b. Within 2 years
    c. Within 3 years
    d. Within 4 years
    e. Over 5 years
    f. Not sure

11. How are you going to use the BWTS?
    a. Installed on the ship
    b. In the form of service in the port
    c. Not sure
    d. Other (Please specify)

12. What is the possible budget price for the BWTS?

13. Please choose the most important factors that affect the purchase decision and user experience of the BWTS:
    a. Size
    b. Delivery time
    c. Availability of spare parts
    d. Availability of technical support
    e. Environmental-friendly
    f. References
    g. Annual operating costs
    h. Mobility
    i. Technology
    j. Price
    k. Other (Please specify)

14. Why are the chosen factors most important?

Appendix 2: Interview guide and questions (translated)

Introduction

- Explain the interview process and interview aim
- Ensure audio recording is accepted

Basic information about the industry and processes

- What is your work background in the maritime industry?
- What is your role in the current company?
- Can you describe the business environment of your company?
- Does your company have a lot of networks, partners, and outsourced activities?
- Can you describe the port call process of a ship?
- Could a BWT service be provided along the other services of a port call process?
- What factors must the BWT service provider consider during the port time of a ship to be effective?

Purchase plans

- **Ports and port operators:** Are you be interested in being a BWTS service provider? Why or why not?
- Do you have BWTS in use?
- Do you have purchase plans for a BWTS?
- What was or is your budget for the BWTS?
- Do you make investment decisions based on the life cycle costs or initial purchase costs?
- Do you know about the needs of other companies for a BWTS?

Customer requirements

- **Shipping companies:** Which option is more interesting: installing a BWTS on-board or purchasing the service at the port? Why?
- What BWTS features affect your purchase decision?
- Is the size of a BWTS important?
- Is the mobility of a BWTS important?
- Do you want additional services along the purchase of the BWTS? What services?

Closing the interview

- Opportunity for additional thoughts
- Thanking the interviewee for their co-operation

Appendix 3: Example of text coding in NVivo

Code	Quote
Issues regarding BWTS	*"The problem for the ships is that when they go to a port that does not have the [BWTS] service. (…) I can say with a 100% certainty that this system will not be provided at every port."* *"It's pretty hard to sell a ship where you don't have this [BWTS] device."*
Motives regarding BWTS	*"We are interested in being a BWT service provider because it allows us to differentiate ourselves from the competition."* *"After all, it would be great, if I could arrive to the harbor and, if necessary, leave the ballast water and clean up the [system] system, because it [BWTS] is an extremely expensive system to install on a ship."*
Budget	*"We are figuring out the budget still, yeah, but it is now somewhere below 100,000 euros per ship."* *"The equipment itself costs 200,000 euros and the installations costs half of it. So, we are talking about 300,000 euros, 400,000 euros."*
Additional services	*"We want to take care of them as much as possible ourselves. (...) The availability and continuity of spare parts is an important thing. But the maintenance of a [BWTS] is simple (…) It's a bit like a car. You change the filters and plugs, and that's it. The fact that we can get that same plug in another 20 years, that is important to us*." *"Previously with our BWTS, we had training and telephone guidance for the equipment if there has been an acute problem. Training is important, so we can use it correctly"*
Product requirements	*"Mobility is quite an important and how fast and efficient it works."* *"It's quality, availability of spare parts and availability of technical support which are very important when deciding where to buy."*